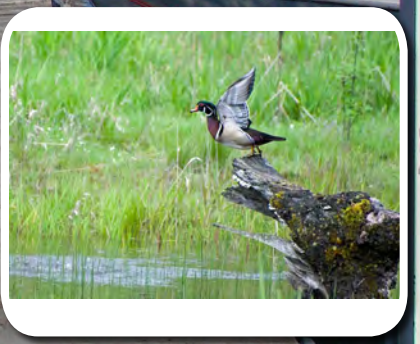
Stormwater Management Plan

Ruddiman Creek, Division Street Outfall and Muskegon Lake Direct Drainage Subwatersheds



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West Michigan Shoreline Regional Development Commission
& Muskegon Lake Watershed Partnership

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1.0 INTRODUCTION

The Muskegon Lake watershed has experienced significant alterations from the pre-settlement conditions of the area. Forests have been cleared and converted to agriculture, residential, and industrial areas. Wetlands have been filled to accommodate additional development of the area. These alterations have resulted in significant impacts to the Muskegon Lake watershed and have warranted Muskegon Lake being listed as an Area of Concern (AOC) by the United States Environmental Protection Agency (EPA) in 1985 for beneficial use impairments (BUIs) of beach closings; restrictions on fish and wildlife consumption; eutrophication or undesirable algae; restrictions on drinking water consumption, or taste and odor; degradation of fish and wildlife populations; degradation of aesthetics; degradation of benthos; restrictions on dredging activities; and loss of fish and wildlife habitat.

This Stormwater Management Plan (SMP) was developed utilizing funds from a Michigan Department of Environmental Quality (MDEQ) Stormwater, Asset Management, and Wastewater (SAW) grant and seeks to address stormwater concerns within three subwatersheds of Muskegon Lake. Previous efforts have been undertaken to identify stormwater issues and corrective actions within the Muskegon Lake watershed including the Muskegon River 319 Watershed Management Plan (GVSU 2002), the Muskegon Lake Watershed Management Plan (FTCH 2005), and the Studies to Support an Implementation-Ready TMDL for Ruddiman Creek (GVSU & FTCH 2013). This SMP will integrate information presented in these previous reports and will build upon the corrective actions described within the reports by recommending site specific Best Management Practices (BMPs) to address stormwater concerns within three subwatersheds of Muskegon Lake.

1.1 Background

Muskegon Lake is a 4,150-acre lake formed in a drowned river mouth where the Muskegon River enters Lake Michigan in Muskegon County, Michigan. In addition to the Muskegon River, Muskegon Lake receives water from Ruddiman Creek, Mosquito Creek, Bear Creek, Ryerson Creek, Green Creek, and Four Mile Creek. The surface water of Beidler's Creek is now a part of the Division Street Outfall storm drain system. The cities of North Muskegon and Laketon Township, and Muskegon are located along the north and south shores; respectively, of Muskegon Lake.

This SMP focuses on three subwatersheds of Muskegon Lake covering 5,472 acres. These subwatersheds are Muskegon Lake Direct Drainage, Division Street Outfall, and Ruddiman Creek (Plan Area). The Plan Area is located along the south shore of Muskegon Lake and encompasses portions of the following cities: Muskegon, Muskegon Heights, Roosevelt Park, and Norton Shores (Figure 1).

The Plan Area is heavily urbanized and includes significant areas of impervious surfaces, leading to flashy hydrology within drainage systems. Surface water in the Plan Area generally flows north before discharging

into Muskegon Lake. Stormwater from the Plan Area has been identified as directly contributing to elevated levels of heavy metals, organic chemicals, and excessive sediment within Muskegon Lake. In the Muskegon River Watershed 319 Management Plan developed by Grand Valley State University (GVSU) other pollutants and impairments of concern include toxic substances, hydrocarbons, nutrients, pathogens, thermal pollution, and unstable hydrology. Degraded water quality has resulted in the following impaired and threatened designated uses of the Watershed: coldwater fishery, warmwater fishery, other indigenous aquatic life and wildlife, and partial and total body recreation. Biological surveys and other watershed studies have found a number of Muskegon Lake's tributaries have poor macroinvertebrate and fish communities (GVSU 2002). Due to the known contamination issues, the Plan Area has been the focus of local efforts to reduce or eliminate the sources of contamination to facilitate the cleanup of contaminated sediments under the U.S. EPA Great Lakes Legacy Act.

1.2 Project Purpose

This SMP seeks to describe present conditions in the Plan Area and to address the impacts of structural BMPs on stormwater runoff within these subwatersheds. In addition to describing overall conditions and strategies, site specific conceptual plans were developed to address surface water runoff within targeted areas of the Plan Area by incorporating green stormwater infrastructure design features. The plans describe the existing conditions of each site and the selected BMPs to be implemented to reduce surface runoff via increased infiltration. Operation and maintenance plans for each site were developed (See Appendix C) and long-term maintenance costs were calculated to ensure implemented BMPs operate to their greatest potential. Finally, the importance of public education and involvement relating to the BMPs is highlighted.

1.3 Project Objectives

Implementation of this SMP seeks to:

- minimize nonpoint pollution;
- maintain the integrity of stream channels for biological and drainage functions;
- reduce flood damage;
- minimize any increase in stormwater runoff from new developments;
- maintain groundwater recharge;
- improve aesthetics of land and water resources within the community;
- develop recommendations for BMP implementation that meet goals identified in the Ruddiman Creek Biota and *E.Coli* TMDLs;
- develop recommendations for BMP implementation that meet goals identified in the Muskegon River Watershed 319 Management Plan (GVSU 2002);
- support the implementation of City of Muskegon Stormwater Ordinance and Muskegon County Site Development Rules; and

- develop recommendations for BMP implementation that meet goals identified in the Michigan Water Strategy.

By achieving these goals, the SMP will contribute to water quality improvements in the Muskegon Lake watershed, specifically by meeting the goals of Muskegon Lake watershed TMDLs, the Muskegon River Section 319 Watershed Management Plan and rehabilitation goals in the AOC, specifically by providing progress towards the removal of eutrophication or undesirable algae, degradation of aesthetics; degradation of benthos, loss of fish and wildlife habitat, and degradation of fish and wildlife populations BUIs. Implementation of this plan will protect what has been restored in the AOC and prevent future degradation by meeting goals of the Great Lakes Action Plan, Lake Michigan Lake Action Management Plan, Michigan Water Strategy, and the Michigan 21st Century Infrastructure Plan. Implementation of this plan will also protect the quality of Lake Michigan, including the source water intakes of the City of Muskegon and the City of Muskegon Heights.

2.0 WATERSHED CHARACTERISTICS

2.1 Hydrology

2.1.1 Storm Sewer System

As a result of the highly-developed nature of the Plan Area, much of the surface water runoff is directed into municipal storm sewers that ultimately discharge into Muskegon Lake and its tributaries (Figure 2). Acreages for each storm sewer watershed are summarized in Table 1. Receiving waters within the Plan Area are Muskegon Lake, Ruddiman Creek, and the lower portions of Ryerson Creek, and the North, Middle and South Branches of the Muskegon River.

Table 1: Summary of Areas for Ruddiman Creek, Muskegon Lake Direct Drainage, and Division Street Outfall Subwatersheds, Muskegon, Michigan.

Subwatershed	Area (Acres)
Ruddiman Creek	2,788
Muskegon Lake Direct Drainage	2,000
Division Street Outfall	690

Storm sewer infrastructure within the Plan Area has been inventoried utilizing Geographic Information Systems (GIS). There are approximately 158 miles of storm sewer lines and 4,686 catch basins within portions of the City of Muskegon, City of Muskegon Heights, City of Roosevelt Park, and City of Norton Shores storm sewer systems comprising the Plan Area. There are 32 mapped discharge points of storm sewer water on Muskegon Lake, and 39 mapped discharge points of storm sewer water on Ruddiman Creek (City of Muskegon 2016, City of Muskegon Heights 2016, City of Norton Shores 2016, & City of Roosevelt Park 2017).

The storm sewer infrastructure within the Plan Area dates back to at least 1923; however, date of installation for storm sewer lines and catch basins are unknown for 88% for storm sewer lines and 92% for catch basins. Known construction materials for storm sewers includes concrete, clay, brick, metal, and plastic. Catch basins within the project area are known to be constructed of brick, concrete, and concrete block (Table 2; City of Muskegon 2016, City of Muskegon Heights 2016, City of Norton Shores 2016, & City of Roosevelt Park 2017).

Table 2: Summary of Construction Materials of Storm Sewers and Catch Basins Within Ruddiman Creek, Muskegon Lake Direct Drainage, and Division Street Outfall Subwatersheds, Muskegon, Michigan.

Construction Material	Sewer Lines (%)	Catch Basins (%)
Concrete	49.5	36.7
Clay	5.5	N/A
Brick	0.2	2.3
Iron/Metal	1.0	N/A
PVC/Plastic	2.8	N/A
Concrete Block	N/A	9.3
Unknown	41.1	51.7

Inclusion of green infrastructure solutions to stormwater runoff is encouraged within the Plan Area. The City of Muskegon requires new construction projects to include on-site storage of stormwater runoff (City of Muskegon 2015). Examples of projects complying with this requirement are summarized in Table 3. Due to extensive areas of historic shoreline filling with foundry sand, it is important to assess environmental conditions to evaluate soils. Often, it is necessary to remove historic foundry fills and replace with clean fill material.

Table 3: Summary of Green Infrastructure Installations Within Ruddiman Creek, Muskegon Lake Direct Drainage, and Division Street Outfall Subwatersheds, Muskegon, Michigan.

Location	Description of Installed Green Infrastructure
Berkshire Senior Housing	• Underground storage tanks for detention of runoff proposed
Former Farmer's Market	• Phyto-remediation installation using tree plantings
Grand Trunk Park	• Native plant rain garden/infiltration areas along shoreline
Grand Valley State University – Annis Water Resources Institute	• Green roof on accessory building • Beach grass/infiltration areas
Grand Valley State University – Muskegon Innovation Hub	• Beach grass/infiltration areas
Heritage Landing Circle Peninsula	• Storm sewer oil and grease interceptors • Native plant rain garden/infiltration areas along shoreline
Shoreline Inn	• Phyto-remediation installation using tree plantings
Muskegon Lakeshore Chamber of Commerce	• Native plant rain garden/infiltration areas
Lafarge Muskegon Cement Terminal	• Beach grass and native landscape infiltration areas
Great Lakes Dock and Materials	• Native plant rain garden/infiltration areas along shoreline
Verplank Trucking	• Native plant rain garden/infiltration areas along shoreline

2.1.2 Wetlands

Wetlands have many benefits relating to stormwater runoff management. These benefits include reducing flow velocities, resulting in deposition of suspended sediments and increased infiltration into ground water systems. Wetlands also serve to filter contaminants from surface water.

Due to the highly urbanized nature of the Plan Area and the significant historical filling of wetlands that have occurred within the area, only 1.0% of the Plan Area was classified as wetlands by the National Wetlands Inventory (NWI) conducted by the United States Fish and Wildlife Service (Figure 3, Table 4).

Table 4: Summary of Wetlands Identified Within Ruddiman Creek, Muskegon Lake Direct Drainage, and Division Street Outfall Subwatersheds, Muskegon, Michigan.

Wetland Type within Plan Area	Percent of Plan Area
PFO	0.11
PSS	0.34
PEM	0.50

[1]*Cowardin Classification: PEM = Palustrine Emergent Wetland; PSS = Palustrine Scrub-Shrub Wetland; PFO = Palustrine Forested Wetland*

Forested wetlands (PFO) are dominated by woody vegetation exceeding 20 feet in height. Common dominant species are red maple (*Acer rubra*), American elm (*Ulmus americana*), ashes (*Fraxinus pennsylvanica* and *F. nigra*), and swamp white oak (*Quercus bicolor*). Wetlands in this category generally occur on mineral soils or highly decomposed organic soils. Forested wetlands within the Plan Area are limited to isolated locations along the immediate Muskegon Lake shoreline.

Scrub-shrub wetlands (PSS) are dominated by woody vegetation less than 20 feet including shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. Common dominant species are alders (*Alnus* spp.), willows (*Salix* spp.), buttonbush (*Cephalanthus occidentalis*), red osier dogwood (*Cornus stolonifera*), and young trees of species such as red maple. Scrub-shrub wetlands within the Plan Area are generally restricted to the immediate vicinity of Ruddiman Creek and the Muskegon River inlet.

Emergent wetlands (PEM) are dominated by erect, rooted, herbaceous hydrophytes, where vegetation is present for most of the growing season in most years. Common dominant species include cattails (*Typha* spp.), bulrushes (*Scirpus* spp.), sedges (*Carex* spp.), and manna grasses (*Glyceria* spp.). Emergent wetlands within the Plan Area are generally located along Ruddiman Creek, the Muskegon River inlet and scattered locations along the Muskegon Lake shoreline.

The NWI is prepared using a compilation of information from sources typically based on remote sensing techniques. It is not unusual for actual site conditions to differ from those depicted on the NWI maps, particularly in areas of historic development or when the unidentified wetland areas are relatively small (e.g., less than 0.25 acres). Therefore, additional unmapped wetlands may be present within the Plan Area.

2.1.3 Floodplains

Floodplains serve many functions in stormwater management. During inundation events, floodplains remove excess sediment and nutrients from surface waters. Where intact floodplains are present, water velocity is slowed allowing greater infiltration of surface waters. Floodplains can also serve as important greenspaces and wildlife corridors in otherwise developed areas.

Through analysis of Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) 8.1% of the Plan Area was mapped as being within a designated high risk flood zone (Figure 4). A designated high risk flood zone is an area with a 1% annual chance of flooding, and is otherwise known as a 100-year floodplain. Floodplains within the Plan Area were generally found along Ruddiman Creek, Four Mile Creek, Ryerson Creek, Muskegon River inlet, and the immediate shoreline areas of Muskegon Lake.

2.1.4 Water Quality

Stormwater runoff from urban areas contributes greatly to surface waters in the Plan Area. The impervious urban areas prevent water from infiltrating into the ground and allow for containments to easily be transported. Most of the point sources of pollution are from industries in Muskegon and have been identified, however non-point sources of pollution from urbanized areas remain a threat. Non-point sources include oil, gas, and grease from streets and parking lots that are transported by stormwater runoff (MCD 2002). The stormwater discharged into Muskegon Lake and its tributaries has resulted in a diminished quality of water resources within those water bodies.

2.1.4.1 Muskegon Lake

Sediment contamination is an issue within Muskegon Lake, with some of the highest levels of contaminants being detected at stormwater discharge outfalls and tributary mouths. The Annis Water Resources Institute at GVSU, Fishbeck, Thompson, Carr, and Huber, Inc. (FTCH), and the EPA, with various partners performed a study to determine the extent of sediment contamination in Muskegon Lake (FTCH 2005). Heavy metals found within Muskegon Lake included: arsenic, barium, cadmium, chromium, copper, nickel, lead, zinc, mercury, and selenium. The MDEQ developed the Stage 2 Muskegon Lake Remedial Action Plan (RAP) in 2011, and determined Muskegon Lake suffers from degraded benthic communities due to the heavy metals and organic chemicals present in storm water discharges. The MDEQ list of impaired of uses for Muskegon Lake includes warmwater fisheries, other indigenous aquatic life and wildlife, partial body contact recreation, and total body contact recreation (MDEQ 2014).

2.1.4.2 Division Street Outfall (Beidler's Creek)

Sediment contamination was significant within three areas of Muskegon Lake, including the Division Street Outfall, the former lakeshore industrial area, and the Ruddiman Creek confluence (FTCH 2005). Division Street Outfall had the highest concentrations of heavy metals, significant sediment toxicity, and an impacted benthic invertebrate community. The Division Street Outfall has been impacted by historic industrial and sanitary cross connections with the storm sewer system. These issues have been addressed, and the EPA conducted the Division Street Outfall Great Lakes Legacy Act Contaminated Sediment Clean-up Project at the outfall location.

2.1.4.3 Ruddiman Creek

Heavy metals were also found in Muskegon Lake near the confluence of Ruddiman Creek and in the downstream deposition basin (FTCH 2005). Ruddiman Creek is known to historically have sediment contamination including heavy metals and polycyclic aromatic hydrocarbon compounds. Another study by the MDEQ found that deep deposits of organic matter were negatively impacting aquatic life, and limiting stream habitat in areas of the creek (FTCH 2005). Stormwater discharges high in nutrients have caused dissolved oxygen in parts of Muskegon Lake impacting aquatic habitat and fish (MCD 2002). Sampling conducted by the MDEQ has also indicated Ruddiman Creek is impacted by high levels of *E. coli* originating from illicit sanitary sewage discharges to the storm sewer system and surface runoff across impervious surfaces washing *E. coli* contaminated materials into the storm sewer system (MDEQ 2010).

Ruddiman Creek's watershed is also highly urbanized with impervious cover exceeding 50% of the land area. Only about three percent of the entire watershed drains naturally to the creek without entering stormwater drains first, resulting in high stormflow events (NOAA 2008). High stormflow events contributes to upstream scour resulting in downstream sediment deposition. This pattern of scour and deposition increases stream width and elevation, resulting in bed aggradation and a loss of benthic habitat (GVSU and FTCH 2013). Stormwater runoff can also result in unstable hydrologic flows since the natural channels are incapable of maintaining a larger capacity of water. The larger volumes of water result in quicker flow rates which can damage stream bed habitats and cause stream bank erosion (MCD 2002). As a result of the excess sediment transport from high stormflow events, Ruddiman Creek is listed on MDEQ's Part 303(d) list of impaired waters due to benthic community impairment. The MDEQ list of impaired designated uses for Ruddiman Creek includes warmwater fisheries, indigenous aquatic life and wildlife, partial body contact recreation, and total body contact recreation (MDEQ 2014). The Eat Safe Fish Guide developed by Michigan Department of Health and Human Services (MDHHS) includes restrictions on fish consumption from Ruddiman Creek Lagoon due to high concentrations of PCBs within the fish community (MDHHS 2016).

A 2006 US EPA Great Lakes Legacy Act cleanup was completed throughout the main branch and the lagoon in an attempt to remediate the historic degradation of Ruddiman Creek. 68,710 cubic meters of contaminated sediments were removed and limited hydrologic improvements were installed following dredging, including a storm water retention basin and channel braiding at two dredged sites (MDEQ 2011).

2.2 Topography

The Plan Area ranges in elevation from approximately 735 feet above mean sea level (amsl) in the Lake Michigan shore dunes near Beachwood Park to 580 feet amsl, which is the approximate surface elevation of Muskegon Lake. Topography within the Plan Area consisted generally of a gentle slope from south to north towards Muskegon Lake. The exceptions to this are the ravine where Ruddiman Creek is located,

the steep slopes of the Lake Michigan shore dunes along the western edge of the Plan Area, and the valley occupying the historic location of Beidler's Creek.

2.3 Soils

The 2014 Natural Resources Conservation Service Soil Survey for Muskegon County indicates there are 17 mapped soil types within the Plan Area. These soils types can be generalized as representing loams, sand, muck, and urban modified soils. The majority of the site (80.4%) consists of urban modified soils characterized by engineered fill of various origins (Figure 5; Table 5).

Table 5: Summary of Soils Identified Within Ruddiman Creek, Muskegon Lake Direct Drainage, and Division Street Outfall Subwatersheds, Muskegon, Michigan.

Soil Type	Percent of Plan Area
Urban Modified	80.4
Sand	15.3
Muck	5.0
Loam	0.4

2.3.1 Hydric Soils

A hydric soil, as defined by the National Technical Committee on Hydric Soils, is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. These soils are typically associated with wetlands, floodplains, and shorelines. Due to the generally poor drainage of these soils, they are not suitable for development or for the induced infiltration of stormwater. Hydric soils accounted for only 2.4% of the plan area and reflects the placement of fill in historically developed portions of the area (Figure 6). Within the Plan Area, hydric soils are present along the course of Ruddiman Creek, Ryerson Creek, Four Mile Creek and near the Muskegon River inlet.

2.3.2 Soil Hydrologic Group

Hydrologic soil groups (HSGs) indicate the minimum rate of infiltration for bare soil after prolonged wetting events. Rate of infiltration for soils indicates the ability of water to enter the soil surface. HSGs also indicate the transmission rate of soils, which represents the ability of water to move through the soil profile.

Group A soils have low runoff potential and high infiltration rates, even when wetted. Group A soils typically consist of deep, well to excessively-drained sand or gravel. Approximately 71% of the Plan Area contains Group A soils, indicating a majority of the Plan Area is capable of high infiltration rates, and thus lower stormwater flow (Figure 7).

Group B soils have moderate infiltration rates and are composed of moderately well to well-drained soils with moderately-fine to moderately-coarse textures. Approximately 1% of the Plan Area contains Group B soils.

Group C soils have low infiltration rates, and thus high storm flow potential. Group C soils typically have a soil layer that restricts the downward movement of water in the soil profile, and are composed of moderately-fine to fine-textured materials. Approximately 5% of the Plan Area contains Group C soils.

Group D soils have very low infiltration rates, resulting in high storm flow potential. These soils primarily consist of clay soils or soils with permanently high water tables. These soils are not found within the Plan Area, unless an area is ineffectively drained.

The remaining 23% of the Plan Area did not have a HSG assigned.

Some soils are listed in two groups because of a high water table that creates a drainage problem, however, if these soils are drained, they are then placed into a different HSG. For example, Kerston muck is classified as B/D. This indicates that the drained Kerston muck soil is in group B and the undrained soil is in group D. Due to the highly developed nature of the Plan Area all areas were considered to be effectively-drained for the purposes of this SMP.

2.3.3 Water Table Depth

Water table depth across the Plan Area ranged from zero to greater than 78 inches below ground surface (bgs) (Table 6). Approximately 78.6% of the Plan Area had water table depths greater than 78 inches below ground surface. Areas with shallow water table depth are generally located in the Ruddiman Creek corridor and in areas of historic fill along the Muskegon Lake shoreline (Figure 8). Shallow water table depth indicates there is potential for groundwater contamination from former industrial uses, stormwater runoff, and leaks from sewer systems.

Table 6: Summary of Water Table Depths Within Ruddiman Creek, Muskegon Lake Direct Drainage, and Division Street Outfall Subwatersheds, Muskegon, Michigan.

Water Table Depth (inches)	Percent of Plan Area
0	1.9
6	0.4
9	0.6
18	16.0
21	0.3
>78	78.6

2.4 Land Use

2.4.1 Pre-European Settlement Conditions

Prior to European-American settlement, the area surrounding Muskegon Lake was inhabited by members of the Ottawa and Potawatomi Native American tribes. Establishment of fur trading posts on Muskegon Lake during the early 1800's initiated European-American settlement of the area. By the mid-1800's

European-American settlement of the area was occurring in substantial numbers and being supported by lumbering in the area. Before the European-Americans arrived, the Plan Area was dominated by a mixed forest consisting of white pine (*Pinus strobus*) and white oak (*Quercus alba*). This habitat type covered approximately 94% of the Plan Area (Figure 9). The remainder of the Plan Area were historic portions of Muskegon Lake that have been filled since pre-settlement conditions.

2.4.2 1978 Conditions

During the 1900's the Muskegon area started to become industrialized with the growth of foundries, metal finishing facilities, petrochemical production, and shipping. Industrial growth and chemical production in the 1950's and 1960's contributed to environmental contamination mainly due to limited knowledge, and lenient/unenforced regulations for the disposal of waste products (MCD 2002). In the 1960's many people began to migrate to outlying, empty areas, changing the land use and further impacting water quality. In 1973 the redirection of municipal and industrial wastewater from Muskegon Lake to the Muskegon County Wastewater Management System was accomplished to improve water quality, however, some areas still remained significantly degraded due to the impacts of urban stormwater runoff (MCD 2002).

Analysis of 1978 land cover data developed by the Michigan Department of Natural Resources indicates the Plan Area was highly developed at this point in time. Approximately 81.7% of the Plan Area was developed with the remainder area being undeveloped habitats or open space areas (Figure 10; Table 7).

Table 7: Summary of 1978 Land Use Within Ruddiman Creek, Muskegon Lake Direct Drainage, and Division Street Outfall Subwatersheds, Muskegon, Michigan.

Land Use	Percent of Plan Area
Residential	49.1
Industrial	18.4
Commercial	13.9
Undeveloped	9.6
Open Space/Recreation	7.0
Other	2.0

2.4.3 2011 Conditions

Land use within the Plan Area now consists of a mix of industrial, commercial, vacant, recreational, and residential areas. Like many areas within the region that historically were centers of manufacturing and industry, the Plan Area has seen declines in these economic sectors. As a result, the 2011 National Land Cover Dataset indicates the developed portion of the Plan Area declined to 80.8%, down from 81.7% in the 1978 data (Figure 11, Table 8). This decline may be attributed to formerly developed brownfields reverting to more natural conditions or being utilized for open space.

Due to the highly developed nature of the Plan Area, impervious surfaces within the Plan Area exceed the 10 to 15% threshold believed to cause biotic impairment in streams. GVSU and FTCH 2013 concluded within the Ruddiman Creek subwatershed, impervious surfaces resulting from developed land was over 50%. Streams with watersheds containing greater than 10 to 15% impervious surfaces exhibit bank erosion, poor fish species richness, low fish community biotic integrity, and impaired base flow (Wang et al. 2001)

Table 8: Summary of 2011 National Land Cover Dataset for Ruddiman Creek, Muskegon Lake Direct Drainage, and Division Street Outfall Subwatersheds, Muskegon, Michigan.

Land Use	Percent of Plan Area
Developed	80.8
Open Space/Recreation	12.2
Undeveloped	7.1

3.0 GREEN INFRASTRUCTURE SOLUTIONS

Traditional stormwater infrastructure is designed to move surface runoff quickly from the source to an outfall on a waterbody or treatment facility. An alternative to traditional stormwater infrastructure, green stormwater infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits. Green infrastructure uses vegetation, soils, and other elements and practices to restore some of the natural processes required to manage water and create healthier urban environments. At the city or county scale, green infrastructure is a patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the neighborhood or site scale, stormwater management systems that mimic nature soak up and store water (EPA 2015).

3.1 Best Management Practices

Green infrastructure can range from small-scale elements integrated into sites to larger scale elements spanning entire watersheds. Examples of BMPs include downspout disconnection, rainwater harvesting, rain gardens, planter boxes, bioswales, permeable pavements, green roofs, urban tree canopy, underground storage structures, native vegetation, infiltration basins, and bioretention islands. Recommended BMPs are discussed in the following sections and conceptual designs for BMPs can be found in Appendix A.

3.1.1 Rain Gardens

Rain gardens are used as infiltration systems in low areas of a site where stormwater can be collected. They are shallow surface depressions with native vegetation which allows water to pool and slowly infiltrate into the garden. A rain garden consist of a geotextile filter layer, 18 inches of compacted stone, 24 inches of engineering soil, two inches of mulch, and native plant vegetation.

3.1.2 Bioswales

Bioswales act as a natural channel which collect and direct stormwater runoff to another stormwater system, such as a rain garden. They are similar in design to a ditch, but tend to be shallower and wider. Bioswales consist of a geotextile filter, 18 inches of compacted stone, 24 inches of engineering soil, two inches of mulch, and native plant vegetation.

3.1.3 Infiltration Trench / Basin

Infiltration systems capture, store and infiltrate stormwater into surrounding soils. Infiltration basins are shallow impoundments that can store and infiltrate stormwater for several days. Infiltration trenches are linear systems used for stormwater infiltration and conveyance. Infiltration trenches consist of a stone filled trench wrapped in a geotextile filter. Infiltration basins are depressions where stormwater can collect, and native plants and existing soil are used to increase infiltration. Infiltration basins consist of 18 inches of compacted stone, 24 inches of engineering soil, two inches of mulch, and native plant vegetation.

3.1.4 Bioretention Island

Bioretention islands are typically surrounded by vertical curbing, and located between a street or parking lot and a sidewalk. Stormwater runoff form the adjacent paved area and sidewalk flows through the curb into the bioretention island, which functions similar to an infiltration basin. Bioretention islands are made up of a geotextile filter fabric, 18 inches of compacted stone, 18 inches of engineering soil, and 2 inches of mulch. Typically a plug or gallon-sized, bush, or tree is planted within the island.

3.2 Site Specific Conceptual Designs

The City of Muskegon, City of Norton Shores, City of Muskegon Heights, City of Roosevelt Park, Muskegon County Road Commission, and Muskegon County Drain Commissioner have developed stormwater pollution prevention initiatives (SWPPIs) to meet National Pollution Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) stormwater requirements, however, these SWPPIs only recommend general stormwater BMPs that are solely focused on city-owned or county-owned properties. Previous studies have also investigated recommended BMPs for the Ruddiman Creek subwatershed specifically. Recommended BMPs for the Ruddiman Creek subwatershed included porous pavement/underground detention, green roofs, rain barrels, and rain gardens. Modeling results for the recommended BMPs within the Ruddiman Creek subwatershed indicated the most beneficial locations for BMPs targeted directly connected impervious areas to Ruddiman Creek (FTCH and GVSU 2013). This SMP seeks to provide site-specific strategies of BMPs to reduce stormwater runoff and pollutant discharges on select properties throughout the Plan Area, and therefore, will go above-and-beyond the existing SWPPIs.

A total of 15 sites were considered for site specific conceptual designs. Of the 15 sites considered, eight were selected for site specific conceptual designs based on a collaborative effort. The eight selected sites

include Grand Trunk Park, Hartshorn Marina East, Hartshorn Marina West, Nelson School, City of Muskegon/Mart Dock East, City of Muskegon West, Seyferth Park, and the Carpenter Brothers site (Figure 12).

Grand Trunk Park, City of Muskegon/Mart Dock East, and City of Muskegon West are located within the Muskegon Lake Direct Drainage Subwatershed. Grand Trunk Park is owned by the Michigan Department of Natural Resources and is maintained by the City of Muskegon. Grand Trunk Park consists of low to medium intensity land use, scrub-shrub, and forested wetlands. City of Muskegon/Mart Dock East is city and privately owned and made up of low to high intensity developed land use. City of Muskegon West is publicly owned and made up of low to high intensity developed land use. Hartshorn Marina East, Hartshorn Marina West, Nelson School, and the Carpenter Brothers sites are located within the Division Street Outfall Subwatershed. Hartshorn Marina East is city owned and the land use is medium to high intensity. Hartshorn Marina West is privately and city owned with medium to high intensity land use. Nelson school is Muskegon Public Schools owned and the land use consists of low to high intensity with peripheral areas of scrub-shrub. Carpenter Brothers is a county owned site, and includes low to medium intensity land use. Seyferth Park is located within the Ruddiman Creek Subwatershed. The site is city owned and land use is low intensity.

The BMPs recommended for the eight sites are low impact developments designed to decrease the amount of stormwater runoff and improve the water quality. These two goals are reached by implementing engineered soil and native plants into each BMP design. The engineered soil, which is a mixture of topsoil, sand and compost, increases plant health and growth while also filtering sediment and pollutants from stormwater. The native plants used for the designs have deeper root systems which allow for increased infiltration. Native plants are also tolerant to flooding and drought and thrive in conditions such as rain gardens, bioswales, infiltration systems, and bioretention islands.

Underdrain and overflow systems are also an option to be considered for the BMP designs. These systems allow for the collection and redirection of stormwater runoff when infiltration is not occurring quickly enough. These systems are not always necessary, and add additional construction and maintenance costs. The soil type and infiltration rate of each site determines whether this precaution is necessary.

3.2.1 Grand Trunk Park

Grand Trunk Park is relatively flat and ranges in elevation from approximately 580 to 592 feet. The highest part of the park is located within the parking lot area and center of the site. The land naturally grades down to the shoreline and stormwater runoff flows from the middle of the site to the lakeshore. An existing stormwater network is located to the south of Grand Trunk Park, with piping and catch basins running along Lakeshore Drive. Grand Trunk Park, however, is not included in the drainage area for the storm system since the site is located so close to the lakeshore, and runoff drains directly to the lake. The northern section

of Grand Trunk Park is located within the FEMA 100-year floodplain of Muskegon Lake, and a freshwater emergent wetland is located adjacent to the southwest end of the site.

Recommended BMPs for Grand Trunk Park include four bioswales, four rain gardens, and an infiltration trench. Three of the four bioswales are suggested to be running south to north, parallel to the large parking lot on the site. These bioswales help to infiltrate and filter stormwater runoff while simultaneously directing the water to rain gardens at their northern ends. One bioswale is also recommended on the north end of the site running west to east. This location has a greater slope towards Muskegon Lake and will reduce runoff from entering the lake before filtration. Two rain gardens would be located at the downstream end of the bioswales running south to north, while the other two are located at the north and south ends of the parking lot. The rain gardens provide infiltration to excess runoff from the bioswales, and runoff from the developed or bare areas on the site. The two rain gardens adjacent to the parking lot will allow for the collection of stormwater runoff from the large paved area. An infiltration trench would also be beneficial in the northwest corner of the site near the lakeshore to increase infiltration before entering Muskegon Lake. Estimated installation cost for the recommended BMPs at Grand Trunk Park is $306,474.

The identified BMPs at Grand Trunk Park would reduce direct sediment inputs to Muskegon Lake from the existing gravel parking and driving areas present at the site. Pollutants from the parking areas would also be removed from surface runoff prior to entering Muskegon Lake. The BMPs would also serve to improve aesthetics and increase the recreational appeal of the area to the community.

3.2.2 Hartshorn Marina East

Hartshorn Marina East is a gently sloping area with an elevation range of 584 to 592. The higher elevations are located to the south of the site and slopes down to the northeast. The majority of stormwater runoff drains to a low area along the Lakeshore Bike Trail causing flooding along the paved trail. The northern portion of Hartshorn Marina East is located within the 100-year flood plain of Muskegon Lake.

The recommended BMPs for Hartshorn Marina East includes five bioswales, seven rain gardens and nine bioretention islands. The seven rain gardens would be placed in areas with short grass, located in adjacent to the parking lot. The southeastern rain garden has potential for four surrounding bioswales. An additional bioswale is proposed along the bike path bordering the northern boundary of the site. The bioswales will help reduce stormwater runoff through infiltration, create filtration, and direct excess runoff to the rain gardens. The bioretention islands are located running along the northern bike path. They are situated between the bike path and a roadway allowing for runoff from the paved areas to be directed through curbs into the islands. All the BMPs to be implemented will help decrease the amount of stormwater runoff collected by the storm sewer systems that drain to Muskegon Lake. Estimated installation cost for the recommended BMPs at Hartshorn Marina East is $166,934.

The recommended BMPs at Hartshorn Marina East would serve to promote more efficient infiltration of stormwater at the site and reduce flooding impacts along the Lakeshore Bike Trail.

3.2.3 Hartshorn Marina West

Hartshorn Marina is a primarily flat area with an elevation range of 580 to 586. The higher elevations are located to the south of the site and slopes down to the northeast. The majority of stormwater runoff drains to Muskegon Lake. The northern portion of Hartshorn Marina West is located within the 100-year flood plain of Muskegon Lake, and there is a freshwater forested scrub-shrub wetland located near the northwest corner.

The recommended BMPs for Hartshorn Marina West includes two bioswales, four rain gardens and eight bioretention islands. Three of the rain gardens would be positioned along the north edge of the parking lot. The northern bare section has enough surrounding space for two bioswales on either side of a rain garden, which would run parallel to the north edge of the parking lot. The bioswales will help reduce stormwater runoff through infiltration, create filtration, and direct excess runoff to the rain gardens. The bioretention islands are located running along the northern bike path. They are situated between the bike path and parking lots allowing for runoff from the paved areas to be directed through curbs into the islands. All the BMPs to be implemented will help decrease the amount of stormwater runoff collected by the storm sewer systems that drain to Muskegon Lake. Estimated installation cost for the recommended BMPs at Hartshorn Marina West is $133,446.

The recommended BMPs at Hartshorn Marina West would serve to disconnect directly-connected impervious areas from the storm sewer system. The recommended BMPs at Hartshorn Marina West are intended to reduce sediment, pollutants originating from impervious urbanized areas, and *E. coli* inputs to storm sewer drains that lead directly to Muskegon Lake. The BMPs are also intended to reduce flooding along the Lakeshore Trail which bisects the site, thus increasing the recreational accessibility of the trail.

3.2.4 Nelson School

Elevations within the Nelson School site range from roughly 598 to 614 feet. The higher elevations are in the developed area of the school consisting of parking lots and buildings. Stormwater runoff from this area drains to grassy areas to the southeast corner and also northwest. The northwest section consists of a soccer field and is predominantly grassed. The lowest area of the northwest section is within the soccer field. Runoff from the school building is collected in a storm sewer pipe running along the north side of the building near the soccer field. The piping and catch basins continue through the northeast parking lot. There is also a catch basin located in the southwest parking lot and a storm sewer system running along the major surrounding roads.

The Nelson school site has potential for two bioswales, two rain gardens, and two infiltration basins. The rain gardens would be positioned adjacent to the parking lots. This allows the rain gardens to collect stormwater runoff from the paved areas, and provide infiltration and filtration of pollutants in the water. The rain gardens are recommended to be placed on the downslope sides of the parking lots for the natural collection of runoff. This is possible if the rain gardens are located on the west edge of the northeast and southwest parking lots. The two bioswales are recommended to be positioned along the northwest and southwest edges of the site with existing topography directing flow to a low point in the northwest corner. If feasible, the access road along the south edge of the soccer field will be removed, allowing the soccer field to be shifted to the south. This would allow additional room for the bioswale along the northern property line. An infiltration basin can be used in the northwest corner for collecting excess runoff from the two bioswales, which will allow for storage of the water and additional infiltration into the natural soil. Another infiltration basin is recommended on the south end of the southwest parking lot for collecting, storing, and infiltrating runoff from the parking lot. Estimated installation cost for the recommended BMPs at Nelson School is $233,034.

The recommended BMPs at Nelson School would serve to disconnect directly-connected impervious areas from the storm sewer system and intercept surface runoff from maintained recreational turf fields. The recommended BMPs at Nelson School are intended to reduce sediment, pollutants originating from impervious urbanized areas, nutrient runoff from maintained turf, and *E. coli* inputs to storm sewer drains that outfall at the Division Street Outfall. The BMPs are also intended to provide a green infrastructure example and educational opportunity to the students of Nelson School.

3.2.5 City of Muskegon/Mart Dock East

City of Muskegon/Mart Dock East is a flat site consisting of a large parking lot at an elevation of approximately 584 feet. A storm sewer system occurs along the northwest edge of the parking lot. Runoff in the parking lot drains towards the northwest edge, and is collected by several catch basins leading to the storm sewer system. The northeast corner of the parking lot is located within the 100-year floodplain of Muskegon Lake.

In order to minimize the amount of stormwater runoff collected by the storm sewer systems at City of Muskegon/Mart Dock East, four bioswales, seven rain gardens, and six bioretention islands are recommended for the site. The bioswales would be located on the southeast side of the parking lot and the rain gardens on the northwest side. The bioretention islands will be spaced throughout the parking lot. The BMPs will help to reduce the amount of stormwater draining to Muskegon Lake by increasing infiltration, and will also enhance the water quality. Two overflow systems are recommended for the City of Muskegon/Mart Dock East site due to the low elevations and limited change in gradation of the site. The overflow system will allow for any excess water not absorbed by the BMPs to be directed to the stormwater

systems to prevent flooding or pooling. Estimated installation cost for the recommended BMPs at City of Muskegon/Mart Dock East is $113,693.

The recommended BMPs at City of Muskegon/Mart Dock East would serve to disconnect directly-connected impervious areas from the storm sewer system. The recommended BMPs at City of Muskegon/Mart Dock East are intended to reduce sediment, pollutants originating from impervious urbanized areas, and *E. coli* inputs to storm sewer drains that directly discharge to Muskegon Lake. The BMPs are also intended to improve aesthetics of parking areas utilized by the City of Muskegon for public events.

3.2.6 City of Muskegon West

City of Muskegon West is a flat site consisting of a large parking lot at an elevation of approximately 584 feet. The parking lot has multiple pipes and catch basins located within it for collecting stormwater. The piping system drains to the southwest into Muskegon Lake. The northwest corner of the parking lot is located within the 100-year floodplain of Muskegon Lake.

In order to minimize the amount of stormwater runoff collected by the storm sewer system at City of Muskegon West, two bioswales, six rain gardens, and ten bioretention islands are recommended for the site. The bioswales are to be located on the south and southwest sides of the parking lot and the rain gardens on the north side. The bioretention islands will be spaced throughout the parking lot. The BMPs will help to reduce the amount of stormwater draining to Muskegon Lake by increasing infiltration, and will also enhance the water quality. Two overflow systems are recommended for the City of Muskegon West site due to the low elevations and limited change in gradation of the site. The overflow system will allow for any excess water not absorbed by the BMPs to be directed to the stormwater systems to prevent flooding or pooling. Estimated installation cost for the recommended BMPs at City of Muskegon West is $137,939.

The recommended BMPs at City of Muskegon West would serve to disconnect directly-connected impervious areas from the storm sewer system. The recommended BMPs at City of Muskegon West are intended to reduce sediment, pollutants originating from impervious urbanized areas, and *E. coli* inputs to storm sewer drains that directly discharge to Muskegon Lake. The BMPs are also intended to improve aesthetics of parking areas utilized by the City of Muskegon for public events.

3.2.7 Seyferth Park

Seyferth Park is fairly flat with an approximate elevation range of 608 to 611 feet. The lower elevations are located towards the south end of the site, where runoff is collected in the storm sewer system. Storm sewer piping and catch basins occur along the southern end of the park and the southern half of the western park boundary. The storm sewer piping runs parallel to Le Boeuf St. and W. Sherman Blvd. There are also storm sewer piping and catch basins located further to the east of the site along Denmark St. No floodplains or

wetlands are located within the Seyferth Park. Seyferth Park is located in an area identified as having a moderate potential to reduce sediment inputs into Ruddiman Creek (GVSU and FTCH 2013).

Eighteen bioretention islands are recommend for Seyferth Park located on the perimeter of the site along surrounding roads. The bioretention islands would be positioned along Crozier Ave, LeBouef St, and Leon St. The bioretention islands would allow for the collection of stormwater from the park and the adjacent roads, and decrease the stormwater quantity collected through the storm sewer systems. The bioretention islands create infiltration and filtration of stormwater, while also increasing the aesthetics of the park. Estimated installation cost for the recommended BMPs at Seyferth Park is $95,011.

The recommended BMPs at Seyferth Park would serve to disconnect directly-connected impervious areas from the storm sewer system and intercept surface runoff from maintained recreational turf fields. The recommended BMPs at Seyferth Park are intended to reduce sediment, pollutants originating from impervious urbanized areas, nutrient runoff from maintained turf, and *E. coli* inputs to storm sewer drains that outfall on Ruddiman Creek. The BMPs are also intended to improve aesthetics of Seyferth Park, thus increasing the recreational appeal of the park to the community.

3.2.8 Carpenter Brothers

The Carpenter Brothers site is relatively flat with a low area located at the southern end. Roughly half of the runoff from the site flows towards the low southern area, and the remaining northern portion flows towards the north. There is a storm water pipe running along the northern end of the site providing collection of runoff. There are no mapped 100-year floodplains or wetlands located within the Carpenter Brothers site.

The Carpenter Brothers site has potential for development in two phases. Phase I would include a large infiltration basin located in the southern end of the site, south of the former warehouse pad. Phase II would entail enlarging the infiltration basin and partially diverting existing storm sewers into the proposed infiltration basin. Estimated installation cost for the Phase I recommended BMPs at Carpenter Brothers is $106,058.

The overall recommended BMPs at Carpenter Brothers would serve to disconnect directly-connected impervious areas from the storm sewer system and intercept surface runoff from maintained grassed areas. Future implementation of Phase II would also provide an opportunity to divert and treat a portion of first flush water during storm events from a significant portion of the Division Street Outfall subwatershed, potentially removing pollutants from the storm water system. The BMPs are intended to improve aesthetics at the Carpenter Brothers site which is prominently visible from Shoreline Drive and is located in an area that essentially serves as a gateway to downtown Muskegon, thus increasing the appeal of the entire community. The recommended BMPs would also occur along the historic location of the Beidler's Creek channel, which was enclosed within the storm sewer system.

3.3 Operation and Maintenance Plan

Green stormwater infrastructure designs tend to be less expensive than conventional designs, however they do require long term maintenance to ensure the BMPs continue to work efficiently (See Appendix C for site specific plans). Vegetation will require regular maintenance within the first few years while becoming established, and then less frequently after establishment. Maintenance primarily includes watering plants as needed, and removing invasive species. Native plants are implemented in the design because they have deeper and more expansive roots which help to increase infiltration, groundwater recharge and biofiltration. Native plants are also more tolerant to flooding and drought conditions and can thrive in rain gardens, bioswales, and bioretention islands. Invasive species are not native to the area and tend to grow and spread quickly without natural controls. If unmanaged, opportunistic, non-native, and potentially invasive species will displace native species (SEMCOG 2008). Maintenance of invasive species is crucial when native plants are being established and require room to grow.

Routine inspections for BMPs are recommended at least once every year. Rain gardens, bioswales, and the bioretention islands should be inspected for debris, erosion, vegetation conditions and coverage, and mulch thickness to determine overall functionality. Inspection checklists for each BMP, along with operations and maintenance plans and costs for the sites are included in Appendix D.

Annual maintenance costs were based on taking a percentage of the total construction costs, and then calculating a long-term cost of 30 years (EORINC 2016). The estimated maintenance costs include aesthetic/nuisance maintenance and functional maintenance. Functional maintenance assures the BMP is performing efficiently and safely, while aesthetic maintenance is primarily for public acceptance, which can help to reduce functional costs. The percentage of construction cost used for each BMP reflects labor, landscaping, and material costs. A typical year of landscaping includes maintenance such as lawn mowing and general care, removal of debris and litter, replanting or seeding vegetation, replenishing mulch, and administration and inspection fees. Maintenance labor is expected to be greater within the first two to three years as vegetation becomes established.

4.0 IMPLEMENTATION

Implementation of this SMP will assist in the achievement of the objectives stated in Section 3.1. Successful implementation of this SMP will require collaboration between community stakeholders and education of the general public regarding the importance of stormwater runoff management. Successful implementation will also require working closely with the property owners of the locations selected for site specific BMP installations. The West Michigan Shoreline Regional Development Commission (WMSRDC) and the Muskegon Lake Watershed Partnership (MLWP) will provide guidance for implementation of this plan and has demonstrated successful collaboration on previous projects within the Muskegon Lake watershed, including the Muskegon Lake Coastal Resiliency Plan, Lower Muskegon River Hydrological Reconnection and Wetland Restoration Project, Bear Creek Hydrological Reconnection and Wetland Restoration Project,

and many others. Guidance from WMSRDC will include presenting proposed BMPs and serving as an information resource for property owners where BMPs are proposed. MLWP will serve as a community liaison to encourage implementation of green infrastructure BMPs on a community-wide basis throughout the Plan Area. WMSRDC will also explore potential funding opportunities to support implementation of the BMPs described in the SMP. Through such efforts, this SMP can be implemented towards removing the BUIs impacting the Muskegon Lake watershed and to meet the goals of the Muskegon River Section 319 Watershed Management Plan, Lake Michigan Lake Action Management Plan, and Great Lakes Action Plans.

4.1 Public Involvement and Education

The Muskegon area community has a large impact on the environmental quality of the Muskegon Lake watershed. The public can help reduce the negative effects stormwater has on the Muskegon Lake watershed by participating in preventative measures. Misuse of storm sewer systems by the public can impact the quality of water. Many people do not understand that storm drains are discharged into local lakes and streams, and not treatment facilities (MCD 2002). For this reason, nothing should be poured down street drains as a disposal method and toxic substances such as fertilizers, herbicides, and pesticides that can be washed into storm drains should be avoided. Other preventive measures can be as simple as mowing / mulching grass clippings into the lawn rather than the street, maintaining vehicles to avoid leaks and spills, and properly disposing of waste oil and automotive fluids.

Muskegon County has various resources available to the public to help increase their knowledge and understanding of the Muskegon Lake watershed and ecosystem. They provide opportunities for community members to become involved through various local programs. A few of these programs are geared to K-12 education: The Muskegon Area Intermediate School District Math Science Center's Great Lakes Stewardship Initiative; Grand Valley State University Annis Water Resources Institute's W.G. Jackson Research Vessel Education Program; and the Muskegon Environmental Research and Education Society youth conservation tours with the Muskegon Conservation District. More information on the programs and ways to become involved can be found on the Muskegon Conservation District webpage at www.muskegoncd.org.

WMSRDC serves as a point of contact for the MLWP's public involvement and watershed education activities by leveraging relationships with local entities to develop awareness of stormwater issues in the community. WMSRDC and MWLP are in the process of completing the Muskegon Lake Ecosystem Master Plan which will further support the implementation of the Muskegon River Section 319 Watershed Management Plan. Portions of the Muskegon Lake Ecosystem Master Plan will highlight the benefits of stormwater management and the use of green infrastructure to rebuild hydrologic integrity within the stormwater system. MLWP will coordinate with conservation and watershed organizations as well as the Muskegon Area Municipal Stormwater Committee (MAMSC) which is responsible for the Municipal

Separate Stormwater Sewer Systems (MS4) program within the Plan Area. MAMSC carries out public education activities to meet MS4 Phase II stormwater permit regulations, and MLWP strives to provide public outreach and education above and beyond the MS4 program to reach a wider audience. The MWLP will continue to hold ongoing monthly public meetings promoting public education of watershed issues. In addition to educational efforts, the MLWP also hosts annual watershed cleanups and other efforts related to public involvement with the maintenance of rain gardens and other green infrastructure and stormwater BMPs. WMSRDC also proposes to implement an urban tree canopy replacement and urban re-forestation program with the intent of reducing non-point source pollutant runoff. More information can be found at www.wmsrdc.org, www.muskegonlake.org, and on the Face Book page of the MLWP.

4.2 Implementation Timeline

Implementation of this SMP is intended to occur within a 10 year period. The locations with site specific BMPs outlined in this plan are considered to be examples of priority areas for implementation. This SMP is intended to serve a as guide for implementing BMPs in priority areas and throughout the plan area. An implementation timeline is provided in Table 9 detailing plan tasks and the expected timeframe for achieving implementation of the identified locations.

Table 9: Implementation Tasks and Timeline for the Storm Water Management Plan for Ruddiman Creek, Muskegon Lake Direct Drainage, and Division Street Outfall Subwatersheds, Muskegon, Michigan.

Stormwater Management Plan Tasks	Timeline for Implementation
Installation of BMPs at Carpenter Brothers	Implementation currently proceeding
Installation of BMPs at Grand Trunk Park	Conceptual plans to be presented to property owner within 1 year and implementation intended to occur within 3 years
Installation of BMPs at Nelson School	Conceptual plans to be presented to property owner within 1 year and implementation intended to occur within 3 years
Installation of BMPs at Hartshorn Marina East	Conceptual plans to be presented to property owner within 1 year and implementation intended to occur within 5 years
Installation of BMPs at Hartshorn Marina West	Conceptual plans to be presented to property owner within 1 year and implementation intended to occur within 5 years
Installation of BMPs at City of Muskegon/Mart Dock East	Conceptual plans to be presented to property owner within 1 year and implementation intended to occur within 5 years
Installation of BMPs at City of Muskegon West	Conceptual plans to be presented to property owner within 1 year and implementation intended to occur within 5 years
Installation of BMPs at Seyferth Park	Conceptual plans to be presented to property owner within 1 year and implementation intended to occur within 5 years
Public Education and Involvement	WMSRDC and MLWP to hold monthly meetings to provide public education and opportunities for public involvement with storm water related issues
Urban Tree Canopy Replacement Program	WMSRDC is initiating this program in the coastal zone region. Anticipated activities over the 10-year period addressed by this SMP

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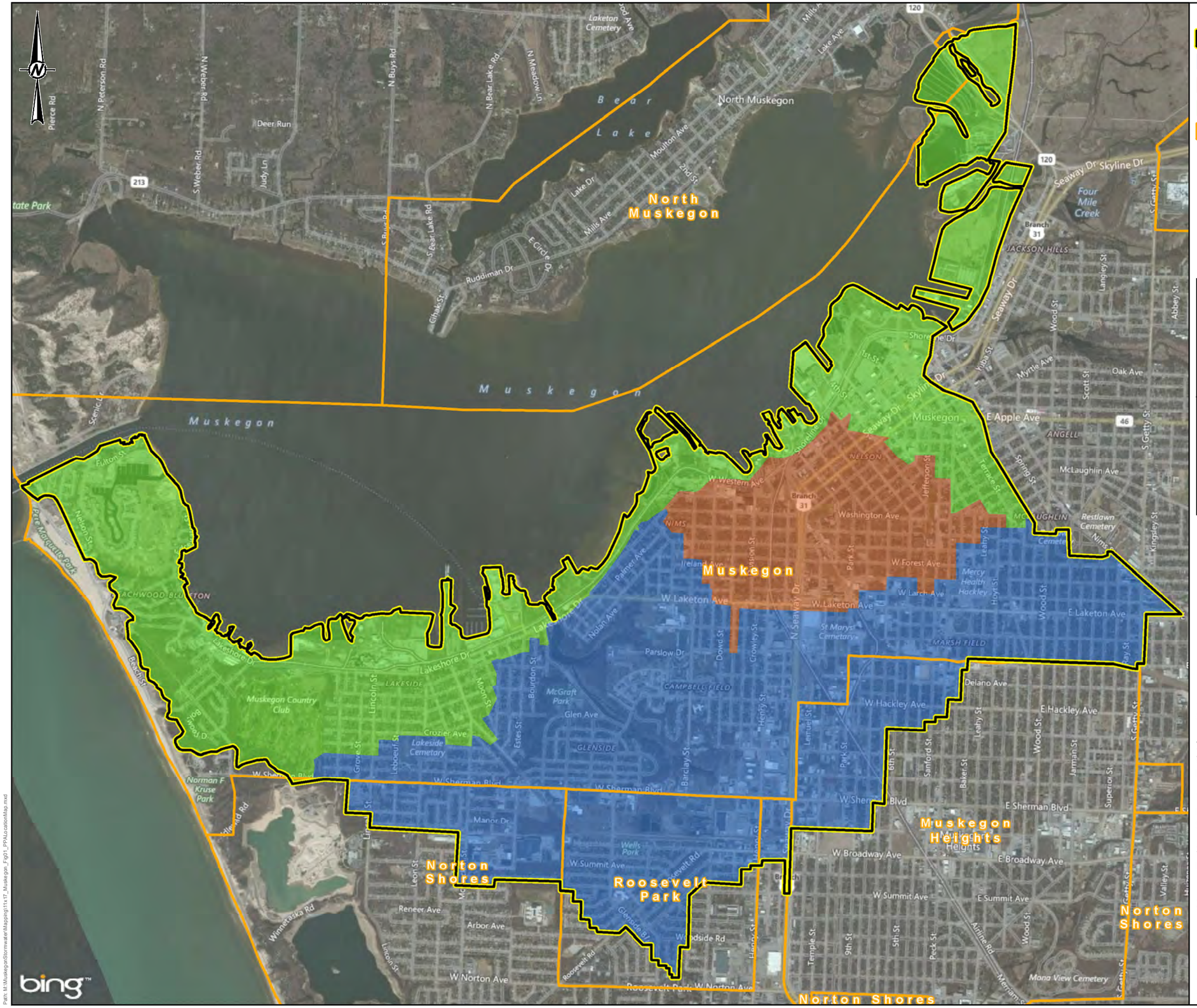
FIGURES



LEGEND

- PROJECT PLANNING AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY

Miles

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REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
PROJECT PLANNING AREA LOCATION MAP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
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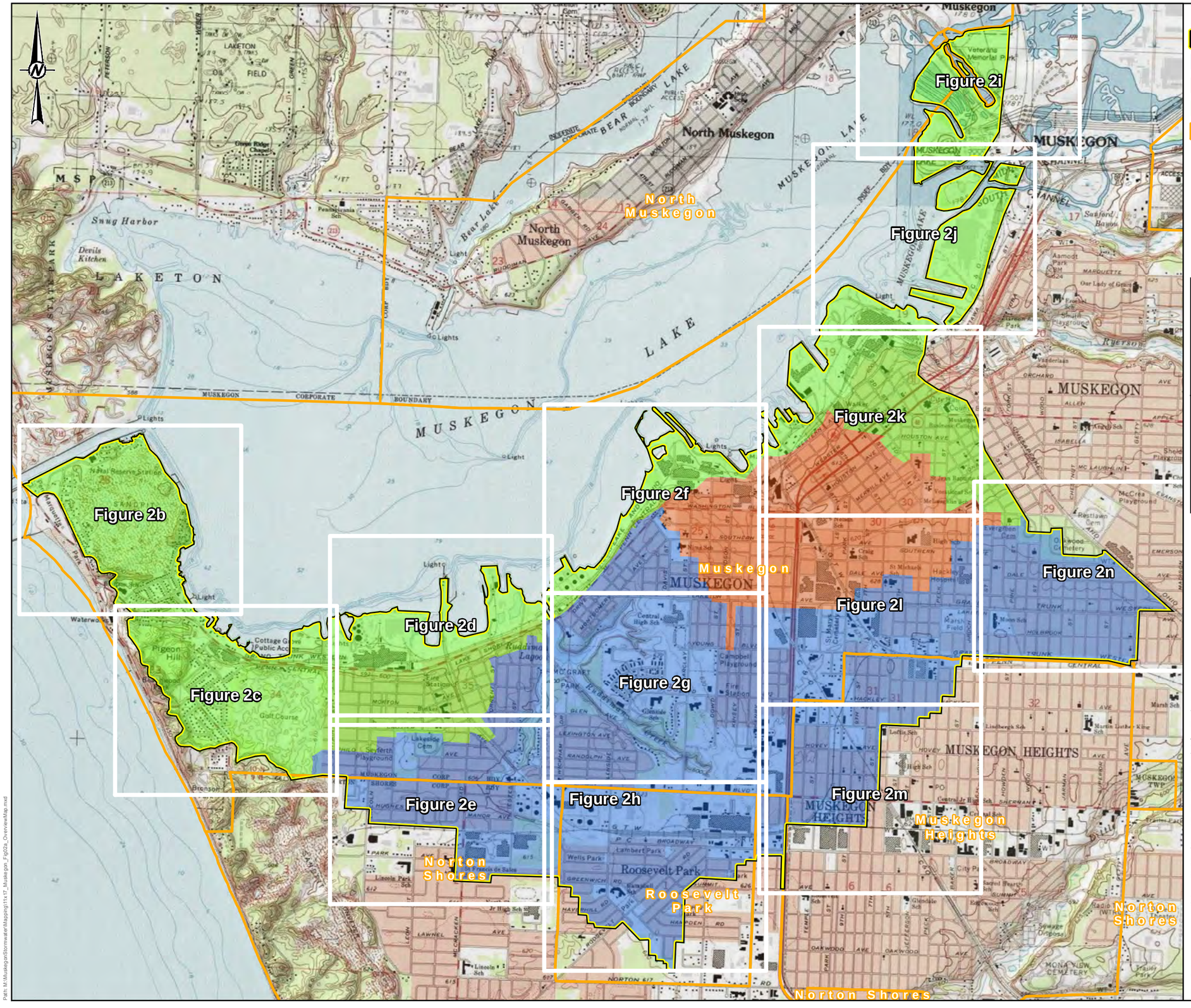
0

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig01_PPAlocationMap.mxd



LEGEND

- PROJECT PLANNING AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY

0 0.25 0.5 1 Miles

REFERENCE

1. TOPOGRAPHIC BACKGROUND: ESRI BASEMAP SERVICES, USGS. 7.5' TOPOGRAPHIC QUADRANGLES SHOWN: "TWIN LAKE, MI", "MUSKEGON EAST, MI", "MUSKEGON WEST, MI", "DALTON, MI".

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
OVERVIEW MAP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-08
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

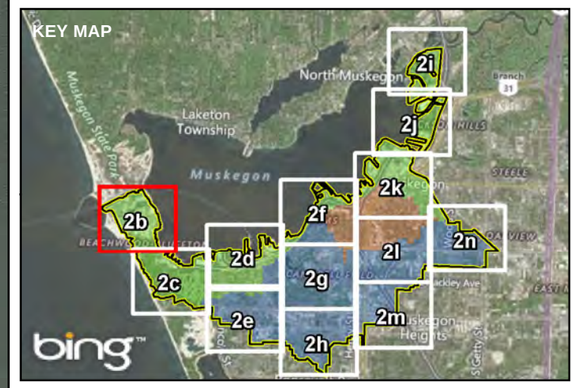
FIGURE
2a

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig02a_OverviewMap.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1in

LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- ENCLOSED DISCHARGE POINT
- OUTLET
- STORM SEWER
- DRAINAGE AREA
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 2 OF 14

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

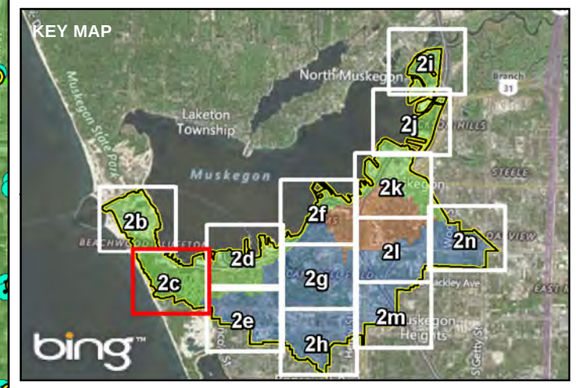
FIGURE
2b

Path: M:\Muskegon\StormwaterMapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- OUTLET
- STORM SEWER
- DRAINAGE AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
   A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
   B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 3 OF 14

CONSULTANT
Golder Associates

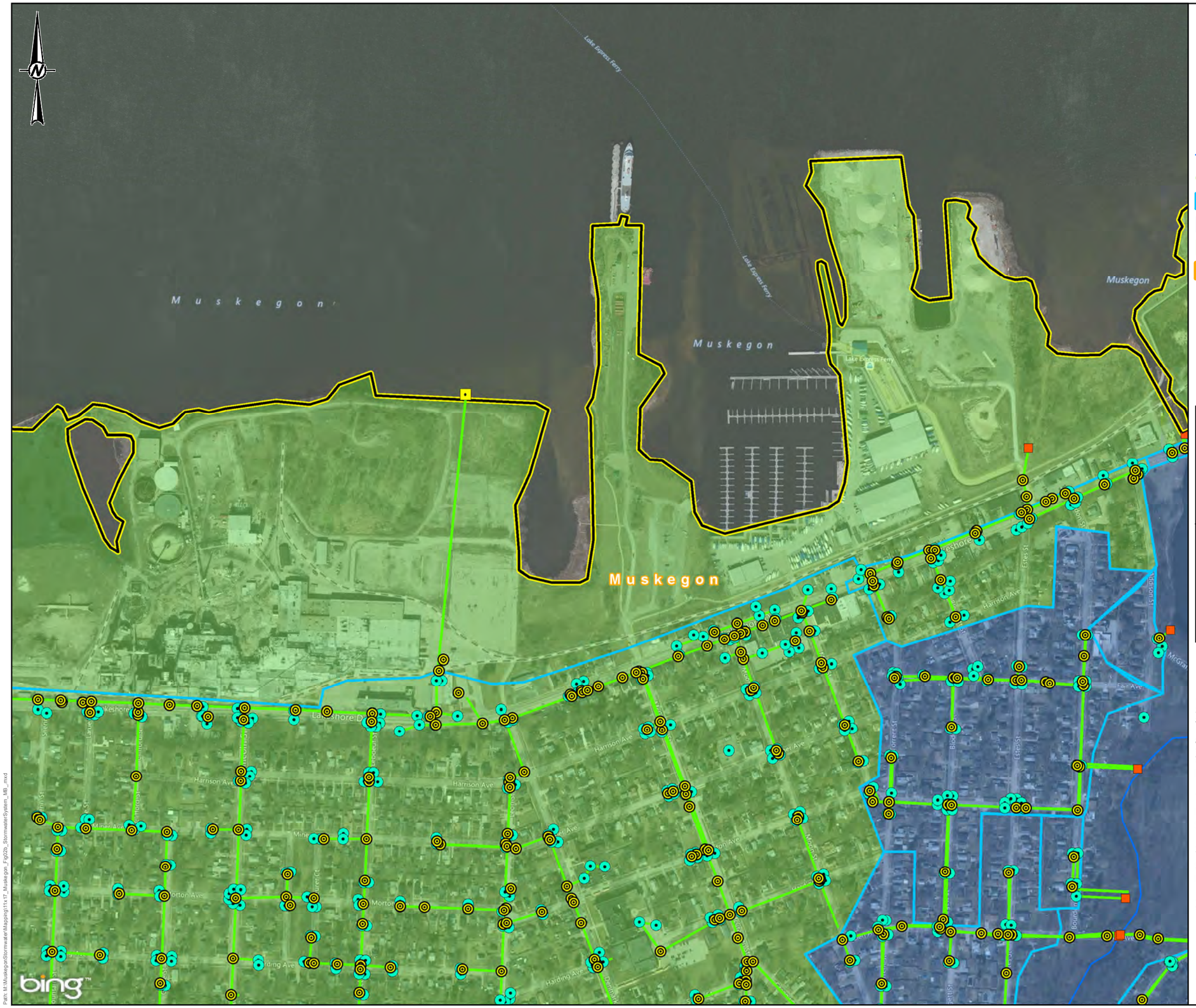
YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
2c

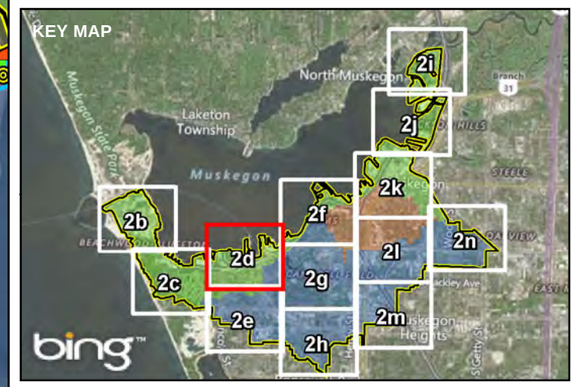
Path: M:\Muskegon\StormwaterMapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11in



LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- ENCLOSED DISCHARGE POINT
- OUTLET
- STREAM
- STORM SEWER
- DRAINAGE AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
   A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
   B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 4 OF 14

CONSULTANT
Golder Associates

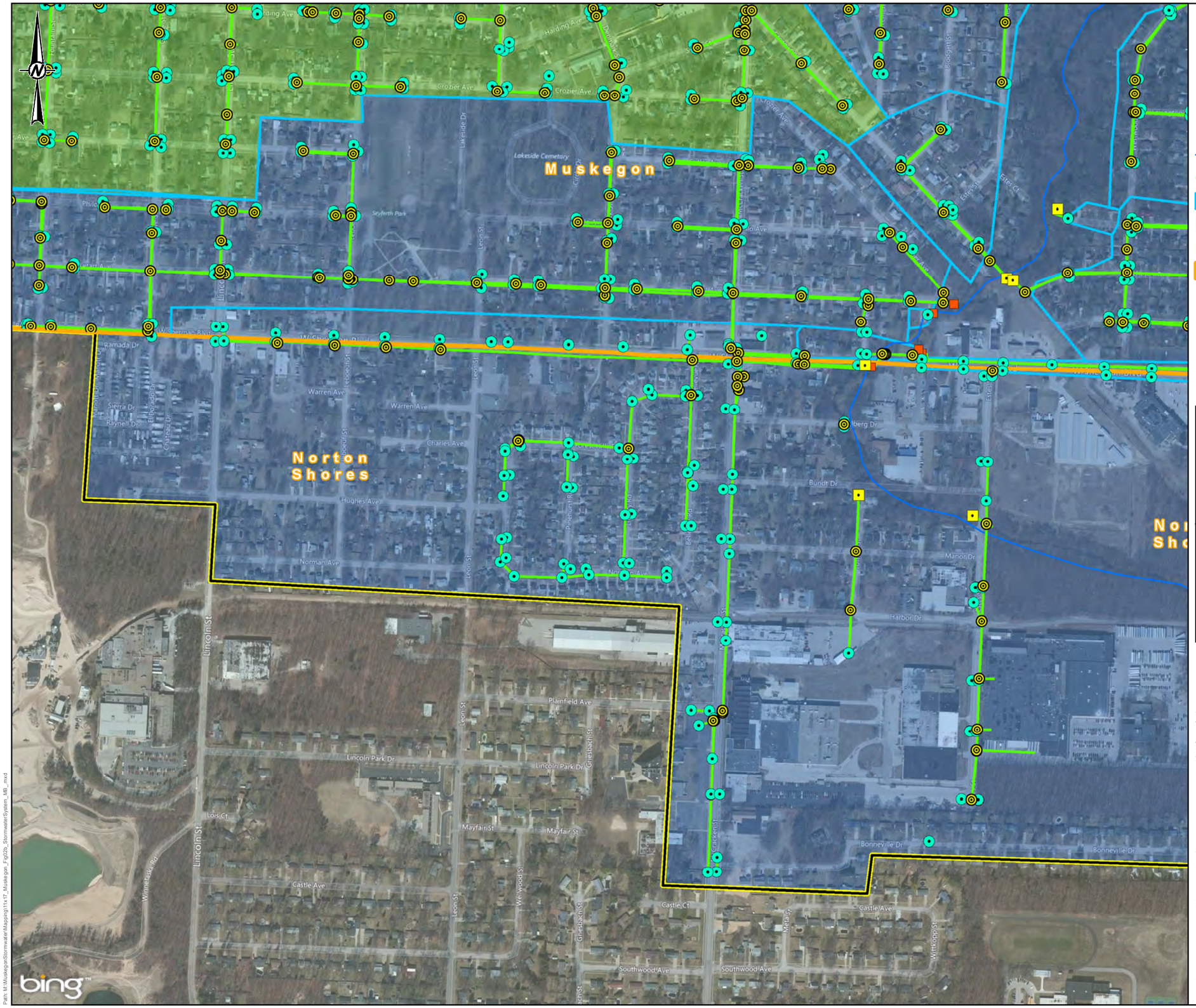
YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
2d

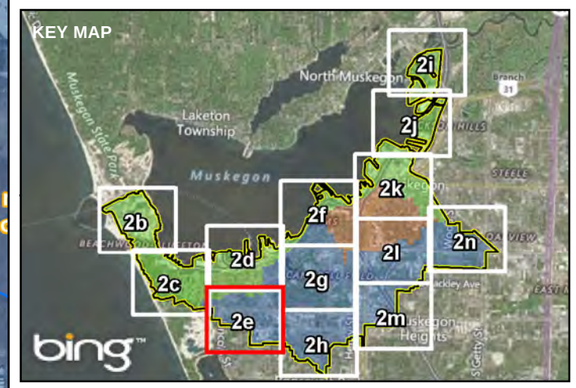
Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
1in
0



LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- ENCLOSED DISCHARGE POINT
- OUTLET
- STREAM
- STORM SEWER
- DRAINAGE AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 5 OF 14

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

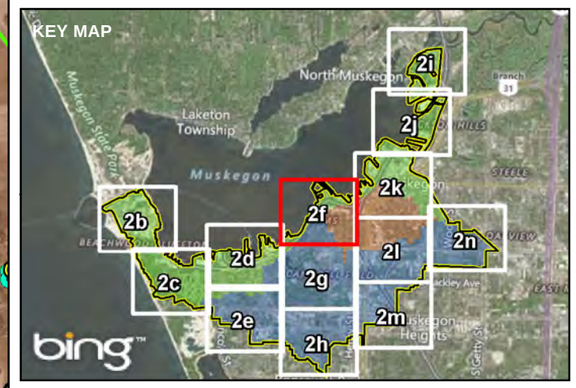
FIGURE
2e

Path: M:\Muskegon\StormwaterMapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- ENCLOSED DISCHARGE POINT
- OUTLET
- STORM SEWER
- DRAINAGE AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 6 OF 14

CONSULTANT
Golder Associates

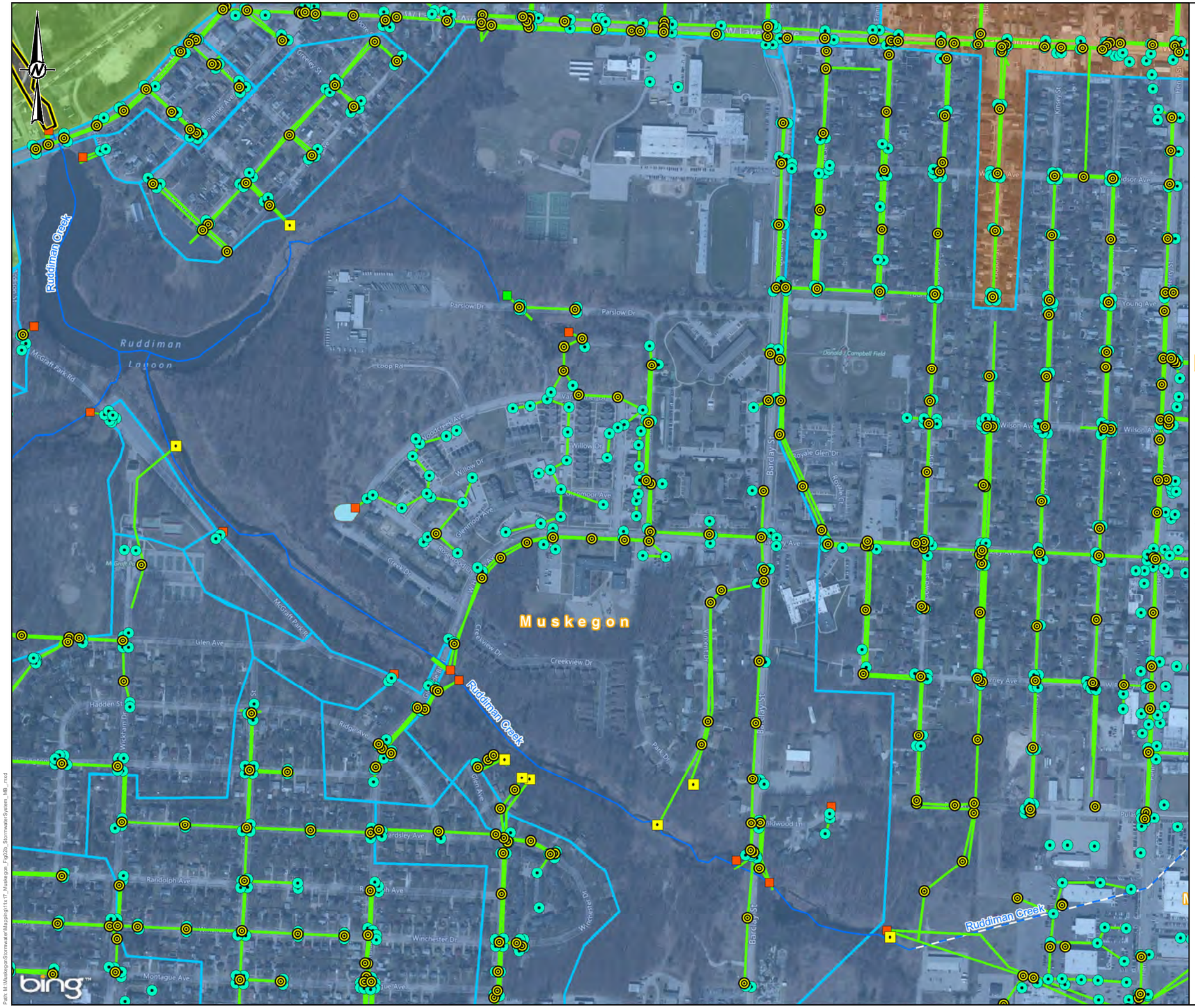
YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
2f

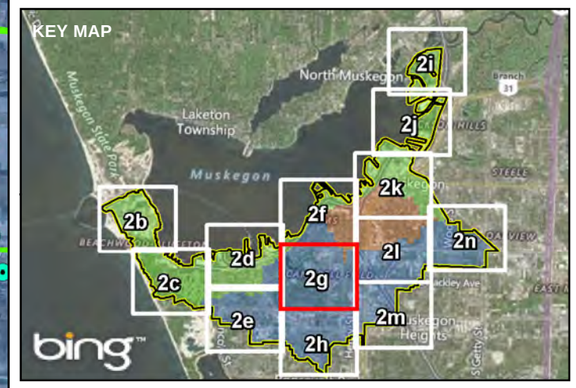
Path: M:\Muskegon\StormwaterMapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
1 in
0



LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- ENCLOSED DISCHARGE POINT
- OPEN DISCHARGE POINT
- OUTLET
- STREAM
- ENCLOSED STREAM
- STORM SEWER
- POND
- DRAINAGE AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 7 OF 14

CONSULTANT
Golder Associates

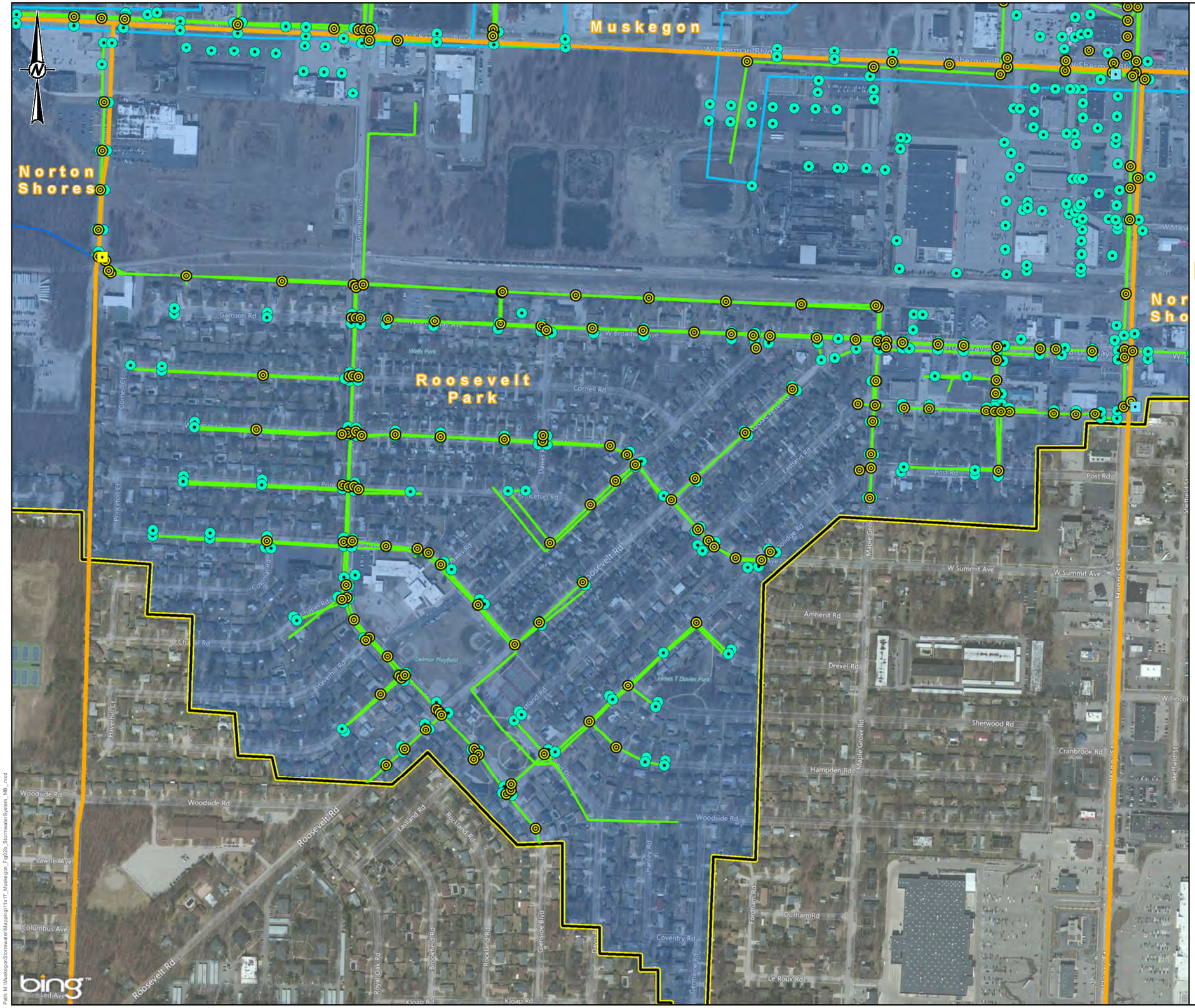
YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
2g

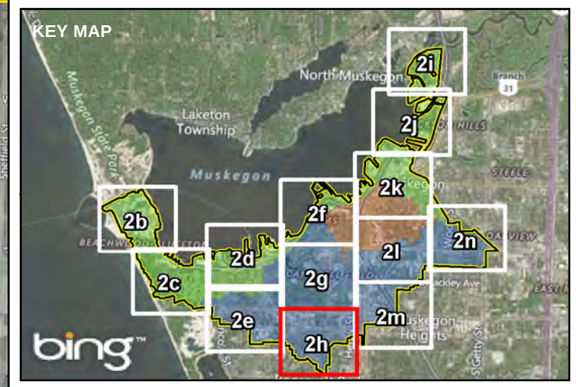
Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:



LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- DISCHARGE POINT (UNKNOWN TYPE)
- INLET
- OUTLET
- STREAM
- STORM SEWER
- DRAINAGE AREA
- RUDDIMAN CREEK SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
   A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
   B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 8 OF 14

CONSULTANT
Golder Associates

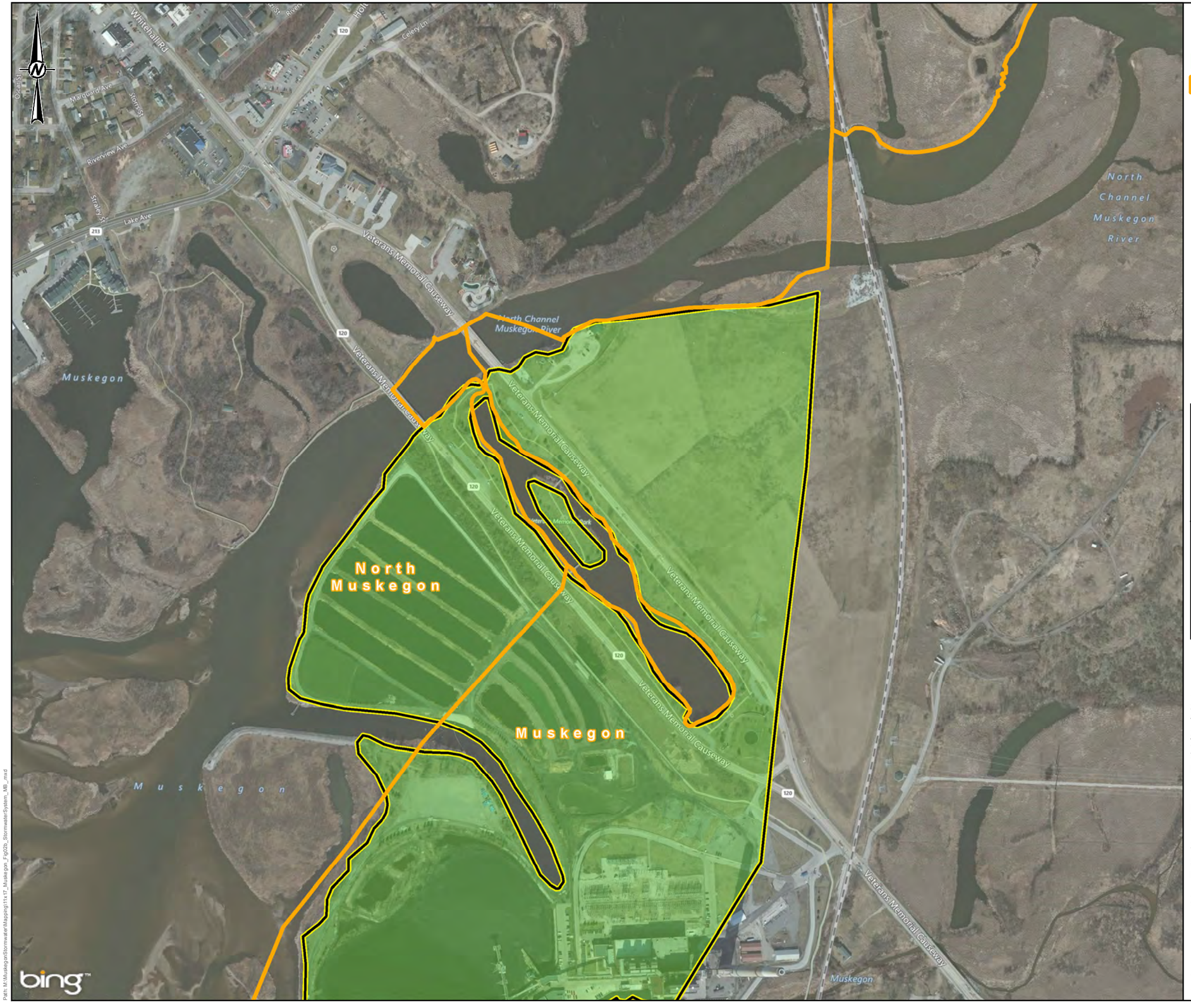
YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
2h

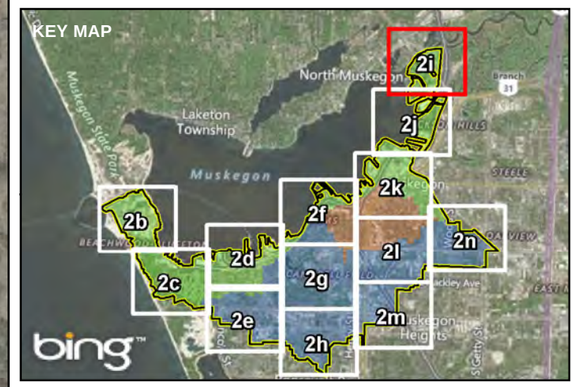
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
1 in
0

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd



LEGEND

- PROJECT PLANNING AREA
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 9 OF 14

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
2i

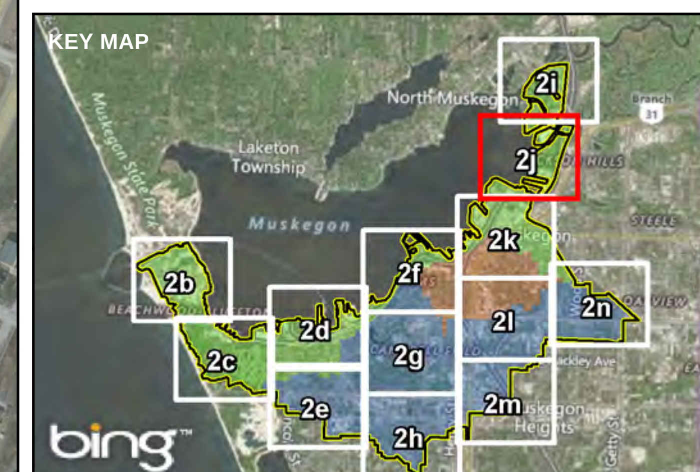
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
1 in
0

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

Path: M:\MuskegonStormwater\Mapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- ENCLOSED DISCHARGE POINT
- OUTLET
- STORM SEWER
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



Feet
0 250 500 1,000

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 10 OF 14

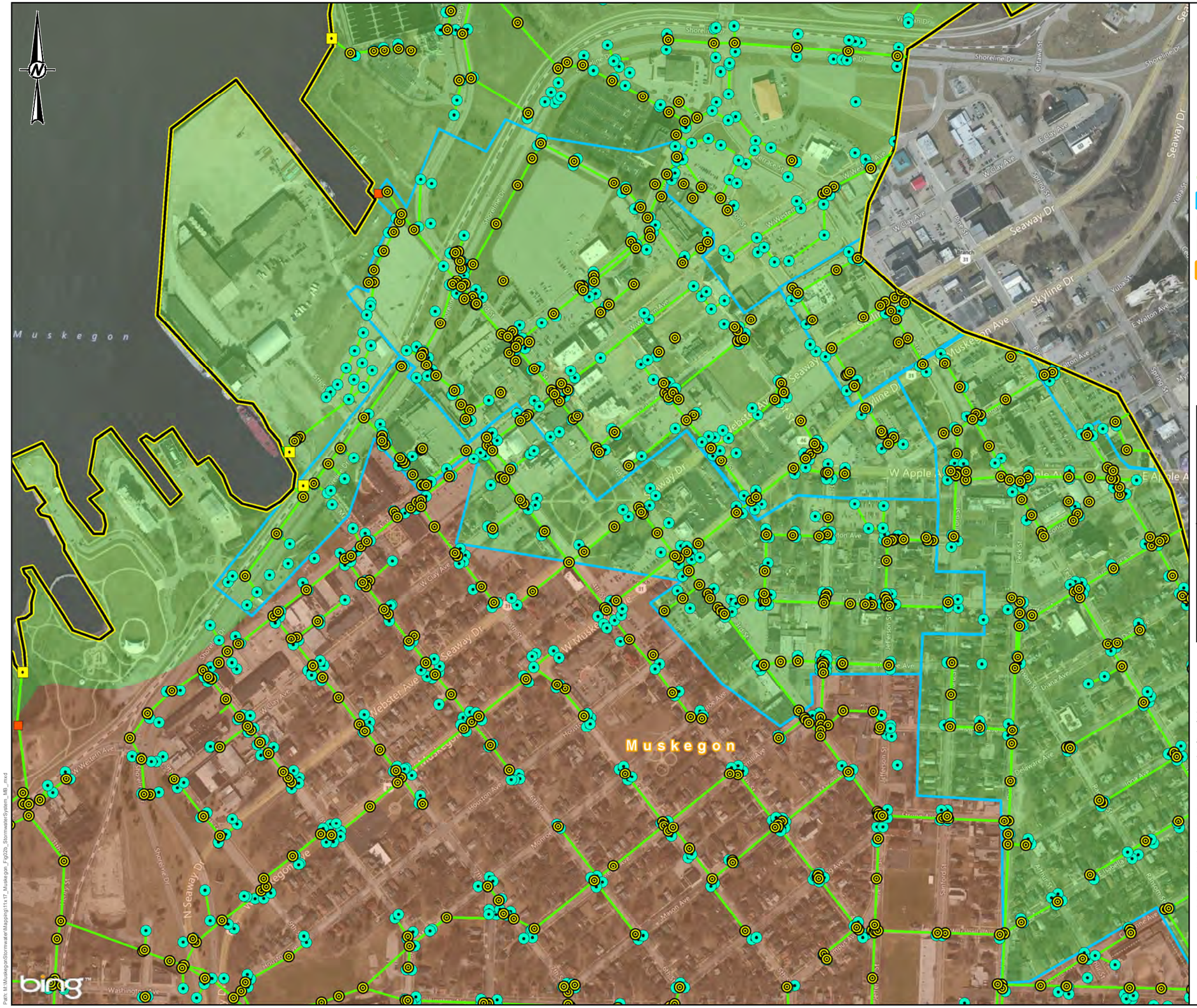
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

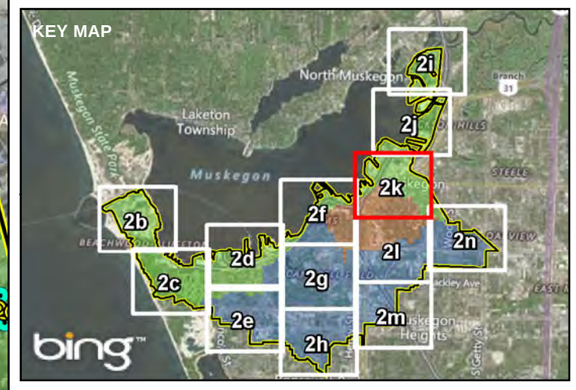
FIGURE
2j

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
1 in
0



LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- ENCLOSED DISCHARGE POINT
- OPEN DISCHARGE POINT
- OUTLET
- STORM SEWER
- DRAINAGE AREA
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 11 OF 14

CONSULTANT
Golder Associates

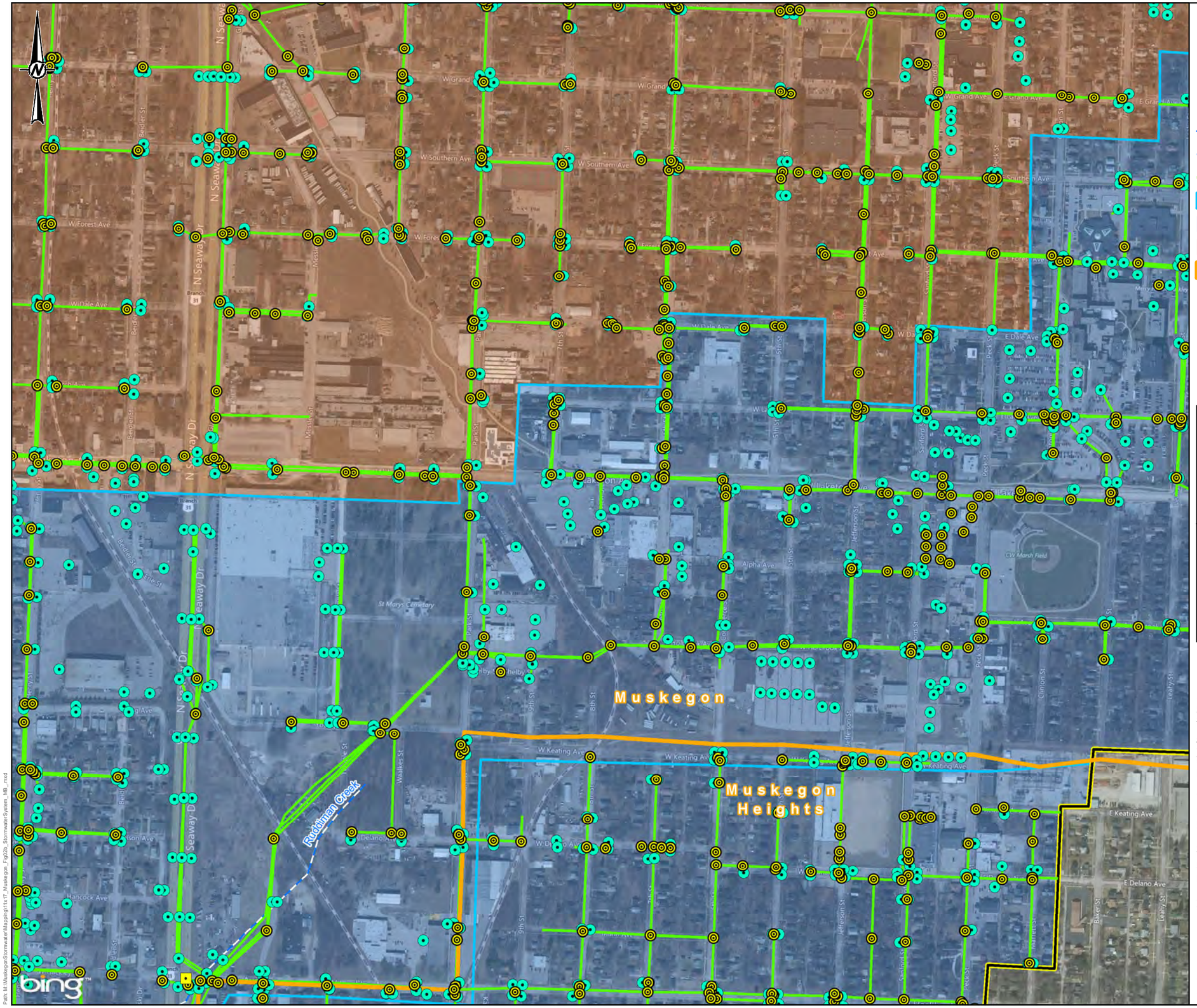
YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
2k

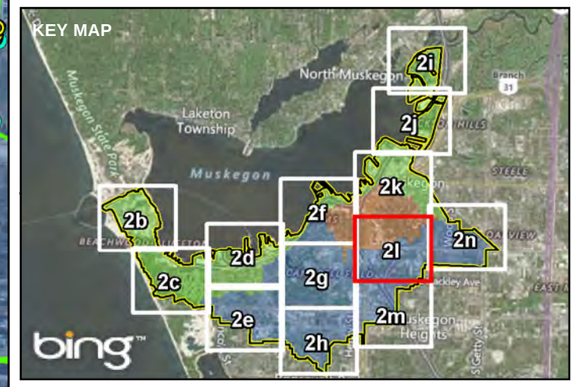
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
1in
0

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd



LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- OUTLET
- STREAM
- ENCLOSED STREAM
- STORM SEWER
- DRAINAGE AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 12 OF 14

CONSULTANT
Golder Associates

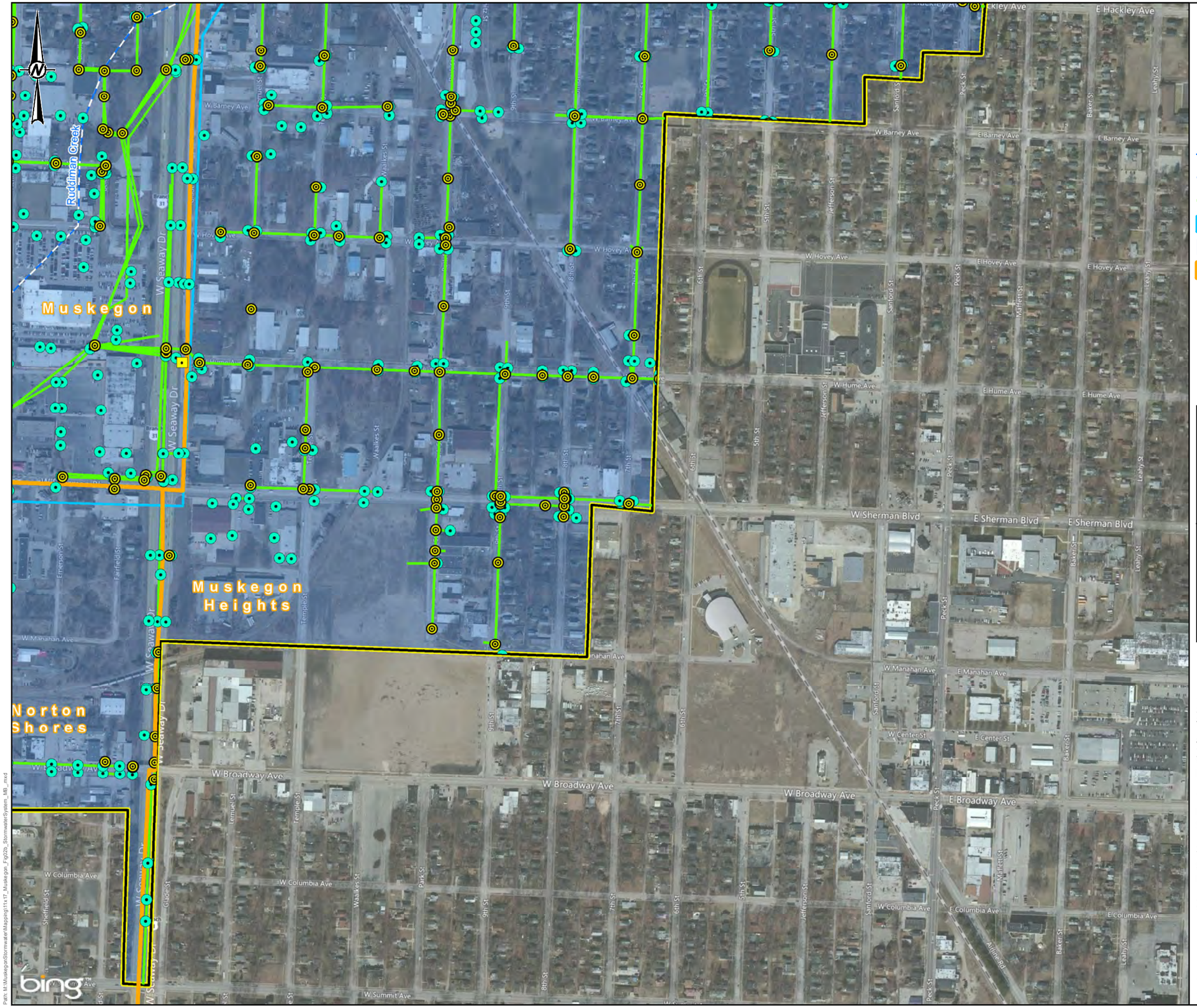
YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
2l

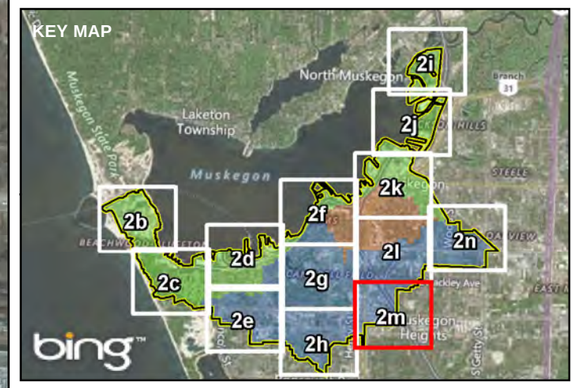
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
1 in
0

Path: M:\Muskegon\StormwaterMapping\11x17_Muskegon_Fig02l_StormwaterSystem_MB_.mxd



LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- DISCHARGE POINT (UNKNOWN TYPE)
- OUTLET
- STREAM
- ENCLOSED STREAM
- STORM SEWER
- DRAINAGE AREA
- RUDDIMAN CREEK SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 13 OF 14

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

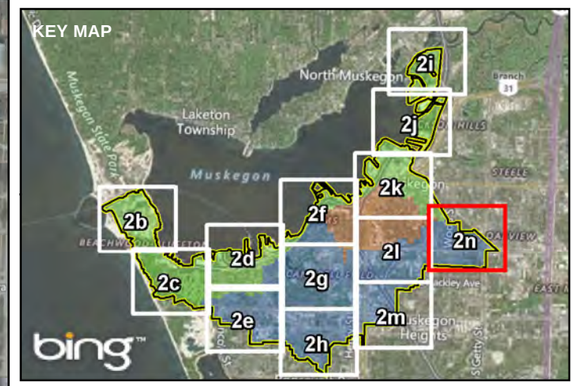
FIGURE
2m

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

LEGEND

- PROJECT PLANNING AREA
- CATCH BASIN
- MANHOLE
- STORM SEWER
- DRAINAGE AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED
- MUNICIPAL BOUNDARY



0 250 500 1,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. STORMWATER SYSTEM DATASETS (SOME MODIFIED BY GOLDER ASSOCIATES):
   A) CITY OF MUSKEGON. DOWNLOADED FEBRUARY 2016.
   B) WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION, 2016.
3. STREAMS: NATIONAL HYDROLOGY DATASET (NHD), USGS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
STORM SEWER MAP
MAP 14 OF 14

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-09
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
2n

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig02b_StormwaterSystem_MB_.mxd

LEGEND

- PROJECT PLANNING AREA

NWI WETLANDS WITHIN PROJECT PLANNING AREA

- FRESHWATER EMERGENT WETLAND (PEM)
- FRESHWATER FORESTED (PFO)
- FRESHWATER SCRUB-SHRUB (PSS)
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

Miles

0 0.25 0.5 1

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. WETLANDS: NATIONAL WETLAND INVENTORY (NWI), USFWS.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
NATIONAL WETLAND INVENTORY (NWI) WETLANDS MAP
U.S. FISH AND WILDLIFE SERVICE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
1in
0

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig03_NWI_Overview.mxd

LEGEND

- PROJECT PLANNING AREA
- FEMA 100-YEAR FLOODPLAIN
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

0 0.25 0.5 1 Miles

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. 100-YEAR FLOODPLAIN: DIGITAL FLOOD INSURANCE RATE MAP, FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA).

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
FEDERAL EMERGENCY MANAGEMENT AGENCY 100-YEAR FLOODPLAIN

CONSULTANT
Golder Associates

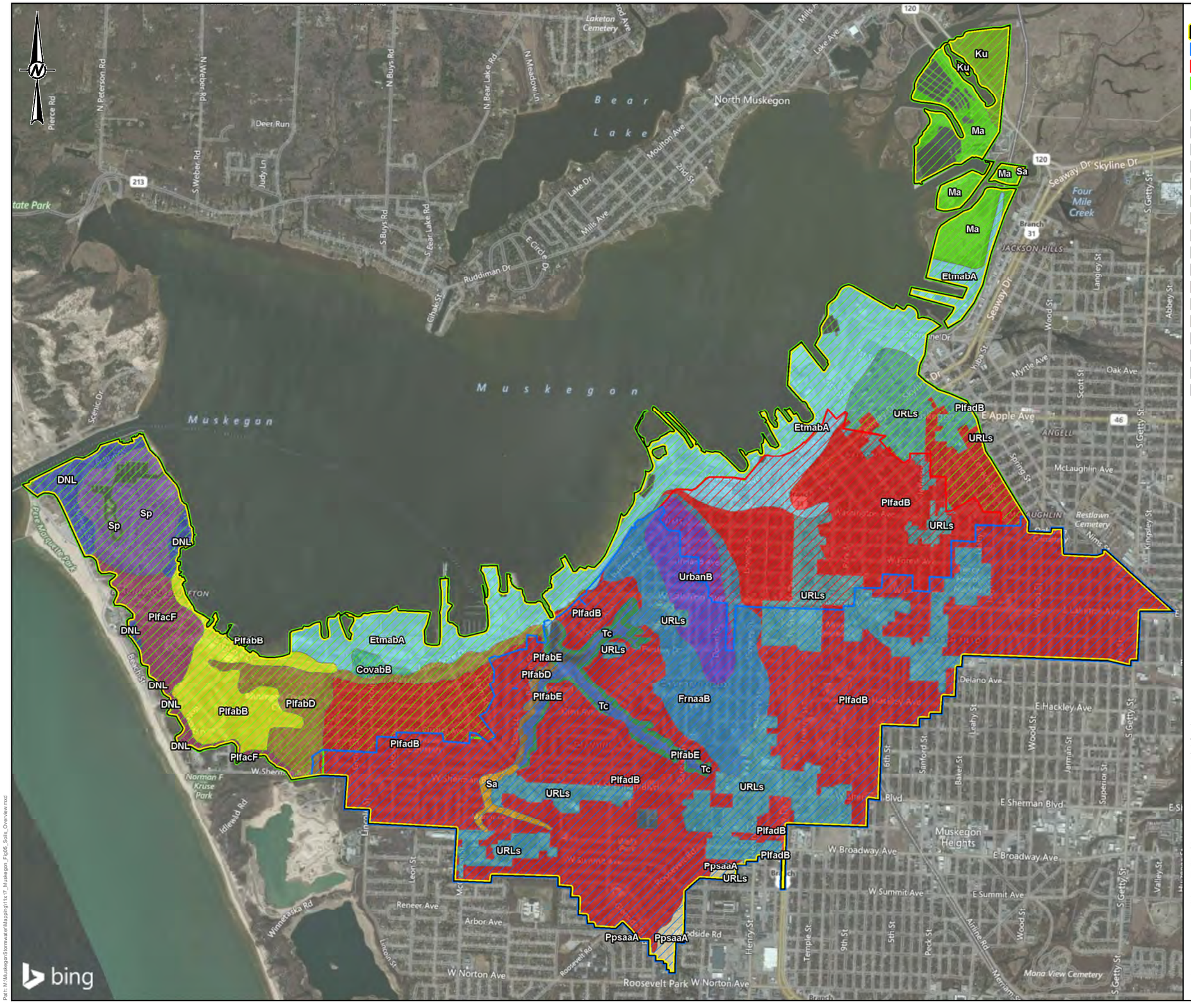
YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No. 1520593

FIGURE 4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11in 0

Path: M:\Muskegon\StormwaterMapping\11x17_Muskegon_Fig04_FEMA_Overview.mxd



LEGEND

- PROJECT PLANNING AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

NRCS SOIL TYPE

- COVABB - COVERT-PIPESTONE SANDS, 0 TO 6 PERCENT SLOPES
- DNL - DUNE LAND
- ETMABA - OXYAQUIC UDIPSAMMENTS-URBAN LAND COMPLEX, NEARLY LEVEL
- FRNAAB - FERN-URBAN LAND COMPLEX, 0 TO 4 PERCENT SLOPES
- KU - KERSTON MUCK
- MA - MARSH
- PLFABB - PLAINFIELD SAND, LAKE PLAIN, 0 TO 6 PERCENT SLOPES
- PLFABD - PLAINFIELD SAND, LAKE PLAIN, 6 TO 18 PERCENT SLOPES
- PLFABE - PLAINFIELD SAND, HIGH ECOLOGICAL SITE, 18 TO 30 PERCENT SLOPES
- PLFACF - PLAINFIELD SAND, DUNES, 18 TO 60 PERCENT SLOPES
- PLFADB - PLAINFIELD-URBAN LAND COMPLEX, 0 TO 6 PERCENT SLOPES
- PPSAAA - PIPESTONE-COVERT-SAUGATUCK SANDS, 0 TO 3 PERCENT SLOPES
- SA - SARANAC LOAM
- SP - SPARTA SAND, 0 TO 2 PERCENT SLOPES
- TC - TAWAS AND CARLISLE MUCKS
- URLS - URBAN LAND, SANDY
- URBANB - URBAN LAND-PERRINTON COMPLEX, 0 TO 6 PERCENT SLOPES

0 0.25 0.5 1 Miles

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. SOILS DATASET: USDA-NRCS SOIL SURVEY GEOGRAPHIC (SSURGO), USDA/NRCS - NATIONAL GEOSPATIAL CENTER OF EXCELLENCE.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
SOIL SURVEY MAP
NATURAL RESOURCE CONSERVATIO SERVICE

CONSULTANT
Golder Associates

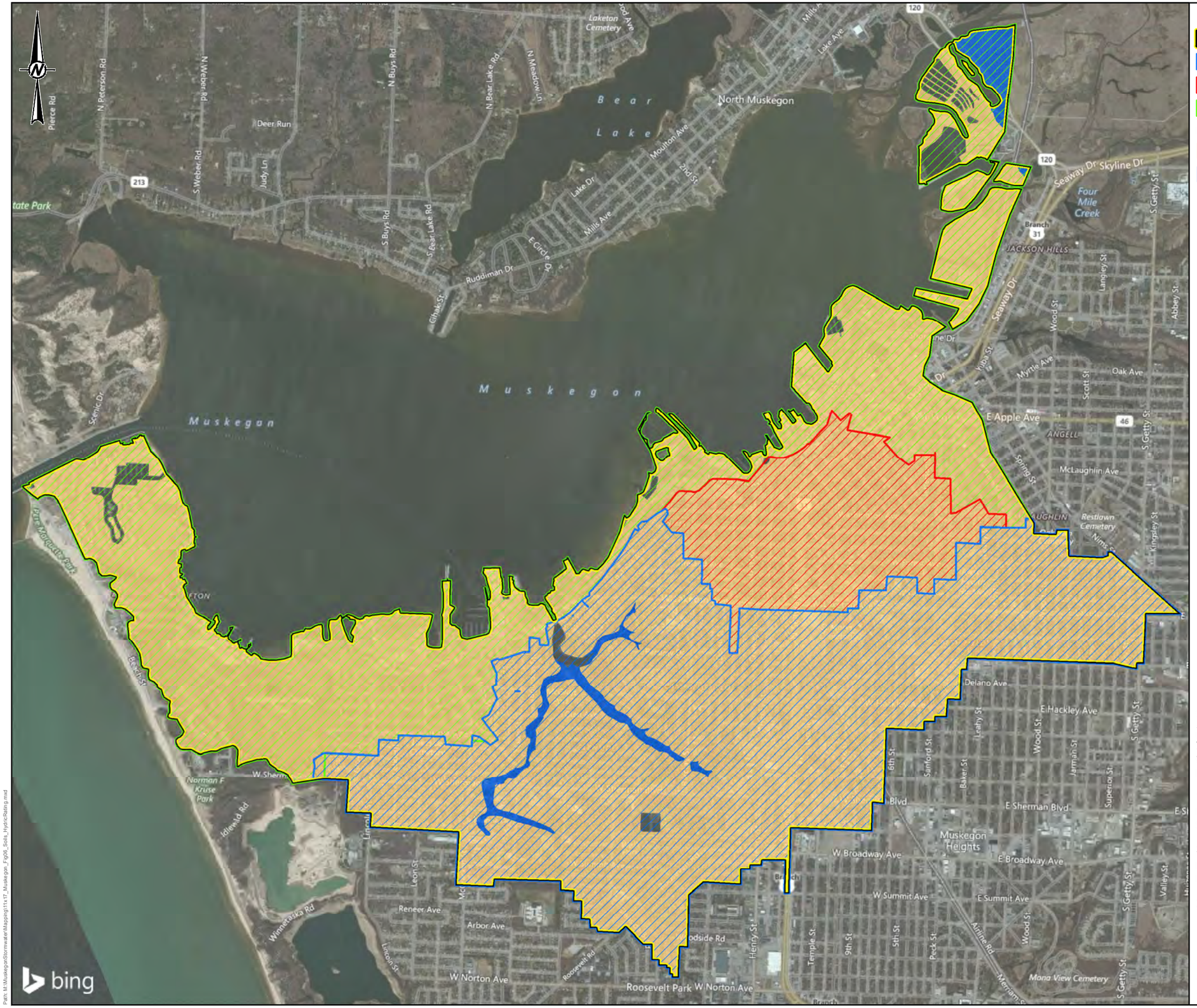
YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No. 1520593

FIGURE 5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig05_Soils_Overview.mxd



LEGEND

- PROJECT PLANNING AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

HYDRIC SOIL RATING

- NON-HYDRIC
- HYDRIC

Miles

0 0.25 0.5 1

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. SOILS DATASET: USDA-NRCS SOIL SURVEY GEOGRAPHIC (SSURGO), USDA/NRCS - NATIONAL GEOSPATIAL CENTER OF EXCELLENCE.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
HYDRIC SOILS MAP
NATURAL RESOURCE CONSERVATION SERVICE

CONSULTANT
Golder Associates

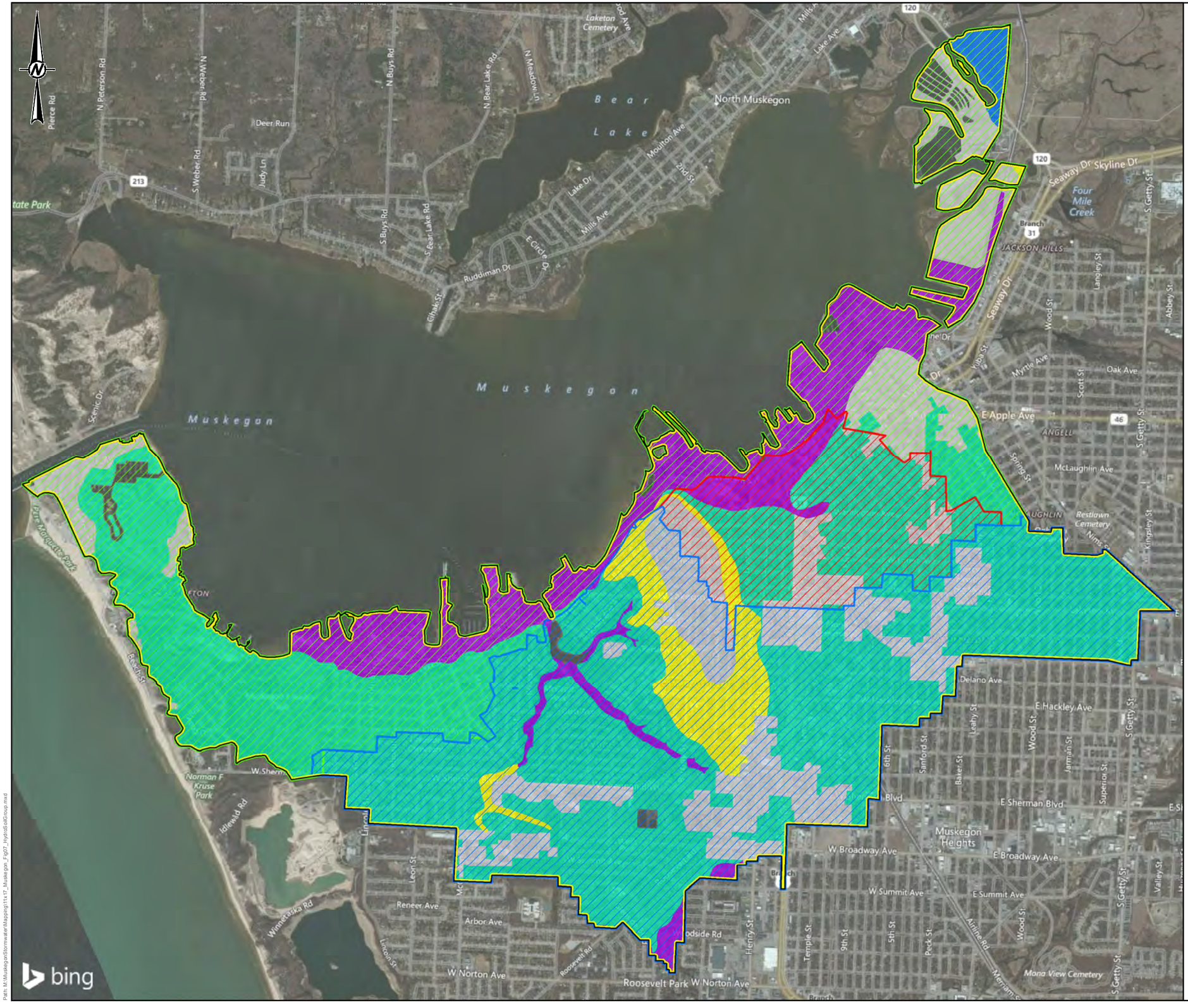
YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11in

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig06_Soils_HydricRating.mxd



LEGEND

- PROJECT PLANNING AREA

HYDROLOGIC SOIL GROUP (SEE NOTES FOR DESCRIPTIONS)

- A
- A/D
- B/D
- C/D
- NO GROUP ASSIGNED
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

0 0.25 0.5 1 Miles

NOTES

GROUP A. SOILS HAVING A HIGH INFILTRATION RATE (LOW RUNOFF POTENTIAL) WHEN THOROUGHLY WET. THESE CONSIST MAINLY OF DEEP, WELL DRAINED TO EXCESSIVELY DRAINED SANDS OR GRAVELLY SANDS. THESE SOILS HAVE A HIGH RATE OF WATER TRANSMISSION.

GROUP B. SOILS HAVING A MODERATE INFILTRATION RATE WHEN THOROUGHLY WET. THESE CONSIST CHIEFLY OF MODERATELY DEEP OR DEEP, MODERATELY WELL DRAINED OR WELL DRAINED SOILS THAT HAVE MODERATELY FINE TEXTURE TO MODERATELY COARSE TEXTURE. THESE SOILS HAVE A MODERATE RATE OF WATER TRANSMISSION.

GROUP C. SOILS HAVING A SLOW INFILTRATION RATE WHEN THOROUGHLY WET. THESE CONSIST CHIEFLY OF SOILS HAVING A LAYER THAT IMPEDES THE DOWNWARD MOVEMENT OF WATER OR SOILS OF MODERATELY FINE TEXTURE OR FINE TEXTURE. THESE SOILS HAVE A SLOW RATE OF WATER TRANSMISSION.

GROUP D. SOILS HAVING A VERY SLOW INFILTRATION RATE (HIGH RUNOFF POTENTIAL) WHEN THOROUGHLY WET. THESE CONSIST CHIEFLY OF CLAYS THAT HAVE A HIGH SHRINK-SWELL POTENTIAL, SOILS THAT HAVE A HIGH WATER TABLE, SOILS THAT HAVE A CLAYPAN OR CLAY LAYER AT OR NEAR THE SURFACE, AND SOILS THAT ARE SHALLOW OVER NEARLY IMPERVIOUS MATERIAL. THESE SOILS HAVE A VERY SLOW RATE OF WATER TRANSMISSION.

IF A SOIL IS ASSIGNED TO A DUAL HYDROLOGIC GROUP (A/D, B/D, OR C/D), THE FIRST LETTER IS FOR DRAINED AREAS AND THE SECOND IS FOR UNDRAINED AREAS. ONLY THE SOILS THAT IN THEIR NATURAL CONDITION ARE IN GROUP D ARE ASSIGNED TO DUAL CLASSES.

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. SOILS DATASET: USDA-NRCS SOIL SURVEY GEOGRAPHIC (SSURGO), USDA/NRCS - NATIONAL GEOSPATIAL CENTER OF EXCELLENCE.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
HYDROLOGIC SOIL GROUPS
NATURAL RESOURCE CONSERVATION SERVICE

CONSULTANT
Golder Associates

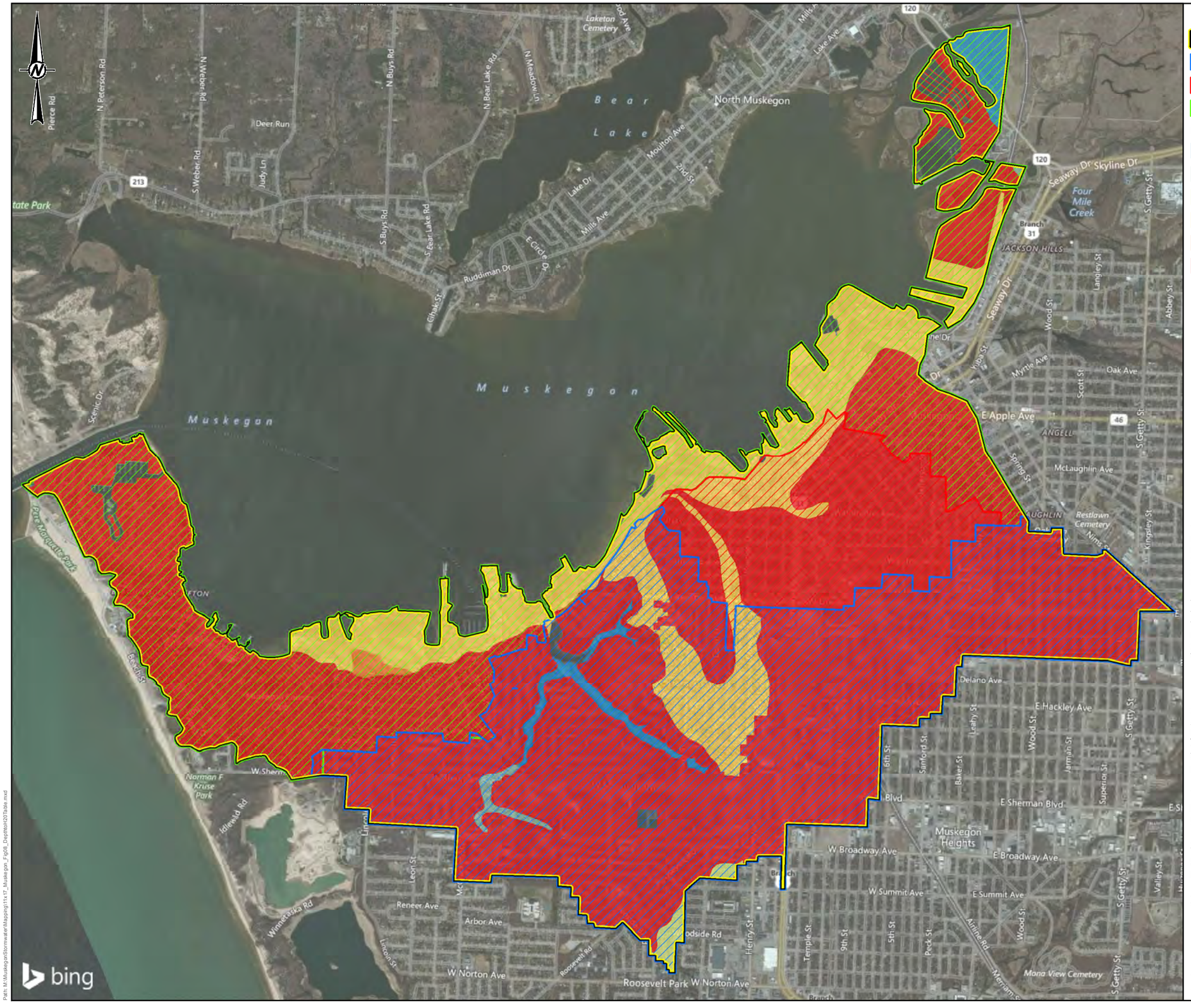
YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11in

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig07_HydrolSoilGroup.mxd



LEGEND

- PROJECT PLANNING AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

DEPTH TO WATER TABLE (IN)

- 0
- 6
- 9
- 18
- 21
- >78

0 0.25 0.5 1 Miles

NOTES

"WATER TABLE" REFERS TO A SATURATED ZONE IN THE SOIL. IT OCCURS DURING SPECIFIED MONTHS. ESTIMATES OF THE UPPER LIMIT ARE BASED MAINLY ON OBSERVATIONS OF THE WATER TABLE AT SELECTED SITES AND ON EVIDENCE OF A SATURATED ZONE, NAMELY GRAYISH COLORS (REDOXIMORPHIC FEATURES) IN THE SOIL. A SATURATED ZONE THAT LASTS FOR LESS THAN A MONTH IS NOT CONSIDERED A WATER TABLE.

THIS ATTRIBUTE IS ACTUALLY RECORDED AS THREE SEPARATE VALUES IN THE DATABASE. A LOW VALUE AND A HIGH VALUE INDICATE THE RANGE OF THIS ATTRIBUTE FOR THE SOIL COMPONENT. A "REPRESENTATIVE" VALUE INDICATES THE EXPECTED VALUE OF THIS ATTRIBUTE FOR THE COMPONENT. FOR THIS SOIL PROPERTY, ONLY THE REPRESENTATIVE VALUE IS USED.

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. SOILS DATASET: USDA-NRCS SOIL SURVEY GEOGRAPHIC (SSURGO), USDA/NRCS - NATIONAL GEOSPATIAL CENTER OF EXCELLENCE.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
SOIL DEPTH TO WATER TABLE
NATURAL RESOURCE CONSERVATION SERVICE

CONSULTANT
Golder Associates

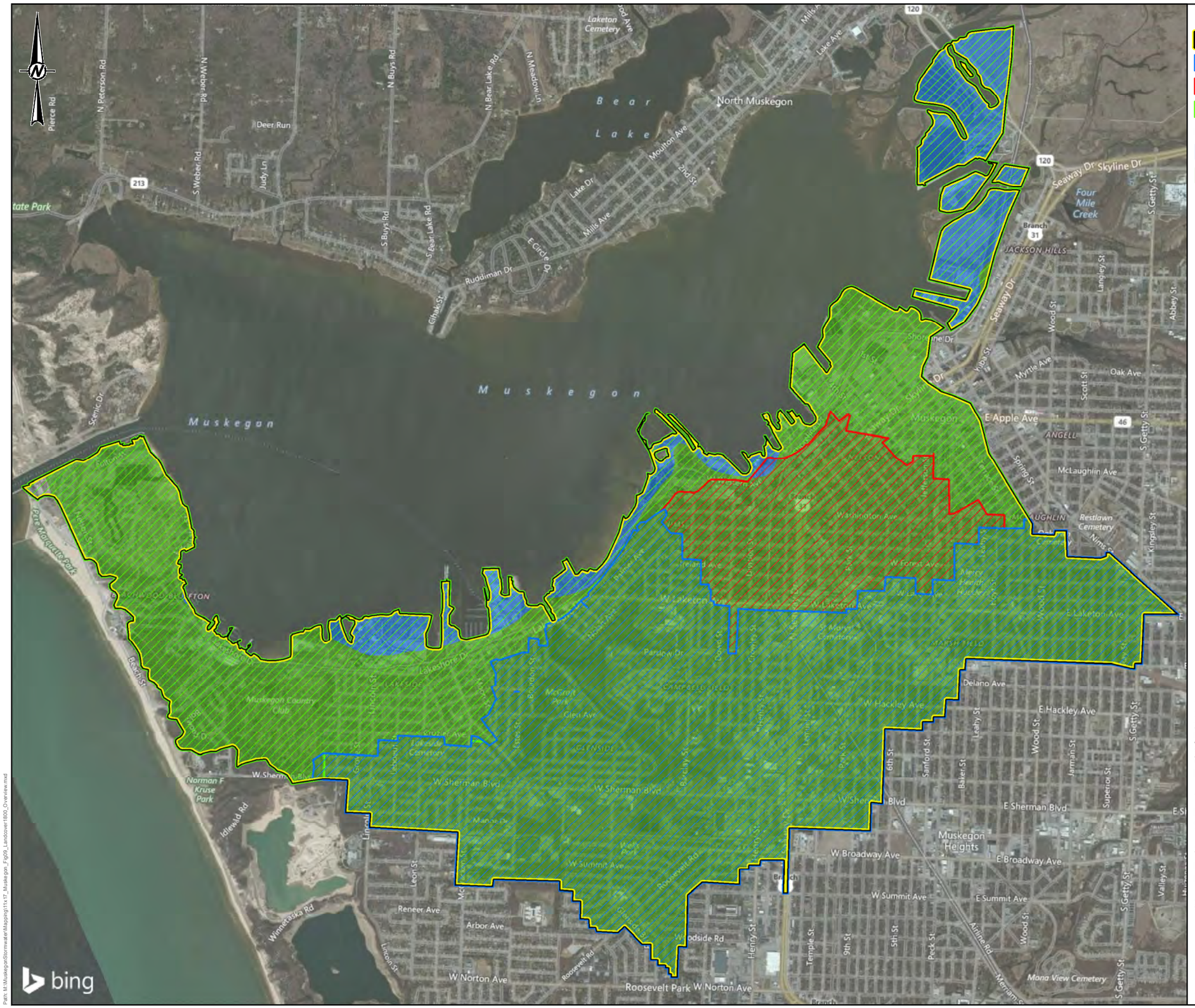
YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No. 1520593

FIGURE **8**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11in 0

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig08_DepthtoH20Table.mxd



LEGEND

- PROJECT PLANNING AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

LANDCOVER TYPE CIRCA 1800

- LAKE/RIVER
- WHITE PINE-WHITE OAK FOREST

0 0.25 0.5 1 Miles

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. LAND COVER DATASET: MICHIGAN CENTER FOR GEOGRAPHIC INFORMATION.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
LANDCOVER MAP - CIRCA 1800
MICHIGAN NATURAL FEATURES INVENTORY

CONSULTANT
Golder Associates

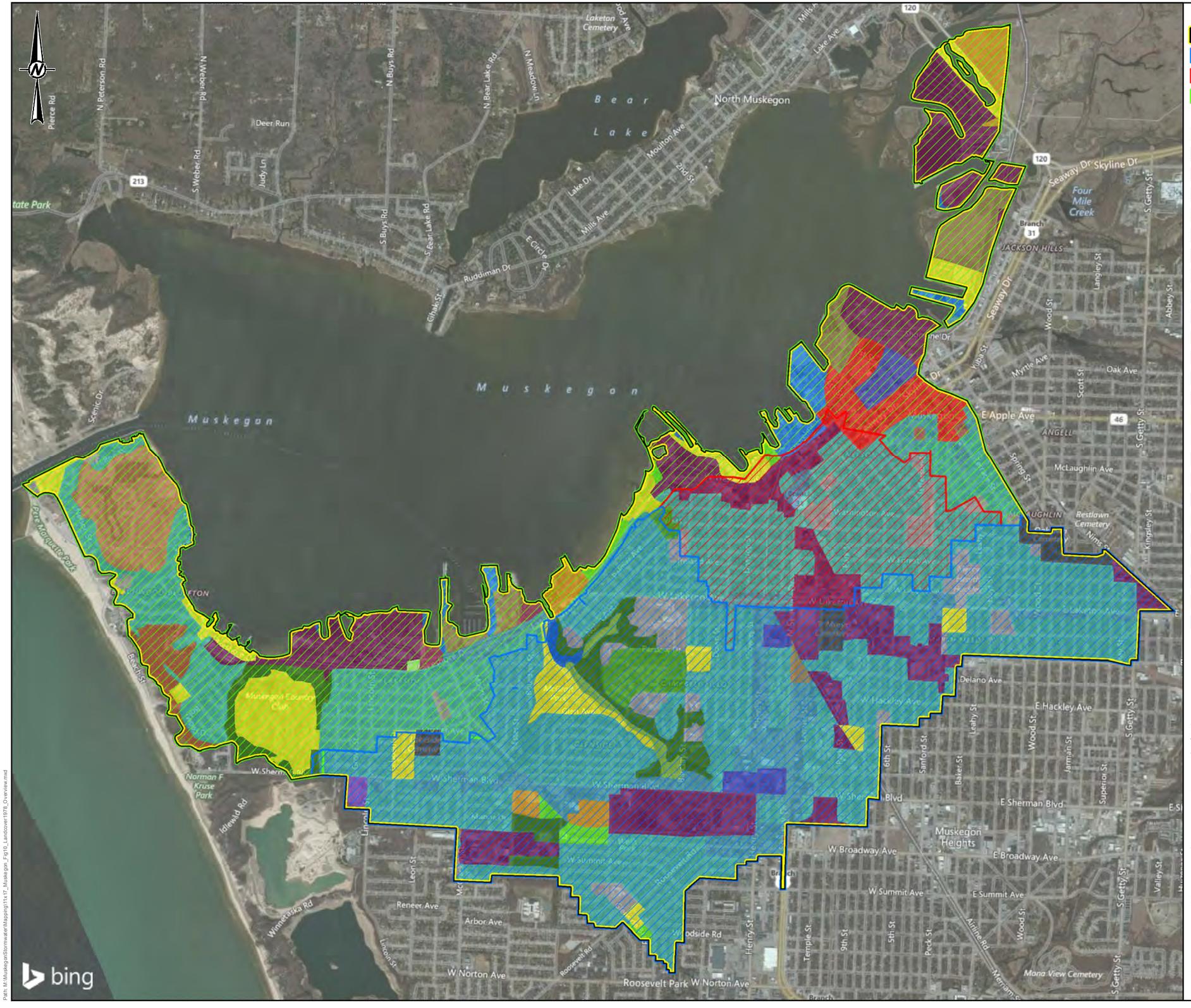
YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1in

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig09_Landcover1800_Overview.mxd



LEGEND

- PROJECT PLANNING AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

1978 LANDCOVER TYPE

- AQUATIC BED WETLAND
- CEMETERIES
- CENTRAL BUSINESS DISTRICT
- CENTRAL HARDWOOD
- EMERGENT WETLAND
- HERBACEOUS RANGELAND
- INDUSTRIAL
- INSTITUTIONAL
- LAKES
- MOBILE HOME PARK
- MULTI-FAMILY-LOW RISE
- MULTI-FAMILY-MEDIUM TO HIGH RISE
- NEIGHBORHOOD BUSINESS
- NORTHERN HARDWOOD
- OUTDOOR RECREATION
- PINE
- ROAD TRANSPORTATION
- SAND OTHER THAN BEACHES
- SHOPPING CENTER, MALL
- SHRUB RANGELAND
- SHRUB/SCRUB WETLAND
- SINGLE FAMILY, DUPLEX
- STREAMS AND WATERWAYS
- UTILITIES, WASTE DISPOSAL
- WATER TRANSPORTATION

0 0.25 0.5 1 Miles

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. LAND COVER DATASET: MICHIGAN CENTER FOR GEOGRAPHIC INFORMATION.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
LANDCOVER MAP - 1978
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

CONSULTANT
Golder Associates

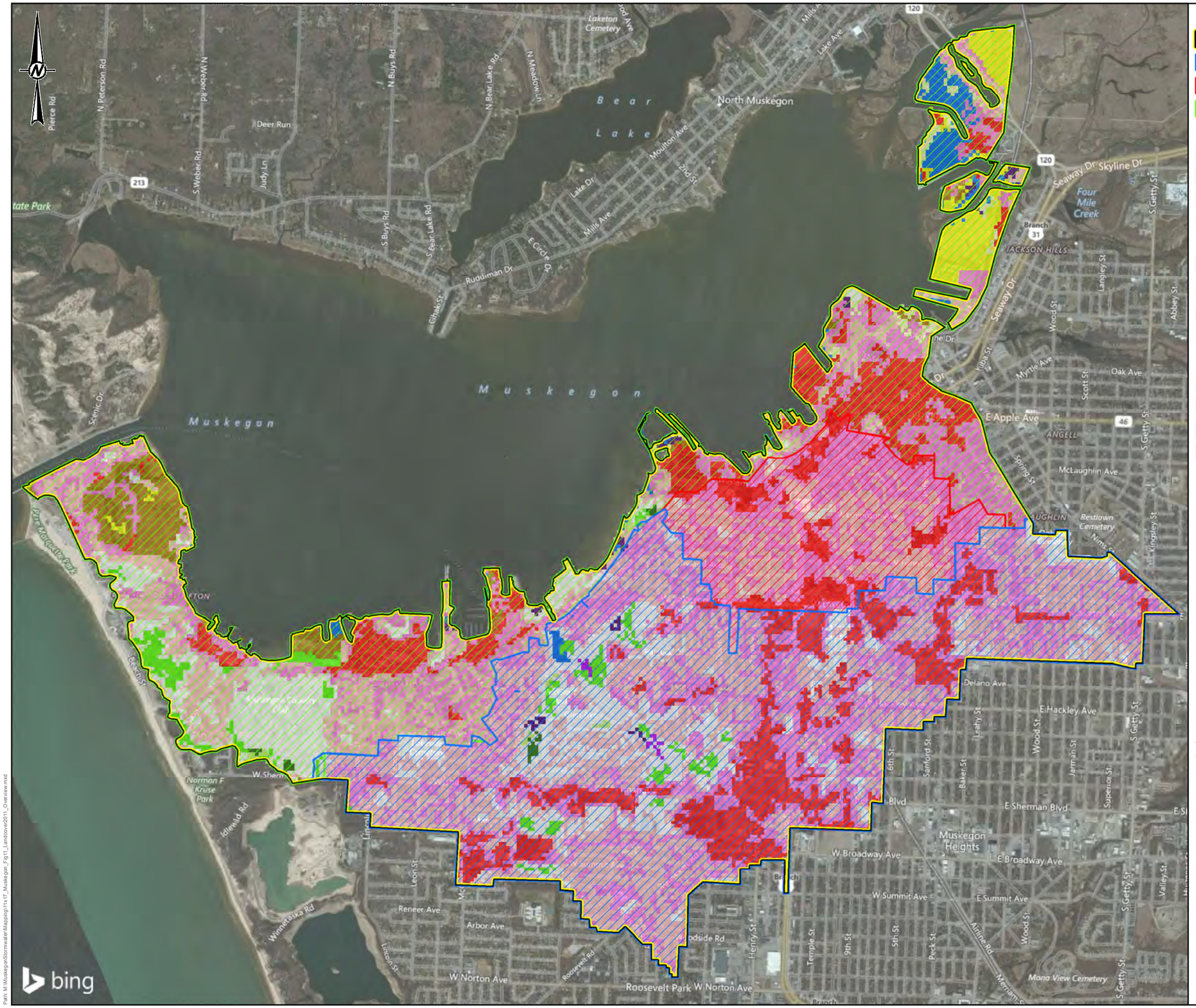
YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11in

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig10_Landcover1978_Overview.mxd



LEGEND

- PROJECT PLANNING AREA
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

NLCD LAND COVER TYPE

- BARREN LAND
- DEVELOPED, HIGH INTENSITY
- DEVELOPED, MEDIUM INTENSITY
- DEVELOPED, LOW INTENSITY
- DEVELOPED, OPEN SPACE
- CULTIVATED CROPS
- DECIDUOUS FOREST
- EVERGREEN FOREST
- MIXED FOREST
- EMERGENT HERBACEUOUS WETLANDS
- HERBACEUOUS
- OPEN WATER
- SHRUB/SCRUB
- WOODY WETLANDS

0 0.25 0.5 1 Miles

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.
2. LAND COVER DATASET: "2011 NATIONAL LAND COVER DATASET (NLCD)", USDA/NRCS - NATIONAL GEOSPATIAL CENTER OF EXCELLENCE.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
LANDCOVER MAP - 2011
NATIONAL LANDCOVER DATASET

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
11

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
0 1in

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig11_Landcover2011_Overview.mxd

Mart Dock East

Mart Dock West

Hartshorn Marina West

Hartshorn Marina East

Carpenter Brothers

Nelson School

Grand Trunk Park

Seyferth Park

LEGEND

- PROJECT PLANNING AREA
- BEST MANAGEMENT PRACTICES IMPLEMENTATION LOCATIONS
- RUDDIMAN CREEK SUB-WATERSHED
- DIVISION STREET OUTFALL SUB-WATERSHED
- DIRECT LAKE DRAINAGE SUB-WATERSHED

Miles

0 0.25 0.5 1

REFERENCE

1. AERIAL IMAGERY: ESRI BASEMAP SERVICES, MICROSOFT CORPORATION ©2015.

CLIENT
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

PROJECT
MUSKEGON LAKE WATERSHED GREEN INFRASTRUCTURE STORMWATER PLANNING AND MANAGEMENT PROJECT

TITLE
SITE SPECIFIC CONCEPTUAL DESIGN LOCATION MAP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-13
PREPARED	KJC
DESIGN	KJC
REVIEW	KL
APPROVED	KL

PROJECT No.
1520593

FIGURE
12

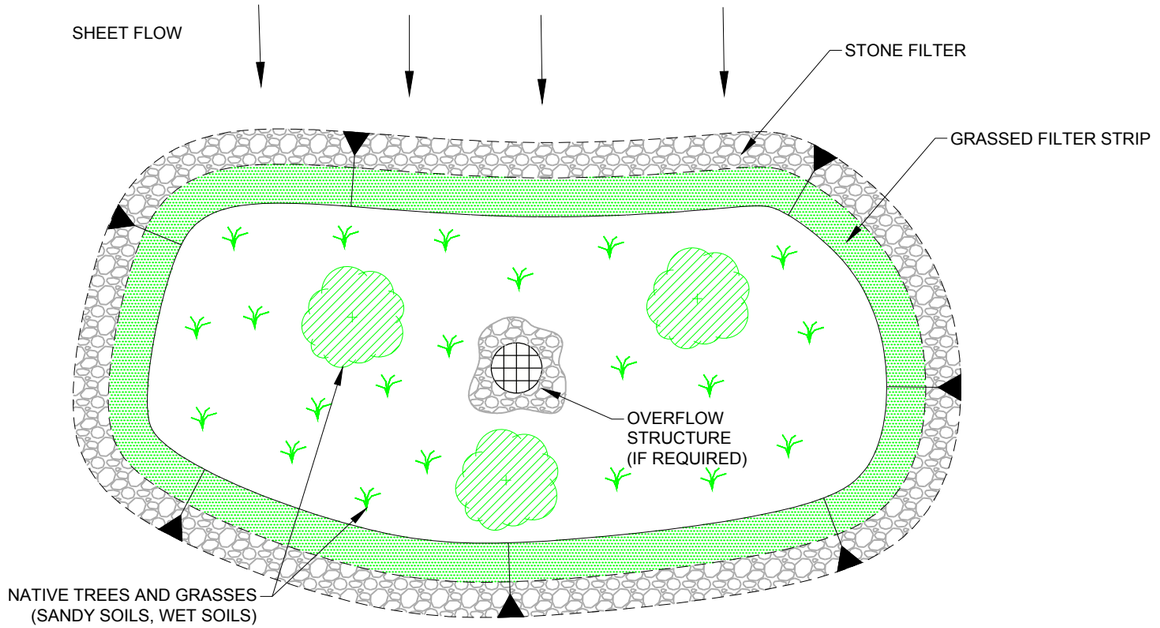
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11 in

Path: M:\Muskegon\Stormwater\Mapping\11x17_Muskegon_Fig12_SiteSpecificConceptualDesignLocationMap.mxd

APPENDICES

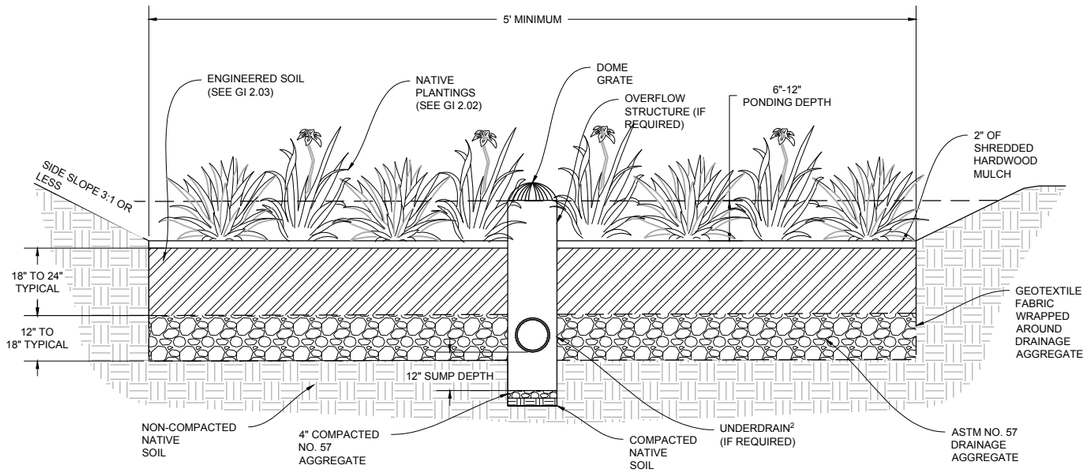
APPENDIX A

Best Management Practices Designs



TYPICAL RAIN GARDEN PLAN

NTS



TYPICAL RAIN GARDEN SECTION

NTS

REFERENCE(S)

"RAIN GARDEN SECTION" TAKEN FROM "GREEN INFRASTRUCTURE DESIGNS, SCALABLE SOLUTIONS TO LOCAL CHALLENGES," PROVIDED BY DELTA INSTITUTE AND GUIDON DESIGN, DATED JULY 2015.

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

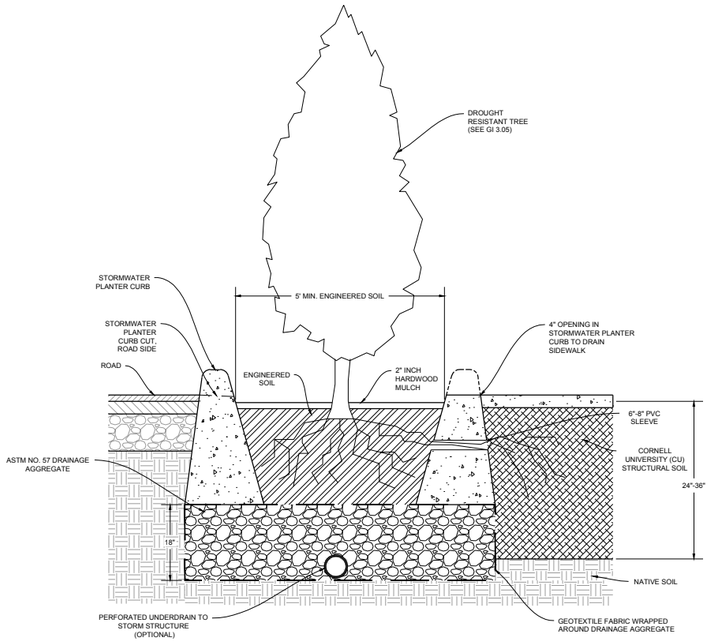
PROJECT
GREEN INFRASTRUCTURE PROJECT

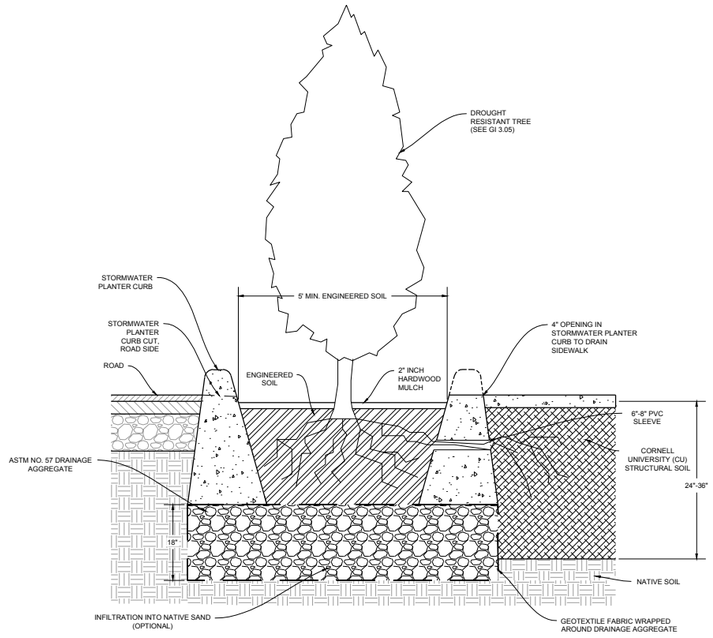
CONSULTANT
Golder Associates

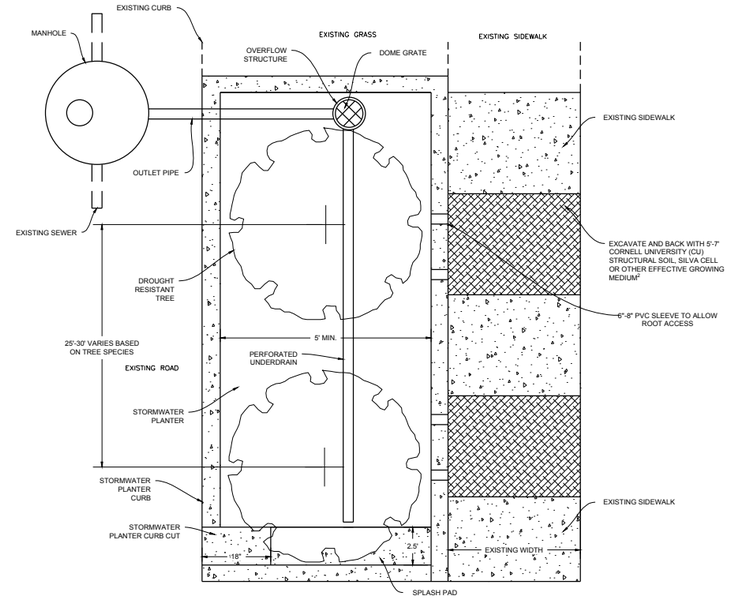
YYYY-MM-DD	2015-11-17
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

TITLE
GENERAL DETAIL
SHEET 1 OF 3

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			1







BIORETENTION ISLAND PLAN

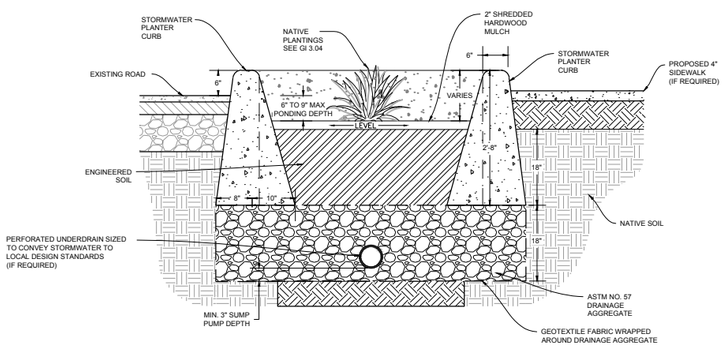
NTS

NOTE

1. STORMWATER PLANTER WITH TREE HAS THE SAME DIMENSIONS AS THE STORMWATER PLANTER SECTION SHOWN ON GI 3.01.

OPTION 1

OPTION 2



OPTION 3

BIORETENTION ISLAND SECTIONS OPTIONS

NTS

REFERENCE(S)

"STORMWATER PLANTER WITH TREE, STORMWATER PLANTER WITH TREE PLAN VIEW AND STORMWATER PLANTER SECTION" TAKEN FROM "GREEN INFRASTRUCTURE DESIGNS, SCALABLE SOLUTIONS TO LOCAL CHALLENGES," PROVIDED BY DELTA INSTITUTE AND GUIDON DESIGN, DATED JULY 2015.

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

PROJECT
GREEN INFRASTRUCTURE PROJECT

CONSULTANT

Golder Associates

YYYY-MM-DD	2015-11-17
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

TITLE
GENERAL DETAIL
SHEET 2 OF 3

PROJECT NO. 1520593 | CONTROL | REV. | FIGURE 2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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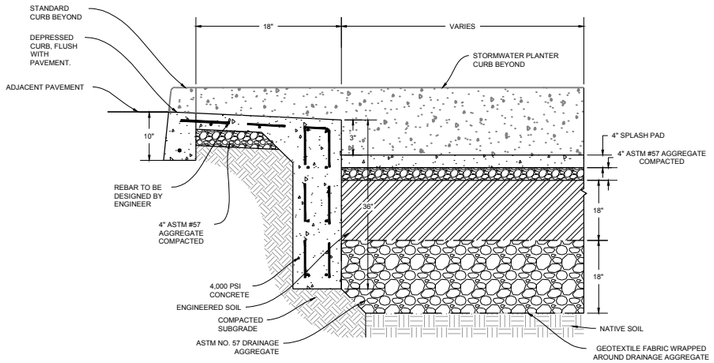
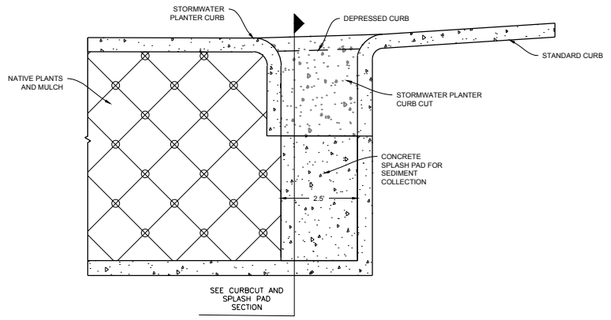
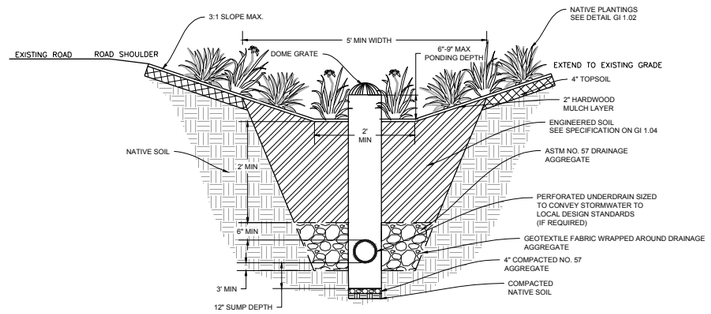




CURB CUT AND SPLASH PAD DETAIL
NTS



DESIGN GUIDANCE

TYPICAL LOCATION: LONG NARROW SPACE WITHIN RIGHT OF WAY, IN PARKING LOT, OR ADJACENT TO BUILDING[1]

WIDTH: 2' MIN BOTTOM / 5' MIN FOR ENGINEERED SOIL MAX WIDTH DEPENDENT ON SPACE AVAILABLE

LENGTH: SCALABLE

CONTRIBUTING DRAINAGE AREA: < 2 ACRES

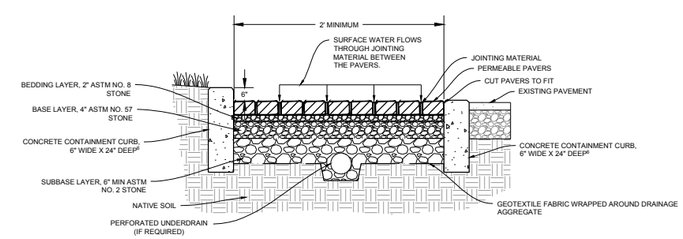
AVAILABLE OPTIONS: OVERFLOW STRUCTURE
UNDERDRAIN VS. INFILTRATION
NATIVE PLANT: PLUGS VS. GALLONS

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ NATIVE SOIL INFILTRATION[2]: _____ IN/HR
- ☐ REQUIRED STORAGE CAPACITY[3]: _____ CUBIC FT
- ☐ CONNECT TO EXISTING STORM NETWORK: YES/NO[4]
- ☐ DEPTH TO GROUNDWATER TABLE >2 FT: YES/NO[5]
- ☐ ADJACENT TO DRIVEWAY CROSSING: YES/NO[6]
- ☐ OUTLET: STORM SEWER OR DAYLIGHT TO GRADE

1. COULD BE USED IN VARIOUS RESIDENTIAL, COMMERCIAL OR INDUSTRIAL APPLICATIONS.
2. NATIVE SOIL INFILTRATION NEEDS TO BE GREATER THAN 0.5 INCHES/HOUR. IF IT IS NOT, AN UNDERDRAIN MUST BE INCLUDED.
3. IF STORAGE CAPACITY REQUIRED EXCEEDS AVAILABLE FOOTPRINT, INCREASE THICKNESS OF DRAINAGE AGGREGATE OR CONSIDER UNDERGROUND STORAGE.
4. CAPACITY OF DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
5. IF NO, TECHNIQUE IS NOT SUITABLE.
6. IF YES, AN OVERFLOW AND UNDERDRAIN MUST BE INCLUDED, OVERFLOW STRUCTURE MUST BE A MINIMUM OF 6" BELOW DRIVEWAY.
7. HTTP://WATER.EPA.GOV/INFRASTRUCTURE/GREENINFRASTRUCTURE/GI_WHAT.CFM

BIOSWALE DETAIL
NTS



DESIGN GUIDANCE

TYPICAL LOCATION: PARALLEL PARKING LANE WITHIN RIGHT OF WAY OR IN PARKING AREA OF REDEVELOPMENT

WIDTH: 2' MIN, SCALEABLE

LENGTH: SCALABLE

CONTRIBUTING DRAINAGE AREA: VARIES ON SCALE

AVAILABLE OPTIONS: UNDERDRAIN
UNDERGROUND STORAGE (GI 5.01)

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ NATIVE SOIL INFILTRATION[2]: _____ IN/HR
- ☐ REQUIRED STORAGE CAPACITY[3]: _____ CUBIC FT
- ☐ CONNECT TO EXISTING STORM NETWORK: YES/NO[4]
- ☐ DEPTH TO GROUNDWATER TABLE > 2 FT: YES/NO[5]

1. AQUA ROC PAVERS BY BELGARD SHOWN IN ALLEY RETROFIT (PHOTO BY GUIDON DESIGN)
2. NATIVE SOIL INFILTRATION NEEDS TO BE GREATER THAN 0.5 INCHES/HOUR. IF IT IS NOT, AN UNDERDRAIN MUST BE INCLUDED.
3. IF STORAGE CAPACITY EXCEEDS AVAILABLE FOOTPRINT SPACE, INCREASE THICKNESS OF DRAINAGE AGGREGATE OR CONSIDER UNDERGROUND STORAGE.
4. IMPACT ON DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
5. IF NO, TECHNIQUE IS NOT SUITABLE.
6. CONCRETE CONTAINMENT CURB MUST BE INSTALLED ON ALL SIDES OF THE PERMEABLE PAVERS.

PERMEABLE PAVEMENT DETAIL
NTS

REFERENCE(S)

"STORMWATER CURB CUT AND SPLASH PAD DETAIL, CURB CUT AND SPLASH PAD PLAN VIEW, BIOSWALE TYPICAL SECTION AND PERMEABLE PAVEMENT SECTION" TAKEN FROM "GREEN INFRASTRUCTURE DESIGNS, SCALABLE SOLUTIONS TO LOCAL CHALLENGES," PROVIDED BY DELTA INSTITUTE AND GUIDON DESIGN, DATED JULY 2015.

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

PROJECT
GREEN INFRASTRUCTURE PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-18
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

TITLE
GENERAL DETAILS
SHEET 3 OF 3

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			3

APPENDIX B

Site Specific Conceptual Designs

REGRADE AREA, SHEET FLOW TO EAST

SWEETWATER INC.

STATE OF MICHIGAN

RAIN GARDEN (TYPICAL)

EXISTING RAIN GARDENS

LOCATION OF EXISTING 24"Ø STORMWATER OUTLET

RAIN GARDEN (TYPICAL)

GRAVEL PARKING LOT OK AS IS, MINOR GRADING TO SWALES AND RAIN GARDENS

BIOSWALE (TYPICAL)

LAKESHORE DRIVE

MOON ST.

McCRACKEN ST.

50029 ×587.67 FENCELINE
50030 ×586.29 FENCELINE
50028 586.68 GROUND SHOT
50026 585.04 GROUND SHOT
50027 581.23 GROUND SHOT
50016 579.97 GROUND SHOT
50015 581.09 GROUND SHOT
50025 585.48 GROUND SHOT
50024 ×585.61 EDGE OF GRAVEL
50017 ×585.16 EDGE OF GRAVEL
50014 585.63 GROUND SHOT
50012 ×580.25 WATER ELEV.
50000 587.31 TRAV. POINT
50011 585.22 GROUND SHOT
50022 ×586.02 EDGE OF GRAVEL
50023 586.03 GROUND SHOT
50018 ×586.12 EDGE OF GRAVEL
50013 585.22 GROUND SHOT
50010 585.63 GROUND SHOT
50019 ×587.72 EDGE OF GRAVEL
50021 ×586.38 EDGE OF GRAVEL
50020 587.67 GROUND SHOT
50008 ×588.07 EDGE OF GRAVEL
50009 ×587.97 EDGE OF GRAVEL
50031 ×588.24 EDGE OF GRAVEL
50032 588.39 GROUND SHOT
50007 590.68 GROUND SHOT
50006 ×588.84 EDGE OF GRAVEL
50004 ×590.95 EDGE OF GRAVEL
50005 ×589.20 EDGE OF GRAVEL
50033 588.95 GROUND SHOT
50034 ×588.94 EDGE OF GRAVEL
50003 593.00 GROUND SHOT
50048 587.61 SANITARY MH
50001 590.73 TRAV. POINT
50036 590.64 GROUND SHOT
50035 590.50 GROUND SHOT
STM MH 50047 RIM 591.83 NO VISIBLE PIPES WATER ELEV 584.23 BOTTOM OF MH 581.63
50047 590.83 UNKNOWN MH
50046 590.28 SANITARY MH
STM CB 50045 (2" DIA) RIM 590.03 12" RCP SE 586.83
50045 590.03 CB
STM MH 50042 RIM 590.72 21" RCP NE 586.47 15" RCP SE 586.42 12" RCP S 587.57 28" RCP SW 586.42
STM MH 50044 RIM 590.79 21" RCP NE 586.69 12" RCP SE 586.74 21" RCP SW 586.49 12" RCP NW 586.79
50044 590.79 STORM MH
STM MH 50043 RIM 590.85 21" RCP NE 586.45 21" RCP SW 586.40 15" RCP NW 587.00
50042 590.72 STORM MH
50043 590.85 STORM MH
STM MH 50038 RIM 591.90 28" RCP NE 586.10 30" RCP SE 586.10 30" RCP SW 585.95
50039 591.97 SANITARY MH
50038 591.90 STORM MH
STM MH 50040 RIM 591.94 30" RCP NE 586.04 12" RCP E 587.54 30" RCP SW 585.94
50041 591.96 SANITARY MH
STM CB 50037 (2" DIA) RIM 591.50 12" RCP W 587.50
50037 591.50 CB
50040 591.94 STORM MH

LEGEND

- PARCEL BOUNDARY
- OPEN LUST (PART 213)
- PART 201 SITE OF ENVIRONMENTAL CONTAMINATION

NOTE(S)

1. THE GRAND TRUCK PARK SITE IS APPROXIMATELY 25.3 ACRES PARCEL AREA AND 12.7 ACRES WATERSHED TREATMENT AREA.
2. THE GRAND TRUCK PARK SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 50 100
1" = 100' FEET

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
GRAND TRUNK PARK

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			1

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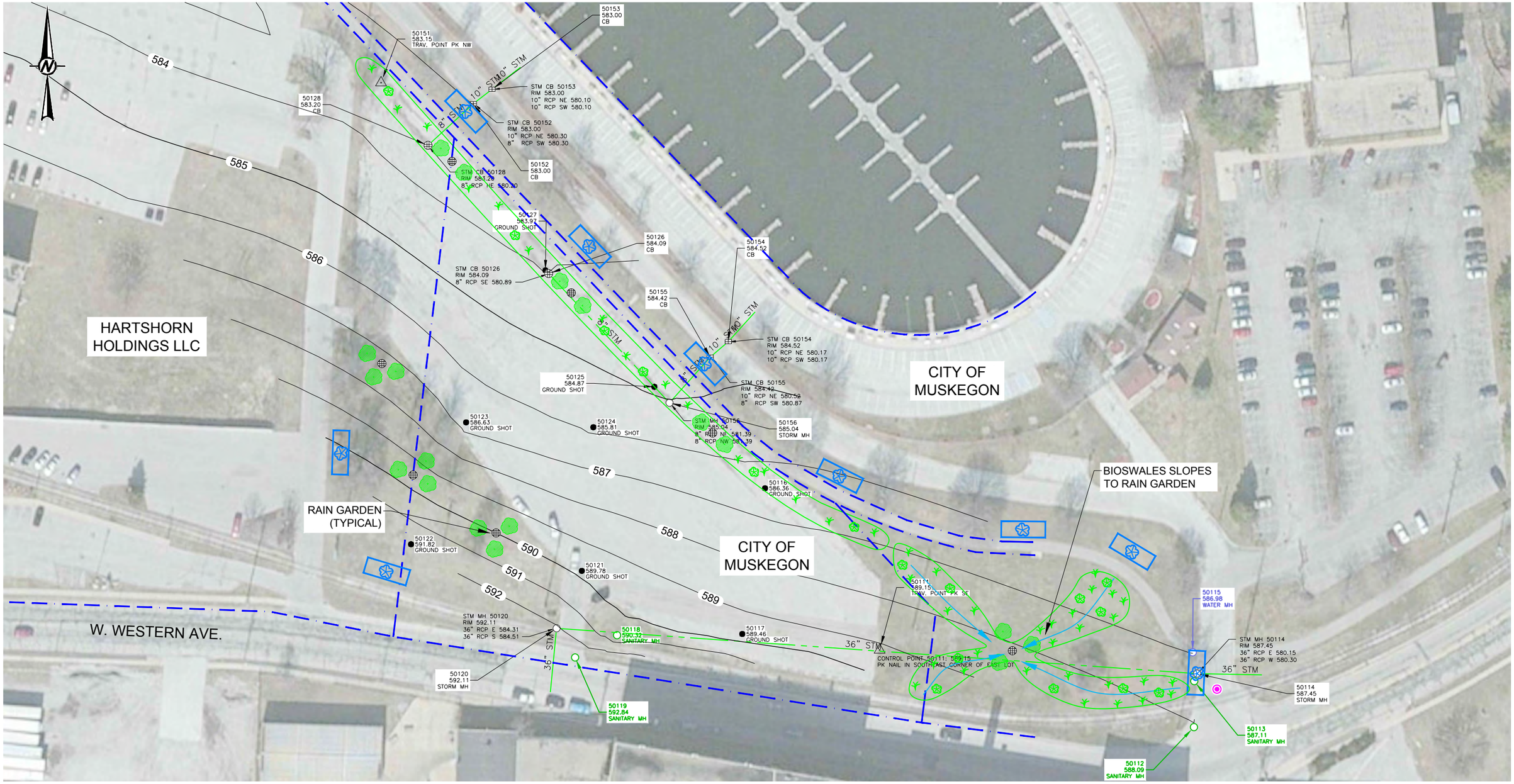

LEGEND

- PARCEL BOUNDARY
- CLOSED LUST (PART 213)
- PART 201 SITE OF ENVIRONMENTAL CONTAMINATION
- CLOSED UST (PART 211)

NOTE(S)

1. THE HARTSHORN MARINA SITE IS APPROXIMATELY 26.5 ACRES PARCEL AREA AND 11.6 ACRES WATERSHED TREATMENT AREA.
2. THE HARTSHORN MARINA SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 40 80
1" = 80' FEET

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
HARTSHORN MARINA EAST

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			2

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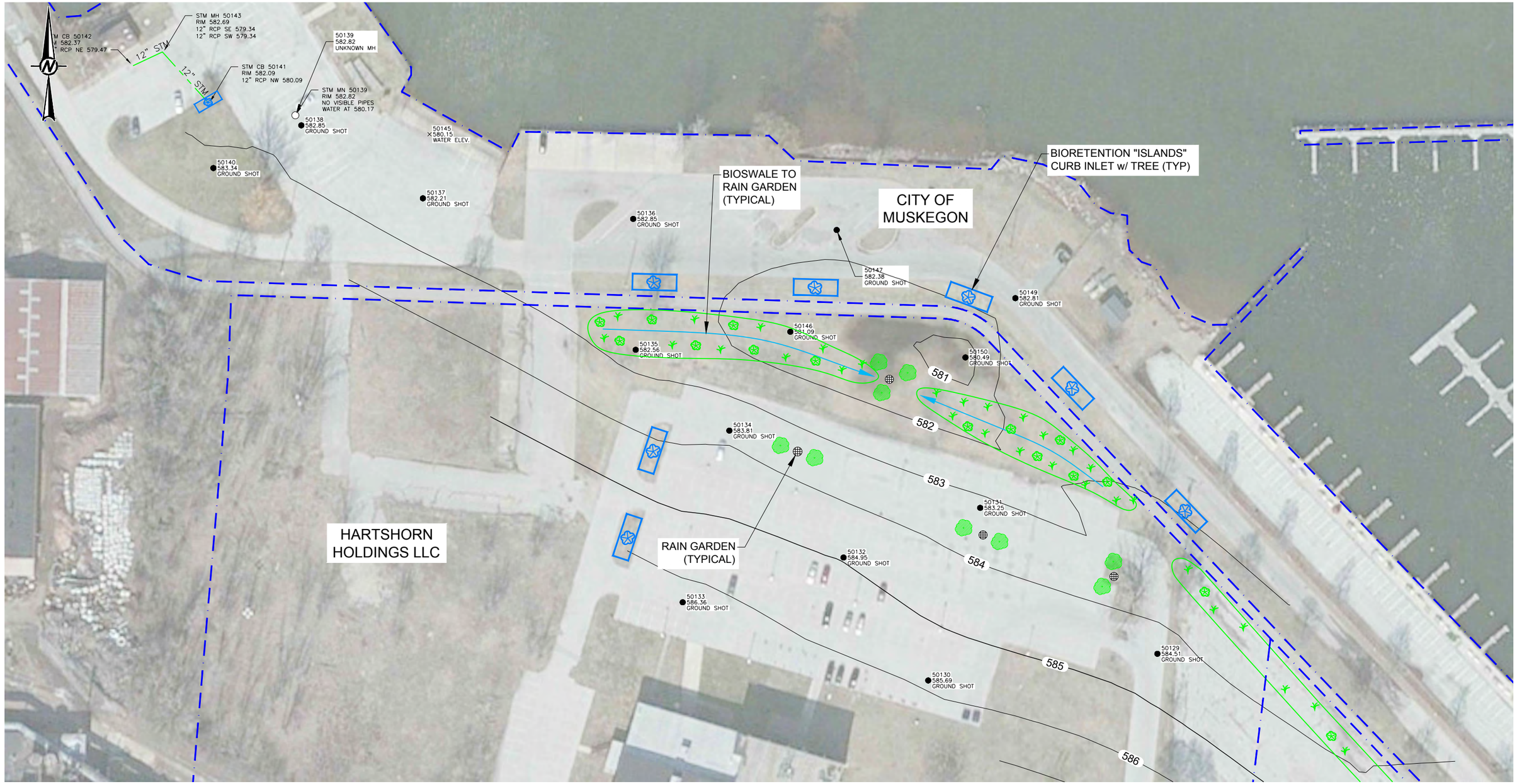

LEGEND

- PARCEL BOUNDARY
- CLOSED LUST (PART 213)
- PART 201 SITE OF ENVIRONMENTAL CONTAMINATION
- CLOSED UST (PART 211)

NOTE(S)

1. THE HARTSHORN MARINA SITE IS APPROXIMATELY 26.5 ACRES PARCEL AREA AND 11.6 ACRES WATERSHED TREATMENT AREA.
2. THE HARTSHORN MARINA SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 40 80
1" = 80' FEET

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	JJS
REVIEWED	DRAFT
APPROVED	DRAFT

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
HARTSHORN MARINA WEST

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			3

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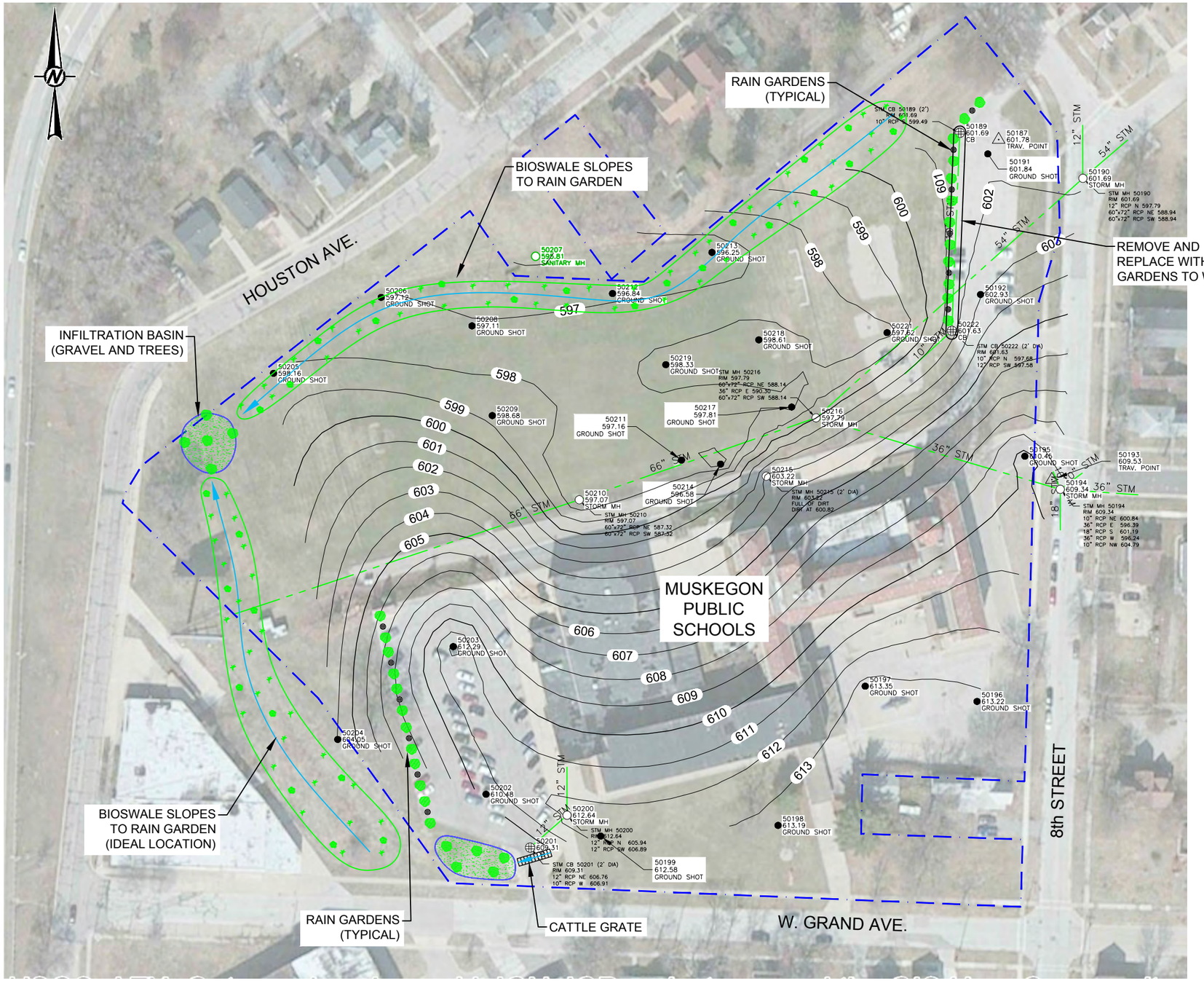

LEGEND

PARCEL BOUNDARY

NOTE(S)

1. THE NELSON SCHOOL SITE IS APPROXIMATELY 9.9 ACRES PARCEL AREA AND 11.0 ACRES WATERSHED TREATMENT AREA.
2. THE NELSON SCHOOL SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

DRAFT

0 50 100
1" = 100' FEET

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
NELSON SCHOOL

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			4

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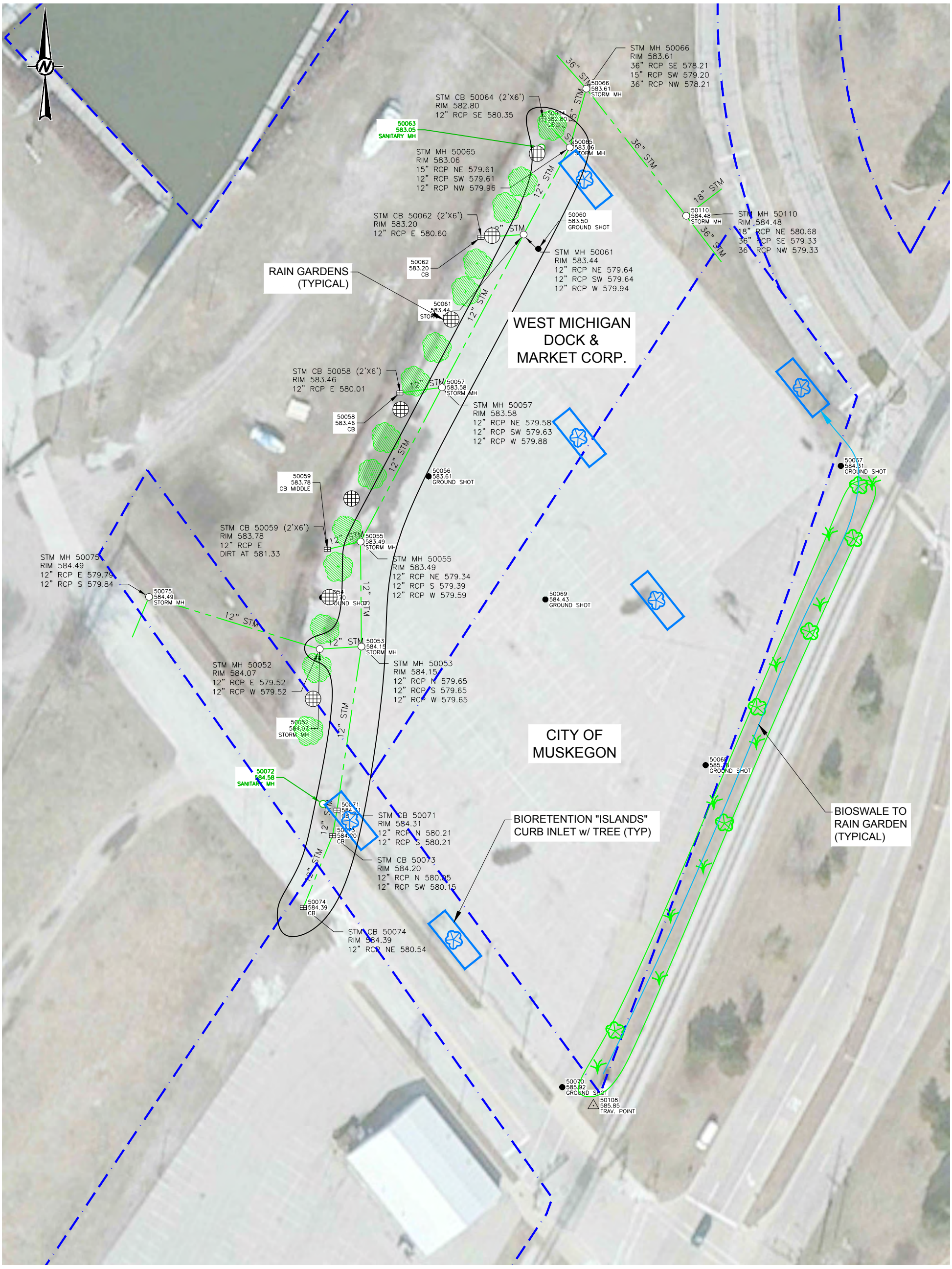


LEGEND

PARCEL BOUNDARY

CLOSED LUST (PART 213)

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 30 60
1" = 60' FEET

NOTE(S)

1. THE MART DOCK SITE IS APPROXIMATELY 46.4 ACRES PARCEL AREA AND 9.1 ACRES WATERSHED TREATMENT AREA.
2. THE MART DOCK SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

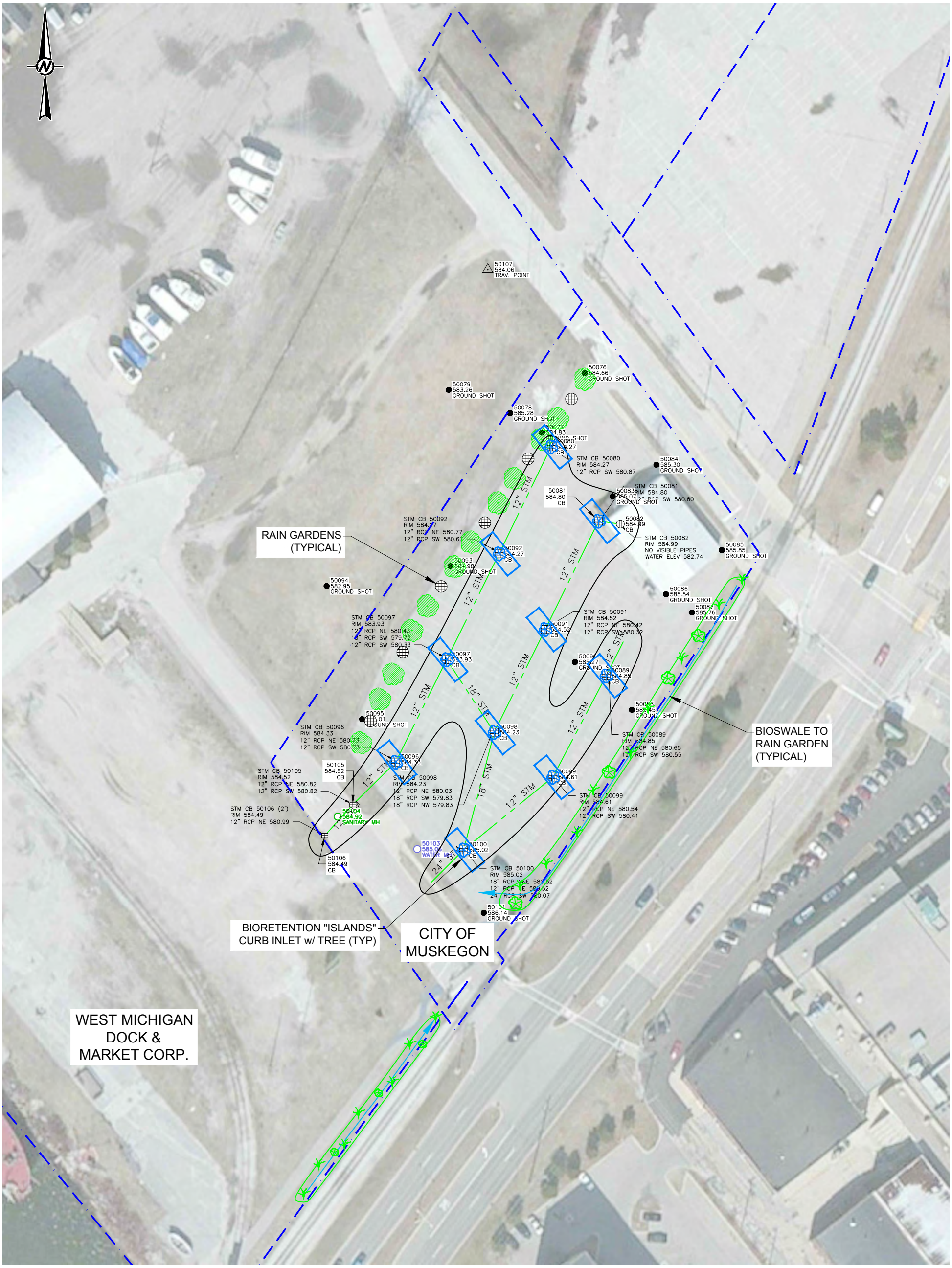
YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
CITY OF MUSKEGON / MART DOCK EAST

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
1 in
0



LEGEND

PARCEL BOUNDARY

CLOSED LUST (PART 213)

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 40 80
1" = 80' FEET

NOTE(S)

1. THE MART DOCK SITE IS APPROXIMATELY 46.4 ACRES PARCEL AREA AND 9.1 ACRES WATERSHED TREATMENT AREA.
2. THE MART DOCK SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	JJS
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
CITY OF MUSKEGON WEST

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
1 in
0

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LEGEND

PARCEL BOUNDARY

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 60 120
1" = 120' FEET

NOTE(S)

1. THE SEYFERTH PARK SITE IS APPROXIMATELY 26.8 ACRES PARCEL AREA AND 19.3 ACRES WATERSHED TREATMENT AREA.
2. THE SEYFERTH PARK SITE IS PRIMARILY PLAINFIELD SAND, 0 TO 6% SLOPES.

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
SEYFERTH PARK

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			7

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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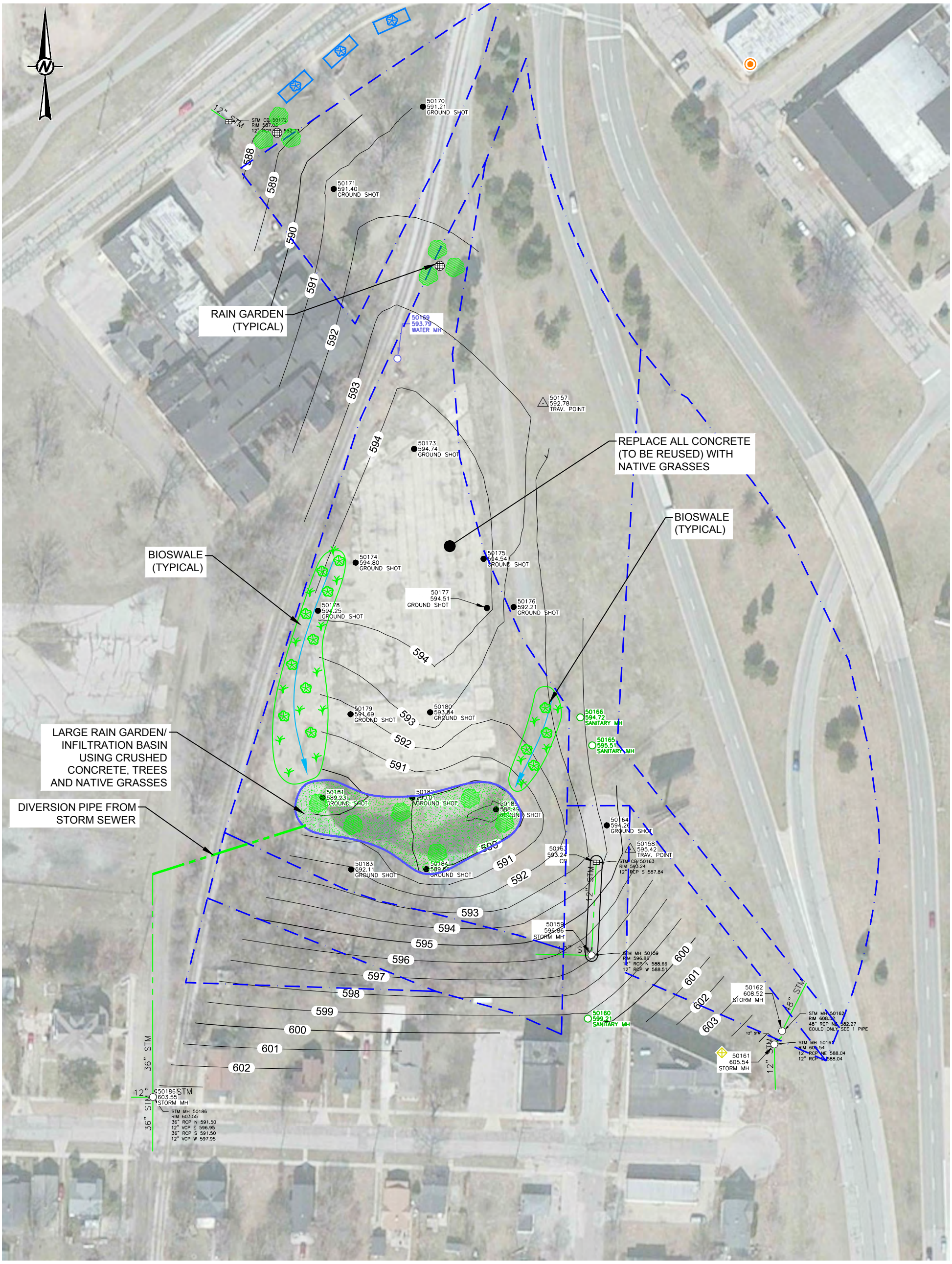

LEGEND

- PARCEL BOUNDARY
- OPEN LUST (PART 213)
- CLOSED UST (PART 211)

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 50 100
1" = 100' FEET

NOTE(S)

1. THE CARPENTER BROTHERS SITE IS APPROXIMATELY 8.2 ACRES PARCEL AREA AND 10.2 ACRES WATERSHED TREATMENT AREA.
2. THE CARPENTER BROTHERS SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND), WITH SOME PLAINFIELD SAND ON THE SOUTHERN PORTION OF THE SITE.

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
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PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
CARPENTER BROTHERS

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			8

APPENDIX C

Site Specific Operation and Maintenance Plans

REPORT

CARPENTER BROTHERS OPERATIONS & MANAGEMENT PLAN

Stormwater Management

Low Impact Developments / Green Infrastructure

Landowner - Muskegon County
990 Terrace St.
Muskegon, MI 49442

Landowner – City of Muskegon
933 Terrace St.
Muskegon, MI 49940

Submitted To: West Michigan Shoreline Regional Development Commission
316 Morris Avenue
Suite 340
Muskegon, Michigan 49440

Submitted By: Golder Associates Inc.
15851 South US 27, Suite 50
Lansing, MI 48906 USA

Distribution: One electronic copy

March 7, 2017

Project No.1520593

A world of capabilities delivered locally

Golder Associates

EXECUTIVE SUMMARY

The Operations and Management (O&M) Plan summarizes the best management practices (BMPs) and low impact development (LID) designs implemented at the Carpenter Brothers site (Site) for improving stormwater management. Golder's Conceptual Plan outlining the BMPs is included in Appendix A. Each structural BMP requires maintenance for continued efficiency and is summarized within the plan. Included in the appendix of the report is a maintenance summary for each BMP (Appendices B, C, and D), and example checklists to be used for routine inspections (Appendix E). The plan provides guidance regarding management of vegetation, a list of recommended Michigan species (Appendix F), and also other recommended materials for the BMPs (Appendix G). Operations and maintenance costs were analyzed for each development, and overall annual cost was calculated for maintaining the site.

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Appendix D Bioretention Island Maintenance Items
Appendix E Example Inspection Checklists
Appendix F List of Michigan Recommended Plants
Appendix G Recommended Materials

1.0 CARPENTER BROTHERS

The Carpenter Brothers site is located in Muskegon, Michigan within the Beidler Creek/Division Street Outfall Watershed. The site is city and county owned, and located within a half mile of Muskegon Lake. The watershed receives stormwater from heavily urbanized areas and the city's storm sewer system. The polluted stormwater discharged to the watershed has resulted in degraded benthic communities, organic chemicals, excessive sediment, and/or flashy hydrology.

With grant support from the Michigan Department of Environmental Quality and the US Environmental Protection Agency, the Muskegon Lake Watershed Partnership, West Michigan Shoreline Regional Development Commission, municipal partners and Golder Associates Inc. recommended design solutions to help reduce stormwater runoff, stormwater pollutants, and improve water quality within the Carpenter Brothers site and the Beidler Creek/Division Street Outfall Watershed. Stormwater LID designs implemented for the site were green infrastructure elements, including a rain garden.

2.0 MAINTENANCE COSTS

Stormwater LID designs are typically less expensive to implement than conventional designs, however they do require long term maintenance to ensure the designs continue to work efficiently. A cost analysis was completed for the Site maintenance at an annual rate, and the cost for maintaining the Site was estimated at $5,303. Annual maintenance costs were based on taking a percentage of the total construction costs, based on a low impact development cost comparison completed by Emmons & Oliver Resources, Inc. (Ref. 2). Rain gardens were estimated to require approximately 5% of construction costs for routine and non-routine maintenance. Operation and maintenance costs for the BMP is summarized in Table 1. The estimated maintenance costs include aesthetic maintenance and functional maintenance. Functional maintenance assures the BMP is performing efficiently and safely, while aesthetic maintenance is mainly for public acceptance, which can help to reduce functional costs. The percentage of construction cost used for each BMP reflects labor, landscaping, and material costs. A typical year of landscaping maintenance includes lawn mowing, removal of debris and litter, replanting or seeding vegetation, and replenishing mulch. Maintenance labor is expected to be greater within the first two to three years as vegetation is established.

Table 1. Operation and Maintenance Costs Summary

Stormwater BMP	Construction Cost ($)	Annual Maintenance Cost (% of Construction Cost)	Annual Maintenance Cost ($)
Rain Garden	106,058	5	5,303
Bioswale	37,800	6	2,268
Biorentention Island	22,410	5	1,121

2.1 Rain Garden

The Site Phase I conceptual stormwater development plan includes a rain garden encompassing approximately 13,068 square feet. The rain garden consists of 12 inches of sand, 36 inches of engineering soil, and two inches of mulch. Regular maintenance of the rain garden is required within the first two to three years when vegetation is becoming established. Less maintenance is required after vegetation becomes established and fills empty spaces between plants. Maintenance requirements for the rain garden can be viewed in Appendix B.

2.2 Bioswale

There are two bioswales implemented in the Site stormwater management plan. The bioswales cover approximately 2,800 square feet, each approximately eight feet wide and totaling 350 linear feet. Bioswales consist of a geotextile filter, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Similar to the rain gardens, the bioswales will be planted with native species and require more maintenance within the first two to three years while vegetation is being established. Routine maintenance items for the bioswales are summarized in Appendix C. The annual maintenance cost of bioswales at the Site was calculated from 6% of the construction costs, totaling $2,268.

2.3 Bioretention Island

Bioretention islands require similar maintenance to rain gardens and bioswales, which predominantly consists of establishing and maintaining vegetation. Bioretention islands are composed of a geotextile filter fabric, 18 inches of compacted stone, 18 inches of engineering soil, and two inches of mulch. There are three bioretention islands at the Site covering approximately 600 square feet. Vegetation in the bioretention islands will include herbaceous plugs/gallons or tree saplings. The maintenance items required for the bioretention islands are summarized in Appendix D. The annual maintenance costs for the bioretention islands were calculated from 5% of the construction costs, equivalent to $1,121.

3.0 ROUTINE INSPECTIONS

Routine inspections for BMPs should be completed at least once every year. Example inspection checklists are included in Appendix E. The example bioretention inspection checklist can be used for inspection of the rain gardens. The rain garden should be inspected for debris, erosion, vegetation conditions and coverage, and mulch thickness to determine overall functionality. Based on the selection of native plants used for the BMP, additional species specific inspections may be required. Inspections of vegetation include determining overall plant health, checking if plants require trimming or pruning, and assuring invasive species are properly managed.

4.0 VEGETATION

The plant species selected for the BMP have a significant impact on the effectiveness of the design. Vegetation will require regular maintenance within the first few years while becoming established. Maintenance involves watering plants as needed, and removing invasive species. Once vegetation is established, less maintenance will be required to maintain the BMP area.

4.1 Native Species

Native plants are implemented in the design because they have deeper and more expansive roots leading to increased infiltration, groundwater recharge and biofiltration. Native plants are also more tolerant to flooding and drought conditions, enabling them to thrive in rain gardens, bioswales, and bioretention islands. Plugs and gallons are common sizes of native plants that can be installed in the BMP. A plug is a small plant that grows in a container roughly two inches wide and five inches deep. A gallon is a more mature plant available in a gallon size container. Both sizes of plants require consistent watering during early development (Delta Institute 2015). Suggested species include: cardinal flower (*Lobelia cardinalis*), blue lobelia (*Lobelia siphilitica*), New England aster (*Aster novae-angliae*), and brown fox sedge (*Carex vulpinoidea*). Additional grasses and wildflowers that could tolerate wet growing conditions recommended by the West Michigan Environmental Action Council include: cotton grass (*Eriophorum angustifolium*), golden alexanders (*Zizia aurea*), and blue flag iris (*Iris versicolor*) (WMEAC 2016). A full list of recommended Michigan plants for the BMP is included in Appendix F (SEMCOG, 2008).

4.1.1 Planting Requirements

Maintenance will be required for any plants that do not successfully grow in the planted environment, and an alternative species may be necessary. Seeding is not the preferred method of planting vegetation since high velocity flows can prohibit the plant from establishing. Plugs or gallon-potted plants installed at one to two foot intervals are recommended for effective establishment of vegetation. Trees and shrubs are also recommended. Seeding should be completed from late April to mid-October if irrigation is available. If irrigation is not available, than seeding can be completed from June 15 or mid-August to mid-October. With dormant seeding, seeding can be completed from November 1 to 30. At all other times of the year, seeding

should have a temporary cover (made of oats/cereal rye or other small grain). Plugs/gallons should be installed from May 1 – June 15. Trees and shrubs should be planted from the middle of April through early June, or the middle of September through the middle of November. A maximum of two to three inches of mulch should be evenly spread in the BMP after installing new plants to help prevent erosion, remove metals, and act as leaf litter in a natural forest environment. The mulch should not be placed directly against the stems of the newly planted vegetation. If wildlife is a threat to newly installed plants additional precautions such as waterfowl barriers are maintenance options.

4.2 Invasive Non-Native Species

Invasive species are not native to the area and tend to grow, and spread quickly without natural controls. If unmanaged, invasive species will displace native species (SEMCOG 2008). Maintenance of invasive species is crucial when native plants are being established. Invasive species can be removed by hand–pulling, mowing, or spot herbicide applications. After native species are established, less maintenance of invasive species is needed. Long term management of invasive species may require removal once every year or as needed. Open areas may require mowing if woody vegetation is noticed encroaching, typically every 3-5 years.

5.0 WINTER CONDITIONS

Winter conditions in Michigan typically include the buildup of snow and the use of de-icing compounds which can negatively affect plant life. Salt tolerant plants are recommended for sites where de-icing and heavy snow occurs. Recommended products for de-icing are nontoxic and organic, such as magnesium chloride-based liquid products or pretreated salt (Delta Institute 2008). Sand and cinder from melted snow has the potential of reducing infiltration into the soil. Preventative measures should be taken to avoid the buildup or piling of snow over infiltration systems.

In the spring, the rain garden should be assessed for winter damages. Buildup of debris and sediment should be cleared, and mulch should be evenly spread in any eroded areas. Plants may also require trimming or rehabilitation. Soil aeriation may also be required in spring to reduce impacts of de-icing agents.

6.0 EDUCATION AND TRAINING

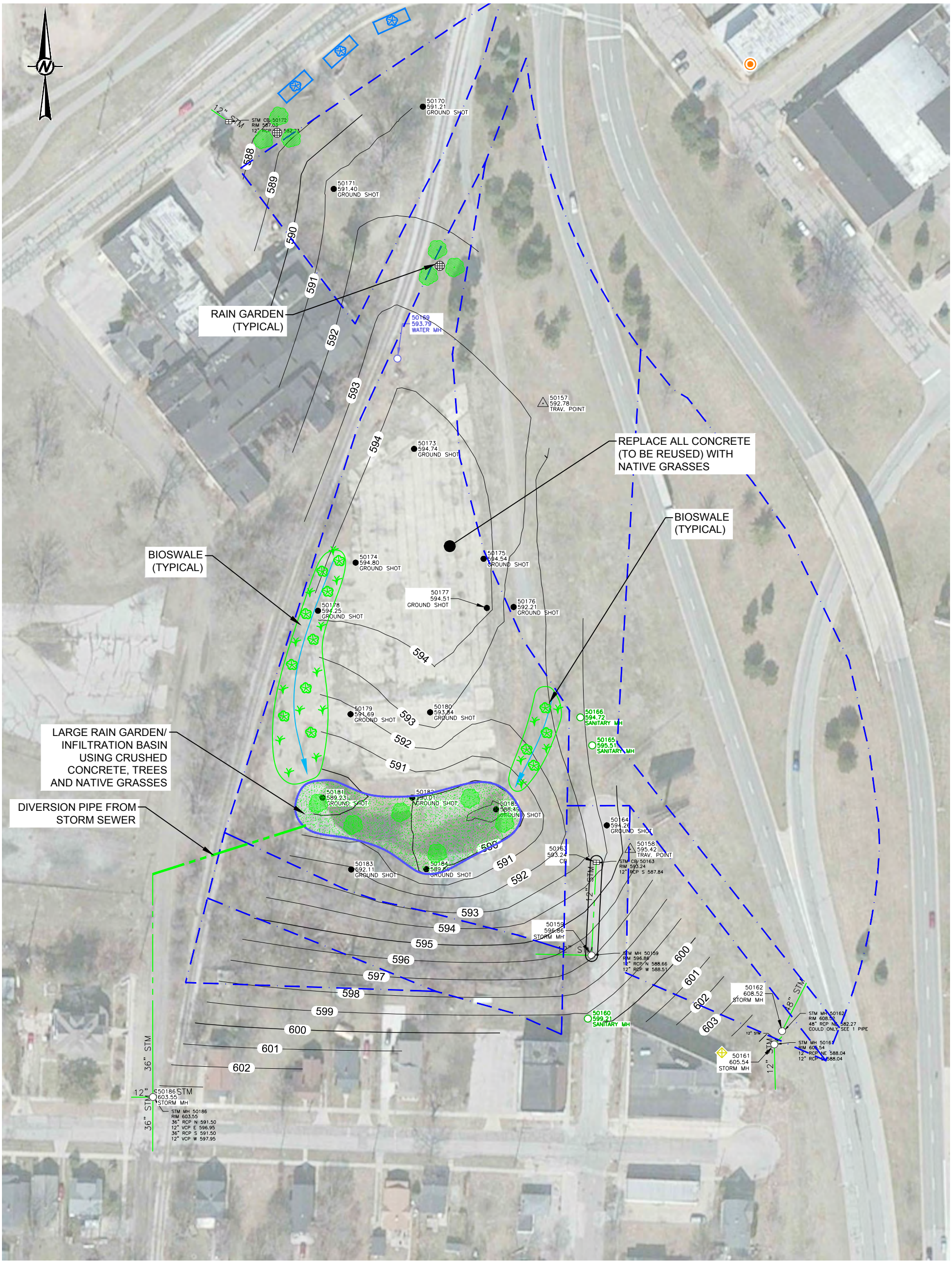
All personnel responsible for the operations and maintenance of the BMP should undergo training to fully understand the care required for the LID design. Training should include reading the O&M plan and discussing procedures with someone of experience. An educated maintenance staff will increase the efficiency and sustainability of the designs.

7.0 REFERENCES

1. Delta Institute and Guidon Design. 2015. Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
2. Emmons & Oliver Resources, Inc. 2015. Minnesota Low Impact Development A comparison, Cost Comparision. A Case Study Comparison of Costs, Water quality and quanity benefits and quality of life. http://www.eorinc.com/pdf/development-maintenance-cost.pdf
3. SEMCOG 2008. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html
4. West Michigan Environmental Action Council. 2016. Rain Gardens of West Michigan. Michigan Native Plants List For Use in Rain Gardens and Landscaped Bioretention Areas. http://www.westmichiganglsi.org/uploads/6/7/9/8/6798898/rain_gardens_native_plant_list.pdf

APPENDIX A

Carpenter Brothers Conceptual Plan



LEGEND

- PARCEL BOUNDARY
- OPEN LUST (PART 213)
- CLOSED UST (PART 211)

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
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0 50 100
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CLIENT
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APPENDIX B

Rain Garden Maintenance Items

RAIN GARDEN

1.0 PUROPOSE

Rain gardens are used to collect stormwater runoff and encourage infiltration and biofiltration with the use of native plants. Native plants are ideal for rain gardens because they have deeper root networks that draw surface water further into the ground. Native plants are also typically drought and flood tolerant and able to thrive in rain gardens. Rain gardens aide in reducing runoff volume, filtering pollutants, recharging groundwater (if no underdrain is used), reducing stormwater temperature impacts, and enhancing site aesthetics.

2.0 MAINTENANCE

Rain gardens require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered and weeded twice weekly through October of the first year and in times of extreme drought. Weeds should be removed by hand.

3.) Organic matter may also need to be removed approximately twice per year, usually by hand.

4.) Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

5.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

6.) Annual mowing should be performed for the first three years of establishment. Mowing should not be completed on a regular basis.

7.) Removal of debris must occur monthly for the life of the rain garden.

8.) Winter conditions may result in plants being effected by deicing chemicals in snow-melt, in this case salt-tolerant plants should be used. Also try to reduce the amount of sand, cinders, and other winter abrasives that come in contact with the vegetation. Additional maintenance in the spring is required to remove abrasives if used.

9.) Rain gardens should be inspected at least twice a year for sediment buildup, erosion, and overall vegetation conditions. If sediment build up reaches 25% of the ponding depth it should be removed. If erosion is occurring, soil stabilization efforts should be applied. If vegetation is in poor health for no apparent reason, a landscape architect should be consulted.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

APPENDIX C

Bioswale Maintenance Items

BIOSWALE

1.0 PUROPOSE

Bioswales are shallow, vegetated, earthen channels that help to slow, filter, and infiltrate stormwater runoff in the process of conveyance. Native plants are ideal vegetation for bioswales due to their deep roots for infiltrating runoff, and their high tolerance for droughts and floods.

2.0 MAINTENANCE

Bioswales require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Vegetation should be established as soon as possible to prevent erosion and scour. Freshly seeded swales require soil stabilization such as erosion control matting or blankets. Erosion controls for seeded swales are required after planting for 75 days after the first storm event occurs. If runoff velocities are high, sodding the swale or diverting runoff until vegetation is well established is an option.

4.) Debris removal, weeding, and pruning should be performed on a monthly basis.

5.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity issues are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

6.) Mow and trim plants within the bioswales annually to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Mow only when dry to avoid rutting. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

7.) In the spring the bioswales will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

8.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

9.) If roadside or parking lot runoff is directed to the swale, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

APPENDIX E

Example Inspection Checklists

Maintenance Inspection Checklists

This appendix contains four checklists available as guides for maintenance inspections of specific BMPs. The maintenance items have been adapted from multiple stormwater programs, including the Rouge River Detention Basin Maintenance Manual, Georgia Stormwater Management Manual, the Vermont Stormwater Management Manual, and the Stormwater Manager's Resource Center.

The checklists are designed to help identify key components of BMPs that require ongoing maintenance as well as a basic schedule of when the maintenance should occur. The checklists have been divided into those items essential for the general operation and functionality of the BMP and those items that optional and may enhance the BMP.

It is suggested that the inspection be undertaken by a licensed PE and/or a person knowledgeable about the design and function of the BMP.

These BMP checklists include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

Detention BMP Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet Pipes			
Structural integrity of inlet/outlet (Are any inlet pipes broken, crumbling, separated?) List Inlet Pipes Approximate Diameter and Type of Material Inlet Pipe 1 _____ Inlet Pipe 2 _____ Inlet Pipe 3 _____ Outlet Pipe Size/Type _____		A	
Riprap at inlet pipe (Is the riprap still present? Is it visible and not covered with sediment?		A	
Stone around outlet pipe (Is the stone clogged with debris and/or sediment?)		A	
Trash or debris blocking inlet/outlet (Inspect to ensure no major obstructions hindering general functionality)		M	
Inspect/clean catch basin upstream of the BMP if accessible.		A	
Inspect inlets and outlet for erosion (Are there eroded areas around the pipes?)		A	
Inspect overflow spillway for signs of erosion.			
Pretreatment (if applicable) (Might include sediment forebay, upstream catch basin, bioswale, rain garden, swirl concentrator)			
Device functioning to trap/collect sediment		A	
Remove accumulated sediment as appropriate for the pretreatment device. forebay		A	
Detention Pond		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inspect side slopes, berms and emergency overflow for erosion		A	
Reestablish permanent native vegetation on eroded slopes		As needed	
Inspect for excess sediment accumulation in pond if not pretreatment device is present		A	
Overall functionality			
Ensure pond is functioning properly (Professional Civil Engineer is recommended)		A	
Ensure the outlet is functioning properly (Professional Civil Engineer is recommended)		A	
Optional/Enhancements			
Maintain 15-20 feet “no mow and chemical free” zone		A	
Mow (or burn) the “no mow” zone		A	
Inspect basin and “no mow” zone for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation in and around pond.		A	
Complaints from residents (note on back)		S	
Encroachment on pond/no- mow zone.		A	
Unauthorized plantings		A	
Aesthetics (e.g., graffiti, unkept maintenance)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Summary

Inspector’s remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Infiltration BMPs Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		A	
Pretreatment for sediment			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure infiltration device is functioning properly (professional civil engineer is recommended)		A	
BMP infiltration surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		S	
Evidence of erosion present		A	
Aggregate (if applicable)			
Surface of aggregate clean		A	
Any replacement of aggregate needed? If clogged with sediment replacement is necessary for continued proper function.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Vegetated surface (if applicable)			
Vegetative cover exists		A	
Optional considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation or creating a native plant infiltration basin area.		A	
Complaints from residents (note on back)		A	
Mowing done when necessary		A	
No fertilizer unless testing requires it		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioretention Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway or catch basin clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		Every 5 years	
Pretreatment for sediment (Generally consists of catch basin or velocity dissapator at inlet such as area of riprap/ collection for sediment)			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure bioretention area is functioning properly (professional civil engineer is recommended)		A	
Bioretention area surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		M	
Evidence of erosion present		A	
Does good vegetative cover exist		A	
Mulch covers entire area (no voids) and to specified thickness		A	
Optional considerations			
Inspect BMP for invasive species.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioswale, Filter Strip Inspection Checklist

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Pretreatment/ Energy Dissipators			
No evidence of flow going around structures		A	
No evidence of erosion		A	
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
BMP surface			
Area free of debris?		M	
No evidence of erosion		A	
Does sediment accumulation currently require removal?		A	
Overall functionality			

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Ensure swale is functioning properly (professional civil engineer is recommended)		A	
Optional Considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

APPENDIX F

List of Michigan Recommended Plants

Recommended Plant Lists for Best Management Practices

This appendix contains recommended native and non-native (when appropriate) plant species for the Best Management Practices detailed throughout the manual. Species have been recommended based on hardiness, aesthetics, functionality, and commercial availability. It is certain that species exist outside the confines of this list that will perform in a comparable way to those listed; however, commercial availability is often a limiting factor in obtaining material for native plantings. Over time, and in certain locales, additional species will become available to supplement those listed below.

An array of planting zones is provided based on normal water levels (Figure C.1). Using these zones will provide the best chances for long-term success of native planting in the context of LID. While plants may naturally occur outside of the given ranges, these ranges are intended to be guidelines for plant installation. Whenever possible and practical in standing water conditions, native plants should be installed in live plant form (rather than seed). Seed or a combination of seed and live plants may be used in upland situations.

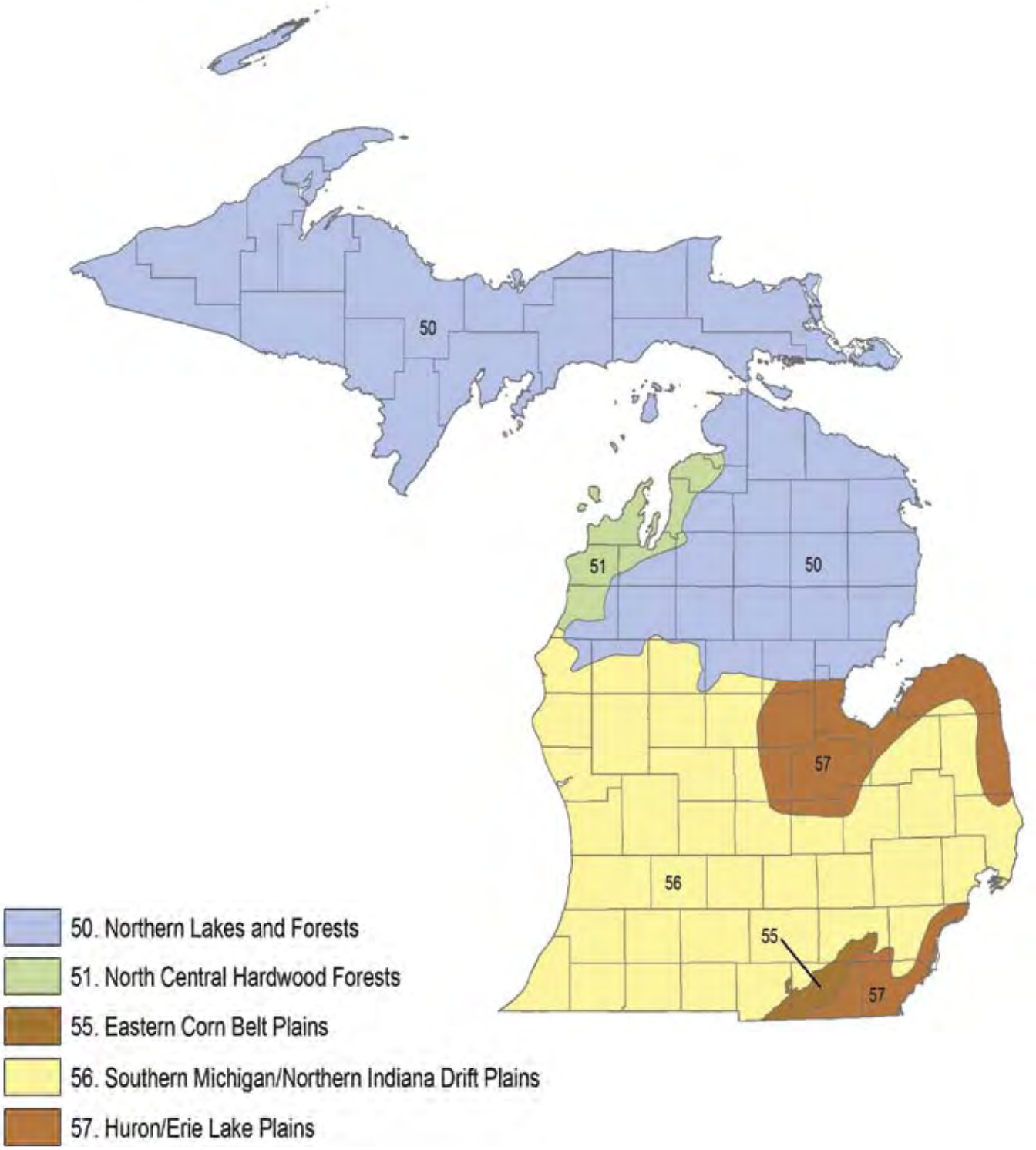
Recommendations are given for height, bloom color, bloom time, sun requirements, salt tolerance, and ecoregion. Please note that these are recommendations based on a range of situations, and a specific plant or population may vary from site-to-site. For sun requirements, F = Full sun required, P = Partial sun tolerated, and S = Shade tolerated. Salt tolerance is classified as Yes (Y) or No (N). This was determined through literature reviews and anecdotal evidence. If there is no information confirming tolerance, a "No" was listed.

Figure C.1
Planting Zone/BMP Matrix

	Zone A — 2"-4" Below Water Level	Zone B — 0"-2" Below Water Level	Zone C — 0"-2" Above Water Level	Zone D — 2"-4" Above Water Level	Zone E — 4"-18" Above Water Level	Zone F — 18"+ Above Water Level	Zone G — Planter Boxes	Zone H — Vegetated Roofs
Rain gardens/Bioretention	✤	✤	✤	✤	✤	✤		
Vegetated Filter Strips			✤	✤	✤	✤		
Vegetated Swales		✤	✤	✤				
Infiltration Basin		✤	✤					
Subsurface Infiltration Basins				✤	✤	✤		
Infiltration Trenches				✤	✤	✤		
Infiltration Berns	✤	✤	✤	✤	✤	✤		
Planter Boxes							✤	
Vegetated Roofs								✤
Constructed Wetlands	✤	✤	✤	✤				
Wet Ponds	✤	✤	✤					
Dry Extended Detention Basins			✤	✤	✤	✤		
Riparian Corridor Restoration			✤	✤				
Native Revegetation	✤	✤	✤	✤	✤	✤	✤	✤

Ecoregion recommendations are also provided for each species (Figure C.2). Whenever possible, the designer/ installer should seek to use species that historically occurred in the same ecoregion as the project. When necessary, species occurring in an adjacent ecoregion may be used.

Figure C.2
EPA Level III Ecoregions for Michigan



Source: USEPA

Plant Installation

Native Seeding

Seasonal consideration: October 1-June 15 (note: seeds should not be planted on frozen ground).

Native seeding is generally recommended for areas above the water line or 1-2" below the water line. Live plant material should be used to establish vegetation at deeper water levels.

Broadcast seeding

Broadcast seeding is preferred over drill seeding on graded, bare soil sites. Apply the seed uniformly over the surface using a combination seeder/cultipacker unit such as a Brillion or Truax Trillion seeder. The Trillion seeder is preferred as it is designed to handle native seeds.

A cone seeder or other similar broadcasting equipment may also be used if the seed mix does not contain fluffy seeds in amounts sufficient to prevent free flowing without plugging. Seed should then be pressed into the surface using a cultipacker or roller.

Drill seeding

A rangeland-type no-till drill designed to plant native grasses and forbs may be used in bare soils although this equipment is specifically designed to plant through existing vegetation which is killed with an herbicide. Cultipacking or rolling before seeding may be required to prevent seed placement depths exceeding .25 inch, but cultipacking or rolling after seeding is not required.

All seeding equipment, whether broadcast or drill, should be calibrated to deliver the seed at the rates and proportions specified in the plans. Equipment should be operated to ensure complete coverage of the entire area to be seeded, and seed must be placed no deeper than .25 inch in the soil. No fertilizers or soil conditioners will be required or allowed.

Native Planting

Seasonal considerations: May 1-July 1

Plant plugs should be installed in holes drilled with an auger the same diameter and depth as the plug within +0.75 inch/- 0.25 inch. In wetland plantings where soil is soft and moist enough, a dibble bar or trowel may also be used. The planting layout should consider the requirements of the individual species regarding soil type, moisture, slope, shading, and other factors for the particular plant species.

Planting densities vary according to budget and project goals and can range from three-to-five foot spacing for plug supplements of seeded areas to six inches to two foot spacing for high visibility landscaping projects with large budgets. Groups of five-to-seven plugs of the same species planted approximately one foot apart is usually preferable to planting all species intermixed randomly across the site at a uniform density.

In wetland or shoreline areas with potential for high wave action or wildlife predation that may dislodge newly planted plugs, plugs should be secured with six inch or eight inch U-shaped wire erosion control blanket staples. Staple length is determined by the density of the planting substrate; softer substrates require longer length to hold plugs adequately.

In areas where potential for wildlife predation exists, such as retention basins or other planting areas adjacent to open water, waterfowl barriers should be installed around a minimum of 50 percent of the plugs. All plugs not protected by barriers should be stapled into the substrate as described above. Barriers may consist of plastic or wire mesh enclosures supported with wooden stakes, adequately constructed to inhibit access by waterfowl for one growing season. Enclosures should extend at least two feet above the plant tops. Methodology should be approved by the project designer with input from a restoration ecologist if necessary. Barriers may be removed after one growing season.

Maintenance and Management

Maintaining vegetated BMPs is typically most important during the first few years following installation. Supplemental irrigation may be needed to help establish plants in drought conditions. Plants may need to be replaced due to predation or other unseen factors. Most commonly, management includes removing invasive species via mowing, hand-pulling, or spot herbicide applications. In larger areas, broadcast herbicide applications may be appropriate. Over time in upland areas, controlled burning may be used as a way to invigorate the plantings and control certain invasive species. If not feasible for social or cultural reasons, an annual or biennial mowing may be used instead of fire.

Long-term management may be necessary, but is typically significantly less intensive. The site should be periodically checked for invasive species infestations. Any prairie or open area may need occasional (every three to five years) burning or mowing to remove woody vegetation that may encroach.

Zone A

Planting Zone = two-to-four inches below water level

These species require continual inundation within the given water depths in order to thrive. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for a majority of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57

Representative Zone A Species

Buttonbush

Pickerel Weed

Swamp Milkweed

Arrowhead

Blue Flag Iris

Source: JFNew

Zone B

Planting Zone = zero-to-two inches below water level

These species tolerate fluctuating water levels within this range. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for most of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-Jun	F	N	50,51,55,56,57
Carex lacustris	Lake sedge	2’-4’	Brown	May-Jun	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Alisma plantago-aquatica	Water plantain	2’-4’	White	Jul-Sep	F	N	50,51,55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard’s tail	2’-4’	White	Jun-Aug	P/S	N	55,56,57

Representative Zone B Species

Blue Flag Iris

Arrowhead

Bristly Sedge

Pickerel Weed

Swamp Milkweed

Source: JFNew

Zone C

Planting Zone = zero-to-two inches above water level

These plants are tolerant of fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Alnus rugosa	Speckled alder	25’	Brown	Mar-May	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Cephalanthus occidentalis	Buttonbush	15’	White	Jun/Aug	F/P/S	N	51,55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	Y	55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Grasses/Sedges/Rushes:							
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Forbs:							
Alisma plantago-aquatica	Water plantain	2'-4'	White	Jul-Sep	F	N	50,51,55,56,57
Anemone canadensis	Canada anemone	1'-2'	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6'-9'	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3'-5'	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3'-6'	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3'-6'	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1'-4'	White	Jul-Oct	F/P	N	50,51,55,56,57
Cassia hebecarpa	Wild senna	3'-5'	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2'-4'	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Eupatorium maculatum	Spotted Joe-pye weed	4'-7'	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3'-5'	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1'-3'	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3'-5'	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5'-12'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2'-3'	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3'-5'	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3'-8'	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2'-5'	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1'-4'	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1'-3'	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2'-4'	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2'-5'	Pink	Aug-Oct	F	Y	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1'-3'	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3'-10'	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Sagittaria latifolila	Arrowhead	1'-4'	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard's tail	2'-4'	White	Jun-Aug	P/S	N	55,56,57
Sisyrinchium angustifolium	Stout blue-eyed grass	1'	Blue	May-Aug	F/P	N	55,56,57
Solidago ohiensis	Ohio goldenrod	2'-3'	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3'-6'	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell's goldenrod	2'-5'	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3'-6'	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2'-5'	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3'-6'	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3'-6'	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3'-5'	Purple	Jul-Sep	F	N	55,56,57
Zizia aurea	Golden Alexanders	1'-3'	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone C Species

Cardinal Flower

Swamp Milkweed

Blue-Eyed Grass

Obedient Plant

Joe-Pye Weed

Path Rush

Red-Osier Dogwood

Monkey Flower

Source: JFNew

Zone D

Planting Zone = two-to-four inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Viburnum trilobum	Cranberry Viburnum	10’	White	Apr-May	F/P/S	N	50,51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Panicum virgatum	Switch grass	3‘-5’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Forbs:							
Anemone canadensis	Canada anemone	1’-2’	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6’-9’	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3’-6’	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1’-4’	White	Jul-Oct	F/P	N	50,51,55,56,57
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2’-4’	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	51,55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium maculatum	Spotted Joe-pye weed	4’-7’	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3’-5’	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1’-3’	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3’-5’	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3’-8’	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2’-5’	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1’-4’	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1’-3’	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2’-4’	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3’-10’	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2‘-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago ohiensis	Ohio goldenrod	2’-3’	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3’-6’	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell’s goldenrod	2’-5’	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3’-6’	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2’-5’	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3’-6’	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3’-6’	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57
Veronicastrum virginicum	Culver’s root	3’-6’	White	Jun-Aug	F/P	N	55,56,57
Zizia aurea	Golden Alexanders	1’-3’	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone D Species

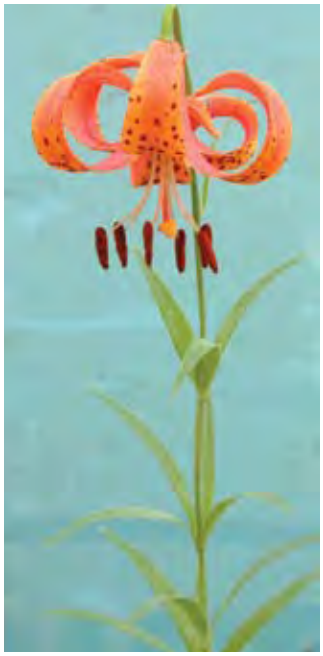
Big Bluestem

Marsh Blazing Star

Wild Columbine

Great Blue Lobelia

Virginia Mountain Mint



Michigan Lily

Meadowsweet

Blue Vervain

Source: JFNew

Zone E

Planting Zone = four-to-18 inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100’	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	N
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80’	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1’-3’	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus florida	Flowering dogwood	30’	White	May-Jun	F/P/S	N	55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85’	White	Jun	F/P	N	55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Pinus banksiana	Jack pine	60’	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100’	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100’	Brown	Jun	F/P/S	N	50,51,55,56,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Prunus americana	American plum	30’	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30’	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7’	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1’-2’	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1’-3’	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1’-2’	Purple	Aug-Oct	F	N	51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Panicum virgatum	Switch grass	3’-6’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2’-4’	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4’-9’	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Stipa spartea	Porcupine grass	2’-4’	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1’-2’	Lavender	Jun-Oct	F/P	N	55,56
Aquilegia canadensis	Wild columbine	1’-3’	Red/ Yellow	Apr-Jun	F/P/S	Y	50,51,55,56,57
Asclepias syriaca	Common milkweed	2’-4’	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1’-3’	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1’-2’	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2’-4’	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3’-5’	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster lateriflorus	Calico aster	1’-3’	White	Jul-Oct	F/P/S	N	50,51,55,56,57
Aster macrophyllus	Big-leaved aster	6”-2’	Lav/ White	Jul-Oct	P/S	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1’-4’	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short’s aster	1’-4’	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Campanula americana	Tall bellflower	2’-6’	Blue	Jul-Nov	P/S	N	55,56,57
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Clematis virginiana	Virgin’s bower	9’ long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2’-5’	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3’-6’	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2’-4’	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1’-2’	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2’-6’	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
elianthus pauciflorus	Prairie sunflower	3’-5’	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2’-4’	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2’-3’	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P/S	N	55,56,57
Liatris scariosa	Savanna blazing star	3’-5’	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2’-4’	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1’-2’	Purple	May-Jul	F/P	N	55,56,57
Phlox divaricata	Wild blue phlox	1’-2’	Blue	Apr-Jun	P/S	N	51,55,56,57
Phlox pilosa	Sand prairie phlox	1’-2’	Pink	May-Aug	F/P	N	56
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1’-3’	White	May-Jul	P/S	N	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Ratibida pinnata	Yellow coneflower	3’-6’	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1’-3’	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2’-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Silphium terebinthinaceum	Prairie-dock	3’-8’	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solo-mon’s seal	1’-3’	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon’s seal	1’-2’	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago juncea	Early goldenrod	2’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1’-3’	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Thalictrum dioicum	Early meadow-rue	1’-3’	Green	Apr-May	P/S	N	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2’-4’	Blue	May-Oct	F/P	N	55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57

Representative Zone E Species

New England Aster

Wild Bergamot

Showy Goldenrod

Tall Bellflower

Wild Geranium

Tall Coreopsis

Redbud

Indian Grass

Source: JFNew

Zone F

Planting Zone = 18+inches above water level

These plants tolerate fluctuating water levels within this range, although they are generally less tolerant than most wetter species. They may tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for upland BMP settings.

Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90'	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100'	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100'	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70'	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80'	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1'-3'	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60'	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25'	Red	Apr-May	F/P/S	N	55,56,57
Cornus florida	Flowering dogwood	30'	White	May-Jun	F/P/S	N	55,56,57
Corylus americana	American hazelnut	10'	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85'	White	Jun	F/P	N	55,56,57
Hamamelis virginiana	Witch hazel	30'	Yellow	Oct-Nov	F/P/S	N	50,51,55,56,57
Juglans nigra	Black walnut	90'	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50'	Brown	Apr-May	F/P	N	55,56,57
Liriodendron tulipifera	Tulip tree	110'	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50'	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100'	Green	May-Jul	F/P/S	Y	51,55,56,57
Pinus banksiana	Jack pine	60'	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100'	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100'	Brown	Jun	F/P/S	N	50,51,55,56,57
Prunus americana	American plum	30'	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30'	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus macrocarpa	Bur oak	85'	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90'	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90'	Green	May-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3'	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100'	Yellow	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100'	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7'	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10'	White	May-Jun	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4'-8'	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1'-2'	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1'-3'	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3'-6'	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3'-5'	Green	Jun-Jul	P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1'-2'	Purple	Aug-Oct	F	N	51,55,56,57
Koeleria macrantha	June grass	1'-2'	White	May-Jul	F/P	N	50,51,55,56,57
Panicum virgatum	Switch grass	3'-6'	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2'-4'	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4'-9'	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6'-7'	Green	Jul-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Stipa spartea	Porcupine grass	2'-4'	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1'-2'	Lavender	Jun-Oct	F/P	N	55,56
Asclepias syriaca	Common milkweed	2'-4'	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1'-3'	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1'-2'	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2'-4'	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3'-5'	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1'-4'	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short's aster	1'-4'	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3'-8'	White	Jun-Oct	F/P/S	N	55,56
Campanulaa americana	Tall bellflower	2'-6'	Blue	Jul-Nov	P/S	N	55,56,57
Clematis virginiana	Virgin's bower	9' long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis lanceolata	Sand coreopsis	1'-2'	Yellow	May-Aug	F/P	N	50,51,55
Coreopsis palmata	Prairie coreopsis	1'-2'	Yellow	Jun-Aug	F/P	N	55
Coreopsis tripteris	Tall coreopsis	4'-8'	Yellow	Aug-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2'-5'	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3'-5'	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3'-6'	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2'-4'	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1'-2'	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2'-6'	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus occidentalis	Western sunflower	2'-4'	Yellow	Aug-Sep	F/P	N	50,51,55,56,57
Helianthus pauciflorus	Prairie sunflower	3'-5'	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4'-6'	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2'-4'	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2'-3'	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris cylindracea	Cylindrical blazing star	1'-2'	Violet	Jul-Oct	F/P	N	51,55,56,57
Liatris scariosa	Savanna blazing star	3'-5'	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Lupinus perennis	Wild lupine	1'-2'	Purple	Apr-Jun	F/P	N	55,56,57
Monarda fistulosa	Wild bergamot	2'-5'	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2'-4'	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1'-2'	Purple	May-Jul	F/P	N	55,56,57
Phlox pilosa	Sand prairie phlox	1'-2'	Pink	May-Aug	F/P	N	56
Polygonatum biflorum	Solomon seal	1'-4'	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1'-3'	White	May-Jul	P/S	N	50,51,55,56,57
Ratibida pinnata	Yellow coneflower	3'-6'	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1'-3'	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Silphium terebinthinaceum	Prairie-dock	3'-8'	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solomon's seal	1'-3'	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon's seal	1'-2'	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1'-2'	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago juncea	Early goldenrod	2'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1'-3'	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2'-4'	Blue	May-Oct	F/P	N	55,56,57
Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Representative Zone F Species

Spiderwort

Butterfly Weed

Yellow Coneflower

Little Bluestem

Foxglove Beardtongue

Wild Lupine

Pale Purple Coneflower

Rattlesnake Master

Sand Coreopsis

Source: JFNew

Zone G

Planter Box Plantings

Although this manual typically recommends using native plants wherever possible, certain situations call for non-native plants due to particular site conditions. Because planter boxes traditionally have a short soil column and are exposed to drier conditions, non-native plants should be considered as long as they are considered non-invasive. Therefore, the list below contains both native and non-native species. Many planter boxes have traditionally used annual flowers. However, we recommend using perennial plants for establishing root systems and lowering maintenance in the long term. Many more species are available for planter boxes than are listed.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun
Ajuga reptans 'Bronze Beauty'	Bronze Beauty Ajuga	6"	Blue	May-Jun	F
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	6"-1'	White	May-Jun	F
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	6"-1'	Blue	Jun-Jul	F
Allium senescens montanum	Mountain Garlic	6"-1'	Pink/Purple	Jun-Aug	F
Allium senescens glaucum	Curly Onion	6"-1'	Pink	Jul-Sep	F
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	6"-1'	Pink	Jul-Aug	F
Aster 'Wood's Light Blue'	Wood's Light Blue Aster	1'-3'	Blue	Aug-Sep	F
Athryium filix-femina	Lady Fern	1'-3'	Green	NA	F/P/S
Blechnum spicant	Deer Fern	1'-2'	Green	NA	F/P/S
Dryopteris erythrosora	Autumn Fern	1'-2'	Green	NA	F/P/S
Euphorbia myrsinites	Mytle Spurge	6"-1'	Yellow	May-Jun	F
Dryopteris intermedia	Fancy Fern	1'-3'	Green	NA	F/P/S
Dyropteris marginalis	Leatherleaf Fern	1'-2'	Green	NA	F/P/S
Geranium x 'Rozanne'	Rozanne Gernaium	1'-2'	Violet	Jun-Sep	F/P
Hemerocallis 'Barbara Mitchell'	Barbara Mitchell Daylily	2'-3'	Pink	Jun-Aug	F/P
Hemerocallis 'Bill Norris'	Bill Norris Daylily	2'-3'	Yellow	Jun-Aug	F/P
Hemerocallis 'Chicago Apache'	Chicago Apache Daylily	2'-3'	Red	Jul-Sep	F/P
Hosta 'Francee'	Francee Hosta	1'-2'	Lavender	Jul-Aug	F/P/S
Hosta 'Guacamole'	Guacamole Hosta	1'-2'	Pink	Aug-Sep	F/P/S
Hosta 'Summer Fragrance'	Summer Fragrance Hosta	1'-2'	Lavender	Aug-Sep	F/P/S
Hosta sieboldiana 'Elegans'	Elegans Hosta	1'-2'	White	Jul-Aug	F/P/S
Sedum 'Autumn Charm'	Autumn Charm Sedum	6"-1'	Pink	Jun-Jul	F
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	6"-1'	Pink	May-Jun	F
Sedum 'Mini Me'	Mini Me Sedum	6"-1'	Green	NA	F
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	6"-1'	Yellow	Jul-Sep	F
Sedum album 'Athoum'	Jelly Bean Sedum	6"-1'	Pink	Aug-Sep	F
Sedum album 'Coral Carpet'	Coral Carpet Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Faro Island'	Faro Island Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Green Ice'	Green Ice Sedum	6"-1'	White	Jun-Jul	F
Sedum album 'Murale'	Wall Sedum	6"-1'	White	Jun-Jul	F
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	6"-1'	Pink	Jul-Aug	F
Sedum divergens	Cascade Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum ellacombianum	Ellacombe's Sedum	6"-1'	Yellow	May-Jun	F
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	6"-1'	Yelow	May-Jun	F
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum grisbachii	Griseback Sedum	6"-1'	Yellow	Jul-Aug	F
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	6"-1'	Yellow	Jun	F
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	6"-1'	Orange	Jul-Aug	F
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	6"-1'	Yellow	May-Jun	F

Representative Zone G Species

Guacamole Hosta

Mountain Garlic

Wall Sedum

Lady Fern

Source: JFNew

Zone H

Vegetated Roof Plantings

Research to-date shows that native plants do not typically thrive in vegetated roofs. Therefore, the list below reflects species that are known to thrive in green roof situations. All species listed below will generally grow to a height of six-to-18 inches.

Botanical Name	Common Name	Color	Bloom Time
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	White	May-Jun
Allium schoenoprasum 'Dwarf'	Dwarf Ornamental Chive	Pink	May-Jun
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	Blue	Jun-Jul
Allium senescens montanum	Mountain Garlic	Pink/Purple	Jun-Aug
Allium senescens glaucum	Curly Onion	Pink	Jul-Sep
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	Pink	Jul-Aug
Euphorbia myrsinites	Mytle Spurge	Yellow	May-Jun
Sedum 'Autumn Charm'	Autumn Charm Sedum	Pink	Jun-Jul
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	Pink	May-Jun
Sedum 'Mini Me'	Mini Me Sedum	Green	NA
Sedum acre 'Aureum'	Gold Leaved Goldmoss Sedum	Yellow	May-Jun
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	Yellow	Jul-Sep
Sedum album 'Athoum'	Jelly Bean Sedum	Pink	Aug-Sep
Sedum album 'Coral Carpet'	Coral Carpet Sedum	White	Jun-Aug
Sedum album 'Faro Island'	Faro Island Sedum	White	Jun-Aug
Sedum album 'Green Ice'	Green Ice Sedum	White	Jun-Jul
Sedum album 'Murale'	Wall Sedum	White	Jun-Jul
Sedum album 'Red Ice'	Red Ice Sedum	White	Jun-Jul
Sedum cautacola 'Bertram Anderson'	Bertram Anderson Sedum	Pink	Jul-Aug
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	Pink	Jul-Aug
Sedum divergens	Cascade Sedum	Yellow	Jun-Jul
Sedum ellacombianum	Ellacombe's Sedum	Yellow	May-Jun
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	Yelow	May-Jun
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	Yellow	Jun-Jul
Sedum grisbachii	Griseback Sedum	Yellow	Jul-Aug
Sedum hispanicum 'Pinkie'	Pinkie Sedum	Pink	Jun-Jul
Sedum hybridum 'Immergunchen'	Evergreen Sedum	Yellow	Jun, Sep
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	Yellow	Jun
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	Orange	Jul-Aug
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	Yellow	May-Jun

*List provided by Hortech, Inc.

Representative Zone H Species

Mountain Garlic

Cascade Sedum

Ellacombe's Sedum

Wall Sedum

Source: JFNew

APPENDIX G

Recommend Materials

Recommended Materials

Numerous BMPs in this manual have similar material needs. These BMPs are listed in the table below. Detailed information on each material requirement follows. In addition, Porous Pavement and Vegetated Roofs have significant material requirements that are listed according to their individual needs.

	Constructed Filters	Dry Well	Infiltration Trench	Planter Boxes	Porous Pavement	Subsurface Infiltration	Vegetated Filter Strip	Vegetated Swale
Check dams							X	X
Non-Woven Geotextile	X	X	X	X	X	X	X	
Pea Gravel							X	
Peat	X			X				
Pervious Berms							X	
Pipe – 8”	X	X	X	X	X	X	X	
Sand	X			X				X
Stone/Gravel	X			X				
Stone – 30%							X	
Stone – 40%			X		X			

Check dams (Vegetated Filter Strip, Vegetated Swale)

An earthen check dam shall be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02 in to 0.04 in, Gravel: AASHTO M-43 0.5 in to 1.0 in). A stone check dam shall be constructed of R-4 rip rap, or equivalent.

Non-Woven Geotextile (Constructed Filter, Dry Well, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should consist of needled nonwoven polypropylene fibers and meet the following properties:

a. Grab Tensile Strength (ASTM-D4632) 120 lbs min.
b. Mullen Burst Strength (ASTM-D3786) 225 psi min.
c. Flow Rate (ASTM-D4491) 110 gal/min/ft2 min.
d. UV Resistance after 500 hrs (ASTM-D4355) 70% min.
e. Puncture strength (ASTM D-4833-00) 90 lb. min.
f. Apparent opening size (ASTM D-4751-99A) 60-70 US Sieve

Heat-set or heat-calendared fabrics are not permitted. Acceptable types include Mirafi 140N, Amoco 4547, Geotex 451, or approved others.

Pea Gravel (Vegetated Filter Strip)

Clean bank-run gravel may also be used and should meet ASTM D 448 and be sized as per No.6 or 1/8” to 3/8”.

Peat (Constructed Filter, Planter Boxes)

Should have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.

Pervious Berms (Vegetated Filter Strip)

The berm shall have a height of 6-12 in and be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02”-0.04”, Gravel: AASHTO M-43 ½” to 1”)

Pipe - (Dry Well, Porous Pavement, Subsurface Infiltration, Constructed Filter, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should be continuously perforated, smooth interior, with a minimum inside diameter as required. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or M294, Type S (12 gauge aluminum or pipe may also be used in seepage pits).

Sand (Constructed Filter, Planter Boxes, Vegetated Swale)

Should be ASTM-C-33 (or AASHTO M-6) size (0.02” – 0.04”), concrete sand, clean, medium to fine sand.

Stone/Gravel (Constructed Filter, Planter Boxes):

Should be uniformly graded coarse aggregate, 1 inch to ½ inch with a wash loss of no more than 0.5%, AASHTO size number 5 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and have voids of 40% as measured by ASTM-C29.

Stone – 40% voids (Infiltration Trench, Porous Pavement, Subsurface Infiltration Bed,)

Infiltration trenches should have stone 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids 40% as measured by ASTM-C29.

Porous Pavement

General

Choker base course aggregate for beds shall be 3/8 inch to 3/4 inch clean, uniformly-graded, coarse, crushed aggregate AASHTO size number 57 per Table 4, AASHTO Specifications, Part I, 19th Ed., 1998 (p. 47).

Porous Asphalt

Bituminous surface course for porous paving shall be 2.5 to 3 inches thick with a bituminous mix of 5.75% to 6.75% by total weight as determined by testing below. Use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of PG 76-22P (in northern Michigan, use PG 76-28P as appropriate) as specified in AASHTO MP-1. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Determination of optimal asphalt content should be determined according the following tests:

- Draindown Test (ASTM Method D6390)
- Moisture Susceptibility Test using the Modifed Lottman Method (AASHTO T283) with the following:
  - Compact using 50 gyrations of Superpave gyratory compactor
  - Apply partial vacuum of 26 inches of Hg for 10 minutes to whatever saturation is achieved.
  - Keep specimens submerged in water during freeze cycle.
  - Required retained tensile strength (TSR) >= 80%
- Air Voids Test (AASHTO T269/ASTM D3203)

Hydrated lime, if required, shall meet the requirements of AASHTO M 303 Type 1 and shall be blended with the damp aggregate at a rate of 1.0% by weight of the total dry aggregate. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

Fibers, if used, shall consist of either cellulose fibers or mineral fibers which are to be treated with a cationic sizing agent to enhance dispersement of the fiber as well as increase cohesion of the fiber to the bitumen. Fiber is to be added at a dosage rate between 0.2% and 0.4% by weight of total mix.

- Mineral fibers shall be from virgin, basalt, diabase, or slag with a maximum average fiber length of 6.35 mm and a maximum average fiber thickness of 0.005 mm.
- Cellulose fiber – Fiber length shall be 6.4 mm (max), Ash Content 18% non-volatiles (±5%), pH 7.5 (± 1), Oil absorption (times fiber weight) 5.0 (± 1), Moisture Content 5.0 (max).

Porous Concrete

The use of Installers or Craftsmen who have been certified by the NRMCA's Pervious Concrete Contractor Certification Program is strongly recommended. Contractor shall furnish a proposed mix design with all applicable information to the Engineer prior to commencement of work. Critical mix characteristics typically include the following:

- Cement Content: 550 to 650 lb/cy
- Fine aggregate, if used: maximum 3 cu. ft. per cu. yd.
- Admixtures: use in accordance with the manufacturer's instructions and recommendations
- An aggregate/cement (A/C) ratio: 4:1 to 4.5:1
- Water/cement (W/C) ratio: 0.27 to 0.34
- Curing: shall begin within 15 minutes after placement and continue for 7 days

The data shall include unit weights determined in accordance with ASTM C29 paragraph 11, jigging procedure.

Cement: Portland Cement Type II or V conforming to ASTM C150 or Portland Cement Type IP or IS conforming to ASTM C595. The total cementitious material shall be between 550 and 650 lb./cy.

Aggregate: Use No 8 coarse aggregate (3/8 to No. 16) per ASTM C33 or No. 89 coarse aggregate (3/8 to No. 50) per ASTM D 448. If other gradation of aggregate is to be used, submit data on proposed material to owner for approval. The volume of aggregate per cu. yd. shall be equal to 27 cu.ft. when calculated as a function of the unit weight determined in accordance with ASTM C 29 jigging procedure. Fine aggregate, if used, should not exceed 3 cu. ft. and shall be included in the total aggregate volume.

Air Entraining Agent: Shall comply with ASTM C 260 and shall be used to improve workability and resistance to freeze/thaw cycles.

Admixtures: The following admixtures shall be used:

- Type D Water Reducing/Retarding – ASTM C 494.
- A hydration stabilizer that also meets the requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding admixtures may be used. This stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles from achieving initial set.

Water: Potable shall be used and shall comply with ASTM C1602. Mix water shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (Mix water yielding a cement paste with a dull-dry appearance has insufficient water for hydration).

- Insufficient water results in inconsistency in the mix and poor bond strength.
- High water content results in the paste sealing the void system primarily at the bottom and poor surface bond.

An aggregate/cement (A/C) ratio range of 4:1 to 4.5:1 and a water/cement (W/C) ratio range of 0.27 to 0.34 should produce pervious pavement of satisfactory properties in regard to permeability, load carrying capacity, and durability characteristics.

Vegetated roofs

Some key components and associated performance-related properties are as follows:

Root-barriers should be thermoplastic membranes with a thickness of at least 30 mils. Thermoplastic sheets can be bonded using hot-air fusion methods, rendering the seams safe from root penetration. Membranes that have been certified for use as root-barriers are recommended. At present only FLL offers a recognized test for root-barriers. Several FLL-certified materials are available in the United States. Interested American manufactures can submit products for testing to FLL-certified labs.

Granular drainage media should be a non-carbonate mineral aggregate conforming to the following specifications:

- Saturated Hydraulic Conductivity >= 25 in/min
- Total Organic Matter, by Wet Combustion (MSA) <= 1%
- Abrasion Resistance (ASTM-C131-96) <= 25% loss
- Soundness (ASTM-C88 or T103 or T103-91) <= 5% loss
- Porosity (ASTM-C29) >= 25%
- Alkalinity, CaCO3 equivalents (MSA) <= 1 %
- Grain-Size Distribution (ASTM-C136)
  - Pct. Passing US#18 sieve <= 1%
  - Pct. Passing ¼-inch sieve <= 30%
  - Pct. Passing 3/8-inch sieve >= 80%

Growth media should be a soil-like mixture containing not more than 15% organic content (wet combustion or loss on ignition methods). The appropriate grain-size distribution is essential for achieving the proper moisture content, permeability, nutrient management, and non-capillary porosity, and 'soil' structure. The grain-size guidelines vary for single and dual media vegetated cover assemblies.

Non-capillary Pore Space at Field Capacity, 0.333 bar (TMECC 03.01, A)	>= 15% (vol)
Moisture Content at Field Capacity (TMECC 03.01, A)	>= 12% (vol)
Maximum Media Water Retention (FLL)	>= 30% (vol)
Alkalinity, Ca CO3 equivalents (MSA)	<= 2.5%
Total Organic Matter by Wet Combustion (MSA)	3-15% (dry wt.)
pH (RCSTP)	6.5-8.0
Soluble Salts (DTPA saturated media extraction)"(RCSTP)	<= 6 mmhos/cm
Cation exchange capacity (MSA)	>= 10 meq/100g
Saturated Hydraulic Conductivity for Single Media Assemblies (FLL)	>= 0.05 in/min
Saturated Hydraulic Conductivity for Dual Media Assemblies (FLL)	>= 0.30 in/min

Grain-size Distribution of the Mineral Fraction (ASTM-D422)

Single Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	<= 5%
Pct. Passing US#60 sieve	<= 10%
Pct. Passing US#18 sieve	5 - 50%
Pct. Passing 1/8-inch sieve	0 - 70%
Pct. Passing 3/8-inch sieve	75 -100%

Dual Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	5-15%
Pct. Passing US#60 sieve	10-25%
Pct. Passing US#18 sieve	20 - 50%
Pct. Passing 1/8-inch sieve	55 - 95%
Pct. Passing 3/8-inch sieve	90 -100%

Macro- and micro-nutrients shall be incorporated in the formulation in initial proportions suitable for support the specified planting.

Separation fabric should be readily penetrated by roots, but provide a durable separation between the drainage and growth media layers (Only lightweight nonwoven geotextiles are recommended for this function.

- Unit Weight (ASTM-D3776) <= 4.25 oz/yd2
- Grab tensile (ASTM-D4632) <= 90 lb
- Mullen Burst Strength (ASTM-D4632) >= 135 lb/in
- Permittivity (ASTM-D4491) >= 2 per second

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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Golder Associates

CITY OF MUSKEGON/MART DOCK EAST OPERATIONS & MANAGEMENT PLAN

Stormwater Management

Low Impact Developments / Green Infrastructure

Landowner - Muskegon County
990 Terrace St.
Muskegon, MI 49440

Landowner – West Michigan Dock & Market Corp.
560 Mart St.
Muskegon, MI 49440

Submitted To: West Michigan Shoreline Regional Development Commission
316 Morris Avenue
Suite 340
Muskegon, Michigan 49440

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Distribution: One electronic copy

March 7, 2017

Project No.1520593

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Golder Associates

EXECUTIVE SUMMARY

The Operations and Management (O&M) Plan summarizes the best management practices (BMPs) and low impact development (LID) designs implemented at City of Muskegon/Mart Dock East for improving stormwater management. The details of each BMP for City of Muskegon/Mart Dock East can be seen in the Conceptual Plan (Appendix A). Each structural BMP requires maintenance for continued efficiency and is summarized within the plan. Included in the appendices of the report is a maintenance summary for each BMP (Appendix B, C, and D), and example checklists to be used for routine inspections (Appendix E). The plan provides guidance regarding management of vegetation, a list of recommended Michigan species (Appendix F), and recommended materials (Appendix G). Operations and maintenance costs were analyzed for each development and maintaining the site.

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1.0 CITY OF MUSKEGON/MART DOCK EAST

City of Muskegon/Mart Dock East is located in Muskegon, Michigan within the Muskegon Lake Direct Drainage Watershed. The site is city and privately owned and located within a half mile of Muskegon Lake. The watershed receives stormwater from heavily urbanized areas and the city's storm sewer system. The polluted stormwater discharged to the watershed has resulted in degraded benthic communities, organic chemicals, excessive sediment, and/or flashy hydrology.

With grant support from the Michigan Department of Environmental Quality and the US Environmental Protection Agency, the Muskegon Lake Watershed Partnership, West Michigan Shoreline Regional Development Commission, municipal partners and Golder Associates Inc. recommended design solutions to reduce stormwater runoff, stormwater pollutants, and improve water quality within City of Muskegon/Mart Dock East and the Lake Direct Drainage Watershed. Stormwater LID designs recommended for the site included seven rain gardens, four bioswales, and six bioretention islands.

2.0 MAINTENANCE COSTS

Stormwater LID designs tend to be less expensive to implement than conventional designs, however they do require long term maintenance to ensure the designs continue to work efficiently. A cost analysis was completed for the City of Muskegon/Mart Dock East maintenance costs at annual and long term rates. Three types of structural BMPs were assessed including rain gardens, bioswales, and bioretention islands. The total annual cost for maintaining the BMPs at City of Muskegon/Mart Dock East was estimated at $6,180. Break down of each BMP is summarized in Table 1 and explained further in the following sections. Annual maintenance costs were based on taking a percentage of the total construction costs, based on a low impact development cost comparison completed by Emmons & Oliver Resources, Inc. (EORINC 2015). Rain gardens were estimated to require approximately 5% to 6% of construction costs for routine and non-routine maintenance. The estimated maintenance costs include aesthetic maintenance and functional maintenance. Functional maintenance assures the BMP is performing efficiently and safely, while aesthetic maintenance is mainly for public acceptance, which can help to reduce functional costs. The percentage of construction cost used for each BMP reflects labor, landscaping, and material costs. A typical year of landscaping includes maintenance such as lawn mowing, removal of debris and litter, replanting or seeding vegetation, and replenishing mulch. Maintenance labor is expected to be greater within the first two to three years as vegetation is established.

Table 1. Operation and Maintenance Costs Summary

Stormwater BMP	Construction Cost ($)	Annual Maintenance Cost (% of Construction Cost)	Annual Maintenance Cost ($)
Rain Garden (without underdrain)	19,425	5	971
Bioswale	52,950	6	2,648
Bioretention Islands	51,220	5	2,561
Total Costs			**6,180**

2.1 Rain Garden

The City of Muskegon/Mart Dock East conceptual stormwater development plan includes seven rain gardens encompassing approximately 1,400 square feet. The rain gardens consist of a geotextile filter layer, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Regular maintenance of the rain gardens is required within the first two to three years when vegetation is becoming established. Less maintenance is required after vegetation becomes established and fills empty spaces between plants. Maintenance requirements for the rain gardens can be viewed in Appendix B. A summary of maintenance cost for the rain gardens is provided in Table 1. The annual operations and maintenance costs for the rain gardens were calculated as 5% of the construction costs. The annual cost to maintain the two rain gardens is $971.

2.2 Bioswale

There is one bioswale implemented in the City of Muskegon/Mart Dock East stormwater management plan. The bioswale covers about 3,920 square feet, and approximately eight feet wide and totaling 490 linear feet. Bioswales consist of a geotextile filter, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Similar to the rain gardens, the bioswales will be planted with native species and require more maintenance within the first two to three years while vegetation is being established. Routine maintenance items for the bioswales are summarized in Appendix C. The annual maintenance cost of the bioswales was calculated from 6% of the construction cost, totaling $2,648.

2.3 Bioretention Island

Bioretention islands require similar maintenance to rain gardens and bioswales. Bioretention islands are designed with geotextile filter fabric, 18 inches of compacted stone, 18 inches of engineering soil, and two inches of mulch. There are six bioretention islands located within City of Muskegon/Mart Dock East covering approximately 1,200 square feet. Vegetation in the bioretention islands will consist of one tree or plug. The

maintenance required for the bioretention islands are summarized in Appendix D. The annual maintenance cost for the bioretention islands was calculated as 5% of the construction costs, equivalent to $2,561, shown in Table 1.

3.0 ROUTINE INSPECTIONS

Routine inspections of BMPs should be completed at least once every year. Example inspection checklists are included in Appendix E. Inspection checklists vary depending on the type of LID design. The stormwater designs in City of Muskegon/Mart Dock East include underdrain and overflow systems within two bioretention islands, so such items on the checklist are only applicable to these two systems. The underdrains and overflow systems will require additional maintenance to ensure there are no blockages or damages at inlets/outlets, and no damages to piping. The example bioretention inspection checklist can be used for inspection of the rain gardens and the bioretention islands. Rain gardens, bioswales, and the bioretention islands should be inspected for debris, erosion, vegetation conditions and coverage, and mulch thickness to determine overall functionality. Based on the selection of native plants used for each BMP, additional species specific inspections may be required. Inspections of vegetation should include determining the overall plant health, checking if plants require trimming or pruning, and assuring invasive species are properly managed.

4.0 VEGETATION

The plant species selected for the BMPs have a significant impact on the effectiveness of the design. Vegetation will require regular maintenance within the first few years while becoming established. Maintenance involves watering plants as needed, and removing invasive species. Once vegetation is established, less maintenance will be required to maintain the BMP areas.

4.1 Native Species

Native plants are implemented in the design because they have deeper and more expansive roots leading to increased infiltration, groundwater recharge and biofiltration. Native plants are also more tolerant to flooding and drought conditions enabling them to thrive in rain gardens, bioswales, and biofiltration islands. Plugs and gallons are common sizes of native plants that can be installed in BMPs. A plug is a small plant that grows in a container roughly two inches wide and five inches deep. A gallon is a more mature plant available in a gallon size container. Both sizes of plants require consistent watering during early development (Delta Institute 2015). Suggested species may include: cardinal flower (*Lobelia cardinalis*), blue lobelia (*Lobelia siphilitica*), New England aster (*Aster novae-angliae*), and brown fox sedge (*Carex vulpinoidea*). A full list of recommended Michigan plants for BMPs is included in Appendix F (SEMCOG 2008). Additional grasses and wildflowers that could tolerate wet growing conditions recommended by the West Michigan Environmental Action Council include: cotton grass (*Eriophorum angustifolium*), golden alexanders (*Zizia aurea*), and blue flag iris (*Iris versicolor*) (WMEAC 2016).

4.1.1 Planting Requirements

Maintenance will be required for any plants that do not successfully grow in the planted environment, and an alternative species may need to be planted. Seeding is not the preferred method of planting vegetation since high velocity flows can prevent the plant from establishing. Plugs or gallon-potted plants installed at one to two foot intervals are recommended for effective establishment of vegetation. Trees and shrubs are also recommended. Seeding should be completed from late April to mid-October if irrigation is available. If irrigation is not available, than seeding can be completed from June 15 or mid-August to mid-October. With dormant seeding, seeding can be completed from November 1 to 30. At all other times of the year, seeding should have a temporary cover (made of oats/cereal rye or other small grain). Plugs and gallons should be installed from May 1 – June 15. Trees and shrubs should be planted from the middle of April through early June, or the middle of September through the middle of November. A maximum of two to three inches of mulch should be evenly spread in the BMPs after installing new plants to help prevent erosion, remove metals, and act as leaf litter in a natural forest environment. The mulch should not be placed directly against the stems of the newly planted vegetation. If wildlife is a threat to newly installed plants additional precautions such as waterfowl barriers are maintenance options.

4.2 Invasive Non-Native Species

Invasive species are not native to the area and tend to grow and spread quickly without natural controls. If unmanaged, invasive species will displace native species (SEMCOG 2008). Maintenance of invasive species is crucial when native plants are being established and require room to grow. Invasive species can be removed by hand–pulling, mowing, or spot herbicide applications. After native species are established, less maintenance of invasive species is needed. Long term management of invasive species may require removal once every year or as needed. Open areas may require mowing if woody vegetation is noticed encroaching, typically every three to five years.

5.0 WINTER CONDITIONS

Winter conditions in Michigan typically include the buildup of snow and the use of de-icing compounds which can negatively affect plant life. Salt tolerant plants are recommended for sites where de-icing and heavy snow occurs. Recommended products for de-icing are nontoxic and organic, such as magnesium chloride-based liquid products or pretreated salt (Delta Institute 2008). Sand and cinder from melted snow also the potential of reducing infiltration into the soil. Preventative measures should be taken to avoid the buildup or piling of snow over infiltration systems.

In the spring, the rain gardens, bioswales, and bioretention islands should all be assessed for winter damages. Buildup of debris and sediment should be cleared, and mulch should be evenly spread in any eroded areas. Plants may also require trimming or rehabilitation. Soil aeriation may also be required in spring to reduce impacts of de-icing agents.

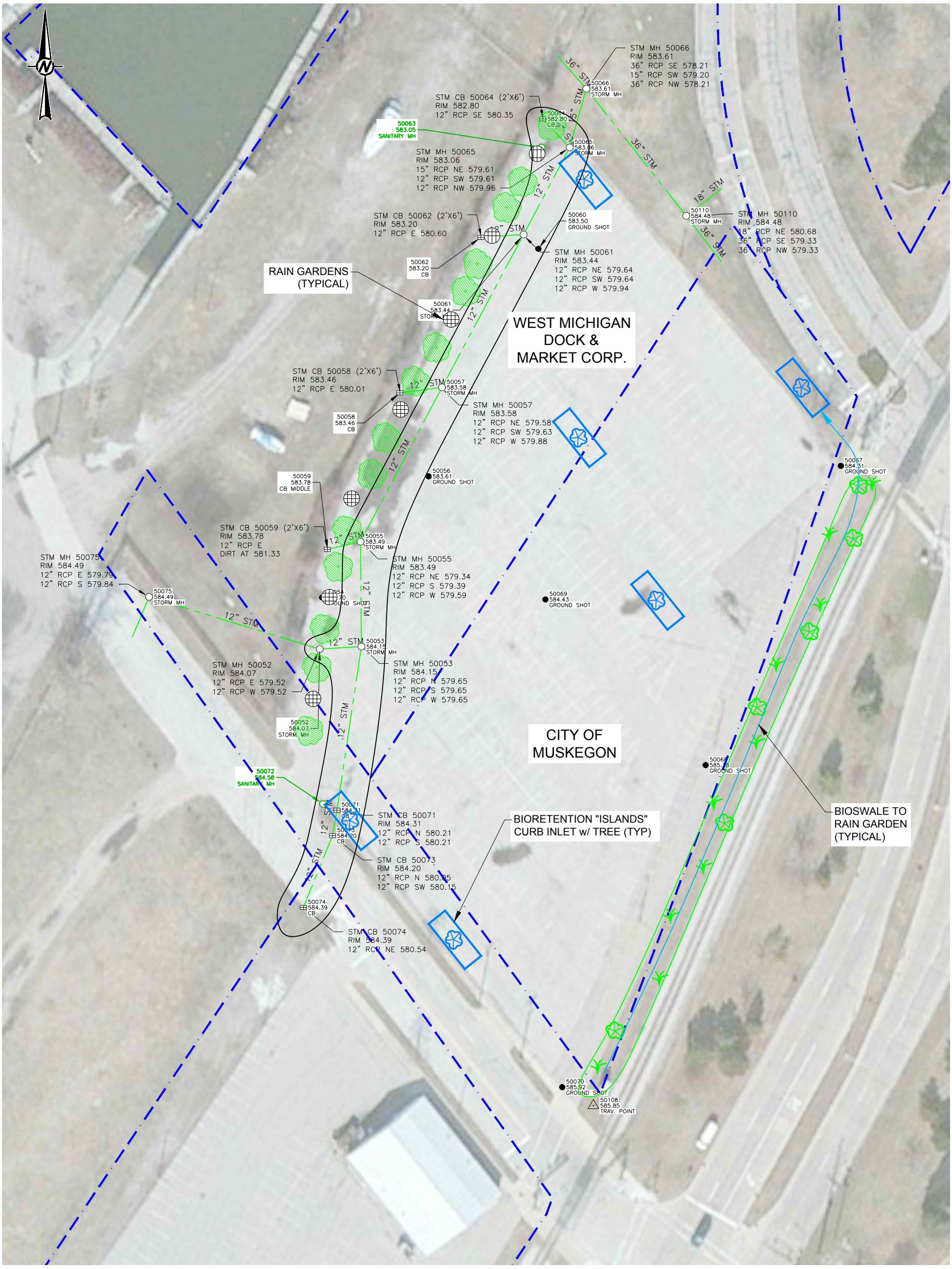
6.0 EDUCATION AND TRAINING

All personnel responsible for the operations and maintenance of the BMPs should undergo training to fully understand the care required for each LID design. Training should include reading the O&M plan and discussing procedures with someone of experience. An educated maintenance staff will increase the efficiency and sustainability of the designs.

7.0 REFERENCES

1. Delta Institute and Guidon Design. 2015. Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
2. Emmons & Oliver Resources, Inc. 2015. Minnesota Low Impact Development A comparison, Cost Comparision. A Case Study Comparison of Costs, Water quality and quanity benefits and quality of life. http://www.eorinc.com/pdf/development-maintenance-cost.pdf
3. SEMCOG. 2008. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html
4. West Michigan Environmental Action Council. 2016. Rain Gardens of West Michigan. Michigan Native Plants List For Use in Rain Gardens and Landscaped Bioretention Areas. http://www.westmichiganglsi.org/uploads/6/7/9/8/6798898/rain_gardens_native_plant_list.pdf

Appendix A
City of Muskegon/Mart Dock East Conceptual Plan



LEGEND

PARCEL BOUNDARY

CLOSED LUST (PART 213)

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 30 60
1" = 60' FEET

NOTE(S)

1. THE MART DOCK SITE IS APPROXIMATELY 46.4 ACRES PARCEL AREA AND 9.1 ACRES WATERSHED TREATMENT AREA.
2. THE MART DOCK SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
CITY OF MUSKEGON / MART DOCK EAST

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
1 in
0

Appendix B
Rain Garden Maintenance Items

RAIN GARDEN

1.0 PUROPOSE

Rain gardens are used to collect stormwater runoff and encourage infiltration and biofiltration with the use of native plants. Native plants are ideal for rain gardens because they have deeper root networks that draw surface water further into the ground. Native plants are also typically drought and flood tolerant and able to thrive in rain gardens. Rain gardens aide in reducing runoff volume, filtering pollutants, recharging groundwater (if no underdrain is used), reducing stormwater temperature impacts, and enhancing site aesthetics.

2.0 MAINTENANCE

Rain gardens require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered and weeded twice weekly through October of the first year and in times of extreme drought. Weeds should be removed by hand.

3.) Organic matter may also need to be removed approximately twice per year, usually by hand.

4.) Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

5.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

6.) Annual mowing should be performed for the first three years of establishment. Mowing should not be completed on a regular basis.

7.) Removal of debris must occur monthly for the life of the rain garden.

8.) Winter conditions may result in plants being effected by deicing chemicals in snow-melt, in this case salt-tolerant plants should be used. Also try to reduce the amount of sand, cinders, and other winter abrasives that come in contact with the vegetation. Additional maintenance in the spring is required to remove abrasives if used.

9.) Rain gardens should be inspected at least twice a year for sediment buildup, erosion, and overall vegetation conditions. If sediment build up reaches 25% of the ponding depth it should be removed. If erosion is occurring, soil stabilization efforts should be applied. If vegetation is in poor health for no apparent reason, a landscape architect should be consulted.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix C
Bioswale Maintenance Items

BIOSWALE

1.0 PUROPOSE

Bioswales are shallow, vegetated, earthen channels that help to slow, filter, and infiltrate stormwater runoff in the process of conveyance. Native plants are ideal vegetation for bioswales due to their deep roots for infiltrating runoff, and their high tolerance for droughts and floods.

2.0 MAINTENANCE

Bioswales require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Vegetation should be established as soon as possible to prevent erosion and scour. Freshly seeded swales require soil stabilization such as erosion control matting or blankets. Erosion controls for seeded swales are required after planting for 75 days after the first storm event occurs. If runoff velocities are high, sodding the swale or diverting runoff until vegetation is well established is an option.

4.) Debris removal, weeding, and pruning should be performed on a monthly basis.

5.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity issues are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

6.) Mow and trim plants within the bioswales annually to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Mow only when dry to avoid rutting. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

7.) In the spring the bioswales will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

8.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

9.) If roadside or parking lot runoff is directed to the swale, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix D
Bioretention Island Maintenance Items

BIORETENTION ISLAND

1.0 PUROPOSE

A Bioretention islands or stormwater planters are a linear infiltration basin typically located in a parking lot or between a street and sidewalk surrounded by vertical curbing. Stormwater is collected from the street, sidewalk, or parking lot and directed into the bioretention island through openings in the curb. Bioretention islands consist of native plants in engineered soil which lay on top of a layer of stone. The stormwater planters are able to reduce, filter, and infiltrate stormwater runoff and aide in recharging groundwater.

2.0 MAINTENANCE

Bioretention islands require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes mature and capable of choking out invasive species, less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Debris removal, weeding, and pruning should be performed on a monthly basis.

4.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

5.) Annually trim plants to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

6.) In the spring the bioretention islands will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

7.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

8.) If roadside or parking lot runoff is directed to the bioretention island, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix E
Example Inspection Checklists

Maintenance Inspection Checklists

This appendix contains four checklists available as guides for maintenance inspections of specific BMPs. The maintenance items have been adapted from multiple stormwater programs, including the Rouge River Detention Basin Maintenance Manual, Georgia Stormwater Management Manual, the Vermont Stormwater Management Manual, and the Stormwater Manager's Resource Center.

The checklists are designed to help identify key components of BMPs that require ongoing maintenance as well as a basic schedule of when the maintenance should occur. The checklists have been divided into those items essential for the general operation and functionality of the BMP and those items that optional and may enhance the BMP.

It is suggested that the inspection be undertaken by a licensed PE and/or a person knowledgeable about the design and function of the BMP.

These BMP checklists include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

Detention BMP Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet Pipes			
Structural integrity of inlet/outlet (Are any inlet pipes broken, crumbling, separated?) List Inlet Pipes Approximate Diameter and Type of Material Inlet Pipe 1 _____ Inlet Pipe 2 _____ Inlet Pipe 3 _____ Outlet Pipe Size/Type _____		A	
Riprap at inlet pipe (Is the riprap still present? Is it visible and not covered with sediment?		A	
Stone around outlet pipe (Is the stone clogged with debris and/or sediment?)		A	
Trash or debris blocking inlet/outlet (Inspect to ensure no major obstructions hindering general functionality)		M	
Inspect/clean catch basin upstream of the BMP if accessible.		A	
Inspect inlets and outlet for erosion (Are there eroded areas around the pipes?)		A	
Inspect overflow spillway for signs of erosion.			
Pretreatment (if applicable) (Might include sediment forebay, upstream catch basin, bioswale, rain garden, swirl concentrator)			
Device functioning to trap/collect sediment		A	
Remove accumulated sediment as appropriate for the pretreatment device. forebay		A	
Detention Pond		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inspect side slopes, berms and emergency overflow for erosion		A	
Reestablish permanent native vegetation on eroded slopes		As needed	
Inspect for excess sediment accumulation in pond if not pretreatment device is present		A	
Overall functionality			
Ensure pond is functioning properly (Professional Civil Engineer is recommended)		A	
Ensure the outlet is functioning properly (Professional Civil Engineer is recommended)		A	
Optional/Enhancements			
Maintain 15-20 feet “no mow and chemical free” zone		A	
Mow (or burn) the “no mow” zone		A	
Inspect basin and “no mow” zone for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation in and around pond.		A	
Complaints from residents (note on back)		S	
Encroachment on pond/no- mow zone.		A	
Unauthorized plantings		A	
Aesthetics (e.g., graffiti, unkept maintenance)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Summary

Inspector’s remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Infiltration BMPs Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		A	
Pretreatment for sediment			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure infiltration device is functioning properly (professional civil engineer is recommended)		A	
BMP infiltration surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		S	
Evidence of erosion present		A	
Aggregate (if applicable)			
Surface of aggregate clean		A	
Any replacement of aggregate needed? If clogged with sediment replacement is necessary for continued proper function.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Vegetated surface (if applicable)			
Vegetative cover exists		A	
Optional considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation or creating a native plant infiltration basin area.		A	
Complaints from residents (note on back)		A	
Mowing done when necessary		A	
No fertilizer unless testing requires it		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioretention Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway or catch basin clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		Every 5 years	
Pretreatment for sediment (Generally consists of catch basin or velocity dissapator at inlet such as area of riprap/ collection for sediment)			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure bioretention area is functioning properly (professional civil engineer is recommended)		A	
Bioretention area surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		M	
Evidence of erosion present		A	
Does good vegetative cover exist		A	
Mulch covers entire area (no voids) and to specified thickness		A	
Optional considerations			
Inspect BMP for invasive species.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioswale, Filter Strip Inspection Checklist

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Pretreatment/ Energy Dissipators			
No evidence of flow going around structures		A	
No evidence of erosion		A	
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
BMP surface			
Area free of debris?		M	
No evidence of erosion		A	
Does sediment accumulation currently require removal?		A	
Overall functionality			

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Ensure swale is functioning properly (professional civil engineer is recommended)		A	
Optional Considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Appendix F
List of Michigan Recommended Plants

Recommended Plant Lists for Best Management Practices

This appendix contains recommended native and non-native (when appropriate) plant species for the Best Management Practices detailed throughout the manual. Species have been recommended based on hardiness, aesthetics, functionality, and commercial availability. It is certain that species exist outside the confines of this list that will perform in a comparable way to those listed; however, commercial availability is often a limiting factor in obtaining material for native plantings. Over time, and in certain locales, additional species will become available to supplement those listed below.

An array of planting zones is provided based on normal water levels (Figure C.1). Using these zones will provide the best chances for long-term success of native planting in the context of LID. While plants may naturally occur outside of the given ranges, these ranges are intended to be guidelines for plant installation. Whenever possible and practical in standing water conditions, native plants should be installed in live plant form (rather than seed). Seed or a combination of seed and live plants may be used in upland situations.

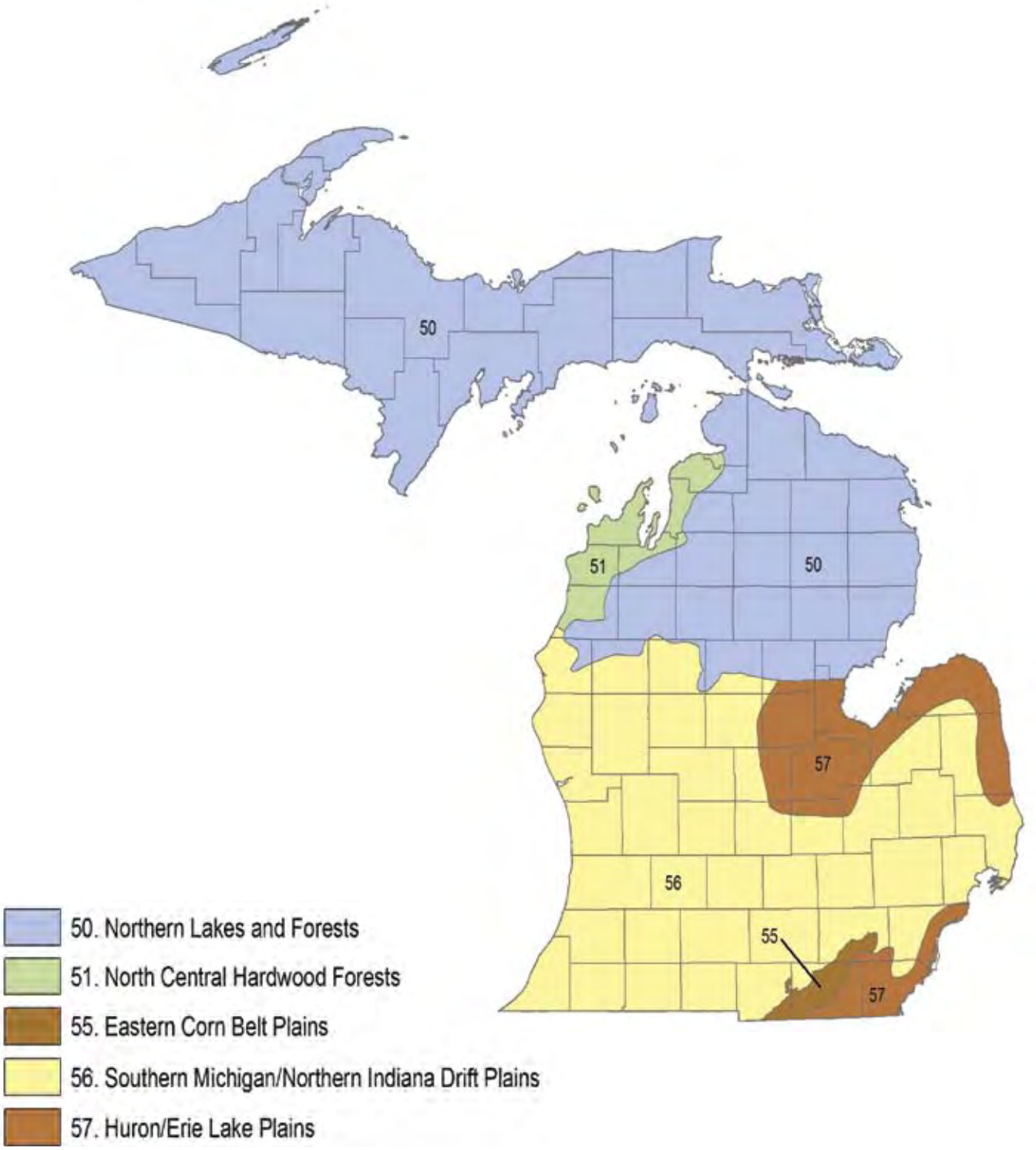
Recommendations are given for height, bloom color, bloom time, sun requirements, salt tolerance, and ecoregion. Please note that these are recommendations based on a range of situations, and a specific plant or population may vary from site-to-site. For sun requirements, F = Full sun required, P = Partial sun tolerated, and S = Shade tolerated. Salt tolerance is classified as Yes (Y) or No (N). This was determined through literature reviews and anecdotal evidence. If there is no information confirming tolerance, a "No" was listed.

Figure C.1
Planting Zone/BMP Matrix

	Zone A — 2"-4" Below Water Level	Zone B — 0"-2" Below Water Level	Zone C — 0"-2" Above Water Level	Zone D — 2"-4" Above Water Level	Zone E — 4"-18" Above Water Level	Zone F — 18"+ Above Water Level	Zone G — Planter Boxes	Zone H — Vegetated Roofs
Rain gardens/Bioretention	✤	✤	✤	✤	✤	✤		
Vegetated Filter Strips			✤	✤	✤	✤		
Vegetated Swales		✤	✤	✤				
Infiltration Basin		✤	✤					
Subsurface Infiltration Basins				✤	✤	✤		
Infiltration Trenches				✤	✤	✤		
Infiltration Berns	✤	✤	✤	✤	✤	✤		
Planter Boxes							✤	
Vegetated Roofs								✤
Constructed Wetlands	✤	✤	✤	✤				
Wet Ponds	✤	✤	✤					
Dry Extended Detention Basins			✤	✤	✤	✤		
Riparian Corridor Restoration			✤	✤				
Native Revegetation	✤	✤	✤	✤	✤	✤	✤	✤

Ecoregion recommendations are also provided for each species (Figure C.2). Whenever possible, the designer/ installer should seek to use species that historically occurred in the same ecoregion as the project. When necessary, species occurring in an adjacent ecoregion may be used.

Figure C.2
EPA Level III Ecoregions for Michigan



Source: USEPA

Plant Installation

Native Seeding

Seasonal consideration: October 1-June 15 (note: seeds should not be planted on frozen ground).

Native seeding is generally recommended for areas above the water line or 1-2" below the water line. Live plant material should be used to establish vegetation at deeper water levels.

Broadcast seeding

Broadcast seeding is preferred over drill seeding on graded, bare soil sites. Apply the seed uniformly over the surface using a combination seeder/cultipacker unit such as a Brillion or Truax Trillion seeder. The Trillion seeder is preferred as it is designed to handle native seeds.

A cone seeder or other similar broadcasting equipment may also be used if the seed mix does not contain fluffy seeds in amounts sufficient to prevent free flowing without plugging. Seed should then be pressed into the surface using a cultipacker or roller.

Drill seeding

A rangeland-type no-till drill designed to plant native grasses and forbs may be used in bare soils although this equipment is specifically designed to plant through existing vegetation which is killed with an herbicide. Cultipacking or rolling before seeding may be required to prevent seed placement depths exceeding .25 inch, but cultipacking or rolling after seeding is not required.

All seeding equipment, whether broadcast or drill, should be calibrated to deliver the seed at the rates and proportions specified in the plans. Equipment should be operated to ensure complete coverage of the entire area to be seeded, and seed must be placed no deeper than .25 inch in the soil. No fertilizers or soil conditioners will be required or allowed.

Native Planting

Seasonal considerations: May 1-July 1

Plant plugs should be installed in holes drilled with an auger the same diameter and depth as the plug within +0.75 inch/- 0.25 inch. In wetland plantings where soil is soft and moist enough, a dibble bar or trowel may also be used. The planting layout should consider the requirements of the individual species regarding soil type, moisture, slope, shading, and other factors for the particular plant species.

Planting densities vary according to budget and project goals and can range from three-to-five foot spacing for plug supplements of seeded areas to six inches to two foot spacing for high visibility landscaping projects with large budgets. Groups of five-to-seven plugs of the same species planted approximately one foot apart is usually preferable to planting all species intermixed randomly across the site at a uniform density.

In wetland or shoreline areas with potential for high wave action or wildlife predation that may dislodge newly planted plugs, plugs should be secured with six inch or eight inch U-shaped wire erosion control blanket staples. Staple length is determined by the density of the planting substrate; softer substrates require longer length to hold plugs adequately.

In areas where potential for wildlife predation exists, such as retention basins or other planting areas adjacent to open water, waterfowl barriers should be installed around a minimum of 50 percent of the plugs. All plugs not protected by barriers should be stapled into the substrate as described above. Barriers may consist of plastic or wire mesh enclosures supported with wooden stakes, adequately constructed to inhibit access by waterfowl for one growing season. Enclosures should extend at least two feet above the plant tops. Methodology should be approved by the project designer with input from a restoration ecologist if necessary. Barriers may be removed after one growing season.

Maintenance and Management

Maintaining vegetated BMPs is typically most important during the first few years following installation. Supplemental irrigation may be needed to help establish plants in drought conditions. Plants may need to be replaced due to predation or other unseen factors. Most commonly, management includes removing invasive species via mowing, hand-pulling, or spot herbicide applications. In larger areas, broadcast herbicide applications may be appropriate. Over time in upland areas, controlled burning may be used as a way to invigorate the plantings and control certain invasive species. If not feasible for social or cultural reasons, an annual or biennial mowing may be used instead of fire.

Long-term management may be necessary, but is typically significantly less intensive. The site should be periodically checked for invasive species infestations. Any prairie or open area may need occasional (every three to five years) burning or mowing to remove woody vegetation that may encroach.

Zone A

Planting Zone = two-to-four inches below water level

These species require continual inundation within the given water depths in order to thrive. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for a majority of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57

Representative Zone A Species

Buttonbush

Pickerel Weed

Swamp Milkweed

Arrowhead

Blue Flag Iris

Source: JFNew

Zone B

Planting Zone = zero-to-two inches below water level

These species tolerate fluctuating water levels within this range. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for most of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-Jun	F	N	50,51,55,56,57
Carex lacustris	Lake sedge	2’-4’	Brown	May-Jun	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Alisma plantago-aquatica	Water plantain	2’-4’	White	Jul-Sep	F	N	50,51,55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard’s tail	2’-4’	White	Jun-Aug	P/S	N	55,56,57

Representative Zone B Species

Blue Flag Iris

Arrowhead

Bristly Sedge

Pickerel Weed

Swamp Milkweed

Source: JFNew

Zone C

Planting Zone = zero-to-two inches above water level

These plants are tolerant of fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Alnus rugosa	Speckled alder	25’	Brown	Mar-May	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Cephalanthus occidentalis	Buttonbush	15’	White	Jun/Aug	F/P/S	N	51,55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	Y	55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Grasses/Sedges/Rushes:							
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Forbs:							
Alisma plantago-aquatica	Water plantain	2'-4'	White	Jul-Sep	F	N	50,51,55,56,57
Anemone canadensis	Canada anemone	1'-2'	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6'-9'	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3'-5'	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3'-6'	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3'-6'	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1'-4'	White	Jul-Oct	F/P	N	50,51,55,56,57
Cassia hebecarpa	Wild senna	3'-5'	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2'-4'	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Eupatorium maculatum	Spotted Joe-pye weed	4'-7'	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3'-5'	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1'-3'	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3'-5'	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5'-12'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2'-3'	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3'-5'	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3'-8'	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2'-5'	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1'-4'	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1'-3'	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2'-4'	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2'-5'	Pink	Aug-Oct	F	Y	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1'-3'	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3'-10'	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Sagittaria latifolila	Arrowhead	1'-4'	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard's tail	2'-4'	White	Jun-Aug	P/S	N	55,56,57
Sisyrinchium angustifolium	Stout blue-eyed grass	1'	Blue	May-Aug	F/P	N	55,56,57
Solidago ohiensis	Ohio goldenrod	2'-3'	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3'-6'	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell's goldenrod	2'-5'	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3'-6'	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2'-5'	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3'-6'	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3'-6'	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3'-5'	Purple	Jul-Sep	F	N	55,56,57
Zizia aurea	Golden Alexanders	1'-3'	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone C Species

Cardinal Flower

Swamp Milkweed

Blue-Eyed Grass

Obedient Plant

Joe-Pye Weed

Path Rush

Red-Osier Dogwood

Monkey Flower

Source: JFNew

Zone D

Planting Zone = two-to-four inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Viburnum trilobum	Cranberry Viburnum	10’	White	Apr-May	F/P/S	N	50,51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Panicum virgatum	Switch grass	3‘-5’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Forbs:							
Anemone canadensis	Canada anemone	1’-2’	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6’-9’	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3’-6’	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1’-4’	White	Jul-Oct	F/P	N	50,51,55,56,57
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2’-4’	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	51,55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium maculatum	Spotted Joe-pye weed	4’-7’	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3’-5’	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1’-3’	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3’-5’	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3’-8’	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2’-5’	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1’-4’	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1’-3’	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2’-4’	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3’-10’	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2‘-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago ohiensis	Ohio goldenrod	2’-3’	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3’-6’	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell’s goldenrod	2’-5’	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3’-6’	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2’-5’	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3’-6’	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3’-6’	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57
Veronicastrum virginicum	Culver’s root	3’-6’	White	Jun-Aug	F/P	N	55,56,57
Zizia aurea	Golden Alexanders	1’-3’	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone D Species

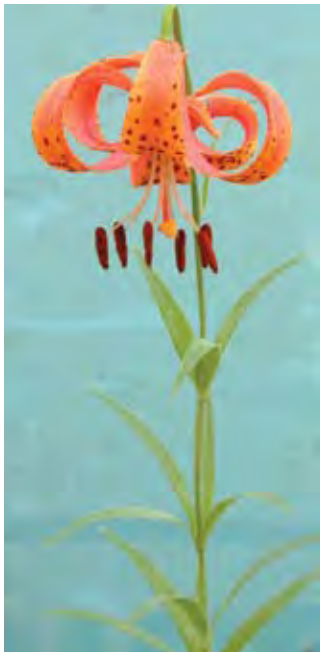
Big Bluestem

Marsh Blazing Star

Wild Columbine

Great Blue Lobelia

Virginia Mountain Mint



Michigan Lily

Meadowsweet

Blue Vervain

Source: JFNew

Zone E

Planting Zone = four-to-18 inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100’	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	N
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80’	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1’-3’	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus florida	Flowering dogwood	30’	White	May-Jun	F/P/S	N	55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85’	White	Jun	F/P	N	55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Pinus banksiana	Jack pine	60’	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100’	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100’	Brown	Jun	F/P/S	N	50,51,55,56,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Prunus americana	American plum	30’	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30’	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7’	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1’-2’	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1’-3’	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1’-2’	Purple	Aug-Oct	F	N	51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Panicum virgatum	Switch grass	3’-6’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2’-4’	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4’-9’	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Stipa spartea	Porcupine grass	2’-4’	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1’-2’	Lavender	Jun-Oct	F/P	N	55,56
Aquilegia canadensis	Wild columbine	1’-3’	Red/ Yellow	Apr-Jun	F/P/S	Y	50,51,55,56,57
Asclepias syriaca	Common milkweed	2’-4’	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1’-3’	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1’-2’	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2’-4’	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3’-5’	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster lateriflorus	Calico aster	1’-3’	White	Jul-Oct	F/P/S	N	50,51,55,56,57
Aster macrophyllus	Big-leaved aster	6”-2’	Lav/ White	Jul-Oct	P/S	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1’-4’	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short’s aster	1’-4’	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Campanula americana	Tall bellflower	2’-6’	Blue	Jul-Nov	P/S	N	55,56,57
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Clematis virginiana	Virgin’s bower	9’ long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2’-5’	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3’-6’	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2’-4’	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1’-2’	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2’-6’	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
elianthus pauciflorus	Prairie sunflower	3’-5’	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2’-4’	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2’-3’	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P/S	N	55,56,57
Liatris scariosa	Savanna blazing star	3’-5’	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2’-4’	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1’-2’	Purple	May-Jul	F/P	N	55,56,57
Phlox divaricata	Wild blue phlox	1’-2’	Blue	Apr-Jun	P/S	N	51,55,56,57
Phlox pilosa	Sand prairie phlox	1’-2’	Pink	May-Aug	F/P	N	56
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1’-3’	White	May-Jul	P/S	N	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Ratibida pinnata	Yellow coneflower	3’-6’	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1’-3’	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2’-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Silphium terebinthinaceum	Prairie-dock	3’-8’	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solo-mon’s seal	1’-3’	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon’s seal	1’-2’	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago juncea	Early goldenrod	2’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1’-3’	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Thalictrum dioicum	Early meadow-rue	1’-3’	Green	Apr-May	P/S	N	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2’-4’	Blue	May-Oct	F/P	N	55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57

Representative Zone E Species

New England Aster

Wild Bergamot

Showy Goldenrod

Tall Bellflower

Wild Geranium

Tall Coreopsis

Redbud

Indian Grass

Source: JFNew

Zone F

Planting Zone = 18+inches above water level

These plants tolerate fluctuating water levels within this range, although they are generally less tolerant than most wetter species. They may tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for upland BMP settings.

Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90'	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100'	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100'	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70'	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80'	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1'-3'	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60'	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25'	Red	Apr-May	F/P/S	N	55,56,57
Cornus florida	Flowering dogwood	30'	White	May-Jun	F/P/S	N	55,56,57
Corylus americana	American hazelnut	10'	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85'	White	Jun	F/P	N	55,56,57
Hamamelis virginiana	Witch hazel	30'	Yellow	Oct-Nov	F/P/S	N	50,51,55,56,57
Juglans nigra	Black walnut	90'	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50'	Brown	Apr-May	F/P	N	55,56,57
Liriodendron tulipifera	Tulip tree	110'	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50'	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100'	Green	May-Jul	F/P/S	Y	51,55,56,57
Pinus banksiana	Jack pine	60'	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100'	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100'	Brown	Jun	F/P/S	N	50,51,55,56,57
Prunus americana	American plum	30'	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30'	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus macrocarpa	Bur oak	85'	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90'	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90'	Green	May-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3'	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100'	Yellow	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100'	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7'	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10'	White	May-Jun	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4'-8'	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1'-2'	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1'-3'	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3'-6'	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3'-5'	Green	Jun-Jul	P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1'-2'	Purple	Aug-Oct	F	N	51,55,56,57
Koeleria macrantha	June grass	1'-2'	White	May-Jul	F/P	N	50,51,55,56,57
Panicum virgatum	Switch grass	3'-6'	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2'-4'	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4'-9'	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6'-7'	Green	Jul-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Stipa spartea	Porcupine grass	2'-4'	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1'-2'	Lavender	Jun-Oct	F/P	N	55,56
Asclepias syriaca	Common milkweed	2'-4'	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1'-3'	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1'-2'	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2'-4'	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3'-5'	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1'-4'	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short's aster	1'-4'	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3'-8'	White	Jun-Oct	F/P/S	N	55,56
Campanulaa americana	Tall bellflower	2'-6'	Blue	Jul-Nov	P/S	N	55,56,57
Clematis virginiana	Virgin's bower	9' long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis lanceolata	Sand coreopsis	1'-2'	Yellow	May-Aug	F/P	N	50,51,55
Coreopsis palmata	Prairie coreopsis	1'-2'	Yellow	Jun-Aug	F/P	N	55
Coreopsis tripteris	Tall coreopsis	4'-8'	Yellow	Aug-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2'-5'	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3'-5'	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3'-6'	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2'-4'	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1'-2'	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2'-6'	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus occidentalis	Western sunflower	2'-4'	Yellow	Aug-Sep	F/P	N	50,51,55,56,57
Helianthus pauciflorus	Prairie sunflower	3'-5'	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4'-6'	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2'-4'	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2'-3'	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris cylindracea	Cylindrical blazing star	1'-2'	Violet	Jul-Oct	F/P	N	51,55,56,57
Liatris scariosa	Savanna blazing star	3'-5'	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Lupinus perennis	Wild lupine	1'-2'	Purple	Apr-Jun	F/P	N	55,56,57
Monarda fistulosa	Wild bergamot	2'-5'	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2'-4'	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1'-2'	Purple	May-Jul	F/P	N	55,56,57
Phlox pilosa	Sand prairie phlox	1'-2'	Pink	May-Aug	F/P	N	56
Polygonatum biflorum	Solomon seal	1'-4'	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1'-3'	White	May-Jul	P/S	N	50,51,55,56,57
Ratibida pinnata	Yellow coneflower	3'-6'	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1'-3'	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Silphium terebinthinaceum	Prairie-dock	3'-8'	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solomon's seal	1'-3'	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon's seal	1'-2'	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1'-2'	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago juncea	Early goldenrod	2'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1'-3'	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2'-4'	Blue	May-Oct	F/P	N	55,56,57
Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Representative Zone F Species

Spiderwort

Butterfly Weed

Yellow Coneflower

Little Bluestem

Foxglove Beardtongue

Wild Lupine

Pale Purple Coneflower

Rattlesnake Master

Sand Coreopsis

Source: JFNew

Zone G

Planter Box Plantings

Although this manual typically recommends using native plants wherever possible, certain situations call for non-native plants due to particular site conditions. Because planter boxes traditionally have a short soil column and are exposed to drier conditions, non-native plants should be considered as long as they are considered non-invasive. Therefore, the list below contains both native and non-native species. Many planter boxes have traditionally used annual flowers. However, we recommend using perennial plants for establishing root systems and lowering maintenance in the long term. Many more species are available for planter boxes than are listed.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun
Ajuga reptans 'Bronze Beauty'	Bronze Beauty Ajuga	6"	Blue	May-Jun	F
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	6"-1'	White	May-Jun	F
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	6"-1'	Blue	Jun-Jul	F
Allium senescens montanum	Mountain Garlic	6"-1'	Pink/Purple	Jun-Aug	F
Allium senescens glaucum	Curly Onion	6"-1'	Pink	Jul-Sep	F
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	6"-1'	Pink	Jul-Aug	F
Aster 'Wood's Light Blue'	Wood's Light Blue Aster	1'-3'	Blue	Aug-Sep	F
Athryium filix-femina	Lady Fern	1'-3'	Green	NA	F/P/S
Blechnum spicant	Deer Fern	1'-2'	Green	NA	F/P/S
Dryopteris erythrosora	Autumn Fern	1'-2'	Green	NA	F/P/S
Euphorbia myrsinites	Mytle Spurge	6"-1'	Yellow	May-Jun	F
Dryopteris intermedia	Fancy Fern	1'-3'	Green	NA	F/P/S
Dyropteris marginalis	Leatherleaf Fern	1'-2'	Green	NA	F/P/S
Geranium x 'Rozanne'	Rozanne Gernaium	1'-2'	Violet	Jun-Sep	F/P
Hemerocallis 'Barbara Mitchell'	Barbara Mitchell Daylily	2'-3'	Pink	Jun-Aug	F/P
Hemerocallis 'Bill Norris'	Bill Norris Daylily	2'-3'	Yellow	Jun-Aug	F/P
Hemerocallis 'Chicago Apache'	Chicago Apache Daylily	2'-3'	Red	Jul-Sep	F/P
Hosta 'Francee'	Francee Hosta	1'-2'	Lavender	Jul-Aug	F/P/S
Hosta 'Guacamole'	Guacamole Hosta	1'-2'	Pink	Aug-Sep	F/P/S
Hosta 'Summer Fragrance'	Summer Fragrance Hosta	1'-2'	Lavender	Aug-Sep	F/P/S
Hosta sieboldiana 'Elegans'	Elegans Hosta	1'-2'	White	Jul-Aug	F/P/S
Sedum 'Autumn Charm'	Autumn Charm Sedum	6"-1'	Pink	Jun-Jul	F
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	6"-1'	Pink	May-Jun	F
Sedum 'Mini Me'	Mini Me Sedum	6"-1'	Green	NA	F
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	6"-1'	Yellow	Jul-Sep	F
Sedum album 'Athoum'	Jelly Bean Sedum	6"-1'	Pink	Aug-Sep	F
Sedum album 'Coral Carpet'	Coral Carpet Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Faro Island'	Faro Island Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Green Ice'	Green Ice Sedum	6"-1'	White	Jun-Jul	F
Sedum album 'Murale'	Wall Sedum	6"-1'	White	Jun-Jul	F
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	6"-1'	Pink	Jul-Aug	F
Sedum divergens	Cascade Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum ellacombianum	Ellacombe's Sedum	6"-1'	Yellow	May-Jun	F
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	6"-1'	Yelow	May-Jun	F
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum grisbachii	Griseback Sedum	6"-1'	Yellow	Jul-Aug	F
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	6"-1'	Yellow	Jun	F
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	6"-1'	Orange	Jul-Aug	F
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	6"-1'	Yellow	May-Jun	F

Representative Zone G Species

Guacamole Hosta

Mountain Garlic

Wall Sedum

Lady Fern

Source: JFNew

Zone H

Vegetated Roof Plantings

Research to-date shows that native plants do not typically thrive in vegetated roofs. Therefore, the list below reflects species that are known to thrive in green roof situations. All species listed below will generally grow to a height of six-to-18 inches.

Botanical Name	Common Name	Color	Bloom Time
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	White	May-Jun
Allium schoenoprasum 'Dwarf'	Dwarf Ornamental Chive	Pink	May-Jun
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	Blue	Jun-Jul
Allium senescens montanum	Mountain Garlic	Pink/Purple	Jun-Aug
Allium senescens glaucum	Curly Onion	Pink	Jul-Sep
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	Pink	Jul-Aug
Euphorbia myrsinites	Mytle Spurge	Yellow	May-Jun
Sedum 'Autumn Charm'	Autumn Charm Sedum	Pink	Jun-Jul
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	Pink	May-Jun
Sedum 'Mini Me'	Mini Me Sedum	Green	NA
Sedum acre 'Aureum'	Gold Leaved Goldmoss Sedum	Yellow	May-Jun
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	Yellow	Jul-Sep
Sedum album 'Athoum'	Jelly Bean Sedum	Pink	Aug-Sep
Sedum album 'Coral Carpet'	Coral Carpet Sedum	White	Jun-Aug
Sedum album 'Faro Island'	Faro Island Sedum	White	Jun-Aug
Sedum album 'Green Ice'	Green Ice Sedum	White	Jun-Jul
Sedum album 'Murale'	Wall Sedum	White	Jun-Jul
Sedum album 'Red Ice'	Red Ice Sedum	White	Jun-Jul
Sedum cautacola 'Bertram Anderson'	Bertram Anderson Sedum	Pink	Jul-Aug
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	Pink	Jul-Aug
Sedum divergens	Cascade Sedum	Yellow	Jun-Jul
Sedum ellacombianum	Ellacombe's Sedum	Yellow	May-Jun
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	Yelow	May-Jun
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	Yellow	Jun-Jul
Sedum grisbachii	Griseback Sedum	Yellow	Jul-Aug
Sedum hispanicum 'Pinkie'	Pinkie Sedum	Pink	Jun-Jul
Sedum hybridum 'Immergunchen'	Evergreen Sedum	Yellow	Jun, Sep
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	Yellow	Jun
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	Orange	Jul-Aug
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	Yellow	May-Jun

*List provided by Hortech, Inc.

Representative Zone H Species

Mountain Garlic

Cascade Sedum

Ellacombe's Sedum

Wall Sedum

Source: JFNew

Appendix G
Recommended Materials

Recommended Materials

Numerous BMPs in this manual have similar material needs. These BMPs are listed in the table below. Detailed information on each material requirement follows. In addition, Porous Pavement and Vegetated Roofs have significant material requirements that are listed according to their individual needs.

	Constructed Filters	Dry Well	Infiltration Trench	Planter Boxes	Porous Pavement	Subsurface Infiltration	Vegetated Filter Strip	Vegetated Swale
Check dams							X	X
Non-Woven Geotextile	X	X	X	X	X	X	X	
Pea Gravel							X	
Peat	X			X				
Pervious Berms							X	
Pipe – 8”	X	X	X	X	X	X	X	
Sand	X			X				X
Stone/Gravel	X			X				
Stone – 30%							X	
Stone – 40%			X		X			

Check dams (Vegetated Filter Strip, Vegetated Swale)

An earthen check dam shall be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02 in to 0.04 in, Gravel: AASHTO M-43 0.5 in to 1.0 in). A stone check dam shall be constructed of R-4 rip rap, or equivalent.

Non-Woven Geotextile (Constructed Filter, Dry Well, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should consist of needled nonwoven polypropylene fibers and meet the following properties:

a. Grab Tensile Strength (ASTM-D4632) 120 lbs min.
b. Mullen Burst Strength (ASTM-D3786) 225 psi min.
c. Flow Rate (ASTM-D4491) 110 gal/min/ft2 min.
d. UV Resistance after 500 hrs (ASTM-D4355) 70% min.
e. Puncture strength (ASTM D-4833-00) 90 lb. min.
f. Apparent opening size (ASTM D-4751-99A) 60-70 US Sieve

Heat-set or heat-calendared fabrics are not permitted. Acceptable types include Mirafi 140N, Amoco 4547, Geotex 451, or approved others.

Pea Gravel (Vegetated Filter Strip)

Clean bank-run gravel may also be used and should meet ASTM D 448 and be sized as per No.6 or 1/8” to 3/8”.

Peat (Constructed Filter, Planter Boxes)

Should have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.

Pervious Berms (Vegetated Filter Strip)

The berm shall have a height of 6-12 in and be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02”-0.04”, Gravel: AASHTO M-43 ½” to 1”)

Pipe - (Dry Well, Porous Pavement, Subsurface Infiltration, Constructed Filter, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should be continuously perforated, smooth interior, with a minimum inside diameter as required. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or M294, Type S (12 gauge aluminum or pipe may also be used in seepage pits).

Sand (Constructed Filter, Planter Boxes, Vegetated Swale)

Should be ASTM-C-33 (or AASHTO M-6) size (0.02” – 0.04”), concrete sand, clean, medium to fine sand.

Stone/Gravel (Constructed Filter, Planter Boxes):

Should be uniformly graded coarse aggregate, 1 inch to ½ inch with a wash loss of no more than 0.5%, AASHTO size number 5 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and have voids of 40% as measured by ASTM-C29.

Stone – 40% voids (Infiltration Trench, Porous Pavement, Subsurface Infiltration Bed,)

Infiltration trenches should have stone 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids 40% as measured by ASTM-C29.

Porous Pavement

General

Choker base course aggregate for beds shall be 3/8 inch to 3/4 inch clean, uniformly-graded, coarse, crushed aggregate AASHTO size number 57 per Table 4, AASHTO Specifications, Part I, 19th Ed., 1998 (p. 47).

Porous Asphalt

Bituminous surface course for porous paving shall be 2.5 to 3 inches thick with a bituminous mix of 5.75% to 6.75% by total weight as determined by testing below. Use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of PG 76-22P (in northern Michigan, use PG 76-28P as appropriate) as specified in AASHTO MP-1. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Determination of optimal asphalt content should be determined according the following tests:

- Draindown Test (ASTM Method D6390)
- Moisture Susceptibility Test using the Modifed Lottman Method (AASHTO T283) with the following:
  - Compact using 50 gyrations of Superpave gyratory compactor
  - Apply partial vacuum of 26 inches of Hg for 10 minutes to whatever saturation is achieved.
  - Keep specimens submerged in water during freeze cycle.
  - Required retained tensile strength (TSR) >= 80%
- Air Voids Test (AASHTO T269/ASTM D3203)

Hydrated lime, if required, shall meet the requirements of AASHTO M 303 Type 1 and shall be blended with the damp aggregate at a rate of 1.0% by weight of the total dry aggregate. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

Fibers, if used, shall consist of either cellulose fibers or mineral fibers which are to be treated with a cationic sizing agent to enhance dispersement of the fiber as well as increase cohesion of the fiber to the bitumen. Fiber is to be added at a dosage rate between 0.2% and 0.4% by weight of total mix.

- Mineral fibers shall be from virgin, basalt, diabase, or slag with a maximum average fiber length of 6.35 mm and a maximum average fiber thickness of 0.005 mm.
- Cellulose fiber – Fiber length shall be 6.4 mm (max), Ash Content 18% non-volatiles (±5%), pH 7.5 (± 1), Oil absorption (times fiber weight) 5.0 (± 1), Moisture Content 5.0 (max).

Porous Concrete

The use of Installers or Craftsmen who have been certified by the NRMCA's Pervious Concrete Contractor Certification Program is strongly recommended. Contractor shall furnish a proposed mix design with all applicable information to the Engineer prior to commencement of work. Critical mix characteristics typically include the following:

- Cement Content: 550 to 650 lb/cy
- Fine aggregate, if used: maximum 3 cu. ft. per cu. yd.
- Admixtures: use in accordance with the manufacturer's instructions and recommendations
- An aggregate/cement (A/C) ratio: 4:1 to 4.5:1
- Water/cement (W/C) ratio: 0.27 to 0.34
- Curing: shall begin within 15 minutes after placement and continue for 7 days

The data shall include unit weights determined in accordance with ASTM C29 paragraph 11, jigging procedure.

Cement: Portland Cement Type II or V conforming to ASTM C150 or Portland Cement Type IP or IS conforming to ASTM C595. The total cementitious material shall be between 550 and 650 lb./cy.

Aggregate: Use No 8 coarse aggregate (3/8 to No. 16) per ASTM C33 or No. 89 coarse aggregate (3/8 to No. 50) per ASTM D 448. If other gradation of aggregate is to be used, submit data on proposed material to owner for approval. The volume of aggregate per cu. yd. shall be equal to 27 cu.ft. when calculated as a function of the unit weight determined in accordance with ASTM C 29 jigging procedure. Fine aggregate, if used, should not exceed 3 cu. ft. and shall be included in the total aggregate volume.

Air Entraining Agent: Shall comply with ASTM C 260 and shall be used to improve workability and resistance to freeze/thaw cycles.

Admixtures: The following admixtures shall be used:

- Type D Water Reducing/Retarding – ASTM C 494.
- A hydration stabilizer that also meets the requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding admixtures may be used. This stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles from achieving initial set.

Water: Potable shall be used and shall comply with ASTM C1602. Mix water shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (Mix water yielding a cement paste with a dull-dry appearance has insufficient water for hydration).

- Insufficient water results in inconsistency in the mix and poor bond strength.
- High water content results in the paste sealing the void system primarily at the bottom and poor surface bond.

An aggregate/cement (A/C) ratio range of 4:1 to 4.5:1 and a water/cement (W/C) ratio range of 0.27 to 0.34 should produce pervious pavement of satisfactory properties in regard to permeability, load carrying capacity, and durability characteristics.

Vegetated roofs

Some key components and associated performance-related properties are as follows:

Root-barriers should be thermoplastic membranes with a thickness of at least 30 mils. Thermoplastic sheets can be bonded using hot-air fusion methods, rendering the seams safe from root penetration. Membranes that have been certified for use as root-barriers are recommended. At present only FLL offers a recognized test for root-barriers. Several FLL-certified materials are available in the United States. Interested American manufactures can submit products for testing to FLL-certified labs.

Granular drainage media should be a non-carbonate mineral aggregate conforming to the following specifications:

- Saturated Hydraulic Conductivity >= 25 in/min
- Total Organic Matter, by Wet Combustion (MSA) <= 1%
- Abrasion Resistance (ASTM-C131-96) <= 25% loss
- Soundness (ASTM-C88 or T103 or T103-91) <= 5% loss
- Porosity (ASTM-C29) >= 25%
- Alkalinity, CaCO3 equivalents (MSA) <= 1 %
- Grain-Size Distribution (ASTM-C136)
  - Pct. Passing US#18 sieve <= 1%
  - Pct. Passing ¼-inch sieve <= 30%
  - Pct. Passing 3/8-inch sieve >= 80%

Growth media should be a soil-like mixture containing not more than 15% organic content (wet combustion or loss on ignition methods). The appropriate grain-size distribution is essential for achieving the proper moisture content, permeability, nutrient management, and non-capillary porosity, and 'soil' structure. The grain-size guidelines vary for single and dual media vegetated cover assemblies.

Non-capillary Pore Space at Field Capacity, 0.333 bar (TMECC 03.01, A)	>= 15% (vol)
Moisture Content at Field Capacity (TMECC 03.01, A)	>= 12% (vol)
Maximum Media Water Retention (FLL)	>= 30% (vol)
Alkalinity, Ca CO3 equivalents (MSA)	<= 2.5%
Total Organic Matter by Wet Combustion (MSA)	3-15% (dry wt.)
pH (RCSTP)	6.5-8.0
Soluble Salts (DTPA saturated media extraction)"(RCSTP)	<= 6 mmhos/cm
Cation exchange capacity (MSA)	>= 10 meq/100g
Saturated Hydraulic Conductivity for Single Media Assemblies (FLL)	>= 0.05 in/min
Saturated Hydraulic Conductivity for Dual Media Assemblies (FLL)	>= 0.30 in/min

Grain-size Distribution of the Mineral Fraction (ASTM-D422)

Single Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	<= 5%
Pct. Passing US#60 sieve	<= 10%
Pct. Passing US#18 sieve	5 - 50%
Pct. Passing 1/8-inch sieve	0 - 70%
Pct. Passing 3/8-inch sieve	75 -100%

Dual Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	5-15%
Pct. Passing US#60 sieve	10-25%
Pct. Passing US#18 sieve	20 - 50%
Pct. Passing 1/8-inch sieve	55 - 95%
Pct. Passing 3/8-inch sieve	90 -100%

Macro- and micro-nutrients shall be incorporated in the formulation in initial proportions suitable for support the specified planting.

Separation fabric should be readily penetrated by roots, but provide a durable separation between the drainage and growth media layers (Only lightweight nonwoven geotextiles are recommended for this function.

- Unit Weight (ASTM-D3776) <= 4.25 oz/yd2
- Grab tensile (ASTM-D4632) <= 90 lb
- Mullen Burst Strength (ASTM-D4632) >= 135 lb/in
- Permittivity (ASTM-D4491) >= 2 per second

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Golder Associates

REPORT

CITY OF MUSKEGON WEST OPERATIONS & MANAGEMENT PLAN

Stormwater Management

Low Impact Developments / Green Infrastructure

Landowner – City of Muskegon
933 Terrace St.
Muskegon, MI 49440

Submitted To: West Michigan Shoreline Regional Development Commission
316 Morris Avenue
Suite 340
Muskegon, Michigan 49440

Submitted By: Golder Associates Inc.
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Distribution: One electronic copy

March 7, 2017

Project No.1520593

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EXECUTIVE SUMMARY

The Operations and Management (O&M) Plan summarizes the best management practices (BMPs) and low impact development (LID) designs implemented in City of Muskegon West for improving stormwater management. The details of each BMP for City of Muskegon West can be seen in the Conceptual Plan (Appendix A). Each structural BMP requires maintenance for continued efficiency and is summarized within the plan. Included in the appendices of the report is a maintenance summary for each BMP (Appendix B, C, and D), and example checklists to be used for routine inspections (Appendix E). The plan provides guidance regarding management of vegetation, a list of recommended Michigan species (Appendix F), and recommended materials (Appendix G). Operations and maintenance costs were analyzed for each development, and an overall annual cost and long term (30 year) cost were calculated for maintaining the site.

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1.0 CITY OF MUSKEGON WEST

City of Muskegon West is located in Muskegon, Michigan within the Muskegon Lake Direct Drainage Watershed. The site is city owned and within half a mile of Muskegon Lake. The watershed receives stormwater from heavily urbanized areas and the city's storm sewer system. The polluted stormwater discharged to the watershed has resulted in degraded benthic communities, organic chemicals, excessive sediment, and/or flashy hydrology.

With grant support from the Michigan Department of Environmental Quality and the US Environmental Protection Agency, the Muskegon Lake Watershed Partnership, West Michigan Shoreline Regional Development Commission, municipal partners and Golder Associates Inc. recommended design solutions to reduce stormwater runoff, stormwater pollutants, and improve water quality within City of Muskegon West and the Lake Direct Drainage Watershed. Stormwater LID designs recommended for the site included six rain gardens, two bioswales, and ten bioretention islands.

2.0 MAINTENANCE COSTS

Stormwater LID designs tend to be less expensive to implement than conventional designs, however they do require long term maintenance to ensure the designs continue to work efficiently. A cost analysis was completed for the City of Muskegon West maintenance costs at annual rates. Three types of structural BMPs were assessed including rain gardens, bioswales, and bioretention islands. The total annual cost for maintaining the BMPs at City of Muskegon West was estimated at $8,025. Annual maintenance costs were based on taking a percentage of the total construction costs, based on a low impact development cost comparison completed by Emmons & Oliver Resources, Inc. (EORINC 2015). Rain gardens were estimated to require approximately 5% to 6% of construction costs for routine and non-routine maintenance. Operation and maintenance costs for the BMPs are summarized in Table 1. The estimated maintenance costs include aesthetic maintenance and functional maintenance. Functional maintenance assures the BMP is performing efficiently and safely, while aesthetic maintenance is mainly for public acceptance, which can help to reduce functional costs. The percentage of construction cost used for each BMP reflects labor, landscaping, and material costs. A typical year of landscaping includes maintenance such as lawn mowing, removal of debris and litter, replanting or seeding vegetation, and replenishing mulch. Maintenance labor is expected to be greater within the first two to three years as vegetation is established.

Table 1. Operation and Maintenance Costs Summary

Stormwater BMP	Construction Cost ($)	Annual Maintenance Cost (% of Construction Cost)	Annual Maintenance Cost ($)
Rain Garden (without underdrain)	16,650	5	833
Bioswale	60,480	6	3,629
Bioretention Islands	71,260	5	3,563
Total Costs			**8,025**

2.1 Rain Garden

City of Muskegon conceptual stormwater development plan includes two rain gardens encompassing approximately 1,200 square feet. The rain gardens consist of a geotextile filter layer, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Regular maintenance of the rain gardens is required within the first two to three years when vegetation is becoming established. Less maintenance is required after vegetation becomes established and fills empty spaces between plants. Maintenance requirements for the rain gardens can be viewed in Appendix B. A summary of maintenance cost for the rain gardens is provided in Table 1. The annual operations and maintenance costs for the rain gardens were calculated as 5% of the construction costs. The annual cost to maintain the two rain gardens is $833.

2.2 Bioswale

There are two bioswales implemented in the City of Muskegon stormwater management plan. The bioswales cover about 4,480 square feet, each approximately eight feet wide and totaling 560 linear feet. Bioswales consist of a geotextile filter, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Similar to the rain gardens the bioswales will be planted with native species and require more maintenance within the first two to three years while vegetation is being established. Routine maintenance items for the bioswales are summarized in Appendix C. The annual maintenance cost of bioswales at the site was calculated as 6% of the construction costs, totaling $3,629.

2.3 Bioretention Island

Bioretention islands require similar maintenance to rain gardens and bioswales. Bioretention islands are designed with geotextile filter fabric, 18 inches of compacted stone, 18 inches of engineering soil, and two inches of mulch. There are ten bioretention islands located within City of Muskegon West covering

approximately 2,000 square feet. Vegetation in the bioretention islands will consist of one tree or plug. The maintenance required for the bioretention islands is summarized in Appendix D. The annual maintenance cost for the bioretention islands was calculated as 5% of the construction costs, equivalent to $3,563.

3.0 ROUTINE INSPECTIONS

Routine inspections of BMPs should be completed at least once every year. Example inspection checklists are included in Appendix E. Inspection checklists vary depending on the type of LID design. The stormwater designs in City of Muskegon West include underdrain and overflow systems within two bioretention islands, so such items on the checklist are only applicable to these two systems. The underdrains and overflow systems will require additional maintenance to ensure there are no blockages or damages at inlets/outlets, and no damages to piping. The example bioretention inspection checklist can be used for inspection of the rain gardens and the bioretention islands. Rain gardens, bioswales, and the bioretention islands should be inspected for debris, erosion, vegetation conditions and coverage, and mulch thickness to determine overall functionality. Based on selection of the native plants used for each BMP, additional species specific inspections may be required. Inspections of vegetation should include determining the overall plant health, checking if plants require trimming or pruning, and assuring invasive species are properly managed.

4.0 VEGETATION

The plant species selected for the BMPs have a significant impact on the effectiveness of the design. Vegetation will require regular maintenance within the first few years while becoming established. Maintenance mainly includes watering plants as needed, and removing invasive species. Once vegetation is established, less maintenance will be required to maintain the BMP areas.

4.1 Native Species

Native plants are implemented in the design because they have deeper and more expansive roots leading to increased infiltration, groundwater recharge and biofiltration. Native plants are also more tolerant to flooding and drought conditions enabling them to thrive in rain gardens, bioswales, and biofiltration islands. Plugs and gallons are common sizes of native plants that can be installed in BMPs. A plug is a small plant that grows in a container roughly two inches wide and five inches deep. A gallon is a more mature plant available in a gallon size container. Both sizes of plants require consistent watering during early development (Delta Institute 2015). Suggested species may include: cardinal flower (*Lobelia cardinalis*), blue lobelia (*Lobelia siphilitica*), New England aster (*Aster novae-angliae*), and brown fox sedge (*Carex vulpinoidea*). Additional grasses and wildflowers that could tolerate wet growing conditions recommended by the West Michigan Environmental Action Council include: cotton grass (*Eriophorum angustifolium*), golden alexanders (*Zizia aurea*), and blue flag iris (*Iris versicolor*) (WMEAC 2016). A full list of recommended Michigan plants for BMPs is included in Appendix F (SEMCOG 2008).

4.1.1 Planting Requirements

Maintenance will be required for any plants that do not successfully grow in the planted environment, and an alternative species may need to be planted. Seeding is not the preferred method of planting vegetation since high velocity flows can prevent the plant from establishing. Plugs or gallon-potted plants installed at one to two foot intervals are recommended for effective establishment of vegetation. Trees and shrubs are also recommended. Seeding should be completed from late April to mid-October if irrigation is available. If irrigation is not available, than seeding can be completed from June 15 or mid-August to mid-October. With dormant seeding, seeding can be completed from November 1 to 30. At all other times of the year, seeding should have a temporary cover (made of oats/cereal rye or other small grain). Plugs and gallons should be installed from May 1 – June 15. Trees and shrubs should be planted from the middle of April through early June, or the middle of September through the middle of November. A maximum of two to three inches of mulch should be evenly spread in the BMPs after installing new plants to help prevent erosion, remove metals, and act as leaf litter in a natural forest environment. The mulch should not be placed directly against the stems of the newly planted vegetation. If wildlife is a threat to newly installed plants additional precautions such as waterfowl barriers are maintenance options.

4.2 Invasive Non-Native Species

Invasive species are not native to the area and tend to grow and spread quickly without natural controls. If unmanaged, invasive species will displace native species (SEMCOG 2008). Maintenance of invasive species is crucial when native plants are being established and require room to grow. Invasive species can be removed from BMPs by hand–pulling, mowing, or spot herbicide applications. After native species are established, less maintenance of invasive species is needed. Long term management of invasive species may require removal once every year or as needed. Open areas may require mowing if woody vegetation is noticed encroaching, typically every three to five years.

5.0 WINTER CONDITIONS

Winter conditions in Michigan typically include the buildup of snow and the use of de-icing compounds which can negatively affect plant life. Salt tolerant plants are recommended for sites where de-icing and heavy snow occurs. Recommended products for de-icing are nontoxic and organic, such as magnesium chloride-based liquid products or pretreated salt (Delta Institute 2008). Sand and cinder from melted snow has the potential of reducing infiltration into the soil. Preventative measures should be taken to avoid the buildup or piling of snow over infiltration systems.

In the spring, the rain gardens, bioswales, and bioretention islands should all be assessed for winter damages. Buildup of debris and sediment should be cleared, and mulch should be evenly spread in any eroded areas. Plants may also require trimming or rehabilitation. Soil aeriation may also be required in spring to reduce impacts of de-icing agents.

6.0 EDUCATION AND TRAINING

All personnel responsible for the operations and maintenance of the BMPs should undergo training to fully understand the care required for each LID design. Training should include reading the O&M plan and discussing procedures with someone of experience. An educated maintenance staff will increase the efficiency and sustainability of the designs.

7.0 REFERENCES

1. Delta Institute and Guidon Design. 2015. Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
2. Emmons & Oliver Resources, Inc. 2015. Minnesota Low Impact Development A comparison, Cost Comparision. A Case Study Comparison of Costs, Water quality and quanity benefits and quality of life. http://www.eorinc.com/pdf/development-maintenance-cost.pdf
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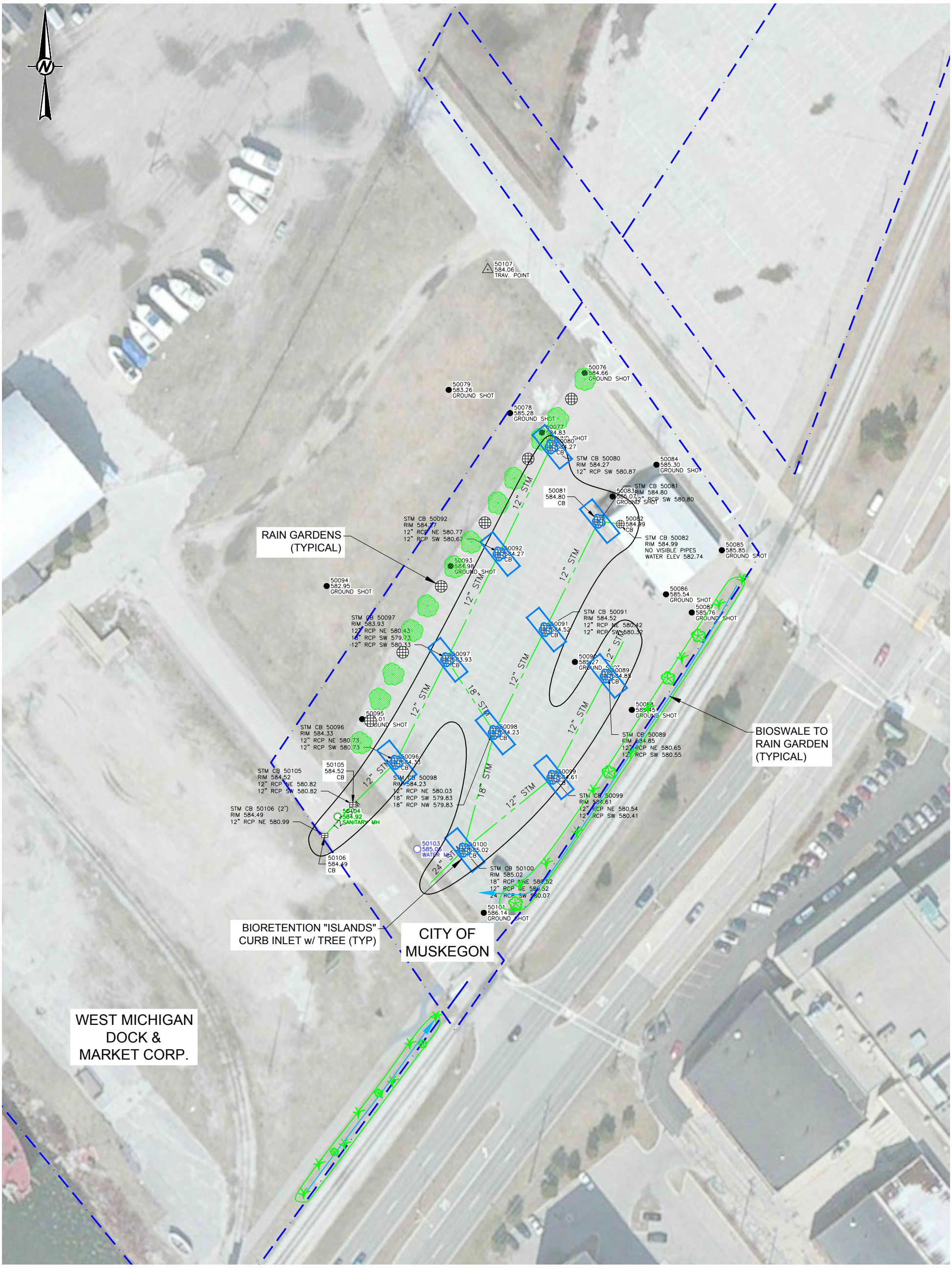
4. West Michigan Environmental Action Council. 2016. Rain Gardens of West Michigan. Michigan Native Plants List For Use in Rain Gardens and Landscaped Bioretention Areas. http://www.westmichiganglsi.org/uploads/6/7/9/8/6798898/rain_gardens_native_plant_list.pdf

Appendix A
City of Muskegon West Conceptual Plan



LEGEND

PARCEL BOUNDARY

CLOSED LUST (PART 213)

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 40 80
1" = 80' FEET

NOTE(S)

1. THE MART DOCK SITE IS APPROXIMATELY 46.4 ACRES PARCEL AREA AND 9.1 ACRES WATERSHED TREATMENT AREA.
2. THE MART DOCK SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	JJS
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
CITY OF MUSKEGON WEST

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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Appendix B
Rain Garden Maintenance Items

RAIN GARDEN

1.0 PUROPOSE

Rain gardens are used to collect stormwater runoff and encourage infiltration and biofiltration with the use of native plants. Native plants are ideal for rain gardens because they have deeper root networks that draw surface water further into the ground. Native plants are also typically drought and flood tolerant and able to thrive in rain gardens. Rain gardens aide in reducing runoff volume, filtering pollutants, recharging groundwater (if no underdrain is used), reducing stormwater temperature impacts, and enhancing site aesthetics.

2.0 MAINTENANCE

Rain gardens require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered and weeded twice weekly through October of the first year and in times of extreme drought. Weeds should be removed by hand.

3.) Organic matter may also need to be removed approximately twice per year, usually by hand.

4.) Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

5.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

6.) Annual mowing should be performed for the first three years of establishment. Mowing should not be completed on a regular basis.

7.) Removal of debris must occur monthly for the life of the rain garden.

8.) Winter conditions may result in plants being effected by deicing chemicals in snow-melt, in this case salt-tolerant plants should be used. Also try to reduce the amount of sand, cinders, and other winter abrasives that come in contact with the vegetation. Additional maintenance in the spring is required to remove abrasives if used.

9.) Rain gardens should be inspected at least twice a year for sediment buildup, erosion, and overall vegetation conditions. If sediment build up reaches 25% of the ponding depth it should be removed. If erosion is occurring, soil stabilization efforts should be applied. If vegetation is in poor health for no apparent reason, a landscape architect should be consulted.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix C
Bioswale Maintenance Items

BIOSWALE

1.0 PUROPOSE

Bioswales are shallow, vegetated, earthen channels that help to slow, filter, and infiltrate stormwater runoff in the process of conveyance. Native plants are ideal vegetation for bioswales due to their deep roots for infiltrating runoff, and their high tolerance for droughts and floods.

2.0 MAINTENANCE

Bioswales require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Vegetation should be established as soon as possible to prevent erosion and scour. Freshly seeded swales require soil stabilization such as erosion control matting or blankets. Erosion controls for seeded swales are required after planting for 75 days after the first storm event occurs. If runoff velocities are high, sodding the swale or diverting runoff until vegetation is well established is an option.

4.) Debris removal, weeding, and pruning should be performed on a monthly basis.

5.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity issues are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

6.) Mow and trim plants within the bioswales annually to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Mow only when dry to avoid rutting. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

7.) In the spring the bioswales will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

8.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

9.) If roadside or parking lot runoff is directed to the swale, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix D
Bioretention Island Maintenance Items

BIORETENTION ISLAND

1.0 PUROPOSE

A Bioretention islands or stormwater planters are a linear infiltration basin typically located in a parking lot or between a street and sidewalk surrounded by vertical curbing. Stormwater is collected from the street, sidewalk, or parking lot and directed into the bioretention island through openings in the curb. Bioretention islands consist of native plants in engineered soil which lay on top of a layer of stone. The stormwater planters are able to reduce, filter, and infiltrate stormwater runoff and aide in recharging groundwater.

2.0 MAINTENANCE

Bioretention islands require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes mature and capable of choking out invasive species, less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Debris removal, weeding, and pruning should be performed on a monthly basis.

4.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

5.) Annually trim plants to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

6.) In the spring the bioretention islands will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

7.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

8.) If roadside or parking lot runoff is directed to the bioretention island, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix E
Example Inspection Checklists

Maintenance Inspection Checklists

This appendix contains four checklists available as guides for maintenance inspections of specific BMPs. The maintenance items have been adapted from multiple stormwater programs, including the Rouge River Detention Basin Maintenance Manual, Georgia Stormwater Management Manual, the Vermont Stormwater Management Manual, and the Stormwater Manager's Resource Center.

The checklists are designed to help identify key components of BMPs that require ongoing maintenance as well as a basic schedule of when the maintenance should occur. The checklists have been divided into those items essential for the general operation and functionality of the BMP and those items that optional and may enhance the BMP.

It is suggested that the inspection be undertaken by a licensed PE and/or a person knowledgeable about the design and function of the BMP.

These BMP checklists include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

Detention BMP Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet Pipes			
Structural integrity of inlet/outlet (Are any inlet pipes broken, crumbling, separated?) List Inlet Pipes Approximate Diameter and Type of Material Inlet Pipe 1 _____ Inlet Pipe 2 _____ Inlet Pipe 3 _____ Outlet Pipe Size/Type _____		A	
Riprap at inlet pipe (Is the riprap still present? Is it visible and not covered with sediment?		A	
Stone around outlet pipe (Is the stone clogged with debris and/or sediment?)		A	
Trash or debris blocking inlet/outlet (Inspect to ensure no major obstructions hindering general functionality)		M	
Inspect/clean catch basin upstream of the BMP if accessible.		A	
Inspect inlets and outlet for erosion (Are there eroded areas around the pipes?)		A	
Inspect overflow spillway for signs of erosion.			
Pretreatment (if applicable) (Might include sediment forebay, upstream catch basin, bioswale, rain garden, swirl concentrator)			
Device functioning to trap/collect sediment		A	
Remove accumulated sediment as appropriate for the pretreatment device. forebay		A	
Detention Pond		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inspect side slopes, berms and emergency overflow for erosion		A	
Reestablish permanent native vegetation on eroded slopes		As needed	
Inspect for excess sediment accumulation in pond if not pretreatment device is present		A	
Overall functionality			
Ensure pond is functioning properly (Professional Civil Engineer is recommended)		A	
Ensure the outlet is functioning properly (Professional Civil Engineer is recommended)		A	
Optional/Enhancements			
Maintain 15-20 feet “no mow and chemical free” zone		A	
Mow (or burn) the “no mow” zone		A	
Inspect basin and “no mow” zone for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation in and around pond.		A	
Complaints from residents (note on back)		S	
Encroachment on pond/no- mow zone.		A	
Unauthorized plantings		A	
Aesthetics (e.g., graffiti, unkept maintenance)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Summary

Inspector’s remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Infiltration BMPs Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		A	
Pretreatment for sediment			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure infiltration device is functioning properly (professional civil engineer is recommended)		A	
BMP infiltration surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		S	
Evidence of erosion present		A	
Aggregate (if applicable)			
Surface of aggregate clean		A	
Any replacement of aggregate needed? If clogged with sediment replacement is necessary for continued proper function.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Vegetated surface (if applicable)			
Vegetative cover exists		A	
Optional considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation or creating a native plant infiltration basin area.		A	
Complaints from residents (note on back)		A	
Mowing done when necessary		A	
No fertilizer unless testing requires it		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioretention Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway or catch basin clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		Every 5 years	
Pretreatment for sediment (Generally consists of catch basin or velocity dissapator at inlet such as area of riprap/ collection for sediment)			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure bioretention area is functioning properly (professional civil engineer is recommended)		A	
Bioretention area surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		M	
Evidence of erosion present		A	
Does good vegetative cover exist		A	
Mulch covers entire area (no voids) and to specified thickness		A	
Optional considerations			
Inspect BMP for invasive species.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioswale, Filter Strip Inspection Checklist

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Pretreatment/ Energy Dissipators			
No evidence of flow going around structures		A	
No evidence of erosion		A	
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
BMP surface			
Area free of debris?		M	
No evidence of erosion		A	
Does sediment accumulation currently require removal?		A	
Overall functionality			

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Ensure swale is functioning properly (professional civil engineer is recommended)		A	
Optional Considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Appendix F
List of Michigan Recommended Plants

Recommended Plant Lists for Best Management Practices

This appendix contains recommended native and non-native (when appropriate) plant species for the Best Management Practices detailed throughout the manual. Species have been recommended based on hardiness, aesthetics, functionality, and commercial availability. It is certain that species exist outside the confines of this list that will perform in a comparable way to those listed; however, commercial availability is often a limiting factor in obtaining material for native plantings. Over time, and in certain locales, additional species will become available to supplement those listed below.

An array of planting zones is provided based on normal water levels (Figure C.1). Using these zones will provide the best chances for long-term success of native planting in the context of LID. While plants may naturally occur outside of the given ranges, these ranges are intended to be guidelines for plant installation. Whenever possible and practical in standing water conditions, native plants should be installed in live plant form (rather than seed). Seed or a combination of seed and live plants may be used in upland situations.

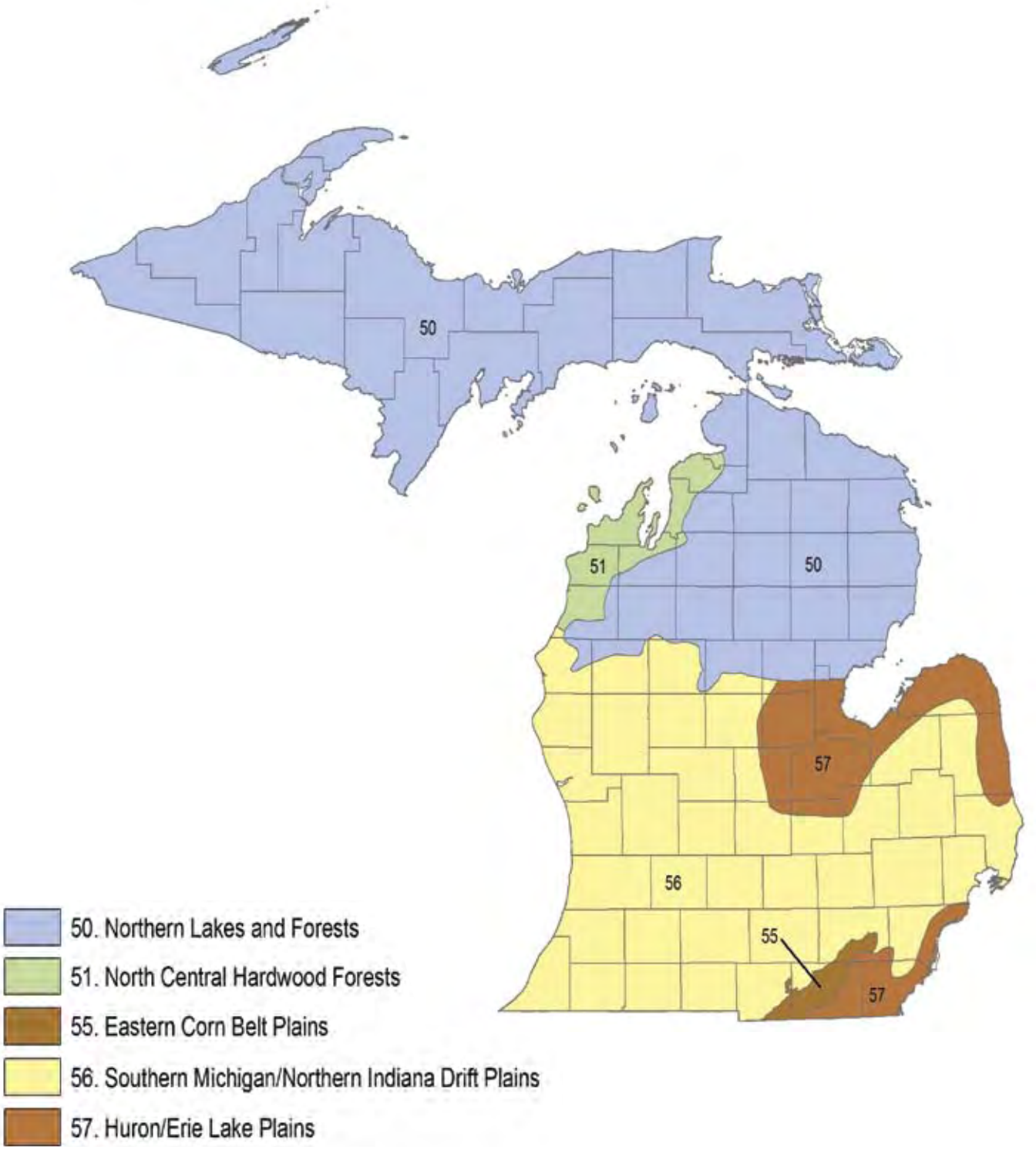
Recommendations are given for height, bloom color, bloom time, sun requirements, salt tolerance, and ecoregion. Please note that these are recommendations based on a range of situations, and a specific plant or population may vary from site-to-site. For sun requirements, F = Full sun required, P = Partial sun tolerated, and S = Shade tolerated. Salt tolerance is classified as Yes (Y) or No (N). This was determined through literature reviews and anecdotal evidence. If there is no information confirming tolerance, a "No" was listed.

Figure C.1
Planting Zone/BMP Matrix

	Zone A — 2"-4" Below Water Level	Zone B — 0"-2" Below Water Level	Zone C — 0"-2" Above Water Level	Zone D — 2"-4" Above Water Level	Zone E — 4"-18" Above Water Level	Zone F — 18"+ Above Water Level	Zone G — Planter Boxes	Zone H — Vegetated Roofs
Rain gardens/Bioretention	✤	✤	✤	✤	✤	✤		
Vegetated Filter Strips			✤	✤	✤	✤		
Vegetated Swales		✤	✤	✤				
Infiltration Basin		✤	✤					
Subsurface Infiltration Basins				✤	✤	✤		
Infiltration Trenches				✤	✤	✤		
Infiltration Berns	✤	✤	✤	✤	✤	✤		
Planter Boxes							✤	
Vegetated Roofs								✤
Constructed Wetlands	✤	✤	✤	✤				
Wet Ponds	✤	✤	✤					
Dry Extended Detention Basins			✤	✤	✤	✤		
Riparian Corridor Restoration			✤	✤				
Native Revegetation	✤	✤	✤	✤	✤	✤	✤	✤

Ecoregion recommendations are also provided for each species (Figure C.2). Whenever possible, the designer/ installer should seek to use species that historically occurred in the same ecoregion as the project. When necessary, species occurring in an adjacent ecoregion may be used.

Figure C.2
EPA Level III Ecoregions for Michigan



Source: USEPA

Plant Installation

Native Seeding

Seasonal consideration: October 1-June 15 (note: seeds should not be planted on frozen ground).

Native seeding is generally recommended for areas above the water line or 1-2" below the water line. Live plant material should be used to establish vegetation at deeper water levels.

Broadcast seeding

Broadcast seeding is preferred over drill seeding on graded, bare soil sites. Apply the seed uniformly over the surface using a combination seeder/cultipacker unit such as a Brillion or Truax Trillion seeder. The Trillion seeder is preferred as it is designed to handle native seeds.

A cone seeder or other similar broadcasting equipment may also be used if the seed mix does not contain fluffy seeds in amounts sufficient to prevent free flowing without plugging. Seed should then be pressed into the surface using a cultipacker or roller.

Drill seeding

A rangeland-type no-till drill designed to plant native grasses and forbs may be used in bare soils although this equipment is specifically designed to plant through existing vegetation which is killed with an herbicide. Cultipacking or rolling before seeding may be required to prevent seed placement depths exceeding .25 inch, but cultipacking or rolling after seeding is not required.

All seeding equipment, whether broadcast or drill, should be calibrated to deliver the seed at the rates and proportions specified in the plans. Equipment should be operated to ensure complete coverage of the entire area to be seeded, and seed must be placed no deeper than .25 inch in the soil. No fertilizers or soil conditioners will be required or allowed.

Native Planting

Seasonal considerations: May 1-July 1

Plant plugs should be installed in holes drilled with an auger the same diameter and depth as the plug within +0.75 inch/- 0.25 inch. In wetland plantings where soil is soft and moist enough, a dibble bar or trowel may also be used. The planting layout should consider the requirements of the individual species regarding soil type, moisture, slope, shading, and other factors for the particular plant species.

Planting densities vary according to budget and project goals and can range from three-to-five foot spacing for plug supplements of seeded areas to six inches to two foot spacing for high visibility landscaping projects with large budgets. Groups of five-to-seven plugs of the same species planted approximately one foot apart is usually preferable to planting all species intermixed randomly across the site at a uniform density.

In wetland or shoreline areas with potential for high wave action or wildlife predation that may dislodge newly planted plugs, plugs should be secured with six inch or eight inch U-shaped wire erosion control blanket staples. Staple length is determined by the density of the planting substrate; softer substrates require longer length to hold plugs adequately.

In areas where potential for wildlife predation exists, such as retention basins or other planting areas adjacent to open water, waterfowl barriers should be installed around a minimum of 50 percent of the plugs. All plugs not protected by barriers should be stapled into the substrate as described above. Barriers may consist of plastic or wire mesh enclosures supported with wooden stakes, adequately constructed to inhibit access by waterfowl for one growing season. Enclosures should extend at least two feet above the plant tops. Methodology should be approved by the project designer with input from a restoration ecologist if necessary. Barriers may be removed after one growing season.

Maintenance and Management

Maintaining vegetated BMPs is typically most important during the first few years following installation. Supplemental irrigation may be needed to help establish plants in drought conditions. Plants may need to be replaced due to predation or other unseen factors. Most commonly, management includes removing invasive species via mowing, hand-pulling, or spot herbicide applications. In larger areas, broadcast herbicide applications may be appropriate. Over time in upland areas, controlled burning may be used as a way to invigorate the plantings and control certain invasive species. If not feasible for social or cultural reasons, an annual or biennial mowing may be used instead of fire.

Long-term management may be necessary, but is typically significantly less intensive. The site should be periodically checked for invasive species infestations. Any prairie or open area may need occasional (every three to five years) burning or mowing to remove woody vegetation that may encroach.

Zone A

Planting Zone = two-to-four inches below water level

These species require continual inundation within the given water depths in order to thrive. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for a majority of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57

Representative Zone A Species

Buttonbush

Pickerel Weed

Swamp Milkweed

Arrowhead

Blue Flag Iris

Source: JFNew

Zone B

Planting Zone = zero-to-two inches below water level

These species tolerate fluctuating water levels within this range. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for most of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-Jun	F	N	50,51,55,56,57
Carex lacustris	Lake sedge	2’-4’	Brown	May-Jun	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Alisma plantago-aquatica	Water plantain	2’-4’	White	Jul-Sep	F	N	50,51,55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard’s tail	2’-4’	White	Jun-Aug	P/S	N	55,56,57

Representative Zone B Species

Blue Flag Iris

Arrowhead

Bristly Sedge

Pickerel Weed

Swamp Milkweed

Source: JFNew

Zone C

Planting Zone = zero-to-two inches above water level

These plants are tolerant of fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Alnus rugosa	Speckled alder	25’	Brown	Mar-May	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Cephalanthus occidentalis	Buttonbush	15’	White	Jun/Aug	F/P/S	N	51,55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	Y	55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Grasses/Sedges/Rushes:							
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Forbs:							
Alisma plantago-aquatica	Water plantain	2'-4'	White	Jul-Sep	F	N	50,51,55,56,57
Anemone canadensis	Canada anemone	1'-2'	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6'-9'	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3'-5'	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3'-6'	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3'-6'	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1'-4'	White	Jul-Oct	F/P	N	50,51,55,56,57
Cassia hebecarpa	Wild senna	3'-5'	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2'-4'	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Eupatorium maculatum	Spotted Joe-pye weed	4'-7'	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3'-5'	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1'-3'	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3'-5'	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5'-12'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2'-3'	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3'-5'	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3'-8'	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2'-5'	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1'-4'	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1'-3'	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2'-4'	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2'-5'	Pink	Aug-Oct	F	Y	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1'-3'	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3'-10'	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Sagittaria latifolila	Arrowhead	1'-4'	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard's tail	2'-4'	White	Jun-Aug	P/S	N	55,56,57
Sisyrinchium angustifolium	Stout blue-eyed grass	1'	Blue	May-Aug	F/P	N	55,56,57
Solidago ohiensis	Ohio goldenrod	2'-3'	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3'-6'	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell's goldenrod	2'-5'	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3'-6'	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2'-5'	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3'-6'	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3'-6'	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3'-5'	Purple	Jul-Sep	F	N	55,56,57
Zizia aurea	Golden Alexanders	1'-3'	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone C Species

Cardinal Flower

Swamp Milkweed

Blue-Eyed Grass

Obedient Plant

Joe-Pye Weed

Path Rush

Red-Osier Dogwood

Monkey Flower

Source: JFNew

Zone D

Planting Zone = two-to-four inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Viburnum trilobum	Cranberry Viburnum	10’	White	Apr-May	F/P/S	N	50,51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Panicum virgatum	Switch grass	3‘-5’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Forbs:							
Anemone canadensis	Canada anemone	1’-2’	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6’-9’	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3’-6’	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1’-4’	White	Jul-Oct	F/P	N	50,51,55,56,57
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2’-4’	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	51,55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium maculatum	Spotted Joe-pye weed	4’-7’	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3’-5’	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1’-3’	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3’-5’	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3’-8’	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2’-5’	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1’-4’	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1’-3’	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2’-4’	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3’-10’	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2‘-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago ohiensis	Ohio goldenrod	2’-3’	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3’-6’	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell’s goldenrod	2’-5’	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3’-6’	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2’-5’	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3’-6’	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3’-6’	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57
Veronicastrum virginicum	Culver’s root	3’-6’	White	Jun-Aug	F/P	N	55,56,57
Zizia aurea	Golden Alexanders	1’-3’	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone D Species

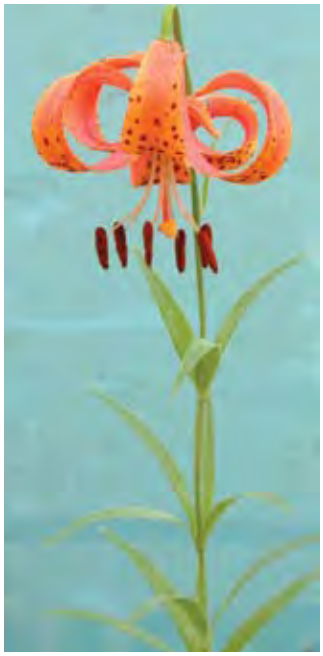
Big Bluestem

Marsh Blazing Star

Wild Columbine

Great Blue Lobelia

Virginia Mountain Mint



Michigan Lily

Meadowsweet

Blue Vervain

Source: JFNew

Zone E

Planting Zone = four-to-18 inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100’	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	N
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80’	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1’-3’	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus florida	Flowering dogwood	30’	White	May-Jun	F/P/S	N	55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85’	White	Jun	F/P	N	55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Pinus banksiana	Jack pine	60’	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100’	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100’	Brown	Jun	F/P/S	N	50,51,55,56,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Prunus americana	American plum	30’	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30’	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7’	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1’-2’	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1’-3’	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1’-2’	Purple	Aug-Oct	F	N	51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Panicum virgatum	Switch grass	3’-6’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2’-4’	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4’-9’	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Stipa spartea	Porcupine grass	2’-4’	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1’-2’	Lavender	Jun-Oct	F/P	N	55,56
Aquilegia canadensis	Wild columbine	1’-3’	Red/ Yellow	Apr-Jun	F/P/S	Y	50,51,55,56,57
Asclepias syriaca	Common milkweed	2’-4’	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1’-3’	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1’-2’	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2’-4’	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3’-5’	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster lateriflorus	Calico aster	1’-3’	White	Jul-Oct	F/P/S	N	50,51,55,56,57
Aster macrophyllus	Big-leaved aster	6”-2’	Lav/ White	Jul-Oct	P/S	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1’-4’	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short’s aster	1’-4’	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Campanula americana	Tall bellflower	2’-6’	Blue	Jul-Nov	P/S	N	55,56,57
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Clematis virginiana	Virgin’s bower	9’ long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2’-5’	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3’-6’	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2’-4’	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1’-2’	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2’-6’	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
elianthus pauciflorus	Prairie sunflower	3’-5’	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2’-4’	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2’-3’	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P/S	N	55,56,57
Liatris scariosa	Savanna blazing star	3’-5’	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2’-4’	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1’-2’	Purple	May-Jul	F/P	N	55,56,57
Phlox divaricata	Wild blue phlox	1’-2’	Blue	Apr-Jun	P/S	N	51,55,56,57
Phlox pilosa	Sand prairie phlox	1’-2’	Pink	May-Aug	F/P	N	56
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1’-3’	White	May-Jul	P/S	N	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Ratibida pinnata	Yellow coneflower	3’-6’	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1’-3’	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2’-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Silphium terebinthinaceum	Prairie-dock	3’-8’	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solo-mon’s seal	1’-3’	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon’s seal	1’-2’	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago juncea	Early goldenrod	2’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1’-3’	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Thalictrum dioicum	Early meadow-rue	1’-3’	Green	Apr-May	P/S	N	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2’-4’	Blue	May-Oct	F/P	N	55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57

Representative Zone E Species

New England Aster

Wild Bergamot

Showy Goldenrod

Tall Bellflower

Wild Geranium

Tall Coreopsis

Redbud

Indian Grass

Source: JFNew

Zone F

Planting Zone = 18+inches above water level

These plants tolerate fluctuating water levels within this range, although they are generally less tolerant than most wetter species. They may tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for upland BMP settings.

Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90'	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100'	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100'	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70'	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80'	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1'-3'	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60'	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25'	Red	Apr-May	F/P/S	N	55,56,57
Cornus florida	Flowering dogwood	30'	White	May-Jun	F/P/S	N	55,56,57
Corylus americana	American hazelnut	10'	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85'	White	Jun	F/P	N	55,56,57
Hamamelis virginiana	Witch hazel	30'	Yellow	Oct-Nov	F/P/S	N	50,51,55,56,57
Juglans nigra	Black walnut	90'	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50'	Brown	Apr-May	F/P	N	55,56,57
Liriodendron tulipifera	Tulip tree	110'	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50'	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100'	Green	May-Jul	F/P/S	Y	51,55,56,57
Pinus banksiana	Jack pine	60'	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100'	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100'	Brown	Jun	F/P/S	N	50,51,55,56,57
Prunus americana	American plum	30'	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30'	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus macrocarpa	Bur oak	85'	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90'	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90'	Green	May-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3'	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100'	Yellow	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100'	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7'	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10'	White	May-Jun	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4'-8'	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1'-2'	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1'-3'	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3'-6'	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3'-5'	Green	Jun-Jul	P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1'-2'	Purple	Aug-Oct	F	N	51,55,56,57
Koeleria macrantha	June grass	1'-2'	White	May-Jul	F/P	N	50,51,55,56,57
Panicum virgatum	Switch grass	3'-6'	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2'-4'	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4'-9'	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6'-7'	Green	Jul-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Stipa spartea	Porcupine grass	2'-4'	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1'-2'	Lavender	Jun-Oct	F/P	N	55,56
Asclepias syriaca	Common milkweed	2'-4'	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1'-3'	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1'-2'	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2'-4'	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3'-5'	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1'-4'	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short's aster	1'-4'	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3'-8'	White	Jun-Oct	F/P/S	N	55,56
Campanulaa americana	Tall bellflower	2'-6'	Blue	Jul-Nov	P/S	N	55,56,57
Clematis virginiana	Virgin's bower	9' long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis lanceolata	Sand coreopsis	1'-2'	Yellow	May-Aug	F/P	N	50,51,55
Coreopsis palmata	Prairie coreopsis	1'-2'	Yellow	Jun-Aug	F/P	N	55
Coreopsis tripteris	Tall coreopsis	4'-8'	Yellow	Aug-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2'-5'	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3'-5'	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3'-6'	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2'-4'	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1'-2'	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2'-6'	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus occidentalis	Western sunflower	2'-4'	Yellow	Aug-Sep	F/P	N	50,51,55,56,57
Helianthus pauciflorus	Prairie sunflower	3'-5'	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4'-6'	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2'-4'	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2'-3'	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris cylindracea	Cylindrical blazing star	1'-2'	Violet	Jul-Oct	F/P	N	51,55,56,57
Liatris scariosa	Savanna blazing star	3'-5'	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Lupinus perennis	Wild lupine	1'-2'	Purple	Apr-Jun	F/P	N	55,56,57
Monarda fistulosa	Wild bergamot	2'-5'	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2'-4'	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1'-2'	Purple	May-Jul	F/P	N	55,56,57
Phlox pilosa	Sand prairie phlox	1'-2'	Pink	May-Aug	F/P	N	56
Polygonatum biflorum	Solomon seal	1'-4'	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1'-3'	White	May-Jul	P/S	N	50,51,55,56,57
Ratibida pinnata	Yellow coneflower	3'-6'	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1'-3'	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Silphium terebinthinaceum	Prairie-dock	3'-8'	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solomon's seal	1'-3'	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon's seal	1'-2'	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1'-2'	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago juncea	Early goldenrod	2'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1'-3'	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2'-4'	Blue	May-Oct	F/P	N	55,56,57
Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Representative Zone F Species

Spiderwort

Butterfly Weed

Yellow Coneflower

Little Bluestem

Foxglove Beardtongue

Wild Lupine

Pale Purple Coneflower

Rattlesnake Master

Sand Coreopsis

Source: JFNew

Zone G

Planter Box Plantings

Although this manual typically recommends using native plants wherever possible, certain situations call for non-native plants due to particular site conditions. Because planter boxes traditionally have a short soil column and are exposed to drier conditions, non-native plants should be considered as long as they are considered non-invasive. Therefore, the list below contains both native and non-native species. Many planter boxes have traditionally used annual flowers. However, we recommend using perennial plants for establishing root systems and lowering maintenance in the long term. Many more species are available for planter boxes than are listed.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun
Ajuga reptans 'Bronze Beauty'	Bronze Beauty Ajuga	6"	Blue	May-Jun	F
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	6"-1'	White	May-Jun	F
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	6"-1'	Blue	Jun-Jul	F
Allium senescens montanum	Mountain Garlic	6"-1'	Pink/Purple	Jun-Aug	F
Allium senescens glaucum	Curly Onion	6"-1'	Pink	Jul-Sep	F
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	6"-1'	Pink	Jul-Aug	F
Aster 'Wood's Light Blue'	Wood's Light Blue Aster	1'-3'	Blue	Aug-Sep	F
Athryium filix-femina	Lady Fern	1'-3'	Green	NA	F/P/S
Blechnum spicant	Deer Fern	1'-2'	Green	NA	F/P/S
Dryopteris erythrosora	Autumn Fern	1'-2'	Green	NA	F/P/S
Euphorbia myrsinites	Mytle Spurge	6"-1'	Yellow	May-Jun	F
Dryopteris intermedia	Fancy Fern	1'-3'	Green	NA	F/P/S
Dyropteris marginalis	Leatherleaf Fern	1'-2'	Green	NA	F/P/S
Geranium x 'Rozanne'	Rozanne Gernaium	1'-2'	Violet	Jun-Sep	F/P
Hemerocallis 'Barbara Mitchell'	Barbara Mitchell Daylily	2'-3'	Pink	Jun-Aug	F/P
Hemerocallis 'Bill Norris'	Bill Norris Daylily	2'-3'	Yellow	Jun-Aug	F/P
Hemerocallis 'Chicago Apache'	Chicago Apache Daylily	2'-3'	Red	Jul-Sep	F/P
Hosta 'Francee'	Francee Hosta	1'-2'	Lavender	Jul-Aug	F/P/S
Hosta 'Guacamole'	Guacamole Hosta	1'-2'	Pink	Aug-Sep	F/P/S
Hosta 'Summer Fragrance'	Summer Fragrance Hosta	1'-2'	Lavender	Aug-Sep	F/P/S
Hosta sieboldiana 'Elegans'	Elegans Hosta	1'-2'	White	Jul-Aug	F/P/S
Sedum 'Autumn Charm'	Autumn Charm Sedum	6"-1'	Pink	Jun-Jul	F
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	6"-1'	Pink	May-Jun	F
Sedum 'Mini Me'	Mini Me Sedum	6"-1'	Green	NA	F
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	6"-1'	Yellow	Jul-Sep	F
Sedum album 'Athoum'	Jelly Bean Sedum	6"-1'	Pink	Aug-Sep	F
Sedum album 'Coral Carpet'	Coral Carpet Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Faro Island'	Faro Island Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Green Ice'	Green Ice Sedum	6"-1'	White	Jun-Jul	F
Sedum album 'Murale'	Wall Sedum	6"-1'	White	Jun-Jul	F
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	6"-1'	Pink	Jul-Aug	F
Sedum divergens	Cascade Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum ellacombianum	Ellacombe's Sedum	6"-1'	Yellow	May-Jun	F
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	6"-1'	Yelow	May-Jun	F
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum grisbachii	Griseback Sedum	6"-1'	Yellow	Jul-Aug	F
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	6"-1'	Yellow	Jun	F
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	6"-1'	Orange	Jul-Aug	F
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	6"-1'	Yellow	May-Jun	F

Representative Zone G Species

Guacamole Hosta

Mountain Garlic

Wall Sedum

Lady Fern

Source: JFNew

Zone H

Vegetated Roof Plantings

Research to-date shows that native plants do not typically thrive in vegetated roofs. Therefore, the list below reflects species that are known to thrive in green roof situations. All species listed below will generally grow to a height of six-to-18 inches.

Botanical Name	Common Name	Color	Bloom Time
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	White	May-Jun
Allium schoenoprasum 'Dwarf'	Dwarf Ornamental Chive	Pink	May-Jun
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	Blue	Jun-Jul
Allium senescens montanum	Mountain Garlic	Pink/Purple	Jun-Aug
Allium senescens glaucum	Curly Onion	Pink	Jul-Sep
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	Pink	Jul-Aug
Euphorbia myrsinites	Mytle Spurge	Yellow	May-Jun
Sedum 'Autumn Charm'	Autumn Charm Sedum	Pink	Jun-Jul
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	Pink	May-Jun
Sedum 'Mini Me'	Mini Me Sedum	Green	NA
Sedum acre 'Aureum'	Gold Leaved Goldmoss Sedum	Yellow	May-Jun
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	Yellow	Jul-Sep
Sedum album 'Athoum'	Jelly Bean Sedum	Pink	Aug-Sep
Sedum album 'Coral Carpet'	Coral Carpet Sedum	White	Jun-Aug
Sedum album 'Faro Island'	Faro Island Sedum	White	Jun-Aug
Sedum album 'Green Ice'	Green Ice Sedum	White	Jun-Jul
Sedum album 'Murale'	Wall Sedum	White	Jun-Jul
Sedum album 'Red Ice'	Red Ice Sedum	White	Jun-Jul
Sedum cautacola 'Bertram Anderson'	Bertram Anderson Sedum	Pink	Jul-Aug
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	Pink	Jul-Aug
Sedum divergens	Cascade Sedum	Yellow	Jun-Jul
Sedum ellacombianum	Ellacombe's Sedum	Yellow	May-Jun
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	Yelow	May-Jun
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	Yellow	Jun-Jul
Sedum grisbachii	Griseback Sedum	Yellow	Jul-Aug
Sedum hispanicum 'Pinkie'	Pinkie Sedum	Pink	Jun-Jul
Sedum hybridum 'Immergunchen'	Evergreen Sedum	Yellow	Jun, Sep
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	Yellow	Jun
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	Orange	Jul-Aug
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	Yellow	May-Jun

*List provided by Hortech, Inc.

Representative Zone H Species

Mountain Garlic

Cascade Sedum

Ellacombe's Sedum

Wall Sedum

Source: JFNew

Appendix G
Recommended Materials

Recommended Materials

Numerous BMPs in this manual have similar material needs. These BMPs are listed in the table below. Detailed information on each material requirement follows. In addition, Porous Pavement and Vegetated Roofs have significant material requirements that are listed according to their individual needs.

	Constructed Filters	Dry Well	Infiltration Trench	Planter Boxes	Porous Pavement	Subsurface Infiltration	Vegetated Filter Strip	Vegetated Swale
Check dams							X	X
Non-Woven Geotextile	X	X	X	X	X	X	X	
Pea Gravel							X	
Peat	X			X				
Pervious Berms							X	
Pipe – 8”	X	X	X	X	X	X	X	
Sand	X			X				X
Stone/Gravel	X			X				
Stone – 30%							X	
Stone – 40%			X		X			

Check dams (Vegetated Filter Strip, Vegetated Swale)

An earthen check dam shall be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02 in to 0.04 in, Gravel: AASHTO M-43 0.5 in to 1.0 in). A stone check dam shall be constructed of R-4 rip rap, or equivalent.

Non-Woven Geotextile (Constructed Filter, Dry Well, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should consist of needled nonwoven polypropylene fibers and meet the following properties:

a. Grab Tensile Strength (ASTM-D4632) 120 lbs min.
b. Mullen Burst Strength (ASTM-D3786) 225 psi min.
c. Flow Rate (ASTM-D4491) 110 gal/min/ft2 min.
d. UV Resistance after 500 hrs (ASTM-D4355) 70% min.
e. Puncture strength (ASTM D-4833-00) 90 lb. min.
f. Apparent opening size (ASTM D-4751-99A) 60-70 US Sieve

Heat-set or heat-calendared fabrics are not permitted. Acceptable types include Mirafi 140N, Amoco 4547, Geotex 451, or approved others.

Pea Gravel (Vegetated Filter Strip)

Clean bank-run gravel may also be used and should meet ASTM D 448 and be sized as per No.6 or 1/8” to 3/8”.

Peat (Constructed Filter, Planter Boxes)

Should have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.

Pervious Berms (Vegetated Filter Strip)

The berm shall have a height of 6-12 in and be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02”-0.04”, Gravel: AASHTO M-43 ½” to 1”)

Pipe - (Dry Well, Porous Pavement, Subsurface Infiltration, Constructed Filter, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should be continuously perforated, smooth interior, with a minimum inside diameter as required. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or M294, Type S (12 gauge aluminum or pipe may also be used in seepage pits).

Sand (Constructed Filter, Planter Boxes, Vegetated Swale)

Should be ASTM-C-33 (or AASHTO M-6) size (0.02” – 0.04”), concrete sand, clean, medium to fine sand.

Stone/Gravel (Constructed Filter, Planter Boxes):

Should be uniformly graded coarse aggregate, 1 inch to ½ inch with a wash loss of no more than 0.5%, AASHTO size number 5 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and have voids of 40% as measured by ASTM-C29.

Stone – 40% voids (Infiltration Trench, Porous Pavement, Subsurface Infiltration Bed,)

Infiltration trenches should have stone 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids 40% as measured by ASTM-C29.

Porous Pavement

General

Choker base course aggregate for beds shall be 3/8 inch to 3/4 inch clean, uniformly-graded, coarse, crushed aggregate AASHTO size number 57 per Table 4, AASHTO Specifications, Part I, 19th Ed., 1998 (p. 47).

Porous Asphalt

Bituminous surface course for porous paving shall be 2.5 to 3 inches thick with a bituminous mix of 5.75% to 6.75% by total weight as determined by testing below. Use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of PG 76-22P (in northern Michigan, use PG 76-28P as appropriate) as specified in AASHTO MP-1. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Determination of optimal asphalt content should be determined according the following tests:

- Draindown Test (ASTM Method D6390)
- Moisture Susceptibility Test using the Modifed Lottman Method (AASHTO T283) with the following:
  - Compact using 50 gyrations of Superpave gyratory compactor
  - Apply partial vacuum of 26 inches of Hg for 10 minutes to whatever saturation is achieved.
  - Keep specimens submerged in water during freeze cycle.
  - Required retained tensile strength (TSR) >= 80%
- Air Voids Test (AASHTO T269/ASTM D3203)

Hydrated lime, if required, shall meet the requirements of AASHTO M 303 Type 1 and shall be blended with the damp aggregate at a rate of 1.0% by weight of the total dry aggregate. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

Fibers, if used, shall consist of either cellulose fibers or mineral fibers which are to be treated with a cationic sizing agent to enhance dispersement of the fiber as well as increase cohesion of the fiber to the bitumen. Fiber is to be added at a dosage rate between 0.2% and 0.4% by weight of total mix.

- Mineral fibers shall be from virgin, basalt, diabase, or slag with a maximum average fiber length of 6.35 mm and a maximum average fiber thickness of 0.005 mm.
- Cellulose fiber – Fiber length shall be 6.4 mm (max), Ash Content 18% non-volatiles (±5%), pH 7.5 (± 1), Oil absorption (times fiber weight) 5.0 (± 1), Moisture Content 5.0 (max).

Porous Concrete

The use of Installers or Craftsmen who have been certified by the NRMCA's Pervious Concrete Contractor Certification Program is strongly recommended. Contractor shall furnish a proposed mix design with all applicable information to the Engineer prior to commencement of work. Critical mix characteristics typically include the following:

- Cement Content: 550 to 650 lb/cy
- Fine aggregate, if used: maximum 3 cu. ft. per cu. yd.
- Admixtures: use in accordance with the manufacturer's instructions and recommendations
- An aggregate/cement (A/C) ratio: 4:1 to 4.5:1
- Water/cement (W/C) ratio: 0.27 to 0.34
- Curing: shall begin within 15 minutes after placement and continue for 7 days

The data shall include unit weights determined in accordance with ASTM C29 paragraph 11, jigging procedure.

Cement: Portland Cement Type II or V conforming to ASTM C150 or Portland Cement Type IP or IS conforming to ASTM C595. The total cementitious material shall be between 550 and 650 lb./cy.

Aggregate: Use No 8 coarse aggregate (3/8 to No. 16) per ASTM C33 or No. 89 coarse aggregate (3/8 to No. 50) per ASTM D 448. If other gradation of aggregate is to be used, submit data on proposed material to owner for approval. The volume of aggregate per cu. yd. shall be equal to 27 cu.ft. when calculated as a function of the unit weight determined in accordance with ASTM C 29 jigging procedure. Fine aggregate, if used, should not exceed 3 cu. ft. and shall be included in the total aggregate volume.

Air Entraining Agent: Shall comply with ASTM C 260 and shall be used to improve workability and resistance to freeze/thaw cycles.

Admixtures: The following admixtures shall be used:

- Type D Water Reducing/Retarding – ASTM C 494.
- A hydration stabilizer that also meets the requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding admixtures may be used. This stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles from achieving initial set.

Water: Potable shall be used and shall comply with ASTM C1602. Mix water shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (Mix water yielding a cement paste with a dull-dry appearance has insufficient water for hydration).

- Insufficient water results in inconsistency in the mix and poor bond strength.
- High water content results in the paste sealing the void system primarily at the bottom and poor surface bond.

An aggregate/cement (A/C) ratio range of 4:1 to 4.5:1 and a water/cement (W/C) ratio range of 0.27 to 0.34 should produce pervious pavement of satisfactory properties in regard to permeability, load carrying capacity, and durability characteristics.

Vegetated roofs

Some key components and associated performance-related properties are as follows:

Root-barriers should be thermoplastic membranes with a thickness of at least 30 mils. Thermoplastic sheets can be bonded using hot-air fusion methods, rendering the seams safe from root penetration. Membranes that have been certified for use as root-barriers are recommended. At present only FLL offers a recognized test for root-barriers. Several FLL-certified materials are available in the United States. Interested American manufactures can submit products for testing to FLL-certified labs.

Granular drainage media should be a non-carbonate mineral aggregate conforming to the following specifications:

- Saturated Hydraulic Conductivity >= 25 in/min
- Total Organic Matter, by Wet Combustion (MSA) <= 1%
- Abrasion Resistance (ASTM-C131-96) <= 25% loss
- Soundness (ASTM-C88 or T103 or T103-91) <= 5% loss
- Porosity (ASTM-C29) >= 25%
- Alkalinity, CaCO3 equivalents (MSA) <= 1 %
- Grain-Size Distribution (ASTM-C136)
  - Pct. Passing US#18 sieve <= 1%
  - Pct. Passing ¼-inch sieve <= 30%
  - Pct. Passing 3/8-inch sieve >= 80%

Growth media should be a soil-like mixture containing not more than 15% organic content (wet combustion or loss on ignition methods). The appropriate grain-size distribution is essential for achieving the proper moisture content, permeability, nutrient management, and non-capillary porosity, and 'soil' structure. The grain-size guidelines vary for single and dual media vegetated cover assemblies.

Non-capillary Pore Space at Field Capacity, 0.333 bar (TMECC 03.01, A)	>= 15% (vol)
Moisture Content at Field Capacity (TMECC 03.01, A)	>= 12% (vol)
Maximum Media Water Retention (FLL)	>= 30% (vol)
Alkalinity, Ca CO3 equivalents (MSA)	<= 2.5%
Total Organic Matter by Wet Combustion (MSA)	3-15% (dry wt.)
pH (RCSTP)	6.5-8.0
Soluble Salts (DTPA saturated media extraction)"(RCSTP)	<= 6 mmhos/cm
Cation exchange capacity (MSA)	>= 10 meq/100g
Saturated Hydraulic Conductivity for Single Media Assemblies (FLL)	>= 0.05 in/min
Saturated Hydraulic Conductivity for Dual Media Assemblies (FLL)	>= 0.30 in/min

Grain-size Distribution of the Mineral Fraction (ASTM-D422)

Single Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	<= 5%
Pct. Passing US#60 sieve	<= 10%
Pct. Passing US#18 sieve	5 - 50%
Pct. Passing 1/8-inch sieve	0 - 70%
Pct. Passing 3/8-inch sieve	75 -100%

Dual Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	5-15%
Pct. Passing US#60 sieve	10-25%
Pct. Passing US#18 sieve	20 - 50%
Pct. Passing 1/8-inch sieve	55 - 95%
Pct. Passing 3/8-inch sieve	90 -100%

Macro- and micro-nutrients shall be incorporated in the formulation in initial proportions suitable for support the specified planting.

Separation fabric should be readily penetrated by roots, but provide a durable separation between the drainage and growth media layers (Only lightweight nonwoven geotextiles are recommended for this function.

- Unit Weight (ASTM-D3776) <= 4.25 oz/yd2
- Grab tensile (ASTM-D4632) <= 90 lb
- Mullen Burst Strength (ASTM-D4632) >= 135 lb/in
- Permittivity (ASTM-D4491) >= 2 per second

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Golder Associates

REPORT

GRAND TRUNK PARK OPERATIONS & MANAGEMENT PLAN

Stormwater Management

Low Impact Developments / Green Infrastructure

Landowner – State of Michigan
P.O. Box 30028
Lansing, MI 48909

Submitted To: West Michigan Shoreline Regional Development Commission
316 Morris Avenue
Suite 340
Muskegon, Michigan 49440

Submitted By: Golder Associates Inc.
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Distribution: One electronic copy

March 7, 2017

Project No.1520593

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EXECUTIVE SUMMARY

The Operations and Management (O&M) Plan summarizes the best management practices (BMPs) and low impact development (LID) designs recommended for Grand Trunk Park for improving stormwater management as shown in the Conceptual Plan (Appendix A). Each structural BMP requires maintenance for continued efficiency, which is summarized within the plan. Included in the appendices of the report is a maintenance summary for each BMP (Appendix B, C, and D), and example checklists to be used for routine inspections (Appendix E). The plan provides guidance regarding management of vegetation, a list of recommended Michigan species (Appendix F), and other recommended materials for the BMPs (Appendix G). Operations and maintenance costs were analyzed for each development and maintaining the site.

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1.0 GRAND TRUNK PARK

Grand Trunk Park is located in Muskegon, Michigan within the Muskegon Lake Direct Drainage Watershed. The site is city owned and located on the lakeshore of Muskegon Lake. The watershed receives stormwater from heavily urbanized areas and the city's storm sewer system. The polluted stormwater discharged to the watershed has resulted in degraded benthic communities, organic chemicals, excessive sediment, and flashy hydrology.

With grant support from the Michigan Department of Environmental Quality and the US Environmental Protection Agency, the Muskegon Lake Watershed Partnership, West Michigan Shoreline Regional Development Commission, municipal partners and Golder Associates, Inc. recommended design solutions to reduce stormwater runoff, stormwater pollutants, and improve water quality within Grand Trunk Park and the Muskegon Lake Direct Drainage Watershed (Appendix A). Stormwater LID designs recommended for the site include five rain gardens, and four bioswales.

2.0 MAINTENANCE COSTS

Stormwater LID designs tend to be less expensive to implement than conventional designs, however they do require long term maintenance to ensure the designs continue to work efficiently. A cost analysis was completed for the Grand Trunk Park maintenance costs at annual and long term rates. Two types of structural BMPs were assessed including rain gardens and bioswales. The total annual cost for maintaining the Grand Trunk Park was estimated at $15,571. The estimated maintenance cost include aesthetic, nuisance materials, and functional maintenance. Functional maintenance assures the BMP is performing efficiently and safely, while aesthetic and nuisance materials maintenance is mainly for public acceptance, which can help to reduce functional costs. The percentage of construction cost used for each BMP reflects labor, landscaping, and material costs. Annual maintenance costs were based on taking a percentage of the total construction costs, based on a low impact development cost comparison completed by Emmons & Oliver Resources, Inc. (EORINC 2015). BMPs were estimated to require approximately 5% to 6% of construction costs for routine and non-routine maintenance. Operation and maintenance costs for the BMPs are summarized in Table 1. Annual maintenance cost was based on a percentage of the total construction costs. A typical year of landscaping includes maintenance such as lawn mowing, removal of debris and litter, replanting or seeding vegetation, and replenishing mulch. Maintenance labor is expected to be greater within the first two to three years as vegetation is established.

Table 1. Operation and Maintenance Costs Summary

Stormwater BMP	Construction Cost ($)	Annual Maintenance Cost (% of Construction Cost)	Annual Maintenance Cost ($)
Rain Garden (without underdrain)	137,754	5	6,888
Bioswale	144,720	6	8,683
Total Costs			**15,571**

2.1 Rain Garden

The Grand Trunk Park conceptual stormwater development plan includes five rain gardens encompassing approximately 10,300 square feet. The rain gardens consist of a geotextile filter layer, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Regular maintenance of the rain gardens is required within the first two to three years when vegetation is becoming established. Less maintenance is required after vegetation becomes established and the density of vegetation coverage increases. All maintenance requirements for the rain gardens can be viewed in Appendix B. A summary of maintenance cost for the rain gardens is provided in Table 1. The annual operations and maintenance cost for the rain gardens was calculated as 5% of the construction costs. The annual cost to maintain the five rain gardens is $6,888.

2.2 Bioswale

There are four bioswales implemented in the Grand Trunk Park stormwater management plan. The bioswales cover approximately 10,720 square feet, each approximately eight feet wide and totaling 1,340 linear feet. Bioswales consist of a geotextile filter, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Similar to the rain gardens, the bioswales will be planted with native species and require more maintenance within the first two to three years while vegetation is being established. Routine maintenance items for the bioswales are summarized in Appendix C. The annual maintenance cost of bioswales in the park was calculated as 6% of the construction cost, totaling $8,683.

3.0 ROUTINE INSPECTIONS

Routine inspections of BMPs should be completed at least once every year. Example inspection checklists are included in Appendix D. Inspection checklists vary depending on the type of LID design. The stormwater designs in the Grand Trunk Park do not include underdrain and overflow systems, so such items on the checklist are not applicable to the site. The example bioretention inspection checklist can be used for inspection of the rain gardens. Rain gardens and bioswales should be inspected for debris, erosion, vegetation conditions and coverage, and mulch thickness to determine overall functionality. Based on the

selection of native plants used for each BMP, additional species specific inspections may be required. Inspections of vegetation should include determining the overall plant health, checking if plants require trimming or pruning, and assuring invasive species are properly managed.

4.0 VEGETATION

The plant species selected the BMPs have a significant impact on the effectiveness of the design. Vegetation will require regular maintenance within the first few years while becoming established. Maintenance involves watering plants as needed, and removing invasive species. Once vegetation is established, less maintenance will be required to maintain the BMP areas.

4.1 Native Species

Native plants are implemented in the design because they have deeper and more expansive roots leading to increased infiltration, groundwater recharge and biofiltration. Native plants are also more tolerant to flooding and drought conditions enabling them to thrive in rain gardens and bioswales. Plugs and gallons are common sizes of native plants that can be installed in BMPs. A plug is a small plant that grows in a container roughly two inches wide and five inches deep. A gallon is a more mature plant available in gallon size container. Both sizes of plants require consistent watering during early development (Delta Institute 2015). Suggested species include: cardinal flower (*Lobelia cardinalis*), blue lobelia (*Lobelia siphilitica*), New England aster (*Aster novae-angliae*), and brown fox sedge (*Carex vulpinoidea*). A full list of recommended Michigan plants for BMPs is included in Appendix E (SEMCOG 2008). Additional grasses and wildflowers that could tolerate wet growing conditions recommended by the West Michigan Environmental Action Council include: cotton grass (*Eriophorum angustifolium*), golden alexanders (*Zizia aurea*), and blue flag iris (*Iris versicolor*) (WMEAC 2016). A full list of recommended Michigan plants for BMPs is included in Appendix F (SEMCOG 2008).

4.1.1 Planting Requirements

Maintenance will be required for any plants that do not successfully grow in the planted environment, and an alternative species may need to be planted. Seeding is not the preferred method of planting vegetation since high velocity flows may prevent the seedlings from establishing. Plugs or gallon-potted plants installed at one to two foot intervals are recommended for effective establishment of vegetation. Trees and shrubs are also recommended. Seeding should be completed from late April to mid-October if irrigation is available. If irrigation is not available, than seeding can be completed from June 15 or mid-August to mid-October. With dormant seeding, seeding can be completed from November 1 to 30. At all other times of the year, seeding should have a temporary cover (made of oats/cereal rye or other small grain). Plugs and gallons should be installed from May 1 – June 15. Trees and shrubs should be planted from the middle of April through early June, or the middle of September through the middle of November. A maximum of two to three inches of mulch should be evenly spread in the BMPs after installing new plants to help prevent

erosion, remove metals, and act as leaf litter in a natural forest environment. The mulch should not be placed directly against the stems of the newly planted vegetation. If wildlife is a threat to newly installed plants additional precautions such as waterfowl barriers are maintenance options.

4.2 Invasive Non-Native Species

Invasive species are not native to the area and tend to grow and spread quickly without natural controls. If unmanaged, invasive species will displace native species (SEMCOG 2008). Maintenance of invasive species is crucial when native plants are being established. Invasive species can be removed by hand–pulling, mowing, or spot herbicide applications. After native species are established, less maintenance of invasive species is needed. Long term management of invasive species may require removal once every year or as needed. Open areas may require mowing if woody vegetation is noticed encroaching, typically every 3-5 years.

5.0 WINTER CONDITIONS

Winter conditions in Michigan typically include the buildup of snow and the use of de-icing compounds which can negatively affect plant life. Salt tolerant plants are recommended for sites where de-icing and heavy snow occurs. Recommended products for de-icing are nontoxic and organic, such as magnesium chloride-based liquid products or pretreated salt (Delta Institute 2008). Sand and cinder from melted snow has the potential of reducing infiltration into the soil (SEMCOG 2008). Preventative measures should be taken to avoid the buildup or piling of snow over infiltration systems.

In the spring, the rain gardens and bioswales should all be assessed for winter damages. Buildup of debris and sediment should be cleared, and mulch should be evenly spread in any eroded or high areas with a maximum of two to three inches. Plants may also require trimming or rehabilitation. Soil aeriation may also be required in spring to reduce impacts of de-icing agents.

6.0 EDUCATION AND TRAINING

All personnel responsible for the operations and maintenance of the BMPs should undergo training to fully understand the care required for each LID design. Training should include reading the O&M plan and discussing procedures with someone of experience. An educated maintenance staff will increase the efficiency and sustainability of the designs.

7.0 REFERENCES

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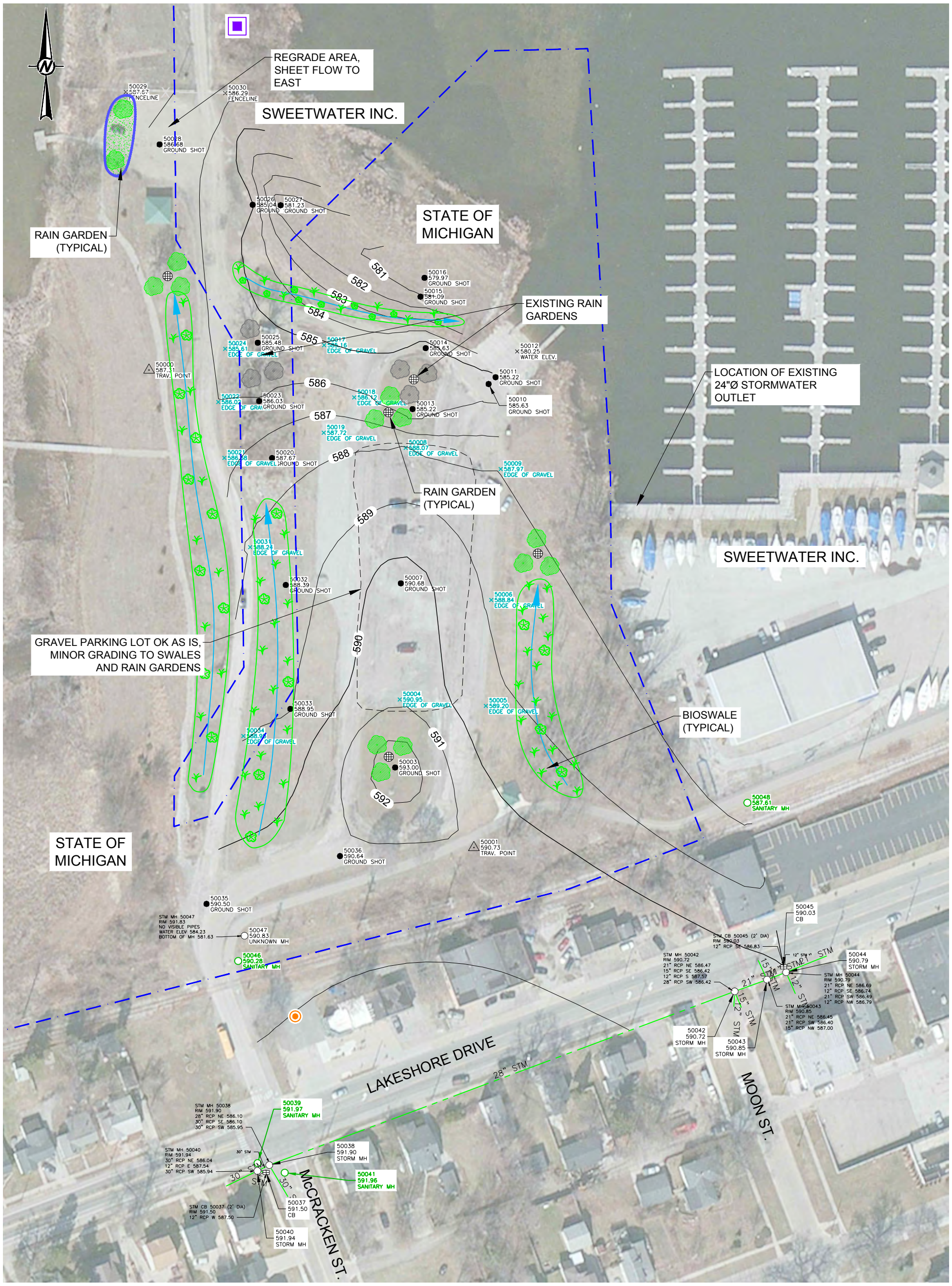
Appendix A
Grand Trunk Park Conceptual Plan



LEGEND

- PARCEL BOUNDARY
- OPEN LUST (PART 213)
- PART 201 SITE OF ENVIRONMENTAL CONTAMINATION

NOTE(S)

1. THE GRAND TRUCK PARK SITE IS APPROXIMATELY 25.3 ACRES PARCEL AREA AND 12.7 ACRES WATERSHED TREATMENT AREA.
2. THE GRAND TRUCK PARK SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 50 100
1" = 100' FEET

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WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
GRAND TRUNK PARK

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			1

Appendix B
Rain Garden Maintenance Items

RAIN GARDEN

1.0 PUROPOSE

Rain gardens are used to collect stormwater runoff and encourage infiltration and biofiltration with the use of native plants. Native plants are ideal for rain gardens because they have deeper root networks that draw surface water further into the ground. Native plants are also typically drought and flood tolerant and able to thrive in rain gardens. Rain gardens aide in reducing runoff volume, filtering pollutants, recharging groundwater (if no underdrain is used), reducing stormwater temperature impacts, and enhancing site aesthetics.

2.0 MAINTENANCE

Rain gardens require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered and weeded twice weekly through October of the first year and in times of extreme drought. Weeds should be removed by hand.

3.) Organic matter may also need to be removed approximately twice per year, usually by hand.

4.) Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

5.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

6.) Annual mowing should be performed for the first three years of establishment. Mowing should not be completed on a regular basis.

7.) Removal of debris must occur monthly for the life of the rain garden.

8.) Winter conditions may result in plants being effected by deicing chemicals in snow-melt, in this case salt-tolerant plants should be used. Also try to reduce the amount of sand, cinders, and other winter abrasives that come in contact with the vegetation. Additional maintenance in the spring is required to remove abrasives if used.

9.) Rain gardens should be inspected at least twice a year for sediment buildup, erosion, and overall vegetation conditions. If sediment build up reaches 25% of the ponding depth it should be removed. If erosion is occurring, soil stabilization efforts should be applied. If vegetation is in poor health for no apparent reason, a landscape architect should be consulted.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix C
Bioswale Maintenance Items

BIOSWALE

1.0 PUROPOSE

Bioswales are shallow, vegetated, earthen channels that help to slow, filter, and infiltrate stormwater runoff in the process of conveyance. Native plants are ideal vegetation for bioswales due to their deep roots for infiltrating runoff, and their high tolerance for droughts and floods.

2.0 MAINTENANCE

Bioswales require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Vegetation should be established as soon as possible to prevent erosion and scour. Freshly seeded swales require soil stabilization such as erosion control matting or blankets. Erosion controls for seeded swales are required after planting for 75 days after the first storm event occurs. If runoff velocities are high, sodding the swale or diverting runoff until vegetation is well established is an option.

4.) Debris removal, weeding, and pruning should be performed on a monthly basis.

5.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity issues are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

6.) Mow and trim plants within the bioswales annually to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Mow only when dry to avoid rutting. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

7.) In the spring the bioswales will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

8.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

9.) If roadside or parking lot runoff is directed to the swale, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix E
Example Inspection Checklists

Maintenance Inspection Checklists

This appendix contains four checklists available as guides for maintenance inspections of specific BMPs. The maintenance items have been adapted from multiple stormwater programs, including the Rouge River Detention Basin Maintenance Manual, Georgia Stormwater Management Manual, the Vermont Stormwater Management Manual, and the Stormwater Manager's Resource Center.

The checklists are designed to help identify key components of BMPs that require ongoing maintenance as well as a basic schedule of when the maintenance should occur. The checklists have been divided into those items essential for the general operation and functionality of the BMP and those items that optional and may enhance the BMP.

It is suggested that the inspection be undertaken by a licensed PE and/or a person knowledgeable about the design and function of the BMP.

These BMP checklists include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

Detention BMP Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet Pipes			
Structural integrity of inlet/outlet (Are any inlet pipes broken, crumbling, separated?) List Inlet Pipes Approximate Diameter and Type of Material Inlet Pipe 1 _____ Inlet Pipe 2 _____ Inlet Pipe 3 _____ Outlet Pipe Size/Type _____		A	
Riprap at inlet pipe (Is the riprap still present? Is it visible and not covered with sediment?		A	
Stone around outlet pipe (Is the stone clogged with debris and/or sediment?)		A	
Trash or debris blocking inlet/outlet (Inspect to ensure no major obstructions hindering general functionality)		M	
Inspect/clean catch basin upstream of the BMP if accessible.		A	
Inspect inlets and outlet for erosion (Are there eroded areas around the pipes?)		A	
Inspect overflow spillway for signs of erosion.			
Pretreatment (if applicable) (Might include sediment forebay, upstream catch basin, bioswale, rain garden, swirl concentrator)			
Device functioning to trap/collect sediment		A	
Remove accumulated sediment as appropriate for the pretreatment device. forebay		A	
Detention Pond		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inspect side slopes, berms and emergency overflow for erosion		A	
Reestablish permanent native vegetation on eroded slopes		As needed	
Inspect for excess sediment accumulation in pond if not pretreatment device is present		A	
Overall functionality			
Ensure pond is functioning properly (Professional Civil Engineer is recommended)		A	
Ensure the outlet is functioning properly (Professional Civil Engineer is recommended)		A	
Optional/Enhancements			
Maintain 15-20 feet “no mow and chemical free” zone		A	
Mow (or burn) the “no mow” zone		A	
Inspect basin and “no mow” zone for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation in and around pond.		A	
Complaints from residents (note on back)		S	
Encroachment on pond/no- mow zone.		A	
Unauthorized plantings		A	
Aesthetics (e.g., graffiti, unkept maintenance)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Summary

Inspector’s remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Infiltration BMPs Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		A	
Pretreatment for sediment			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure infiltration device is functioning properly (professional civil engineer is recommended)		A	
BMP infiltration surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		S	
Evidence of erosion present		A	
Aggregate (if applicable)			
Surface of aggregate clean		A	
Any replacement of aggregate needed? If clogged with sediment replacement is necessary for continued proper function.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Vegetated surface (if applicable)			
Vegetative cover exists		A	
Optional considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation or creating a native plant infiltration basin area.		A	
Complaints from residents (note on back)		A	
Mowing done when necessary		A	
No fertilizer unless testing requires it		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioretention Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway or catch basin clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		Every 5 years	
Pretreatment for sediment (Generally consists of catch basin or velocity dissapator at inlet such as area of riprap/ collection for sediment)			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure bioretention area is functioning properly (professional civil engineer is recommended)		A	
Bioretention area surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		M	
Evidence of erosion present		A	
Does good vegetative cover exist		A	
Mulch covers entire area (no voids) and to specified thickness		A	
Optional considerations			
Inspect BMP for invasive species.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioswale, Filter Strip Inspection Checklist

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Pretreatment/ Energy Dissipators			
No evidence of flow going around structures		A	
No evidence of erosion		A	
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
BMP surface			
Area free of debris?		M	
No evidence of erosion		A	
Does sediment accumulation currently require removal?		A	
Overall functionality			

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Ensure swale is functioning properly (professional civil engineer is recommended)		A	
Optional Considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Appendix F
List of Michigan Recommended Plants

Recommended Plant Lists for Best Management Practices

This appendix contains recommended native and non-native (when appropriate) plant species for the Best Management Practices detailed throughout the manual. Species have been recommended based on hardiness, aesthetics, functionality, and commercial availability. It is certain that species exist outside the confines of this list that will perform in a comparable way to those listed; however, commercial availability is often a limiting factor in obtaining material for native plantings. Over time, and in certain locales, additional species will become available to supplement those listed below.

An array of planting zones is provided based on normal water levels (Figure C.1). Using these zones will provide the best chances for long-term success of native planting in the context of LID. While plants may naturally occur outside of the given ranges, these ranges are intended to be guidelines for plant installation. Whenever possible and practical in standing water conditions, native plants should be installed in live plant form (rather than seed). Seed or a combination of seed and live plants may be used in upland situations.

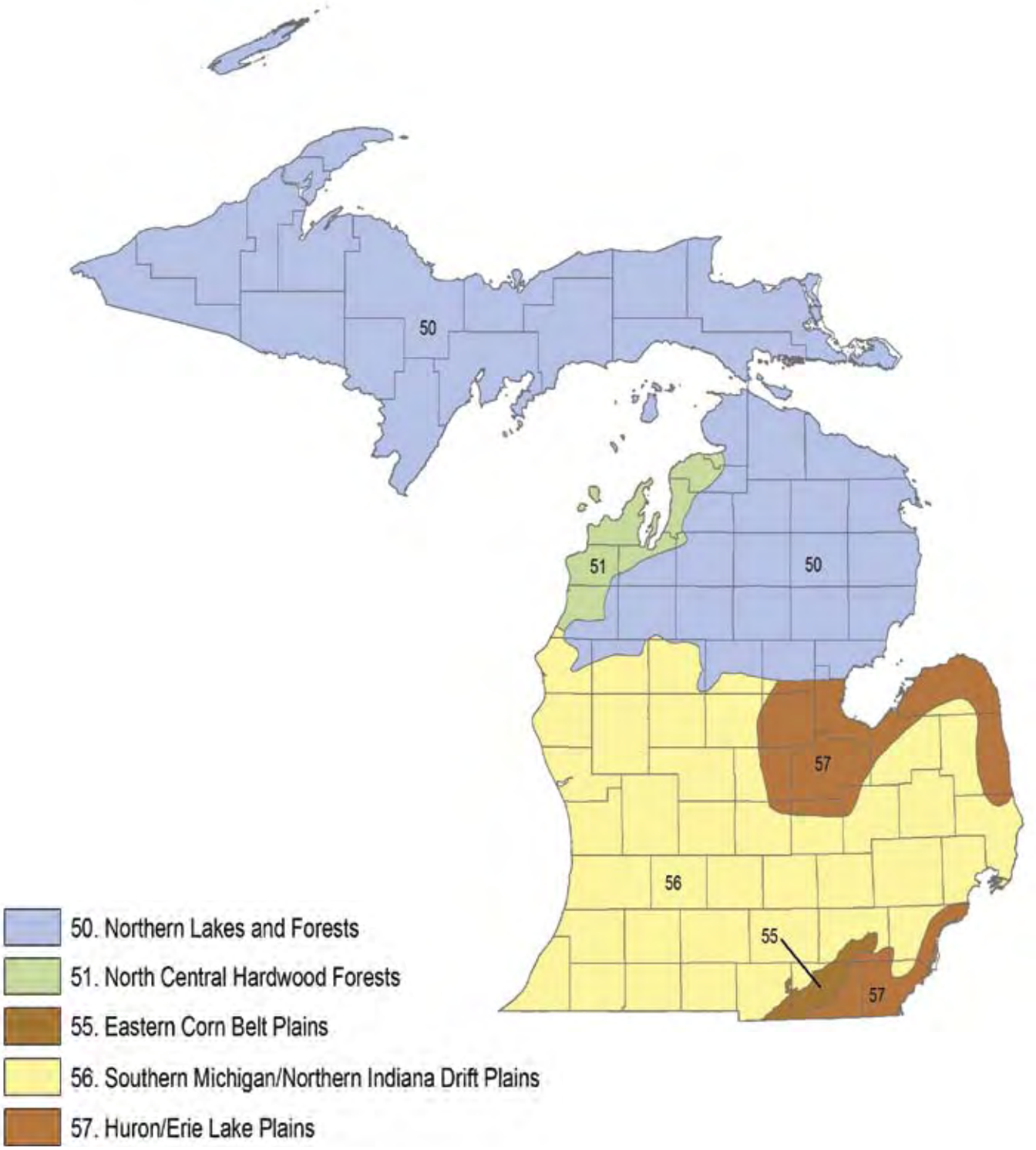
Recommendations are given for height, bloom color, bloom time, sun requirements, salt tolerance, and ecoregion. Please note that these are recommendations based on a range of situations, and a specific plant or population may vary from site-to-site. For sun requirements, F = Full sun required, P = Partial sun tolerated, and S = Shade tolerated. Salt tolerance is classified as Yes (Y) or No (N). This was determined through literature reviews and anecdotal evidence. If there is no information confirming tolerance, a "No" was listed.

Figure C.1
Planting Zone/BMP Matrix

	Zone A — 2"-4" Below Water Level	Zone B — 0"-2" Below Water Level	Zone C — 0"-2" Above Water Level	Zone D — 2"-4" Above Water Level	Zone E — 4"-18" Above Water Level	Zone F — 18"+ Above Water Level	Zone G — Planter Boxes	Zone H — Vegetated Roofs
Rain gardens/Bioretention	✤	✤	✤	✤	✤	✤		
Vegetated Filter Strips			✤	✤	✤	✤		
Vegetated Swales		✤	✤	✤				
Infiltration Basin		✤	✤					
Subsurface Infiltration Basins				✤	✤	✤		
Infiltration Trenches				✤	✤	✤		
Infiltration Berns	✤	✤	✤	✤	✤	✤		
Planter Boxes							✤	
Vegetated Roofs								✤
Constructed Wetlands	✤	✤	✤	✤				
Wet Ponds	✤	✤	✤					
Dry Extended Detention Basins			✤	✤	✤	✤		
Riparian Corridor Restoration			✤	✤				
Native Revegetation	✤	✤	✤	✤	✤	✤	✤	✤

Ecoregion recommendations are also provided for each species (Figure C.2). Whenever possible, the designer/ installer should seek to use species that historically occurred in the same ecoregion as the project. When necessary, species occurring in an adjacent ecoregion may be used.

Figure C.2
EPA Level III Ecoregions for Michigan



Source: USEPA

Plant Installation

Native Seeding

Seasonal consideration: October 1-June 15 (note: seeds should not be planted on frozen ground).

Native seeding is generally recommended for areas above the water line or 1-2" below the water line. Live plant material should be used to establish vegetation at deeper water levels.

Broadcast seeding

Broadcast seeding is preferred over drill seeding on graded, bare soil sites. Apply the seed uniformly over the surface using a combination seeder/cultipacker unit such as a Brillion or Truax Trillion seeder. The Trillion seeder is preferred as it is designed to handle native seeds.

A cone seeder or other similar broadcasting equipment may also be used if the seed mix does not contain fluffy seeds in amounts sufficient to prevent free flowing without plugging. Seed should then be pressed into the surface using a cultipacker or roller.

Drill seeding

A rangeland-type no-till drill designed to plant native grasses and forbs may be used in bare soils although this equipment is specifically designed to plant through existing vegetation which is killed with an herbicide. Cultipacking or rolling before seeding may be required to prevent seed placement depths exceeding .25 inch, but cultipacking or rolling after seeding is not required.

All seeding equipment, whether broadcast or drill, should be calibrated to deliver the seed at the rates and proportions specified in the plans. Equipment should be operated to ensure complete coverage of the entire area to be seeded, and seed must be placed no deeper than .25 inch in the soil. No fertilizers or soil conditioners will be required or allowed.

Native Planting

Seasonal considerations: May 1-July 1

Plant plugs should be installed in holes drilled with an auger the same diameter and depth as the plug within +0.75 inch/- 0.25 inch. In wetland plantings where soil is soft and moist enough, a dibble bar or trowel may also be used. The planting layout should consider the requirements of the individual species regarding soil type, moisture, slope, shading, and other factors for the particular plant species.

Planting densities vary according to budget and project goals and can range from three-to-five foot spacing for plug supplements of seeded areas to six inches to two foot spacing for high visibility landscaping projects with large budgets. Groups of five-to-seven plugs of the same species planted approximately one foot apart is usually preferable to planting all species intermixed randomly across the site at a uniform density.

In wetland or shoreline areas with potential for high wave action or wildlife predation that may dislodge newly planted plugs, plugs should be secured with six inch or eight inch U-shaped wire erosion control blanket staples. Staple length is determined by the density of the planting substrate; softer substrates require longer length to hold plugs adequately.

In areas where potential for wildlife predation exists, such as retention basins or other planting areas adjacent to open water, waterfowl barriers should be installed around a minimum of 50 percent of the plugs. All plugs not protected by barriers should be stapled into the substrate as described above. Barriers may consist of plastic or wire mesh enclosures supported with wooden stakes, adequately constructed to inhibit access by waterfowl for one growing season. Enclosures should extend at least two feet above the plant tops. Methodology should be approved by the project designer with input from a restoration ecologist if necessary. Barriers may be removed after one growing season.

Maintenance and Management

Maintaining vegetated BMPs is typically most important during the first few years following installation. Supplemental irrigation may be needed to help establish plants in drought conditions. Plants may need to be replaced due to predation or other unseen factors. Most commonly, management includes removing invasive species via mowing, hand-pulling, or spot herbicide applications. In larger areas, broadcast herbicide applications may be appropriate. Over time in upland areas, controlled burning may be used as a way to invigorate the plantings and control certain invasive species. If not feasible for social or cultural reasons, an annual or biennial mowing may be used instead of fire.

Long-term management may be necessary, but is typically significantly less intensive. The site should be periodically checked for invasive species infestations. Any prairie or open area may need occasional (every three to five years) burning or mowing to remove woody vegetation that may encroach.

Zone A

Planting Zone = two-to-four inches below water level

These species require continual inundation within the given water depths in order to thrive. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for a majority of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57

Representative Zone A Species

Buttonbush

Pickerel Weed

Swamp Milkweed

Arrowhead

Blue Flag Iris

Source: JFNew

Zone B

Planting Zone = zero-to-two inches below water level

These species tolerate fluctuating water levels within this range. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for most of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-Jun	F	N	50,51,55,56,57
Carex lacustris	Lake sedge	2’-4’	Brown	May-Jun	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Alisma plantago-aquatica	Water plantain	2’-4’	White	Jul-Sep	F	N	50,51,55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard’s tail	2’-4’	White	Jun-Aug	P/S	N	55,56,57

Representative Zone B Species

Blue Flag Iris

Arrowhead

Bristly Sedge

Pickerel Weed

Swamp Milkweed

Source: JFNew

Zone C

Planting Zone = zero-to-two inches above water level

These plants are tolerant of fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Alnus rugosa	Speckled alder	25’	Brown	Mar-May	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Cephalanthus occidentalis	Buttonbush	15’	White	Jun/Aug	F/P/S	N	51,55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	Y	55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Grasses/Sedges/Rushes:							
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Forbs:							
Alisma plantago-aquatica	Water plantain	2'-4'	White	Jul-Sep	F	N	50,51,55,56,57
Anemone canadensis	Canada anemone	1'-2'	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6'-9'	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3'-5'	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3'-6'	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3'-6'	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1'-4'	White	Jul-Oct	F/P	N	50,51,55,56,57
Cassia hebecarpa	Wild senna	3'-5'	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2'-4'	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Eupatorium maculatum	Spotted Joe-pye weed	4'-7'	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3'-5'	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1'-3'	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3'-5'	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5'-12'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2'-3'	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3'-5'	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3'-8'	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2'-5'	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1'-4'	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1'-3'	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2'-4'	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2'-5'	Pink	Aug-Oct	F	Y	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1'-3'	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3'-10'	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Sagittaria latifolila	Arrowhead	1'-4'	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard's tail	2'-4'	White	Jun-Aug	P/S	N	55,56,57
Sisyrinchium angustifolium	Stout blue-eyed grass	1'	Blue	May-Aug	F/P	N	55,56,57
Solidago ohiensis	Ohio goldenrod	2'-3'	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3'-6'	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell's goldenrod	2'-5'	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3'-6'	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2'-5'	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3'-6'	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3'-6'	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3'-5'	Purple	Jul-Sep	F	N	55,56,57
Zizia aurea	Golden Alexanders	1'-3'	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone C Species

Cardinal Flower

Swamp Milkweed

Blue-Eyed Grass

Obedient Plant

Joe-Pye Weed

Path Rush

Red-Osier Dogwood

Monkey Flower

Source: JFNew

Zone D

Planting Zone = two-to-four inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Viburnum trilobum	Cranberry Viburnum	10’	White	Apr-May	F/P/S	N	50,51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Panicum virgatum	Switch grass	3‘-5’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Forbs:							
Anemone canadensis	Canada anemone	1’-2’	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6’-9’	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3’-6’	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1’-4’	White	Jul-Oct	F/P	N	50,51,55,56,57
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2’-4’	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	51,55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium maculatum	Spotted Joe-pye weed	4’-7’	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3’-5’	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1’-3’	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3’-5’	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3’-8’	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2’-5’	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1’-4’	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1’-3’	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2’-4’	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3’-10’	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2‘-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago ohiensis	Ohio goldenrod	2’-3’	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3’-6’	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell’s goldenrod	2’-5’	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3’-6’	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2’-5’	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3’-6’	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3’-6’	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57
Veronicastrum virginicum	Culver’s root	3’-6’	White	Jun-Aug	F/P	N	55,56,57
Zizia aurea	Golden Alexanders	1’-3’	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone D Species

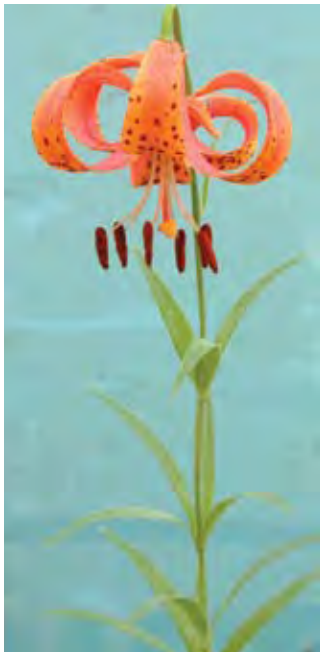
Big Bluestem

Marsh Blazing Star

Wild Columbine

Great Blue Lobelia

Virginia Mountain Mint



Michigan Lily

Meadowsweet

Blue Vervain

Source: JFNew

Zone E

Planting Zone = four-to-18 inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100’	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	N
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80’	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1’-3’	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus florida	Flowering dogwood	30’	White	May-Jun	F/P/S	N	55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85’	White	Jun	F/P	N	55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Pinus banksiana	Jack pine	60’	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100’	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100’	Brown	Jun	F/P/S	N	50,51,55,56,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Prunus americana	American plum	30’	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30’	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7’	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1’-2’	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1’-3’	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1’-2’	Purple	Aug-Oct	F	N	51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Panicum virgatum	Switch grass	3’-6’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2’-4’	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4’-9’	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Stipa spartea	Porcupine grass	2’-4’	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1’-2’	Lavender	Jun-Oct	F/P	N	55,56
Aquilegia canadensis	Wild columbine	1’-3’	Red/ Yellow	Apr-Jun	F/P/S	Y	50,51,55,56,57
Asclepias syriaca	Common milkweed	2’-4’	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1’-3’	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1’-2’	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2’-4’	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3’-5’	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster lateriflorus	Calico aster	1’-3’	White	Jul-Oct	F/P/S	N	50,51,55,56,57
Aster macrophyllus	Big-leaved aster	6”-2’	Lav/ White	Jul-Oct	P/S	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1’-4’	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short’s aster	1’-4’	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Campanula americana	Tall bellflower	2’-6’	Blue	Jul-Nov	P/S	N	55,56,57
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Clematis virginiana	Virgin’s bower	9’ long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2’-5’	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3’-6’	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2’-4’	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1’-2’	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2’-6’	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
elianthus pauciflorus	Prairie sunflower	3’-5’	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2’-4’	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2’-3’	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P/S	N	55,56,57
Liatris scariosa	Savanna blazing star	3’-5’	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2’-4’	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1’-2’	Purple	May-Jul	F/P	N	55,56,57
Phlox divaricata	Wild blue phlox	1’-2’	Blue	Apr-Jun	P/S	N	51,55,56,57
Phlox pilosa	Sand prairie phlox	1’-2’	Pink	May-Aug	F/P	N	56
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1’-3’	White	May-Jul	P/S	N	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Ratibida pinnata	Yellow coneflower	3’-6’	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1’-3’	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2’-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Silphium terebinthinaceum	Prairie-dock	3’-8’	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solo-mon’s seal	1’-3’	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon’s seal	1’-2’	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago juncea	Early goldenrod	2’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1’-3’	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Thalictrum dioicum	Early meadow-rue	1’-3’	Green	Apr-May	P/S	N	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2’-4’	Blue	May-Oct	F/P	N	55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57

Representative Zone E Species

New England Aster

Wild Bergamot

Showy Goldenrod

Tall Bellflower

Wild Geranium

Tall Coreopsis

Redbud

Indian Grass

Source: JFNew

Zone F

Planting Zone = 18+inches above water level

These plants tolerate fluctuating water levels within this range, although they are generally less tolerant than most wetter species. They may tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for upland BMP settings.

Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90'	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100'	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100'	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70'	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80'	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1'-3'	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60'	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25'	Red	Apr-May	F/P/S	N	55,56,57
Cornus florida	Flowering dogwood	30'	White	May-Jun	F/P/S	N	55,56,57
Corylus americana	American hazelnut	10'	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85'	White	Jun	F/P	N	55,56,57
Hamamelis virginiana	Witch hazel	30'	Yellow	Oct-Nov	F/P/S	N	50,51,55,56,57
Juglans nigra	Black walnut	90'	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50'	Brown	Apr-May	F/P	N	55,56,57
Liriodendron tulipifera	Tulip tree	110'	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50'	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100'	Green	May-Jul	F/P/S	Y	51,55,56,57
Pinus banksiana	Jack pine	60'	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100'	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100'	Brown	Jun	F/P/S	N	50,51,55,56,57
Prunus americana	American plum	30'	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30'	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus macrocarpa	Bur oak	85'	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90'	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90'	Green	May-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3'	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100'	Yellow	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100'	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7'	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10'	White	May-Jun	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4'-8'	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1'-2'	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1'-3'	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3'-6'	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3'-5'	Green	Jun-Jul	P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1'-2'	Purple	Aug-Oct	F	N	51,55,56,57
Koeleria macrantha	June grass	1'-2'	White	May-Jul	F/P	N	50,51,55,56,57
Panicum virgatum	Switch grass	3'-6'	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2'-4'	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4'-9'	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6'-7'	Green	Jul-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Stipa spartea	Porcupine grass	2'-4'	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1'-2'	Lavender	Jun-Oct	F/P	N	55,56
Asclepias syriaca	Common milkweed	2'-4'	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1'-3'	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1'-2'	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2'-4'	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3'-5'	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1'-4'	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short's aster	1'-4'	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3'-8'	White	Jun-Oct	F/P/S	N	55,56
Campanulaa americana	Tall bellflower	2'-6'	Blue	Jul-Nov	P/S	N	55,56,57
Clematis virginiana	Virgin's bower	9' long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis lanceolata	Sand coreopsis	1'-2'	Yellow	May-Aug	F/P	N	50,51,55
Coreopsis palmata	Prairie coreopsis	1'-2'	Yellow	Jun-Aug	F/P	N	55
Coreopsis tripteris	Tall coreopsis	4'-8'	Yellow	Aug-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2'-5'	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3'-5'	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3'-6'	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2'-4'	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1'-2'	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2'-6'	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus occidentalis	Western sunflower	2'-4'	Yellow	Aug-Sep	F/P	N	50,51,55,56,57
Helianthus pauciflorus	Prairie sunflower	3'-5'	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4'-6'	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2'-4'	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2'-3'	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris cylindracea	Cylindrical blazing star	1'-2'	Violet	Jul-Oct	F/P	N	51,55,56,57
Liatris scariosa	Savanna blazing star	3'-5'	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Lupinus perennis	Wild lupine	1'-2'	Purple	Apr-Jun	F/P	N	55,56,57
Monarda fistulosa	Wild bergamot	2'-5'	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2'-4'	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1'-2'	Purple	May-Jul	F/P	N	55,56,57
Phlox pilosa	Sand prairie phlox	1'-2'	Pink	May-Aug	F/P	N	56
Polygonatum biflorum	Solomon seal	1'-4'	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1'-3'	White	May-Jul	P/S	N	50,51,55,56,57
Ratibida pinnata	Yellow coneflower	3'-6'	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1'-3'	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Silphium terebinthinaceum	Prairie-dock	3'-8'	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solomon's seal	1'-3'	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon's seal	1'-2'	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1'-2'	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago juncea	Early goldenrod	2'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1'-3'	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2'-4'	Blue	May-Oct	F/P	N	55,56,57
Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Representative Zone F Species

Spiderwort

Butterfly Weed

Yellow Coneflower

Little Bluestem

Foxglove Beardtongue

Wild Lupine

Pale Purple Coneflower

Rattlesnake Master

Sand Coreopsis

Source: JFNew

Zone G

Planter Box Plantings

Although this manual typically recommends using native plants wherever possible, certain situations call for non-native plants due to particular site conditions. Because planter boxes traditionally have a short soil column and are exposed to drier conditions, non-native plants should be considered as long as they are considered non-invasive. Therefore, the list below contains both native and non-native species. Many planter boxes have traditionally used annual flowers. However, we recommend using perennial plants for establishing root systems and lowering maintenance in the long term. Many more species are available for planter boxes than are listed.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun
Ajuga reptans 'Bronze Beauty'	Bronze Beauty Ajuga	6"	Blue	May-Jun	F
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	6"-1'	White	May-Jun	F
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	6"-1'	Blue	Jun-Jul	F
Allium senescens montanum	Mountain Garlic	6"-1'	Pink/Purple	Jun-Aug	F
Allium senescens glaucum	Curly Onion	6"-1'	Pink	Jul-Sep	F
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	6"-1'	Pink	Jul-Aug	F
Aster 'Wood's Light Blue'	Wood's Light Blue Aster	1'-3'	Blue	Aug-Sep	F
Athryium filix-femina	Lady Fern	1'-3'	Green	NA	F/P/S
Blechnum spicant	Deer Fern	1'-2'	Green	NA	F/P/S
Dryopteris erythrosora	Autumn Fern	1'-2'	Green	NA	F/P/S
Euphorbia myrsinites	Mytle Spurge	6"-1'	Yellow	May-Jun	F
Dryopteris intermedia	Fancy Fern	1'-3'	Green	NA	F/P/S
Dyropteris marginalis	Leatherleaf Fern	1'-2'	Green	NA	F/P/S
Geranium x 'Rozanne'	Rozanne Gernaium	1'-2'	Violet	Jun-Sep	F/P
Hemerocallis 'Barbara Mitchell'	Barbara Mitchell Daylily	2'-3'	Pink	Jun-Aug	F/P
Hemerocallis 'Bill Norris'	Bill Norris Daylily	2'-3'	Yellow	Jun-Aug	F/P
Hemerocallis 'Chicago Apache'	Chicago Apache Daylily	2'-3'	Red	Jul-Sep	F/P
Hosta 'Francee'	Francee Hosta	1'-2'	Lavender	Jul-Aug	F/P/S
Hosta 'Guacamole'	Guacamole Hosta	1'-2'	Pink	Aug-Sep	F/P/S
Hosta 'Summer Fragrance'	Summer Fragrance Hosta	1'-2'	Lavender	Aug-Sep	F/P/S
Hosta sieboldiana 'Elegans'	Elegans Hosta	1'-2'	White	Jul-Aug	F/P/S
Sedum 'Autumn Charm'	Autumn Charm Sedum	6"-1'	Pink	Jun-Jul	F
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	6"-1'	Pink	May-Jun	F
Sedum 'Mini Me'	Mini Me Sedum	6"-1'	Green	NA	F
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	6"-1'	Yellow	Jul-Sep	F
Sedum album 'Athoum'	Jelly Bean Sedum	6"-1'	Pink	Aug-Sep	F
Sedum album 'Coral Carpet'	Coral Carpet Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Faro Island'	Faro Island Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Green Ice'	Green Ice Sedum	6"-1'	White	Jun-Jul	F
Sedum album 'Murale'	Wall Sedum	6"-1'	White	Jun-Jul	F
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	6"-1'	Pink	Jul-Aug	F
Sedum divergens	Cascade Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum ellacombianum	Ellacombe's Sedum	6"-1'	Yellow	May-Jun	F
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	6"-1'	Yelow	May-Jun	F
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum grisbachii	Griseback Sedum	6"-1'	Yellow	Jul-Aug	F
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	6"-1'	Yellow	Jun	F
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	6"-1'	Orange	Jul-Aug	F
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	6"-1'	Yellow	May-Jun	F

Representative Zone G Species

Guacamole Hosta

Mountain Garlic

Wall Sedum

Lady Fern

Source: JFNew

Zone H

Vegetated Roof Plantings

Research to-date shows that native plants do not typically thrive in vegetated roofs. Therefore, the list below reflects species that are known to thrive in green roof situations. All species listed below will generally grow to a height of six-to-18 inches.

Botanical Name	Common Name	Color	Bloom Time
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	White	May-Jun
Allium schoenoprasum 'Dwarf'	Dwarf Ornamental Chive	Pink	May-Jun
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	Blue	Jun-Jul
Allium senescens montanum	Mountain Garlic	Pink/Purple	Jun-Aug
Allium senescens glaucum	Curly Onion	Pink	Jul-Sep
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	Pink	Jul-Aug
Euphorbia myrsinites	Mytle Spurge	Yellow	May-Jun
Sedum 'Autumn Charm'	Autumn Charm Sedum	Pink	Jun-Jul
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	Pink	May-Jun
Sedum 'Mini Me'	Mini Me Sedum	Green	NA
Sedum acre 'Aureum'	Gold Leaved Goldmoss Sedum	Yellow	May-Jun
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	Yellow	Jul-Sep
Sedum album 'Athoum'	Jelly Bean Sedum	Pink	Aug-Sep
Sedum album 'Coral Carpet'	Coral Carpet Sedum	White	Jun-Aug
Sedum album 'Faro Island'	Faro Island Sedum	White	Jun-Aug
Sedum album 'Green Ice'	Green Ice Sedum	White	Jun-Jul
Sedum album 'Murale'	Wall Sedum	White	Jun-Jul
Sedum album 'Red Ice'	Red Ice Sedum	White	Jun-Jul
Sedum cautacola 'Bertram Anderson'	Bertram Anderson Sedum	Pink	Jul-Aug
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	Pink	Jul-Aug
Sedum divergens	Cascade Sedum	Yellow	Jun-Jul
Sedum ellacombianum	Ellacombe's Sedum	Yellow	May-Jun
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	Yelow	May-Jun
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	Yellow	Jun-Jul
Sedum grisbachii	Griseback Sedum	Yellow	Jul-Aug
Sedum hispanicum 'Pinkie'	Pinkie Sedum	Pink	Jun-Jul
Sedum hybridum 'Immergunchen'	Evergreen Sedum	Yellow	Jun, Sep
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	Yellow	Jun
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	Orange	Jul-Aug
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	Yellow	May-Jun

*List provided by Hortech, Inc.

Representative Zone H Species

Mountain Garlic

Cascade Sedum

Ellacombe's Sedum

Wall Sedum

Source: JFNew

Appendix G
Recommended Materials

Recommended Materials

Numerous BMPs in this manual have similar material needs. These BMPs are listed in the table below. Detailed information on each material requirement follows. In addition, Porous Pavement and Vegetated Roofs have significant material requirements that are listed according to their individual needs.

	Constructed Filters	Dry Well	Infiltration Trench	Planter Boxes	Porous Pavement	Subsurface Infiltration	Vegetated Filter Strip	Vegetated Swale
Check dams							X	X
Non-Woven Geotextile	X	X	X	X	X	X	X	
Pea Gravel							X	
Peat	X			X				
Pervious Berms							X	
Pipe – 8”	X	X	X	X	X	X	X	
Sand	X			X				X
Stone/Gravel	X			X				
Stone – 30%							X	
Stone – 40%			X		X			

Check dams (Vegetated Filter Strip, Vegetated Swale)

An earthen check dam shall be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02 in to 0.04 in, Gravel: AASHTO M-43 0.5 in to 1.0 in). A stone check dam shall be constructed of R-4 rip rap, or equivalent.

Non-Woven Geotextile (Constructed Filter, Dry Well, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should consist of needled nonwoven polypropylene fibers and meet the following properties:

a. Grab Tensile Strength (ASTM-D4632) 120 lbs min.
b. Mullen Burst Strength (ASTM-D3786) 225 psi min.
c. Flow Rate (ASTM-D4491) 110 gal/min/ft2 min.
d. UV Resistance after 500 hrs (ASTM-D4355) 70% min.
e. Puncture strength (ASTM D-4833-00) 90 lb. min.
f. Apparent opening size (ASTM D-4751-99A) 60-70 US Sieve

Heat-set or heat-calendared fabrics are not permitted. Acceptable types include Mirafi 140N, Amoco 4547, Geotex 451, or approved others.

Pea Gravel (Vegetated Filter Strip)

Clean bank-run gravel may also be used and should meet ASTM D 448 and be sized as per No.6 or 1/8” to 3/8”.

Peat (Constructed Filter, Planter Boxes)

Should have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.

Pervious Berms (Vegetated Filter Strip)

The berm shall have a height of 6-12 in and be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02”-0.04”, Gravel: AASHTO M-43 ½” to 1”)

Pipe - (Dry Well, Porous Pavement, Subsurface Infiltration, Constructed Filter, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should be continuously perforated, smooth interior, with a minimum inside diameter as required. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or M294, Type S (12 gauge aluminum or pipe may also be used in seepage pits).

Sand (Constructed Filter, Planter Boxes, Vegetated Swale)

Should be ASTM-C-33 (or AASHTO M-6) size (0.02” – 0.04”), concrete sand, clean, medium to fine sand.

Stone/Gravel (Constructed Filter, Planter Boxes):

Should be uniformly graded coarse aggregate, 1 inch to ½ inch with a wash loss of no more than 0.5%, AASHTO size number 5 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and have voids of 40% as measured by ASTM-C29.

Stone – 40% voids (Infiltration Trench, Porous Pavement, Subsurface Infiltration Bed,)

Infiltration trenches should have stone 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids 40% as measured by ASTM-C29.

Porous Pavement

General

Choker base course aggregate for beds shall be 3/8 inch to 3/4 inch clean, uniformly-graded, coarse, crushed aggregate AASHTO size number 57 per Table 4, AASHTO Specifications, Part I, 19th Ed., 1998 (p. 47).

Porous Asphalt

Bituminous surface course for porous paving shall be 2.5 to 3 inches thick with a bituminous mix of 5.75% to 6.75% by total weight as determined by testing below. Use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of PG 76-22P (in northern Michigan, use PG 76-28P as appropriate) as specified in AASHTO MP-1. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Determination of optimal asphalt content should be determined according the following tests:

- Draindown Test (ASTM Method D6390)
- Moisture Susceptibility Test using the Modifed Lottman Method (AASHTO T283) with the following:
  - Compact using 50 gyrations of Superpave gyratory compactor
  - Apply partial vacuum of 26 inches of Hg for 10 minutes to whatever saturation is achieved.
  - Keep specimens submerged in water during freeze cycle.
  - Required retained tensile strength (TSR) >= 80%
- Air Voids Test (AASHTO T269/ASTM D3203)

Hydrated lime, if required, shall meet the requirements of AASHTO M 303 Type 1 and shall be blended with the damp aggregate at a rate of 1.0% by weight of the total dry aggregate. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

Fibers, if used, shall consist of either cellulose fibers or mineral fibers which are to be treated with a cationic sizing agent to enhance dispersement of the fiber as well as increase cohesion of the fiber to the bitumen. Fiber is to be added at a dosage rate between 0.2% and 0.4% by weight of total mix.

- Mineral fibers shall be from virgin, basalt, diabase, or slag with a maximum average fiber length of 6.35 mm and a maximum average fiber thickness of 0.005 mm.
- Cellulose fiber – Fiber length shall be 6.4 mm (max), Ash Content 18% non-volatiles (±5%), pH 7.5 (± 1), Oil absorption (times fiber weight) 5.0 (± 1), Moisture Content 5.0 (max).

Porous Concrete

The use of Installers or Craftsmen who have been certified by the NRMCA's Pervious Concrete Contractor Certification Program is strongly recommended. Contractor shall furnish a proposed mix design with all applicable information to the Engineer prior to commencement of work. Critical mix characteristics typically include the following:

- Cement Content: 550 to 650 lb/cy
- Fine aggregate, if used: maximum 3 cu. ft. per cu. yd.
- Admixtures: use in accordance with the manufacturer's instructions and recommendations
- An aggregate/cement (A/C) ratio: 4:1 to 4.5:1
- Water/cement (W/C) ratio: 0.27 to 0.34
- Curing: shall begin within 15 minutes after placement and continue for 7 days

The data shall include unit weights determined in accordance with ASTM C29 paragraph 11, jigging procedure.

Cement: Portland Cement Type II or V conforming to ASTM C150 or Portland Cement Type IP or IS conforming to ASTM C595. The total cementitious material shall be between 550 and 650 lb./cy.

Aggregate: Use No 8 coarse aggregate (3/8 to No. 16) per ASTM C33 or No. 89 coarse aggregate (3/8 to No. 50) per ASTM D 448. If other gradation of aggregate is to be used, submit data on proposed material to owner for approval. The volume of aggregate per cu. yd. shall be equal to 27 cu.ft. when calculated as a function of the unit weight determined in accordance with ASTM C 29 jigging procedure. Fine aggregate, if used, should not exceed 3 cu. ft. and shall be included in the total aggregate volume.

Air Entraining Agent: Shall comply with ASTM C 260 and shall be used to improve workability and resistance to freeze/thaw cycles.

Admixtures: The following admixtures shall be used:

- Type D Water Reducing/Retarding – ASTM C 494.
- A hydration stabilizer that also meets the requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding admixtures may be used. This stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles from achieving initial set.

Water: Potable shall be used and shall comply with ASTM C1602. Mix water shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (Mix water yielding a cement paste with a dull-dry appearance has insufficient water for hydration).

- Insufficient water results in inconsistency in the mix and poor bond strength.
- High water content results in the paste sealing the void system primarily at the bottom and poor surface bond.

An aggregate/cement (A/C) ratio range of 4:1 to 4.5:1 and a water/cement (W/C) ratio range of 0.27 to 0.34 should produce pervious pavement of satisfactory properties in regard to permeability, load carrying capacity, and durability characteristics.

Vegetated roofs

Some key components and associated performance-related properties are as follows:

Root-barriers should be thermoplastic membranes with a thickness of at least 30 mils. Thermoplastic sheets can be bonded using hot-air fusion methods, rendering the seams safe from root penetration. Membranes that have been certified for use as root-barriers are recommended. At present only FLL offers a recognized test for root-barriers. Several FLL-certified materials are available in the United States. Interested American manufactures can submit products for testing to FLL-certified labs.

Granular drainage media should be a non-carbonate mineral aggregate conforming to the following specifications:

- Saturated Hydraulic Conductivity >= 25 in/min
- Total Organic Matter, by Wet Combustion (MSA) <= 1%
- Abrasion Resistance (ASTM-C131-96) <= 25% loss
- Soundness (ASTM-C88 or T103 or T103-91) <= 5% loss
- Porosity (ASTM-C29) >= 25%
- Alkalinity, CaCO3 equivalents (MSA) <= 1 %
- Grain-Size Distribution (ASTM-C136)
  - Pct. Passing US#18 sieve <= 1%
  - Pct. Passing ¼-inch sieve <= 30%
  - Pct. Passing 3/8-inch sieve >= 80%

Growth media should be a soil-like mixture containing not more than 15% organic content (wet combustion or loss on ignition methods). The appropriate grain-size distribution is essential for achieving the proper moisture content, permeability, nutrient management, and non-capillary porosity, and 'soil' structure. The grain-size guidelines vary for single and dual media vegetated cover assemblies.

Non-capillary Pore Space at Field Capacity, 0.333 bar (TMECC 03.01, A)	>= 15% (vol)
Moisture Content at Field Capacity (TMECC 03.01, A)	>= 12% (vol)
Maximum Media Water Retention (FLL)	>= 30% (vol)
Alkalinity, Ca CO3 equivalents (MSA)	<= 2.5%
Total Organic Matter by Wet Combustion (MSA)	3-15% (dry wt.)
pH (RCSTP)	6.5-8.0
Soluble Salts (DTPA saturated media extraction)"(RCSTP)	<= 6 mmhos/cm
Cation exchange capacity (MSA)	>= 10 meq/100g
Saturated Hydraulic Conductivity for Single Media Assemblies (FLL)	>= 0.05 in/min
Saturated Hydraulic Conductivity for Dual Media Assemblies (FLL)	>= 0.30 in/min

Grain-size Distribution of the Mineral Fraction (ASTM-D422)

Single Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	<= 5%
Pct. Passing US#60 sieve	<= 10%
Pct. Passing US#18 sieve	5 - 50%
Pct. Passing 1/8-inch sieve	0 - 70%
Pct. Passing 3/8-inch sieve	75 -100%

Dual Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	5-15%
Pct. Passing US#60 sieve	10-25%
Pct. Passing US#18 sieve	20 - 50%
Pct. Passing 1/8-inch sieve	55 - 95%
Pct. Passing 3/8-inch sieve	90 -100%

Macro- and micro-nutrients shall be incorporated in the formulation in initial proportions suitable for support the specified planting.

Separation fabric should be readily penetrated by roots, but provide a durable separation between the drainage and growth media layers (Only lightweight nonwoven geotextiles are recommended for this function.

- Unit Weight (ASTM-D3776) <= 4.25 oz/yd2
- Grab tensile (ASTM-D4632) <= 90 lb
- Mullen Burst Strength (ASTM-D4632) >= 135 lb/in
- Permittivity (ASTM-D4491) >= 2 per second

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REPORT

HARTSHORN MARINA EAST OPERATIONS & MANAGEMENT PLAN

Stormwater Management

Low Impact Developments / Green Infrastructure

Landowner - Muskegon County
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Muskegon, MI 49442

Submitted To: West Michigan Shoreline Regional Development Commission
316 Morris Avenue
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EXECUTIVE SUMMARY

The Operations and Management (O&M) Plan summarizes the best management practices (BMPs) and low impact development (LID) designs recommended at Hartshorn Marina East for improving stormwater management (Appendix A). Each structural BMP requires maintenance for continued efficiency and is summarized within the plan. Included in the appendices of the report is a maintenance summary for each BMP (Appendices B, C, and D), and example checklists to be used for routine inspections (Appendix E). The plan also provides guidance regarding management of vegetation, a list of recommended Michigan species (Appendix F), and a list of other recommend materials (Appendix G). Operations and maintenance costs were analyzed for each development and maintaining the site.

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1.0 HARTSHORN MARINA EAST

Hartshorn Marina East is located in Muskegon, Michigan within the Beidler Creek/Division Street Outfall Watershed. The site is city owned and located on the lakeshore of Muskegon Lake. The watershed receives stormwater from heavily urbanized areas and the city's storm sewer system. The polluted stormwater discharged to the watershed has resulted in degraded benthic communities, organic chemicals, excessive sediment, and/or flashy hydrology.

With grant support from the Michigan Department of Environmental Quality and the US Environmental Protection Agency, the Muskegon Lake Watershed Partnership, West Michigan Shoreline Regional Development Commission, municipal partners and Golder Associates Inc. recommended design solutions to reduce stormwater runoff, stormwater pollutants, and improve water quality within Hartshorn Marina East and the Beidler Creek/Division Street Outfall Watershed. Stormwater LID designs implemented for the site included seven rain gardens, four bioswales, and six bioretention islands.

2.0 MAINTENANCE COSTS

Stormwater LID designs tend to be less expensive to implement than conventional designs, however they do require long term maintenance to ensure the designs continue to work efficiently. A cost analysis was completed for the Hartshorn Marina East maintenance costs at annual and long term rates. Three types of structural BMPs were assessed including rain gardens, bioswales, and bioretention islands. The total annual cost for maintaining the BMPs at Hartshorn Marina East was estimated at $17,267. Operation and maintenance costs of each BMP are summarized in Table 1. Annual maintenance costs were based on taking a percentage of the total construction costs, based on a low impact development cost comparison completed by Emmons & Oliver Resources, Inc. (EORINC 2015). BMPs were estimated to require approximately 5% to 6% of construction costs for routine and non-routine maintenance. The estimated maintenance costs include aesthetic maintenance and functional maintenance. Functional maintenance assures the BMP is performing efficiently and safely, while aesthetic maintenance is mainly for public acceptance, which can help to reduce functional costs. The percentage of construction cost used for each BMP reflects labor, landscaping, and material costs. A typical year of landscaping includes maintenance such as lawn mowing, removal of debris and litter, replanting or seeding vegetation, replenishing mulch. Maintenance labor is expected to be greater within the first two to three years as vegetation is established.

Table 1. Operation and Maintenance Costs Summary

Stormwater BMP	Construction Cost ($)	Annual Maintenance Cost (% of Construction Cost)	Annual Maintenance Cost ($)
Rain Garden (without underdrain)	63,825	5	3,191
Bioswale	197,019	6	11,821
Bioretention Islands	45,090	5	2,255
Total Costs			**17,267**

2.1 Rain Garden

Hartshorn Marina East conceptual stormwater development plan includes seven rain gardens encompassing approximately 4,500 square feet. The rain gardens consist of a geotextile filter layer, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Regular maintenance of the rain gardens is required within the first two to three years when vegetation is becoming established. Less maintenance is required after vegetation becomes established and fills empty spaces between plants. Maintenance requirements for the rain gardens can be viewed in Appendix B. A summary of maintenance cost for the rain gardens is provided in Table 1. The annual operations and maintenance costs for the rain gardens were calculated as 5% of the construction costs. The annual cost to maintain the seven rain gardens is $3,191.

2.2 Bioswale

There are four bioswales implemented in the Hartshorn Marina East stormwater management plan. The bioswales cover about 14,594 square feet. Bioswales consist of a geotextile filter, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Similar to the rain gardens the bioswales will be planted with native species, and require more maintenance within the first two to three years while vegetation is being established. Routine maintenance items for the bioswales are summarized in Appendix C. The annual maintenance cost of bioswales at the site was calculated as 6% of the construction costs, totaling $11,821.

2.3 Bioretention Island

Bioretention islands require similar maintenance to rain gardens to successfully establish vegetation within the planter box. The planter box consists of a geotextile filter fabric, 18 inches of compacted stone, 18 inches of engineering soil, and two inches of mulch. There are nine bioretention islands implemented within Hartshorn Marina East covering approximately 1,800 square feet. Vegetation within the planter boxes will

consist of a plug, gallon, or tree. The maintenance required for the bioretention islands is summarized in Appendix D. The annual maintenance cost for the bioretention islands was calculated as 5% of the construction cost, equivalent to $2,255.

3.0 ROUTINE INSPECTIONS

Routine inspections of BMPs should be completed at least once every year. Example inspection checklists are included in Appendix E. Inspection checklists vary depending on the type of LID design. The stormwater designs for Hartshorn Marina East do not include underdrain and overflow systems, so such items on the checklist are not applicable to the site. The example bioretention inspection checklist can be used for inspection of the rain gardens. Rain gardens, bioswales, and bioretention islands should be inspected for debris, erosion, vegetation conditions and coverage, and mulch thickness to determine overall functionality. Based on the selection of native plants used for each BMP, additional species specific inspections may be required. Inspections of vegetation should include determining the overall plant health, checking if plants require trimming or pruning, and assuring invasive species are properly managed.

4.0 VEGETATION

The plant species selected to be used for the BMPs have a significant impact on the effectiveness of the design. Vegetation will require regular maintenance within the first few years while becoming established. Maintenance involves watering plants as needed, and removing invasive species. Once vegetation is established, less maintenance will be required to maintain the BMP areas.

4.1 Native Species

Native plants are implemented in the design because they have deeper and more expansive roots leading to increased infiltration, groundwater recharge and biofiltration. Native plants are also more tolerant to flooding and drought conditions enabling them to thrive in rain gardens, bioswales, and bioretention islands. Plugs and gallons are common sizes of native plants that can be installed in BMPs. A plug is a small plant that grows in a container roughly two inches wide and five inches deep. A gallon is a more mature available in a gallon size container. Both sizes of plants require consistent watering during early development (Delta Institute 2015). Suggested species include: cardinal flower (*Lobelia cardinalis*), blue lobelia (*Lobelia siphilitica*), New England aster (*Aster novae-angliae*), and brown fox sedge (*Carex vulpinoidea*). Additional grasses and wildflowers that could tolerate wet growing conditions recommended by the West Michigan Environmental Action Council include: cotton grass (*Eriophorum angustifolium*), golden alexanders (*Zizia aurea*), and blue flag iris (*Iris versicolor*) (WMEAC 2016). A full list of recommended Michigan plants for BMPs is included in Appendix F (SEMCOG 2008).

4.1.1 Planting Requirements

Maintenance will be required for any plants that do not successfully grow in the planted environment, and alternative species may need to be planted. Seeding is not the preferred method of planting vegetation since high velocity flows can prevent the plant from establishing. Plugs or gallon-potted plants installed at one to two foot intervals are recommended for easier establishment of vegetation. Trees and shrubs are also recommended. Seeding should be completed from late April to mid-October if irrigation is available. If irrigation is not available, than seeding can be completed from June 15 or mid-August to mid-October. With dormant seeding, seeding can be completed from November 1 to 30. At all other times of the year, seeding should have a temporary cover (made of oats/cereal rye or other small grain). Plugs and gallons should be installed from May 1 – June 15. Trees and shrubs should be planted from the middle of April through early June, or the middle of September through the middle of November. A maximum of two to three inches of mulch should be evenly spread in the BMPs after installing new plants to help prevent erosion, remove metals, and act as leaf litter in a natural forest environment. The mulch should not be placed directly against the stems of the newly planted vegetation. If wildlife is a threat to newly installed plants additional precautions such as waterfowl barriers are maintenance options.

4.2 Invasive Non-Native Species

Invasive species are not native to the area and tend to grow and spread quickly without natural controls. If unmanaged, invasive species will displace native species (SEMCOG 2008). Maintenance of invasive species is crucial when native plants are being established and require room to grow. Invasive species can be removed by hand–pulling, mowing, or spot herbicide applications. After native species are established, less maintenance of invasive species is needed. Long term management of invasive species may require removal once every year or as needed. Open areas may require mowing if woody vegetation is noticed encroaching, typically every three to five years.

5.0 WINTER CONDITIONS

Winter conditions in Michigan typically include the buildup of snow and the use of de-icing compounds which can negatively affect plant life. Salt tolerant plants are recommended for sites where de-icing and heavy snow occurs. Recommended products for de-icing are nontoxic and organic, such as magnesium chloride-based liquid products or pretreated salt (Delta Institute, 2008). Sand and cinder from melted snow has the potential of reducing infiltration into the soil. Preventative measures should be taken to avoid the buildup or piling of snow over infiltration systems.

In the spring, the rain gardens, bioswales, and bioretention islands should all be assessed for winter damages. Buildup of debris and sediment should be cleared, and mulch should be evenly spread in any eroded areas with a maximum of two to three inches. Plants may also require trimming or rehabilitation. Soil aeriation may also be required in spring to reduce impacts of de-icing agents.

6.0 EDUCATION AND TRAINING

All personnel responsible for the operations and maintenance of the BMPs should undergo training to fully understand the care required for each LID design. Training should include reading the O&M plan and discussing procedures with someone of experience. An educated maintenance staff will increase the efficiency and sustainability of the designs.

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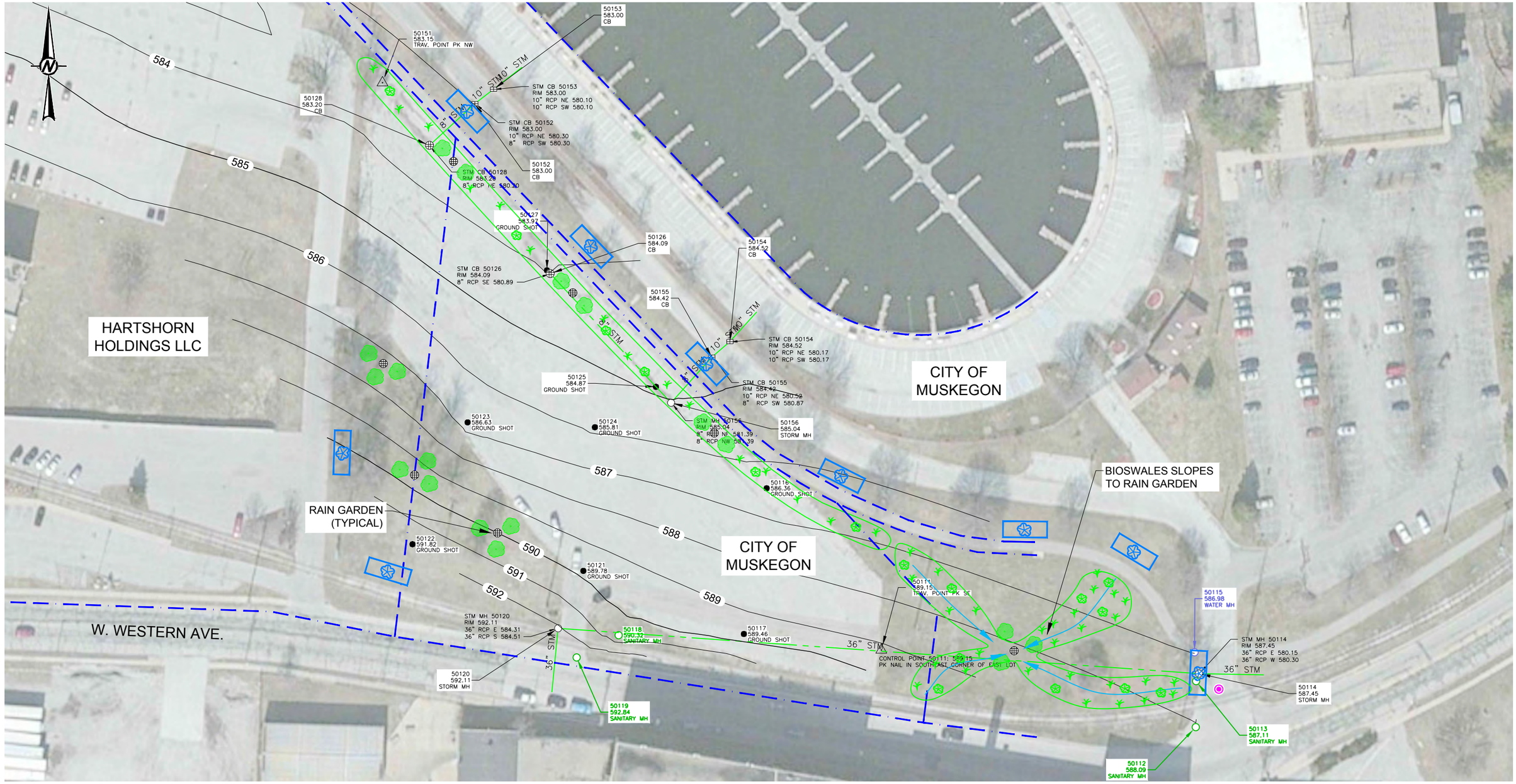
4. West Michigan Environmental Action Council. 2016. Rain Gardens of West Michigan. Michigan Native Plants List For Use in Rain Gardens and Landscaped Bioretention Areas. http://www.westmichiganglsi.org/uploads/6/7/9/8/6798898/rain_gardens_native_plant_list.pdf

Appendix A
Hartshorn Marina East Conceptual Plan



LEGEND

- PARCEL BOUNDARY
- CLOSED LUST (PART 213)
- PART 201 SITE OF ENVIRONMENTAL CONTAMINATION
- CLOSED UST (PART 211)

NOTE(S)

1. THE HARTSHORN MARINA SITE IS APPROXIMATELY 26.5 ACRES PARCEL AREA AND 11.6 ACRES WATERSHED TREATMENT AREA.
2. THE HARTSHORN MARINA SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 40 80
1" = 80' FEET

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	DRAFT
APPROVED	DRAFT

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
HARTSHORN MARINA EAST

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			2

Appendix B
Rain Garden Maintenance Items

RAIN GARDEN

1.0 PUROPOSE

Rain gardens are used to collect stormwater runoff and encourage infiltration and biofiltration with the use of native plants. Native plants are ideal for rain gardens because they have deeper root networks that draw surface water further into the ground. Native plants are also typically drought and flood tolerant and able to thrive in rain gardens. Rain gardens aide in reducing runoff volume, filtering pollutants, recharging groundwater (if no underdrain is used), reducing stormwater temperature impacts, and enhancing site aesthetics.

2.0 MAINTENANCE

Rain gardens require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered and weeded twice weekly through October of the first year and in times of extreme drought. Weeds should be removed by hand.

3.) Organic matter may also need to be removed approximately twice per year, usually by hand.

4.) Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

5.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

6.) Annual mowing should be performed for the first three years of establishment. Mowing should not be completed on a regular basis.

7.) Removal of debris must occur monthly for the life of the rain garden.

8.) Winter conditions may result in plants being effected by deicing chemicals in snow-melt, in this case salt-tolerant plants should be used. Also try to reduce the amount of sand, cinders, and other winter abrasives that come in contact with the vegetation. Additional maintenance in the spring is required to remove abrasives if used.

9.) Rain gardens should be inspected at least twice a year for sediment buildup, erosion, and overall vegetation conditions. If sediment build up reaches 25% of the ponding depth it should be removed. If erosion is occurring, soil stabilization efforts should be applied. If vegetation is in poor health for no apparent reason, a landscape architect should be consulted.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix C
Bioswale Maintenance Items

BIOSWALE

1.0 PUROPOSE

Bioswales are shallow, vegetated, earthen channels that help to slow, filter, and infiltrate stormwater runoff in the process of conveyance. Native plants are ideal vegetation for bioswales due to their deep roots for infiltrating runoff, and their high tolerance for droughts and floods.

2.0 MAINTENANCE

Bioswales require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Vegetation should be established as soon as possible to prevent erosion and scour. Freshly seeded swales require soil stabilization such as erosion control matting or blankets. Erosion controls for seeded swales are required after planting for 75 days after the first storm event occurs. If runoff velocities are high, sodding the swale or diverting runoff until vegetation is well established is an option.

4.) Debris removal, weeding, and pruning should be performed on a monthly basis.

5.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity issues are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

6.) Mow and trim plants within the bioswales annually to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Mow only when dry to avoid rutting. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

7.) In the spring the bioswales will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

8.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

9.) If roadside or parking lot runoff is directed to the swale, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix D
Bioretention Island Maintenance Items

BIORETENTION ISLAND

1.0 PUROPOSE

A Bioretention islands or stormwater planters are a linear infiltration basin typically located in a parking lot or between a street and sidewalk surrounded by vertical curbing. Stormwater is collected from the street, sidewalk, or parking lot and directed into the bioretention island through openings in the curb. Bioretention islands consist of native plants in engineered soil which lay on top of a layer of stone. The stormwater planters are able to reduce, filter, and infiltrate stormwater runoff and aide in recharging groundwater.

2.0 MAINTENANCE

Bioretention islands require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes mature and capable of choking out invasive species, less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Debris removal, weeding, and pruning should be performed on a monthly basis.

4.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

5.) Annually trim plants to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

6.) In the spring the bioretention islands will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

7.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

8.) If roadside or parking lot runoff is directed to the bioretention island, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix E
Example Inspection Checklists

Maintenance Inspection Checklists

This appendix contains four checklists available as guides for maintenance inspections of specific BMPs. The maintenance items have been adapted from multiple stormwater programs, including the Rouge River Detention Basin Maintenance Manual, Georgia Stormwater Management Manual, the Vermont Stormwater Management Manual, and the Stormwater Manager's Resource Center.

The checklists are designed to help identify key components of BMPs that require ongoing maintenance as well as a basic schedule of when the maintenance should occur. The checklists have been divided into those items essential for the general operation and functionality of the BMP and those items that optional and may enhance the BMP.

It is suggested that the inspection be undertaken by a licensed PE and/or a person knowledgeable about the design and function of the BMP.

These BMP checklists include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

Detention BMP Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet Pipes			
Structural integrity of inlet/outlet (Are any inlet pipes broken, crumbling, separated?) List Inlet Pipes Approximate Diameter and Type of Material Inlet Pipe 1 _____ Inlet Pipe 2 _____ Inlet Pipe 3 _____ Outlet Pipe Size/Type _____		A	
Riprap at inlet pipe (Is the riprap still present? Is it visible and not covered with sediment?		A	
Stone around outlet pipe (Is the stone clogged with debris and/or sediment?)		A	
Trash or debris blocking inlet/outlet (Inspect to ensure no major obstructions hindering general functionality)		M	
Inspect/clean catch basin upstream of the BMP if accessible.		A	
Inspect inlets and outlet for erosion (Are there eroded areas around the pipes?)		A	
Inspect overflow spillway for signs of erosion.			
Pretreatment (if applicable) (Might include sediment forebay, upstream catch basin, bioswale, rain garden, swirl concentrator)			
Device functioning to trap/collect sediment		A	
Remove accumulated sediment as appropriate for the pretreatment device. forebay		A	
Detention Pond		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inspect side slopes, berms and emergency overflow for erosion		A	
Reestablish permanent native vegetation on eroded slopes		As needed	
Inspect for excess sediment accumulation in pond if not pretreatment device is present		A	
Overall functionality			
Ensure pond is functioning properly (Professional Civil Engineer is recommended)		A	
Ensure the outlet is functioning properly (Professional Civil Engineer is recommended)		A	
Optional/Enhancements			
Maintain 15-20 feet “no mow and chemical free” zone		A	
Mow (or burn) the “no mow” zone		A	
Inspect basin and “no mow” zone for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation in and around pond.		A	
Complaints from residents (note on back)		S	
Encroachment on pond/no- mow zone.		A	
Unauthorized plantings		A	
Aesthetics (e.g., graffiti, unkept maintenance)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Summary

Inspector’s remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Infiltration BMPs Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		A	
Pretreatment for sediment			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure infiltration device is functioning properly (professional civil engineer is recommended)		A	
BMP infiltration surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		S	
Evidence of erosion present		A	
Aggregate (if applicable)			
Surface of aggregate clean		A	
Any replacement of aggregate needed? If clogged with sediment replacement is necessary for continued proper function.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Vegetated surface (if applicable)			
Vegetative cover exists		A	
Optional considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation or creating a native plant infiltration basin area.		A	
Complaints from residents (note on back)		A	
Mowing done when necessary		A	
No fertilizer unless testing requires it		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioretention Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway or catch basin clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		Every 5 years	
Pretreatment for sediment (Generally consists of catch basin or velocity dissapator at inlet such as area of riprap/ collection for sediment)			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure bioretention area is functioning properly (professional civil engineer is recommended)		A	
Bioretention area surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		M	
Evidence of erosion present		A	
Does good vegetative cover exist		A	
Mulch covers entire area (no voids) and to specified thickness		A	
Optional considerations			
Inspect BMP for invasive species.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioswale, Filter Strip Inspection Checklist

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Pretreatment/ Energy Dissipators			
No evidence of flow going around structures		A	
No evidence of erosion		A	
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
BMP surface			
Area free of debris?		M	
No evidence of erosion		A	
Does sediment accumulation currently require removal?		A	
Overall functionality			

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Ensure swale is functioning properly (professional civil engineer is recommended)		A	
Optional Considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Appendix F
List of Michigan Recommended Plants

Recommended Plant Lists for Best Management Practices

This appendix contains recommended native and non-native (when appropriate) plant species for the Best Management Practices detailed throughout the manual. Species have been recommended based on hardiness, aesthetics, functionality, and commercial availability. It is certain that species exist outside the confines of this list that will perform in a comparable way to those listed; however, commercial availability is often a limiting factor in obtaining material for native plantings. Over time, and in certain locales, additional species will become available to supplement those listed below.

An array of planting zones is provided based on normal water levels (Figure C.1). Using these zones will provide the best chances for long-term success of native planting in the context of LID. While plants may naturally occur outside of the given ranges, these ranges are intended to be guidelines for plant installation. Whenever possible and practical in standing water conditions, native plants should be installed in live plant form (rather than seed). Seed or a combination of seed and live plants may be used in upland situations.

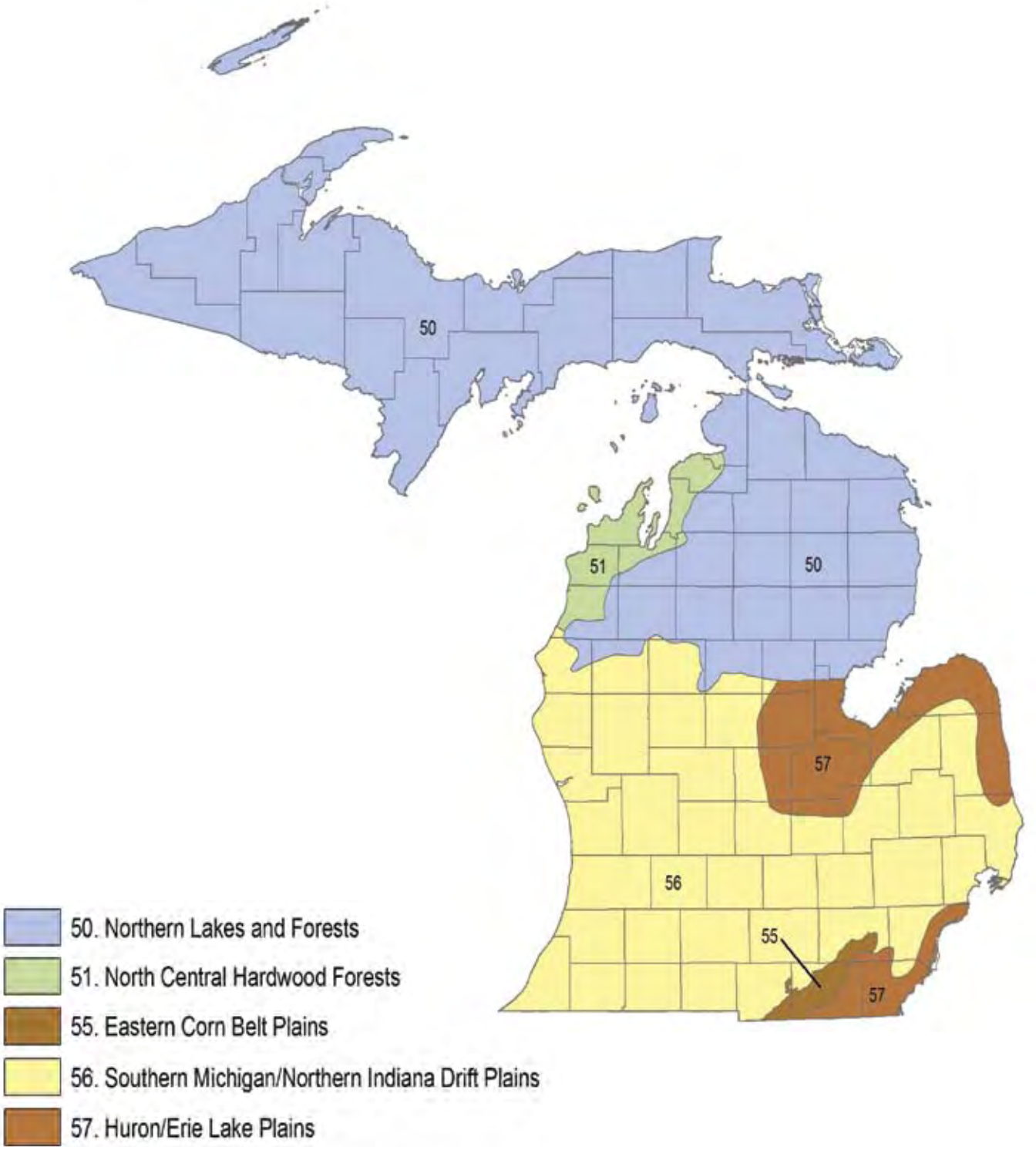
Recommendations are given for height, bloom color, bloom time, sun requirements, salt tolerance, and ecoregion. Please note that these are recommendations based on a range of situations, and a specific plant or population may vary from site-to-site. For sun requirements, F = Full sun required, P = Partial sun tolerated, and S = Shade tolerated. Salt tolerance is classified as Yes (Y) or No (N). This was determined through literature reviews and anecdotal evidence. If there is no information confirming tolerance, a "No" was listed.

Figure C.1
Planting Zone/BMP Matrix

	Zone A — 2"-4" Below Water Level	Zone B — 0"-2" Below Water Level	Zone C — 0"-2" Above Water Level	Zone D — 2"-4" Above Water Level	Zone E — 4"-18" Above Water Level	Zone F — 18"+ Above Water Level	Zone G — Planter Boxes	Zone H — Vegetated Roofs
Rain gardens/Bioretention	✤	✤	✤	✤	✤	✤		
Vegetated Filter Strips			✤	✤	✤	✤		
Vegetated Swales		✤	✤	✤				
Infiltration Basin		✤	✤					
Subsurface Infiltration Basins				✤	✤	✤		
Infiltration Trenches				✤	✤	✤		
Infiltration Berns	✤	✤	✤	✤	✤	✤		
Planter Boxes							✤	
Vegetated Roofs								✤
Constructed Wetlands	✤	✤	✤	✤				
Wet Ponds	✤	✤	✤					
Dry Extended Detention Basins			✤	✤	✤	✤		
Riparian Corridor Restoration			✤	✤				
Native Revegetation	✤	✤	✤	✤	✤	✤	✤	✤

Ecoregion recommendations are also provided for each species (Figure C.2). Whenever possible, the designer/ installer should seek to use species that historically occurred in the same ecoregion as the project. When necessary, species occurring in an adjacent ecoregion may be used.

Figure C.2
EPA Level III Ecoregions for Michigan



Source: USEPA

Plant Installation

Native Seeding

Seasonal consideration: October 1-June 15 (note: seeds should not be planted on frozen ground).

Native seeding is generally recommended for areas above the water line or 1-2" below the water line. Live plant material should be used to establish vegetation at deeper water levels.

Broadcast seeding

Broadcast seeding is preferred over drill seeding on graded, bare soil sites. Apply the seed uniformly over the surface using a combination seeder/cultipacker unit such as a Brillion or Truax Trillion seeder. The Trillion seeder is preferred as it is designed to handle native seeds.

A cone seeder or other similar broadcasting equipment may also be used if the seed mix does not contain fluffy seeds in amounts sufficient to prevent free flowing without plugging. Seed should then be pressed into the surface using a cultipacker or roller.

Drill seeding

A rangeland-type no-till drill designed to plant native grasses and forbs may be used in bare soils although this equipment is specifically designed to plant through existing vegetation which is killed with an herbicide. Cultipacking or rolling before seeding may be required to prevent seed placement depths exceeding .25 inch, but cultipacking or rolling after seeding is not required.

All seeding equipment, whether broadcast or drill, should be calibrated to deliver the seed at the rates and proportions specified in the plans. Equipment should be operated to ensure complete coverage of the entire area to be seeded, and seed must be placed no deeper than .25 inch in the soil. No fertilizers or soil conditioners will be required or allowed.

Native Planting

Seasonal considerations: May 1-July 1

Plant plugs should be installed in holes drilled with an auger the same diameter and depth as the plug within +0.75 inch/- 0.25 inch. In wetland plantings where soil is soft and moist enough, a dibble bar or trowel may also be used. The planting layout should consider the requirements of the individual species regarding soil type, moisture, slope, shading, and other factors for the particular plant species.

Planting densities vary according to budget and project goals and can range from three-to-five foot spacing for plug supplements of seeded areas to six inches to two foot spacing for high visibility landscaping projects with large budgets. Groups of five-to-seven plugs of the same species planted approximately one foot apart is usually preferable to planting all species intermixed randomly across the site at a uniform density.

In wetland or shoreline areas with potential for high wave action or wildlife predation that may dislodge newly planted plugs, plugs should be secured with six inch or eight inch U-shaped wire erosion control blanket staples. Staple length is determined by the density of the planting substrate; softer substrates require longer length to hold plugs adequately.

In areas where potential for wildlife predation exists, such as retention basins or other planting areas adjacent to open water, waterfowl barriers should be installed around a minimum of 50 percent of the plugs. All plugs not protected by barriers should be stapled into the substrate as described above. Barriers may consist of plastic or wire mesh enclosures supported with wooden stakes, adequately constructed to inhibit access by waterfowl for one growing season. Enclosures should extend at least two feet above the plant tops. Methodology should be approved by the project designer with input from a restoration ecologist if necessary. Barriers may be removed after one growing season.

Maintenance and Management

Maintaining vegetated BMPs is typically most important during the first few years following installation. Supplemental irrigation may be needed to help establish plants in drought conditions. Plants may need to be replaced due to predation or other unseen factors. Most commonly, management includes removing invasive species via mowing, hand-pulling, or spot herbicide applications. In larger areas, broadcast herbicide applications may be appropriate. Over time in upland areas, controlled burning may be used as a way to invigorate the plantings and control certain invasive species. If not feasible for social or cultural reasons, an annual or biennial mowing may be used instead of fire.

Long-term management may be necessary, but is typically significantly less intensive. The site should be periodically checked for invasive species infestations. Any prairie or open area may need occasional (every three to five years) burning or mowing to remove woody vegetation that may encroach.

Zone A

Planting Zone = two-to-four inches below water level

These species require continual inundation within the given water depths in order to thrive. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for a majority of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57

Representative Zone A Species

Buttonbush

Pickerel Weed

Swamp Milkweed

Arrowhead

Blue Flag Iris

Source: JFNew

Zone B

Planting Zone = zero-to-two inches below water level

These species tolerate fluctuating water levels within this range. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for most of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-Jun	F	N	50,51,55,56,57
Carex lacustris	Lake sedge	2’-4’	Brown	May-Jun	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Alisma plantago-aquatica	Water plantain	2’-4’	White	Jul-Sep	F	N	50,51,55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard’s tail	2’-4’	White	Jun-Aug	P/S	N	55,56,57

Representative Zone B Species

Blue Flag Iris

Arrowhead

Bristly Sedge

Pickerel Weed

Swamp Milkweed

Source: JFNew

Zone C

Planting Zone = zero-to-two inches above water level

These plants are tolerant of fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Alnus rugosa	Speckled alder	25’	Brown	Mar-May	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Cephalanthus occidentalis	Buttonbush	15’	White	Jun/Aug	F/P/S	N	51,55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	Y	55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Grasses/Sedges/Rushes:							
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Forbs:							
Alisma plantago-aquatica	Water plantain	2'-4'	White	Jul-Sep	F	N	50,51,55,56,57
Anemone canadensis	Canada anemone	1'-2'	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6'-9'	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3'-5'	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3'-6'	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3'-6'	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1'-4'	White	Jul-Oct	F/P	N	50,51,55,56,57
Cassia hebecarpa	Wild senna	3'-5'	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2'-4'	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Eupatorium maculatum	Spotted Joe-pye weed	4'-7'	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3'-5'	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1'-3'	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3'-5'	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5'-12'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2'-3'	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3'-5'	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3'-8'	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2'-5'	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1'-4'	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1'-3'	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2'-4'	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2'-5'	Pink	Aug-Oct	F	Y	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1'-3'	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3'-10'	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Sagittaria latifolila	Arrowhead	1'-4'	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard's tail	2'-4'	White	Jun-Aug	P/S	N	55,56,57
Sisyrinchium angustifolium	Stout blue-eyed grass	1'	Blue	May-Aug	F/P	N	55,56,57
Solidago ohiensis	Ohio goldenrod	2'-3'	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3'-6'	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell's goldenrod	2'-5'	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3'-6'	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2'-5'	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3'-6'	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3'-6'	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3'-5'	Purple	Jul-Sep	F	N	55,56,57
Zizia aurea	Golden Alexanders	1'-3'	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone C Species

Cardinal Flower

Swamp Milkweed

Blue-Eyed Grass

Obedient Plant

Joe-Pye Weed

Path Rush

Red-Osier Dogwood

Monkey Flower

Source: JFNew

Zone D

Planting Zone = two-to-four inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Viburnum trilobum	Cranberry Viburnum	10’	White	Apr-May	F/P/S	N	50,51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Panicum virgatum	Switch grass	3‘-5’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Forbs:							
Anemone canadensis	Canada anemone	1’-2’	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6’-9’	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3’-6’	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1’-4’	White	Jul-Oct	F/P	N	50,51,55,56,57
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2’-4’	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	51,55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium maculatum	Spotted Joe-pye weed	4’-7’	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3’-5’	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1’-3’	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3’-5’	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3’-8’	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2’-5’	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1’-4’	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1’-3’	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2’-4’	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3’-10’	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2‘-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago ohiensis	Ohio goldenrod	2’-3’	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3’-6’	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell’s goldenrod	2’-5’	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3’-6’	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2’-5’	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3’-6’	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3’-6’	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57
Veronicastrum virginicum	Culver’s root	3’-6’	White	Jun-Aug	F/P	N	55,56,57
Zizia aurea	Golden Alexanders	1’-3’	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone D Species

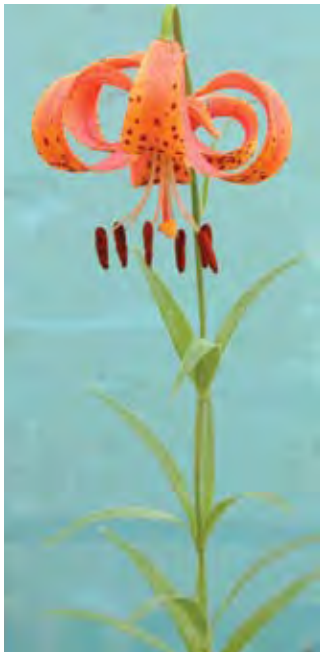
Big Bluestem

Marsh Blazing Star

Wild Columbine

Great Blue Lobelia

Virginia Mountain Mint



Michigan Lily

Meadowsweet

Blue Vervain

Source: JFNew

Zone E

Planting Zone = four-to-18 inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100’	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	N
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80’	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1’-3’	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus florida	Flowering dogwood	30’	White	May-Jun	F/P/S	N	55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85’	White	Jun	F/P	N	55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Pinus banksiana	Jack pine	60’	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100’	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100’	Brown	Jun	F/P/S	N	50,51,55,56,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Prunus americana	American plum	30’	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30’	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7’	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1’-2’	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1’-3’	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1’-2’	Purple	Aug-Oct	F	N	51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Panicum virgatum	Switch grass	3’-6’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2’-4’	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4’-9’	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Stipa spartea	Porcupine grass	2’-4’	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1’-2’	Lavender	Jun-Oct	F/P	N	55,56
Aquilegia canadensis	Wild columbine	1’-3’	Red/ Yellow	Apr-Jun	F/P/S	Y	50,51,55,56,57
Asclepias syriaca	Common milkweed	2’-4’	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1’-3’	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1’-2’	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2’-4’	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3’-5’	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster lateriflorus	Calico aster	1’-3’	White	Jul-Oct	F/P/S	N	50,51,55,56,57
Aster macrophyllus	Big-leaved aster	6”-2’	Lav/ White	Jul-Oct	P/S	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1’-4’	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short’s aster	1’-4’	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Campanula americana	Tall bellflower	2’-6’	Blue	Jul-Nov	P/S	N	55,56,57
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Clematis virginiana	Virgin’s bower	9’ long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2’-5’	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3’-6’	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2’-4’	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1’-2’	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2’-6’	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
elianthus pauciflorus	Prairie sunflower	3’-5’	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2’-4’	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2’-3’	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P/S	N	55,56,57
Liatris scariosa	Savanna blazing star	3’-5’	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2’-4’	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1’-2’	Purple	May-Jul	F/P	N	55,56,57
Phlox divaricata	Wild blue phlox	1’-2’	Blue	Apr-Jun	P/S	N	51,55,56,57
Phlox pilosa	Sand prairie phlox	1’-2’	Pink	May-Aug	F/P	N	56
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1’-3’	White	May-Jul	P/S	N	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Ratibida pinnata	Yellow coneflower	3’-6’	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1’-3’	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2’-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Silphium terebinthinaceum	Prairie-dock	3’-8’	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solo-mon’s seal	1’-3’	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon’s seal	1’-2’	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago juncea	Early goldenrod	2’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1’-3’	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Thalictrum dioicum	Early meadow-rue	1’-3’	Green	Apr-May	P/S	N	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2’-4’	Blue	May-Oct	F/P	N	55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57

Representative Zone E Species

New England Aster

Wild Bergamot

Showy Goldenrod

Tall Bellflower

Wild Geranium

Tall Coreopsis

Redbud

Indian Grass

Source: JFNew

Zone F

Planting Zone = 18+inches above water level

These plants tolerate fluctuating water levels within this range, although they are generally less tolerant than most wetter species. They may tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for upland BMP settings.

Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90'	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100'	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100'	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70'	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80'	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1'-3'	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60'	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25'	Red	Apr-May	F/P/S	N	55,56,57
Cornus florida	Flowering dogwood	30'	White	May-Jun	F/P/S	N	55,56,57
Corylus americana	American hazelnut	10'	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85'	White	Jun	F/P	N	55,56,57
Hamamelis virginiana	Witch hazel	30'	Yellow	Oct-Nov	F/P/S	N	50,51,55,56,57
Juglans nigra	Black walnut	90'	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50'	Brown	Apr-May	F/P	N	55,56,57
Liriodendron tulipifera	Tulip tree	110'	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50'	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100'	Green	May-Jul	F/P/S	Y	51,55,56,57
Pinus banksiana	Jack pine	60'	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100'	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100'	Brown	Jun	F/P/S	N	50,51,55,56,57
Prunus americana	American plum	30'	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30'	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus macrocarpa	Bur oak	85'	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90'	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90'	Green	May-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3'	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100'	Yellow	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100'	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7'	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10'	White	May-Jun	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4'-8'	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1'-2'	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1'-3'	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3'-6'	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3'-5'	Green	Jun-Jul	P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1'-2'	Purple	Aug-Oct	F	N	51,55,56,57
Koeleria macrantha	June grass	1'-2'	White	May-Jul	F/P	N	50,51,55,56,57
Panicum virgatum	Switch grass	3'-6'	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2'-4'	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4'-9'	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6'-7'	Green	Jul-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Stipa spartea	Porcupine grass	2'-4'	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1'-2'	Lavender	Jun-Oct	F/P	N	55,56
Asclepias syriaca	Common milkweed	2'-4'	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1'-3'	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1'-2'	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2'-4'	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3'-5'	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1'-4'	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short's aster	1'-4'	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3'-8'	White	Jun-Oct	F/P/S	N	55,56
Campanulaa americana	Tall bellflower	2'-6'	Blue	Jul-Nov	P/S	N	55,56,57
Clematis virginiana	Virgin's bower	9' long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis lanceolata	Sand coreopsis	1'-2'	Yellow	May-Aug	F/P	N	50,51,55
Coreopsis palmata	Prairie coreopsis	1'-2'	Yellow	Jun-Aug	F/P	N	55
Coreopsis tripteris	Tall coreopsis	4'-8'	Yellow	Aug-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2'-5'	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3'-5'	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3'-6'	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2'-4'	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1'-2'	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2'-6'	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus occidentalis	Western sunflower	2'-4'	Yellow	Aug-Sep	F/P	N	50,51,55,56,57
Helianthus pauciflorus	Prairie sunflower	3'-5'	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4'-6'	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2'-4'	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2'-3'	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris cylindracea	Cylindrical blazing star	1'-2'	Violet	Jul-Oct	F/P	N	51,55,56,57
Liatris scariosa	Savanna blazing star	3'-5'	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Lupinus perennis	Wild lupine	1'-2'	Purple	Apr-Jun	F/P	N	55,56,57
Monarda fistulosa	Wild bergamot	2'-5'	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2'-4'	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1'-2'	Purple	May-Jul	F/P	N	55,56,57
Phlox pilosa	Sand prairie phlox	1'-2'	Pink	May-Aug	F/P	N	56
Polygonatum biflorum	Solomon seal	1'-4'	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1'-3'	White	May-Jul	P/S	N	50,51,55,56,57
Ratibida pinnata	Yellow coneflower	3'-6'	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1'-3'	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Silphium terebinthinaceum	Prairie-dock	3'-8'	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solomon's seal	1'-3'	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon's seal	1'-2'	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1'-2'	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago juncea	Early goldenrod	2'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1'-3'	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2'-4'	Blue	May-Oct	F/P	N	55,56,57
Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Representative Zone F Species

Spiderwort

Butterfly Weed

Yellow Coneflower

Little Bluestem

Foxglove Beardtongue

Wild Lupine

Pale Purple Coneflower

Rattlesnake Master

Sand Coreopsis

Source: JFNew

Zone G

Planter Box Plantings

Although this manual typically recommends using native plants wherever possible, certain situations call for non-native plants due to particular site conditions. Because planter boxes traditionally have a short soil column and are exposed to drier conditions, non-native plants should be considered as long as they are considered non-invasive. Therefore, the list below contains both native and non-native species. Many planter boxes have traditionally used annual flowers. However, we recommend using perennial plants for establishing root systems and lowering maintenance in the long term. Many more species are available for planter boxes than are listed.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun
Ajuga reptans 'Bronze Beauty'	Bronze Beauty Ajuga	6"	Blue	May-Jun	F
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	6"-1'	White	May-Jun	F
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	6"-1'	Blue	Jun-Jul	F
Allium senescens montanum	Mountain Garlic	6"-1'	Pink/Purple	Jun-Aug	F
Allium senescens glaucum	Curly Onion	6"-1'	Pink	Jul-Sep	F
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	6"-1'	Pink	Jul-Aug	F
Aster 'Wood's Light Blue'	Wood's Light Blue Aster	1'-3'	Blue	Aug-Sep	F
Athryium filix-femina	Lady Fern	1'-3'	Green	NA	F/P/S
Blechnum spicant	Deer Fern	1'-2'	Green	NA	F/P/S
Dryopteris erythrosora	Autumn Fern	1'-2'	Green	NA	F/P/S
Euphorbia myrsinites	Mytle Spurge	6"-1'	Yellow	May-Jun	F
Dryopteris intermedia	Fancy Fern	1'-3'	Green	NA	F/P/S
Dyropteris marginalis	Leatherleaf Fern	1'-2'	Green	NA	F/P/S
Geranium x 'Rozanne'	Rozanne Gernaium	1'-2'	Violet	Jun-Sep	F/P
Hemerocallis 'Barbara Mitchell'	Barbara Mitchell Daylily	2'-3'	Pink	Jun-Aug	F/P
Hemerocallis 'Bill Norris'	Bill Norris Daylily	2'-3'	Yellow	Jun-Aug	F/P
Hemerocallis 'Chicago Apache'	Chicago Apache Daylily	2'-3'	Red	Jul-Sep	F/P
Hosta 'Francee'	Francee Hosta	1'-2'	Lavender	Jul-Aug	F/P/S
Hosta 'Guacamole'	Guacamole Hosta	1'-2'	Pink	Aug-Sep	F/P/S
Hosta 'Summer Fragrance'	Summer Fragrance Hosta	1'-2'	Lavender	Aug-Sep	F/P/S
Hosta sieboldiana 'Elegans'	Elegans Hosta	1'-2'	White	Jul-Aug	F/P/S
Sedum 'Autumn Charm'	Autumn Charm Sedum	6"-1'	Pink	Jun-Jul	F
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	6"-1'	Pink	May-Jun	F
Sedum 'Mini Me'	Mini Me Sedum	6"-1'	Green	NA	F
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	6"-1'	Yellow	Jul-Sep	F
Sedum album 'Athoum'	Jelly Bean Sedum	6"-1'	Pink	Aug-Sep	F
Sedum album 'Coral Carpet'	Coral Carpet Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Faro Island'	Faro Island Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Green Ice'	Green Ice Sedum	6"-1'	White	Jun-Jul	F
Sedum album 'Murale'	Wall Sedum	6"-1'	White	Jun-Jul	F
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	6"-1'	Pink	Jul-Aug	F
Sedum divergens	Cascade Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum ellacombianum	Ellacombe's Sedum	6"-1'	Yellow	May-Jun	F
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	6"-1'	Yelow	May-Jun	F
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum grisbachii	Griseback Sedum	6"-1'	Yellow	Jul-Aug	F
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	6"-1'	Yellow	Jun	F
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	6"-1'	Orange	Jul-Aug	F
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	6"-1'	Yellow	May-Jun	F

Representative Zone G Species

Guacamole Hosta

Mountain Garlic

Wall Sedum

Lady Fern

Source: JFNew

Zone H

Vegetated Roof Plantings

Research to-date shows that native plants do not typically thrive in vegetated roofs. Therefore, the list below reflects species that are known to thrive in green roof situations. All species listed below will generally grow to a height of six-to-18 inches.

Botanical Name	Common Name	Color	Bloom Time
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	White	May-Jun
Allium schoenoprasum 'Dwarf'	Dwarf Ornamental Chive	Pink	May-Jun
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	Blue	Jun-Jul
Allium senescens montanum	Mountain Garlic	Pink/Purple	Jun-Aug
Allium senescens glaucum	Curly Onion	Pink	Jul-Sep
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	Pink	Jul-Aug
Euphorbia myrsinites	Mytle Spurge	Yellow	May-Jun
Sedum 'Autumn Charm'	Autumn Charm Sedum	Pink	Jun-Jul
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	Pink	May-Jun
Sedum 'Mini Me'	Mini Me Sedum	Green	NA
Sedum acre 'Aureum'	Gold Leaved Goldmoss Sedum	Yellow	May-Jun
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	Yellow	Jul-Sep
Sedum album 'Athoum'	Jelly Bean Sedum	Pink	Aug-Sep
Sedum album 'Coral Carpet'	Coral Carpet Sedum	White	Jun-Aug
Sedum album 'Faro Island'	Faro Island Sedum	White	Jun-Aug
Sedum album 'Green Ice'	Green Ice Sedum	White	Jun-Jul
Sedum album 'Murale'	Wall Sedum	White	Jun-Jul
Sedum album 'Red Ice'	Red Ice Sedum	White	Jun-Jul
Sedum cautacola 'Bertram Anderson'	Bertram Anderson Sedum	Pink	Jul-Aug
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	Pink	Jul-Aug
Sedum divergens	Cascade Sedum	Yellow	Jun-Jul
Sedum ellacombianum	Ellacombe's Sedum	Yellow	May-Jun
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	Yelow	May-Jun
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	Yellow	Jun-Jul
Sedum grisbachii	Griseback Sedum	Yellow	Jul-Aug
Sedum hispanicum 'Pinkie'	Pinkie Sedum	Pink	Jun-Jul
Sedum hybridum 'Immergunchen'	Evergreen Sedum	Yellow	Jun, Sep
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	Yellow	Jun
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	Orange	Jul-Aug
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	Yellow	May-Jun

*List provided by Hortech, Inc.

Representative Zone H Species

Mountain Garlic

Cascade Sedum

Ellacombe's Sedum

Wall Sedum

Source: JFNew

Appendix G
Recommended Materials

Recommended Materials

Numerous BMPs in this manual have similar material needs. These BMPs are listed in the table below. Detailed information on each material requirement follows. In addition, Porous Pavement and Vegetated Roofs have significant material requirements that are listed according to their individual needs.

	Constructed Filters	Dry Well	Infiltration Trench	Planter Boxes	Porous Pavement	Subsurface Infiltration	Vegetated Filter Strip	Vegetated Swale
Check dams							X	X
Non-Woven Geotextile	X	X	X	X	X	X	X	
Pea Gravel							X	
Peat	X			X				
Pervious Berms							X	
Pipe – 8”	X	X	X	X	X	X	X	
Sand	X			X				X
Stone/Gravel	X			X				
Stone – 30%							X	
Stone – 40%			X		X			

Check dams (Vegetated Filter Strip, Vegetated Swale)

An earthen check dam shall be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02 in to 0.04 in, Gravel: AASHTO M-43 0.5 in to 1.0 in). A stone check dam shall be constructed of R-4 rip rap, or equivalent.

Non-Woven Geotextile (Constructed Filter, Dry Well, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should consist of needled nonwoven polypropylene fibers and meet the following properties:

a. Grab Tensile Strength (ASTM-D4632) 120 lbs min.
b. Mullen Burst Strength (ASTM-D3786) 225 psi min.
c. Flow Rate (ASTM-D4491) 110 gal/min/ft2 min.
d. UV Resistance after 500 hrs (ASTM-D4355) 70% min.
e. Puncture strength (ASTM D-4833-00) 90 lb. min.
f. Apparent opening size (ASTM D-4751-99A) 60-70 US Sieve

Heat-set or heat-calendared fabrics are not permitted. Acceptable types include Mirafi 140N, Amoco 4547, Geotex 451, or approved others.

Pea Gravel (Vegetated Filter Strip)

Clean bank-run gravel may also be used and should meet ASTM D 448 and be sized as per No.6 or 1/8” to 3/8”.

Peat (Constructed Filter, Planter Boxes)

Should have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.

Pervious Berms (Vegetated Filter Strip)

The berm shall have a height of 6-12 in and be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02”-0.04”, Gravel: AASHTO M-43 ½” to 1”)

Pipe - (Dry Well, Porous Pavement, Subsurface Infiltration, Constructed Filter, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should be continuously perforated, smooth interior, with a minimum inside diameter as required. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or M294, Type S (12 gauge aluminum or pipe may also be used in seepage pits).

Sand (Constructed Filter, Planter Boxes, Vegetated Swale)

Should be ASTM-C-33 (or AASHTO M-6) size (0.02” – 0.04”), concrete sand, clean, medium to fine sand.

Stone/Gravel (Constructed Filter, Planter Boxes):

Should be uniformly graded coarse aggregate, 1 inch to ½ inch with a wash loss of no more than 0.5%, AASHTO size number 5 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and have voids of 40% as measured by ASTM-C29.

Stone – 40% voids (Infiltration Trench, Porous Pavement, Subsurface Infiltration Bed,)

Infiltration trenches should have stone 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids 40% as measured by ASTM-C29.

Porous Pavement

General

Choker base course aggregate for beds shall be 3/8 inch to 3/4 inch clean, uniformly-graded, coarse, crushed aggregate AASHTO size number 57 per Table 4, AASHTO Specifications, Part I, 19th Ed., 1998 (p. 47).

Porous Asphalt

Bituminous surface course for porous paving shall be 2.5 to 3 inches thick with a bituminous mix of 5.75% to 6.75% by total weight as determined by testing below. Use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of PG 76-22P (in northern Michigan, use PG 76-28P as appropriate) as specified in AASHTO MP-1. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Determination of optimal asphalt content should be determined according the following tests:

- Draindown Test (ASTM Method D6390)
- Moisture Susceptibility Test using the Modifed Lottman Method (AASHTO T283) with the following:
  - Compact using 50 gyrations of Superpave gyratory compactor
  - Apply partial vacuum of 26 inches of Hg for 10 minutes to whatever saturation is achieved.
  - Keep specimens submerged in water during freeze cycle.
  - Required retained tensile strength (TSR) >= 80%
- Air Voids Test (AASHTO T269/ASTM D3203)

Hydrated lime, if required, shall meet the requirements of AASHTO M 303 Type 1 and shall be blended with the damp aggregate at a rate of 1.0% by weight of the total dry aggregate. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

Fibers, if used, shall consist of either cellulose fibers or mineral fibers which are to be treated with a cationic sizing agent to enhance dispersement of the fiber as well as increase cohesion of the fiber to the bitumen. Fiber is to be added at a dosage rate between 0.2% and 0.4% by weight of total mix.

- Mineral fibers shall be from virgin, basalt, diabase, or slag with a maximum average fiber length of 6.35 mm and a maximum average fiber thickness of 0.005 mm.
- Cellulose fiber – Fiber length shall be 6.4 mm (max), Ash Content 18% non-volatiles (±5%), pH 7.5 (± 1), Oil absorption (times fiber weight) 5.0 (± 1), Moisture Content 5.0 (max).

Porous Concrete

The use of Installers or Craftsmen who have been certified by the NRMCA's Pervious Concrete Contractor Certification Program is strongly recommended. Contractor shall furnish a proposed mix design with all applicable information to the Engineer prior to commencement of work. Critical mix characteristics typically include the following:

- Cement Content: 550 to 650 lb/cy
- Fine aggregate, if used: maximum 3 cu. ft. per cu. yd.
- Admixtures: use in accordance with the manufacturer's instructions and recommendations
- An aggregate/cement (A/C) ratio: 4:1 to 4.5:1
- Water/cement (W/C) ratio: 0.27 to 0.34
- Curing: shall begin within 15 minutes after placement and continue for 7 days

The data shall include unit weights determined in accordance with ASTM C29 paragraph 11, jigging procedure.

Cement: Portland Cement Type II or V conforming to ASTM C150 or Portland Cement Type IP or IS conforming to ASTM C595. The total cementitious material shall be between 550 and 650 lb./cy.

Aggregate: Use No 8 coarse aggregate (3/8 to No. 16) per ASTM C33 or No. 89 coarse aggregate (3/8 to No. 50) per ASTM D 448. If other gradation of aggregate is to be used, submit data on proposed material to owner for approval. The volume of aggregate per cu. yd. shall be equal to 27 cu.ft. when calculated as a function of the unit weight determined in accordance with ASTM C 29 jigging procedure. Fine aggregate, if used, should not exceed 3 cu. ft. and shall be included in the total aggregate volume.

Air Entraining Agent: Shall comply with ASTM C 260 and shall be used to improve workability and resistance to freeze/thaw cycles.

Admixtures: The following admixtures shall be used:

- Type D Water Reducing/Retarding – ASTM C 494.
- A hydration stabilizer that also meets the requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding admixtures may be used. This stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles from achieving initial set.

Water: Potable shall be used and shall comply with ASTM C1602. Mix water shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (Mix water yielding a cement paste with a dull-dry appearance has insufficient water for hydration).

- Insufficient water results in inconsistency in the mix and poor bond strength.
- High water content results in the paste sealing the void system primarily at the bottom and poor surface bond.

An aggregate/cement (A/C) ratio range of 4:1 to 4.5:1 and a water/cement (W/C) ratio range of 0.27 to 0.34 should produce pervious pavement of satisfactory properties in regard to permeability, load carrying capacity, and durability characteristics.

Vegetated roofs

Some key components and associated performance-related properties are as follows:

Root-barriers should be thermoplastic membranes with a thickness of at least 30 mils. Thermoplastic sheets can be bonded using hot-air fusion methods, rendering the seams safe from root penetration. Membranes that have been certified for use as root-barriers are recommended. At present only FLL offers a recognized test for root-barriers. Several FLL-certified materials are available in the United States. Interested American manufactures can submit products for testing to FLL-certified labs.

Granular drainage media should be a non-carbonate mineral aggregate conforming to the following specifications:

- Saturated Hydraulic Conductivity >= 25 in/min
- Total Organic Matter, by Wet Combustion (MSA) <= 1%
- Abrasion Resistance (ASTM-C131-96) <= 25% loss
- Soundness (ASTM-C88 or T103 or T103-91) <= 5% loss
- Porosity (ASTM-C29) >= 25%
- Alkalinity, CaCO3 equivalents (MSA) <= 1 %
- Grain-Size Distribution (ASTM-C136)
  - Pct. Passing US#18 sieve <= 1%
  - Pct. Passing ¼-inch sieve <= 30%
  - Pct. Passing 3/8-inch sieve >= 80%

Growth media should be a soil-like mixture containing not more than 15% organic content (wet combustion or loss on ignition methods). The appropriate grain-size distribution is essential for achieving the proper moisture content, permeability, nutrient management, and non-capillary porosity, and 'soil' structure. The grain-size guidelines vary for single and dual media vegetated cover assemblies.

Non-capillary Pore Space at Field Capacity, 0.333 bar (TMECC 03.01, A)	>= 15% (vol)
Moisture Content at Field Capacity (TMECC 03.01, A)	>= 12% (vol)
Maximum Media Water Retention (FLL)	>= 30% (vol)
Alkalinity, Ca CO3 equivalents (MSA)	<= 2.5%
Total Organic Matter by Wet Combustion (MSA)	3-15% (dry wt.)
pH (RCSTP)	6.5-8.0
Soluble Salts (DTPA saturated media extraction)"(RCSTP)	<= 6 mmhos/cm
Cation exchange capacity (MSA)	>= 10 meq/100g
Saturated Hydraulic Conductivity for Single Media Assemblies (FLL)	>= 0.05 in/min
Saturated Hydraulic Conductivity for Dual Media Assemblies (FLL)	>= 0.30 in/min

Grain-size Distribution of the Mineral Fraction (ASTM-D422)

Single Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	<= 5%
Pct. Passing US#60 sieve	<= 10%
Pct. Passing US#18 sieve	5 - 50%
Pct. Passing 1/8-inch sieve	0 - 70%
Pct. Passing 3/8-inch sieve	75 -100%

Dual Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	5-15%
Pct. Passing US#60 sieve	10-25%
Pct. Passing US#18 sieve	20 - 50%
Pct. Passing 1/8-inch sieve	55 - 95%
Pct. Passing 3/8-inch sieve	90 -100%

Macro- and micro-nutrients shall be incorporated in the formulation in initial proportions suitable for support the specified planting.

Separation fabric should be readily penetrated by roots, but provide a durable separation between the drainage and growth media layers (Only lightweight nonwoven geotextiles are recommended for this function.

- Unit Weight (ASTM-D3776) <= 4.25 oz/yd2
- Grab tensile (ASTM-D4632) <= 90 lb
- Mullen Burst Strength (ASTM-D4632) >= 135 lb/in
- Permittivity (ASTM-D4491) >= 2 per second

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Golder Associates

REPORT

HARTSHORN MARINA WEST OPERATIONS & MANAGEMENT PLAN

Stormwater Management

Low Impact Developments / Green Infrastructure

Landowner – City of Muskegon
933 Terrace St.
Muskegon, MI 49440

Landowner – Hartshorn Holdings, LLC.
17923 Wildwood Springs Parkway
Spring Lake, MI 49456

Submitted To: West Michigan Shoreline Regional Development Commission
316 Morris Avenue
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Distribution: One electronic copy

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EXECUTIVE SUMMARY

The Operations and Management (O&M) Plan summarizes the best management practices (BMPs) and low impact development (LID) designs recommended at Hartshorn Marina West for improving stormwater management (Appendix A). Each structural BMP requires maintenance for continued efficiency and is summarized within the plan. Included in the appendices of the report is a maintenance summary for each BMP (Appendix B, C, and D), and example checklists to be used for routine inspections (Appendix E). The plan provides guidance regarding management of vegetation, a list of recommended Michigan species (Appendix F), and a list of other recommend materials (Appendix G). Operations and maintenance costs were analyzed for each development and maintaining the site.

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1.0 HARTSHORN MARINA WEST

Hartshorn Marina West is located in Muskegon, Michigan within the Beidler Creek/Division Street Outfall Watershed. The site is privately owned and located on the lakeshore of Muskegon Lake. The watershed receives stormwater from heavily urbanized areas and the city's storm sewer system. The polluted stormwater discharged to the watershed has resulted in degraded benthic communities, organic chemicals, excessive sediment, and/or flashy hydrology.

With grant support from the Michigan Department of Environmental Quality and the US Environmental Protection Agency, the Muskegon Lake Watershed Partnership, West Michigan Shoreline Regional Development Commission, municipal partners and Golder Associates Inc. recommended design solutions to reduce stormwater runoff, stormwater pollutants, and improve water quality within Hartshorn Marina West and the Beidler Creek/Division Street Outfall Watershed. Stormwater LID designs implemented for the site included four rain gardens, two bioswales, and eight bioretention islands.

2.0 MAINTENANCE COSTS

Stormwater LID designs tend to be less expensive to implement than conventional designs, however they do require long term maintenance to ensure the designs continue to work efficiently. A cost analysis was completed for the Hartshorn Marina West maintenance costs at annual and long term rates. Three types of structural BMPs were assessed including rain gardens, bioswales, and bioretention islands. The total annual costs for maintaining the BMPs at Hartshorn Marina West was estimated at $6,674.Operation and maintenance costs of each BMP are summarized in Table 1. Annual maintenance costs were based on taking a percentage of the total construction costs, based on a low impact development cost comparison completed by Emmons & Oliver Resources, Inc. (EORINC 2015). BMPs were estimated to require approximately 5% to 6% of construction costs for routine and non-routine maintenance. The estimated maintenance costs include aesthetic maintenance and functional maintenance. Functional maintenance assures the BMP is performing efficiently and safely, while aesthetic maintenance is mainly for public acceptance, which can help to reduce functional costs. The percentage of construction cost used for each BMP reflects labor, landscaping, and material costs. A typical year of landscaping includes maintenance such as lawn mowing, removal of debris and litter, replanting or seeding vegetation, and replenishing mulch. Maintenance labor is expected to be greater within the first two to three years as vegetation is established.

Table 1. Operation and Maintenance Costs Summary

Stormwater BMP	Construction Cost ($)	Annual Maintenance Cost (% of Construction Cost)	Annual Maintenance Cost ($)
Rain Garden (without underdrain)	36,075	5	1,804
Bioswale	45,900	6	2,754
Bioretention Islands	42,320	5	2,116
Total Costs			**6,674**

2.1 Rain Garden

The Hartshorn Marina West conceptual stormwater development plan includes four rain gardens encompassing approximately 2,600 square feet. The rain gardens consist of a geotextile filter layer, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Regular maintenance of the rain gardens are required within the first two to three years when vegetation is becoming established. Less maintenance is required after vegetation becomes established and fills empty spaces between plants. Maintenance requirements for the rain gardens can be viewed in Appendix B. A summary of maintenance cost for the rain gardens are provided in Table 1. The annual operations and maintenance costs for the rain gardens were calculated as 5% of the construction costs. The annual cost to maintain the eleven rain gardens is $1,804.

2.2 Bioswale

There are two bioswales implemented in the Hartshorn Marina West stormwater management plan. The bioswales cover about 3,400 square feet, each approximately eight feet wide and totaling 425 linear feet. Bioswales consist of a geotextile filter, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Similar to the rain gardens, the bioswales will be planted with native species and require more maintenance within the first two to three years while vegetation is being established. Routine maintenance items for the bioswales are summarized in Appendix C. The annual maintenance cost of bioswales in the park was calculated as 6% of the construction cost, totaling $2,754.

2.3 Bioretention Island

Bioretention islands require similar maintenance to rain gardens to successfully establish vegetation within the planter box. The planter box consists of a geotextile filter fabric, 18 inches of compacted stone, 18 inches of engineering soil, and two inches of mulch. There are eight bioretention islands implemented within Hartshorn Marina West covering approximately 1,600 square feet. Vegetation within the planter boxes will

consist of a plug, gallon, or tree. The maintenance required for the bioretention islands is summarized in Appendix D. The annual maintenance cost for the bioretention islands was calculated as 5% of the construction cost, equivalent to $2,116.

3.0 ROUTINE INSPECTIONS

Routine inspections of BMPs should be completed at least once every year. Example inspection checklists are included in Appendix E. Inspection checklists vary depending on the type of LID design. The stormwater designs in the Hartshorn Marina West do not include underdrain and overflow systems, so such items on the checklist are not applicable to the site. The example bioretention inspection checklist can be used for inspection of the rain gardens. Rain gardens, bioswales, and bioretention islands should be inspected for debris, erosion, vegetation conditions and coverage, and mulch thickness to determine overall functionality. Based on the selection of native plants used for each BMP, additional species specific inspections may be required. Inspections of vegetation should include determining the overall plant health, checking if plants require trimming or pruning, and assuring invasive species are properly managed.

4.0 VEGETATION

The plant species selected to be used for the BMPs have a significant impact on the effectiveness of the design. Vegetation will require regular maintenance within the first few years while becoming established. Maintenance mainly includes watering plants as needed, and removing invasive species. Once vegetation is established, less maintenance will be required to maintain the BMP areas.

4.1 Native Species

Native plants are implemented in the design because they have deeper and more expansive roots leading to increased infiltration, groundwater recharge and biofiltration. Native plants are also more tolerant to flooding and drought conditions enabling them to thrive in rain gardens, bioswales, and bioretention islands. Plugs and gallons are common sizes of native plants that can be installed in BMPs. A plug is a small plant that grows in a container roughly two inches wide and five inches deep. A gallon is a more mature plant available in a gallon size container. Both sizes of plants require consistent watering during early development (Delta Institute 2015). Suggested species include: cardinal flower (*Lobelia cardinalis*), blue lobelia (*Lobelia siphilitica*), New England aster (*Aster novae-angliae*), and brown fox sedge (*Carex vulpinoidea*). Additional grasses and wildflowers that could tolerate wet growing conditions recommended by the West Michigan Environmental Action Council include: cotton grass (*Eriophorum angustifolium*), golden alexanders (*Zizia aurea*), and blue flag iris (*Iris versicolor*) (WMEAC 2016). A full list of recommended Michigan plants for BMPs is included in Appendix F (SEMCOG, 2008).

4.1.1 Planting Requirements

Maintenance will be required for any plants that do not successfully grow in the planted environment, and an alternative species may need to be planted. Seeding is not the preferred method of planting vegetation since high velocity flows can prevent the plant from establishing. Plugs or gallon-potted plants installed at one to two foot intervals are recommended for effective establishment of vegetation. Trees and shrubs are also recommended. . Seeding should be completed from late April to mid-October if irrigation is available. If irrigation is not available, than seeding can be completed from June 15 or mid-August to mid-October. With dormant seeding, seeding can be completed from November 1 to 30. At all other times of the year, seeding should have a temporary cover (made of oats/cereal rye or other small grain). Plugs and gallons should be installed from May 1 – June 15. Trees and shrubs should be planted from the middle of April through early June, or the middle of September through the middle of November. A maximum of two to three inches of mulch should be evenly spread in the BMPs after installing new plants to help prevent erosion, remove metals, and act as leaf litter in a natural forest environment. The mulch should not be placed directly against the stems of the newly planted vegetation. If wildlife is a threat to newly installed plants additional precautions such as waterfowl barriers are maintenance options.

4.2 Invasive Non-Native Species

Invasive species are not native to the area and tend to grow and spread quickly without natural controls. If unmanaged, invasive species will displace native species (SEMCOG, 2008). Maintenance of invasive species is crucial when native plants are being established and require room to grow. Invasive species can be removed by hand–pulling, mowing, or spot herbicide applications. After native species are established, less maintenance of invasive species is needed. Long term management of invasive species may require removal once every year or as needed. Open areas may require mowing if woody vegetation is noticed encroaching, typically every three to five years.

5.0 WINTER CONDITIONS

Winter conditions in Michigan typically include the buildup of snow and the use of de-icing compounds which can negatively affect plant life. Salt tolerant plants are recommended for sites where de-icing and heavy snow occurs. Recommended products for de-icing are nontoxic and organic, such as magnesium chloride-based liquid products or pretreated salt (Delta Institute, 2008). Sand and cinder from melted snow has the potential of reducing infiltration into the soil. Preventative measures should be taken to avoid the buildup or piling of snow over infiltration systems.

In the spring, the rain gardens, bioswales, and bioretention islands should all be assessed for winter damages. Buildup of debris and sediment should be cleared, and mulch should be evenly spread in any eroded areas. Plants may also require trimming or rehabilitation. Soil aeriation may also be required in spring to reduce impacts of de-icing agents.

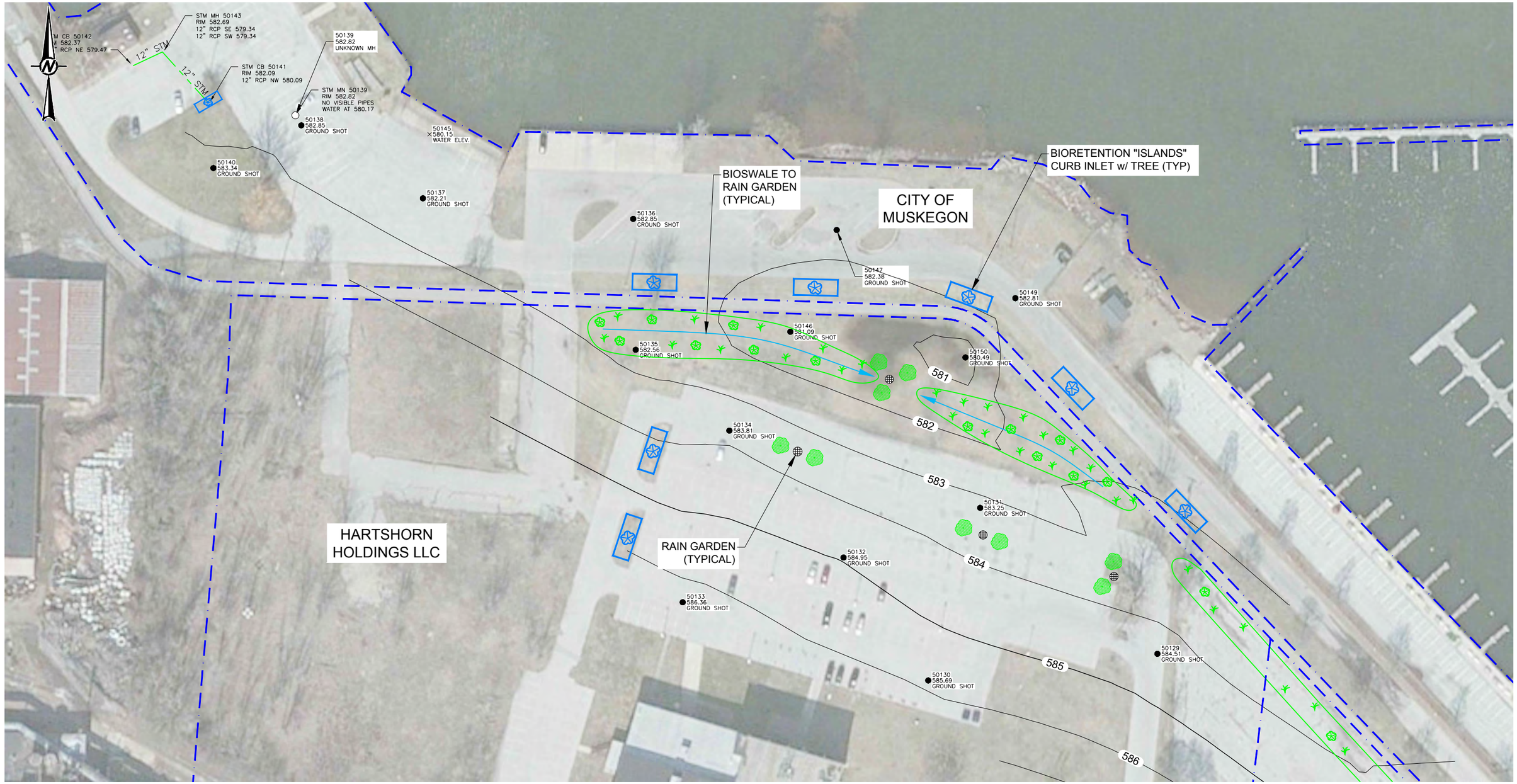
6.0 EDUCATION AND TRAINING

All personnel responsible for the operations and maintenance of the BMPs should undergo training to fully understand the care required for each LID design. Training should include reading the O&M plan and discussing procedures with someone of experience. An educated maintenance staff will increase the efficiency and sustainability of the designs.

7.0 REFERENCES

1. Delta Institute and Guidon Design. 2015. Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
2. Emmons & Oliver Resources, Inc. 2015. Minnesota Low Impact Development A comparison, Cost Comparision. A Case Study Comparison of Costs, Water quality and quanity benefits and quality of life. http://www.eorinc.com/pdf/development-maintenance-cost.pdf
3. SEMCOG (2008). Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html
4. West Michigan Environmental Action Council. 2016. Rain Gardens of West Michigan. Michigan Native Plants List For Use in Rain Gardens and Landscaped Bioretention Areas. http://www.westmichiganglsi.org/uploads/6/7/9/8/6798898/rain_gardens_native_plant_list.pdf

Appendix A
Hartshorn Marina West Conceptual Plan



LEGEND

- PARCEL BOUNDARY
- CLOSED LUST (PART 213)
- PART 201 SITE OF ENVIRONMENTAL CONTAMINATION
- CLOSED UST (PART 211)

NOTE(S)

1. THE HARTSHORN MARINA SITE IS APPROXIMATELY 26.5 ACRES PARCEL AREA AND 11.6 ACRES WATERSHED TREATMENT AREA.
2. THE HARTSHORN MARINA SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 40 80
1" = 80' FEET

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	JJS
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
HARTSHORN MARINA WEST

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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Path: \\farsng\CAD\Projects\15x-Projects\1520593_WMSRDC Green Infrastructure Project\PRODUCTION\B_CONCEPTUAL DESIGN | File Name: 1520593B001.dwg

Appendix B
Rain Garden Maintenance Items

RAIN GARDEN

1.0 PUROPOSE

Rain gardens are used to collect stormwater runoff and encourage infiltration and biofiltration with the use of native plants. Native plants are ideal for rain gardens because they have deeper root networks that draw surface water further into the ground. Native plants are also typically drought and flood tolerant and able to thrive in rain gardens. Rain gardens aide in reducing runoff volume, filtering pollutants, recharging groundwater (if no underdrain is used), reducing stormwater temperature impacts, and enhancing site aesthetics.

2.0 MAINTENANCE

Rain gardens require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered and weeded twice weekly through October of the first year and in times of extreme drought. Weeds should be removed by hand.

3.) Organic matter may also need to be removed approximately twice per year, usually by hand.

4.) Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

5.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

6.) Annual mowing should be performed for the first three years of establishment. Mowing should not be completed on a regular basis.

7.) Removal of debris must occur monthly for the life of the rain garden.

8.) Winter conditions may result in plants being effected by deicing chemicals in snow-melt, in this case salt-tolerant plants should be used. Also try to reduce the amount of sand, cinders, and other winter abrasives that come in contact with the vegetation. Additional maintenance in the spring is required to remove abrasives if used.

9.) Rain gardens should be inspected at least twice a year for sediment buildup, erosion, and overall vegetation conditions. If sediment build up reaches 25% of the ponding depth it should be removed. If erosion is occurring, soil stabilization efforts should be applied. If vegetation is in poor health for no apparent reason, a landscape architect should be consulted.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix C
Bioswale Maintenance Items

BIOSWALE

1.0 PUROPOSE

Bioswales are shallow, vegetated, earthen channels that help to slow, filter, and infiltrate stormwater runoff in the process of conveyance. Native plants are ideal vegetation for bioswales due to their deep roots for infiltrating runoff, and their high tolerance for droughts and floods.

2.0 MAINTENANCE

Bioswales require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Vegetation should be established as soon as possible to prevent erosion and scour. Freshly seeded swales require soil stabilization such as erosion control matting or blankets. Erosion controls for seeded swales are required after planting for 75 days after the first storm event occurs. If runoff velocities are high, sodding the swale or diverting runoff until vegetation is well established is an option.

4.) Debris removal, weeding, and pruning should be performed on a monthly basis.

5.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity issues are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

6.) Mow and trim plants within the bioswales annually to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Mow only when dry to avoid rutting. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

7.) In the spring the bioswales will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

8.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

9.) If roadside or parking lot runoff is directed to the swale, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix D
Bioretention Island Maintenance Items

BIORETENTION ISLAND

1.0 PUROPOSE

A Bioretention islands or stormwater planters are a linear infiltration basin typically located in a parking lot or between a street and sidewalk surrounded by vertical curbing. Stormwater is collected from the street, sidewalk, or parking lot and directed into the bioretention island through openings in the curb. Bioretention islands consist of native plants in engineered soil which lay on top of a layer of stone. The stormwater planters are able to reduce, filter, and infiltrate stormwater runoff and aide in recharging groundwater.

2.0 MAINTENANCE

Bioretention islands require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes mature and capable of choking out invasive species, less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Debris removal, weeding, and pruning should be performed on a monthly basis.

4.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

5.) Annually trim plants to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

6.) In the spring the bioretention islands will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

7.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

8.) If roadside or parking lot runoff is directed to the bioretention island, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix E
Example Inspection Checklists

Maintenance Inspection Checklists

This appendix contains four checklists available as guides for maintenance inspections of specific BMPs. The maintenance items have been adapted from multiple stormwater programs, including the Rouge River Detention Basin Maintenance Manual, Georgia Stormwater Management Manual, the Vermont Stormwater Management Manual, and the Stormwater Manager's Resource Center.

The checklists are designed to help identify key components of BMPs that require ongoing maintenance as well as a basic schedule of when the maintenance should occur. The checklists have been divided into those items essential for the general operation and functionality of the BMP and those items that optional and may enhance the BMP.

It is suggested that the inspection be undertaken by a licensed PE and/or a person knowledgeable about the design and function of the BMP.

These BMP checklists include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

Detention BMP Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet Pipes			
Structural integrity of inlet/outlet (Are any inlet pipes broken, crumbling, separated?) List Inlet Pipes Approximate Diameter and Type of Material Inlet Pipe 1 _____ Inlet Pipe 2 _____ Inlet Pipe 3 _____ Outlet Pipe Size/Type _____		A	
Riprap at inlet pipe (Is the riprap still present? Is it visible and not covered with sediment?		A	
Stone around outlet pipe (Is the stone clogged with debris and/or sediment?)		A	
Trash or debris blocking inlet/outlet (Inspect to ensure no major obstructions hindering general functionality)		M	
Inspect/clean catch basin upstream of the BMP if accessible.		A	
Inspect inlets and outlet for erosion (Are there eroded areas around the pipes?)		A	
Inspect overflow spillway for signs of erosion.			
Pretreatment (if applicable) (Might include sediment forebay, upstream catch basin, bioswale, rain garden, swirl concentrator)			
Device functioning to trap/collect sediment		A	
Remove accumulated sediment as appropriate for the pretreatment device. forebay		A	
Detention Pond		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inspect side slopes, berms and emergency overflow for erosion		A	
Reestablish permanent native vegetation on eroded slopes		As needed	
Inspect for excess sediment accumulation in pond if not pretreatment device is present		A	
Overall functionality			
Ensure pond is functioning properly (Professional Civil Engineer is recommended)		A	
Ensure the outlet is functioning properly (Professional Civil Engineer is recommended)		A	
Optional/Enhancements			
Maintain 15-20 feet “no mow and chemical free” zone		A	
Mow (or burn) the “no mow” zone		A	
Inspect basin and “no mow” zone for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation in and around pond.		A	
Complaints from residents (note on back)		S	
Encroachment on pond/no- mow zone.		A	
Unauthorized plantings		A	
Aesthetics (e.g., graffiti, unkept maintenance)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Summary

Inspector’s remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Infiltration BMPs Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		A	
Pretreatment for sediment			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure infiltration device is functioning properly (professional civil engineer is recommended)		A	
BMP infiltration surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		S	
Evidence of erosion present		A	
Aggregate (if applicable)			
Surface of aggregate clean		A	
Any replacement of aggregate needed? If clogged with sediment replacement is necessary for continued proper function.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Vegetated surface (if applicable)			
Vegetative cover exists		A	
Optional considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation or creating a native plant infiltration basin area.		A	
Complaints from residents (note on back)		A	
Mowing done when necessary		A	
No fertilizer unless testing requires it		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioretention Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway or catch basin clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		Every 5 years	
Pretreatment for sediment (Generally consists of catch basin or velocity dissapator at inlet such as area of riprap/ collection for sediment)			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure bioretention area is functioning properly (professional civil engineer is recommended)		A	
Bioretention area surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		M	
Evidence of erosion present		A	
Does good vegetative cover exist		A	
Mulch covers entire area (no voids) and to specified thickness		A	
Optional considerations			
Inspect BMP for invasive species.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioswale, Filter Strip Inspection Checklist

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Pretreatment/ Energy Dissipators			
No evidence of flow going around structures		A	
No evidence of erosion		A	
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
BMP surface			
Area free of debris?		M	
No evidence of erosion		A	
Does sediment accumulation currently require removal?		A	
Overall functionality			

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Ensure swale is functioning properly (professional civil engineer is recommended)		A	
Optional Considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Appendix F
List of Michigan Recommended Plants

Recommended Plant Lists for Best Management Practices

This appendix contains recommended native and non-native (when appropriate) plant species for the Best Management Practices detailed throughout the manual. Species have been recommended based on hardiness, aesthetics, functionality, and commercial availability. It is certain that species exist outside the confines of this list that will perform in a comparable way to those listed; however, commercial availability is often a limiting factor in obtaining material for native plantings. Over time, and in certain locales, additional species will become available to supplement those listed below.

An array of planting zones is provided based on normal water levels (Figure C.1). Using these zones will provide the best chances for long-term success of native planting in the context of LID. While plants may naturally occur outside of the given ranges, these ranges are intended to be guidelines for plant installation. Whenever possible and practical in standing water conditions, native plants should be installed in live plant form (rather than seed). Seed or a combination of seed and live plants may be used in upland situations.

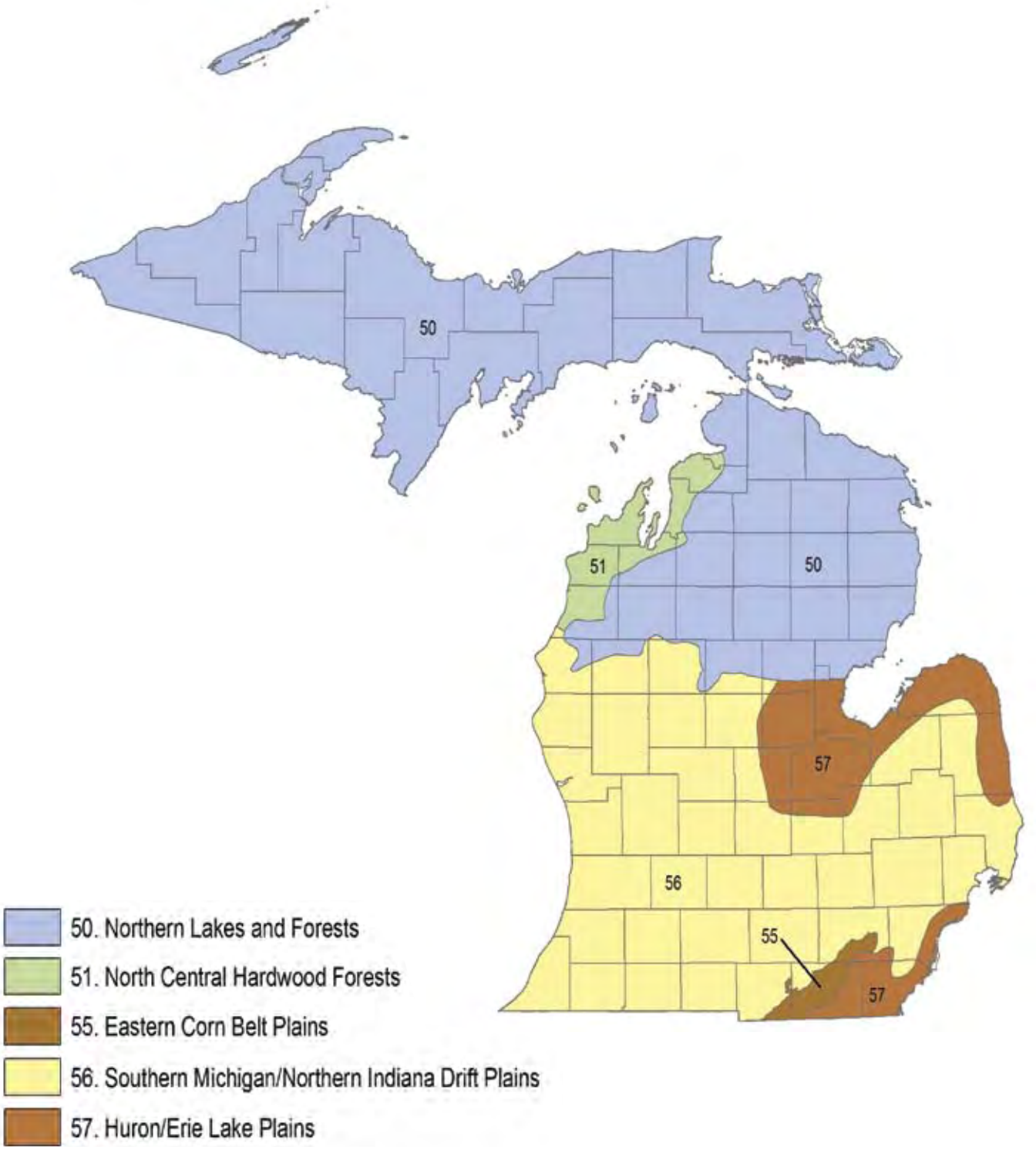
Recommendations are given for height, bloom color, bloom time, sun requirements, salt tolerance, and ecoregion. Please note that these are recommendations based on a range of situations, and a specific plant or population may vary from site-to-site. For sun requirements, F = Full sun required, P = Partial sun tolerated, and S = Shade tolerated. Salt tolerance is classified as Yes (Y) or No (N). This was determined through literature reviews and anecdotal evidence. If there is no information confirming tolerance, a "No" was listed.

Figure C.1
Planting Zone/BMP Matrix

	Zone A — 2"-4" Below Water Level	Zone B — 0"-2" Below Water Level	Zone C — 0"-2" Above Water Level	Zone D — 2"-4" Above Water Level	Zone E — 4"-18" Above Water Level	Zone F — 18"+ Above Water Level	Zone G — Planter Boxes	Zone H — Vegetated Roofs
Rain gardens/Bioretention	✤	✤	✤	✤	✤	✤		
Vegetated Filter Strips			✤	✤	✤	✤		
Vegetated Swales		✤	✤	✤				
Infiltration Basin		✤	✤					
Subsurface Infiltration Basins				✤	✤	✤		
Infiltration Trenches				✤	✤	✤		
Infiltration Berns	✤	✤	✤	✤	✤	✤		
Planter Boxes							✤	
Vegetated Roofs								✤
Constructed Wetlands	✤	✤	✤	✤				
Wet Ponds	✤	✤	✤					
Dry Extended Detention Basins			✤	✤	✤	✤		
Riparian Corridor Restoration			✤	✤				
Native Revegetation	✤	✤	✤	✤	✤	✤	✤	✤

Ecoregion recommendations are also provided for each species (Figure C.2). Whenever possible, the designer/ installer should seek to use species that historically occurred in the same ecoregion as the project. When necessary, species occurring in an adjacent ecoregion may be used.

Figure C.2
EPA Level III Ecoregions for Michigan



Source: USEPA

Plant Installation

Native Seeding

Seasonal consideration: October 1-June 15 (note: seeds should not be planted on frozen ground).

Native seeding is generally recommended for areas above the water line or 1-2" below the water line. Live plant material should be used to establish vegetation at deeper water levels.

Broadcast seeding

Broadcast seeding is preferred over drill seeding on graded, bare soil sites. Apply the seed uniformly over the surface using a combination seeder/cultipacker unit such as a Brillion or Truax Trillion seeder. The Trillion seeder is preferred as it is designed to handle native seeds.

A cone seeder or other similar broadcasting equipment may also be used if the seed mix does not contain fluffy seeds in amounts sufficient to prevent free flowing without plugging. Seed should then be pressed into the surface using a cultipacker or roller.

Drill seeding

A rangeland-type no-till drill designed to plant native grasses and forbs may be used in bare soils although this equipment is specifically designed to plant through existing vegetation which is killed with an herbicide. Cultipacking or rolling before seeding may be required to prevent seed placement depths exceeding .25 inch, but cultipacking or rolling after seeding is not required.

All seeding equipment, whether broadcast or drill, should be calibrated to deliver the seed at the rates and proportions specified in the plans. Equipment should be operated to ensure complete coverage of the entire area to be seeded, and seed must be placed no deeper than .25 inch in the soil. No fertilizers or soil conditioners will be required or allowed.

Native Planting

Seasonal considerations: May 1-July 1

Plant plugs should be installed in holes drilled with an auger the same diameter and depth as the plug within +0.75 inch/- 0.25 inch. In wetland plantings where soil is soft and moist enough, a dibble bar or trowel may also be used. The planting layout should consider the requirements of the individual species regarding soil type, moisture, slope, shading, and other factors for the particular plant species.

Planting densities vary according to budget and project goals and can range from three-to-five foot spacing for plug supplements of seeded areas to six inches to two foot spacing for high visibility landscaping projects with large budgets. Groups of five-to-seven plugs of the same species planted approximately one foot apart is usually preferable to planting all species intermixed randomly across the site at a uniform density.

In wetland or shoreline areas with potential for high wave action or wildlife predation that may dislodge newly planted plugs, plugs should be secured with six inch or eight inch U-shaped wire erosion control blanket staples. Staple length is determined by the density of the planting substrate; softer substrates require longer length to hold plugs adequately.

In areas where potential for wildlife predation exists, such as retention basins or other planting areas adjacent to open water, waterfowl barriers should be installed around a minimum of 50 percent of the plugs. All plugs not protected by barriers should be stapled into the substrate as described above. Barriers may consist of plastic or wire mesh enclosures supported with wooden stakes, adequately constructed to inhibit access by waterfowl for one growing season. Enclosures should extend at least two feet above the plant tops. Methodology should be approved by the project designer with input from a restoration ecologist if necessary. Barriers may be removed after one growing season.

Maintenance and Management

Maintaining vegetated BMPs is typically most important during the first few years following installation. Supplemental irrigation may be needed to help establish plants in drought conditions. Plants may need to be replaced due to predation or other unseen factors. Most commonly, management includes removing invasive species via mowing, hand-pulling, or spot herbicide applications. In larger areas, broadcast herbicide applications may be appropriate. Over time in upland areas, controlled burning may be used as a way to invigorate the plantings and control certain invasive species. If not feasible for social or cultural reasons, an annual or biennial mowing may be used instead of fire.

Long-term management may be necessary, but is typically significantly less intensive. The site should be periodically checked for invasive species infestations. Any prairie or open area may need occasional (every three to five years) burning or mowing to remove woody vegetation that may encroach.

Zone A

Planting Zone = two-to-four inches below water level

These species require continual inundation within the given water depths in order to thrive. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for a majority of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57

Representative Zone A Species

Buttonbush

Pickerel Weed

Swamp Milkweed

Arrowhead

Blue Flag Iris

Source: JFNew

Zone B

Planting Zone = zero-to-two inches below water level

These species tolerate fluctuating water levels within this range. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for most of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-Jun	F	N	50,51,55,56,57
Carex lacustris	Lake sedge	2’-4’	Brown	May-Jun	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Alisma plantago-aquatica	Water plantain	2’-4’	White	Jul-Sep	F	N	50,51,55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard’s tail	2’-4’	White	Jun-Aug	P/S	N	55,56,57

Representative Zone B Species

Blue Flag Iris

Arrowhead

Bristly Sedge

Pickerel Weed

Swamp Milkweed

Source: JFNew

Zone C

Planting Zone = zero-to-two inches above water level

These plants are tolerant of fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Alnus rugosa	Speckled alder	25’	Brown	Mar-May	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Cephalanthus occidentalis	Buttonbush	15’	White	Jun/Aug	F/P/S	N	51,55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	Y	55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Grasses/Sedges/Rushes:							
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Forbs:							
Alisma plantago-aquatica	Water plantain	2'-4'	White	Jul-Sep	F	N	50,51,55,56,57
Anemone canadensis	Canada anemone	1'-2'	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6'-9'	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3'-5'	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3'-6'	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3'-6'	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1'-4'	White	Jul-Oct	F/P	N	50,51,55,56,57
Cassia hebecarpa	Wild senna	3'-5'	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2'-4'	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Eupatorium maculatum	Spotted Joe-pye weed	4'-7'	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3'-5'	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1'-3'	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3'-5'	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5'-12'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2'-3'	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3'-5'	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3'-8'	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2'-5'	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1'-4'	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1'-3'	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2'-4'	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2'-5'	Pink	Aug-Oct	F	Y	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1'-3'	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3'-10'	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Sagittaria latifolila	Arrowhead	1'-4'	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard's tail	2'-4'	White	Jun-Aug	P/S	N	55,56,57
Sisyrinchium angustifolium	Stout blue-eyed grass	1'	Blue	May-Aug	F/P	N	55,56,57
Solidago ohiensis	Ohio goldenrod	2'-3'	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3'-6'	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell's goldenrod	2'-5'	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3'-6'	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2'-5'	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3'-6'	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3'-6'	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3'-5'	Purple	Jul-Sep	F	N	55,56,57
Zizia aurea	Golden Alexanders	1'-3'	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone C Species

Cardinal Flower

Swamp Milkweed

Blue-Eyed Grass

Obedient Plant

Joe-Pye Weed

Path Rush

Red-Osier Dogwood

Monkey Flower

Source: JFNew

Zone D

Planting Zone = two-to-four inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Viburnum trilobum	Cranberry Viburnum	10’	White	Apr-May	F/P/S	N	50,51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Panicum virgatum	Switch grass	3‘-5’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Forbs:							
Anemone canadensis	Canada anemone	1’-2’	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6’-9’	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3’-6’	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1’-4’	White	Jul-Oct	F/P	N	50,51,55,56,57
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2’-4’	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	51,55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium maculatum	Spotted Joe-pye weed	4’-7’	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3’-5’	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1’-3’	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3’-5’	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3’-8’	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2’-5’	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1’-4’	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1’-3’	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2’-4’	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3’-10’	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2‘-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago ohiensis	Ohio goldenrod	2’-3’	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3’-6’	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell’s goldenrod	2’-5’	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3’-6’	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2’-5’	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3’-6’	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3’-6’	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57
Veronicastrum virginicum	Culver’s root	3’-6’	White	Jun-Aug	F/P	N	55,56,57
Zizia aurea	Golden Alexanders	1’-3’	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone D Species

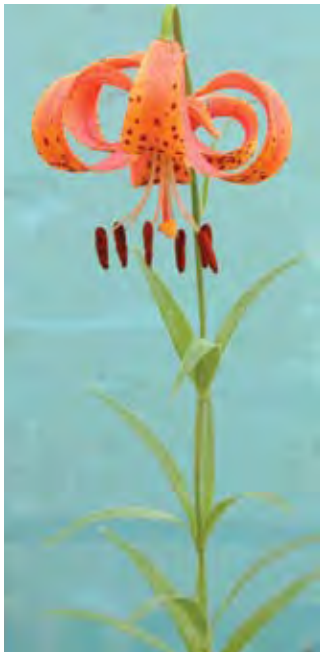
Big Bluestem

Marsh Blazing Star

Wild Columbine

Great Blue Lobelia

Virginia Mountain Mint



Michigan Lily

Meadowsweet

Blue Vervain

Source: JFNew

Zone E

Planting Zone = four-to-18 inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100’	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	N
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80’	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1’-3’	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus florida	Flowering dogwood	30’	White	May-Jun	F/P/S	N	55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85’	White	Jun	F/P	N	55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Pinus banksiana	Jack pine	60’	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100’	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100’	Brown	Jun	F/P/S	N	50,51,55,56,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Prunus americana	American plum	30’	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30’	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7’	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1’-2’	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1’-3’	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1’-2’	Purple	Aug-Oct	F	N	51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Panicum virgatum	Switch grass	3’-6’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2’-4’	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4’-9’	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Stipa spartea	Porcupine grass	2’-4’	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1’-2’	Lavender	Jun-Oct	F/P	N	55,56
Aquilegia canadensis	Wild columbine	1’-3’	Red/ Yellow	Apr-Jun	F/P/S	Y	50,51,55,56,57
Asclepias syriaca	Common milkweed	2’-4’	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1’-3’	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1’-2’	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2’-4’	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3’-5’	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster lateriflorus	Calico aster	1’-3’	White	Jul-Oct	F/P/S	N	50,51,55,56,57
Aster macrophyllus	Big-leaved aster	6”-2’	Lav/ White	Jul-Oct	P/S	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1’-4’	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short’s aster	1’-4’	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Campanula americana	Tall bellflower	2’-6’	Blue	Jul-Nov	P/S	N	55,56,57
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Clematis virginiana	Virgin’s bower	9’ long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2’-5’	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3’-6’	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2’-4’	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1’-2’	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2’-6’	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
elianthus pauciflorus	Prairie sunflower	3’-5’	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2’-4’	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2’-3’	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P/S	N	55,56,57
Liatris scariosa	Savanna blazing star	3’-5’	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2’-4’	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1’-2’	Purple	May-Jul	F/P	N	55,56,57
Phlox divaricata	Wild blue phlox	1’-2’	Blue	Apr-Jun	P/S	N	51,55,56,57
Phlox pilosa	Sand prairie phlox	1’-2’	Pink	May-Aug	F/P	N	56
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1’-3’	White	May-Jul	P/S	N	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Ratibida pinnata	Yellow coneflower	3’-6’	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1’-3’	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2’-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Silphium terebinthinaceum	Prairie-dock	3’-8’	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solo-mon’s seal	1’-3’	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon’s seal	1’-2’	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago juncea	Early goldenrod	2’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1’-3’	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Thalictrum dioicum	Early meadow-rue	1’-3’	Green	Apr-May	P/S	N	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2’-4’	Blue	May-Oct	F/P	N	55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57

Representative Zone E Species

New England Aster

Wild Bergamot

Showy Goldenrod

Tall Bellflower

Wild Geranium

Tall Coreopsis

Redbud

Indian Grass

Source: JFNew

Zone F

Planting Zone = 18+inches above water level

These plants tolerate fluctuating water levels within this range, although they are generally less tolerant than most wetter species. They may tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for upland BMP settings.

Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90'	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100'	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100'	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70'	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80'	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1'-3'	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60'	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25'	Red	Apr-May	F/P/S	N	55,56,57
Cornus florida	Flowering dogwood	30'	White	May-Jun	F/P/S	N	55,56,57
Corylus americana	American hazelnut	10'	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85'	White	Jun	F/P	N	55,56,57
Hamamelis virginiana	Witch hazel	30'	Yellow	Oct-Nov	F/P/S	N	50,51,55,56,57
Juglans nigra	Black walnut	90'	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50'	Brown	Apr-May	F/P	N	55,56,57
Liriodendron tulipifera	Tulip tree	110'	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50'	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100'	Green	May-Jul	F/P/S	Y	51,55,56,57
Pinus banksiana	Jack pine	60'	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100'	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100'	Brown	Jun	F/P/S	N	50,51,55,56,57
Prunus americana	American plum	30'	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30'	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus macrocarpa	Bur oak	85'	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90'	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90'	Green	May-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3'	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100'	Yellow	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100'	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7'	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10'	White	May-Jun	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4'-8'	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1'-2'	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1'-3'	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3'-6'	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3'-5'	Green	Jun-Jul	P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1'-2'	Purple	Aug-Oct	F	N	51,55,56,57
Koeleria macrantha	June grass	1'-2'	White	May-Jul	F/P	N	50,51,55,56,57
Panicum virgatum	Switch grass	3'-6'	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2'-4'	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4'-9'	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6'-7'	Green	Jul-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Stipa spartea	Porcupine grass	2'-4'	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1'-2'	Lavender	Jun-Oct	F/P	N	55,56
Asclepias syriaca	Common milkweed	2'-4'	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1'-3'	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1'-2'	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2'-4'	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3'-5'	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1'-4'	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short's aster	1'-4'	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3'-8'	White	Jun-Oct	F/P/S	N	55,56
Campanulaa americana	Tall bellflower	2'-6'	Blue	Jul-Nov	P/S	N	55,56,57
Clematis virginiana	Virgin's bower	9' long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis lanceolata	Sand coreopsis	1'-2'	Yellow	May-Aug	F/P	N	50,51,55
Coreopsis palmata	Prairie coreopsis	1'-2'	Yellow	Jun-Aug	F/P	N	55
Coreopsis tripteris	Tall coreopsis	4'-8'	Yellow	Aug-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2'-5'	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3'-5'	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3'-6'	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2'-4'	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1'-2'	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2'-6'	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus occidentalis	Western sunflower	2'-4'	Yellow	Aug-Sep	F/P	N	50,51,55,56,57
Helianthus pauciflorus	Prairie sunflower	3'-5'	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4'-6'	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2'-4'	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2'-3'	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris cylindracea	Cylindrical blazing star	1'-2'	Violet	Jul-Oct	F/P	N	51,55,56,57
Liatris scariosa	Savanna blazing star	3'-5'	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Lupinus perennis	Wild lupine	1'-2'	Purple	Apr-Jun	F/P	N	55,56,57
Monarda fistulosa	Wild bergamot	2'-5'	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2'-4'	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1'-2'	Purple	May-Jul	F/P	N	55,56,57
Phlox pilosa	Sand prairie phlox	1'-2'	Pink	May-Aug	F/P	N	56
Polygonatum biflorum	Solomon seal	1'-4'	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1'-3'	White	May-Jul	P/S	N	50,51,55,56,57
Ratibida pinnata	Yellow coneflower	3'-6'	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1'-3'	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Silphium terebinthinaceum	Prairie-dock	3'-8'	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solomon's seal	1'-3'	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon's seal	1'-2'	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1'-2'	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago juncea	Early goldenrod	2'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1'-3'	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2'-4'	Blue	May-Oct	F/P	N	55,56,57
Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Representative Zone F Species

Spiderwort

Butterfly Weed

Yellow Coneflower

Little Bluestem

Foxglove Beardtongue

Wild Lupine

Pale Purple Coneflower

Rattlesnake Master

Sand Coreopsis

Source: JFNew

Zone G

Planter Box Plantings

Although this manual typically recommends using native plants wherever possible, certain situations call for non-native plants due to particular site conditions. Because planter boxes traditionally have a short soil column and are exposed to drier conditions, non-native plants should be considered as long as they are considered non-invasive. Therefore, the list below contains both native and non-native species. Many planter boxes have traditionally used annual flowers. However, we recommend using perennial plants for establishing root systems and lowering maintenance in the long term. Many more species are available for planter boxes than are listed.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun
Ajuga reptans 'Bronze Beauty'	Bronze Beauty Ajuga	6"	Blue	May-Jun	F
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	6"-1'	White	May-Jun	F
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	6"-1'	Blue	Jun-Jul	F
Allium senescens montanum	Mountain Garlic	6"-1'	Pink/Purple	Jun-Aug	F
Allium senescens glaucum	Curly Onion	6"-1'	Pink	Jul-Sep	F
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	6"-1'	Pink	Jul-Aug	F
Aster 'Wood's Light Blue'	Wood's Light Blue Aster	1'-3'	Blue	Aug-Sep	F
Athryium filix-femina	Lady Fern	1'-3'	Green	NA	F/P/S
Blechnum spicant	Deer Fern	1'-2'	Green	NA	F/P/S
Dryopteris erythrosora	Autumn Fern	1'-2'	Green	NA	F/P/S
Euphorbia myrsinites	Mytle Spurge	6"-1'	Yellow	May-Jun	F
Dryopteris intermedia	Fancy Fern	1'-3'	Green	NA	F/P/S
Dyropteris marginalis	Leatherleaf Fern	1'-2'	Green	NA	F/P/S
Geranium x 'Rozanne'	Rozanne Gernaium	1'-2'	Violet	Jun-Sep	F/P
Hemerocallis 'Barbara Mitchell'	Barbara Mitchell Daylily	2'-3'	Pink	Jun-Aug	F/P
Hemerocallis 'Bill Norris'	Bill Norris Daylily	2'-3'	Yellow	Jun-Aug	F/P
Hemerocallis 'Chicago Apache'	Chicago Apache Daylily	2'-3'	Red	Jul-Sep	F/P
Hosta 'Francee'	Francee Hosta	1'-2'	Lavender	Jul-Aug	F/P/S
Hosta 'Guacamole'	Guacamole Hosta	1'-2'	Pink	Aug-Sep	F/P/S
Hosta 'Summer Fragrance'	Summer Fragrance Hosta	1'-2'	Lavender	Aug-Sep	F/P/S
Hosta sieboldiana 'Elegans'	Elegans Hosta	1'-2'	White	Jul-Aug	F/P/S
Sedum 'Autumn Charm'	Autumn Charm Sedum	6"-1'	Pink	Jun-Jul	F
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	6"-1'	Pink	May-Jun	F
Sedum 'Mini Me'	Mini Me Sedum	6"-1'	Green	NA	F
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	6"-1'	Yellow	Jul-Sep	F
Sedum album 'Athoum'	Jelly Bean Sedum	6"-1'	Pink	Aug-Sep	F
Sedum album 'Coral Carpet'	Coral Carpet Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Faro Island'	Faro Island Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Green Ice'	Green Ice Sedum	6"-1'	White	Jun-Jul	F
Sedum album 'Murale'	Wall Sedum	6"-1'	White	Jun-Jul	F
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	6"-1'	Pink	Jul-Aug	F
Sedum divergens	Cascade Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum ellacombianum	Ellacombe's Sedum	6"-1'	Yellow	May-Jun	F
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	6"-1'	Yelow	May-Jun	F
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum grisbachii	Griseback Sedum	6"-1'	Yellow	Jul-Aug	F
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	6"-1'	Yellow	Jun	F
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	6"-1'	Orange	Jul-Aug	F
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	6"-1'	Yellow	May-Jun	F

Representative Zone G Species

Guacamole Hosta

Mountain Garlic

Wall Sedum

Lady Fern

Source: JFNew

Zone H

Vegetated Roof Plantings

Research to-date shows that native plants do not typically thrive in vegetated roofs. Therefore, the list below reflects species that are known to thrive in green roof situations. All species listed below will generally grow to a height of six-to-18 inches.

Botanical Name	Common Name	Color	Bloom Time
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	White	May-Jun
Allium schoenoprasum 'Dwarf'	Dwarf Ornamental Chive	Pink	May-Jun
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	Blue	Jun-Jul
Allium senescens montanum	Mountain Garlic	Pink/Purple	Jun-Aug
Allium senescens glaucum	Curly Onion	Pink	Jul-Sep
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	Pink	Jul-Aug
Euphorbia myrsinites	Mytle Spurge	Yellow	May-Jun
Sedum 'Autumn Charm'	Autumn Charm Sedum	Pink	Jun-Jul
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	Pink	May-Jun
Sedum 'Mini Me'	Mini Me Sedum	Green	NA
Sedum acre 'Aureum'	Gold Leaved Goldmoss Sedum	Yellow	May-Jun
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	Yellow	Jul-Sep
Sedum album 'Athoum'	Jelly Bean Sedum	Pink	Aug-Sep
Sedum album 'Coral Carpet'	Coral Carpet Sedum	White	Jun-Aug
Sedum album 'Faro Island'	Faro Island Sedum	White	Jun-Aug
Sedum album 'Green Ice'	Green Ice Sedum	White	Jun-Jul
Sedum album 'Murale'	Wall Sedum	White	Jun-Jul
Sedum album 'Red Ice'	Red Ice Sedum	White	Jun-Jul
Sedum cautacola 'Bertram Anderson'	Bertram Anderson Sedum	Pink	Jul-Aug
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	Pink	Jul-Aug
Sedum divergens	Cascade Sedum	Yellow	Jun-Jul
Sedum ellacombianum	Ellacombe's Sedum	Yellow	May-Jun
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	Yelow	May-Jun
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	Yellow	Jun-Jul
Sedum grisbachii	Griseback Sedum	Yellow	Jul-Aug
Sedum hispanicum 'Pinkie'	Pinkie Sedum	Pink	Jun-Jul
Sedum hybridum 'Immergunchen'	Evergreen Sedum	Yellow	Jun, Sep
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	Yellow	Jun
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	Orange	Jul-Aug
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	Yellow	May-Jun

*List provided by Hortech, Inc.

Representative Zone H Species

Mountain Garlic

Cascade Sedum

Ellacombe's Sedum

Wall Sedum

Source: JFNew

Appendix G
Recommended Materials

Recommended Materials

Numerous BMPs in this manual have similar material needs. These BMPs are listed in the table below. Detailed information on each material requirement follows. In addition, Porous Pavement and Vegetated Roofs have significant material requirements that are listed according to their individual needs.

	Constructed Filters	Dry Well	Infiltration Trench	Planter Boxes	Porous Pavement	Subsurface Infiltration	Vegetated Filter Strip	Vegetated Swale
Check dams							X	X
Non-Woven Geotextile	X	X	X	X	X	X	X	
Pea Gravel							X	
Peat	X			X				
Pervious Berms							X	
Pipe – 8”	X	X	X	X	X	X	X	
Sand	X			X				X
Stone/Gravel	X			X				
Stone – 30%							X	
Stone – 40%			X		X			

Check dams (Vegetated Filter Strip, Vegetated Swale)

An earthen check dam shall be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02 in to 0.04 in, Gravel: AASHTO M-43 0.5 in to 1.0 in). A stone check dam shall be constructed of R-4 rip rap, or equivalent.

Non-Woven Geotextile (Constructed Filter, Dry Well, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should consist of needled nonwoven polypropylene fibers and meet the following properties:

a. Grab Tensile Strength (ASTM-D4632) 120 lbs min.
b. Mullen Burst Strength (ASTM-D3786) 225 psi min.
c. Flow Rate (ASTM-D4491) 110 gal/min/ft2 min.
d. UV Resistance after 500 hrs (ASTM-D4355) 70% min.
e. Puncture strength (ASTM D-4833-00) 90 lb. min.
f. Apparent opening size (ASTM D-4751-99A) 60-70 US Sieve

Heat-set or heat-calendared fabrics are not permitted. Acceptable types include Mirafi 140N, Amoco 4547, Geotex 451, or approved others.

Pea Gravel (Vegetated Filter Strip)

Clean bank-run gravel may also be used and should meet ASTM D 448 and be sized as per No.6 or 1/8” to 3/8”.

Peat (Constructed Filter, Planter Boxes)

Should have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.

Pervious Berms (Vegetated Filter Strip)

The berm shall have a height of 6-12 in and be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02”-0.04”, Gravel: AASHTO M-43 ½” to 1”)

Pipe - (Dry Well, Porous Pavement, Subsurface Infiltration, Constructed Filter, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should be continuously perforated, smooth interior, with a minimum inside diameter as required. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or M294, Type S (12 gauge aluminum or pipe may also be used in seepage pits).

Sand (Constructed Filter, Planter Boxes, Vegetated Swale)

Should be ASTM-C-33 (or AASHTO M-6) size (0.02” – 0.04”), concrete sand, clean, medium to fine sand.

Stone/Gravel (Constructed Filter, Planter Boxes):

Should be uniformly graded coarse aggregate, 1 inch to ½ inch with a wash loss of no more than 0.5%, AASHTO size number 5 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and have voids of 40% as measured by ASTM-C29.

Stone – 40% voids (Infiltration Trench, Porous Pavement, Subsurface Infiltration Bed,)

Infiltration trenches should have stone 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids 40% as measured by ASTM-C29.

Porous Pavement

General

Choker base course aggregate for beds shall be 3/8 inch to 3/4 inch clean, uniformly-graded, coarse, crushed aggregate AASHTO size number 57 per Table 4, AASHTO Specifications, Part I, 19th Ed., 1998 (p. 47).

Porous Asphalt

Bituminous surface course for porous paving shall be 2.5 to 3 inches thick with a bituminous mix of 5.75% to 6.75% by total weight as determined by testing below. Use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of PG 76-22P (in northern Michigan, use PG 76-28P as appropriate) as specified in AASHTO MP-1. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Determination of optimal asphalt content should be determined according the following tests:

- Draindown Test (ASTM Method D6390)
- Moisture Susceptibility Test using the Modifed Lottman Method (AASHTO T283) with the following:
  - Compact using 50 gyrations of Superpave gyratory compactor
  - Apply partial vacuum of 26 inches of Hg for 10 minutes to whatever saturation is achieved.
  - Keep specimens submerged in water during freeze cycle.
  - Required retained tensile strength (TSR) >= 80%
- Air Voids Test (AASHTO T269/ASTM D3203)

Hydrated lime, if required, shall meet the requirements of AASHTO M 303 Type 1 and shall be blended with the damp aggregate at a rate of 1.0% by weight of the total dry aggregate. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

Fibers, if used, shall consist of either cellulose fibers or mineral fibers which are to be treated with a cationic sizing agent to enhance dispersement of the fiber as well as increase cohesion of the fiber to the bitumen. Fiber is to be added at a dosage rate between 0.2% and 0.4% by weight of total mix.

- Mineral fibers shall be from virgin, basalt, diabase, or slag with a maximum average fiber length of 6.35 mm and a maximum average fiber thickness of 0.005 mm.
- Cellulose fiber – Fiber length shall be 6.4 mm (max), Ash Content 18% non-volatiles (±5%), pH 7.5 (± 1), Oil absorption (times fiber weight) 5.0 (± 1), Moisture Content 5.0 (max).

Porous Concrete

The use of Installers or Craftsmen who have been certified by the NRMCA's Pervious Concrete Contractor Certification Program is strongly recommended. Contractor shall furnish a proposed mix design with all applicable information to the Engineer prior to commencement of work. Critical mix characteristics typically include the following:

- Cement Content: 550 to 650 lb/cy
- Fine aggregate, if used: maximum 3 cu. ft. per cu. yd.
- Admixtures: use in accordance with the manufacturer's instructions and recommendations
- An aggregate/cement (A/C) ratio: 4:1 to 4.5:1
- Water/cement (W/C) ratio: 0.27 to 0.34
- Curing: shall begin within 15 minutes after placement and continue for 7 days

The data shall include unit weights determined in accordance with ASTM C29 paragraph 11, jigging procedure.

Cement: Portland Cement Type II or V conforming to ASTM C150 or Portland Cement Type IP or IS conforming to ASTM C595. The total cementitious material shall be between 550 and 650 lb./cy.

Aggregate: Use No 8 coarse aggregate (3/8 to No. 16) per ASTM C33 or No. 89 coarse aggregate (3/8 to No. 50) per ASTM D 448. If other gradation of aggregate is to be used, submit data on proposed material to owner for approval. The volume of aggregate per cu. yd. shall be equal to 27 cu.ft. when calculated as a function of the unit weight determined in accordance with ASTM C 29 jigging procedure. Fine aggregate, if used, should not exceed 3 cu. ft. and shall be included in the total aggregate volume.

Air Entraining Agent: Shall comply with ASTM C 260 and shall be used to improve workability and resistance to freeze/thaw cycles.

Admixtures: The following admixtures shall be used:

- Type D Water Reducing/Retarding – ASTM C 494.
- A hydration stabilizer that also meets the requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding admixtures may be used. This stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles from achieving initial set.

Water: Potable shall be used and shall comply with ASTM C1602. Mix water shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (Mix water yielding a cement paste with a dull-dry appearance has insufficient water for hydration).

- Insufficient water results in inconsistency in the mix and poor bond strength.
- High water content results in the paste sealing the void system primarily at the bottom and poor surface bond.

An aggregate/cement (A/C) ratio range of 4:1 to 4.5:1 and a water/cement (W/C) ratio range of 0.27 to 0.34 should produce pervious pavement of satisfactory properties in regard to permeability, load carrying capacity, and durability characteristics.

Vegetated roofs

Some key components and associated performance-related properties are as follows:

Root-barriers should be thermoplastic membranes with a thickness of at least 30 mils. Thermoplastic sheets can be bonded using hot-air fusion methods, rendering the seams safe from root penetration. Membranes that have been certified for use as root-barriers are recommended. At present only FLL offers a recognized test for root-barriers. Several FLL-certified materials are available in the United States. Interested American manufactures can submit products for testing to FLL-certified labs.

Granular drainage media should be a non-carbonate mineral aggregate conforming to the following specifications:

- Saturated Hydraulic Conductivity >= 25 in/min
- Total Organic Matter, by Wet Combustion (MSA) <= 1%
- Abrasion Resistance (ASTM-C131-96) <= 25% loss
- Soundness (ASTM-C88 or T103 or T103-91) <= 5% loss
- Porosity (ASTM-C29) >= 25%
- Alkalinity, CaCO3 equivalents (MSA) <= 1 %
- Grain-Size Distribution (ASTM-C136)
  - Pct. Passing US#18 sieve <= 1%
  - Pct. Passing ¼-inch sieve <= 30%
  - Pct. Passing 3/8-inch sieve >= 80%

Growth media should be a soil-like mixture containing not more than 15% organic content (wet combustion or loss on ignition methods). The appropriate grain-size distribution is essential for achieving the proper moisture content, permeability, nutrient management, and non-capillary porosity, and 'soil' structure. The grain-size guidelines vary for single and dual media vegetated cover assemblies.

Non-capillary Pore Space at Field Capacity, 0.333 bar (TMECC 03.01, A)	>= 15% (vol)
Moisture Content at Field Capacity (TMECC 03.01, A)	>= 12% (vol)
Maximum Media Water Retention (FLL)	>= 30% (vol)
Alkalinity, Ca CO3 equivalents (MSA)	<= 2.5%
Total Organic Matter by Wet Combustion (MSA)	3-15% (dry wt.)
pH (RCSTP)	6.5-8.0
Soluble Salts (DTPA saturated media extraction)"(RCSTP)	<= 6 mmhos/cm
Cation exchange capacity (MSA)	>= 10 meq/100g
Saturated Hydraulic Conductivity for Single Media Assemblies (FLL)	>= 0.05 in/min
Saturated Hydraulic Conductivity for Dual Media Assemblies (FLL)	>= 0.30 in/min

Grain-size Distribution of the Mineral Fraction (ASTM-D422)

Single Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	<= 5%
Pct. Passing US#60 sieve	<= 10%
Pct. Passing US#18 sieve	5 - 50%
Pct. Passing 1/8-inch sieve	0 - 70%
Pct. Passing 3/8-inch sieve	75 -100%

Dual Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	5-15%
Pct. Passing US#60 sieve	10-25%
Pct. Passing US#18 sieve	20 - 50%
Pct. Passing 1/8-inch sieve	55 - 95%
Pct. Passing 3/8-inch sieve	90 -100%

Macro- and micro-nutrients shall be incorporated in the formulation in initial proportions suitable for support the specified planting.

Separation fabric should be readily penetrated by roots, but provide a durable separation between the drainage and growth media layers (Only lightweight nonwoven geotextiles are recommended for this function.

- Unit Weight (ASTM-D3776) <= 4.25 oz/yd2
- Grab tensile (ASTM-D4632) <= 90 lb
- Mullen Burst Strength (ASTM-D4632) >= 135 lb/in
- Permittivity (ASTM-D4491) >= 2 per second

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REPORT

NELSON SCHOOL OPERATIONS & MANAGEMENT PLAN

Stormwater Management

Low Impact Developments / Green Infrastructure

Landowner – Muskegon Public Schools
349 W. Webster Avenue
Muskegon, MI 49440

Submitted To: West Michigan Shoreline Regional Development Commission
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Project No.1520593

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EXECUTIVE SUMMARY

The Operations and Management (O&M) Plan summarizes the best management practices (BMPs) and low impact development (LID) designs implemented in Nelson School for improving stormwater management. The details of each BMP are provided in the Nelson School Conceptual Plan (Appendix A). Each structural BMP requires maintenance for continued efficiency and is summarized within the plan. Included in the appendices of the report is a maintenance summary for each BMP (Appendix B, C, and D), and example checklists to be used for routine inspections (Appendix E). The plan provides guidance regarding management of vegetation, a list of recommended Michigan species (Appendix F), and a list of other recommend materials (Appendix G). Operations and maintenance costs were analyzed for each development and for maintaining the site.

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1.0 NELSON SCHOOL

Nelson School is located in Muskegon, Michigan within the Beidler Creek/Division Street Outfall Watershed. The site is state owned and within a half of a mile of Muskegon Lake. The watershed receives stormwater from heavily urbanized areas and the city's storm sewer system. The polluted stormwater discharged to the watershed has resulted in degraded benthic communities, organic chemicals, excessive sediment, and/or flashy hydrology.

Golder Associates Inc. recommended design solutions to reduce stormwater runoff, stormwater pollutants, and improve water quality within Nelson School and Beidler Creek/Division Street Outfall Watershed. Stormwater LID designs implemented for the site included four rain gardens, two large bioswales, and one infiltration basin.

2.0 MAINTENANCE COSTS

Stormwater LID designs tend to be less expensive to implement than conventional designs, however they do require long term maintenance to ensure the designs continue to work efficiently. A cost analysis was completed for Nelson School maintenance costs at annual and long term rates. Three types of structural BMPs were assessed including rain gardens, bioswales, and an infiltration basin. The total annual costs for maintaining Nelson School were estimated at $11,841. Annual maintenance costs were based on taking a percentage of the total construction costs, based on a low impact development cost comparison completed by Emmons & Oliver Resources, Inc. (EORINC 2015). BMPs were estimated to require approximately 5% to 6% of construction costs for routine and non-routine maintenance. The estimated maintenance costs include aesthetic maintenance and functional maintenance. Functional maintenance assures the BMP is performing efficiently and safely, while aesthetic maintenance is mainly for public acceptance, which can help to reduce functional costs. The percentage of construction cost used for each BMP reflects labor, landscaping, and material costs. A typical year of landscaping includes maintenance such as lawn mowing, removal of debris and litter, replanting or seeding vegetation, and replenishing mulch. Maintenance labor is expected to be greater within the first two to three years as vegetation is established.

Table 1. Operation and Maintenance Costs Summary

Stormwater BMP	Construction Cost ($)	Annual Maintenance Cost (% of Construction Cost)	Annual Maintenance Cost ($)
Rain Garden (without underdrain)	62,438	5	3,122
Bioswale	119,880	6	7,193
Infiltration Basin	30,525	5	1,526
Total Costs			**11,841**

2.1 Rain Garden

Nelson School conceptual stormwater development plan includes four rain gardens encompassing approximately 4,500 square feet. The rain gardens consist of a geotextile filter layer, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Regular maintenance of the rain gardens is required within the first two to three years when vegetation is becoming established. Less maintenance is required after vegetation becomes established and fills empty spaces between plants. Maintenance requirements for the rain gardens can be viewed in Appendix B. A summary of the maintenance cost for the rain gardens is provided in Table 1. The annual operations and maintenance costs for the rain gardens were calculated as 5% of the construction costs. The annual cost to maintain the four rain gardens is $3,122.

2.2 Bioswale

There are two bioswales implemented in the Nelson School stormwater management plan. The bioswales cover about 8,800 square feet, each approximately eight feet wide and totaling 1,110 linear feet. Bioswales consist of a geotextile filter, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch. Similar to the rain gardens the bioswales will be planted with native species and require more maintenance within the first two to three years while vegetation is being established. Routine maintenance items for the bioswales are summarized in Appendix C. The annual maintenance cost of bioswales at the site was calculated as 6% of the construction cost, totaling $7,193.

2.3 Infiltration Basin

Infiltration basins require less maintenance than rain gardens and bioswales. Maintenance for infiltration basins consists of establishing and maintaining vegetation upstream and overlaying the subsurface infiltration system. The infiltration basin has similar design layers to the bioswale and rain garden including geotextile fabric, 18 inches of compacted stone, 24 inches of engineering soil, and two inches of mulch.

There is one infiltration basin located within the Nelson School site covering approximately 2,200 square feet. Vegetation for the infiltration basin will include grass and five or six trees. The maintenance required for the infiltration basin is summarized in Appendix D. The annual maintenance cost for the infiltration basin was calculated as 5% of the construction cost, equivalent to $1,526.

3.0 ROUTINE INSPECTIONS

Routine inspections of BMPs should be completed at least once every year. Example inspection checklists are included in Appendix E. Inspection checklists vary depending on the type of LID design. The stormwater designs for Nelson School do not include underdrain and overflow systems, so such items on the checklist are not applicable to the site. The example bioretention inspection checklist can be used for inspection of the rain gardens. Rain gardens, bioswales, and the infiltration trench should be inspected for debris, erosion, vegetation conditions and coverage, and mulch thickness to determine overall functionality. Based on the selection of native plants used for each BMP, additional species specific inspections may be required. Inspections of vegetation should include determining the overall plant health, checking if plants require trimming or pruning, and assuring invasive species are properly managed.

4.0 VEGETATION

The plant species selected for the BMPs have a significant impact on the effectiveness of the design. Vegetation will require regular maintenance within the first few years while becoming established. Maintenance involves watering plants as needed, and removing invasive species. Once vegetation is established, less maintenance will be required to maintain the BMP areas.

4.1 Native Species

Native plants are implemented in the design because they have deeper and more expansive roots leading to increased infiltration, groundwater recharge and biofiltration. Native plants are also more tolerant to flooding and drought conditions enabling them to thrive in rain gardens, bioswales, and infiltration basins. Plugs and gallons are common sizes of native plants that can be installed in BMPs. A plug is a small plant that grows in a container roughly two inches wide and five inches deep. A gallon is a more mature plant available in a gallon size container. Both sizes of plants require consistent watering during early development (Delta Institute 2015). Suggested species may include: cardinal flower (*Lobelia cardinalis*), blue lobelia (*Lobelia siphilitica*), New England aster (*Aster novae-angliae*), and brown fox sedge (*Carex vulpinoidea*). Additional grasses and wildflowers that could tolerate wet growing conditions recommended by the West Michigan Environmental Action Council include: cotton grass (*Eriophorum angustifolium*), golden alexanders (*Zizia aurea*), and blue flag iris (Iris versicolor) (WMEAC 2016). A full list of recommended Michigan plants for BMPs is included in Appendix F (SEMCOG, 2008).

4.1.1 Planting Requirements

Maintenance will be required for any plants that do not successfully grow in the planted environment, and an alternative species may need to be planted. Seeding is not the preferred method of planting vegetation since high velocity flows can prevent the plant from establishing. Plugs or gallon-potted plants installed at one to two foot intervals are recommended for effective establishment of vegetation. Trees and shrubs are also recommended. Seeding should be completed from late April to mid-October if irrigation is available. If irrigation is not available, than seeding can be completed from June 15 or mid-August to mid-October. With dormant seeding, seeding can be completed from November 1 to 30. At all other times of the year, seeding should have a temporary cover (made of oats/cereal rye or other small grain). Plugs and gallons should be installed from May 1 – June 15. Trees and shrubs should be planted from the middle of April through early June, or the middle of September through the middle of November. A maximum of two to three inches of mulch should be evenly spread in the BMPs after installing new plants to help prevent erosion, remove metals, and act as leaf litter in a natural forest environment. The mulch should not be placed directly against the stems of the newly planted vegetation. If wildlife is a threat to newly installed plants additional precautions such as\waterfowl barriers are maintenance options.

4.2 Invasive Non-Native Species

Invasive species are not native to the area and tend to grow and spread quickly without natural controls. If unmanaged, invasive species will displace native species (SEMCOG, 2008). Maintenance of invasive species is crucial when native plants are being established and require room to grow. Invasive species can be removed by hand–pulling, mowing, or spot herbicide applications. After native species are established, less maintenance of invasive species is needed. Long term management of invasive species may require removal once every year or as needed. Open areas may require mowing if woody vegetation is noticed encroaching, typically every three to five years.

5.0 WINTER CONDITIONS

Winter conditions in Michigan typically include the buildup of snow and the use of de-icing compounds which can negatively affect plant life. Salt tolerant plants are recommended for sites where de-icing and heavy snow occurs. Recommended products for de-icing are nontoxic and organic, such as magnesium chloride-based liquid products or pretreated salt (Delta Institute, 2008). Sand and cinder from melted snow have the potential of reducing infiltration into the soil. Preventative measures should be taken to avoid the buildup or piling of snow over infiltration systems.

In the spring, the rain gardens, bioswales, and infiltration basin should all be assessed for winter damages. Buildup of debris and sediment should be cleared, and mulch should be evenly spread in any eroded areas. Plants may also require trimming or rehabilitation. Soil aeriation may also be required in spring to reduce impacts of de-icing agents.

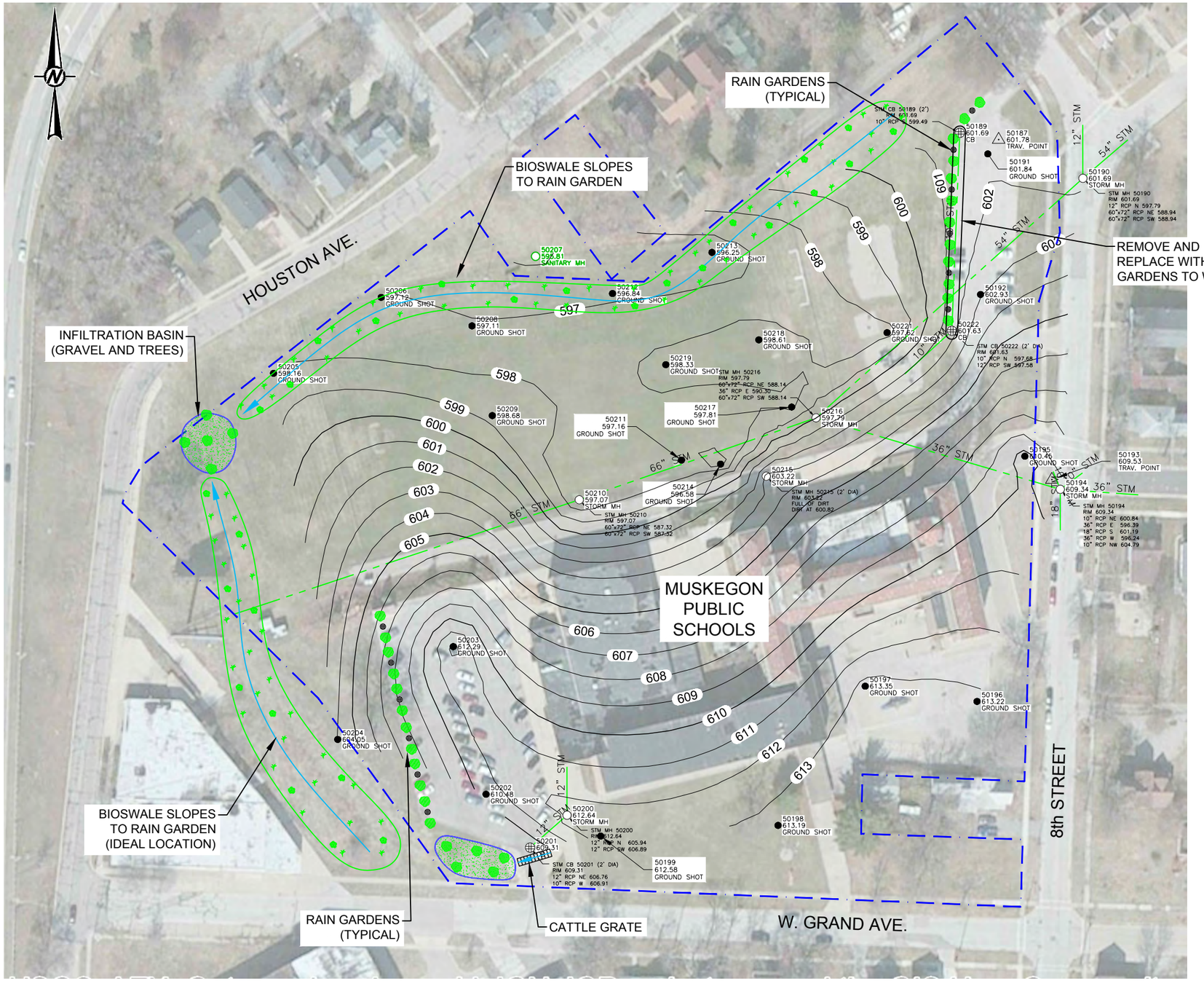
6.0 EDUCATION AND TRAINING

All personnel responsible for the operations and maintenance of the BMPs should undergo training to fully understand the care required for each LID design. Training should include reading the O&M plan and discussing procedures with someone of experience. An educated maintenance staff will increase the efficiency and sustainability of the designs.

7.0 REFERENCES

1. Delta Institute and Guidon Design. 2015. Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
2. Emmons & Oliver Resources, Inc. 2015. Minnesota Low Impact Development A comparison, Cost Comparision. A Case Study Comparison of Costs, Water quality and quanity benefits and quality of life. http://www.eorinc.com/pdf/development-maintenance-cost.pdf
3. SEMCOG. 2008. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html
4. West Michigan Environmental Action Council. 2016. Rain Gardens of West Michigan. Michigan Native Plants List For Use in Rain Gardens and Landscaped Bioretention Areas. http://www.westmichiganglsi.org/uploads/6/7/9/8/6798898/rain_gardens_native_plant_list.pdf

Appendix A
Nelson School Conceptual Plan



LEGEND

PARCEL BOUNDARY

NOTE(S)

1. THE NELSON SCHOOL SITE IS APPROXIMATELY 9.9 ACRES PARCEL AREA AND 11.0 ACRES WATERSHED TREATMENT AREA.
2. THE NELSON SCHOOL SITE IS PRIMARILY OXYAQUIC UDIPSAMMENTS TYPE SOILS -99% SAND (USUALLY SATURATED SAND).

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 50 100
1" = 100' FEET

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
NELSON SCHOOL

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Path: \\arsrng\GAD\Projects\15x-Projects\1520593_WMSRDC Green Infrastructure Project\PRODUCTION\B_CONCEPTUAL DESIGN\ | File Name: 1520593B001.dwg

Appendix B
Rain Garden Maintenance Items

RAIN GARDEN

1.0 PUROPOSE

Rain gardens are used to collect stormwater runoff and encourage infiltration and biofiltration with the use of native plants. Native plants are ideal for rain gardens because they have deeper root networks that draw surface water further into the ground. Native plants are also typically drought and flood tolerant and able to thrive in rain gardens. Rain gardens aide in reducing runoff volume, filtering pollutants, recharging groundwater (if no underdrain is used), reducing stormwater temperature impacts, and enhancing site aesthetics.

2.0 MAINTENANCE

Rain gardens require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered and weeded twice weekly through October of the first year and in times of extreme drought. Weeds should be removed by hand.

3.) Organic matter may also need to be removed approximately twice per year, usually by hand.

4.) Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

5.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

6.) Annual mowing should be performed for the first three years of establishment. Mowing should not be completed on a regular basis.

7.) Removal of debris must occur monthly for the life of the rain garden.

8.) Winter conditions may result in plants being effected by deicing chemicals in snow-melt, in this case salt-tolerant plants should be used. Also try to reduce the amount of sand, cinders, and other winter abrasives that come in contact with the vegetation. Additional maintenance in the spring is required to remove abrasives if used.

9.) Rain gardens should be inspected at least twice a year for sediment buildup, erosion, and overall vegetation conditions. If sediment build up reaches 25% of the ponding depth it should be removed. If erosion is occurring, soil stabilization efforts should be applied. If vegetation is in poor health for no apparent reason, a landscape architect should be consulted.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix C
Bioswale Maintenance Items

BIOSWALE

1.0 PUROPOSE

Bioswales are shallow, vegetated, earthen channels that help to slow, filter, and infiltrate stormwater runoff in the process of conveyance. Native plants are ideal vegetation for bioswales due to their deep roots for infiltrating runoff, and their high tolerance for droughts and floods.

2.0 MAINTENANCE

Bioswales require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes established less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Vegetation should be established as soon as possible to prevent erosion and scour. Freshly seeded swales require soil stabilization such as erosion control matting or blankets. Erosion controls for seeded swales are required after planting for 75 days after the first storm event occurs. If runoff velocities are high, sodding the swale or diverting runoff until vegetation is well established is an option.

4.) Debris removal, weeding, and pruning should be performed on a monthly basis.

5.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity issues are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

6.) Mow and trim plants within the bioswales annually to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Mow only when dry to avoid rutting. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

7.) In the spring the bioswales will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

8.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

9.) If roadside or parking lot runoff is directed to the swale, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix D
Bioretention Island Maintenance Items

BIORETENTION ISLAND

1.0 PUROPOSE

A Bioretention islands or stormwater planters are a linear infiltration basin typically located in a parking lot or between a street and sidewalk surrounded by vertical curbing. Stormwater is collected from the street, sidewalk, or parking lot and directed into the bioretention island through openings in the curb. Bioretention islands consist of native plants in engineered soil which lay on top of a layer of stone. The stormwater planters are able to reduce, filter, and infiltrate stormwater runoff and aide in recharging groundwater.

2.0 MAINTENANCE

Bioretention islands require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes mature and capable of choking out invasive species, less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Debris removal, weeding, and pruning should be performed on a monthly basis.

4.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

5.) Annually trim plants to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

6.) In the spring the bioretention islands will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

7.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

8.) If roadside or parking lot runoff is directed to the bioretention island, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix E
Example Inspection Checklists

Maintenance Inspection Checklists

This appendix contains four checklists available as guides for maintenance inspections of specific BMPs. The maintenance items have been adapted from multiple stormwater programs, including the Rouge River Detention Basin Maintenance Manual, Georgia Stormwater Management Manual, the Vermont Stormwater Management Manual, and the Stormwater Manager's Resource Center.

The checklists are designed to help identify key components of BMPs that require ongoing maintenance as well as a basic schedule of when the maintenance should occur. The checklists have been divided into those items essential for the general operation and functionality of the BMP and those items that optional and may enhance the BMP.

It is suggested that the inspection be undertaken by a licensed PE and/or a person knowledgeable about the design and function of the BMP.

These BMP checklists include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

Detention BMP Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet Pipes			
Structural integrity of inlet/outlet (Are any inlet pipes broken, crumbling, separated?) List Inlet Pipes Approximate Diameter and Type of Material Inlet Pipe 1 _____ Inlet Pipe 2 _____ Inlet Pipe 3 _____ Outlet Pipe Size/Type _____		A	
Riprap at inlet pipe (Is the riprap still present? Is it visible and not covered with sediment?		A	
Stone around outlet pipe (Is the stone clogged with debris and/or sediment?)		A	
Trash or debris blocking inlet/outlet (Inspect to ensure no major obstructions hindering general functionality)		M	
Inspect/clean catch basin upstream of the BMP if accessible.		A	
Inspect inlets and outlet for erosion (Are there eroded areas around the pipes?)		A	
Inspect overflow spillway for signs of erosion.			
Pretreatment (if applicable) (Might include sediment forebay, upstream catch basin, bioswale, rain garden, swirl concentrator)			
Device functioning to trap/collect sediment		A	
Remove accumulated sediment as appropriate for the pretreatment device. forebay		A	
Detention Pond		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inspect side slopes, berms and emergency overflow for erosion		A	
Reestablish permanent native vegetation on eroded slopes		As needed	
Inspect for excess sediment accumulation in pond if not pretreatment device is present		A	
Overall functionality			
Ensure pond is functioning properly (Professional Civil Engineer is recommended)		A	
Ensure the outlet is functioning properly (Professional Civil Engineer is recommended)		A	
Optional/Enhancements			
Maintain 15-20 feet “no mow and chemical free” zone		A	
Mow (or burn) the “no mow” zone		A	
Inspect basin and “no mow” zone for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation in and around pond.		A	
Complaints from residents (note on back)		S	
Encroachment on pond/no- mow zone.		A	
Unauthorized plantings		A	
Aesthetics (e.g., graffiti, unkept maintenance)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Summary

Inspector’s remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Infiltration BMPs Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		A	
Pretreatment for sediment			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure infiltration device is functioning properly (professional civil engineer is recommended)		A	
BMP infiltration surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		S	
Evidence of erosion present		A	
Aggregate (if applicable)			
Surface of aggregate clean		A	
Any replacement of aggregate needed? If clogged with sediment replacement is necessary for continued proper function.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Vegetated surface (if applicable)			
Vegetative cover exists		A	
Optional considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation or creating a native plant infiltration basin area.		A	
Complaints from residents (note on back)		A	
Mowing done when necessary		A	
No fertilizer unless testing requires it		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioretention Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway or catch basin clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		Every 5 years	
Pretreatment for sediment (Generally consists of catch basin or velocity dissapator at inlet such as area of riprap/ collection for sediment)			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure bioretention area is functioning properly (professional civil engineer is recommended)		A	
Bioretention area surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		M	
Evidence of erosion present		A	
Does good vegetative cover exist		A	
Mulch covers entire area (no voids) and to specified thickness		A	
Optional considerations			
Inspect BMP for invasive species.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioswale, Filter Strip Inspection Checklist

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Pretreatment/ Energy Dissipators			
No evidence of flow going around structures		A	
No evidence of erosion		A	
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
BMP surface			
Area free of debris?		M	
No evidence of erosion		A	
Does sediment accumulation currently require removal?		A	
Overall functionality			

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Ensure swale is functioning properly (professional civil engineer is recommended)		A	
Optional Considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Appendix F
List of Michigan Recommended Plants

Recommended Plant Lists for Best Management Practices

This appendix contains recommended native and non-native (when appropriate) plant species for the Best Management Practices detailed throughout the manual. Species have been recommended based on hardiness, aesthetics, functionality, and commercial availability. It is certain that species exist outside the confines of this list that will perform in a comparable way to those listed; however, commercial availability is often a limiting factor in obtaining material for native plantings. Over time, and in certain locales, additional species will become available to supplement those listed below.

An array of planting zones is provided based on normal water levels (Figure C.1). Using these zones will provide the best chances for long-term success of native planting in the context of LID. While plants may naturally occur outside of the given ranges, these ranges are intended to be guidelines for plant installation. Whenever possible and practical in standing water conditions, native plants should be installed in live plant form (rather than seed). Seed or a combination of seed and live plants may be used in upland situations.

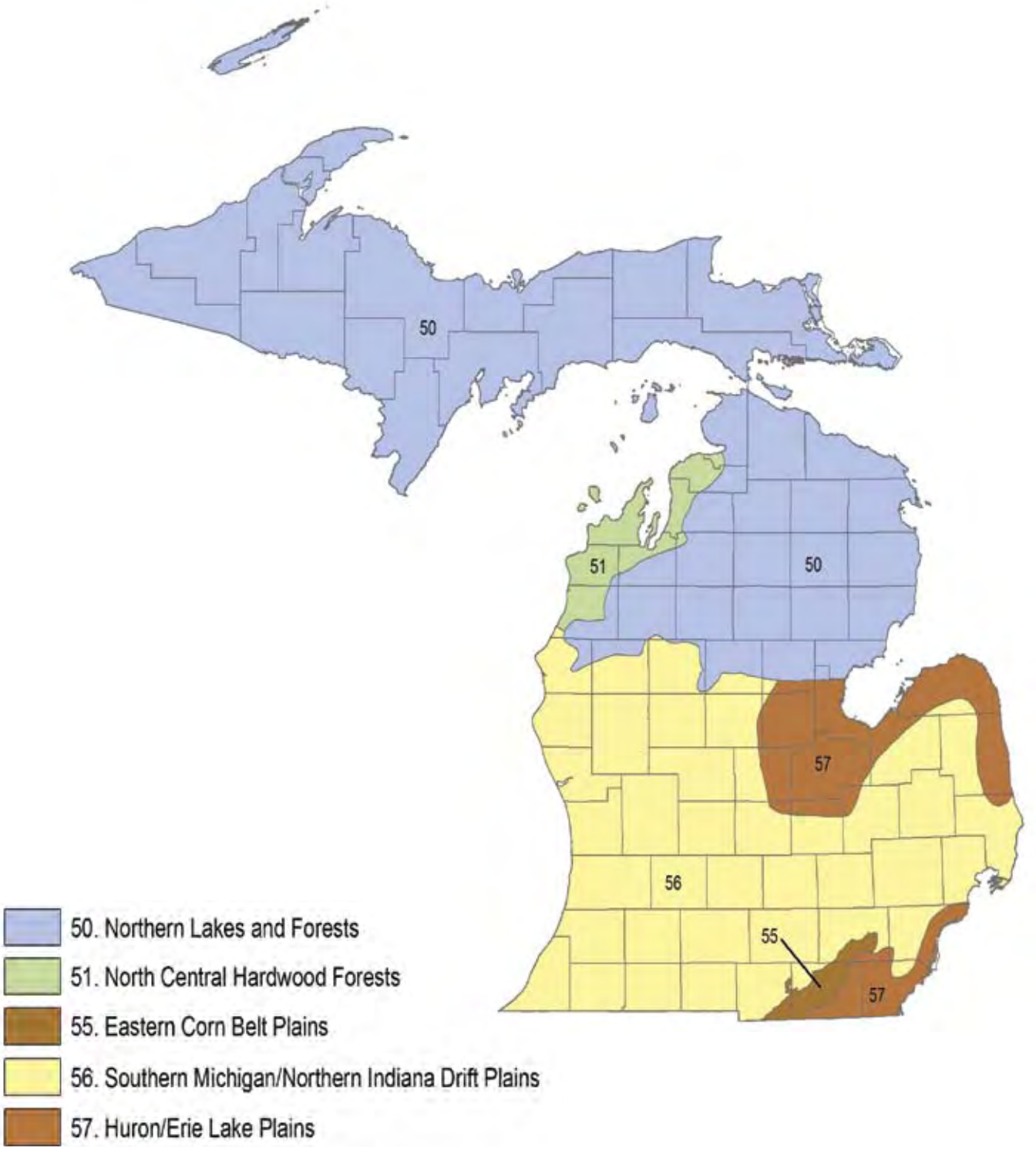
Recommendations are given for height, bloom color, bloom time, sun requirements, salt tolerance, and ecoregion. Please note that these are recommendations based on a range of situations, and a specific plant or population may vary from site-to-site. For sun requirements, F = Full sun required, P = Partial sun tolerated, and S = Shade tolerated. Salt tolerance is classified as Yes (Y) or No (N). This was determined through literature reviews and anecdotal evidence. If there is no information confirming tolerance, a "No" was listed.

Figure C.1
Planting Zone/BMP Matrix

	Zone A — 2"-4" Below Water Level	Zone B — 0"-2" Below Water Level	Zone C — 0"-2" Above Water Level	Zone D — 2"-4" Above Water Level	Zone E — 4"-18" Above Water Level	Zone F — 18"+ Above Water Level	Zone G — Planter Boxes	Zone H — Vegetated Roofs
Rain gardens/Bioretention	✤	✤	✤	✤	✤	✤		
Vegetated Filter Strips			✤	✤	✤	✤		
Vegetated Swales		✤	✤	✤				
Infiltration Basin		✤	✤					
Subsurface Infiltration Basins				✤	✤	✤		
Infiltration Trenches				✤	✤	✤		
Infiltration Berns	✤	✤	✤	✤	✤	✤		
Planter Boxes							✤	
Vegetated Roofs								✤
Constructed Wetlands	✤	✤	✤	✤				
Wet Ponds	✤	✤	✤					
Dry Extended Detention Basins			✤	✤	✤	✤		
Riparian Corridor Restoration			✤	✤				
Native Revegetation	✤	✤	✤	✤	✤	✤	✤	✤

Ecoregion recommendations are also provided for each species (Figure C.2). Whenever possible, the designer/ installer should seek to use species that historically occurred in the same ecoregion as the project. When necessary, species occurring in an adjacent ecoregion may be used.

Figure C.2
EPA Level III Ecoregions for Michigan



Source: USEPA

Plant Installation

Native Seeding

Seasonal consideration: October 1-June 15 (note: seeds should not be planted on frozen ground).

Native seeding is generally recommended for areas above the water line or 1-2" below the water line. Live plant material should be used to establish vegetation at deeper water levels.

Broadcast seeding

Broadcast seeding is preferred over drill seeding on graded, bare soil sites. Apply the seed uniformly over the surface using a combination seeder/cultipacker unit such as a Brillion or Truax Trillion seeder. The Trillion seeder is preferred as it is designed to handle native seeds.

A cone seeder or other similar broadcasting equipment may also be used if the seed mix does not contain fluffy seeds in amounts sufficient to prevent free flowing without plugging. Seed should then be pressed into the surface using a cultipacker or roller.

Drill seeding

A rangeland-type no-till drill designed to plant native grasses and forbs may be used in bare soils although this equipment is specifically designed to plant through existing vegetation which is killed with an herbicide. Cultipacking or rolling before seeding may be required to prevent seed placement depths exceeding .25 inch, but cultipacking or rolling after seeding is not required.

All seeding equipment, whether broadcast or drill, should be calibrated to deliver the seed at the rates and proportions specified in the plans. Equipment should be operated to ensure complete coverage of the entire area to be seeded, and seed must be placed no deeper than .25 inch in the soil. No fertilizers or soil conditioners will be required or allowed.

Native Planting

Seasonal considerations: May 1-July 1

Plant plugs should be installed in holes drilled with an auger the same diameter and depth as the plug within +0.75 inch/- 0.25 inch. In wetland plantings where soil is soft and moist enough, a dibble bar or trowel may also be used. The planting layout should consider the requirements of the individual species regarding soil type, moisture, slope, shading, and other factors for the particular plant species.

Planting densities vary according to budget and project goals and can range from three-to-five foot spacing for plug supplements of seeded areas to six inches to two foot spacing for high visibility landscaping projects with large budgets. Groups of five-to-seven plugs of the same species planted approximately one foot apart is usually preferable to planting all species intermixed randomly across the site at a uniform density.

In wetland or shoreline areas with potential for high wave action or wildlife predation that may dislodge newly planted plugs, plugs should be secured with six inch or eight inch U-shaped wire erosion control blanket staples. Staple length is determined by the density of the planting substrate; softer substrates require longer length to hold plugs adequately.

In areas where potential for wildlife predation exists, such as retention basins or other planting areas adjacent to open water, waterfowl barriers should be installed around a minimum of 50 percent of the plugs. All plugs not protected by barriers should be stapled into the substrate as described above. Barriers may consist of plastic or wire mesh enclosures supported with wooden stakes, adequately constructed to inhibit access by waterfowl for one growing season. Enclosures should extend at least two feet above the plant tops. Methodology should be approved by the project designer with input from a restoration ecologist if necessary. Barriers may be removed after one growing season.

Maintenance and Management

Maintaining vegetated BMPs is typically most important during the first few years following installation. Supplemental irrigation may be needed to help establish plants in drought conditions. Plants may need to be replaced due to predation or other unseen factors. Most commonly, management includes removing invasive species via mowing, hand-pulling, or spot herbicide applications. In larger areas, broadcast herbicide applications may be appropriate. Over time in upland areas, controlled burning may be used as a way to invigorate the plantings and control certain invasive species. If not feasible for social or cultural reasons, an annual or biennial mowing may be used instead of fire.

Long-term management may be necessary, but is typically significantly less intensive. The site should be periodically checked for invasive species infestations. Any prairie or open area may need occasional (every three to five years) burning or mowing to remove woody vegetation that may encroach.

Zone A

Planting Zone = two-to-four inches below water level

These species require continual inundation within the given water depths in order to thrive. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for a majority of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57

Representative Zone A Species

Buttonbush

Pickerel Weed

Swamp Milkweed

Arrowhead

Blue Flag Iris

Source: JFNew

Zone B

Planting Zone = zero-to-two inches below water level

These species tolerate fluctuating water levels within this range. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for most of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-Jun	F	N	50,51,55,56,57
Carex lacustris	Lake sedge	2’-4’	Brown	May-Jun	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Alisma plantago-aquatica	Water plantain	2’-4’	White	Jul-Sep	F	N	50,51,55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard’s tail	2’-4’	White	Jun-Aug	P/S	N	55,56,57

Representative Zone B Species

Blue Flag Iris

Arrowhead

Bristly Sedge

Pickerel Weed

Swamp Milkweed

Source: JFNew

Zone C

Planting Zone = zero-to-two inches above water level

These plants are tolerant of fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Alnus rugosa	Speckled alder	25’	Brown	Mar-May	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Cephalanthus occidentalis	Buttonbush	15’	White	Jun/Aug	F/P/S	N	51,55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	Y	55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Grasses/Sedges/Rushes:							
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Forbs:							
Alisma plantago-aquatica	Water plantain	2'-4'	White	Jul-Sep	F	N	50,51,55,56,57
Anemone canadensis	Canada anemone	1'-2'	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6'-9'	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3'-5'	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3'-6'	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3'-6'	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1'-4'	White	Jul-Oct	F/P	N	50,51,55,56,57
Cassia hebecarpa	Wild senna	3'-5'	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2'-4'	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Eupatorium maculatum	Spotted Joe-pye weed	4'-7'	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3'-5'	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1'-3'	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3'-5'	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5'-12'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2'-3'	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3'-5'	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3'-8'	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2'-5'	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1'-4'	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1'-3'	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2'-4'	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2'-5'	Pink	Aug-Oct	F	Y	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1'-3'	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3'-10'	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Sagittaria latifolila	Arrowhead	1'-4'	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard's tail	2'-4'	White	Jun-Aug	P/S	N	55,56,57
Sisyrinchium angustifolium	Stout blue-eyed grass	1'	Blue	May-Aug	F/P	N	55,56,57
Solidago ohiensis	Ohio goldenrod	2'-3'	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3'-6'	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell's goldenrod	2'-5'	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3'-6'	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2'-5'	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3'-6'	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3'-6'	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3'-5'	Purple	Jul-Sep	F	N	55,56,57
Zizia aurea	Golden Alexanders	1'-3'	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone C Species

Cardinal Flower

Swamp Milkweed

Blue-Eyed Grass

Obedient Plant

Joe-Pye Weed

Path Rush

Red-Osier Dogwood

Monkey Flower

Source: JFNew

Zone D

Planting Zone = two-to-four inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Viburnum trilobum	Cranberry Viburnum	10’	White	Apr-May	F/P/S	N	50,51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Panicum virgatum	Switch grass	3‘-5’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Forbs:							
Anemone canadensis	Canada anemone	1’-2’	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6’-9’	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3’-6’	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1’-4’	White	Jul-Oct	F/P	N	50,51,55,56,57
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2’-4’	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	51,55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium maculatum	Spotted Joe-pye weed	4’-7’	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3’-5’	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1’-3’	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3’-5’	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3’-8’	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2’-5’	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1’-4’	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1’-3’	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2’-4’	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3’-10’	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2‘-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago ohiensis	Ohio goldenrod	2’-3’	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3’-6’	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell’s goldenrod	2’-5’	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3’-6’	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2’-5’	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3’-6’	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3’-6’	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57
Veronicastrum virginicum	Culver’s root	3’-6’	White	Jun-Aug	F/P	N	55,56,57
Zizia aurea	Golden Alexanders	1’-3’	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone D Species

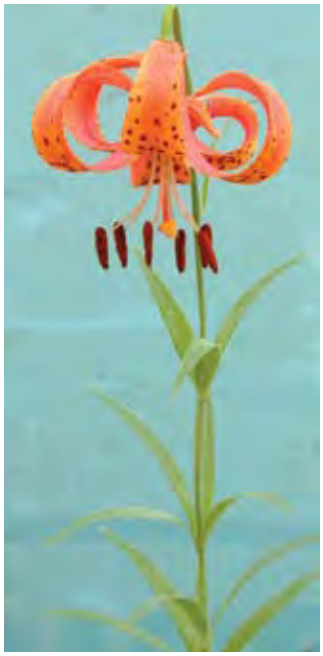
Big Bluestem

Marsh Blazing Star

Wild Columbine

Great Blue Lobelia

Virginia Mountain Mint



Michigan Lily

Meadowsweet

Blue Vervain

Source: JFNew

Zone E

Planting Zone = four-to-18 inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100’	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	N
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80’	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1’-3’	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus florida	Flowering dogwood	30’	White	May-Jun	F/P/S	N	55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85’	White	Jun	F/P	N	55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Pinus banksiana	Jack pine	60’	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100’	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100’	Brown	Jun	F/P/S	N	50,51,55,56,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Prunus americana	American plum	30’	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30’	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7’	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1’-2’	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1’-3’	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1’-2’	Purple	Aug-Oct	F	N	51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Panicum virgatum	Switch grass	3’-6’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2’-4’	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4’-9’	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Stipa spartea	Porcupine grass	2’-4’	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1’-2’	Lavender	Jun-Oct	F/P	N	55,56
Aquilegia canadensis	Wild columbine	1’-3’	Red/ Yellow	Apr-Jun	F/P/S	Y	50,51,55,56,57
Asclepias syriaca	Common milkweed	2’-4’	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1’-3’	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1’-2’	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2’-4’	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3’-5’	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster lateriflorus	Calico aster	1’-3’	White	Jul-Oct	F/P/S	N	50,51,55,56,57
Aster macrophyllus	Big-leaved aster	6”-2’	Lav/ White	Jul-Oct	P/S	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1’-4’	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short’s aster	1’-4’	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Campanula americana	Tall bellflower	2’-6’	Blue	Jul-Nov	P/S	N	55,56,57
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Clematis virginiana	Virgin’s bower	9’ long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2’-5’	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3’-6’	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2’-4’	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1’-2’	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2’-6’	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
elianthus pauciflorus	Prairie sunflower	3’-5’	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2’-4’	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2’-3’	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P/S	N	55,56,57
Liatris scariosa	Savanna blazing star	3’-5’	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2’-4’	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1’-2’	Purple	May-Jul	F/P	N	55,56,57
Phlox divaricata	Wild blue phlox	1’-2’	Blue	Apr-Jun	P/S	N	51,55,56,57
Phlox pilosa	Sand prairie phlox	1’-2’	Pink	May-Aug	F/P	N	56
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1’-3’	White	May-Jul	P/S	N	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Ratibida pinnata	Yellow coneflower	3’-6’	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1’-3’	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2’-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Silphium terebinthinaceum	Prairie-dock	3’-8’	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solo-mon’s seal	1’-3’	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon’s seal	1’-2’	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago juncea	Early goldenrod	2’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1’-3’	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Thalictrum dioicum	Early meadow-rue	1’-3’	Green	Apr-May	P/S	N	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2’-4’	Blue	May-Oct	F/P	N	55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57

Representative Zone E Species

New England Aster

Wild Bergamot

Showy Goldenrod

Tall Bellflower

Wild Geranium

Tall Coreopsis

Redbud

Indian Grass

Source: JFNew

Zone F

Planting Zone = 18+inches above water level

These plants tolerate fluctuating water levels within this range, although they are generally less tolerant than most wetter species. They may tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for upland BMP settings.

Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90'	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100'	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100'	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70'	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80'	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1'-3'	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60'	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25'	Red	Apr-May	F/P/S	N	55,56,57
Cornus florida	Flowering dogwood	30'	White	May-Jun	F/P/S	N	55,56,57
Corylus americana	American hazelnut	10'	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85'	White	Jun	F/P	N	55,56,57
Hamamelis virginiana	Witch hazel	30'	Yellow	Oct-Nov	F/P/S	N	50,51,55,56,57
Juglans nigra	Black walnut	90'	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50'	Brown	Apr-May	F/P	N	55,56,57
Liriodendron tulipifera	Tulip tree	110'	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50'	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100'	Green	May-Jul	F/P/S	Y	51,55,56,57
Pinus banksiana	Jack pine	60'	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100'	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100'	Brown	Jun	F/P/S	N	50,51,55,56,57
Prunus americana	American plum	30'	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30'	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus macrocarpa	Bur oak	85'	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90'	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90'	Green	May-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3'	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100'	Yellow	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100'	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7'	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10'	White	May-Jun	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4'-8'	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1'-2'	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1'-3'	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3'-6'	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3'-5'	Green	Jun-Jul	P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1'-2'	Purple	Aug-Oct	F	N	51,55,56,57
Koeleria macrantha	June grass	1'-2'	White	May-Jul	F/P	N	50,51,55,56,57
Panicum virgatum	Switch grass	3'-6'	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2'-4'	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4'-9'	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6'-7'	Green	Jul-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Stipa spartea	Porcupine grass	2'-4'	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1'-2'	Lavender	Jun-Oct	F/P	N	55,56
Asclepias syriaca	Common milkweed	2'-4'	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1'-3'	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1'-2'	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2'-4'	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3'-5'	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1'-4'	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short's aster	1'-4'	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3'-8'	White	Jun-Oct	F/P/S	N	55,56
Campanulaa americana	Tall bellflower	2'-6'	Blue	Jul-Nov	P/S	N	55,56,57
Clematis virginiana	Virgin's bower	9' long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis lanceolata	Sand coreopsis	1'-2'	Yellow	May-Aug	F/P	N	50,51,55
Coreopsis palmata	Prairie coreopsis	1'-2'	Yellow	Jun-Aug	F/P	N	55
Coreopsis tripteris	Tall coreopsis	4'-8'	Yellow	Aug-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2'-5'	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3'-5'	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3'-6'	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2'-4'	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1'-2'	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2'-6'	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus occidentalis	Western sunflower	2'-4'	Yellow	Aug-Sep	F/P	N	50,51,55,56,57
Helianthus pauciflorus	Prairie sunflower	3'-5'	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4'-6'	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2'-4'	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2'-3'	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris cylindracea	Cylindrical blazing star	1'-2'	Violet	Jul-Oct	F/P	N	51,55,56,57
Liatris scariosa	Savanna blazing star	3'-5'	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Lupinus perennis	Wild lupine	1'-2'	Purple	Apr-Jun	F/P	N	55,56,57
Monarda fistulosa	Wild bergamot	2'-5'	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2'-4'	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1'-2'	Purple	May-Jul	F/P	N	55,56,57
Phlox pilosa	Sand prairie phlox	1'-2'	Pink	May-Aug	F/P	N	56
Polygonatum biflorum	Solomon seal	1'-4'	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1'-3'	White	May-Jul	P/S	N	50,51,55,56,57
Ratibida pinnata	Yellow coneflower	3'-6'	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1'-3'	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Silphium terebinthinaceum	Prairie-dock	3'-8'	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solomon's seal	1'-3'	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon's seal	1'-2'	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1'-2'	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago juncea	Early goldenrod	2'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1'-3'	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2'-4'	Blue	May-Oct	F/P	N	55,56,57
Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Representative Zone F Species

Spiderwort

Butterfly Weed

Yellow Coneflower

Little Bluestem

Foxglove Beardtongue

Wild Lupine

Pale Purple Coneflower

Rattlesnake Master

Sand Coreopsis

Source: JFNew

Zone G

Planter Box Plantings

Although this manual typically recommends using native plants wherever possible, certain situations call for non-native plants due to particular site conditions. Because planter boxes traditionally have a short soil column and are exposed to drier conditions, non-native plants should be considered as long as they are considered non-invasive. Therefore, the list below contains both native and non-native species. Many planter boxes have traditionally used annual flowers. However, we recommend using perennial plants for establishing root systems and lowering maintenance in the long term. Many more species are available for planter boxes than are listed.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun
Ajuga reptans 'Bronze Beauty'	Bronze Beauty Ajuga	6"	Blue	May-Jun	F
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	6"-1'	White	May-Jun	F
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	6"-1'	Blue	Jun-Jul	F
Allium senescens montanum	Mountain Garlic	6"-1'	Pink/Purple	Jun-Aug	F
Allium senescens glaucum	Curly Onion	6"-1'	Pink	Jul-Sep	F
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	6"-1'	Pink	Jul-Aug	F
Aster 'Wood's Light Blue'	Wood's Light Blue Aster	1'-3'	Blue	Aug-Sep	F
Athryium filix-femina	Lady Fern	1'-3'	Green	NA	F/P/S
Blechnum spicant	Deer Fern	1'-2'	Green	NA	F/P/S
Dryopteris erythrosora	Autumn Fern	1'-2'	Green	NA	F/P/S
Euphorbia myrsinites	Mytle Spurge	6"-1'	Yellow	May-Jun	F
Dryopteris intermedia	Fancy Fern	1'-3'	Green	NA	F/P/S
Dyropteris marginalis	Leatherleaf Fern	1'-2'	Green	NA	F/P/S
Geranium x 'Rozanne'	Rozanne Gernaium	1'-2'	Violet	Jun-Sep	F/P
Hemerocallis 'Barbara Mitchell'	Barbara Mitchell Daylily	2'-3'	Pink	Jun-Aug	F/P
Hemerocallis 'Bill Norris'	Bill Norris Daylily	2'-3'	Yellow	Jun-Aug	F/P
Hemerocallis 'Chicago Apache'	Chicago Apache Daylily	2'-3'	Red	Jul-Sep	F/P
Hosta 'Francee'	Francee Hosta	1'-2'	Lavender	Jul-Aug	F/P/S
Hosta 'Guacamole'	Guacamole Hosta	1'-2'	Pink	Aug-Sep	F/P/S
Hosta 'Summer Fragrance'	Summer Fragrance Hosta	1'-2'	Lavender	Aug-Sep	F/P/S
Hosta sieboldiana 'Elegans'	Elegans Hosta	1'-2'	White	Jul-Aug	F/P/S
Sedum 'Autumn Charm'	Autumn Charm Sedum	6"-1'	Pink	Jun-Jul	F
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	6"-1'	Pink	May-Jun	F
Sedum 'Mini Me'	Mini Me Sedum	6"-1'	Green	NA	F
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	6"-1'	Yellow	Jul-Sep	F
Sedum album 'Athoum'	Jelly Bean Sedum	6"-1'	Pink	Aug-Sep	F
Sedum album 'Coral Carpet'	Coral Carpet Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Faro Island'	Faro Island Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Green Ice'	Green Ice Sedum	6"-1'	White	Jun-Jul	F
Sedum album 'Murale'	Wall Sedum	6"-1'	White	Jun-Jul	F
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	6"-1'	Pink	Jul-Aug	F
Sedum divergens	Cascade Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum ellacombianum	Ellacombe's Sedum	6"-1'	Yellow	May-Jun	F
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	6"-1'	Yelow	May-Jun	F
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum grisbachii	Griseback Sedum	6"-1'	Yellow	Jul-Aug	F
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	6"-1'	Yellow	Jun	F
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	6"-1'	Orange	Jul-Aug	F
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	6"-1'	Yellow	May-Jun	F

Representative Zone G Species

Guacamole Hosta

Mountain Garlic

Wall Sedum

Lady Fern

Source: JFNew

Zone H

Vegetated Roof Plantings

Research to-date shows that native plants do not typically thrive in vegetated roofs. Therefore, the list below reflects species that are known to thrive in green roof situations. All species listed below will generally grow to a height of six-to-18 inches.

Botanical Name	Common Name	Color	Bloom Time
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	White	May-Jun
Allium schoenoprasum 'Dwarf'	Dwarf Ornamental Chive	Pink	May-Jun
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	Blue	Jun-Jul
Allium senescens montanum	Mountain Garlic	Pink/Purple	Jun-Aug
Allium senescens glaucum	Curly Onion	Pink	Jul-Sep
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	Pink	Jul-Aug
Euphorbia myrsinites	Mytle Spurge	Yellow	May-Jun
Sedum 'Autumn Charm'	Autumn Charm Sedum	Pink	Jun-Jul
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	Pink	May-Jun
Sedum 'Mini Me'	Mini Me Sedum	Green	NA
Sedum acre 'Aureum'	Gold Leaved Goldmoss Sedum	Yellow	May-Jun
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	Yellow	Jul-Sep
Sedum album 'Athoum'	Jelly Bean Sedum	Pink	Aug-Sep
Sedum album 'Coral Carpet'	Coral Carpet Sedum	White	Jun-Aug
Sedum album 'Faro Island'	Faro Island Sedum	White	Jun-Aug
Sedum album 'Green Ice'	Green Ice Sedum	White	Jun-Jul
Sedum album 'Murale'	Wall Sedum	White	Jun-Jul
Sedum album 'Red Ice'	Red Ice Sedum	White	Jun-Jul
Sedum cautacola 'Bertram Anderson'	Bertram Anderson Sedum	Pink	Jul-Aug
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	Pink	Jul-Aug
Sedum divergens	Cascade Sedum	Yellow	Jun-Jul
Sedum ellacombianum	Ellacombe's Sedum	Yellow	May-Jun
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	Yelow	May-Jun
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	Yellow	Jun-Jul
Sedum grisbachii	Griseback Sedum	Yellow	Jul-Aug
Sedum hispanicum 'Pinkie'	Pinkie Sedum	Pink	Jun-Jul
Sedum hybridum 'Immergunchen'	Evergreen Sedum	Yellow	Jun, Sep
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	Yellow	Jun
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	Orange	Jul-Aug
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	Yellow	May-Jun

*List provided by Hortech, Inc.

Representative Zone H Species

Mountain Garlic

Cascade Sedum

Ellacombe's Sedum

Wall Sedum

Source: JFNew

Appendix G
Recommended Materials

Recommended Materials

Numerous BMPs in this manual have similar material needs. These BMPs are listed in the table below. Detailed information on each material requirement follows. In addition, Porous Pavement and Vegetated Roofs have significant material requirements that are listed according to their individual needs.

	Constructed Filters	Dry Well	Infiltration Trench	Planter Boxes	Porous Pavement	Subsurface Infiltration	Vegetated Filter Strip	Vegetated Swale
Check dams							X	X
Non-Woven Geotextile	X	X	X	X	X	X	X	
Pea Gravel							X	
Peat	X			X				
Pervious Berms							X	
Pipe – 8”	X	X	X	X	X	X	X	
Sand	X			X				X
Stone/Gravel	X			X				
Stone – 30%							X	
Stone – 40%			X		X			

Check dams (Vegetated Filter Strip, Vegetated Swale)

An earthen check dam shall be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02 in to 0.04 in, Gravel: AASHTO M-43 0.5 in to 1.0 in). A stone check dam shall be constructed of R-4 rip rap, or equivalent.

Non-Woven Geotextile (Constructed Filter, Dry Well, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should consist of needled nonwoven polypropylene fibers and meet the following properties:

a. Grab Tensile Strength (ASTM-D4632) 120 lbs min.
b. Mullen Burst Strength (ASTM-D3786) 225 psi min.
c. Flow Rate (ASTM-D4491) 110 gal/min/ft2 min.
d. UV Resistance after 500 hrs (ASTM-D4355) 70% min.
e. Puncture strength (ASTM D-4833-00) 90 lb. min.
f. Apparent opening size (ASTM D-4751-99A) 60-70 US Sieve

Heat-set or heat-calendared fabrics are not permitted. Acceptable types include Mirafi 140N, Amoco 4547, Geotex 451, or approved others.

Pea Gravel (Vegetated Filter Strip)

Clean bank-run gravel may also be used and should meet ASTM D 448 and be sized as per No.6 or 1/8” to 3/8”.

Peat (Constructed Filter, Planter Boxes)

Should have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.

Pervious Berms (Vegetated Filter Strip)

The berm shall have a height of 6-12 in and be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02”-0.04”, Gravel: AASHTO M-43 ½” to 1”)

Pipe - (Dry Well, Porous Pavement, Subsurface Infiltration, Constructed Filter, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should be continuously perforated, smooth interior, with a minimum inside diameter as required. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or M294, Type S (12 gauge aluminum or pipe may also be used in seepage pits).

Sand (Constructed Filter, Planter Boxes, Vegetated Swale)

Should be ASTM-C-33 (or AASHTO M-6) size (0.02” – 0.04”), concrete sand, clean, medium to fine sand.

Stone/Gravel (Constructed Filter, Planter Boxes):

Should be uniformly graded coarse aggregate, 1 inch to ½ inch with a wash loss of no more than 0.5%, AASHTO size number 5 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and have voids of 40% as measured by ASTM-C29.

Stone – 40% voids (Infiltration Trench, Porous Pavement, Subsurface Infiltration Bed,)

Infiltration trenches should have stone 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids 40% as measured by ASTM-C29.

Porous Pavement

General

Choker base course aggregate for beds shall be 3/8 inch to 3/4 inch clean, uniformly-graded, coarse, crushed aggregate AASHTO size number 57 per Table 4, AASHTO Specifications, Part I, 19th Ed., 1998 (p. 47).

Porous Asphalt

Bituminous surface course for porous paving shall be 2.5 to 3 inches thick with a bituminous mix of 5.75% to 6.75% by total weight as determined by testing below. Use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of PG 76-22P (in northern Michigan, use PG 76-28P as appropriate) as specified in AASHTO MP-1. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Determination of optimal asphalt content should be determined according the following tests:

- Draindown Test (ASTM Method D6390)
- Moisture Susceptibility Test using the Modifed Lottman Method (AASHTO T283) with the following:
  - Compact using 50 gyrations of Superpave gyratory compactor
  - Apply partial vacuum of 26 inches of Hg for 10 minutes to whatever saturation is achieved.
  - Keep specimens submerged in water during freeze cycle.
  - Required retained tensile strength (TSR) >= 80%
- Air Voids Test (AASHTO T269/ASTM D3203)

Hydrated lime, if required, shall meet the requirements of AASHTO M 303 Type 1 and shall be blended with the damp aggregate at a rate of 1.0% by weight of the total dry aggregate. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

Fibers, if used, shall consist of either cellulose fibers or mineral fibers which are to be treated with a cationic sizing agent to enhance dispersement of the fiber as well as increase cohesion of the fiber to the bitumen. Fiber is to be added at a dosage rate between 0.2% and 0.4% by weight of total mix.

- Mineral fibers shall be from virgin, basalt, diabase, or slag with a maximum average fiber length of 6.35 mm and a maximum average fiber thickness of 0.005 mm.
- Cellulose fiber – Fiber length shall be 6.4 mm (max), Ash Content 18% non-volatiles (±5%), pH 7.5 (± 1), Oil absorption (times fiber weight) 5.0 (± 1), Moisture Content 5.0 (max).

Porous Concrete

The use of Installers or Craftsmen who have been certified by the NRMCA's Pervious Concrete Contractor Certification Program is strongly recommended. Contractor shall furnish a proposed mix design with all applicable information to the Engineer prior to commencement of work. Critical mix characteristics typically include the following:

- Cement Content: 550 to 650 lb/cy
- Fine aggregate, if used: maximum 3 cu. ft. per cu. yd.
- Admixtures: use in accordance with the manufacturer's instructions and recommendations
- An aggregate/cement (A/C) ratio: 4:1 to 4.5:1
- Water/cement (W/C) ratio: 0.27 to 0.34
- Curing: shall begin within 15 minutes after placement and continue for 7 days

The data shall include unit weights determined in accordance with ASTM C29 paragraph 11, jigging procedure.

Cement: Portland Cement Type II or V conforming to ASTM C150 or Portland Cement Type IP or IS conforming to ASTM C595. The total cementitious material shall be between 550 and 650 lb./cy.

Aggregate: Use No 8 coarse aggregate (3/8 to No. 16) per ASTM C33 or No. 89 coarse aggregate (3/8 to No. 50) per ASTM D 448. If other gradation of aggregate is to be used, submit data on proposed material to owner for approval. The volume of aggregate per cu. yd. shall be equal to 27 cu.ft. when calculated as a function of the unit weight determined in accordance with ASTM C 29 jigging procedure. Fine aggregate, if used, should not exceed 3 cu. ft. and shall be included in the total aggregate volume.

Air Entraining Agent: Shall comply with ASTM C 260 and shall be used to improve workability and resistance to freeze/thaw cycles.

Admixtures: The following admixtures shall be used:

- Type D Water Reducing/Retarding – ASTM C 494.
- A hydration stabilizer that also meets the requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding admixtures may be used. This stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles from achieving initial set.

Water: Potable shall be used and shall comply with ASTM C1602. Mix water shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (Mix water yielding a cement paste with a dull-dry appearance has insufficient water for hydration).

- Insufficient water results in inconsistency in the mix and poor bond strength.
- High water content results in the paste sealing the void system primarily at the bottom and poor surface bond.

An aggregate/cement (A/C) ratio range of 4:1 to 4.5:1 and a water/cement (W/C) ratio range of 0.27 to 0.34 should produce pervious pavement of satisfactory properties in regard to permeability, load carrying capacity, and durability characteristics.

Vegetated roofs

Some key components and associated performance-related properties are as follows:

Root-barriers should be thermoplastic membranes with a thickness of at least 30 mils. Thermoplastic sheets can be bonded using hot-air fusion methods, rendering the seams safe from root penetration. Membranes that have been certified for use as root-barriers are recommended. At present only FLL offers a recognized test for root-barriers. Several FLL-certified materials are available in the United States. Interested American manufactures can submit products for testing to FLL-certified labs.

Granular drainage media should be a non-carbonate mineral aggregate conforming to the following specifications:

- Saturated Hydraulic Conductivity >= 25 in/min
- Total Organic Matter, by Wet Combustion (MSA) <= 1%
- Abrasion Resistance (ASTM-C131-96) <= 25% loss
- Soundness (ASTM-C88 or T103 or T103-91) <= 5% loss
- Porosity (ASTM-C29) >= 25%
- Alkalinity, CaCO3 equivalents (MSA) <= 1 %
- Grain-Size Distribution (ASTM-C136)
  - Pct. Passing US#18 sieve <= 1%
  - Pct. Passing ¼-inch sieve <= 30%
  - Pct. Passing 3/8-inch sieve >= 80%

Growth media should be a soil-like mixture containing not more than 15% organic content (wet combustion or loss on ignition methods). The appropriate grain-size distribution is essential for achieving the proper moisture content, permeability, nutrient management, and non-capillary porosity, and 'soil' structure. The grain-size guidelines vary for single and dual media vegetated cover assemblies.

Non-capillary Pore Space at Field Capacity, 0.333 bar (TMECC 03.01, A)	>= 15% (vol)
Moisture Content at Field Capacity (TMECC 03.01, A)	>= 12% (vol)
Maximum Media Water Retention (FLL)	>= 30% (vol)
Alkalinity, Ca CO3 equivalents (MSA)	<= 2.5%
Total Organic Matter by Wet Combustion (MSA)	3-15% (dry wt.)
pH (RCSTP)	6.5-8.0
Soluble Salts (DTPA saturated media extraction)"(RCSTP)	<= 6 mmhos/cm
Cation exchange capacity (MSA)	>= 10 meq/100g
Saturated Hydraulic Conductivity for Single Media Assemblies (FLL)	>= 0.05 in/min
Saturated Hydraulic Conductivity for Dual Media Assemblies (FLL)	>= 0.30 in/min

Grain-size Distribution of the Mineral Fraction (ASTM-D422)

Single Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	<= 5%
Pct. Passing US#60 sieve	<= 10%
Pct. Passing US#18 sieve	5 - 50%
Pct. Passing 1/8-inch sieve	0 - 70%
Pct. Passing 3/8-inch sieve	75 -100%

Dual Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	5-15%
Pct. Passing US#60 sieve	10-25%
Pct. Passing US#18 sieve	20 - 50%
Pct. Passing 1/8-inch sieve	55 - 95%
Pct. Passing 3/8-inch sieve	90 -100%

Macro- and micro-nutrients shall be incorporated in the formulation in initial proportions suitable for support the specified planting.

Separation fabric should be readily penetrated by roots, but provide a durable separation between the drainage and growth media layers (Only lightweight nonwoven geotextiles are recommended for this function.

- Unit Weight (ASTM-D3776) <= 4.25 oz/yd2
- Grab tensile (ASTM-D4632) <= 90 lb
- Mullen Burst Strength (ASTM-D4632) >= 135 lb/in
- Permittivity (ASTM-D4491) >= 2 per second

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Golder Associates

REPORT

SEYFERTH PARK OPERATIONS & MANAGEMENT PLAN

Stormwater Management

Low Impact Developments / Green Infrastructure

Landowner – City of Muskegon
933 Terrace St.
Muskegon, MI 49440

Submitted To: West Michigan Shoreline Regional Development Commission
316 Morris Avenue
Suite 340
Muskegon, Michigan 49440

Submitted By: Golder Associates Inc.
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Distribution: One electronic copy

March 7, 2017 **Project No.1520593**

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EXECUTIVE SUMMARY

The Operations and Management (O&M) Plan summarizes the best management practices (BMPs) and low impact development (LID) designs implemented in Seyferth Park for improving stormwater management. Details of each BMP can be seen in the Seyferth Park Conceptual Plan (Appendix A). Each structural BMP requires maintenance for continued efficiency and is summarized within the plan. Included in the appendices of the report is a maintenance summary for each BMP (Appendix B), and example checklists to be used for routine inspections (Appendix C). The plan provides guidance regarding management of vegetation, a list of recommended Michigan species (Appendix D), and a list of other recommended materials (Appendix E). Operations and maintenance costs were analyzed for each development and maintaining the site.

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1.0 SEYFERTH PARK

Seyferth Park is located in Muskegon, Michigan within the Ruddiman Creek Watershed. The site is city owned and located within a half mile of Muskegon Lake. The watershed receives stormwater from heavily urbanized areas and the city's storm sewer system. The polluted stormwater discharged to the watershed has resulted in degraded benthic communities, organic chemicals, excessive sediment, and/or flashy hydrology.

With grant support from the Michigan Department of Environmental Quality and the US Environmental Protection Agency, the Muskegon Lake Watershed Partnership, West Michigan Shoreline Regional Development Commission, municipal partners and Golder Associates Inc. recommended design solutions to reduce stormwater runoff, stormwater pollutants, and improve water quality within Seyferth Park and the Ruddiman Creek Watershed. Stormwater LID designs implemented for the site included eighteen bioretention islands.

2.0 MAINTENANCE COSTS

Stormwater LID designs tend to be less expensive to implement than conventional designs, however they do require long term maintenance to ensure the designs continue to work efficiently. Annual and long term cost analyses were completed for maintaining the eighteen bioretention islands in Seyferth Park. The total annual cost for maintaining the BMPs at Seyferth Park was estimated at $5,567.Annual maintenance costs were based on taking a percentage of the total construction costs, based on a low impact development cost comparison completed by Emmons & Oliver Resources, Inc. BMPs were estimated to require approximately 5% to 6% of construction costs for routine and non-routine maintenance. The estimated maintenance costs include aesthetic maintenance and functional maintenance. Functional maintenance assures the BMP is performing efficiently and safely, while aesthetic maintenance is mainly for public acceptance, which can help to reduce functional costs. The percentage of construction cost used for each BMP reflects labor, landscaping, and material costs. A typical year of landscaping includes maintenance such as lawn mowing, removal of debris and litter, replanting or seeding vegetation, and replenishing mulch. Maintenance labor is expected to be greater within the first two to three years as vegetation is established.

Table 1. Operation and Maintenance Costs Summary

Stormwater BMP	Construction Cost ($)	Annual Maintenance Cost (% of Construction Cost)	Annual Maintenance Cost ($)
Bioretention Islands	111,340	5	5,567
Total Costs			**5,567**

2.1 Bioretention Island

The Seyferth Park conceptual stormwater development plan includes eighteen bioretention islands covering 3,600 square feet. The bioretention islands consist of a geotextile filter layer, 18 inches of compacted stone, 18 inches of engineering soil, and two inches of mulch. One plug, gallon, or tree is maintained in each planter. Regular maintenance of the rain gardens are required within the first two to three years when vegetation is becoming established. Less maintenance is required after vegetation becomes established and fills more of the empty area in the planter. Maintenance requirements for the bioretention islands can be viewed in Appendix B. A summary of maintenance costs for the bioretention islands are provided in Table 1. The annual operations and maintenance costs for the bioretention islands were calculated as 5% of the construction cost. The annual cost to maintain the eighteen rain gardens is $5,567.

3.0 ROUTINE INSPECTIONS

Routine inspections of BMPs should be completed at least once every year. Example inspection checklists are included in Appendix C. Inspection checklists vary depending on the type of LID design. The stormwater designs in Seyferth Park include underdrain and overflow systems for two of the bioretention islands, which can be inspected by checking for blockages at inlets and outlets, and for damaged piping. The checklists include inspection items for the underdrain and overflow systems, which are only applicable for two of the planters. Bioretention islands should be inspected for debris, erosion, vegetation conditions and coverage, and mulch thickness to determine overall functionality. Based on the selection of native plants used for each BMP, additional species specific inspections may be required. Inspections of vegetation should include determining the overall plant health, checking if plants require trimming or pruning, and assuring invasive species are properly managed.

4.0 VEGETATION

The plant species selected for the BMPs have a significant impact on the effectiveness of the design. Vegetation will require regular maintenance within the first few years while becoming established. Maintenance involves watering plants as needed, and removing invasive species. Once vegetation is established, less maintenance will be required to maintain the BMP areas.

4.1 Native Species

Native plants are implemented in the design because they have deeper and more expansive roots leading to increased infiltration, groundwater recharge and biofiltration. Native plants are also more tolerant to flooding and drought conditions enabling them to thrive in bioretention islands. Plugs and gallons are common sizes of native plants that can be installed in BMPs. A plug is a small plant that grows in a container roughly two inches wide and five inches deep. A gallon is a more mature plant available in a gallon size container. Both sizes of plants require consistent watering during early development (Delta Institute, 2015).

Suggested species include: cardinal flower (*Lobelia cardinalis*), blue lobelia (*Lobelia siphilitica*), New England aster (*Aster novae-angliae*), and brown fox sedge (*Carex vulpinoidea*). Additional grasses and wildflowers that could tolerate wet growing conditions recommended by the West Michigan Environmental Action Council include: cotton grass (*Eriophorum angustifolium*), golden alexanders (Zizia aurea), and blue flag iris (*Iris versicolor*) (WMEAC 2016). A full list of recommended Michigan plants for BMPs is included in Appendix F (SEMCOG, 2008).

4.1.1 Planting Requirements

Maintenance will be required for any plants that do not successfully grow in the planted environment, and an alternative species may need to be planted. Seeding is not the preferred method of planting vegetation since high velocity flows can prevent the plant from establishing. Plugs or gallon-potted plants installed at one to two foot intervals are recommended for effective establishment of vegetation. Trees and shrubs are also recommended. Seeding should be completed from late April to mid-October if irrigation is available. If irrigation is not available, than seeding can be completed from June 15 or mid-August to mid-October. With dormant seeding, seeding can be completed from November 1 to 30. At all other times of the year, seeding should have a temporary cover (made of oats/cereal rye or other small grain). Plugs/gallons should be installed from May 1 – June 15. Trees and shrubs should be planted from the middle of April through early June, or the middle of September through the middle of November. A maximum of two to three inches of mulch should be evenly spread in the BMPs after installing new plants to help prevent erosion, remove metals, and act as leaf litter in a natural forest environment. The mulch should not be placed directly against the stems of the newly planted vegetation. If wildlife is a threat to newly installed plants additional precautions such as waterfowl barriers are maintenance options.

4.2 Invasive Non-Native Species

Invasive species are not native to the area and tend to grow and spread quickly without natural controls. If unmanaged, invasive species will displace native species (SEMCOG, 2008). Maintenance of invasive species is crucial when native plants are being established and require room to grow. Invasive species can be removed by hand–pulling, mowing, or spot herbicide applications. After native species are established, less maintenance of invasive species is needed. Long term management of invasive species may require removal once every year or as needed.

5.0 WINTER CONDITIONS

Winter conditions in Michigan typically include the buildup of snow and the use of de-icing compounds which can negatively affect plant life. Salt tolerant plants are recommended for sites where de-icing and heavy snow occurs. Recommended products for de-icing are nontoxic and organic, such as magnesium chloride-based liquid products or pretreated salt (Delta Institute 2008). Sand and cinder from melted snow

have the potential of reducing infiltration into the soil. Preventative measures should be taken to avoid the buildup or piling of snow over infiltration systems.

In the spring, the bioretention islands should all be assessed for winter damages. Buildup of debris and sediment should be cleared, and mulch should be evenly spread in any eroded areas. Plants may also require trimming or rehabilitation. Soil aeriation may also be required in spring to reduce impacts of de-icing agents.

6.0 EDUCATION AND TRAINING

All personnel responsible for the operations and maintenance of the BMPs should undergo training to fully understand the care required for each LID design. Training should include reading the O&M plan and discussing procedures with someone of experience. An educated maintenance staff will increase the efficiency and sustainability of the designs.

7.0 REFERENCES

1. Delta Institute and Guidon Design. 2015. Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
2. Emmons & Oliver Resources, Inc. 2015. Minnesota Low Impact Development A comparison, Cost Comparision. A Case Study Comparison of Costs, Water quality and quanity benefits and quality of life. http://www.eorinc.com/pdf/development-maintenance-cost.pdf
3. SEMCOG. 2008. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html
4. West Michigan Environmental Action Council. 2016. Rain Gardens of West Michigan. Michigan Native Plants List For Use in Rain Gardens and Landscaped Bioretention Areas. http://www.westmichiganglsi.org/uploads/6/7/9/8/6798898/rain_gardens_native_plant_list.pdf

Appendix A
Seyferth Park Conceptual Plan

Path: \\lansing\CAD\Projects\15x-Projects\1520593_WMSRDC Green Infrastructure Project\PRODUCTION\B_CONCEPTUAL DESIGN\ | File Name: 1520593B001.dwg

LEGEND

PARCEL BOUNDARY

REFERENCE(S)

1. BASE MAP TAKEN FROM ctopo150457.dwg, DATED OCTOBER 21, 2015, PROVIDED BY FISHBECK, THOMPSON, CARR & HUBER, INC.
2. WORLD IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.

0 60 120
1" = 120' FEET

NOTE(S)

1. THE SEYFERTH PARK SITE IS APPROXIMATELY 26.8 ACRES PARCEL AREA AND 19.3 ACRES WATERSHED TREATMENT AREA.
2. THE SEYFERTH PARK SITE IS PRIMARILY PLAINFIELD SAND, 0 TO 6% SLOPES.

CLIENT
WEST MICHIGAN SHORELINE DEVELOPMENT COUNCIL
MUSKEGON, MUSKEGON COUNTY, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-11-16
DESIGNED	JJS
PREPARED	TDJ
REVIEWED	KPL
APPROVED	JBM

PROJECT
GREEN INFRASTRUCTURE PROJECT

TITLE
SEYFERTH PARK

PROJECT NO.	CONTROL	REV.	FIGURE
1520593			7

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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Appendix B
Bioretention Island Maintenance Items

BIORETENTION ISLAND

1.0 PUROPOSE

A Bioretention islands or stormwater planters are a linear infiltration basin typically located in a parking lot or between a street and sidewalk surrounded by vertical curbing. Stormwater is collected from the street, sidewalk, or parking lot and directed into the bioretention island through openings in the curb. Bioretention islands consist of native plants in engineered soil which lay on top of a layer of stone. The stormwater planters are able to reduce, filter, and infiltrate stormwater runoff and aide in recharging groundwater.

2.0 MAINTENANCE

Bioretention islands require regular maintenance within the first year or two to establish vegetation. Once the native vegetation becomes mature and capable of choking out invasive species, less maintenance is required. Maintenance items include:

1.) The native plants need to be watered at least 3 times per week on a time-honored schedule for the first 4 weeks after installation. Newly planted species should receive approximately one inch of water per week throughout the first season.

2.) For the first year of establishment, vegetation will need to be watered twice weekly through October of the first year and in times of extreme drought.

3.) Debris removal, weeding, and pruning should be performed on a monthly basis.

4.) Annual inspections and repairs of erosion problems, damaged vegetation, sediment and debris accumulation, and slope uniformity are required. If sediment or debris is greater than three inches in any location or covering vegetation, maintenance is required.

5.) Annually trim plants to increase safety, aesthetics, proper operations, and to suppress weeds and invasive species. Perennial plants may be trimmed at the end of the growing season to enhance root establishment. Other trimming, removal, and replacement of dead plants is required as-needed.

6.) In the spring the bioretention islands will need to be inspected and cleaned after snow melts to remove debris, provide plant care, and replenish mulch.

7.) Mulch should be replenished when erosion is evident and at least annually for the first 3 years until plants begin to fill the empty areas.

8.) If roadside or parking lot runoff is directed to the bioretention island, mulching and/or soil aeration may be required in the spring to reduce the impacts of de-icing agents. If possible use nontoxic, organic, de-icing agents such as blended, magnesium chloride-based liquid products or pretreated salt. Also consider using salt-tolerant vegetation in the bioswales.

3.0 REFERENCES

- Delta Institute and Guidon Design (July 2015). Green Infrastructure Designs, Scalable Solutions to Local Challenges. Chicago, USA. http://delta-institute.org/delta/wp-content/uploads/Green-Infrastructure-Designs-July-2015.pdf
- SEMCOG (2008). MDEQ. Low Impact Development Manual for Michigan. A design Guide for Implementers and Reviewers. http://www.semcog.org/Reports/LID/index.html

Appendix C
Example Inspection Checklists

Maintenance Inspection Checklists

This appendix contains four checklists available as guides for maintenance inspections of specific BMPs. The maintenance items have been adapted from multiple stormwater programs, including the Rouge River Detention Basin Maintenance Manual, Georgia Stormwater Management Manual, the Vermont Stormwater Management Manual, and the Stormwater Manager's Resource Center.

The checklists are designed to help identify key components of BMPs that require ongoing maintenance as well as a basic schedule of when the maintenance should occur. The checklists have been divided into those items essential for the general operation and functionality of the BMP and those items that optional and may enhance the BMP.

It is suggested that the inspection be undertaken by a licensed PE and/or a person knowledgeable about the design and function of the BMP.

These BMP checklists include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

Detention BMP Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet Pipes			
Structural integrity of inlet/outlet (Are any inlet pipes broken, crumbling, separated?) List Inlet Pipes Approximate Diameter and Type of Material Inlet Pipe 1 _____ Inlet Pipe 2 _____ Inlet Pipe 3 _____ Outlet Pipe Size/Type _____		A	
Riprap at inlet pipe (Is the riprap still present? Is it visible and not covered with sediment?		A	
Stone around outlet pipe (Is the stone clogged with debris and/or sediment?)		A	
Trash or debris blocking inlet/outlet (Inspect to ensure no major obstructions hindering general functionality)		M	
Inspect/clean catch basin upstream of the BMP if accessible.		A	
Inspect inlets and outlet for erosion (Are there eroded areas around the pipes?)		A	
Inspect overflow spillway for signs of erosion.			
Pretreatment (if applicable) (Might include sediment forebay, upstream catch basin, bioswale, rain garden, swirl concentrator)			
Device functioning to trap/collect sediment		A	
Remove accumulated sediment as appropriate for the pretreatment device. forebay		A	
Detention Pond		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inspect side slopes, berms and emergency overflow for erosion		A	
Reestablish permanent native vegetation on eroded slopes		As needed	
Inspect for excess sediment accumulation in pond if not pretreatment device is present		A	
Overall functionality			
Ensure pond is functioning properly (Professional Civil Engineer is recommended)		A	
Ensure the outlet is functioning properly (Professional Civil Engineer is recommended)		A	
Optional/Enhancements			
Maintain 15-20 feet “no mow and chemical free” zone		A	
Mow (or burn) the “no mow” zone		A	
Inspect basin and “no mow” zone for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation in and around pond.		A	
Complaints from residents (note on back)		S	
Encroachment on pond/no- mow zone.		A	
Unauthorized plantings		A	
Aesthetics (e.g., graffiti, unkept maintenance)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Summary

Inspector’s remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*It is recommended to review and inspect the basin with the engineering as-built plans.

Infiltration BMPs Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		A	
Pretreatment for sediment			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure infiltration device is functioning properly (professional civil engineer is recommended)		A	
BMP infiltration surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		S	
Evidence of erosion present		A	
Aggregate (if applicable)			
Surface of aggregate clean		A	
Any replacement of aggregate needed? If clogged with sediment replacement is necessary for continued proper function.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Vegetated surface (if applicable)			
Vegetative cover exists		A	
Optional considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation or creating a native plant infiltration basin area.		A	
Complaints from residents (note on back)		A	
Mowing done when necessary		A	
No fertilizer unless testing requires it		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioretention Inspection Checklist*

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Overflow spillway or catch basin clear of debris		M	
Erosion control at inlet in place (e.g., rock, mat)/ evidence of erosion		A	
Erosion control at outlet in place/evidence of erosion		A	
Inspect/clean catch basin upstream of BMP		Every 5 years	
Pretreatment for sediment (Generally consists of catch basin or velocity dissapator at inlet such as area of riprap/ collection for sediment)			
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
Overall functionality			
Ensure bioretention area is functioning properly (professional civil engineer is recommended)		A	
Bioretention area surface			
Any evidence of sedimentation in BMP		A	
Does sediment accumulation currently require removal		A	
Debris in BMP		M	
Evidence of erosion present		A	
Does good vegetative cover exist		A	
Mulch covers entire area (no voids) and to specified thickness		A	
Optional considerations			
Inspect BMP for invasive species.		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Bioswale, Filter Strip Inspection Checklist

Project Location:_____

Date/Time: _____

Inspector:_____

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Inlet/Outlet			
Structural integrity of inlet/outlet		A	
Inlet/outlet clear of debris		M	
Pretreatment/ Energy Dissipators			
No evidence of flow going around structures		A	
No evidence of erosion		A	
Device functioning to trap sediment		A	
Remove accumulated sediment		A	
BMP surface			
Area free of debris?		M	
No evidence of erosion		A	
Does sediment accumulation currently require removal?		A	
Overall functionality			

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Maintenance Item	Satisfactory/ Unsatisfactory	Recommended Inspection Frequency	Comments
Ensure swale is functioning properly (professional civil engineer is recommended)		A	
Optional Considerations			
Inspect BMP for invasive species.		A	
Qualified professional applicator selectively herbicide invasive species		A	
Increase plant diversity by planting additional vegetation		A	
Complaints from residents (note on back)		A	

Inspection frequency key — A = Annual, M = Monthly, S = After major storm
*Prior to field inspection, it is recommended to review the as-built plans.

Summary

Inspector's remarks: _____

_____

Overall condition of facility (acceptable or unacceptable): _____

Dates any maintenance must be completed by: _____

Appendix D
List of Michigan Recommended Plants

Recommended Plant Lists for Best Management Practices

This appendix contains recommended native and non-native (when appropriate) plant species for the Best Management Practices detailed throughout the manual. Species have been recommended based on hardiness, aesthetics, functionality, and commercial availability. It is certain that species exist outside the confines of this list that will perform in a comparable way to those listed; however, commercial availability is often a limiting factor in obtaining material for native plantings. Over time, and in certain locales, additional species will become available to supplement those listed below.

An array of planting zones is provided based on normal water levels (Figure C.1). Using these zones will provide the best chances for long-term success of native planting in the context of LID. While plants may naturally occur outside of the given ranges, these ranges are intended to be guidelines for plant installation. Whenever possible and practical in standing water conditions, native plants should be installed in live plant form (rather than seed). Seed or a combination of seed and live plants may be used in upland situations.

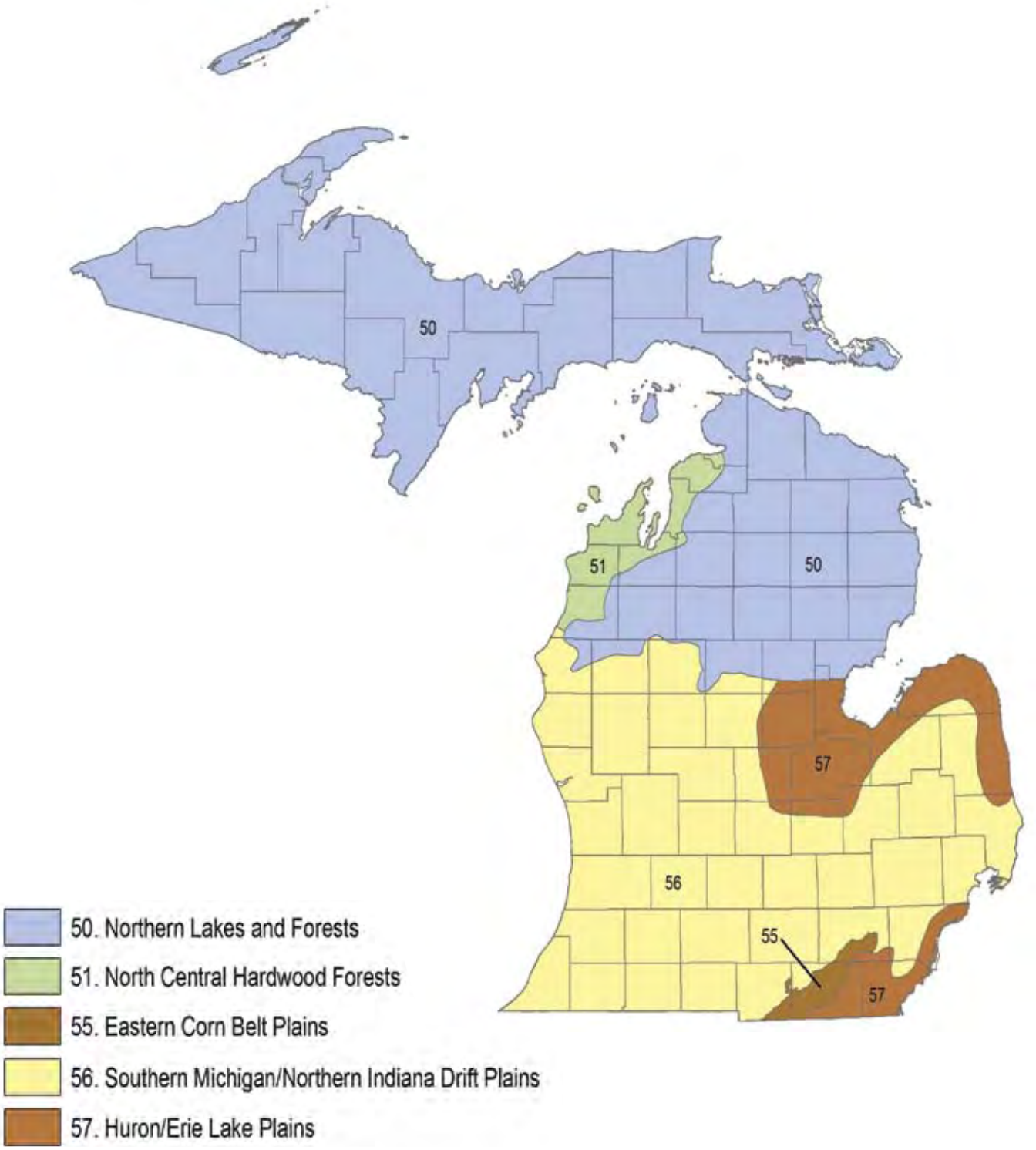
Recommendations are given for height, bloom color, bloom time, sun requirements, salt tolerance, and ecoregion. Please note that these are recommendations based on a range of situations, and a specific plant or population may vary from site-to-site. For sun requirements, F = Full sun required, P = Partial sun tolerated, and S = Shade tolerated. Salt tolerance is classified as Yes (Y) or No (N). This was determined through literature reviews and anecdotal evidence. If there is no information confirming tolerance, a "No" was listed.

Figure C.1
Planting Zone/BMP Matrix

	Zone A — 2"-4" Below Water Level	Zone B — 0"-2" Below Water Level	Zone C — 0"-2" Above Water Level	Zone D — 2"-4" Above Water Level	Zone E — 4"-18" Above Water Level	Zone F — 18"+ Above Water Level	Zone G — Planter Boxes	Zone H — Vegetated Roofs
Rain gardens/Bioretention	✤	✤	✤	✤	✤	✤		
Vegetated Filter Strips			✤	✤	✤	✤		
Vegetated Swales		✤	✤	✤				
Infiltration Basin		✤	✤					
Subsurface Infiltration Basins				✤	✤	✤		
Infiltration Trenches				✤	✤	✤		
Infiltration Berns	✤	✤	✤	✤	✤	✤		
Planter Boxes							✤	
Vegetated Roofs								✤
Constructed Wetlands	✤	✤	✤	✤				
Wet Ponds	✤	✤	✤					
Dry Extended Detention Basins			✤	✤	✤	✤		
Riparian Corridor Restoration			✤	✤				
Native Revegetation	✤	✤	✤	✤	✤	✤	✤	✤

Ecoregion recommendations are also provided for each species (Figure C.2). Whenever possible, the designer/ installer should seek to use species that historically occurred in the same ecoregion as the project. When necessary, species occurring in an adjacent ecoregion may be used.

Figure C.2
EPA Level III Ecoregions for Michigan



Source: USEPA

Plant Installation

Native Seeding

Seasonal consideration: October 1-June 15 (note: seeds should not be planted on frozen ground).

Native seeding is generally recommended for areas above the water line or 1-2" below the water line. Live plant material should be used to establish vegetation at deeper water levels.

Broadcast seeding

Broadcast seeding is preferred over drill seeding on graded, bare soil sites. Apply the seed uniformly over the surface using a combination seeder/cultipacker unit such as a Brillion or Truax Trillion seeder. The Trillion seeder is preferred as it is designed to handle native seeds.

A cone seeder or other similar broadcasting equipment may also be used if the seed mix does not contain fluffy seeds in amounts sufficient to prevent free flowing without plugging. Seed should then be pressed into the surface using a cultipacker or roller.

Drill seeding

A rangeland-type no-till drill designed to plant native grasses and forbs may be used in bare soils although this equipment is specifically designed to plant through existing vegetation which is killed with an herbicide. Cultipacking or rolling before seeding may be required to prevent seed placement depths exceeding .25 inch, but cultipacking or rolling after seeding is not required.

All seeding equipment, whether broadcast or drill, should be calibrated to deliver the seed at the rates and proportions specified in the plans. Equipment should be operated to ensure complete coverage of the entire area to be seeded, and seed must be placed no deeper than .25 inch in the soil. No fertilizers or soil conditioners will be required or allowed.

Native Planting

Seasonal considerations: May 1-July 1

Plant plugs should be installed in holes drilled with an auger the same diameter and depth as the plug within +0.75 inch/- 0.25 inch. In wetland plantings where soil is soft and moist enough, a dibble bar or trowel may also be used. The planting layout should consider the requirements of the individual species regarding soil type, moisture, slope, shading, and other factors for the particular plant species.

Planting densities vary according to budget and project goals and can range from three-to-five foot spacing for plug supplements of seeded areas to six inches to two foot spacing for high visibility landscaping projects with large budgets. Groups of five-to-seven plugs of the same species planted approximately one foot apart is usually preferable to planting all species intermixed randomly across the site at a uniform density.

In wetland or shoreline areas with potential for high wave action or wildlife predation that may dislodge newly planted plugs, plugs should be secured with six inch or eight inch U-shaped wire erosion control blanket staples. Staple length is determined by the density of the planting substrate; softer substrates require longer length to hold plugs adequately.

In areas where potential for wildlife predation exists, such as retention basins or other planting areas adjacent to open water, waterfowl barriers should be installed around a minimum of 50 percent of the plugs. All plugs not protected by barriers should be stapled into the substrate as described above. Barriers may consist of plastic or wire mesh enclosures supported with wooden stakes, adequately constructed to inhibit access by waterfowl for one growing season. Enclosures should extend at least two feet above the plant tops. Methodology should be approved by the project designer with input from a restoration ecologist if necessary. Barriers may be removed after one growing season.

Maintenance and Management

Maintaining vegetated BMPs is typically most important during the first few years following installation. Supplemental irrigation may be needed to help establish plants in drought conditions. Plants may need to be replaced due to predation or other unseen factors. Most commonly, management includes removing invasive species via mowing, hand-pulling, or spot herbicide applications. In larger areas, broadcast herbicide applications may be appropriate. Over time in upland areas, controlled burning may be used as a way to invigorate the plantings and control certain invasive species. If not feasible for social or cultural reasons, an annual or biennial mowing may be used instead of fire.

Long-term management may be necessary, but is typically significantly less intensive. The site should be periodically checked for invasive species infestations. Any prairie or open area may need occasional (every three to five years) burning or mowing to remove woody vegetation that may encroach.

Zone A

Planting Zone = two-to-four inches below water level

These species require continual inundation within the given water depths in order to thrive. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for a majority of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57

Representative Zone A Species

Buttonbush

Pickerel Weed

Swamp Milkweed

Arrowhead

Blue Flag Iris

Source: JFNew

Zone B

Planting Zone = zero-to-two inches below water level

These species tolerate fluctuating water levels within this range. Although slight, short-term variances may be tolerated (+/-five inches for a period of 48 hours or less), water levels must remain in this range for most of the growing season for maximum plant growth and survival.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Cephalanthus occidentalis	Buttonbush	15’	White	Jun-Aug	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Acorus calamus	Sweet flag	1’-4’	Green	May-Jun	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-Jun	F	N	50,51,55,56,57
Carex lacustris	Lake sedge	2’-4’	Brown	May-Jun	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57
Sparganium americanum	American bur reed	2’-5’	Green	Jun-Aug	F/P	N	50,51,55,56,57
Sparganium eurycarpum	Common bur reed	2’-6’	Green	May-Aug	F	N	50,51,55,56,57
Forbs:							
Alisma plantago-aquatica	Water plantain	2’-4’	White	Jul-Sep	F	N	50,51,55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Decodon verticillatus	Swamp loosestrife	2’-4’	Purple	Jul-Sep	F/P	N	51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Peltandra virginica	Arrow arum	2’-5’	Green	Jun-Jul	F/P/S	N	55,56,57
Pontedaria cordata	Pickerelweed	1’-3’	Violet	Jun-Sep	F/P	N	50,51,55,56,57
Sagittaria latifolia	Arrowhead	1’-4’	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard’s tail	2’-4’	White	Jun-Aug	P/S	N	55,56,57

Representative Zone B Species

Blue Flag Iris

Arrowhead

Bristly Sedge

Pickerel Weed

Swamp Milkweed

Source: JFNew

Zone C

Planting Zone = zero-to-two inches above water level

These plants are tolerant of fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Alnus rugosa	Speckled alder	25’	Brown	Mar-May	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Cephalanthus occidentalis	Buttonbush	15’	White	Jun/Aug	F/P/S	N	51,55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	Y	55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Grasses/Sedges/Rushes:							
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Eleocharis acicularis	Needle spike rush	6”	Green	May-Oct	F	N	50,51,55,56,57
Eleocharis obtusa	Blunt spike rush	1’-2’	Green	May-Sep	F/P	N	50,51,55,56,57
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus effusus	Soft rush	1’-4’	Brown	July	F/P	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Scirpus acutus	Hard-stemmed bulrush	4’-6’	Brown	Apr-Aug	F	Y	50,51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Scirpus validus	Great bulrush	4’-8’	Brown	May-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Forbs:							
Alisma plantago-aquatica	Water plantain	2'-4'	White	Jul-Sep	F	N	50,51,55,56,57
Anemone canadensis	Canada anemone	1'-2'	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6'-9'	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3'-5'	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3'-6'	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3'-6'	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1'-4'	White	Jul-Oct	F/P	N	50,51,55,56,57
Cassia hebecarpa	Wild senna	3'-5'	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2'-4'	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Eupatorium maculatum	Spotted Joe-pye weed	4'-7'	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3'-5'	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1'-3'	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3'-5'	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5'-12'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2'-3'	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3'-5'	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3'-8'	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2'-5'	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1'-4'	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1'-3'	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2'-4'	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2'-5'	Pink	Aug-Oct	F	Y	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1'-3'	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3'-10'	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Sagittaria latifolila	Arrowhead	1'-4'	White	Jun-Sep	F/P	N	50,51,55,56,57
Saururus cernuus	Lizard's tail	2'-4'	White	Jun-Aug	P/S	N	55,56,57
Sisyrinchium angustifolium	Stout blue-eyed grass	1'	Blue	May-Aug	F/P	N	55,56,57
Solidago ohiensis	Ohio goldenrod	2'-3'	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3'-6'	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell's goldenrod	2'-5'	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3'-6'	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2'-5'	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3'-6'	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3'-6'	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3'-5'	Purple	Jul-Sep	F	N	55,56,57
Zizia aurea	Golden Alexanders	1'-3'	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone C Species

Cardinal Flower

Swamp Milkweed

Blue-Eyed Grass

Obedient Plant

Joe-Pye Weed

Path Rush

Red-Osier Dogwood

Monkey Flower

Source: JFNew

Zone D

Planting Zone = two-to-four inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	50,51,55,56,57
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula alleghaniensis	Yellow birch	100’	Purple/ Yellow	Apr-May	P/S	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Ilex verticillata	Winterberry	10’	White	June	F/P/S	Y	50,51,55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Rosa palustris	Swamp rose	2’-7’	Pink	Jun-Aug	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum lentago	Nannyberry	20’	White	Apr-Jun	P/S	Y	50,51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Viburnum trilobum	Cranberry Viburnum	10’	White	Apr-May	F/P/S	N	50,51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Calamagrostis canadensis	Blue joint grass	2’-4’	Brown	June	F/P	N	50,51,55,56,57
Carex comosa	Bristly sedge	2’-3’	Green	May-June	F/P	N	50,51,55,56,57
Carex crinita	Fringed sedge	2’-5’	Green	May	F/P/S	N	50,51,55,56,57
Carex hystericina	Porcupine sedge	2’-3’	Green	May-June	F/P/S	N	50,51,55,56,57
Carex lupulina	Common hop sedge	2’-3’	Green/ Brown	May-June	F/P/S	N	50,51,55,56,57
Carex muskingumensis	Palm sedge	1’-2’	Brown	May-June	S	N	55,56,57
Carex stipata	Common fox sedge	1’-3’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Carex stricta	Tussock sedge	2’-3’	Brown	Apr-Jun	F/P	N	50,51,55,56,57
Carex vulpinoidea	Brown fox sedge	2’-3’	Brown	May-Jun	F/P	N	50,51,55,56,57
Cinna arundinacea	Common wood reed	3’-4’	Green	Aug-Sep	P/S	N	55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Glyceria striata	Fowl manna grass	1’-5’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Juncus torreyi	Torrey’s rush	1’-2’	Brown	Jun-Sep	F	Y	51,55,56,57
Panicum virgatum	Switch grass	3‘-5’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Scirpus atrovirens	Dark green rush	3’-5’	Brown	Jun-Aug	F	N	50,51,55,56,57
Scirpus cyperinus	Wool grass	3’-5’	Tan	Jun-Sep	F	Y	50,51,55,56,57
Scirpus pendulus	Red bulrush	2’-4’	Brown	May-Jun	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Forbs:							
Anemone canadensis	Canada anemone	1’-2’	White	May-Sep	F/P	N	50,51,55,56,57
Angelica atropurpurea	Great angelica	6’-9’	White	May-Jun	F/P	N	55,56,57
Asclepias incarnata	Swamp milkweed	3’-5’	Pink	Jun-Sep	F/P	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster puniceus	Swamp aster	3’-6’	Lav/ White	Aug-Oct	F	Y	50,51,55,56,57
Aster umbellatus	Flat-topped aster	1’-4’	White	Jul-Oct	F/P	N	50,51,55,56,57
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Chelone glabra	Turtlehead	2’-4’	Cream	Aug-Sep	F/P/S	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	51,55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium maculatum	Spotted Joe-pye weed	4’-7’	Pink	Jun-Oct	F/P	N	50,51,55,56,57
Eupatorium perfoliatum	Boneset	3’-5’	White	Jul-Oct	F/P	Y	50,51,55,56,57
Euthamia graminifolia	Grass-leaved gold-enrod	1’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Gentiana andrewsii	Bottle gentian	1’-3’	Blue	Aug-Oct	F/P	N	50,51,55,56,57
Helenium autumnale	Sneezeweed	3’-5’	Yellow	Jul-Nov	F/P	Y	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Iris virginica	Blue flag iris	2’-3’	Purple	May-Jul	F/P/S	N	50,51,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P	N	55,56,57
Lilium michiganense	Michigan lily	3’-8’	Orange	Jul-Aug	P/S	N	55,56,57
Lobelia cardinalis	Cardinal flower	2’-5’	Red	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia siphilitica	Great blue lobelia	1’-4’	Blue	Jul-Oct	F/P/S	N	50,51,55,56,57
Lobelia spicata	Pale spiked lobelia	1’-3’	Lavender	May-Aug	F/P	N	50,51,55,56,57
Mimulus ringens	Monkeyflower	2’-4’	Lavender	Jun-Sep	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Rudbeckia laciniata	Cutleaf coneflower	3’-10’	Yellow	Jul-Nov	F/P/S	N	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2‘-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago ohiensis	Ohio goldenrod	2’-3’	Yellow	Jul-Oct	F/P	N	50,51,55,56,57
Solidago patula	Swamp goldenrod	3’-6’	Yellow	Aug-Oct	F/P/S	N	50,51,55,56,57
Solidago riddellii	Riddell’s goldenrod	2’-5’	Yellow	Sep-Nov	F	N	55,56,57
Spiraea alba	Meadowsweet	3’-6’	White	June-Sep	F/P	Y	50,51,55,56,57
Spiraea tomentosa	Steeplebush	2’-5’	Pink	Jul-Sep	F/P	Y	55,56,57
Thalictrum dasycarpum	Purple meadow-rue	3’-6’	Cream	May-Jul	F/P	N	50,51,55,56,57
Verbena hastata	Blue vervain	3’-6’	Violet	Jun-Sep	F	N	50,51,55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57
Veronicastrum virginicum	Culver’s root	3’-6’	White	Jun-Aug	F/P	N	55,56,57
Zizia aurea	Golden Alexanders	1’-3’	Yellow	Apr-Jun	F/P/S	Y	55,56,57

Representative Zone D Species

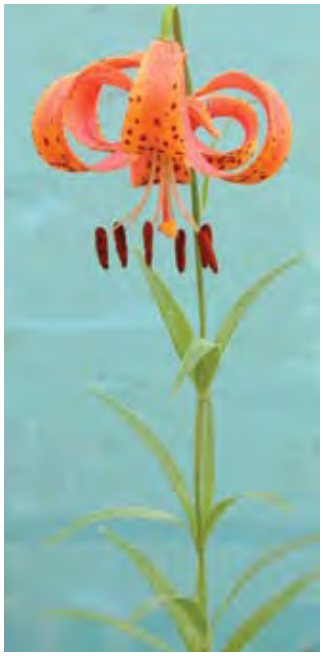
Big Bluestem

Marsh Blazing Star

Wild Columbine

Great Blue Lobelia

Virginia Mountain Mint



Michigan Lily

Meadowsweet

Blue Vervain

Source: JFNew

Zone E

Planting Zone = four-to-18 inches above water level

These plants tolerate fluctuating water levels within this range. They will also tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for BMP settings.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90’	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100’	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100’	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Amelanchier arborea	Downy serviceberry	40’	White	April	F/P/S	N	N
Aronia prunifolia	Purple chokeberry	10’	White	Apr-Jul	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70’	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80’	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1’-3’	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60’	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25’	Red	Apr-May	F/P/S	N	55,56,57
Cornus amomum	Silky dogwood	10’	White	May-Jul	F/P	N	51,55,56,57
Cornus florida	Flowering dogwood	30’	White	May-Jun	F/P/S	N	55,56,57
Cornus sericea	Red-osier dogwood	10’	White	May-Sep	F/P	N	50,51,55,56,57
Corylus americana	American hazelnut	10’	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85’	White	Jun	F/P	N	55,56,57
Juglans nigra	Black walnut	90’	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50’	Brown	Apr-May	F/P	N	55,56,57
Larix laricina	American larch	75’	Brown	May	F/P	N	50,51,55,56,57
Lindera benzoin	Spicebush	15’	Yellow	Apr-May	P/S	N	51,55,56,57
Liriodendron tulipifera	Tulip tree	110’	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50’	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100’	Green	May-Jul	F/P/S	Y	51,55,56,57
Physocarpus opulifolius	Ninebark	10’	White	May-Jun	F/P	N	50,51,55,56,57
Picea mariana	Black spruce	60’	Brown	May-Jun	F/P/S	N	50,51,57
Pinus banksiana	Jack pine	60’	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100’	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100’	Brown	Jun	F/P/S	N	50,51,55,56,57
Platanus occidentalis	Sycamore	100’	Green	May	F/P	N	55,56,57
Prunus americana	American plum	30’	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30’	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus bicolor	Swamp white oak	70’	Green/ yellow	May	F/P/S	N	55,56,57
Quercus macrocarpa	Bur oak	85’	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90’	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90’	Green	May-Jun	F/P/S	N	50,51,55,56,57
Ribes americanum	Wild black currant	5’	Yellow	Apr-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3’	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100’	White	Jun-Jul	F/P/S	N	50,51,55,56,57
Thuja occidentalis	White cedar	50’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100’	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Ulmus americana	American elm	100’	Brown	Mar-Apr	F/P/S	N	50,51,55,56,57
Ulmus rubra	Slippery elm	80’	Green	Mar-Apr	F/P/S	N	51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7’	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10’	White	May-Jun	F/P/S	N	51,55,56,57
Viburnum prunifolium	Black haw	10’	White	Apr-May	F/P	N	55
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4’-8’	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1’-2’	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1’-3’	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3’-6’	Green	Jun-Sep	F/P	N	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Elymus hystrix	Bottlebrush Grass	3’-5’	Green	Jun-Jul	P/S	N	
Elymus virginicus	Virginia wild rye	2’-4’	Green	Jun	F/P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1’-2’	Purple	Aug-Oct	F	N	51,55,56,57
Juncus tenuis	Path rush	6”-2’	Brown	June	F/P/S	N	50,51,55,56,57
Panicum virgatum	Switch grass	3’-6’	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2’-4’	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4’-9’	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6’-7’	Green	Jul-Aug	F	Y	50,51,55,56,57
Stipa spartea	Porcupine grass	2’-4’	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1’-2’	Lavender	Jun-Oct	F/P	N	55,56
Aquilegia canadensis	Wild columbine	1’-3’	Red/ Yellow	Apr-Jun	F/P/S	Y	50,51,55,56,57
Asclepias syriaca	Common milkweed	2’-4’	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1’-3’	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1’-2’	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2’-4’	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3’-5’	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster lateriflorus	Calico aster	1’-3’	White	Jul-Oct	F/P/S	N	50,51,55,56,57
Aster macrophyllus	Big-leaved aster	6”-2’	Lav/ White	Jul-Oct	P/S	N	50,51,55,56,57
Aster novae-angliae	New England aster	3’-6’	Violet	Jul-Oct	F/P	N	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1’-4’	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short’s aster	1’-4’	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3’-8’	White	Jun-Oct	F/P/S	N	55,56
Campanula americana	Tall bellflower	2’-6’	Blue	Jul-Nov	P/S	N	55,56,57
Cassia hebecarpa	Wild senna	3’-5’	Yellow	Jul-Aug	F/P	N	55,56
Clematis virginiana	Virgin’s bower	9’ long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis tripteris	Tall coreopsis	4’-8’	Yellow	Aug-Sep	F/P	N	55,56,57
Desmodium canadense	Showy tick-trefoil	2’-5’	Purple	Jun-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2’-5’	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3’-5’	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3’-6’	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2’-4’	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1’-2’	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2’-6’	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus giganteus	Tall sunflower	5’-12’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
elianthus pauciflorus	Prairie sunflower	3’-5’	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4’-6’	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2’-4’	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2’-3’	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris spicata	Marsh blazing star	3’-5’	Pink	Jul-Sep	F/P/S	N	55,56,57
Liatris scariosa	Savanna blazing star	3’-5’	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Monarda fistulosa	Wild bergamot	2’-5’	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2’-4’	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1’-2’	Purple	May-Jul	F/P	N	55,56,57
Phlox divaricata	Wild blue phlox	1’-2’	Blue	Apr-Jun	P/S	N	51,55,56,57
Phlox pilosa	Sand prairie phlox	1’-2’	Pink	May-Aug	F/P	N	56
Physostegia virginiana	Obedient plant	2’-5’	Pink	Aug-Oct	F	Y	50,51,55,56,57
Polygonatum biflorum	Solomon seal	1’-4’	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1’-3’	White	May-Jul	P/S	N	50,51,55,56,57
Pycnanthemum virginianum	Mountain mint	1’-3’	White	Jun-Oct	F/P	N	55,56,57
Ratibida pinnata	Yellow coneflower	3’-6’	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1’-3’	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Rudbeckia triloba	Three-lobed cone-flower	2’-5’	Yellow	Aug-Oct	F/P	N	55,56,57
Silphium terebinthinaceum	Prairie-dock	3’-8’	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solo-mon’s seal	1’-3’	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon’s seal	1’-2’	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1’-2’	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago flexicaulis	Zigzag goldenrod	1’-3’	Yellow	Aug/Oct	P/S	N	50,51,55,56,57
Solidago juncea	Early goldenrod	2’-4’	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1’-3’	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Thalictrum dioicum	Early meadow-rue	1’-3’	Green	Apr-May	P/S	N	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2’-4’	Blue	May-Oct	F/P	N	55,56,57
Vernonia missurica	Missouri ironweed	3’-5’	Purple	Jul-Sep	F	N	55,56,57

Representative Zone E Species

New England Aster

Wild Bergamot

Showy Goldenrod

Tall Bellflower

Wild Geranium

Tall Coreopsis

Redbud

Indian Grass

Source: JFNew

Zone F

Planting Zone = 18+inches above water level

These plants tolerate fluctuating water levels within this range, although they are generally less tolerant than most wetter species. They may tolerate short periods of inundation, not to exceed 48 hours in most situations, making them appropriate for upland BMP settings.

Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Woody Species:							
Acer rubrum	Red maple	90'	Green/ red	Mar-May	F/P/S	N	50,51,55,56,57
Acer saccharum	Sugar maple	100'	Green	Apr-May	F/P/S	N	50,51,55,56,57
Acer saccharinum	Silver Maple	100'	Yellow	Mar-Apr	F/P	N	50,51,55,56,57
Betula papyrifera	Paper birch	70'	Brown	Apr-May	F/P	N	50,51,55,56,57
Carya ovata	Shagbark hickory	80'	Green	May-Jun	F/P/S	N	55,56,57
Ceanothus americanus	New Jersey tea	1'-3'	White	Jun-Oct	F/P	N	50,51,55,56,57
Celtis occidentalis	Hackberry	60'	Green	May	F/P/S	N	55,56,57
Cercis canadensis	Redbud	25'	Red	Apr-May	F/P/S	N	55,56,57
Cornus florida	Flowering dogwood	30'	White	May-Jun	F/P/S	N	55,56,57
Corylus americana	American hazelnut	10'	Yellow	Apr-May	F/P	N	55,56,57
Gymnocladus dioicus	Kentucky coffee tree	85'	White	Jun	F/P	N	55,56,57
Hamamelis virginiana	Witch hazel	30'	Yellow	Oct-Nov	F/P/S	N	50,51,55,56,57
Juglans nigra	Black walnut	90'	Green	May	F/P	N	51,55,56,57
Juniperus virginiana	Red-cedar	50'	Brown	Apr-May	F/P	N	55,56,57
Liriodendron tulipifera	Tulip tree	110'	Green	May-Jun	F/P	N	55,56,57
Morus rubra	Red mulberry	50'	Green	May-Jun	F/P/S	N	55,56,57
Nyssa sylvatica	Black gum	100'	Green	May-Jul	F/P/S	Y	51,55,56,57
Pinus banksiana	Jack pine	60'	Brown	May-Jun	F/P	N	50,51,55,57
Pinus resinosa	Red pine	100'	Brown	Apr-May	F/P	N	50,51,55,57
Pinus strobus	White pine	100'	Brown	Jun	F/P/S	N	50,51,55,56,57
Prunus americana	American plum	30'	Red	Apr-May	F/P	N	55,56,57
Prunus virginiana	Choke cherry	30'	White	May-Jun	F/P/S	N	50,51,55,56,57
Quercus macrocarpa	Bur oak	85'	Yellow	May-Jun	F/P/S	N	50,51,55,56,57
Quercus palustris	Pin oak	90'	Green/ yellow	Apr-May	F/P/S	Y	55,56,57
Quercus rubra	Red Oak	90'	Green	May-Jun	F/P/S	N	50,51,55,56,57
Rosa carolina	Pasture rose	3'	Pink	Jun-Sep	F/P	N	55,56,57
Tilia americana	Basswood	100'	Yellow	Jun-Jul	F/P/S	N	50,51,55,56,57
Tsuga canadensis	Hemlock	100'	Brown	Apr-May	F/P/S	N	50,51,55,56,57
Viburnum acerifolium	Maple-leaved Viburnum	7'	White	May-Aug	F/P	N	50,51,55,56,57
Viburnum dentatum	Arrowwood	10'	White	May-Jun	F/P/S	N	51,55,56,57
Grasses/Sedges/Rushes:							
Andropogon gerardii	Big bluestem	4'-8'	Purple	Jul-Sep	F	N	50,51,55,56,57
Carex bicknellii	Copper-shouldered oval sedge	1'-2'	Brown	May-Jun	F	N	55,56
Carex muhlenbergii	Sand bracted sedge	1'-3'	Brown	May-Jun	F/P/S	N	51,55,56,57
Elymus canadensis	Canada wild rye	3'-6'	Green	Jun-Sep	F/P	N	50,51,55,56,57
Elymus hystrix	Bottlebrush Grass	3'-5'	Green	Jun-Jul	P/S	N	50,51,55,56,57
Eragrostis spectabilis	Purple love grass	1'-2'	Purple	Aug-Oct	F	N	51,55,56,57
Koeleria macrantha	June grass	1'-2'	White	May-Jul	F/P	N	50,51,55,56,57
Panicum virgatum	Switch grass	3'-6'	Green/ Purple	Jun-Oct	F/P	Y	51,55,56,57
Schizachyrium scoparium	Little bluestem	2'-4'	Brown	Aug-Sep	F/P	Y	50,51,55,56,57
Sorghastrum nutans	Indian grass	4'-9'	Green	Aug-Sep	F	N	51,55,56,57
Spartina pectinata	Prairie cordgrass	6'-7'	Green	Jul-Aug	F	Y	50,51,55,56,57

Botanical Name	Common Name	Height	Color	Bloom Time	Sun	Salt Tolerant	Ecoregion
Stipa spartea	Porcupine grass	2'-4'	Green	Aug-Sep	F	Y	55,56,57
Forbs:							
Allium cernuum	Nodding wild onion	1'-2'	Lavender	Jun-Oct	F/P	N	55,56
Asclepias syriaca	Common milkweed	2'-4'	Pink	Jun-Aug	F/P	N	50,51,55,56,57
Asclepias tuberosa	Butterflyweed	1'-3'	Orange	Jun-Sep	F/P	Y	51,55,56,57
Asclepias verticillata	Whorled milkweed	1'-2'	White	Jun-Sep	F/P	N	51,55,56,57
Aster cordifolius	Heart-leaved aster	2'-4'	Blue/ White	Sep-Oct	P/S	N	55,56,57
Aster laevis	Smooth aster	3'-5'	Blue	Aug-Oct	F	Y	50,51,55,56,57
Aster oolentangiensis	Sky-blue aster	1'-4'	Blue	Jul-Nov	F/P	Y	55,56,57
Aster shortii	Short's aster	1'-4'	Blue	Aug-Oct	P/S	N	55,56
Cacalia atriplicifolia	Pale Indian plantain	3'-8'	White	Jun-Oct	F/P/S	N	55,56
Campanulaa americana	Tall bellflower	2'-6'	Blue	Jul-Nov	P/S	N	55,56,57
Clematis virginiana	Virgin's bower	9' long	White	Jul-Aug	F/P	N	50,51,55,56,57
Coreopsis lanceolata	Sand coreopsis	1'-2'	Yellow	May-Aug	F/P	N	50,51,55
Coreopsis palmata	Prairie coreopsis	1'-2'	Yellow	Jun-Aug	F/P	N	55
Coreopsis tripteris	Tall coreopsis	4'-8'	Yellow	Aug-Sep	F/P	N	55,56,57
Echinacea pallida	Purple coneflower	2'-5'	Lavender	May-Aug	F	N	55,56,57
Eryngium yuccifolium	Rattlesnake master	3'-5'	White	Jul-Sep	F	N	55
Eupatorium purpureum	Purple Joe-pye weed	3'-6'	Pink	Jul-Sep	P	N	55,56,57
Euphorbia corollata	Flowering spurge	2'-4'	White	May-Oct	F/P	N	51,55,56,57
Geranium maculatum	Wild geranium	1'-2'	Pink	Apr-Jul	F/P/S	N	55,56,57
Helianthus divaricatus	Woodland sunflower	2'-6'	Yellow	Jun-Sep	P/S	N	50,51,55,56,57
Helianthus occidentalis	Western sunflower	2'-4'	Yellow	Aug-Sep	F/P	N	50,51,55,56,57
Helianthus pauciflorus	Prairie sunflower	3'-5'	Yellow	Jul-Oct	F	N	50,55,56,57
Heliopsis helianthoides	False sunflower	4'-6'	Yellow	Jun-Oct	F/P	N	50,51,55,56,57
Lespedeza capitata	Round-headed bush clover	2'-4'	Green	Jul-Sep	F/P	N	55,56,57
Liatris aspera	Rough blazing star	2'-3'	Violet	Jul-Nov	F/P	Y	50,55,56,57
Liatris cylindracea	Cylindrical blazing star	1'-2'	Violet	Jul-Oct	F/P	N	51,55,56,57
Liatris scariosa	Savanna blazing star	3'-5'	Violet	Aug-Oct	F/P	N	50,51,55,56,57
Lupinus perennis	Wild lupine	1'-2'	Purple	Apr-Jun	F/P	N	55,56,57
Monarda fistulosa	Wild bergamot	2'-5'	Lavender	Jul-Sep	F/P	N	50,51,55,56,57
Penstemon digitalis	Foxglove beardtongue	2'-4'	White	May-Jul	F/P	N	50,51,55,56,57
Penstemon hirsutus	Hairy beardtongue	1'-2'	Purple	May-Jul	F/P	N	55,56,57
Phlox pilosa	Sand prairie phlox	1'-2'	Pink	May-Aug	F/P	N	56
Polygonatum biflorum	Solomon seal	1'-4'	Green/ White	May/Jul	P/S	N	55,56,57
Polygonatum pubescens	Downy Solomon seal	1'-3'	White	May-Jul	P/S	N	50,51,55,56,57
Ratibida pinnata	Yellow coneflower	3'-6'	Yellow	Jul-Oct	F	N	55,56
Rudbeckia hirta	Black-eyed Susan	1'-3'	Yellow	May-Oct	F/P	Y	50,51,55,56,57
Silphium terebinthinaceum	Prairie-dock	3'-8'	Yellow	Jun-Sep	F	N	55,56,57
Smilacina racemosa	Feathery false Solomon's seal	1'-3'	White	Apr-Jun	P/S	N	50,51,55,56,57
Smilacina stellata	Starry false Solomon's seal	1'-2'	White	Apr-Jun	F/P	N	50,51,55,56,57
Solidago caesia	Bluestem goldenrod	1'-2'	Yellow	Sep-Oct	P/S	N	51,55,56,57
Solidago juncea	Early goldenrod	2'-4'	Yellow	Jul-Sep	F/P	N	50,51,55,56,57
Solidago speciosa	Showy goldenrod	1'-3'	Yellow	Jul-Oct	F/P	Y	50,51,55,56,57
Tradescantia ohiensis	Spiderwort	2'-4'	Blue	May-Oct	F/P	N	55,56,57
Veronicastrum virginicum	Culver's root	3'-6'	White	Jun-Aug	F/P	N	55,56,57

Representative Zone F Species

Spiderwort

Butterfly Weed

Yellow Coneflower

Little Bluestem

Foxglove Beardtongue

Wild Lupine

Pale Purple Coneflower

Rattlesnake Master

Sand Coreopsis

Source: JFNew

Zone G

Planter Box Plantings

Although this manual typically recommends using native plants wherever possible, certain situations call for non-native plants due to particular site conditions. Because planter boxes traditionally have a short soil column and are exposed to drier conditions, non-native plants should be considered as long as they are considered non-invasive. Therefore, the list below contains both native and non-native species. Many planter boxes have traditionally used annual flowers. However, we recommend using perennial plants for establishing root systems and lowering maintenance in the long term. Many more species are available for planter boxes than are listed.

Botanical Name	Common Name	Height	Color	Bloom Time	Sun
Ajuga reptans 'Bronze Beauty'	Bronze Beauty Ajuga	6"	Blue	May-Jun	F
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	6"-1'	White	May-Jun	F
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	6"-1'	Blue	Jun-Jul	F
Allium senescens montanum	Mountain Garlic	6"-1'	Pink/Purple	Jun-Aug	F
Allium senescens glaucum	Curly Onion	6"-1'	Pink	Jul-Sep	F
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	6"-1'	Pink	Jul-Aug	F
Aster 'Wood's Light Blue'	Wood's Light Blue Aster	1'-3'	Blue	Aug-Sep	F
Athryium filix-femina	Lady Fern	1'-3'	Green	NA	F/P/S
Blechnum spicant	Deer Fern	1'-2'	Green	NA	F/P/S
Dryopteris erythrosora	Autumn Fern	1'-2'	Green	NA	F/P/S
Euphorbia myrsinites	Mytle Spurge	6"-1'	Yellow	May-Jun	F
Dryopteris intermedia	Fancy Fern	1'-3'	Green	NA	F/P/S
Dyropteris marginalis	Leatherleaf Fern	1'-2'	Green	NA	F/P/S
Geranium x 'Rozanne'	Rozanne Gernaium	1'-2'	Violet	Jun-Sep	F/P
Hemerocallis 'Barbara Mitchell'	Barbara Mitchell Daylily	2'-3'	Pink	Jun-Aug	F/P
Hemerocallis 'Bill Norris'	Bill Norris Daylily	2'-3'	Yellow	Jun-Aug	F/P
Hemerocallis 'Chicago Apache'	Chicago Apache Daylily	2'-3'	Red	Jul-Sep	F/P
Hosta 'Francee'	Francee Hosta	1'-2'	Lavender	Jul-Aug	F/P/S
Hosta 'Guacamole'	Guacamole Hosta	1'-2'	Pink	Aug-Sep	F/P/S
Hosta 'Summer Fragrance'	Summer Fragrance Hosta	1'-2'	Lavender	Aug-Sep	F/P/S
Hosta sieboldiana 'Elegans'	Elegans Hosta	1'-2'	White	Jul-Aug	F/P/S
Sedum 'Autumn Charm'	Autumn Charm Sedum	6"-1'	Pink	Jun-Jul	F
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	6"-1'	Pink	May-Jun	F
Sedum 'Mini Me'	Mini Me Sedum	6"-1'	Green	NA	F
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	6"-1'	Yellow	Jul-Sep	F
Sedum album 'Athoum'	Jelly Bean Sedum	6"-1'	Pink	Aug-Sep	F
Sedum album 'Coral Carpet'	Coral Carpet Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Faro Island'	Faro Island Sedum	6"-1'	White	Jun-Aug	F
Sedum album 'Green Ice'	Green Ice Sedum	6"-1'	White	Jun-Jul	F
Sedum album 'Murale'	Wall Sedum	6"-1'	White	Jun-Jul	F
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	6"-1'	Pink	Jul-Aug	F
Sedum divergens	Cascade Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum ellacombianum	Ellacombe's Sedum	6"-1'	Yellow	May-Jun	F
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	6"-1'	Yelow	May-Jun	F
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	6"-1'	Yellow	Jun-Jul	F
Sedum grisbachii	Griseback Sedum	6"-1'	Yellow	Jul-Aug	F
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	6"-1'	Yellow	Jun	F
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	6"-1'	Orange	Jul-Aug	F
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	6"-1'	Yellow	May-Jun	F

Representative Zone G Species

Guacamole Hosta

Mountain Garlic

Wall Sedum

Lady Fern

Source: JFNew

Zone H

Vegetated Roof Plantings

Research to-date shows that native plants do not typically thrive in vegetated roofs. Therefore, the list below reflects species that are known to thrive in green roof situations. All species listed below will generally grow to a height of six-to-18 inches.

Botanical Name	Common Name	Color	Bloom Time
Allium maximowiczii 'Alba'	White Flowered Ornamental Chive	White	May-Jun
Allium schoenoprasum 'Dwarf'	Dwarf Ornamental Chive	Pink	May-Jun
Allium schoenoprasum 'Glaucum'	Blue Flowered Ornamental Chive	Blue	Jun-Jul
Allium senescens montanum	Mountain Garlic	Pink/Purple	Jun-Aug
Allium senescens glaucum	Curly Onion	Pink	Jul-Sep
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	Pink	Jul-Aug
Euphorbia myrsinites	Mytle Spurge	Yellow	May-Jun
Sedum 'Autumn Charm'	Autumn Charm Sedum	Pink	Jun-Jul
Sedum 'Joyce Henderson'	Joyce Henderson Sedum	Pink	May-Jun
Sedum 'Mini Me'	Mini Me Sedum	Green	NA
Sedum acre 'Aureum'	Gold Leaved Goldmoss Sedum	Yellow	May-Jun
Sedum acre 'Oktoberfest'	Oktoberfest Sedum	Yellow	Jul-Sep
Sedum album 'Athoum'	Jelly Bean Sedum	Pink	Aug-Sep
Sedum album 'Coral Carpet'	Coral Carpet Sedum	White	Jun-Aug
Sedum album 'Faro Island'	Faro Island Sedum	White	Jun-Aug
Sedum album 'Green Ice'	Green Ice Sedum	White	Jun-Jul
Sedum album 'Murale'	Wall Sedum	White	Jun-Jul
Sedum album 'Red Ice'	Red Ice Sedum	White	Jun-Jul
Sedum cautacola 'Bertram Anderson'	Bertram Anderson Sedum	Pink	Jul-Aug
Sedum cauticola 'Sunset Cloud'	Sunset Cloud Sedum	Pink	Jul-Aug
Sedum divergens	Cascade Sedum	Yellow	Jun-Jul
Sedum ellacombianum	Ellacombe's Sedum	Yellow	May-Jun
Sedum ellacombianum 'Variegatum'	Variegated Ellacombe's Sedum	Yelow	May-Jun
Sedum floriferum 'Weihenstephaner Gold'	Weihenstephaner Gold Sedum	Yellow	Jun-Jul
Sedum grisbachii	Griseback Sedum	Yellow	Jul-Aug
Sedum hispanicum 'Pinkie'	Pinkie Sedum	Pink	Jun-Jul
Sedum hybridum 'Immergunchen'	Evergreen Sedum	Yellow	Jun, Sep
Sedum hybridum 'Tekaridake'	Tekaridake Kamtschatka Sedum	Yellow	Jun
Sedum kamtschaticum 'Variegatum'	Variegated Kamtschatka Sedum	Orange	Jul-Aug
Sedum middendorfianum var. diffusum	Diffuse Middendorf's Sedum	Yellow	May-Jun

*List provided by Hortech, Inc.

Representative Zone H Species

Mountain Garlic

Cascade Sedum

Ellacombe's Sedum

Wall Sedum

Source: JFNew

Appendix E
Recommended Materials

Recommended Materials

Numerous BMPs in this manual have similar material needs. These BMPs are listed in the table below. Detailed information on each material requirement follows. In addition, Porous Pavement and Vegetated Roofs have significant material requirements that are listed according to their individual needs.

	Constructed Filters	Dry Well	Infiltration Trench	Planter Boxes	Porous Pavement	Subsurface Infiltration	Vegetated Filter Strip	Vegetated Swale
Check dams							X	X
Non-Woven Geotextile	X	X	X	X	X	X	X	
Pea Gravel							X	
Peat	X			X				
Pervious Berms							X	
Pipe – 8”	X	X	X	X	X	X	X	
Sand	X			X				X
Stone/Gravel	X			X				
Stone – 30%							X	
Stone – 40%			X		X			

Check dams (Vegetated Filter Strip, Vegetated Swale)

An earthen check dam shall be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02 in to 0.04 in, Gravel: AASHTO M-43 0.5 in to 1.0 in). A stone check dam shall be constructed of R-4 rip rap, or equivalent.

Non-Woven Geotextile (Constructed Filter, Dry Well, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should consist of needled nonwoven polypropylene fibers and meet the following properties:

a. Grab Tensile Strength (ASTM-D4632) 120 lbs min.
b. Mullen Burst Strength (ASTM-D3786) 225 psi min.
c. Flow Rate (ASTM-D4491) 110 gal/min/ft2 min.
d. UV Resistance after 500 hrs (ASTM-D4355) 70% min.
e. Puncture strength (ASTM D-4833-00) 90 lb. min.
f. Apparent opening size (ASTM D-4751-99A) 60-70 US Sieve

Heat-set or heat-calendared fabrics are not permitted. Acceptable types include Mirafi 140N, Amoco 4547, Geotex 451, or approved others.

Pea Gravel (Vegetated Filter Strip)

Clean bank-run gravel may also be used and should meet ASTM D 448 and be sized as per No.6 or 1/8” to 3/8”.

Peat (Constructed Filter, Planter Boxes)

Should have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.

Pervious Berms (Vegetated Filter Strip)

The berm shall have a height of 6-12 in and be constructed of sand, gravel, and sandy loam to encourage grass cover. (Sand: ASTM C-33 fine aggregate concrete sand 0.02”-0.04”, Gravel: AASHTO M-43 ½” to 1”)

Pipe - (Dry Well, Porous Pavement, Subsurface Infiltration, Constructed Filter, Infiltration Trench, Planter Boxes, Vegetated Filter Strip)

Should be continuously perforated, smooth interior, with a minimum inside diameter as required. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or M294, Type S (12 gauge aluminum or pipe may also be used in seepage pits).

Sand (Constructed Filter, Planter Boxes, Vegetated Swale)

Should be ASTM-C-33 (or AASHTO M-6) size (0.02” – 0.04”), concrete sand, clean, medium to fine sand.

Stone/Gravel (Constructed Filter, Planter Boxes):

Should be uniformly graded coarse aggregate, 1 inch to ½ inch with a wash loss of no more than 0.5%, AASHTO size number 5 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and have voids of 40% as measured by ASTM-C29.

Stone – 40% voids (Infiltration Trench, Porous Pavement, Subsurface Infiltration Bed,)

Infiltration trenches should have stone 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids 40% as measured by ASTM-C29.

Porous Pavement

General

Choker base course aggregate for beds shall be 3/8 inch to 3/4 inch clean, uniformly-graded, coarse, crushed aggregate AASHTO size number 57 per Table 4, AASHTO Specifications, Part I, 19th Ed., 1998 (p. 47).

Porous Asphalt

Bituminous surface course for porous paving shall be 2.5 to 3 inches thick with a bituminous mix of 5.75% to 6.75% by total weight as determined by testing below. Use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of PG 76-22P (in northern Michigan, use PG 76-28P as appropriate) as specified in AASHTO MP-1. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Determination of optimal asphalt content should be determined according the following tests:

- Draindown Test (ASTM Method D6390)
- Moisture Susceptibility Test using the Modifed Lottman Method (AASHTO T283) with the following:
  - Compact using 50 gyrations of Superpave gyratory compactor
  - Apply partial vacuum of 26 inches of Hg for 10 minutes to whatever saturation is achieved.
  - Keep specimens submerged in water during freeze cycle.
  - Required retained tensile strength (TSR) >= 80%
- Air Voids Test (AASHTO T269/ASTM D3203)

Hydrated lime, if required, shall meet the requirements of AASHTO M 303 Type 1 and shall be blended with the damp aggregate at a rate of 1.0% by weight of the total dry aggregate. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

Fibers, if used, shall consist of either cellulose fibers or mineral fibers which are to be treated with a cationic sizing agent to enhance dispersement of the fiber as well as increase cohesion of the fiber to the bitumen. Fiber is to be added at a dosage rate between 0.2% and 0.4% by weight of total mix.

- Mineral fibers shall be from virgin, basalt, diabase, or slag with a maximum average fiber length of 6.35 mm and a maximum average fiber thickness of 0.005 mm.
- Cellulose fiber – Fiber length shall be 6.4 mm (max), Ash Content 18% non-volatiles (±5%), pH 7.5 (± 1), Oil absorption (times fiber weight) 5.0 (± 1), Moisture Content 5.0 (max).

Porous Concrete

The use of Installers or Craftsmen who have been certified by the NRMCA's Pervious Concrete Contractor Certification Program is strongly recommended. Contractor shall furnish a proposed mix design with all applicable information to the Engineer prior to commencement of work. Critical mix characteristics typically include the following:

- Cement Content: 550 to 650 lb/cy
- Fine aggregate, if used: maximum 3 cu. ft. per cu. yd.
- Admixtures: use in accordance with the manufacturer's instructions and recommendations
- An aggregate/cement (A/C) ratio: 4:1 to 4.5:1
- Water/cement (W/C) ratio: 0.27 to 0.34
- Curing: shall begin within 15 minutes after placement and continue for 7 days

The data shall include unit weights determined in accordance with ASTM C29 paragraph 11, jigging procedure.

Cement: Portland Cement Type II or V conforming to ASTM C150 or Portland Cement Type IP or IS conforming to ASTM C595. The total cementitious material shall be between 550 and 650 lb./cy.

Aggregate: Use No 8 coarse aggregate (3/8 to No. 16) per ASTM C33 or No. 89 coarse aggregate (3/8 to No. 50) per ASTM D 448. If other gradation of aggregate is to be used, submit data on proposed material to owner for approval. The volume of aggregate per cu. yd. shall be equal to 27 cu.ft. when calculated as a function of the unit weight determined in accordance with ASTM C 29 jigging procedure. Fine aggregate, if used, should not exceed 3 cu. ft. and shall be included in the total aggregate volume.

Air Entraining Agent: Shall comply with ASTM C 260 and shall be used to improve workability and resistance to freeze/thaw cycles.

Admixtures: The following admixtures shall be used:

- Type D Water Reducing/Retarding – ASTM C 494.
- A hydration stabilizer that also meets the requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding admixtures may be used. This stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles from achieving initial set.

Water: Potable shall be used and shall comply with ASTM C1602. Mix water shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (Mix water yielding a cement paste with a dull-dry appearance has insufficient water for hydration).

- Insufficient water results in inconsistency in the mix and poor bond strength.
- High water content results in the paste sealing the void system primarily at the bottom and poor surface bond.

An aggregate/cement (A/C) ratio range of 4:1 to 4.5:1 and a water/cement (W/C) ratio range of 0.27 to 0.34 should produce pervious pavement of satisfactory properties in regard to permeability, load carrying capacity, and durability characteristics.

Vegetated roofs

Some key components and associated performance-related properties are as follows:

Root-barriers should be thermoplastic membranes with a thickness of at least 30 mils. Thermoplastic sheets can be bonded using hot-air fusion methods, rendering the seams safe from root penetration. Membranes that have been certified for use as root-barriers are recommended. At present only FLL offers a recognized test for root-barriers. Several FLL-certified materials are available in the United States. Interested American manufactures can submit products for testing to FLL-certified labs.

Granular drainage media should be a non-carbonate mineral aggregate conforming to the following specifications:

- Saturated Hydraulic Conductivity >= 25 in/min
- Total Organic Matter, by Wet Combustion (MSA) <= 1%
- Abrasion Resistance (ASTM-C131-96) <= 25% loss
- Soundness (ASTM-C88 or T103 or T103-91) <= 5% loss
- Porosity (ASTM-C29) >= 25%
- Alkalinity, CaCO3 equivalents (MSA) <= 1 %
- Grain-Size Distribution (ASTM-C136)
  - Pct. Passing US#18 sieve <= 1%
  - Pct. Passing ¼-inch sieve <= 30%
  - Pct. Passing 3/8-inch sieve >= 80%

Growth media should be a soil-like mixture containing not more than 15% organic content (wet combustion or loss on ignition methods). The appropriate grain-size distribution is essential for achieving the proper moisture content, permeability, nutrient management, and non-capillary porosity, and 'soil' structure. The grain-size guidelines vary for single and dual media vegetated cover assemblies.

Non-capillary Pore Space at Field Capacity, 0.333 bar (TMECC 03.01, A)	>= 15% (vol)
Moisture Content at Field Capacity (TMECC 03.01, A)	>= 12% (vol)
Maximum Media Water Retention (FLL)	>= 30% (vol)
Alkalinity, Ca CO3 equivalents (MSA)	<= 2.5%
Total Organic Matter by Wet Combustion (MSA)	3-15% (dry wt.)
pH (RCSTP)	6.5-8.0
Soluble Salts (DTPA saturated media extraction)"(RCSTP)	<= 6 mmhos/cm
Cation exchange capacity (MSA)	>= 10 meq/100g
Saturated Hydraulic Conductivity for Single Media Assemblies (FLL)	>= 0.05 in/min
Saturated Hydraulic Conductivity for Dual Media Assemblies (FLL)	>= 0.30 in/min

Grain-size Distribution of the Mineral Fraction (ASTM-D422)

Single Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	<= 5%
Pct. Passing US#60 sieve	<= 10%
Pct. Passing US#18 sieve	5 - 50%
Pct. Passing 1/8-inch sieve	0 - 70%
Pct. Passing 3/8-inch sieve	75 -100%

Dual Media Assemblies:

Clay fraction (2 micron)	0
Pct. Passing US#200 sieve (i.e., silt fraction)	5-15%
Pct. Passing US#60 sieve	10-25%
Pct. Passing US#18 sieve	20 - 50%
Pct. Passing 1/8-inch sieve	55 - 95%
Pct. Passing 3/8-inch sieve	90 -100%

Macro- and micro-nutrients shall be incorporated in the formulation in initial proportions suitable for support the specified planting.

Separation fabric should be readily penetrated by roots, but provide a durable separation between the drainage and growth media layers (Only lightweight nonwoven geotextiles are recommended for this function.

- Unit Weight (ASTM-D3776) <= 4.25 oz/yd2
- Grab tensile (ASTM-D4632) <= 90 lb
- Mullen Burst Strength (ASTM-D4632) >= 135 lb/in
- Permittivity (ASTM-D4491) >= 2 per second

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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