MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

GREEN INFRASTRUCTURE

Standard Specifications and Plan Templates Report

OCTOBER 2016

MMSD
PARTNERS FOR A CLEANER ENVIRONMENT

FRESHCOAST 740
MILWAUKEE, WISCONSIN

TABLE OF CONTENTS

1.) INTRODUCTION

1.1 Introduction and Purpose

The Milwaukee Metropolitan Sewer District (District) has adopted its 2035 Vision that includes multiple objectives of zero basement backups, zero overflows, reduced water quantity, and improved water quality consistent with the Regional Green Infrastructure Plan. To help achieve these objectives, the District has initiated the Green Solutions program to provide financial incentive to District municipalities with the goal of implementing green infrastructure strategies throughout its service area. The District intends to use green infrastructure strategies to capture and manage the first 0.5 inches of rainfall that falls on impervious cover, with a long-term goal of providing approximately 740 million gallons of storage volume through the green infrastructure strategies.

The objective of the Green Infrastructure Standard Specifications and Plan Templates project is to develop simplified planning and design tools to promote more widespread implementation of green infrastructure strategies throughout the District's service area. This project was initiated at the request of the District's Technical Advisory Team (TAT) Green Infrastructure Subcommittee. The intent is for the simplified tools to be used initially by local municipalities served by the District to assist primarily with capturing and reducing the quantity of stormwater runoff, while also providing a secondary benefit of improving municipal stormwater management and water quality consistent with Total Maximum Daily Load (TMDL) objectives. These simplified tools can also be used to assist in meeting the District's 2035 Vision for zero basement backups, zero overflows, reduced water quantity, and improved water quality.

Effective implementation of green infrastructure strategies is predicated upon the successful execution of all three phases: planning, design, and construction/post-construction. As such, the Green Infrastructure Standard Specifications and Plan Templates project includes tools and materials to provide information and guidance on all three phases. For the planning phase, a spreadsheet-based green infrastructure sizing tool has been developed to allow the user to easily adjust variables that impact the sizing of green infrastructure strategies based on site-specific data. For the design phase, typical details and technical specifications have been generated for a variety of green infrastructure strategies that can be easily edited as needed by the user to accommodate specific designs. For the construction and post-construction phases, inspection and maintenance checklists have been created. These planning, design, and construction tools and materials have been either compiled or referenced into this Green Infrastructure Standard Specifications and Plan Templates report. The report is not intended to be an elaborate manual, but rather a streamlined and user-friendly document with specifications and plan templates (typical details) that can be adjusted to accommodate site-specific conditions. This report should be used as a reference document to supplement the green infrastructure sizing tool, typical details, and technical specifications. Information on a variety of green infrastructure strategies is provided in this report to further assist local municipalities during the planning and design phases of a green infrastructure project.

1.2 Spreadsheet-Based Green Infrastructure Sizing Tool

To assist local municipalities during the planning phase to select appropriate green infrastructure strategies and to provide initial sizing calculations, a spreadsheet-based green infrastructure sizing tool has been developed. The objective of the sizing tool is to provide local municipalities with a simplified user-friendly product that can easily be updated and adapted for specific projects. The sizing tool allows the user to easily adjust variables that impact the sizing of green infrastructure strategies based on site-specific data such as drainage area, percent imperviousness, soil characteristics, and side slopes.

The sizing tool also allows the user to adjust components of the green infrastructure design including depth of surface ponding, depth of amended soil, and depth of aggregate storage to accommodate site-specific conditions.

The spreadsheet-based tool has initially been developed to size green infrastructure strategies to manage the first 0.5 inches of rainfall that falls on impervious cover, regardless of the project location within either the combined sewer service area or the municipal separate storm sewer system (MS4) area. Green infrastructure sizing criteria can ultimately be tailored primarily around water quantity reduction criteria for locations within the combined sewer service area and within the MS4 area, while also considering water quality improvements for locations within the MS4 area. The sizing tool does not take the place of the District's Low Impact Development (LID) Quicksheet nor should it be used directly for compliance with the District's Chapter 13 regulations, although it may be useful indirectly for Chapter 13 compliance.

Figure 1.2-1 Green Infrastructure Sizing Tool Interface

The sizing tool has been initially developed for green infrastructure strategies whose footprints are primarily influenced by tributary drainage area including bioretention/bioswales, porous pavement, and rain gardens. Information on additional green infrastructure strategies, including stormwater trees, native landscaping, and soil amendments are also included. Individual tabs have been created for each specific green infrastructure strategy, which also include links to planning-level quantities, opinions of probable construction cost, standard specifications, and plan templates (typical details).

Preliminary opinions of probable construction cost included within the sizing tool can assist local municipalities with planning-level budgets for green infrastructure implementation. For each green infrastructure strategy included in the sizing tool, typical bid items are summarized with quantities calculated based on the size of the project. Standard unit costs are also provided for each of the items, but can be adjusted by local municipalities if necessary. The unit costs are based on current dollars (2016), and the sizing tool includes options for adjustable inflation rates in circumstances when construction may not occur for several years. Because of the planning-level nature of the sizing tool, contingencies are included with the opinion of probable construction cost until the design is advanced and all required bid items are included. Additionally, anticipated operation and maintenance costs are included for each green infrastructure strategy based on a percentage of the opinion of probable construction cost.

1.3 Summary of Green Infrastructure Strategies

Because of the District's goal of widespread implementation of sustainable stormwater management throughout its service area, a variety of green infrastructure strategies will need to be implemented to effectively capture and manage stormwater runoff from impervious surfaces. This Green Infrastructure Standard Specifications and Plan Templates report includes the following green infrastructure strategies:

- Bioretention/Bioswales
- Rain Gardens
- Porous Pavement
- Stormwater Trees
- Native Landscaping
- Soil Amendments

The report is structured so that each section that follows provides information for each of the six strategies listed above, including a brief description, site suitability considerations, design considerations, costs, plan templates/typical details, specifications, and inspection and maintenance.

2.) BIORETENTION/BIOSWALES

2.1 Description

Bioretention/bioswales are designed to promote stormwater storage, water quantity reduction through infiltration and evapotranspiration, peak flow rate reduction, and water quality improvement. Although comparable in nature to rain gardens, bioretention/bioswales are intended to capture stormwater runoff from larger drainage areas and include deeper layers of materials. Bioretention/bioswales consist of designed layers of surface water ponding, hardwood mulch, engineered soil media, pea gravel, aggregate or sand storage, and an underdrain constructed at nearly flat slopes which collectively provide storage and water quality improvement. Bioretention/bioswales also provide an added benefit of reducing total suspended solids (TSS) and removing other nutrients conveyed by stormwater runoff. This strategy is typically planted with native plants which serve to stabilize the surface to prevent erosion, promote absorption and evapotranspiration, and prevent engineered soil compaction through root growth.

Figure 2.1-1 Bioretention/Bioswale Example

2.2 Site Suitability Considerations

Table 2.2-1 summarizes site suitability considerations that should be evaluated or considered when planning and selecting a suitable location for a bioretention/bioswale system.

Table 2.2-1 Bioretention/Bioswales Site Suitability Considerations

SITE CONSIDERATION	VALUE / DESCRIPTION
Maximum Drainage Area	Less than 2 Acres
Maximum Impervious Drainage Area	Less than 2 Acres
Soil Hydrologic Group and Infiltration Rate	A (Underdrain Required if Infiltration Less than 3.6 in/hr) B, C, D (Underdrain Required)
Prohibited Adjacent Land Use	Construction, Unstable Landscaping, Agricultural
Construct within Right-of-Way	Yes
Construct Above Buried Utilities	No
Maximum Adjacent Site Slope	0.5 to 20 Percent
Maximum Longitudinal Slope	Less than 1 Percent
Distance from Wastewater Treatment	More than 50 Feet
Distance from Building Foundations	More than 10 Feet

Designers should review the Wisconsin Department of Natural Resources (WDNR) Conservation Practice Standards (CPS) section titled “Site Evaluation for Stormwater Infiltration (Section 1002)” for additional details related to green infrastructure strategy siting considerations.

2.3 Design Considerations

Table 2.3-1 summarizes design considerations that should be evaluated or considered when designing a bioretention/bioswale system. Refer to Appendix D for plant lists that can be considered for bioretention/bioswale green infrastructure strategies.

Table 2.3-1 Bioretention/Bioswales Design Considerations

DESIGN CONSIDERATION	VALUE / DESCRIPTION
Surface Area	Size to Provide Storage for the 0.5-Inch Rainfall Event Using Green Infrastructure Sizing Tool
Length to Width Ratio	2:1 (Suggested)
Ponding Area Side Slopes	Maximum of 2:1
Ponding Area Depth	Maximum of 12 Inches
Mulch Layer Depth	2 to 3 Inches
Engineered Soil Media Layer Depth	Minimum of 24 Inches
Pea Gravel Layer Depth	Maximum of 4 Inches (Required if Aggregate Storage Layer is Used)
Storage Layer Depth	Maximum of 48 Inches, Either Washed Aggregate or Sand
Sand/Soil Interface Depth	3 Inches, Required When Native Soil Infiltration Rate is Less than 3.6 in/hr
Ponding Drawdown Time	Maximum of 24 Hours
Total System Drawdown Time	Maximum of 72 Hours
Underdrain	Minimum 6-Inch-Diameter Perforated Pipe (Optional Control Orifice Can Be Added to Increase Detention Time, Sized to Meet Maximum Drawdown Times)
Overflow Structure	Required to Limit Maximum Ponding Depth
Pretreatment	Sediment Forebays, Vegetated Channels, or Filter Strips

Designers should review the WDNR CPS section titled “Bioretention for Infiltration (Section 1004)” for additional design considerations for bioretention/bioswale green infrastructure strategies.

2.4 Costs

2.4.a. Construction Costs

Construction costs are variable depending on the specific characteristics of the project including, but not limited to, location, existing surface features, adjacent surface improvements, the depths of the bioretention/bioswale layers, and surface area. Designers are encouraged to refer to the Green Infrastructure Sizing Calculator for a listing of typical items, quantities, and unit costs for bioretention/bioswale green infrastructure strategies to develop a planning-level opinion of probable construction cost. For bioretention/bioswale green infrastructure strategies utilizing the default design from the Green Infrastructure Sizing Calculator, the typical cost per square foot is between $\$35/ft^2$ and $\$55/ft^2$.

2.4.b. Operation and Maintenance Costs

Operation and maintenance (O&M) costs include the costs for weeding of the planting surface, watering, and general upkeep. Typical O&M activities are included in Appendix C. Replacement of major components, including engineered soil media and plantings, is not anticipated for

annual operation and maintenance of bioretention/bioswales. Based on a review of various sources of O&M cost data of green infrastructure strategies, the annual O&M cost for bioretention/bioswales is approximately 5 percent of the initial construction cost. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to get implemented.

2.4.c. Life Cycle Costs

Each green infrastructure strategy has an anticipated useful life, and this must be considered when performing a life cycle cost analysis. The useful lives of green infrastructure strategies are not as well established as traditional storm water features (i.e., piping). Consequently, a review of published values may yield differing results. Based on a review of various sources of life cycle cost data of green infrastructure strategies, the useful life expectancy for bioretention/bioswale green infrastructure strategies is approximately 20 years. After this time frame, major components may require complete replacement depending upon the magnitude of sediment buildup over a long-term duration, including the potential replacement of engineered soil media, aggregate storage layers, and plantings. Infiltration tests and geotechnical assessments of the engineered soil profile can help determine the potential magnitude of replacement at the end of the anticipated useful life. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to be implemented.

2.5 Plan Templates/Example Typical Details

Refer to Appendix A for plan templates/example typical details for bioretention/bioswale systems.

2.6 Specifications

Refer to Appendix B for specifications for bioretention/bioswale systems.

2.7 Inspection and Maintenance

Refer to Appendix C for an inspection and maintenance checklist for bioretention/bioswale systems.

3.) RAIN GARDENS

3.1 Description

Rain gardens are typically smaller-scale (less than 300 square feet), residential green infrastructure strategies that are designed to capture stormwater runoff and infiltrate it into native soil. Rain gardens are installed in a depression in the existing topography or creation of a small berm to impound runoff. The existing native soil can remain or can be amended with an engineered soil media to improve runoff capture and treatment and are generally designed to include vertical space for approximately 6 inches of water ponding. Rain gardens can be planted with native plants, ornamental plants, or grass.

Figure 3.1-1 Rain Garden Example

3.2 Site Suitability Considerations

Table 3.2-1 summarizes site suitability considerations that should be evaluated or considered when planning and selecting a suitable location for a rain garden.

Table 3.2-1 Rain Garden Site Suitability Considerations

SITE CONSIDERATION	VALUE / DESCRIPTION
Maximum Drainage Area	Limited to Smaller-Scale Drainage Areas (Such as Residential Settings), and Limited to a Maximum Impervious Drainage Area of Approximately 4,000 ft^2
Maximum Impervious Drainage Area	Approximately 4,000 ft^2
Soil Hydrologic Group and Infiltration Rate	Any Soil Group (Better Drainage in A and B Soils)
Prohibited Adjacent Land Use	Erodible Soils, Construction, Unstable Landscaping
Construct within Right-of-Way	No
Construct Above Buried Utilities	No
Maximum Adjacent Site Slope	Less than 20 Percent
Maximum Longitudinal Slope	Less than 12 Percent
Distance from Wastewater Treatment	More than 50 Feet
Distance from Building Foundations	More than 10 Feet

Designers should review the WDNR CPS section titled “Site Evaluation for Stormwater Infiltration (Section 1002)” for additional details related to green infrastructure strategy siting considerations.

3.3 Design Considerations

Table 3.3-1 summarizes design considerations that should be evaluated or considered when designing a rain garden. Refer to Appendix D for plant lists that can be considered for rain gardens.

Table 3.3-1 Rain Garden Design Considerations

DESIGN CONSIDERATION	VALUE / DESCRIPTION
Surface Area	Maximum of 300 ft^2 (Size to Provide Storage for the 0.5-Inch Rainfall Event Using Green Infrastructure Sizing Tool)
Length to Width Ratio	2:1 to 3:1
Ponding Area Side Slopes	Maximum of 1:1
Ponding Area Depth	Maximum of 8 Inches
Mulch Layer Depth	2 Inches
Engineered Soil Media Layer Depth	6 Inches (Recommended, Not Required)
Ponding Drawdown Time	Maximum of 6 Hours
Total System Drawdown Time	Maximum of 18 Hours
Underdrain	Not Required
Pretreatment	Not Required

Designers should review the WDNR "Rain Garden: How to for Homeowners" manual for additional design considerations for rain garden strategies.

The composition of the engineered soil media layer, if used, shall be consistent with the engineered soil media requirements included in the bioretention/bioswale specifications.

3.4 Costs

3.4.a. Construction Costs

Construction costs are variable depending on the specific characteristics of the project including, but not limited to, location, existing surface features, adjacent surface improvements, the use of engineered soil, and surface area. Designers are encouraged to refer to the Green Infrastructure Sizing Calculator for a listing of typical items, quantities, and unit costs for rain garden green infrastructure strategies to develop a planning-level opinion of probable construction cost. For rain garden green infrastructure strategies using the default design from the Green Infrastructure Sizing Calculator, the typical cost per square foot is between \$12/ft^2 and \$25/ft^2.

3.4.b. Operation and Maintenance Costs

O&M costs are highly dependent on the surface treatment (i.e., native plantings or grass) provided for the rain garden green infrastructure strategy. If the surface is planted in grass, there are no additional O&M cost beyond the current costs of mowing. If the surface is planted with native or ornamental plants, O&M includes the costs for weeding of the planting surface, watering, and general upkeep. Typical O&M activities are included in Appendix C. Replacement of major components, including engineered soil media and plantings, is not anticipated for annual operation and maintenance of rain gardens. Based on a review of various sources of O&M cost data of green infrastructure strategies, the annual O&M cost for rain gardens is approximately 5 percent of the initial construction cost. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to get implemented.

3.4.c. Life Cycle Costs

Each green infrastructure strategy has an anticipated useful life, and this must be considered when performing a life cycle cost analysis. The useful lives of green infrastructure strategies are not as well established as traditional storm water features (i.e., piping). Consequently, a review of published values may yield differing results. Based on a review of various sources of life cycle cost data of green infrastructure strategies, the useful life expectancy for rain garden green infrastructure strategies is approximately 20 years. After this time frame, major components may require complete replacement depending upon the magnitude of sediment buildup over a long-term duration, including the potential replacement of engineered soil media and plantings. Infiltration tests and geotechnical assessments of the engineered soil profile can help determine the potential magnitude of replacement at the end of the anticipated useful life. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to get implemented.

3.5 Plan Templates/Example Typical Details

Refer to Appendix A for plan templates/example typical details for rain gardens.

3.6 Specifications

Refer to Appendix B for specifications for rain gardens.

3.7 Inspection and Maintenance

Refer to Appendix C for an inspection and maintenance checklist for rain gardens.

4.) POROUS PAVEMENT

4.1 Description

Porous pavements are designed to infiltrate stormwater runoff through the pavement. The porous pavements are generally constructed on gently sloping or flat grades. Stormwater runoff flows onto the surface and permeates through the pavement either through voids in the material in the case of pervious concrete or porous asphalt or through the joints between the blocks in the case of permeable pavers. The runoff is then stored in the aggregate storage layer below the pavement surface. The stored runoff infiltrates into the soil below or is conveyed out of the system to a downstream storm sewer system. Porous pavements can be constructed in private parking areas, alleys, or public roads, though it is not typically recommended for heavily traveled roads.

Figure 4.1-1 Porous Pavement Example

4.2 Site Suitability Considerations

Table 4.2-1 summarizes site suitability considerations that should be evaluated or considered when planning and selecting a suitable location for porous pavement.

Table 4.2-1 Porous Pavement Site Suitability Considerations

SITE CONSIDERATION	VALUE / DESCRIPTION
Maximum Drainage Area	N/A
Maximum Impervious Drainage Area	N/A
Soil Hydrologic Group and Infiltration Rate	A (Underdrain Required if Infiltration Less than 3.6 in/hr) B, C, D (Underdrain Required)
Prohibited Adjacent Land Use	Industrial Storage and Loading, Fueling, Construction, Agricultural, Unstable Landscaping
Construct within Right-of-Way	Yes
Construct Above Buried Utilities	Yes
Maximum Adjacent Site Slope	N/A
Maximum Longitudinal Slope	2 Percent (Subgrade)
Distance from Wastewater Treatment	More than 50 Feet
Distance from Building Foundations	More than 10 Feet

Designers should review the WDNR CPS section titled “Site Evaluation for Stormwater Infiltration (Section 1002)” for additional details related to green infrastructure strategy siting considerations.

4.3 Design Considerations

Table 4.3-1 summarizes design considerations that should be evaluated or considered when designing porous pavement.

Table 4.3-1 Porous Pavement Design Considerations

DESIGN CONSIDERATION	VALUE / DESCRIPTION
Surface Area	Size to Provide Storage for the 0.5-Inch Rainfall Event From Tributary Impervious Surface Utilizing Sizing Calculator
Length to Width Ratio	2:1 to 3:1
Pavement Surface	Consists of Either Pervious Concrete, Porous Asphalt, Permeable Interlocking Pavers, or Permeable Blocks
Pavement Surface Joints	Joints Between Permeable Interlocking Pavers and Permeable Blocks Shall Be Either Filled with Aggregate or Remain Open
Bedding Layer	Required for Permeable Interlocking Pavers and Permeable Blocks
Bedding Layer Depth	Minimum of 5 Inches for Combined Bedding Layer and Joint Fill Depth
Base Course Layer	Required for Permeable Interlocking Pavers
Base Course Layer Depth	4 Inches
Storage Layer	Washed Aggregate with Minimum 30% Porosity and Less Than 5% Passing No. 200 Sieve
Storage Layer Depth	Minimum 12 Inches
Underdrain	Minimum 4-Inch Diameter Perforated Pipe (Optional Control Orifice Can Be Added to Increase Detention Time, Sized to Meet Maximum Drawdown Times)
Total System Drawdown Time	Maximum of 72 Hours

Designers should review the WDNR CPS section titled “Permeable Pavement (Section 1008)” for additional design considerations for porous pavement green infrastructure strategies.

4.4 Costs

4.4.a. Construction Costs

Construction costs are variable depending on the specific characteristics of the project including, but not limited to, location, type of porous pavement (pervious concrete, porous asphalt, permeable interlocking pavers, or permeable blocks), the depths of the porous pavement layers, and surface area. Designers are encouraged to refer to the Green Infrastructure Sizing Calculator for a listing of typical items, quantities, and unit costs for porous pavement green infrastructure strategies to develop a planning-level opinion of probable construction cost. For porous pavement green infrastructure strategies using the default design from the Green Infrastructure Sizing Calculator, the typical cost per square foot is between $\$16/ft^2$ and $\$27/ft^2$.

4.4.b. Operation and Maintenance Costs

O&M costs include the costs for vacuuming particulate buildup from void spaces, replacement of joint fill, and general upkeep. Typical O&M activities are included in Appendix C. Based on a review of various sources of O&M cost data of green infrastructure strategies, the annual O&M cost for porous pavement is approximately 4 percent of the initial construction cost. Local

municipalities should review the suggested value and compare it with their own experience and data as projects continue to get implemented.

4.4.c. Life Cycle Costs

Each green infrastructure strategy has an anticipated useful life, and this must be considered when performing a life cycle cost analysis. The useful lives of green infrastructure strategies are not as well established as traditional storm water features (i.e., piping). Consequently, a review of published values may yield differing results. Based on a review of various sources of life cycle cost data of green infrastructure strategies, the useful life expectancy for porous pavement green infrastructure strategies is approximately 20 years for pervious concrete and porous asphalt, and approximately 35 years for permeable pavers. After this time frame, major components may require complete replacement depending upon the magnitude of sediment buildup over a long-term duration, including the potential replacement of the permeable pavement surface and underlying aggregate system. Infiltration tests and geotechnical assessments of the porous pavement profile can help determine the potential magnitude of replacement at the end of the anticipated useful life. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to be implemented.

4.5 Plan Templates/Example Typical Details

Refer to Appendix A for plan templates/example typical details for porous pavement.

4.6 Specifications

Refer to Appendix B for specifications for porous pavement.

4.7 Inspection and Maintenance

Refer to Appendix C for an inspection and maintenance checklist for porous pavement.

5.) STORMWATER TREES

5.1 Description

Stormwater trees allow for stormwater runoff to infiltrate into the adjacent soil, soak up soil moisture through roots, keep rain water on the leaves, and evapotranspirate water back into the atmosphere. This reduces peak flows from stormwater runoff and provides for some storage. Stormwater trees can be used in conjunction with other green infrastructure strategies to increase benefits such as planting in engineered soil media and combining with an aggregate storage layer and underdrain system.

Figure 5.1-1 Stormwater Tree Example

5.2 Site Suitability Considerations

Table 5.2-1 summarizes site suitability considerations that should be evaluated or considered when planning and selecting a suitable location for a stormwater tree.

Table 5.2-1 Stormwater Tree Site Suitability Considerations

SITE CONSIDERATION	VALUE / DESCRIPTION
Maximum Drainage Area	N/A
Maximum Impervious Drainage Area	N/A
Soil Hydrologic Group and Infiltration Rate	Suitable for proposed tree
Prohibited Adjacent Land Use	N/A
Construct within Right-of-Way	Yes
Construct Above Buried Utilities	No
Maximum Adjacent Site Slope	Do not install in depressed location unless used in conjunction with other green infrastructure strategies that include adequate drainage (i.e., underdrain system).
Maximum Longitudinal Slope	N/A
Distance from Wastewater Treatment	More than 50 Feet
Distance from Building Foundations	More than 20 Feet

Designers should review the WDNR CPS section titled “Site Evaluation for Stormwater Infiltration (Section 1002)” for additional details related to green infrastructure strategy siting considerations.

5.3 Design Considerations

Table 5.3-1 summarizes design considerations that should be evaluated or considered when designing a stormwater tree. Refer to Appendix D for tree species that can be considered for the purposes of improving water quality.

Table 5.3-1 Stormwater Tree Design Considerations

DESIGN CONSIDERATION	VALUE / DESCRIPTION
Surface Area	Assumed to have a 10-foot canopy radius with 50 percent over impervious surface. Tree is assumed to manage runoff from impervious surface equal to half the area of tree canopy.
Ponding Area Depth	Maximum of 12 Inches (If Placed in a Depressed Area)
Mulch Layer Depth	2 to 4 Inches
Engineered Soil Media Layer Depth	Minimum of 24 Inches
Pretreatment	Not Required

5.4 Costs

5.4.a. Construction Costs

Construction costs are variable depending on the specific characteristics of the project including, but not limited to, location, existing surface features, adjacent surface improvements, backfill material, use of a concrete containment wall, and the species and size of tree planted. Designers are encouraged to refer to the Green Infrastructure Sizing Calculator for a listing of typical items, quantities, and unit costs for stormwater tree green infrastructure strategies to develop a planning-level opinion of probable construction cost. For stormwater tree green infrastructure strategies using the default design from the Green Infrastructure Sizing Calculator without concrete containment, the typical cost per stormwater tree is approximately $500. Stormwater tree green infrastructure strategies that use concrete containment walls and a layer profile similar to that of bioretention/bioswale green infrastructure strategies will have significantly higher costs and be highly dependent on the surface area of the feature.

5.4.b. Operation and Maintenance Costs

O&M costs include the costs for weeding of the planting surface, watering, pruning, and general upkeep. Typical O&M activities are included in Appendix C. Based on a review of various sources of O&M cost data of green infrastructure strategies, the annual O&M cost for stormwater trees is approximately 10 percent of the initial construction cost. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to get implemented.

5.4.c. Life Cycle Costs

Each green infrastructure strategy has an anticipated useful life, and this must be considered when performing a life cycle cost analysis. The useful lives of green infrastructure strategies are not as well established as traditional storm water features (i.e., piping). Consequently, a review of published values may yield differing results. Based on a review of various sources of life cycle cost data of green infrastructure strategies, the useful life expectancy for the engineered soil used with a stormwater tree is approximately 20 years, while the stormwater tree itself could have a life expectancy between 50 and 100 years. After this time frame, major components may require complete replacement depending upon the magnitude of sediment buildup over a long-term duration, including the potential replacement of engineered soil media. Infiltration tests and geotechnical assessments of the engineered soil profile can help determine the potential magnitude of replacement at the end of the anticipated useful life. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to be implemented.

5.5 Plan Templates/Example Typical Details

Refer to Appendix A for plan templates/example typical details for stormwater trees.

5.6 Specifications

Refer to Appendix B for specifications for stormwater trees.

5.7 Inspection and Maintenance

Refer to Appendix C for an inspection and maintenance checklist for stormwater trees.

6.) NATIVE LANDSCAPING

6.1 Description

Native landscaping is the practice of replacing turf grass with more native or ornamental plantings to help reduce stormwater runoff and promote infiltration. Plant root systems, which are deeper than grass from native plants, limits soil compaction and creates channels for runoff to infiltrate into the ground. They also absorb groundwater through the root system and decrease the velocity of stormwater runoff by creating greater impedance to the flow. A secondary benefit of native landscaping is the creation of habitat and food sources for wildlife. Native landscaping is typically employed in residential areas, but can also be applied in other settings such as public right-of-way.

Figure 6.1-1 Native Landscaping Example

6.2 Site Suitability Considerations

Table 6.2-1 summarizes site suitability considerations that should be evaluated or considered when planning and selecting a suitable location for native landscaping.

Table 6.2-1 Native Landscaping Site Suitability Considerations

SITE CONSIDERATION	VALUE / DESCRIPTION
Maximum Drainage Area	N/A
Maximum Impervious Drainage Area	N/A
Soil Hydrologic Group and Infiltration Rate	Suitable for proposed plants
Prohibited Adjacent Land Use	Suitable for proposed plants
Construct within Right-of-Way	Yes
Construct Above Buried Utilities	Varies depending on planting root depth
Maximum Adjacent Site Slope	N/A
Maximum Longitudinal Slope	N/A
Distance from Wastewater Treatment	More than 50 Feet
Distance from Building Foundations	N/A

Designers should review the WDNR CPS section titled “Site Evaluation for Stormwater Infiltration (Section 1002)” for additional details related to green infrastructure strategy siting considerations.

6.3 Design Considerations

Table 6.3-1 summarizes design considerations that should be evaluated or considered when designing native landscaping. Refer to Appendix D for plant lists that can be considered for native landscaping.

Table 6.3-1 Native Landscaping Design Considerations

DESIGN CONSIDERATION	VALUE / DESCRIPTION
Surface Area	Varies. Assume storage of 0.4 gallons/ft^2 of native landscape.
Mulch Layer Depth	2 Inches
Engineered Soil Media Layer	Varies based on plant requirements
Underdrain	Not Required
Pretreatment	Not Required

6.4 Costs

6.4.a. Construction Costs

Construction costs are variable depending on the specific characteristics of the project including, but not limited to, location, existing surface features, adjacent surface improvements, backfill material, surface area, and especially the type of plant. Designers are encouraged to refer to the Green Infrastructure Sizing Calculator for a listing of typical items, quantities, and unit costs for native landscaping green infrastructure strategies to develop a planning-level opinion of probable construction cost. For native landscaping green infrastructure strategies using the default design from the Green Infrastructure Sizing Calculator, the typical cost per square foot is approximately \$5/ft^2.

6.4.b. Operation and Maintenance Costs

O&M costs include the costs for weeding of the planting surface, watering, pruning, and general upkeep. Typical O&M activities are included in Appendix C. Based on a review of various sources of O&M cost data of green infrastructure strategies, the annual O&M cost for native landscaping is not well documented, but is assumed to be comparable to rain garden strategies. Therefore, the annual O&M cost is approximately 5 percent of the initial construction cost. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to be implemented.

6.4.c. Life Cycle Costs

Each green infrastructure strategy has an anticipated useful life, and this must be considered when performing a life cycle cost analysis. The useful lives of green infrastructure strategies are not as well established as traditional storm water features (i.e., piping). Consequently, a review of published values may yield differing results. Based on a review of various sources of life cycle cost data of green infrastructure strategies, the useful life expectancy for native landscaping is approximately 20 years. After this time frame, major components may require complete replacement depending upon the magnitude of sediment buildup over a long-term duration, including the potential replacement of engineered soil media and plantings. Infiltration tests and geotechnical assessments of the engineered soil profile can help determine the potential magnitude of replacement at the end of the anticipated useful life. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to be implemented.

6.5 Plan Templates/Example Typical Details

Refer to Appendix A for plan templates/example typical details for native landscaping.

6.6 Specifications

Refer to Appendix B for specifications for native landscaping.

6.7 Inspection and Maintenance

Refer to Appendix C for an inspection and maintenance checklist for native landscaping.

7.) SOIL AMENDMENTS

7.1 Description

Soil amendment is the procedure of altering the composition of the existing soil through a variety of techniques. Amendments can be achieved by mixing materials such as mulch, compost, or sand into the existing soil to enhance the stormwater holding capacity, infiltration rate, and vegetation carrying capacity. Aeration is another method of soil amendment which can encourage infiltration. Soil amendments can be applied in almost any location there is existing soil, but is more beneficial in areas where runoff is currently flowing or ponding.

7.2 Site Suitability Considerations

Table 7.2-1 summarizes site suitability considerations that should be evaluated or considered when planning and selecting a suitable location for soil amendments.

Table 7.2-1 Soil Amendments Site Suitability Considerations

SITE CONSIDERATION	VALUE / DESCRIPTION
Maximum Drainage Area	N/A
Maximum Impervious Drainage Area	N/A
Soil Hydrologic Group and Infiltration Rate	Typically B, C, and D
Prohibited Adjacent Land Use	N/A
Construct within Right-of-Way	Yes
Construct Above Buried Utilities	Yes
Maximum Adjacent Site Slope	N/A
Maximum Longitudinal Slope	N/A
Distance from Wastewater Treatment	N/A
Distance from Building Foundations	N/A

Designers should review the WDNR CPS section titled “Site Evaluation for Stormwater Infiltration (Section 1002)” for additional details related to green infrastructure strategy siting considerations.

7.3 Design Considerations

Table 7.3-1 summarizes design considerations that should be evaluated or considered when designing soil amendments.

Table 7.3-1 Soil Amendments Design Considerations

DESIGN CONSIDERATION	VALUE / DESCRIPTION
Surface Area	Varies. Assume storage of 0.2 gallons/ft^2 of soil amendment
Engineered Soil Media Layer	Varies based on site constraints
Underdrain	Not Required
Pretreatment	Required for the specific BMP with which soil amendments are applied

7.4 Costs

7.4.a. Construction Costs

Construction costs are variable depending on the specific characteristics of the project including, but not limited to, location, existing surface features, adjacent surface improvements, mixing material, surface area, and surface treatment. Designers are encouraged to refer to the Green Infrastructure Sizing Calculator for a listing of typical items, quantities, and unit costs for soil amendment green infrastructure strategies to develop a planning-level opinion of probable construction cost. For soil amendment green infrastructure strategies utilizing the default design from the Green Infrastructure Sizing Calculator, the typical cost per square foot is approximately $\$2/ft^2$.

7.4.b. Operation and Maintenance Costs

O&M costs are dependent on the surface treatment atop the soil amendment green infrastructure strategy. If the surface is planted in grass there are no additional annual O&M costs beyond the current costs of mowing. If the surface is planted with native or ornamental plants, annual O&M includes the costs for weeding of the planting surface, watering, and general upkeep. Typical O&M activities are included in Appendix C. Based on a review of various sources of O&M cost data of green infrastructure strategies, the annual O&M cost for soil amendments is not well documented, but is assumed to be lower than rain garden strategies. Therefore, the annual O&M cost is approximately 3 percent of the initial construction cost. Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to get implemented.

7.4.c. Life Cycle Costs

Each green infrastructure strategy has an anticipated useful life, and this must be considered when performing a life cycle cost analysis. The useful lives of green infrastructure strategies are not as well established as traditional storm water features (i.e., piping). Consequently, a review of published values may yield differing results. Based on a review of various sources of life cycle cost data of green infrastructure strategies, the useful life expectancy for soil amendments is limited but assumed to be approximately 50 years (comparable to vegetated filter strip strategies). Local municipalities should review the suggested value and compare it with their own experience and data as projects continue to get implemented.

7.5 Plan Templates/Example Typical Details

Refer to Appendix A for plan templates/example typical details for soil amendments.

7.6 Specifications

Refer to Appendix B for specifications for soil amendments.

7.7 Inspection and Maintenance

Refer to Appendix C for an inspection and maintenance checklist for soil amendments.

8.) TMDL Considerations

Because of water quality impairments in the Milwaukee River basin, the United States Environmental Protection Agency (USEPA) Region 5 has recently developed a draft report titled *Total Maximum Daily Loads for Total Phosphorous, Total Suspended Solids, and Fecal Coliform in Milwaukee River Basin, Wisconsin* (July 21, 2016). The draft TMDL requires specific loading reductions for these pollutants of concern for both non-point and point sources of stormwater runoff, with the objective of improving water quality by limiting the pollutant loading.

Stormwater runoff generated within municipal separate storm sewer systems (MS4s) typically contains some of the pollutants that are being regulated by the draft TMDL including total phosphorous (TP) and total suspended solids (TSS). As a result, one of the point sources regulated through the TMDL program includes discharges from MS4 communities. The draft TMDL includes pollutant loading reduction targets for three major waterbodies in the Milwaukee River basin, including the Milwaukee River, the Menomonee River, and the Kinnickinnic River. A variety of municipalities or MS4 communities are included in the draft TMDL, and specific pollutant loading reduction targets have been established on stream reaches within each of their respective jurisdictions. Table 9.1 lists all of the municipalities within the District service area that have been assigned specific pollutant loading reductions within their respective jurisdictions. This information was extracted from the following locations in the draft TMDL:

- Appendix A–Table A.29 (MI)–Required Percent Reduction of MS4 TP and TSS by Municipality–Draft, 7/19/2016 (Page 90-91 of 92)
- Appendix A–Table A.29 (MN)–Required Percent Reduction of MS4 TP and TSS by Municipality–Draft, 7/19/2016 (Page 57-58 of 59)
- Appendix A–Table A.29 (KK)–Required Percent Reduction of MS4 TP and TSS by Municipality–Draft, 7/19/2016 (Page 35 of 36)

Table 9.1 TMDL Percent Reduction Targets for Municipalities in District Service Area

Municipality	River	Reach	Area (acres)	Average TP % Reduction	Average TSS % Reduction
Bayside, Village	Milwaukee	MI-30	245	73%	57%
Brookfield, City	Menomonee	MN-08	2,540	53%	62%
	Menomonee	MN-10	555	23%	59%
	Menomonee	MN-11	4,172	58%	65%
	Menomonee	MN-12	526	73%	75%
	Menomonee	MN-13	831	66%	71%
Brookfield, Town	Menomonee	MN-11	113	58%	65%
Brown Deer, Village	Milwaukee	MI-27	373	48%	66%
	Milwaukee	MI-28	1,222	87%	66%
	Milwaukee	MI-29	1,066	86%	64%
	Milwaukee	MI-31	160	84%	64%
Butler, Village	Menomonee	MN-06	58	65%	67%
	Menomonee	MN-08	13	53%	62%
	Menomonee	MN-10	446	23%	59%
Cudahy, City	Kinnickinnic	KK-4	953	88%	80%
Elm Grove, Village	Menomonee	MN-11	435	58%	65%
	Menomonee	MN-12	1,649	73%	75%

Municipality	River	Reach	Area (acres)	Average TP % Reduction	Average TSS % Reduction
Elm Grove, Village	Menomonee	MN-13	15	66%	71%
Fox Point, Village	Milwaukee	MI-27	73	48%	66%
	Milwaukee	MI-30	959	73%	57%
Germantown, Village	Milwaukee	MI-21	3,279	75%	76%
	Menomonee	MN-01	11,578	59%	58%
	Menomonee	MN-02	1,119	41%	54%
Germantown, Village	Menomonee	MN-03	1,664	55%	57%
	Menomonee	MN-04	2,149	45%	55%
	Menomonee	MN-05	1,909	69%	63%
	Menomonee	MN-06	134	65%	67%
	Menomonee	MN-09	249	60%	63%
Glendale, City	Milwaukee	MI-27	2,737	48%	66%
	Milwaukee	MI-30	121	73%	57%
	Milwaukee	MI-31	430	84%	64%
	Milwaukee	MI-32	492	14%	48%
Greendale, Village	Menomonee	MN-15	73	63%	67%
Greenfield, City	Menomonee	MN-15	1,840	63%	67%
	Kinnickinnic	KK-1	108	64%	73%
	Kinnickinnic	KK-2	111	64%	72%
	Kinnickinnic	KK-4	649	88%	80%
	Kinnickinnic	KK-6	556	65%	72%
Menomonee Falls, Village	Menomonee	MN-01	2,170	59%	58%
	Menomonee	MN-04	539	45%	55%
	Menomonee	MN-05	376	69%	63%
	Menomonee	MN-06	4,031	65%	67%
	Menomonee	MN-07	3,640	60%	63%
	Menomonee	MN-08	1,070	53%	62%
	Menomonee	MN-10	13	23%	59%
Mequon, City	Milwaukee	MI-21	41	75%	76%
	Milwaukee	MI-24	524	77%	67%
	Milwaukee	MI-25	8,821	36%	77%
	Milwaukee	MI-26	5,328	87%	88%
	Milwaukee	MI-27	5,397	48%	66%
	Milwaukee	MI-28	28	87%	66%
	Menomonee	MN-01	547	59%	58%
	Menomonee	MN-05	420	69%	63%
	Menomonee	MN-06	92	65%	67%
	Menomonee	MN-09	6,399	60%	63%

Municipality	River	Reach	Area (acres)	Average TP % Reduction	Average TSS % Reduction
Milwaukee, City	Milwaukee	MI-27	1,162	48%	66%
	Milwaukee	MI-28	924	87%	66%
	Milwaukee	MI-29	771	86%	64%
	Milwaukee	MI-31	12,084	84%	64%
	Milwaukee	MI-32	901	14%	48%
	Menomonee	MN-06	2,124	65%	67%
	Menomonee	MN-09	7,305	60%	63%
	Menomonee	MN-10	2,501	23%	59%
	Menomonee	MN-12	53	73%	75%
	Menomonee	MN-13	198	66%	71%
	Menomonee	MN-14	67	43%	56%
	Menomonee	MN-15	2,185	63%	67%
	Menomonee	MN-16	2,002	43%	65%
	Kinnickinnic	KK-1	745	64%	73%
	Kinnickinnic	KK-2	1,218	64%	72%
	Kinnickinnic	KK-3	60	76%	71%
	Kinnickinnic	KK-4	3,671	88%	80%
	Kinnickinnic	KK-5	1,099	76%	75%
	Kinnickinnic	KK-6	59	65%	72%
	Kinnickinnic	KK-7	2,536	38%	69%
New Berlin, City	Menomonee	MN-13	431	66%	71%
River Hills, Village	Milwaukee	MI-27	2,044	48%	66%
	Milwaukee	MI-29	30	86%	64%
	Milwaukee	MI-30	660	73%	57%
Shorewood, Village	Milwaukee	MI-32	461	14%	48%
St. Francis, City	Kinnickinnic	KK-4	66	88%	80%
Thiensville, Village	Milwaukee	MI-25	196	36%	77%
	Milwaukee	MI-26	417	87%	88%
	Milwaukee	MI-27	67	48%	66%
Wauwatosa, City	Menomonee	MN-10	2,236	23%	59%
	Menomonee	MN-12	2,445	73%	75%
	Menomonee	MN-13	101	66%	71%
	Menomonee	MN-14	705	43%	56%
	Menomonee	MN-15	150	63%	67%
	Menomonee	MN-16	2,827	43%	65%
West Allis, City	Menomonee	MN-13	1,766	66%	71%
	Menomonee	MN-15	2,258	63%	67%
	Menomonee	MN-16	316	43%	65%
	Kinnickinnic	KK-2	340	64%	72%
	Kinnickinnic	KK-3	734	76%	71%

Municipality	River	Reach	Area (acres)	Average TP % Reduction	Average TSS % Reduction
West Milwaukee, Village	Menomonee	MN-16	413	43%	65%
	Kinnickinnic	KK-3	304	76%	71%
Whitefish Bay, Village	Milwaukee	MI-27	68	48%	66%
	Milwaukee	MI-32	414	14%	48%
Maximum				**88%**	**88%**
Minimum				**14%**	**48%**
Average				**61%**	**66%**

Note: Several municipalities within the District's service area are not included in the draft TMDL, including Caledonia, Franklin, Oak Creek, Hales Corners, and Muskego.

As noted above, the average TP reduction for municipalities within the District's service area is approximately 61 percent, while the average TSS reduction for municipalities within the District's service area is approximately 66 percent. Although the main objective of the Green Solutions Program is to implement green infrastructure strategies throughout the District service area consistent with the goals of the 2035 Vision, green infrastructure can also be implemented to improve water quality as required by the draft TMDL. To achieve the required pollutant loading reductions included in the draft TMDL, local MS4 municipalities within the District's service area may need to implement a range of water quality improvement initiatives, including a more widespread implementation of green infrastructure strategies which can typically reduce pollutant loadings such as TP and TSS.

In an effort to understand and document the potential water quality improvement benefit that can be achieved by green infrastructure strategies, WDNR requires municipalities to use a stormwater model to simulate runoff that is captured, stored, and either infiltrated or discharged from green infrastructure strategies. One such program that is acceptable to WDNR is the Source Loading and Management Model (WinSLAMM), which includes green infrastructure strategies such as bioretention systems and rain gardens, porous pavement, filter strips, and wet ponds, amongst others. WinSLAMM allows the user to provide a detailed breakdown of different land uses within the drainage area needed to estimate typical pollutant concentrations and loadings. For example, different types of impervious surfaces (i.e., rooftops, roadways, parking lots) typically have varying levels of pollutant concentrations, and can also be influenced by residential, industrial, and commercial land uses. For example, runoff from roadways and pervious surfaces typically has a higher TSS concentration than runoff from rooftop areas. Table 9.2 summarizes the typical pollutant concentrations for TSS and TP that are included in the WinSLAMM model.

Table 9.2 Pollutant Concentrations for Different Land Uses (from WinSLAMM)

Land Use Type	Commercial TSS Conc. (mg/L)	Industrial TSS Conc. (mg/L)	Residential TSS Conc. (mg/L)	Commercial TP Conc. (mg/L)	Industrial TP Conc. (mg/L)	Residential TP Conc. (mg/L)
Roof Area	33	33	37	0.214	0.087	0.162
Parking Area	130	250	250	0.215	0.284	0.284
Driveway Area	154	154	154	0.495	0.495	0.495
Sidewalk Area	75	75	75	0.303	0.303	0.303
Street Area	242	242	242	0.678	0.678	0.678
Pervious Area	227	227	227	1.634	1.634	1.634

Another benefit of the WinSLAMM program is the capability of continuous simulation modeling, which can be useful to estimate the pollutant loading reductions that can be achieved by green infrastructure over a longer duration in lieu of single-event based modeling. For post-construction stormwater management, WDNR requires that green infrastructure performance standards be met on an average annual basis. As a result, WDNR requires that a specific annual rainfall file be used when conducting long-term simulations using WinSLAMM. For the Milwaukee region, rainfall from 1969 has been required for use in modeling by WDNR because it is representative of a typical year of rainfall. Approximately 33 inches of rainfall occurred during this year, with approximately 29 inches of rainfall during the non-winter season when green infrastructure strategies are more effective at improving water quality.

Using this typical year of rainfall and the default pollutant concentrations described above, a series of simulations were conducted using WinSLAMM to estimate potential pollutant loading reductions for several green infrastructure strategies, including bioretention/bioswales, porous pavement, and rain gardens. The WinSLAMM model does not include options to simulate the water quality benefits of other green infrastructure strategies included in the Green Solutions Program, such as stormwater trees, soil amendments, and native landscaping. According to WDNR's document *Modeling Post-Construction Storm Water Management Treatment Guidance # 3800-2015-04*, the following parameters were used for WinSLAMM modeling:

- TSS and TP removal credit for volume of runoff infiltrated into native soil = 100 percent
- TSS and TP removal credit for volume of runoff that overflows or bypasses green infrastructure strategy = 0 percent
- TSS removal credit for volume of runoff that is filtered through an engineered soil filtering layer and that is discharged via an underdrain = 80 percent
- TSS removal credit for volume of runoff that is filtered through a porous pavement system and that is discharged via an underdrain = 65 percent (refer to WDNR's *Permeable Pavement Technical Standard 1008*).
- TP removal credit for volume of runoff that is filtered through a porous pavement system and that is discharged via an underdrain = 35 percent
- TP removal credit for volume of runoff that is filtered through an engineered soil filtering layer and that is discharged via an underdrain is currently subject to additional studies by WDNR. The TP removal credit for the volume of runoff that is filtered through an engineered soil filtering layer is dependent on the engineered soil media selected. Current research conducted by WDNR indicates that soil media with compost component can leach out phosphorous, either limiting the overall reduction or causing a negative reduction, while soil media that is composed entirely of sand can achieve a TP reduction benefit of approximately 35% for the portion of the runoff discharged via an underdrain. The Green Infrastructure Sizing Calculator currently assumes the TP removal credit for volume of runoff that is filtered through an engineered soil filter layer that is discharged via an underdrain = 0%, based on WDNR's current engineered soil mixture described in *Bioretention for Infiltration Technical Standard 1004*.

Table 9.3 summarizes the typical pollutant loading reductions for several green infrastructure strategies. The estimated runoff reduction, TSS reduction, and TP reduction values are based on WinSLAMM modeling results using the default sizing of strategies included in the Sizing Calculator. The results represent coarse planning-level values that are intended to provide typical pollutant loading reductions that can generally be expected when green infrastructure strategies are sized to capture the 0.5-inch rainfall event from impervious surfaces.

Table 9.3 Estimated Pollutant Loading Reductions for Green Infrastructure Strategies

Green Infrastructure Strategy	Estimated Runoff Reduction (%)	Estimated TSS Reduction (%)	Estimated TP Reduction (%)
Bioretention/Bioswales	20%	65%	20%
Porous Pavement	30%	75%	55%
Rain Gardens	60%	60%	60%

The information above appears to indicate that rain gardens have the greatest potential for runoff volume reduction. This is primarily due to rain gardens not including an underdrain system to convey runoff that is filtered through an engineered soil layer. It is worth noting that rain gardens are typically only installed in residential settings with small drainage areas, so the overall benefit within a municipality could be somewhat limited unless implemented on a broad scale. The estimated TSS reductions appear to be relatively consistent amongst the green infrastructure strategies, and also appear to be generally capable of meeting the average TSS reduction target of 66 percent included in the draft TMDL. The estimated TP reduction for porous pavement and rain gardens are in line with the average TP reduction target of 61 percent included in the draft TMDL. The TP reduction benefits of bioretention/bioswale strategies is very limited by WDNR's requirement of no credit for TP removal credit for volume of runoff that is filtered through an engineered soil filtering layer and that is discharged via an underdrain. WDNR has indicated that the current engineered soil mixture used in Wisconsin has not shown a reduction in TP that is filtered, but WDNR is in the process of developing an engineered soil mixture that could reduce TP in filtered runoff.

All of the water quality and TMDL information described above is included in the Green Infrastructure Sizing Tool. The Sizing Tool summarizes the potential water quality benefits of these types of green infrastructure strategies. This will allow municipalities to quickly determine the anticipated pollutant loading reduction that could be achieved by the green infrastructure strategies when sized using the Green Infrastructure Sizing Tool.

9.) Recommendations for Further Study/Phase 2

The objective of the Green Infrastructure Standard Specifications and Plan Templates project is to develop simplified planning and design tools to promote more widespread implementation of green infrastructure strategies throughout the District's service area. This initial phase of the project is intended to provide local municipalities with tools that provide an initial reference for green infrastructure planning (selection, sizing, and costing) and to provide links and references to pertinent specifications and details. These tools are not intended to provide final design documents.

As green infrastructure projects continue to be implemented locally, planning and design tools may need to be updated or supplemented in a next phase of this project (Phase 2) to further assist local municipalities with the planning, design, and construction of green infrastructure strategies. The list below describes several additional enhancements that could be considered during Phase 2 of the project to supplement the Phase 1 work product.

- GIS-based tools to further assist with green infrastructure sizing and siting: GIS-based tools could be developed to further assist with green infrastructure sizing and siting. Although these tools would not produce a final design, plan view visuals could help supplement the information in the Green Infrastructure Sizing Calculator to make more informed decisions during the green infrastructure planning phase.

- Database to document and track location and benefits of constructed green infrastructure projects: A detailed database with GIS-based user interface could be developed to allow the District and local municipalities to efficiently view the locations of constructed green infrastructure projects, along with project-specific information on construction costs, stormwater storage potential, annual pollutant load reductions (related to TMDLs), and O&M activities.

- Modified tools to accommodate audiences other than local municipalities: To achieve the stormwater storage objectives described in the District's 2035 Vision, additional stakeholders throughout the service area (such as residential homeowners) will need to be targeted to implement more wide-spread green infrastructure. More detailed information and tools could be developed to allow for more participation. This could result in strategies implemented more routinely, such as rain gardens, native landscaping, and soil amendments.

- Updated specifications and/or typical details: As research on green infrastructure strategies continues to evolve and referenced specifications or guidance materials are updated (such as WDNR references), the District's standard specifications and typical details may need to be updated or revised to stay current with industry trends and standards.

- Additional green infrastructure strategies: The first phase of this project was focused on six specific green infrastructure strategies included in this report. However, the District recognizes additional green infrastructure strategies that can be used to meet stormwater management or storage objectives. User-friendly tools could also be developed for additional strategies during Phase 2 of the project, and include tools such as a supplemental green infrastructure sizing tool, standard specifications, and typical details.

Appendix A

Plan Templates/Example Typical Details

Contract Documents

Milwaukee Metropolitan
Sewerage District

WATERCOURSE
Green Infrastructure
Specifications and Plan Templates

Contract M03064P21

Plans

For information regarding this project call: MMSD Project Manager : Tel. 414.272.5100

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M03064PP21-G-1.dgn

INDEX TO DRAWINGS

FINAL

VERIFY SCALES

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0" ——— 0.5"

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APVD	JTL

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PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

GENERAL
INDEX TO DRAWINGS

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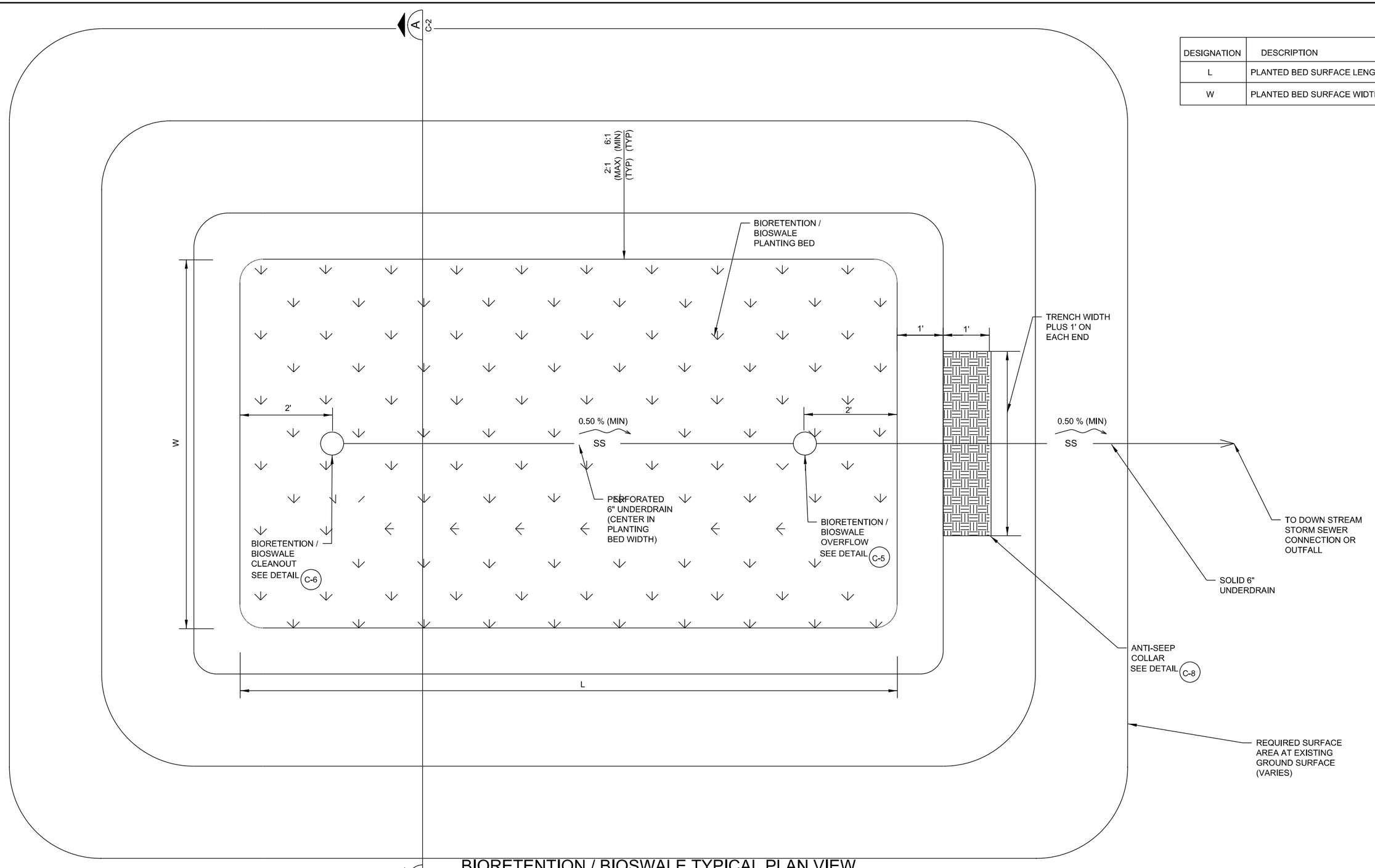

BIORETENTION / BIOSWALE TYPICAL PLAN VIEW (SLOPED SIDES)

NTS

FINAL

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MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
BIORETENTION / BIOSWALE TYPICAL PLAN VIEW (SLOPED SIDES)

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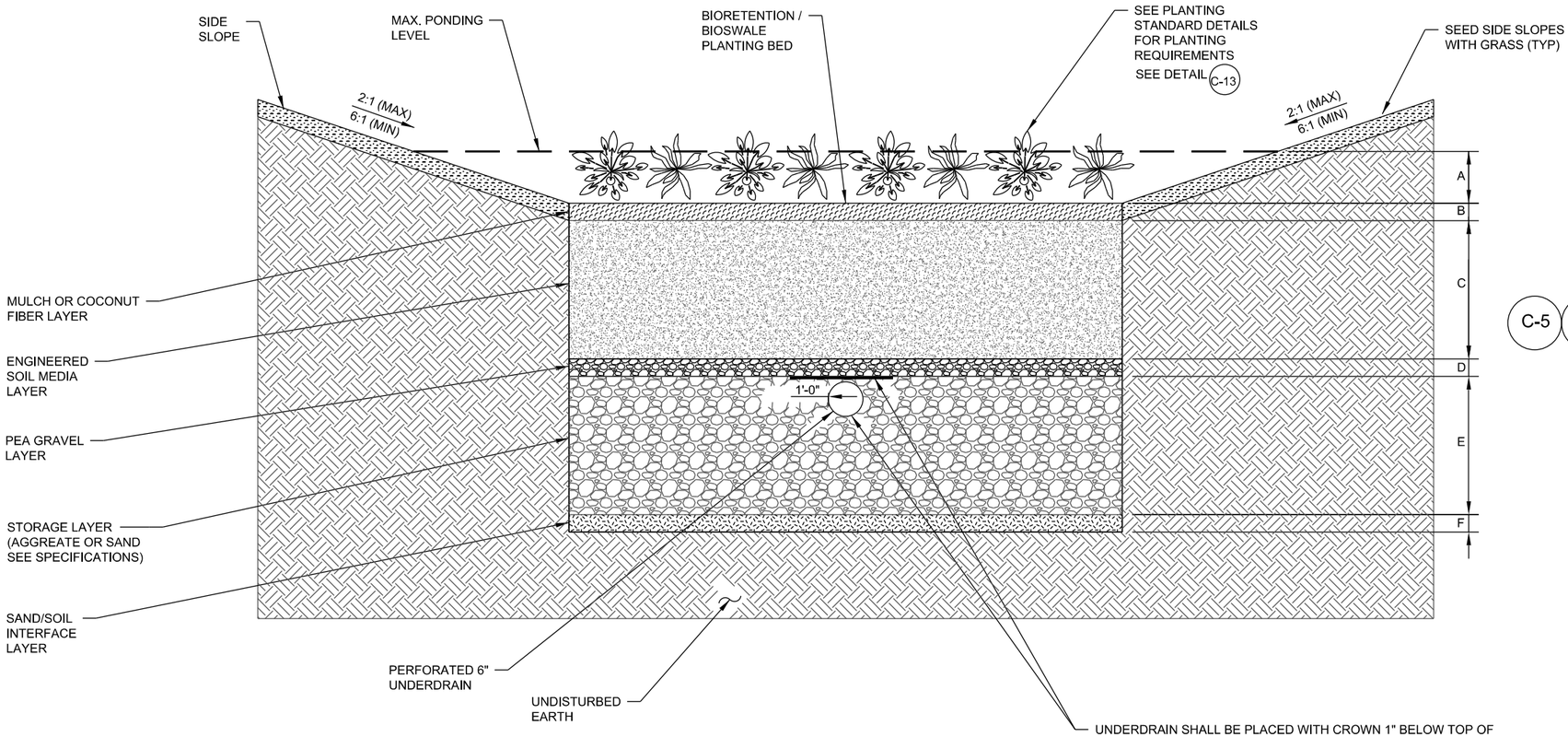

C-5 C-6 C-7 C-9 C-11

C-5 C-6 C-7 C-9 C-11

DIMENSION	LAYER NAME	DEPTH
A	SURFACE PONDING	X
B	MULCH OR COCONUT FIBER	X
C	ENGINEERED SOIL MEDIA	X
D	PEA GRAVEL	X
E	STORAGE	X
F	SAND/SOIL INTERFACE	X

BIORETENTION / BIOSWALE TYPICAL CROSS-SECTION (SLOPED SIDES)

SECTION A C-1

NTS

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BIORETENTION / BIOSWALE TYPICAL CROSS-SECTION (SLOPED SIDES)

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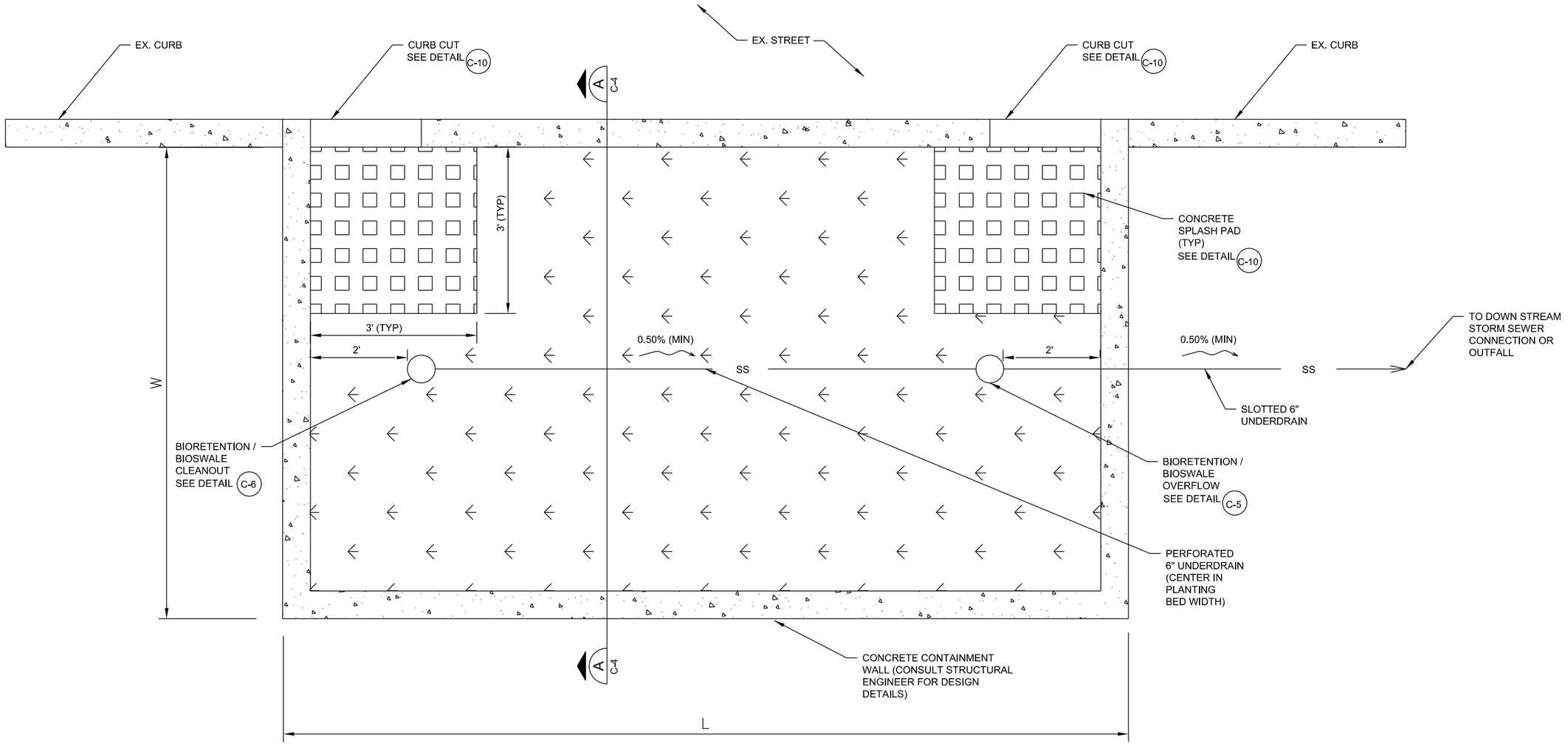

BIORETENTION TYPICAL PLAN VIEW (CONCRETE PERIMETER CURB)

NTS

FINAL

VERIFY SCALES

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0" 0.5"

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MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

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CIVIL
BIORETENTION TYPICAL PLAN VIEW (CONCRETE PERIMETER CURB)

DRAWING NO.:	C-3
SHEET:	5
DATE:	JULY, 2016
CONTRACT:	M03064P21
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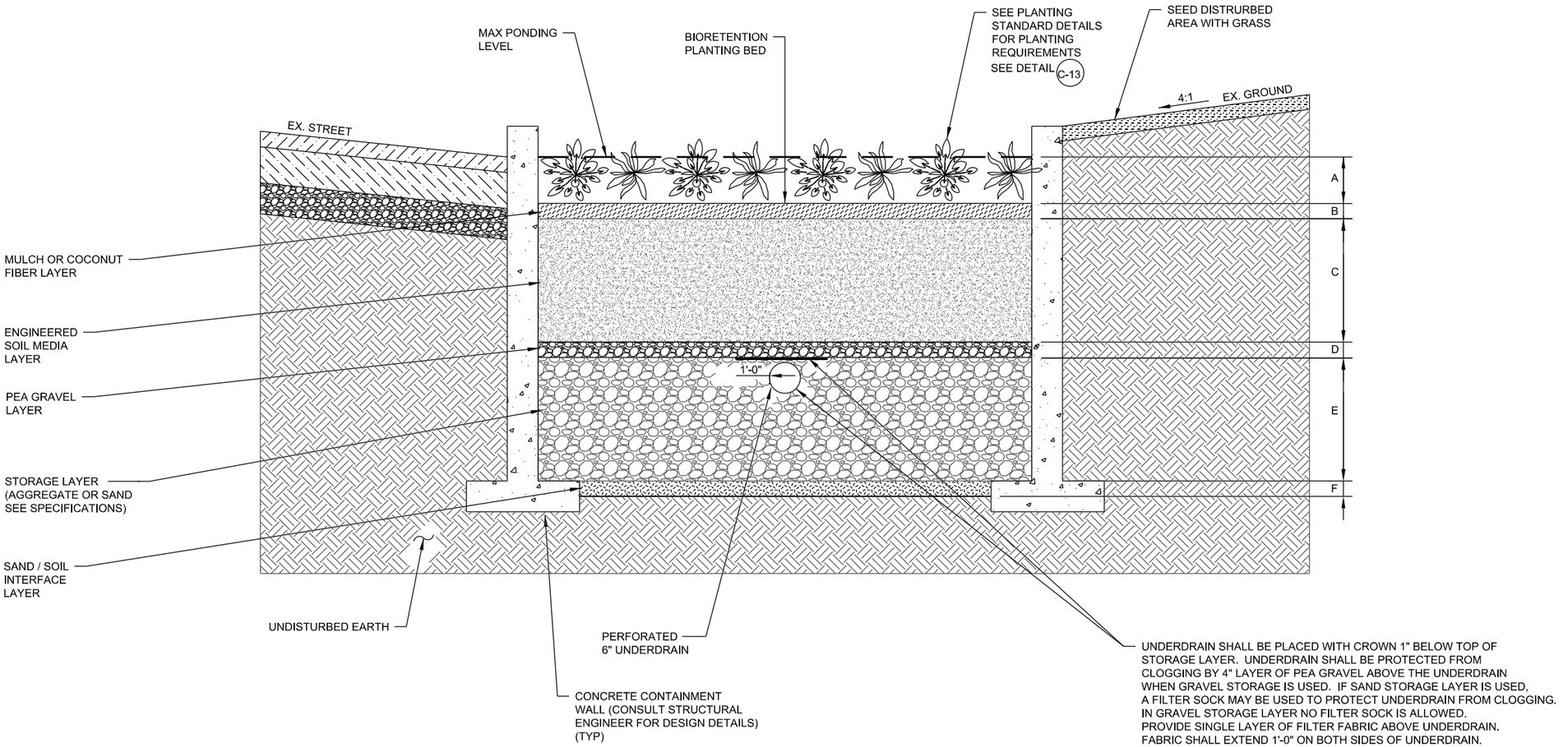


BIORETENTION TYPICAL CROSS-SECTION (CONCRETE PERIMETER CURB)

SECTION A
NTS C-3

DIMENSION	LAYER NAME	DEPTH
A	SURFACE PONDING	X
B	MULCH OR COCONUT FIBER	X
C	ENGINEERED SOIL MEDIA	X
D	PEA GRAVEL	X
E	STORAGE	X
F	SAND/SOIL INTERFACE	X

FINAL

VERIFY SCALES
BAR IS ONE-HALF INCH ON ORIGINAL DRAWING
0" 0.5"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

DSGN HPK
DR PA ROEPER
CHK CJR
APVD JTL

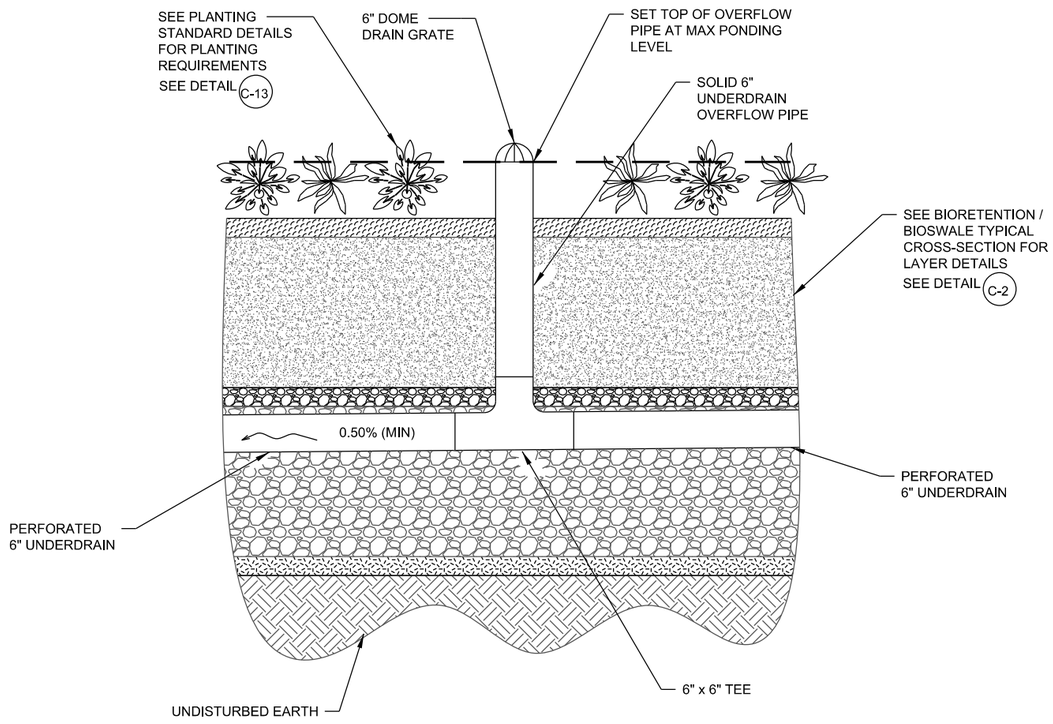
This Design Prepared For MMSD By:
STRAND ASSOCIATES®

REV. NO.	DATE	REVISION DESCRIPTION	BY	APVD

MMSD PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
BIORETENTION TYPICAL CROSS-SECTION (CONCRETE PERIMETER CURB)

DRAWING NO.:	C-4
SHEET:	6
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



BIORETENTION / BIOSWALE OVERFLOW

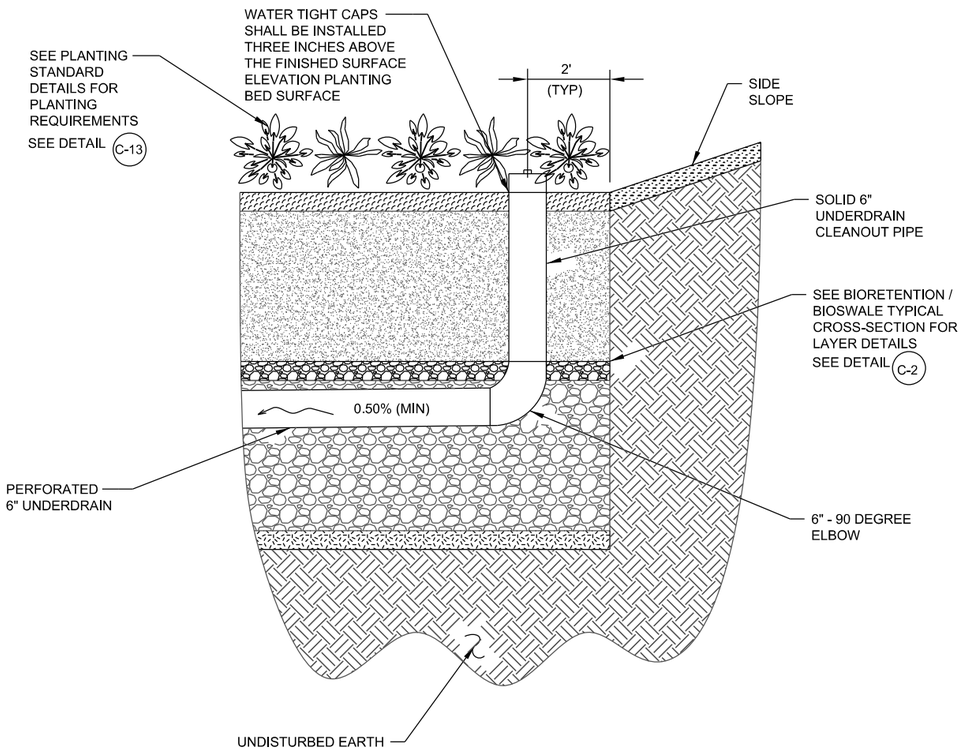
NTS

DETAIL 5 C-1 / 5 C-3

NTS

FINAL

REUSE OF DOCUMENTS THIS DOCUMENT AND THE IDEAS AND DESIGNS INCORPORATED HEREIN IS AN INSTRUMENT OF PROFESSIONAL SERVICE AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT.	**VERIFY SCALES** BAR IS ONE-HALF INCH ON ORIGINAL DRAWING 0" — 0.5" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	DSGN HPK DR PA ROEPER CHK CJR APVD JTL	This Design Prepared For MMSD By: STRAND ASSOCIATES®	REV. NO.	DATE	REVISION DESCRIPTION	BY	APVD	MMSD PARTNERS FOR A CLEANER ENVIRONMENT	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT WATERCOURSE GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES CIVIL BIORETENTION / BIOSWALE OVERFLOW	DRAWING NO.: C-5 SHEET: 7 DATE: JULY, 2016 CONTRACT: M03064P21 MMSD FILE:



BIORETENTION / BIOSWALE CLEANOUT

DETAIL 6 (C-1) 6 (C-3) 6 (C-11)

NTS

FINAL

VERIFY SCALES
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0" —— 0.5"
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DSGN HPK
DR PA ROEPER
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APVD JTL

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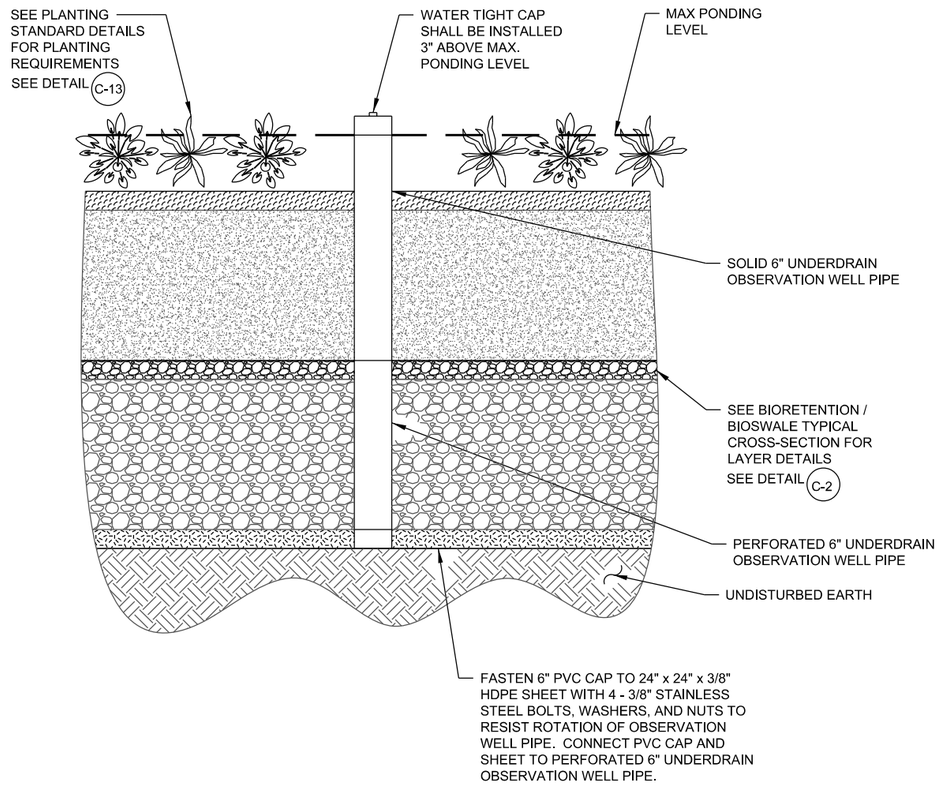
REV. NO.	DATE	REVISION DESCRIPTION	BY	APVD

MMSD PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
BIORETENTION / BIOSWALE CLEANOUT

DRAWING NO.:	C-6
SHEET:	8
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



NOTE

1. ONE OBSERVATION WELL REQUIRED PER 1,000 SQUARE FEET OF SURFACE AREA LOCATED IN CENTER

BIORETENTION / BIOSWALE OBSERVATION WELL

DETAIL 7
NTS

FINAL

VERIFY SCALES
BAR IS ONE-HALF INCH ON ORIGINAL DRAWING
0" 0.5"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

DSGN HPK
DR PA ROEPER
CHK CJR
APVD JTL

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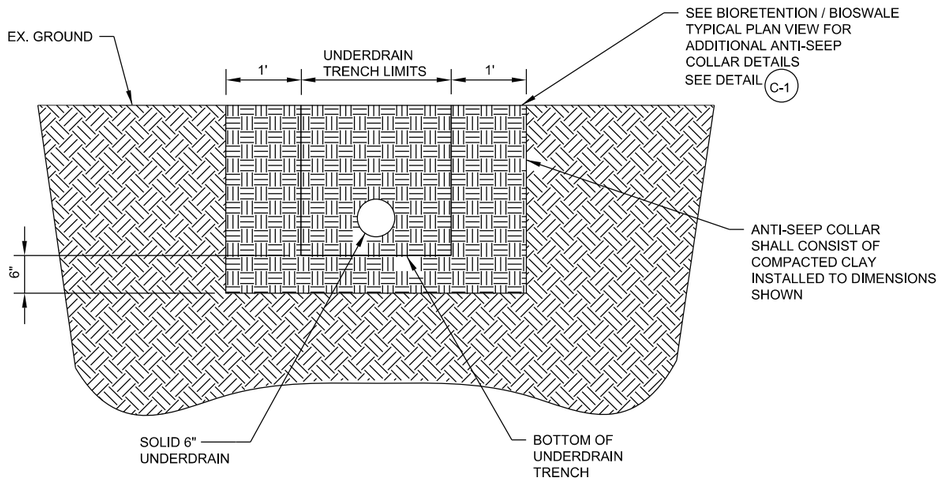
MMSD PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
BIORETENTION / BIOSWALE OBSERVATION WELL

DRAWING NO.:	C-7
SHEET:	9
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



ANTI - SEEP COLLAR

DETAIL 1
NTS C-8

FINAL

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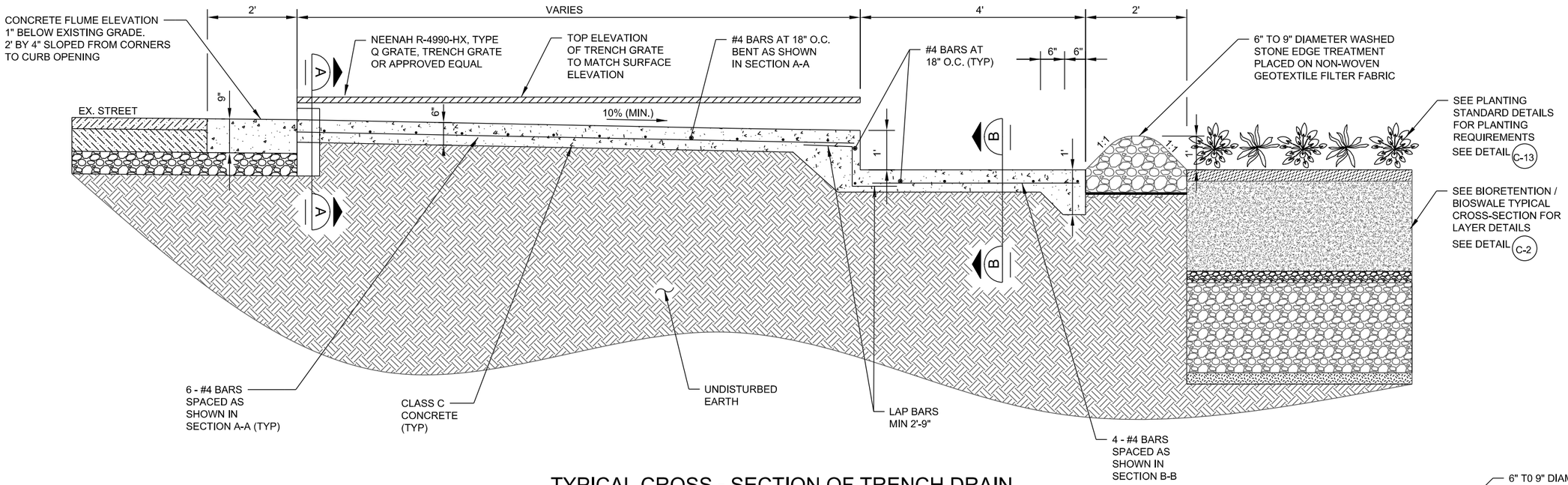
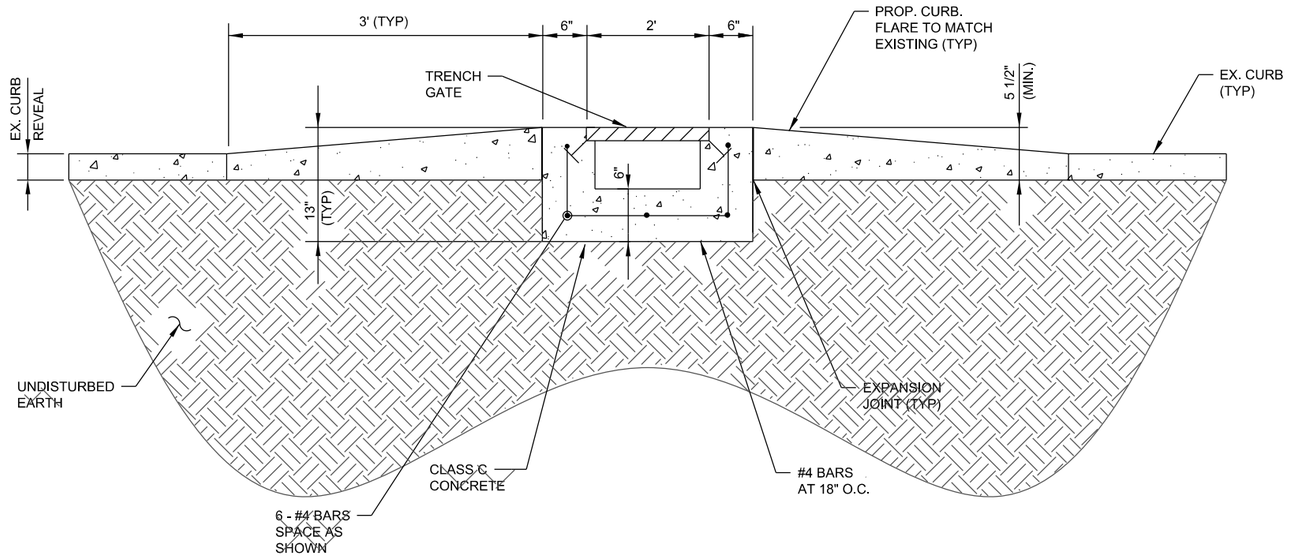
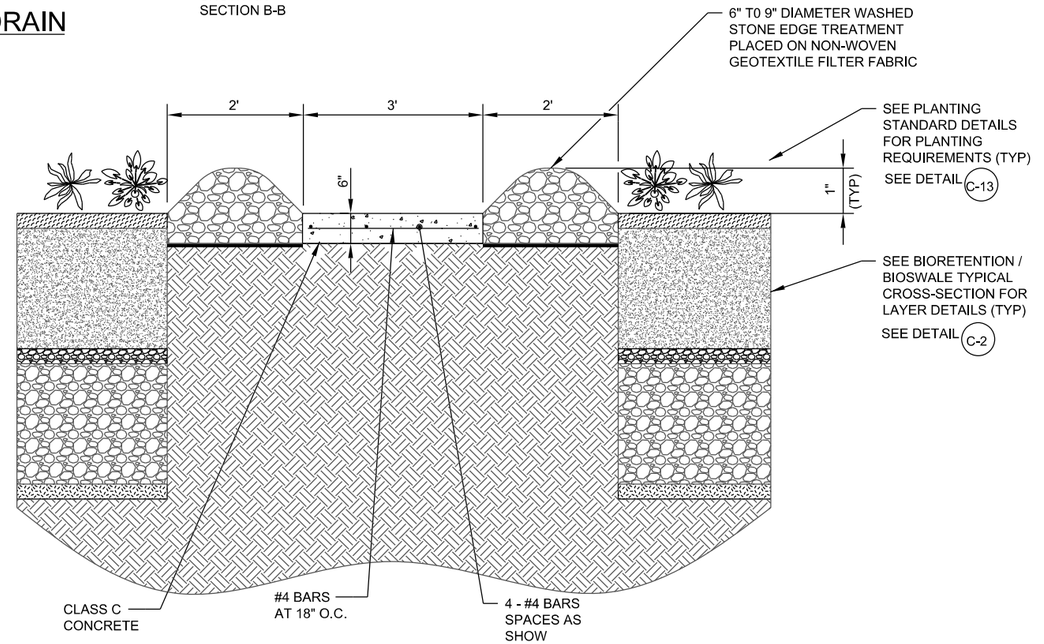


TYPICAL CROSS - SECTION OF TRENCH DRAIN

NTS





TRENCH DRAIN TYPICAL CROSS - SECTION

SECTION B

NTS

FINAL

VERIFY SCALES
BAR IS ONE-HALF INCH ON ORIGINAL DRAWING
0" 0.5"
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DSGN HPK
DR PA ROEPER
CHK CJR
APVD JTL

This Design Prepared For MMSD By:
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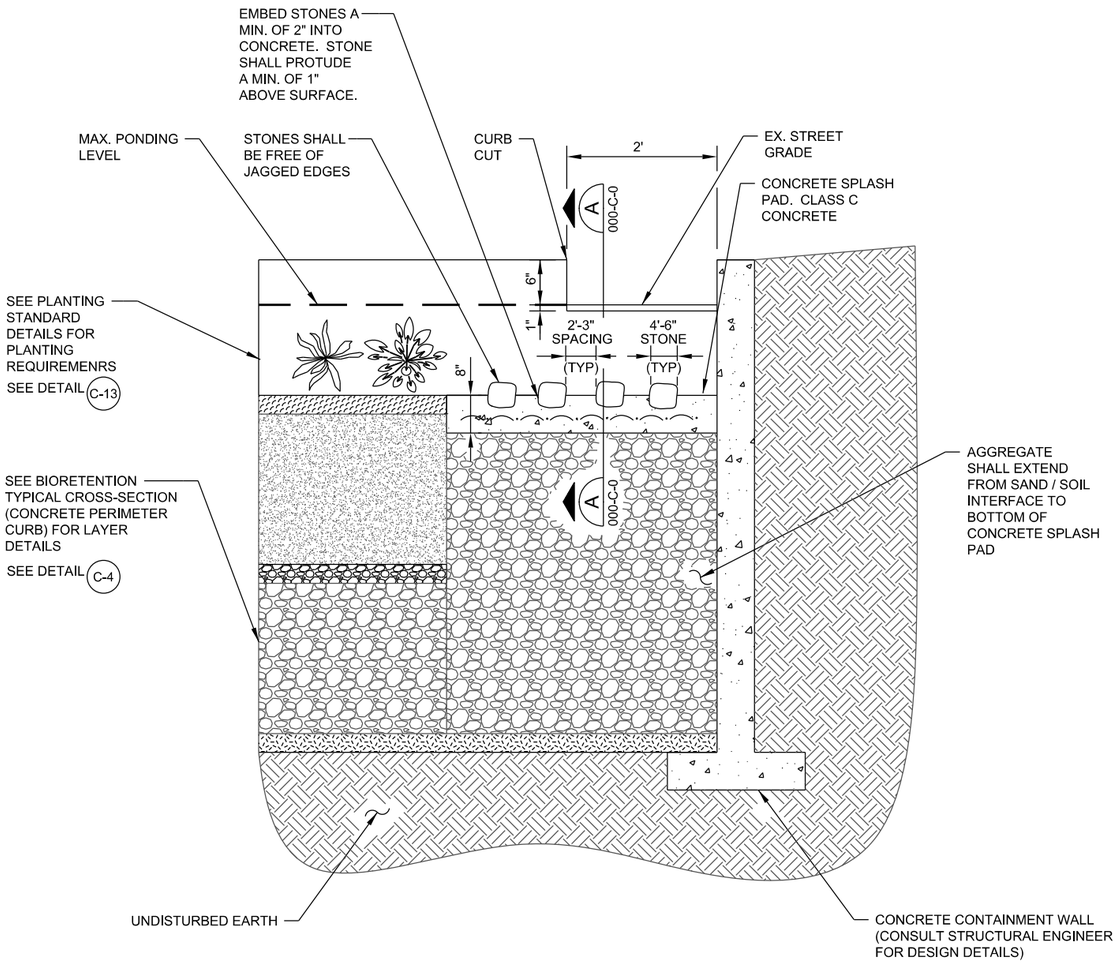
MMSD PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
TYPICAL CROSS-SECTION OF TRENCH DRAIN

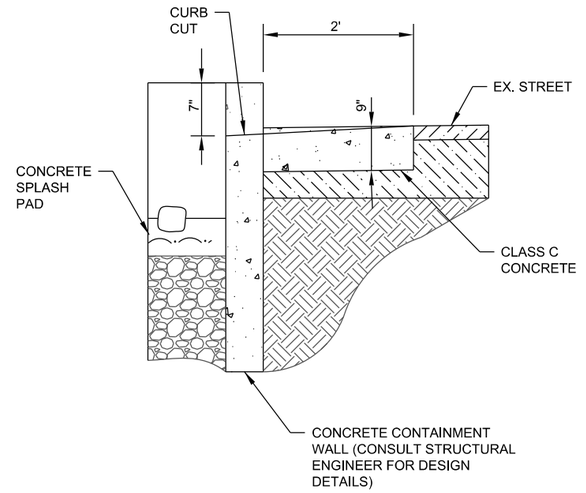
DRAWING NO.:	C-9
SHEET:	11
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



CONCRETE SPLASH PAD AND CURB CUT TYPICAL CROSS - SECTION

DETAIL 10 C-3 / 10 C-11

NTS



CONCRETE SPLASH PAD AND CURB CUT TYPICAL CROSS - SECTION

SECTION A C-11

NTS

FINAL

VERIFY SCALES
BAR IS ONE-HALF INCH ON ORIGINAL DRAWING
0" 0.5"
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DSGN HPK
DR PA ROEPER
CHK CJR
APVD JTL

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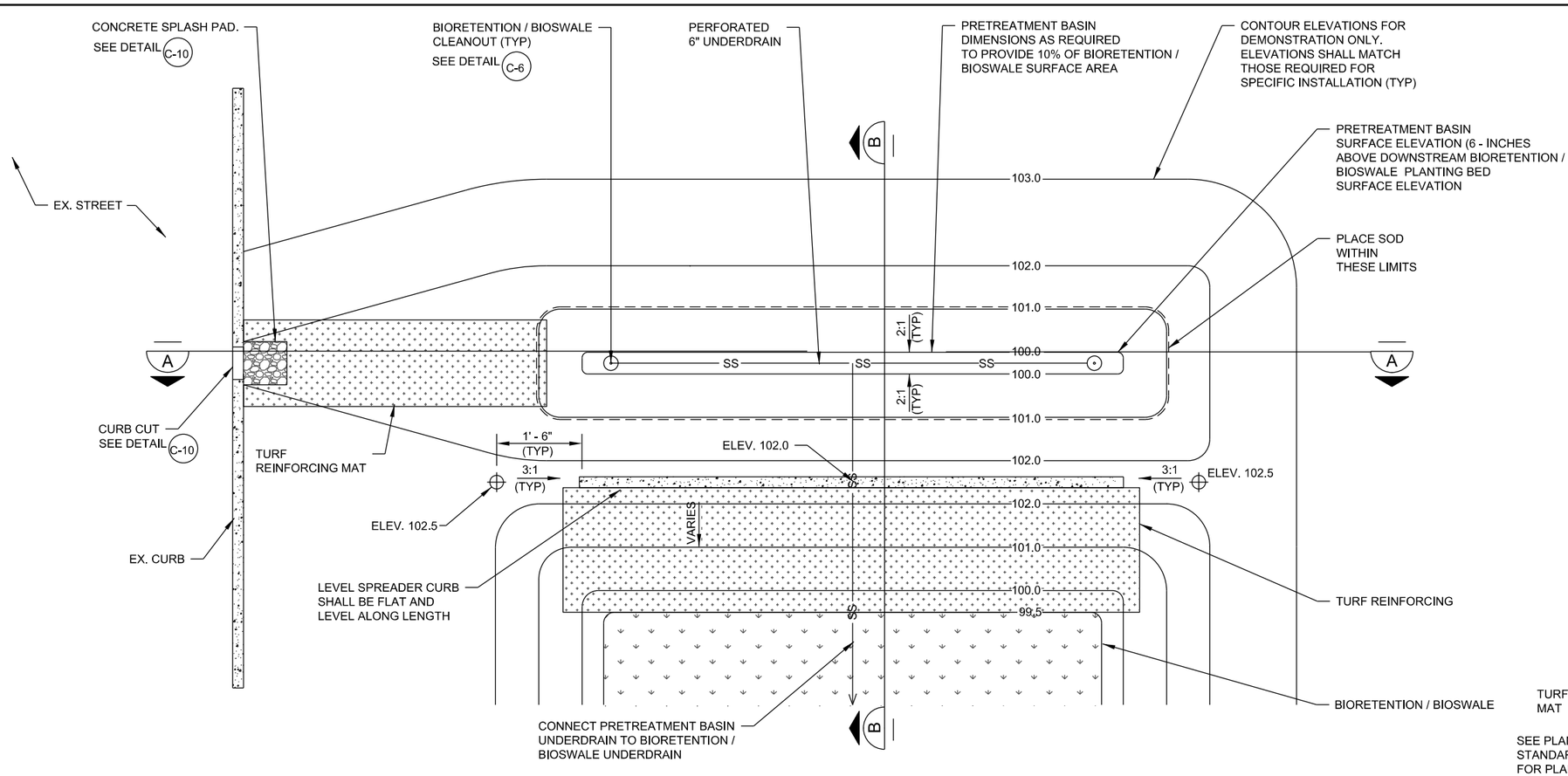
MMSD PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

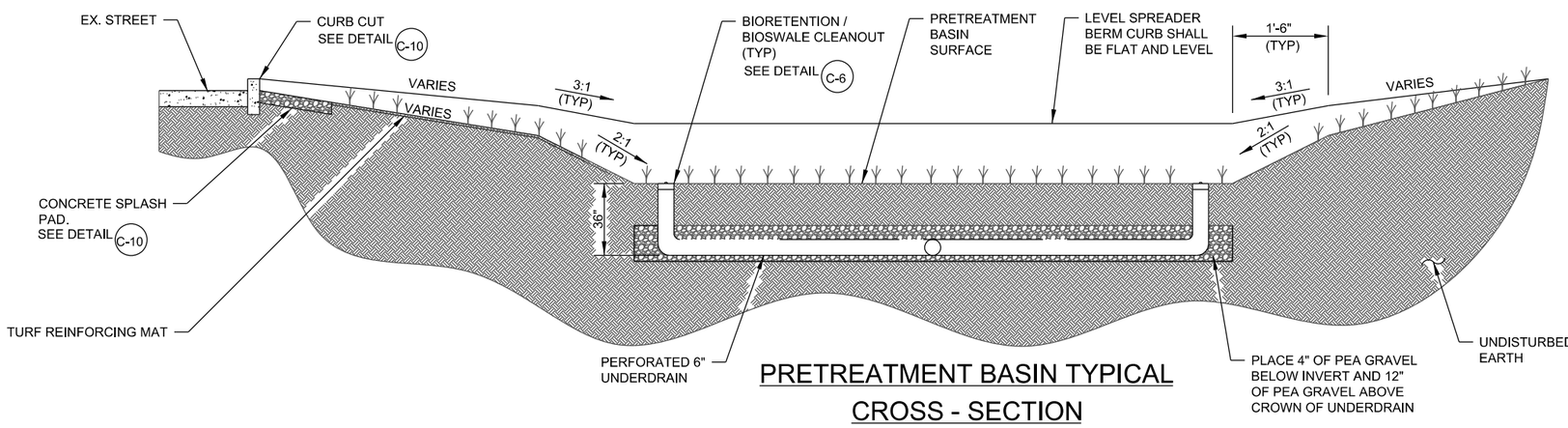
CIVIL
CONCRETE SPLASH PAD AND CURB CUT TYPICAL CROSS-SECTIONS

DRAWING NO.:	C-10
SHEET:	12
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



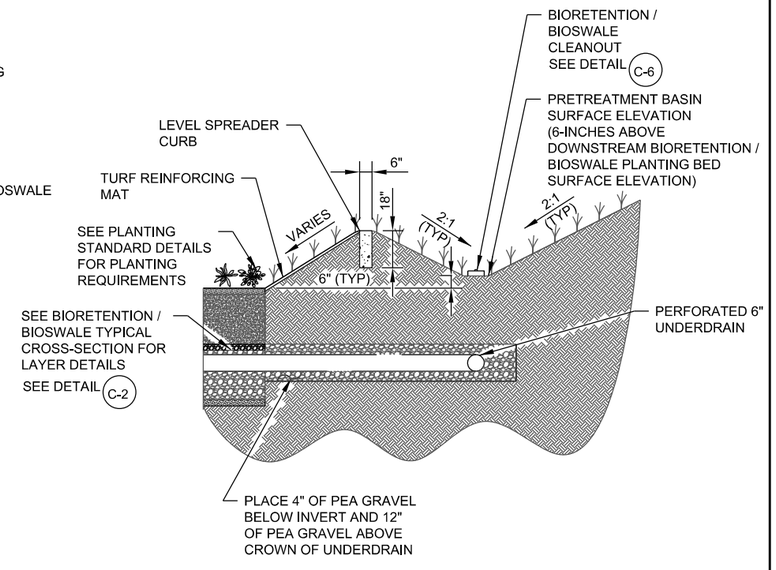
PRETREATMENT BASIN TYPICAL PLAN VIEW

NTS



PRETREATMENT BASIN TYPICAL CROSS - SECTION SECTION A

NTS



PRETREATMENT BASIN TYPICAL CROSS - SECTION SECTION B

NTS

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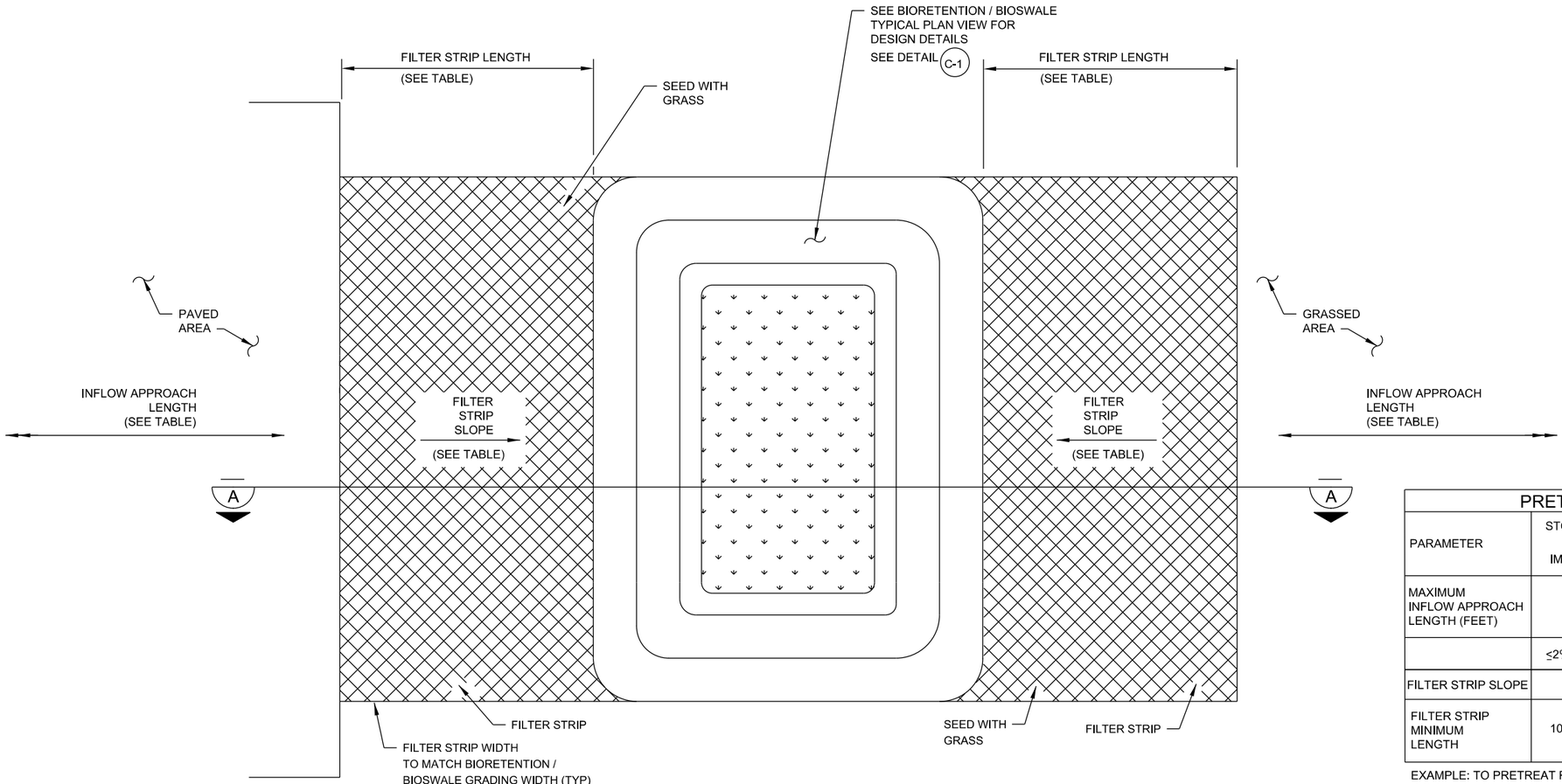
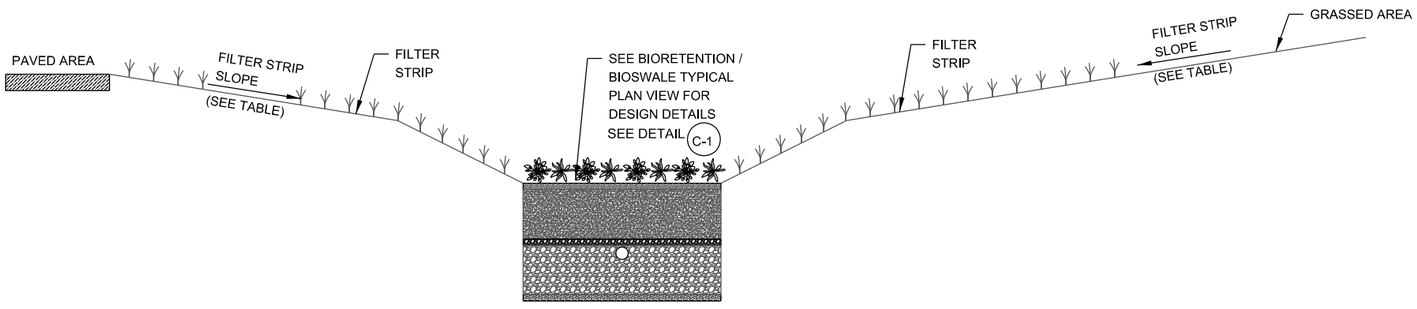


FILTER STRIP TYPICAL PLAN VIEW

NTS



FILTER STRIP TYPICAL CROSS SECTION

SECTION A

NTS

PRETREATMENT FILTER STRIP SIZING GUIDANCE

PARAMETER	STORMWATER RUNOFF INFLOW APPROACH FROM IMPERVIOUS PARKING LOTS				STORMWATER RUNOFF INFLOW APPROACH FROM LAWNS / LANDSCAPED AREAS				NOTES
MAXIMUM INFLOW APPROACH LENGTH (FEET)	35		75		75		150		
	≤2%	>2%	≤2%	>2%	≤2%	>2%	≤2%	>2%	MAXIMUM
FILTER STRIP SLOPE									SLOPE = 6%
FILTER STRIP MINIMUM LENGTH	10'	15'	20'	25'	10'	12'	15'	18'	

EXAMPLE: TO PRETREAT RUNOFF THAT FLOWS 75 FEET ACROSS A PARKING LOT BEFORE REACHING THE BIORETENTION DEVICE, THE FILTER STRIP SHOULD BE 20 FEET LONG IF THE FILTER STRIP SLOPE IS LESS THAN OR EQUAL TO 2% AND 25 FEET LONG IF THE FILTER STRIP SLOPE IS OVER 2%.

FINAL

VERIFY SCALES
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0" 0.5"
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DSGN HPK
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APVD JTL

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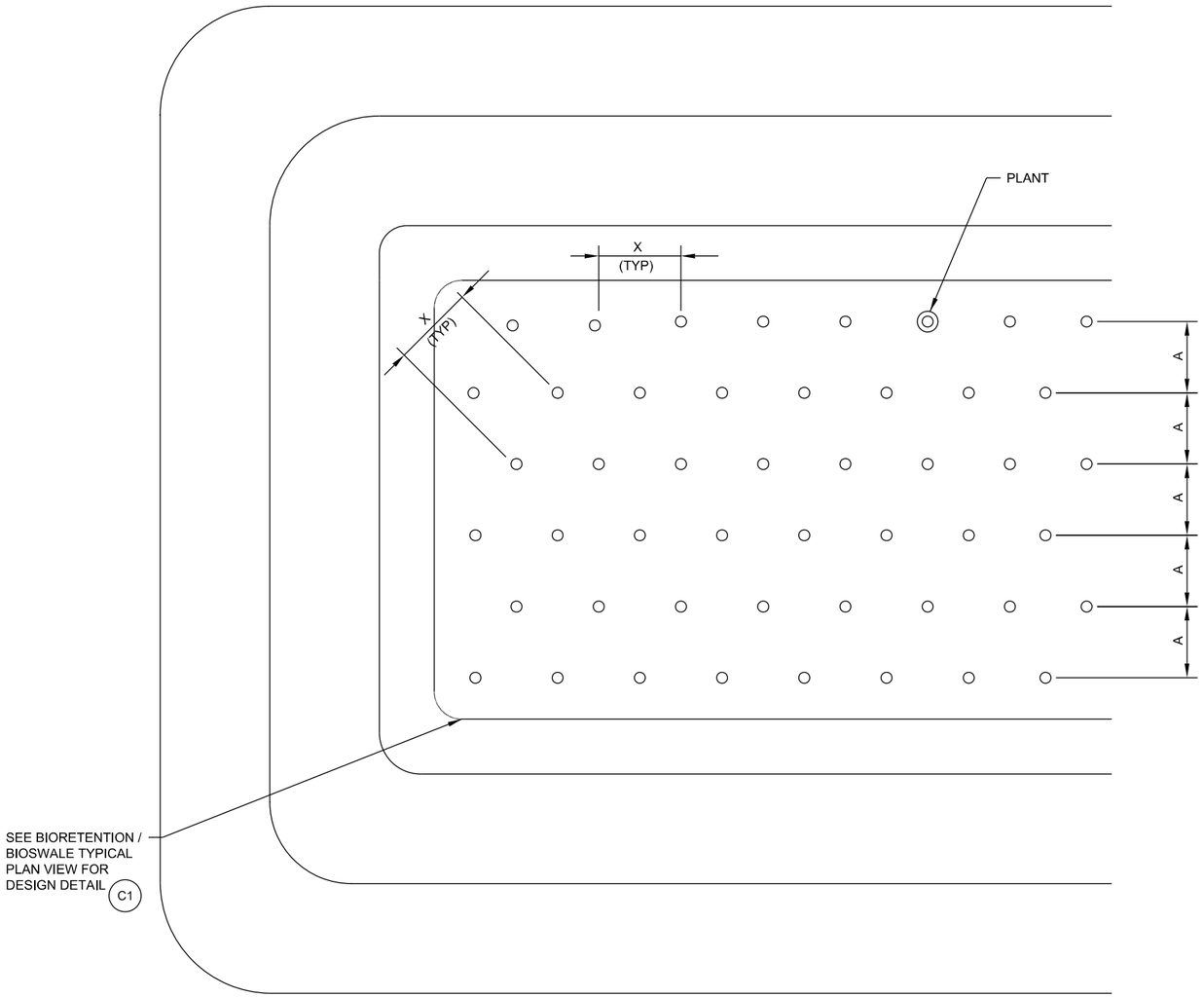
MMSD PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
WATERCOURSE
GREN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
FILTER STRIP TYPICAL PLAN VIEW

DRAWING NO.: C-12
SHEET: 14
DATE: JULY, 2016
CONTRACT: M03064P21
MMSD FILE:



SPACING SCHEDULE	
SPACING "X" (SUGGESTED PLANT SPACING)	SPACING "A"
8" O.C.	7"
12" O.C.	10 1/2"
18" O.C.	15 1/2"
24" O.C.	20 3/4"
30" O.C.	26"
36" O.C.	31"
42" O.C.	36"
60" O.C.	52"

BIORETENTION / BIOSWALE
PLANT SPACING

DETAIL
NTS

13 C-2 | 13 C-4 | 13 C-5 | 13 C-6 | 13 C-9 | 13 C-10

FINAL

VERIFY SCALES
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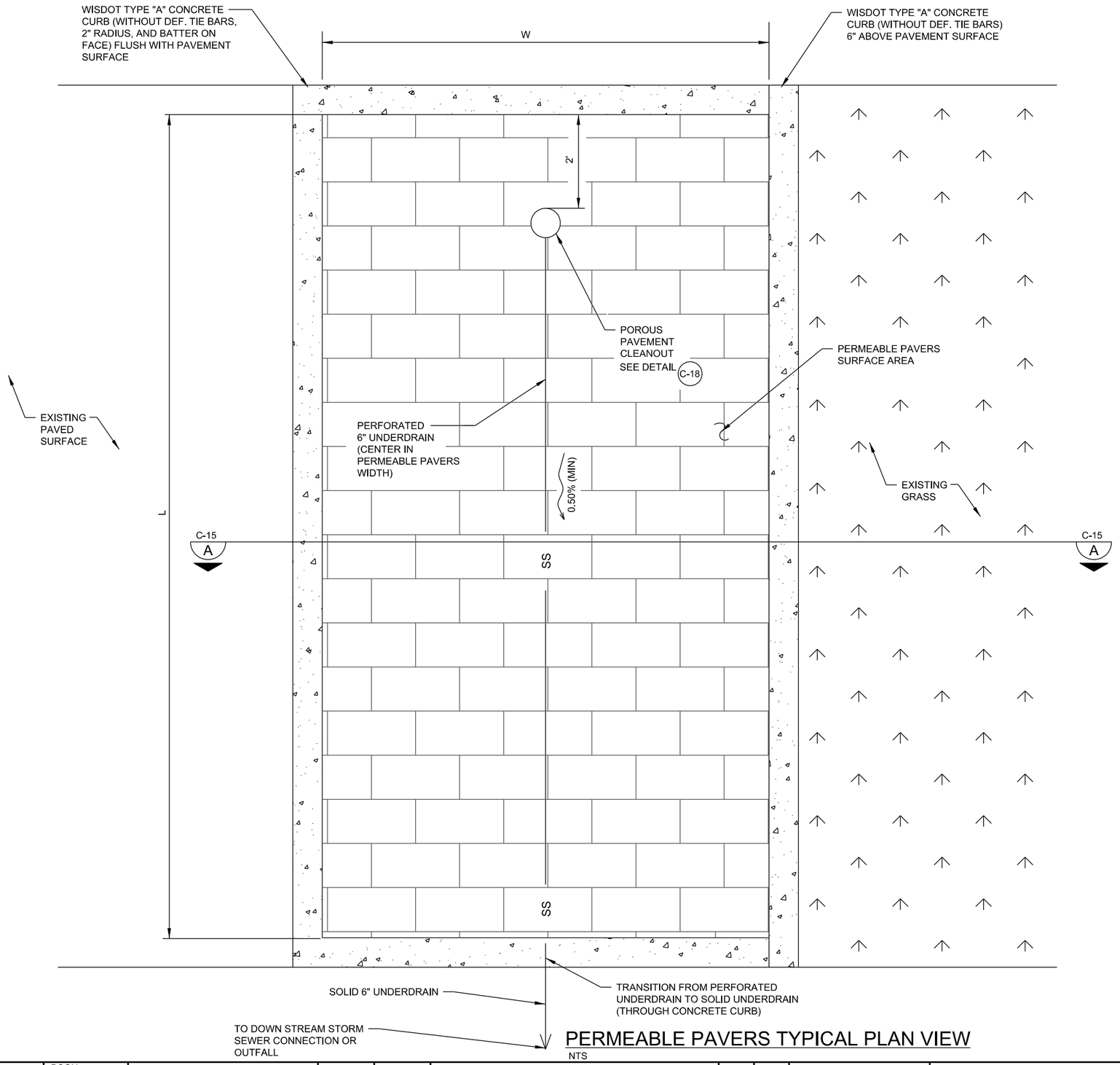
MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
BIORETENTION / BIOSWALE PLANT SPACING

DRAWING NO.: C-13
SHEET: 15
DATE: JULY, 2016
CONTRACT: M03064P21
MMSD FILE:



DIMENSION	DESCRIPTION	DISTANCE
L	PERMEABLE PAVERS SURFACE LENGTH	X
W	PERMEABLE PAVERS SURFACE WIDTH	X

PERMEABLE PAVERS TYPICAL PLAN VIEW

NTS

FINAL

VERIFY SCALES

BAR IS ONE-HALF INCH ON ORIGINAL DRAWING

0" 0.5"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

DSGN	HPK
DR	PA ROEPER
CHK	CJR
APVD	JTL

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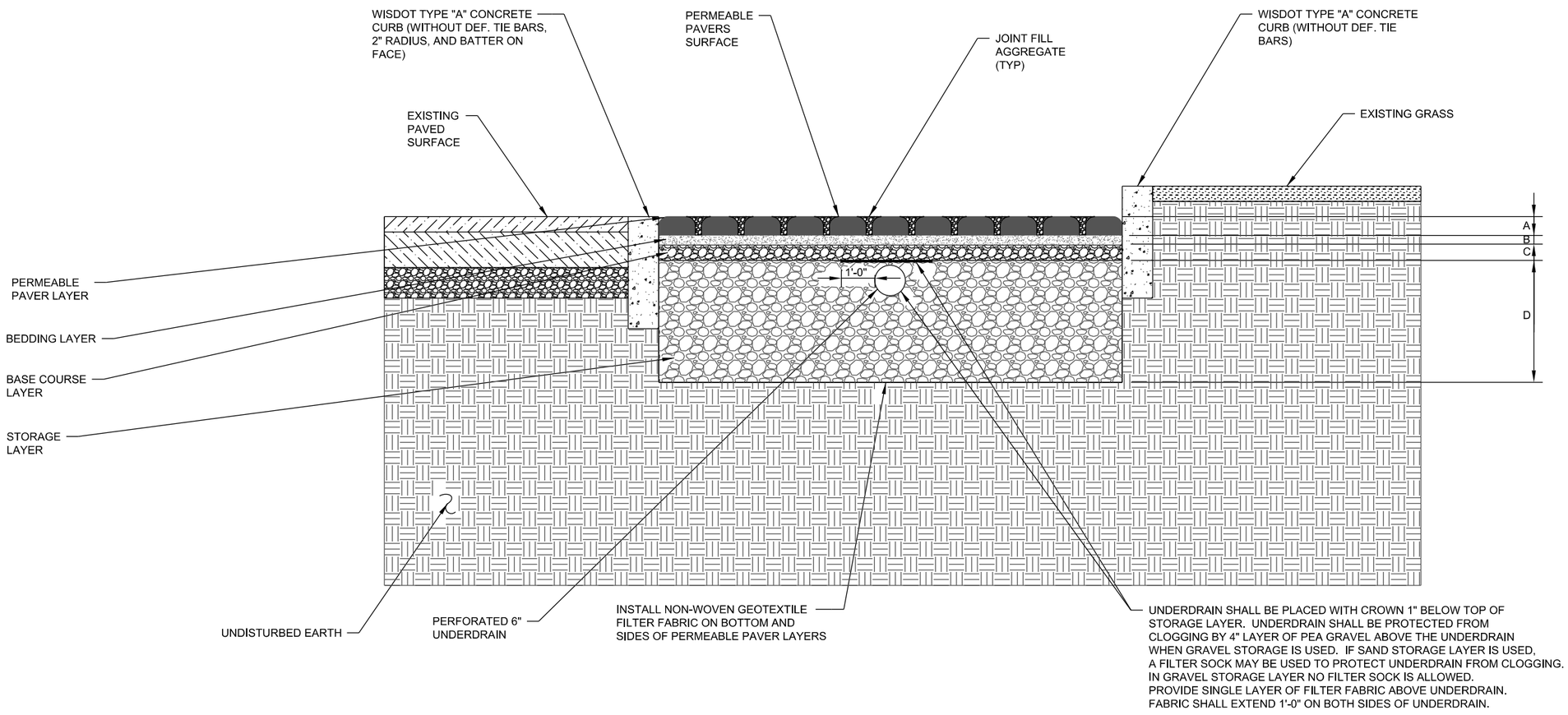
MMSD PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
PERMEABLE PAVERS TYPICAL PLAN VIEW

DRAWING NO.:	C-14
SHEET:	16
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



DIMENSION	LAYER NAME	DEPTH
A	PERMEABLE PAVERS	X
B	BEDDING	X
C	BASE COURSE	X
D	STORAGE	X

PERMEABLE PAVERS TYPICAL CROSS-SECTION

SECTION A
NTS C-14

FINAL

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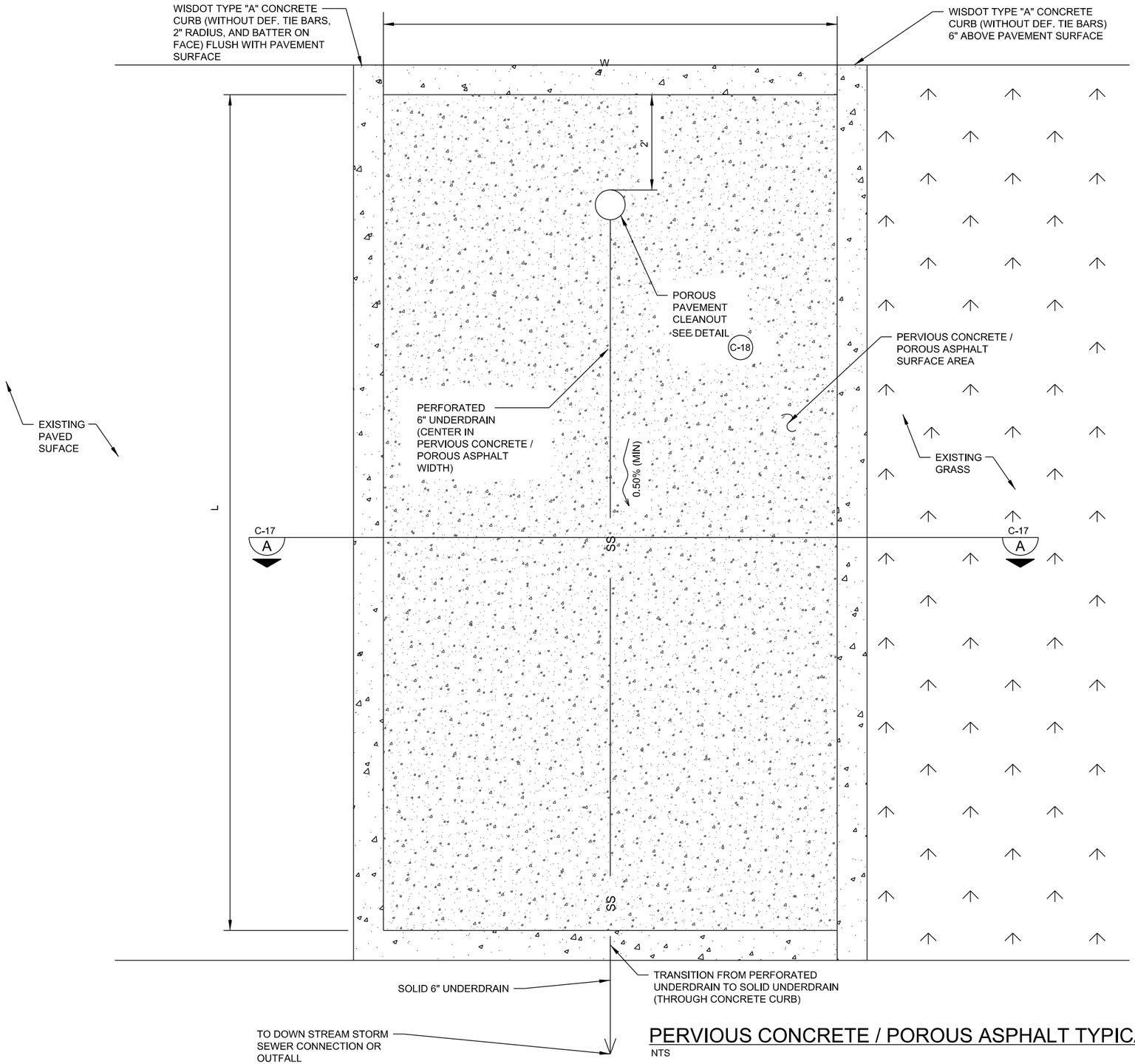
MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
PERMEABLE PAVERS TYPICAL CROSS-SECTION

DRAWING NO.: C-15
SHEET: 17
DATE: JULY, 2016
CONTRACT: M03064P21
MMSD FILE:



DIMENSION	DESCRIPTION	DISTANCE
L	PERVIOUS CONCRETE/ POROUS ASPHALT SURFACE LENGTH	X
W	PERVIOUS CONCRETE/ POROUS ASPHALT SURFACE WIDTH	X

PERVIOUS CONCRETE / POROUS ASPHALT TYPICAL PLAN VIEW

NTS

FINAL

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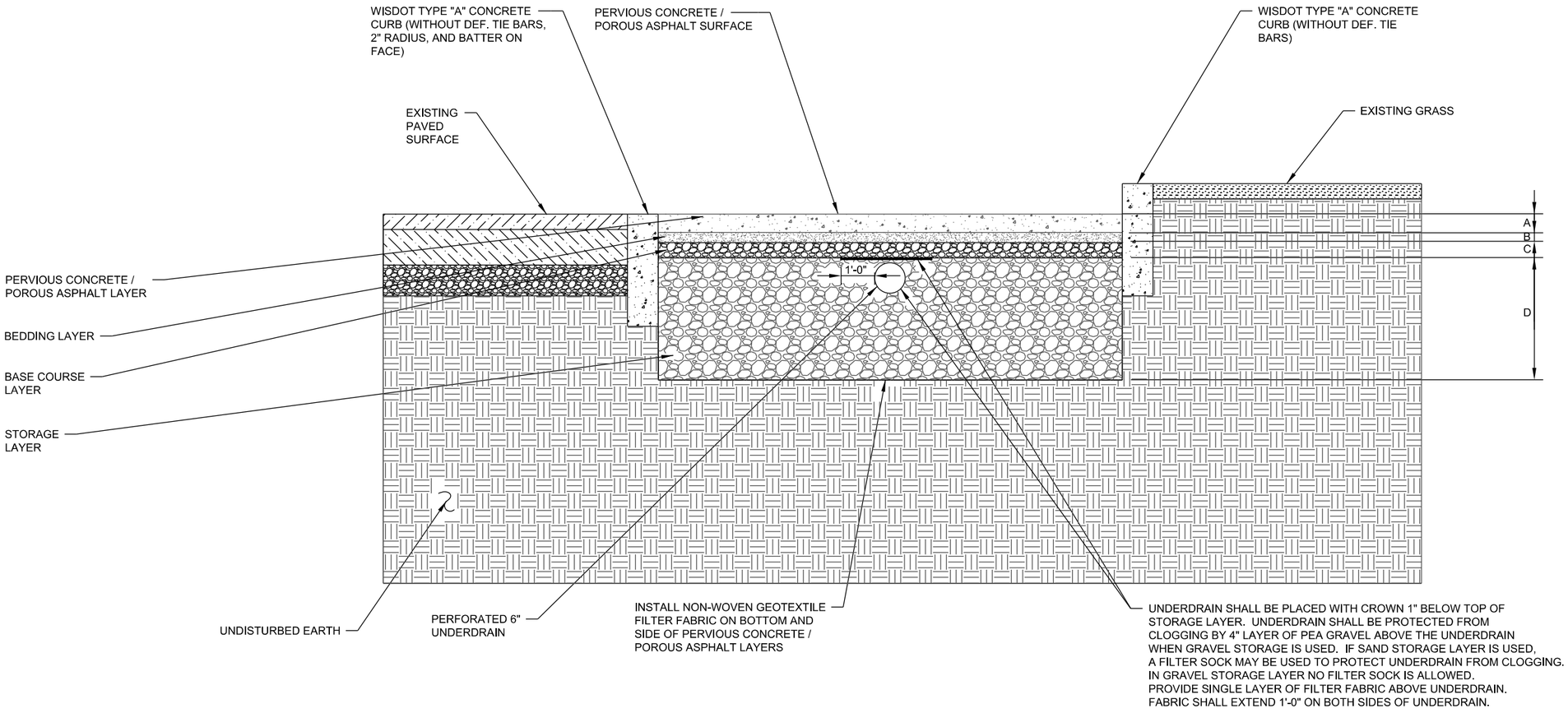
MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
PERVIOUS CONCRETE / POROUS ASPHALT TYPICAL PLAN VIEW

DRAWING NO.:	C-16
SHEET:	18
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



DIMENSION	LAYER NAME	DEPTH
A	PERVIOUS CONCRETE / POROUS ASPHALT	X
B	BEDDING	X
C	BASE COURSE	X
D	STORAGE	X

PERVIOUS CONCRETE / POROUS ASPHALT TYPICAL CROSS-SECTION

SECTION A
NTS C-16

FINAL

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REV. NO.	DATE	REVISION DESCRIPTION	BY	APVD

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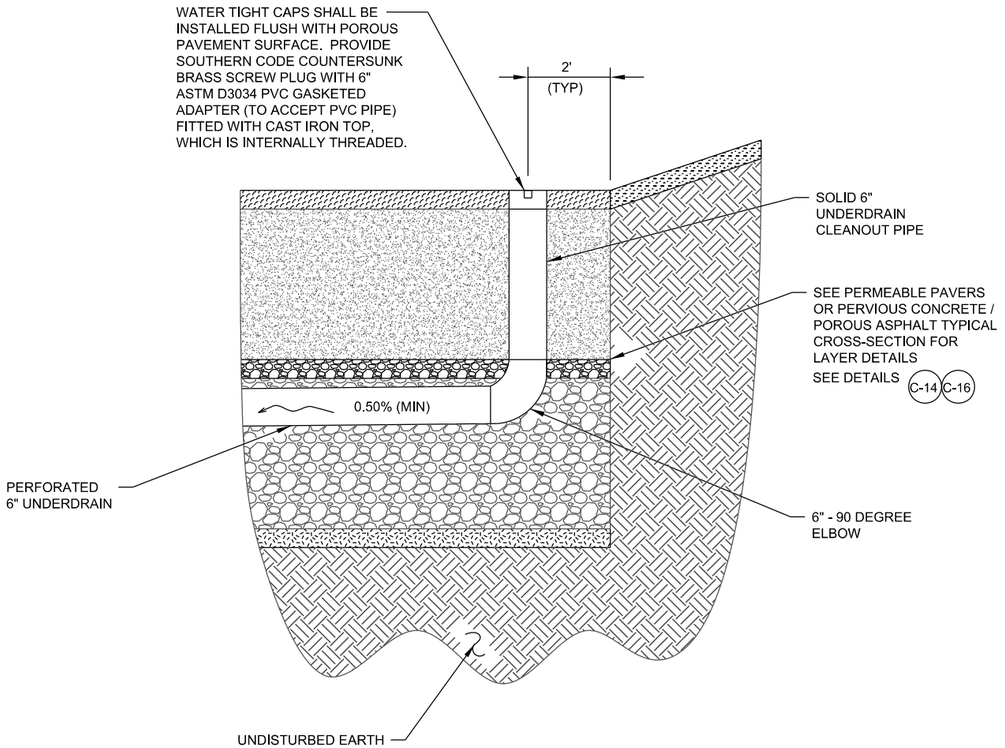
MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
PERVIOUS CONCRETE / POROUS ASPHALT TYPICAL CROSS-SECTION

DRAWING NO.: C-17
SHEET: 19
DATE: JULY, 2016
CONTRACT: M03064P21
MMSD FILE:



POROUS PAVEMENT CLEANOUT

DETAIL 6 / C-14 — 6 / C-16

NTS

FINAL

VERIFY SCALES
BAR IS ONE-HALF INCH ON ORIGINAL DRAWING
0" —— 0.5"
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DSGN HPK
DR PA ROEPER
CHK CJR
APVD JTL

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REV. NO.	DATE	REVISION DESCRIPTION	BY	APVD

MMSD PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

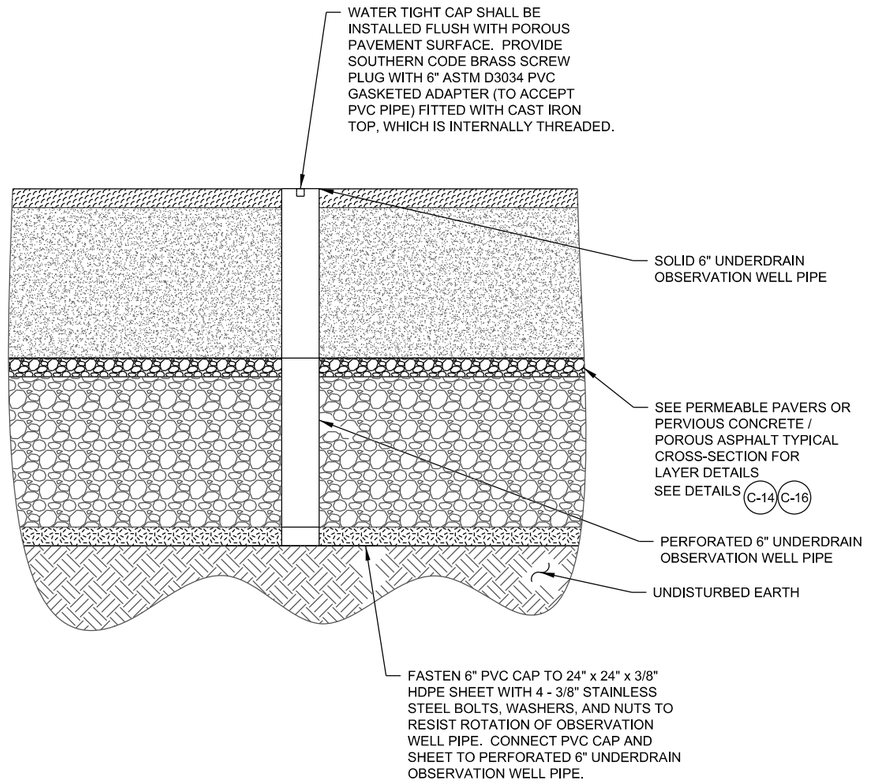
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
POROUS PAVEMENT CLEANOUT

DRAWING NO.:	C-18
SHEET:	20
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	

NOTE

1. ONE OBSERVATION WELL REQUIRED PER ACRE OF SURFACE AREA LOCATED IN CENTER OF AREA.



POROUS PAVEMENT OBSERVATION WELL

NTS

FINAL

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DSGN	HPK
DR	PA ROEPER
CHK	CJR
APVD	JTL

This Design Prepared For MMSD By:
STRAND ASSOCIATES®

REV. NO.	DATE	REVISION DESCRIPTION	BY	APVD

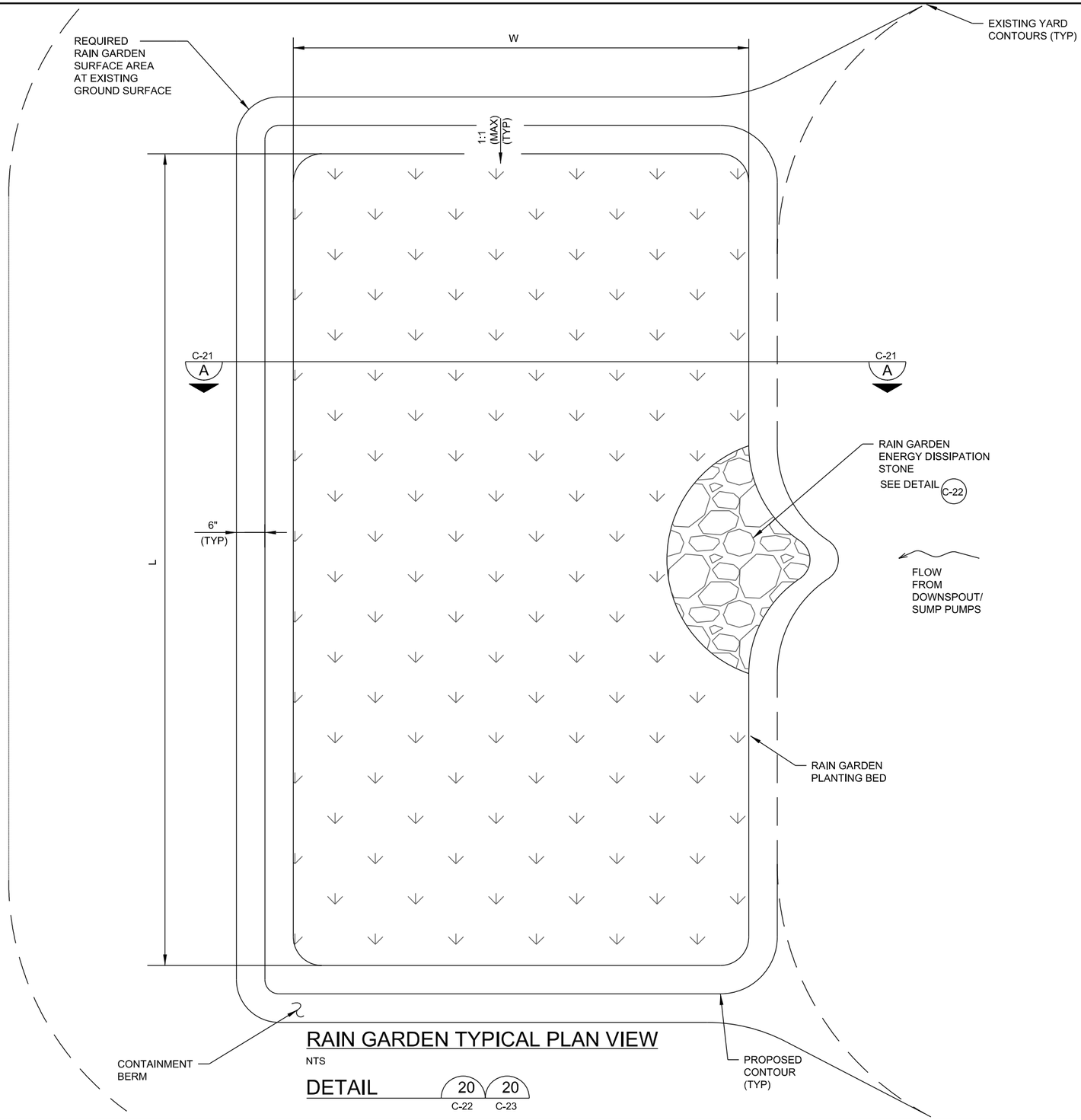
MMSD
PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
POROUS PAVEMENT OBSERVATION WELL

DRAWING NO.:	C-19
SHEET:	21
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



RAIN GARDEN TYPICAL PLAN VIEW

NTS

DETAIL 20 C-22 20 C-23

DIMENSION	DESCRIPTION	DISTANCE
L	PLANTED BED SURFACE LENGTH	X
W	PLANTED BED SURFACE WIDTH	X

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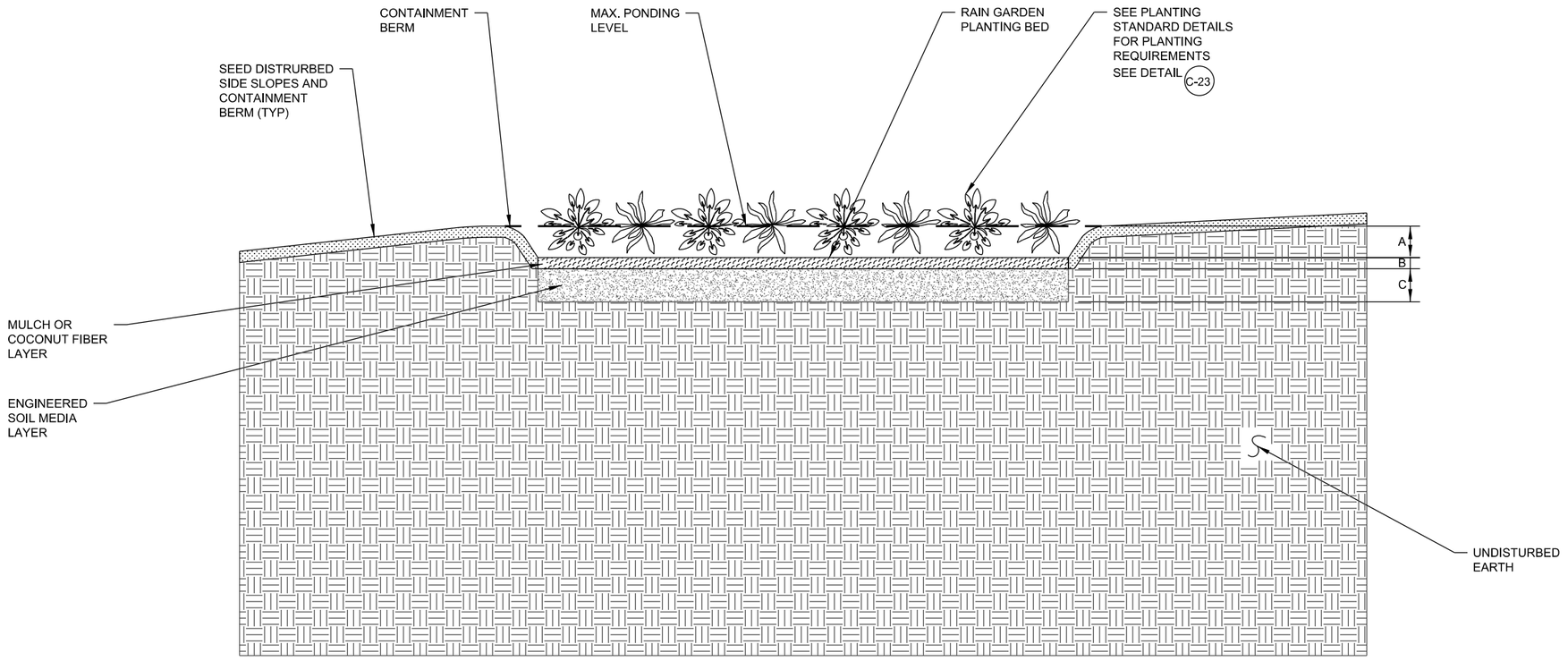
MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
RAIN GARDEN TYPICAL PLAN VIEW

DRAWING NO.:	C-20
SHEET:	22
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



DIMENSION	LAYER NAME	DEPTH
A	SURFACE PONDING	X
B	MULCH OR COCONUT FIBER	X
C	ENGINEERED SOIL MEDIA	X

RAIN GARDEN TYPICAL CROSS-SECTION

SECTION A
NTS C-20

DETAIL 21
C-22

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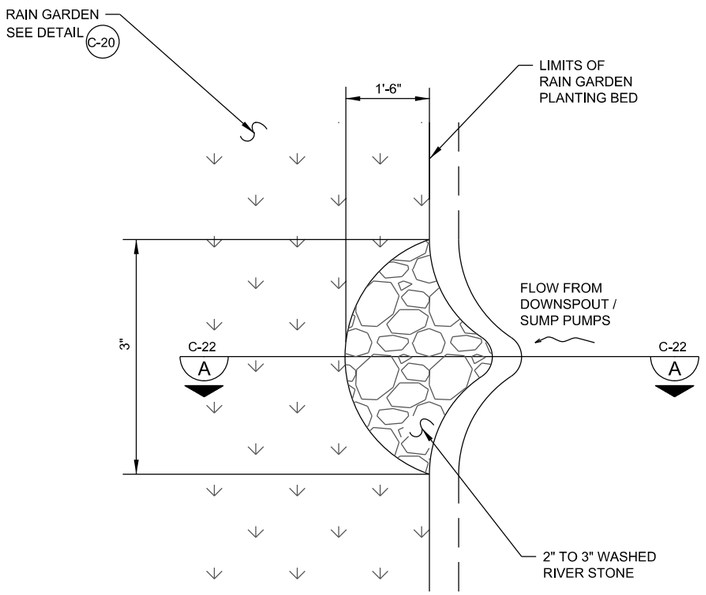
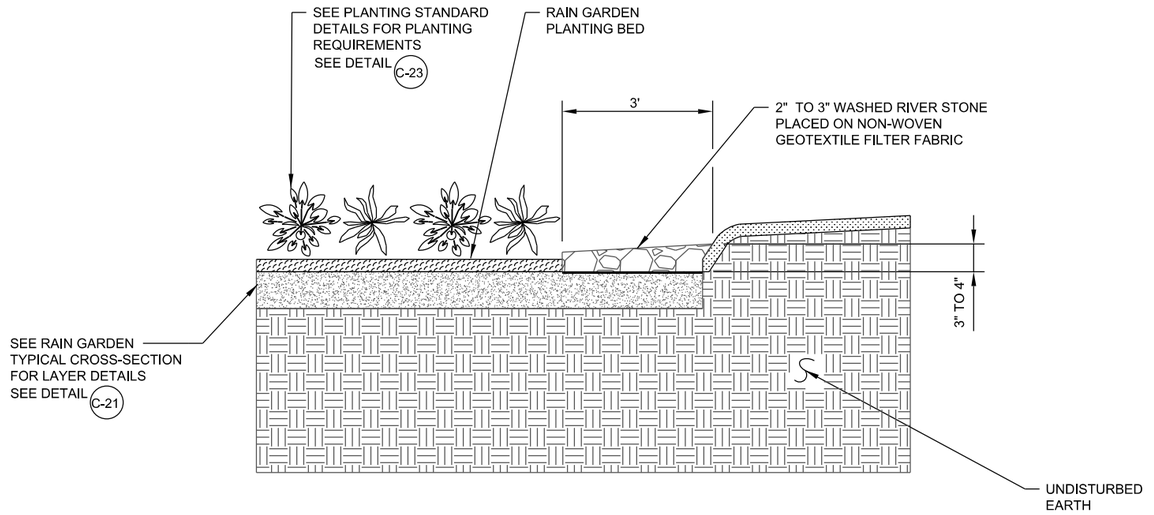
MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
RAIN GARDEN TYPICAL CROSS-SECTION

DRAWING NO.: C-21
SHEET: 23
DATE: JULY, 2016
CONTRACT: M03064P21
MMSD FILE:



PLAN VIEW



SECTION A

RAIN GARDEN ENERGY DISSIPATION STONE

NTS

DETAIL 22 C-20

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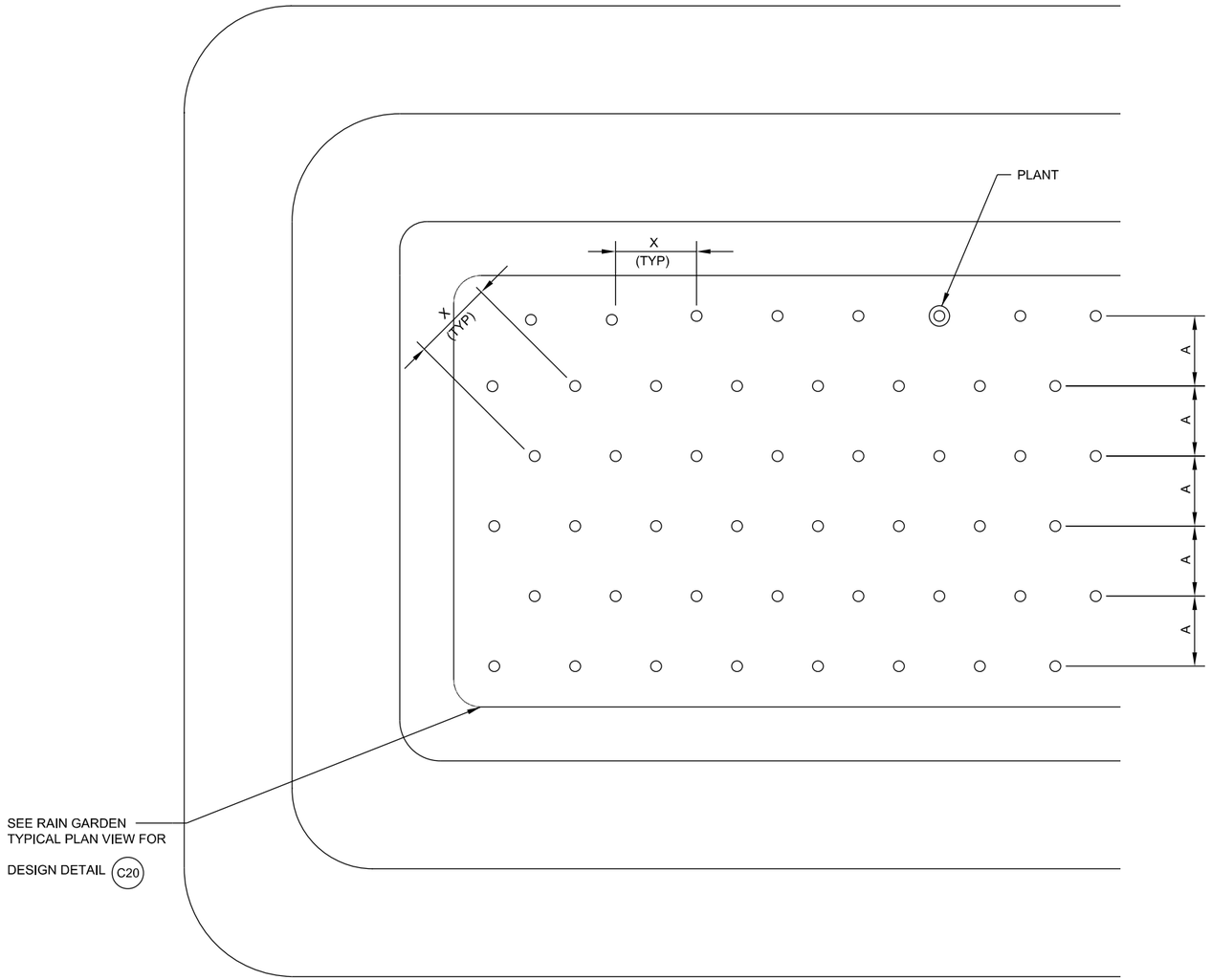
MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
RAIN GARDEN ENERGY DISSIPATION STONE

DRAWING NO.:	C-22
SHEET:	24
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



SPACING SCHEDULE	
SPACING "X" (SUGGESTED PLANT SPACING)	SPACING "A"
8" O.C.	7"
12" O.C.	10 1/2"
18" O.C.	15 1/2"
24" O.C.	20 3/4"
30" O.C.	26"
36" O.C.	31"
42" O.C.	36"
60" O.C.	52"

RAIN GARDEN
PLANT SPACING

DETAIL 23 C-21 23 C-22

NTS

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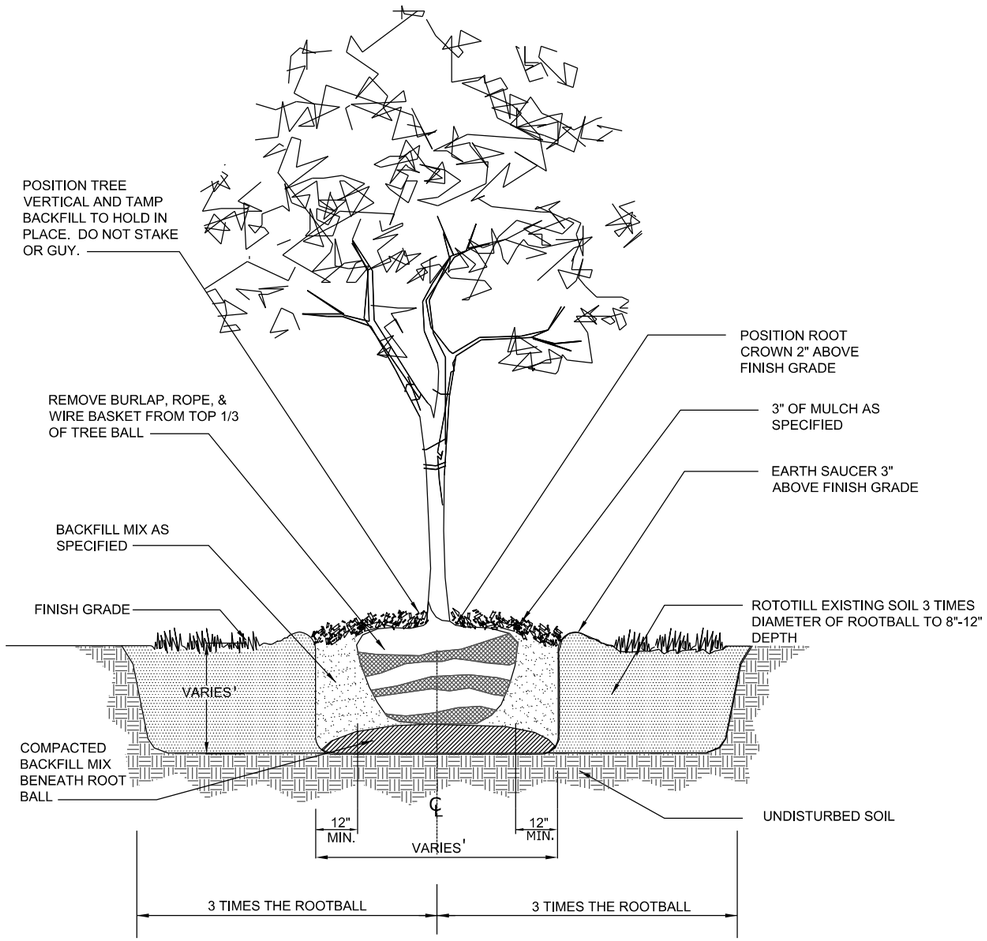
MMSD PARTNERS FOR A CLEANER ENVIRONMENT

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
RAIN GARDEN PLANT SPACING

DRAWING NO.:	C-23
SHEET:	25
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	



STORMWATER TREE DETAIL

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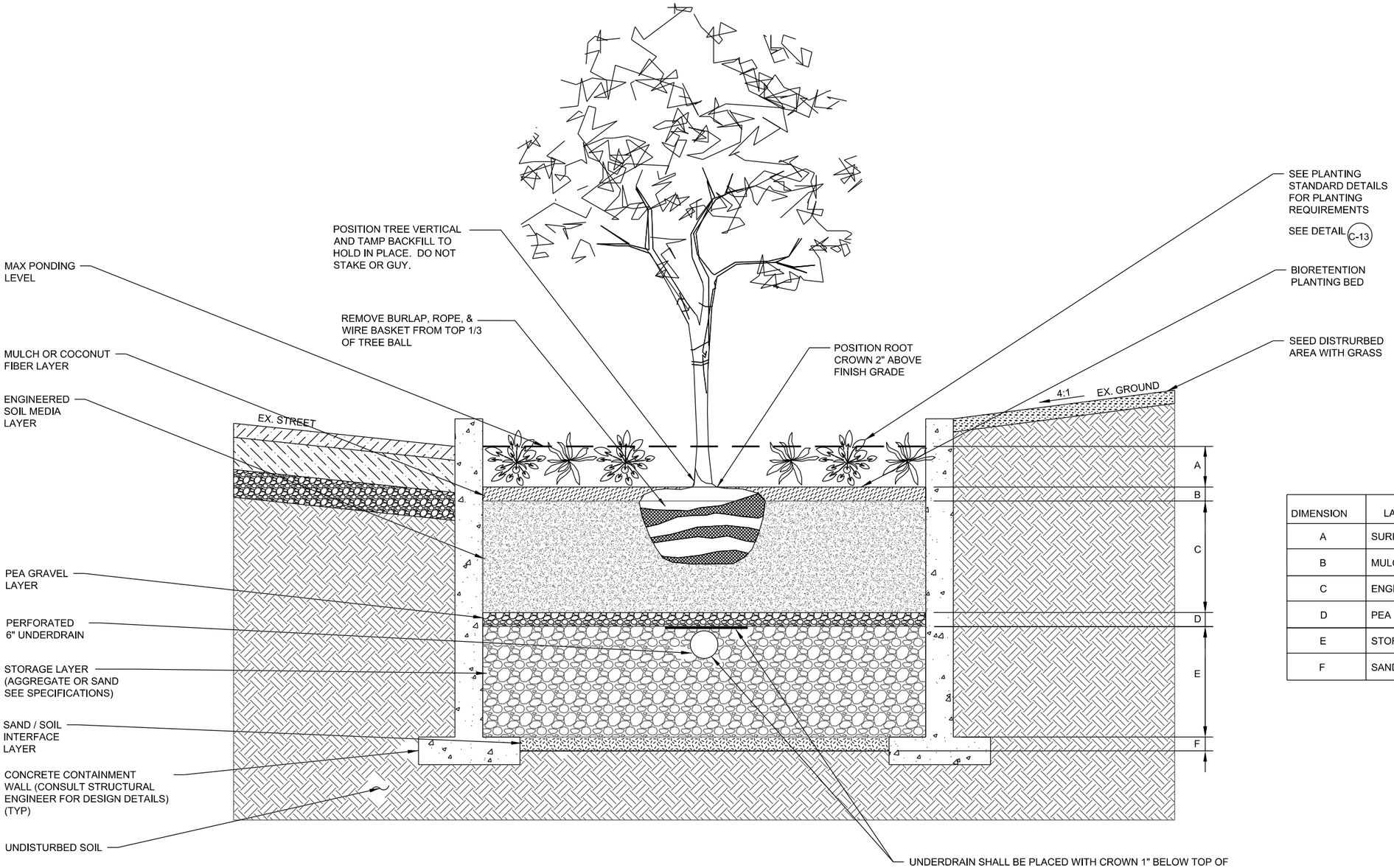

DIMENSION	LAYER NAME	DEPTH
A	SURFACE PONDING	X
B	MULCH OR COCONUT FIBER	X
C	ENGINEERED SOIL MEDIA	X
D	PEA GRAVEL	X
E	STORAGE	X
F	SAND/SOIL INTERFACE	X

STORMWATER TREE DETAIL IN BIORETENTION PLANTER

NTS

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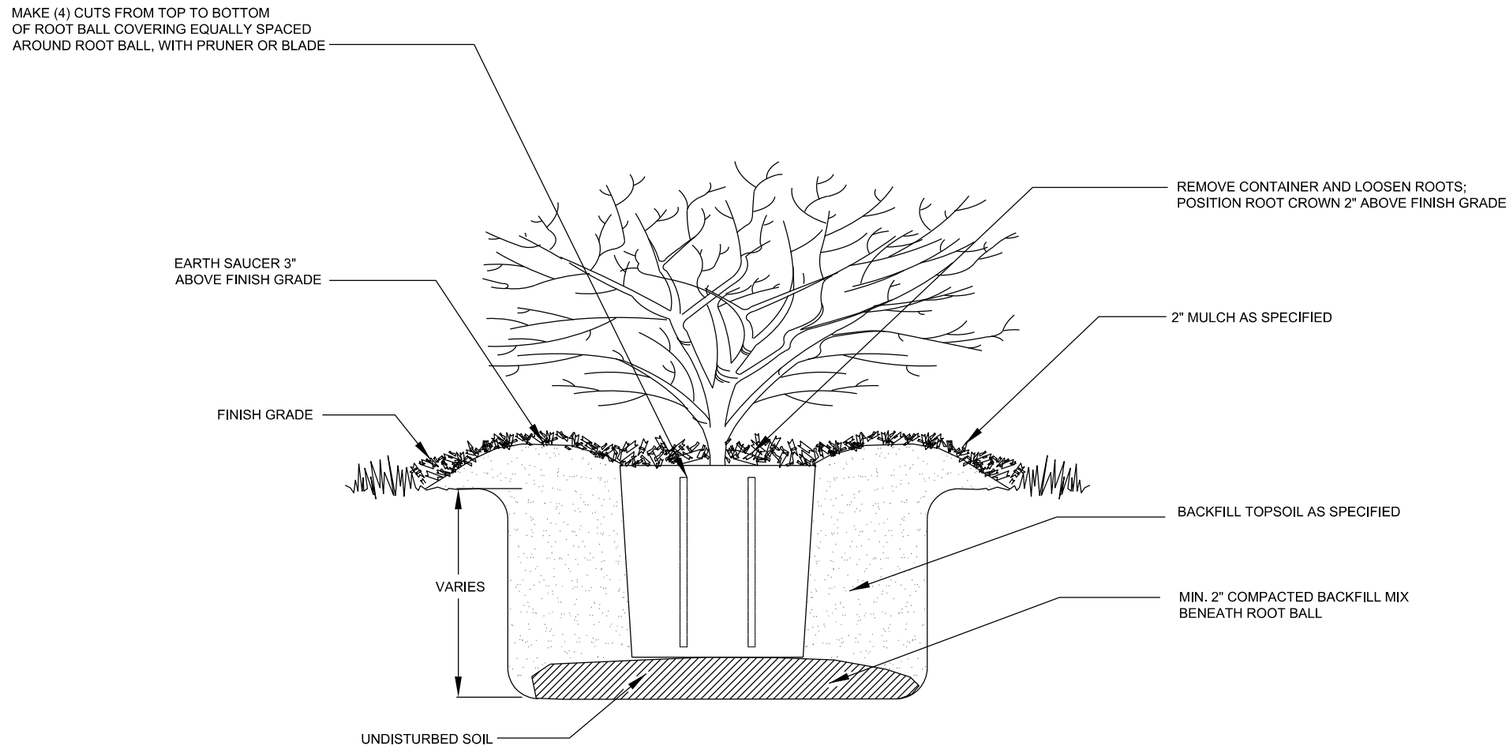
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
STORMWATER TREE DETAIL IN BIORETENTION PLANTER

DRAWING NO.: C-25
SHEET: 27
DATE: JULY, 2016
CONTRACT: M03064P21
MMSD FILE:



NATIVE LANDSCAPING DETAIL

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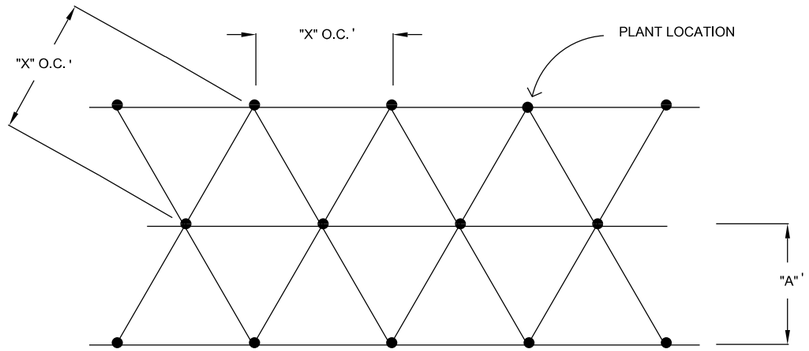
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES
CIVIL
NATIVE LANDSCAPING DETAIL

DRAWING NO.:	C-26
SHEET:	28
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	XXX-XXX.dgn



SPACING SCHEDULE	
SPACING "X"	ROW "A"
9" O.C.	7 3/4"
12" O.C.	10 1/2"
18" O.C.	15 1/2"
24" O.C.	20 3/4"
30" O.C.	26"
36" O.C.	30"
4' O.C.	3'-6"
5' O.C.	4'-4"

NATIVE LANDSCAPING SPACING

NTS

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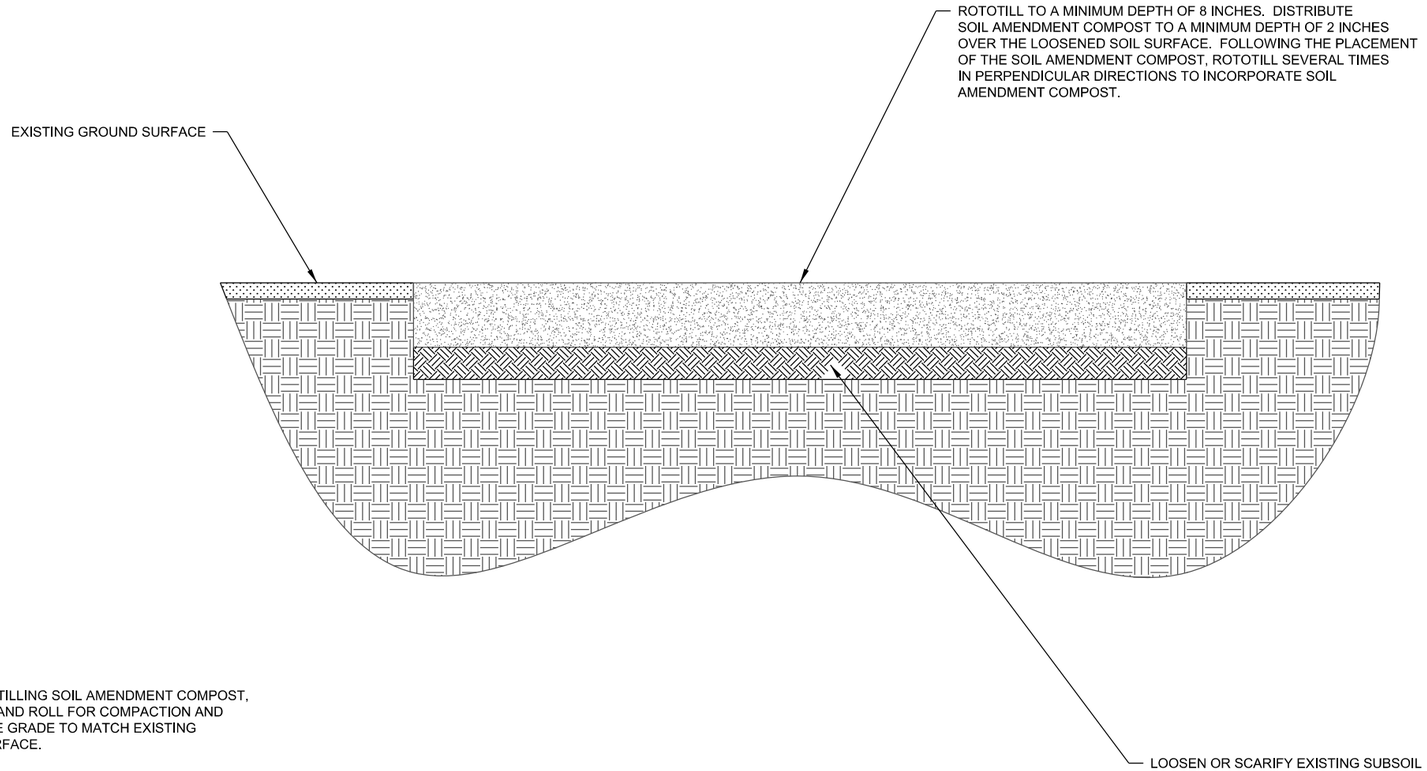
WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
NATIVE LANDSCAPING SPACING

DRAWING NO.:	C-27
SHEET:	29
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	XXX-XXX.dgn



NOTE

1. AFTER ROTOTILLING SOIL AMENDMENT COMPOST, WATER OR HAND ROLL FOR COMPACTION AND RAKE TO FINE GRADE TO MATCH EXISTING GROUND SURFACE.

SOIL AMMENDMENT TYPICAL CROSS-SECTION

NTS

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MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

WATERCOURSE
GREEN INFRASTRUCTURE STANDARD SPECIFICATIONS AND PLAN TEMPLATES

CIVIL
SOIL AMENDMENT TYPICAL CROSS-SECTION

DRAWING NO.:	C-28
SHEET:	30
DATE:	JULY, 2016
CONTRACT:	M03064P21
MMSD FILE:	

Appendix B

Specifications

02837 BIORETENTION / BIOSWALE GREEN INFRASTRUCTURE STRATEGY

[NTS: This specification is intended to be used as part of the Milwaukee Metropolitan Sewerage District's Green Solutions Program for implementation of green infrastructure strategies into Contract Documents by local municipalities or other entities. The specification is also intended to be used in conjunction with the Green Infrastructure Sizing Calculator and the Green Infrastructure Typical Details developed for the Green Solutions Program. The specification is considered to be a technical guidance document to assist users with the design of green infrastructure strategies. It is the responsibility of the local municipality or design engineer to make revisions to the specification as needed for specific design projects. It is recommended the documents are reviewed by a licensed professional engineer before releasing for construction. Note that the specification was last updated by the District in 2016.]

A. SCOPE

This Section covers the work necessary to furnish and install bioretention / bioswale green infrastructure strategies, including the engineered soil media layer, surface mulch layer or coconut fiber mat, stormwater storage layer, underdrain piping, cleanouts, observation wells, anti-seep collar, and overflow structures.

1. GENERAL

[NTS: Update language of this Section as necessary based on applicable references to front-end specifications.]

See CONDITIONS OF THE CONTRACT, and Division 1, GENERAL REQUIREMENTS, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

2. RELATED WORK

[NTS: The list below may not be fully inclusive depending upon the specifics of each individual project. Update language of this Section as necessary based on applicable references to other technical specification sections.]

The applicable requirements, materials and workmanship specified in the following Sections are included by reference in this Section. The list below is from the Wisconsin Department of Transportation (WisDOT) Standards and Specifications for Highway and Structure Construction, latest edition.

Section 201 Clearing and Grubbing
Section 205 Roadway and Drainage Excavation
Section 501 Concrete
Section 601 Concrete Curb and Gutter
Section 602 Concrete Sidewalks
Section 611 Catch Basins, Manholes, and Inlets
Section 612 Underdrains

Section 627 Mulching
Section 628 Erosion Control
Section 630 Seeding
Section 631 Sodding
Section 645 Geotextile Fabrics

The following specification as developed for the Milwaukee Metropolitan Sewerage District's Green Solutions Program may also include related work.

Section 02840 Exterior Plants (Native Landscaping and Stormwater Trees)

3. SUBMITTALS

a. SUBMITTALS REQUIRED PRIOR TO BID OPENING

Prebid approval of materials is not required. Suppliers and products have been identified as a means of establishing quality, but not for purposes of limiting competition.

b. SUBMITTALS DURING CONSTRUCTION

[NTS: Update language of this Section as necessary based on applicable references to front-end specifications.]

Submittals during construction shall be made in accordance with Section 01300 in Division 1, GENERAL REQUIREMENTS. In addition, the following specific information shall be provided:

1. CONTRACTOR's Qualifications: CONTRACTOR shall submit information showing conformance with qualification requirements listed in specifications. Submit CONTRACTOR Qualifications to OWNER for review prior Notice to Proceed.

2. Engineered Soil Media Mixture Analysis: CONTRACTOR shall submit soil analysis by a qualified soil-testing laboratory showing conformance with engineered soil media mixture specifications. Submit soil analysis to OWNER for review and approval prior to installation.

3. Engineered Soil Media Infiltration Test: CONTRACTOR shall conduct and submit results of an on-site infiltration test of the engineered soil media to ensure conformance with saturated hydraulic conductivity criteria. Using 5 cubic yards of the prepared engineered soil media, CONTRACTOR shall place the material on site at the proper location and depth, allow for proper settlement of the engineered soil media, and conduct an infiltration test using a double-ring infiltrometer in accordance with ASTM D3385. Submit

infiltration test results to OWNER for review and approval prior to installation of the remaining engineered soil media.

4. Surface Mulch: CONTRACTOR shall submit 1/2 lb. of mulch sample placed in labeled plastic bag as well as shop drawings of materials showing conformance with specifications. Submit sample and shop drawings to OWNER for review and approval prior to installation.

5. Storage Layer: CONTRACTOR shall submit sieve analysis by a qualified testing laboratory showing conformance with specifications. Submit sieve analysis to OWNER for review and approval prior to installation.

6. Underdrain Piping: CONTRACTOR shall submit shop drawings of underdrain piping showing conformance with specifications. Submit shop drawings to OWNER for review and approval prior to installation.

7. Overflow Structure: CONTRACTOR shall submit shop drawings of overflow structure showing conformance with specifications. Submit shop drawings to OWNER for review and approval prior to installation.

8. Anti-Seep Collar: CONTRACTOR shall submit soil analysis by a qualified soil-testing laboratory showing conformance with anti-seep collar specifications. Submit soil analysis to OWNER for review and approval prior to installation.

9. Geotextile Filter Fabric: CONTRACTOR shall submit shop drawings of geotextile filter fabric showing conformance with specifications. Submit shop drawings to OWNER for review and approval prior to installation.

4. DEPARTURES FROM PLANS AND SPECIFICATIONS

Submit in writing to the OWNER for review, details of any proposed departures from these Contract Documents, and the reasons therefor. Submit such requests as soon as practicable after the Notice to Proceed. Make no such departures without prior written acceptance of the OWNER.

5. SHOP DRAWINGS, MATERIAL REVIEW AND SAMPLES

a. Engineered Soil Media Mixture Analysis

b. Engineered Soil Media Infiltration Test

c. Surface Mulch or Coconut Fiber Mat

d. Storage Layer

e. Underdrain Piping

f. Overflow Structure

g. Geotextile Filter Fabric

6. CONTRACTOR QUALIFICATIONS

The CONTRACTOR shall have five years' experience (minimum) and shall have completed green infrastructure work similar in material, design, and extent to that indicated for this Project. CONTRACTOR must provide five or more successful installations of green infrastructure projects.

7. TOLERANCES

Tolerances for bioretention / bioswale green infrastructure strategy construction and materials shall conform to the requirements hereinafter specified. The finished surface elevation of the bioretention / bioswale green infrastructure strategy shall be within 0.10 feet (+/-) of the finished surface elevation as specified in the drawings.

B. MATERIALS

1. GENERAL

All bioretention / bioswale green infrastructure strategies shall meet the requirements of the following specifications. The OWNER reserves the right to take samples of materials whenever deemed necessary.

2. ENGINEERED SOIL MEDIA

The engineered soil media shall conform to the following specifications:

a. The engineered soil media mixture shall consist of a mixture of 70% to 85% sand and 15% to 30% compost. The percentages are based on volume. Special attention should be given to plant selection when the percentage of sand exceeds 75%.

b. The sand component of the engineered soil media shall meet one of the following gradation requirements:

1. USDA Coarse Sand (.02 - .04 inches).
2. ASTM C33 (Fine Aggregate Concrete Sand).
3. Wisconsin Standards and Specifications for Highway and Structure

Construction, Section 501.2.5.3.4. (Fine Aggregate Concrete Sand) latest edition, or an equivalent as approved by the OWNER. The sand shall meet the following gradation requirements:

Sieve Size	Percent Passing by Weight
3/8-inch	100
No. 4	90 to 100
No. 16	45 to 85
No. 50	5 to 30
No. 100	0 to 10

The preferred sand component consists of mostly $Si0_2$, but sand consisting of dolomite or calcium carbonate may also be used. Manufactured sand or stone dust is not allowed. The sand shall be washed and drained to remove clay and silt particles prior to mixing.

c. The compost component of the engineered soil media shall meet the requirements of Wisconsin Department of Natural Resources Specification S100, Compost, as follows:

1. Particle Size – 98% of the compost shall pass through a 0.75-inch screen.
2. Physical Contaminants – Less than 1% combined glass, metal and plastic.
3. Organic Matter/Ash Content – At least 40% organic matter; less than 60% ash content.
4. Carbon to Nitrogen Ratio – 10-20:1 C:N ratio.
5. pH – Between 6 and 8.
6. Soluble Salt – Electrical conductivity below 10 dS m^{-1} (mmhos cm^{-1})
7. Moisture Content – Between 35% and 50% by weight.
8. Maturity – The compost shall be resistant to further decomposition and free of compounds, such as ammonia and organic acids, in concentrations toxic to plant growth.
9. Residual Seeds & Pathogens – Pathogens and noxious seeds shall be minimized.
10. Pathogens – The compost shall meet the Class A requirements for pathogens as specified in s. NR 204.07(6)(a), Wis. Adm. Code.
11. Other Chemical Contaminants – The compost shall meet the high quality pollutant concentrations as specified in s. NR 204.07(5)(c), Wis. Adm. Code.

d. The engineered soil media mixture shall be free of rocks, stumps, roots, brush or other material over 1 inch in diameter. No other materials shall be mixed with the planting soil that may be harmful to plant growth or prove a hindrance to planting or maintenance.

e. The engineered soil media mixture shall have a pH between 5.5 and 8.0.

f. The engineered soil media mixture shall have adequate nutrient content to meet plant growth requirements.

g. The saturated hydraulic conductivity of the engineered soil media mixture shall be 6 to 10 inches per hour tested in accordance with ASTM F1815. The total porosity shall be 35% to 55% and the moisture holding capacity shall be 15% to 25%. Conduct infiltration test to ensure soil mix meets the saturated hydraulic conductivity criteria.

3. SURFACE MULCH LAYER / COCONUT FIBER MAT

Shredded hardwood mulch or chips, aged a minimum of 12 months, or a Class II erosion control mat (blanket) made of coconut fibers shall be placed on the surface of the bioretention / bioswale area. The shredded hardwood mulch or chips shall be 2 to 3 inches in depth and the mat shall be overlapped, and anchored with hardwood stakes (6 inches or longer to hold the mat to the media). The use of an erosion control mat shall also be placed over the hardwood mulch to prevent the mulch from floating, at least until dense vegetation is established. The mulch shall be free of foreign material, including other plant material.

4. STORAGE LAYER

The storage layer below the engineered soil media is intended for temporary storage of stormwater runoff and required when the infiltration rate of the native soil is less than 3.6 inches/hour. The storage layer shall consist of either gravel or sand that shall conform to the following specifications:

a. The gravel shall be a well-graded coarse aggregate that meets the coarse aggregate specifications of Wisconsin Standards and Specifications for Highway and Structure Construction, Section 501.2.5, latest edition, or an equivalent as approved by the OWNER. Gravel shall be double-washed. The aggregate shall be sized in accordance with AASHTO No. 4 aggregate (size number according to AASHTO M43) to meet the following gradation requirements:

Sieve Size	Percent Passing by Weight
2-inch	100
1 1/2-inch	90 to 100
1-inch	20 to 55
3/4-inch	0 to 15
3/8-inch	0 to 5

b. The sand shall meet the same requirements specified above in the Engineered Soil Media materials section for sand.

5. SAND/NATIVE SOIL INTERFACE LAYER

A sand/native soil interface layer is required when the design infiltration rate of the native soil is less than 3.6 inches per hour as determined using WDNR Technical Standard 1002, "Site Evaluation for Stormwater Infiltration." The sand/native soil interface layer shall conform to the following specifications:

a. 3 inches of sand shall be placed below the storage layer, and vertically mixed with the native soil interface to a depth of 2-4 inches.

b. The sand shall meet the same requirements specified above in the Engineered Soil Media materials section for sand.

6. UNDERDRAIN PIPING

The underdrain pipe shall conform to the following specifications:

a. The underdrain pipe shall have a minimum diameter of 6 inches and be made of SDR-35 PVC or other material approved by the OWNER. The pipe shall be capable of withstanding expected traffic loads over portions of the pipe extending beyond the soil planting bed.

b. The underdrain orifice shall be restricted as necessary so that the design infiltration rate plus the underdrain rate equals the design draw down rate. The restriction shall be achieved by using an adjustable restrictor plate or valve. The restriction device shall be accessible for adjustment.

c. The total opening area of all perforation holes combined shall be sufficient to allow the underdrain pipe to discharge at full capacity, as would occur if there were no orifice restriction. The amount of perforations shall be increased to provide a margin of safety but shall not be so great as to compromise structural integrity of the pipe material. The size of the perforations shall be small enough to prevent surrounding aggregate material from traveling through the perforations. A minimum of three rows of perforations shall be used.

d. The underdrain pipe shall be protected from clogging by use of a filter fabric or filter sock. If the storage layer is sand, a filter sock shall be used. A cover of pea gravel may also be used. The pea gravel, filter fabric, and filter sock shall conform to the following specifications:

1. Pea gravel - If used, the pea gravel layer shall be at least 4 inches thick. Pea gravel shall be washed. Pea gravel shall be large enough to prevent its falling through the perforations of the underdrain pipe. The pea gravel shall be sized in accordance with AASHTO No. 8 aggregate (size number according to AASHTO M43) to meet the following gradation requirements:

Sieve Size	Percent Passing by Weight
1/2-inch	100
3/8-inch	85 to 100
No. 4	10 to 30
No. 8	0 to 10
No. 16	0 to 5

2. Filter fabric - Filter fabric shall cover the underdrain pipe and shall not extend laterally from either side of the pipe more than two feet. The fabric shall meet the specifications of Wisconsin Standards and Specifications for Highway and Structure Construction, Section 645.2.4, Schedule Test B, latest edition, or an equivalent approved by the OWNER.

3. Filter sock - A filter sock shall only be used to protect the underdrain pipe when a sand storage layer is used. A filter sock is not permitted when an aggregate storage layer is used. The openings in the fabric shall be small enough to prevent sand particles from entering the underdrain pipe. The flow rate of the fabric shall be capable of passing water at a rate equal to or greater than the flow rate capacity of the total combined perforations in the underdrain pipe. In addition, the fabric shall meet the other requirements of Wisconsin Standards and Specifications for Highway and Structure Construction, Section 612.2.8(1-3), latest edition, or an equivalent approved by the OWNER.

e. The underdrain pipe shall have a vertical, connecting standpipe to serve as a clean-out port for the underdrain pipe. The pipe shall be rigid, non-perforated SDR-35 PVC pipe, a minimum of 6 inches in diameter and covered with a watertight cap that is 3 inches above the finished surface elevation of the bioretention device.

7. OBSERVATION WELLS

If there is no underdrain, one or more observation wells shall be installed to monitor drainage from the bioretention / bioswale green infrastructure strategy. The observation wells shall conform to the following specifications:

a. The observation well shall be a minimum 6 inch diameter slotted SDR 35 PVC pipe from the bottom of the sand soil interface layer to the top of the storage layer and then solid wall PVC pipe from the top of the storage layer to 3 inches above the maximum ponding depth, anchored vertically to a footplate at the bottom of the bioretention device. The top of the pipe shall be high enough to prevent the entry of water ponded within the infiltration device bed.

b. Foot plate shall be 24 inch by 24 inch by 3/8 inch thick HDPE sheet with PVC cap to match dimension of the observation well pipe and shall be anchored to the HDPE sheet with four 3/8 inch stainless steel bolts and washers to prevent movement and rotation. Observation well PVC pipe shall be connected to PVC cap in accordance with manufacturer's recommendations.

c. The observation well shall have a secured aboveground cap.

8. OVERFLOW STRUCTURE

The overflow structure shall conform to the following specifications:

a. The overflow structure shall be either a weir or standpipe to regulate the maximum ponding depth on the surface of the bioretention / bioswale green infrastructure strategy. The invert of the overflow structure shall be at the elevation of the maximum ponding depth of the bioretention / bioswale strategy.

b. The overflow structure standpipe shall consist of a vertical standpipe connected to the underdrain. The pipe shall be rigid, non-perforated SDR-35 PVC pipe, a minimum of 6 inches in diameter. The maximum elevation of the top of the overflow structure standpipe shall match the maximum ponding elevation. The top opening shall be fitted with a minimum 6 inch dome grate.

9. ANTI-SEEP COLLAR

Anti-seep collar consisting of compacted clay material shall be installed at all locations where underdrain piping or storm sewer conveyance systems leave a bioretention / bioswale green infrastructure strategy to prevent groundwater from flowing through the bedding material of the underdrain piping or storm sewer conveyance system. Anti-seep collar shall extend from the bottom of the trench excavation to within 6 inches of the ground surface and 1 foot beyond the normal trench width on both sides of the trench. Material for clay bedding dike shall be classified as either CH or CL according to the Unified Soil Classification System with minimal sand content.

C. <u>WORKMANSHIP</u>

1. CONSTRUCTION SITE STABILIZATION

a. CONTRACTOR shall not construct bioretention / bioswale strategies until all of the contributing drainage areas are stabilized to the satisfaction of the OWNER. Do not use the bioretention / bioswale strategies as temporary sediment control facilities during construction. It is the responsibility of the CONTRACTOR to sequence the construction of the bioretention / bioswale

strategies in a manner such to prevent sediment from entering the bioretention / bioswale strategies as a result of construction activities.

b. Construction site runoff from disturbed areas shall not be allowed to enter the bioretention / bioswale strategies. CONTRACTOR shall use sediment control measures as necessary to prevent construction site runoff from entering the bioretention / bioswale strategies. Sediment control measures indicated on design drawings are not intended to limit the CONTRACTOR in the manner and techniques to control erosion. It is the responsibility of the CONTRACTOR to control erosion from this site during construction.

c. Sediment that enters the bioretention / bioswale strategies during construction as a result of construction activities shall be removed by the CONTRACTOR at no cost to the OWNER. In circumstances where, in the opinion of the OWNER, sediment significantly impacts the functionality of the underdrains, backfill materials, engineered soil media, or plantings, these items shall be completely replaced by the CONTRACTOR at no cost to the OWNER.

d. CONTRACTOR shall not store any equipment or materials within the perimeter of the bioretention / bioswale engineered soil media area.

2. SUITABLE WEATHER

a. Construction of the bioretention / bioswale strategies shall be suspended during periods of rainfall or snowmelt. Construction shall remain suspended if ponded water is present or if residual soil moisture contributes significantly to the potential for clumping or other forms of compaction within the bioretention / bioswale strategies. CONTRACTOR shall inspect and maintain all sediment control measures protecting both the bioretention / bioswale strategies and the entire project site following periods of rainfall or snowmelt.

3. COMPACTION AVOIDANCE

a. Compaction and smearing of the soils beneath the floor and side slopes of the bioretention / bioswale area, and compaction of the soils used for backfill in the soil planting bed, shall be minimized. During site development, the area dedicated to the bioretention / bioswale area shall be cordoned off to prevent access by heavy equipment. Acceptable equipment for constructing the bioretention / bioswale strategy includes excavation hoes, light equipment with turf type tires, marsh equipment or wide-track loaders.

b. If compaction occurs at the base of the bioretention / bioswale strategy, the soil shall be refractured to a depth of at least 12 inches. If smearing occurs, the smeared areas of the interface shall be corrected by raking or roto-tilling.

Refracturing shall not be used by CONTRACTOR in lieu of proper compaction avoidance techniques.

4. PLACEMENT AND SETTLING OF ENGINEERED SOIL MIXTURE

a. Placement and Settling of Engineered Soil - The following apply:

1. Prior to placement in the bioretention / bioswale strategy, the engineered soil mixture shall be premixed and the moisture content shall be low enough to prevent clumping and compaction during placement. OWNER shall review the bioretention soil mixture upon completion of premixing and before delivery to the site. No onsite mixing of soils shall be allowed. Only approved tested material shall be delivered to the site.
2. The engineered soil mixture shall be placed in multiple lifts, each approximately 12 inches in depth.
3. As approved by OWNER, steps may be taken to induce mild settling of the engineered soil bed as needed to prepare a stable planting medium and to stabilize the ponding depth. Vibrating plate-style compactors shall not be used to induce settling.
4. The entire soil planting bed shall be mulched prior to planting vegetation to help prevent compaction of the planting soil during the planting process. Mulch shall be pushed aside for the placement of each plant.

5. NOTIFICATION

a. CONTRACTOR shall notify OWNER following the excavation of bioretention / bioswale strategies, prior to installation of underdrains, backfill materials, and engineered soil media. CONTRACTOR shall only proceed with the installation of underdrains, backfill materials, and engineered soil media with approval of the OWNER.

D. PAYMENT

Except as noted otherwise hereinafter payment for the work in this Section will be based on the quantities and unit bid prices for each of the individual bid items for the bioretention / bioswale green infrastructure strategy. Payment will be made at the unit prices stated in the Bid. The unit prices shall constitute full compensation for all labor, equipment, materials, and incidentals necessary for the satisfactory completion of the work.

* * * * * *

02838 RAIN GARDEN GREEN INFRASTRUCTURE STRATEGY

[NTS: This specification is intended to be used as part of the Milwaukee Metropolitan Sewerage District's Green Solutions Program for implementation of green infrastructure strategies into Contract Documents by local municipalities or other entities. The specification is also intended to be used in conjunction with the Green Infrastructure Sizing Calculator and the Green Infrastructure Typical Details developed for the Green Solutions Program. The specification is considered to be a technical guidance document to assist users with the design of green infrastructure strategies. It is the responsibility of the local municipality or design engineer to make revisions to the specification as needed for specific design projects. It is recommended the documents are reviewed by a licensed professional engineer before releasing for construction. Note that the specification was last updated by the District in 2016.]

A. SCOPE

This Section covers the work necessary to furnish and install rain garden green infrastructure strategies, including the engineered soil media layer, surface mulch layer or coconut fiber mat, and energy dissipation stone.

1. GENERAL

[NTS: Update language of this Section as necessary based on applicable references to front-end specifications.]

See CONDITIONS OF THE CONTRACT, and Division 1, GENERAL REQUIREMENTS, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

2. RELATED WORK

[NTS: The list below may not be fully inclusive depending upon the specifics of each individual project. Update language of this Section as necessary based on applicable references to other technical specification sections.]

The applicable requirements, materials and workmanship specified in the following Sections are included by reference in this Section. The list below is from the Wisconsin Department of Transportation (WisDOT) Standards and Specifications for Highway and Structure Construction, latest edition.

Section 201 Clearing and Grubbing
Section 205 Roadway and Drainage Excavation
Section 627 Mulching
Section 628 Erosion Control
Section 630 Seeding
Section 631 Sodding

The following specification as developed for the Milwaukee Metropolitan Sewerage

District's Green Solutions Program may also include related work.

Section 02840 Exterior Plants (Native Landscaping and Stormwater Trees)

3. SUBMITTALS

a. SUBMITTALS REQUIRED PRIOR TO BID OPENING

Prebid approval of materials is not required. Suppliers and products have been identified as a means of establishing quality, but not for purposes of limiting competition.

b. SUBMITTALS DURING CONSTRUCTION

[NTS: Update language of this Section as necessary based on applicable references to front-end specifications.]

Submittals during construction shall be made in accordance with Section 01300 in Division 1, GENERAL REQUIREMENTS. In addition, the following specific information shall be provided:

1. CONTRACTOR's Qualifications: CONTRACTOR shall submit information showing conformance with qualification requirements listed in specifications. Submit CONTRACTOR Qualifications to OWNER for review prior Notice to Proceed.

2. Engineered Soil Media Mixture Analysis: CONTRACTOR shall submit soil analysis by a qualified soil-testing laboratory showing conformance with engineered soil media mixture specifications. Submit soil analysis to OWNER for review and approval prior to installation.

3. Engineered Soil Media Infiltration Test: CONTRACTOR shall conduct and submit results of an on-site infiltration test of the engineered soil media to ensure conformance with saturated hydraulic conductivity criteria. Using 5 cubic yards of the prepared engineered soil media, CONTRACTOR shall place the material on site at the proper location and depth, allow for proper settlement of the engineered soil media, and conduct an infiltration test using a double-ring infiltrometer in accordance with ASTM D3385. Submit infiltration test results to OWNER for review and approval prior to installation of the remaining engineered soil media.

4. Surface Mulch: CONTRACTOR shall submit 1/2 lb. of mulch sample placed in labeled plastic bag as well as shop drawings of materials showing conformance with specifications. Submit sample and shop drawings to OWNER for review and approval prior to

installation.

5. Energy Dissipation Stone: CONTRACTOR shall submit sieve analysis by a qualified testing laboratory showing conformance with specifications. Submit sieve analysis to OWNER for review and approval prior to installation.

4. DEPARTURES FROM PLANS AND SPECIFICATIONS

Submit in writing to the OWNER for review, details of any proposed departures from these Contract Documents, and the reasons therefor. Submit such requests as soon as practicable after the Notice to Proceed. Make no such departures without prior written acceptance of the OWNER.

5. SHOP DRAWINGS, MATERIAL REVIEW AND SAMPLES

a. Engineered Soil Media Mixture Analysis

b. Engineered Soil Media Infiltration Test

c. Surface Mulch or Coconut Fiber Mat

d. Energy Dissipation Stone

6. CONTRACTOR QUALIFICATIONS

The CONTRACTOR shall have five years' experience (minimum) and shall have completed green infrastructure work similar in material, design, and extent to that indicated for this Project. CONTRACTOR must provide five or more successful installations of green infrastructure projects.

7. TOLERANCES

Tolerances for rain garden green infrastructure strategy construction and materials shall conform to the requirements hereinafter specified. The finished surface elevation of the rain garden green infrastructure strategy shall be within 0.10 feet (+/-) of the finished surface elevation as specified in the drawings.

B. MATERIALS

1. GENERAL

All rain garden green infrastructure strategies shall meet the requirements of the following specifications. The OWNER reserves the right to take samples of materials whenever deemed necessary.

2. ENGINEERED SOIL MEDIA

The engineered soil media shall conform to the following specifications:

a. The engineered soil media mixture shall consist of a mixture of 70% to 85% sand and 15% to 30% compost. The percentages are based on volume. Special attention should be given to plant selection when the percentage of sand exceeds 75%.

b. The sand component of the engineered soil media shall meet one of the following gradation requirements:

1. USDA Coarse Sand (.02 - .04 inches).
2. ASTM C33 (Fine Aggregate Concrete Sand).
3. Wisconsin Standards and Specifications for Highway and Structure Construction, Section 501.2.5.3.4. (Fine Aggregate Concrete Sand) latest edition, or an equivalent as approved by the OWNER. The sand shall meet the following gradation requirements:

Sieve Size	Percent Passing by Weight
3/8-inch	100
No. 4	90 to 100
No. 16	45 to 85
No. 50	5 to 30
No. 100	0 to 10

The preferred sand component consists of mostly $Si0_2$, but sand consisting of dolomite or calcium carbonate may also be used. Manufactured sand or stone dust is not allowed. The sand shall be washed and drained to remove clay and silt particles prior to mixing.

c. The compost component of the engineered soil media shall meet the requirements of Wisconsin Department of Natural Resources Specification S100, Compost, as follows:

1. Particle Size – 98% of the compost shall pass through a 0.75-inch screen.
2. Physical Contaminants – Less than 1% combined glass, metal and plastic.
3. Organic Matter/Ash Content – At least 40% organic matter; less than 60% ash content.
4. Carbon to Nitrogen Ratio – 10-20:1 C:N ratio.
5. pH – Between 6 and 8.
6. Soluble Salt – Electrical conductivity below 10 dS m^{-1} (mmhos cm^{-1})
7. Moisture Content – Between 35% and 50% by weight.
8. Maturity – The compost shall be resistant to further decomposition and free of compounds, such as ammonia and organic acids, in

concentrations toxic to plant growth.

9. Residual Seeds & Pathogens – Pathogens and noxious seeds shall be minimized.
10. Pathogens – The compost shall meet the Class A requirements for pathogens as specified in s. NR 204.07(6)(a), Wis. Adm. Code.
11. Other Chemical Contaminants – The compost shall meet the high quality pollutant concentrations as specified in s. NR 204.07(5)(c), Wis. Adm. Code.

d. The engineered soil media mixture shall be free of rocks, stumps, roots, brush or other material over 1 inch in diameter. No other materials shall be mixed with the planting soil that may be harmful to plant growth or prove a hindrance to planting or maintenance.

e. The engineered soil media mixture shall have a pH between 5.5 and 8.0.

f. The engineered soil media mixture shall have adequate nutrient content to meet plant growth requirements.

g. The saturated hydraulic conductivity of the engineered soil media mixture shall be 6 to 10 inches per hour tested in accordance with ASTM F1815. The total porosity shall be 35% to 55% and the moisture holding capacity shall be 15% to 25%. Conduct infiltration test to ensure soil mix meets the saturated hydraulic conductivity criteria.

3. SURFACE MULCH LAYER / COCONUT FIBER MAT

Shredded hardwood mulch or chips, aged a minimum of 12 months, or a Class II erosion control mat (blanket) made of coconut fibers shall be placed on the surface of the rain garden area. The shredded hardwood mulch or chips shall be 2 to 3 inches in depth and the mat shall be overlapped, and anchored with hardwood stakes (6 inches or longer to hold the mat to the media). The use of an erosion control mat shall also be placed over the hardwood mulch to prevent the mulch from floating, at least until dense vegetation is established. The mulch shall be free of foreign material, including other plant material.

4. ENERGY DISSIPATION STONE

The energy dissipation stone on the surface of the rain garden is intended to dissipate stormwater runoff flow coming directly from downspout disconnections or other points where concentrated flow enters the rain garden. The energy dissipation stone shall be a washed rounded river stone ranging in diameter between 2 and 3 inches, or an equivalent as approved by the OWNER.

C. WORKMANSHIP

1. CONSTRUCTION SITE STABILIZATION

a. CONTRACTOR shall not construct rain garden strategies until all of the contributing drainage areas are stabilized to the satisfaction of the OWNER. Do not use the rain garden strategies as temporary sediment control facilities during construction. It is the responsibility of the CONTRACTOR to sequence the construction of the rain garden strategies in a manner such to prevent sediment from entering the rain garden as a result of construction activities.

b. Construction site runoff from disturbed areas shall not be allowed to enter the rain garden areas. CONTRACTOR shall use sediment control measures as necessary to prevent construction site runoff from entering the rain garden areas. Sediment control measures indicated on design drawings are not intended to limit the CONTRACTOR in the manner and techniques to control erosion. It is the responsibility of the CONTRACTOR to control erosion from this site during construction.

c. Sediment that enters the rain garden areas during construction as a result of construction activities shall be removed by the CONTRACTOR at no cost to the OWNER. In circumstances where, in the opinion of the OWNER, sediment significantly impacts the functionality of the engineered soil media or plantings, these items shall be completely replaced by the CONTRACTOR at no cost to the OWNER.

d. CONTRACTOR shall not store any equipment or materials within the perimeter of the rain garden engineered soil media area.

2. SUITABLE WEATHER

a. Construction of the rain garden strategies shall be suspended during periods of rainfall or snowmelt. Construction shall remain suspended if ponded water is present or if residual soil moisture contributes significantly to the potential for clumping or other forms of compaction within the rain garden strategies. CONTRACTOR shall inspect and maintain all sediment control measures protecting both the rain garden strategies and the entire project site following periods of rainfall or snowmelt.

3. COMPACTION AVOIDANCE

a. Compaction and smearing of the soils beneath the floor and side slopes of the rain garden area, and compaction of the soils used for backfill in the soil planting bed, shall be minimized. During site development, the area dedicated to the rain garden area shall be cordoned off to prevent access by heavy equipment. Acceptable equipment for constructing the rain garden strategy includes excavation hoes, light equipment with turf type tires, marsh equipment or wide-track loaders.

b. If compaction occurs at the base of the rain garden strategy, the soil shall be

refractured to a depth of at least 12 inches. If smearing occurs, the smeared areas of the interface shall be corrected by raking or roto-tilling. Refracturing shall not be used by CONTRACTOR in lieu of proper compaction avoidance techniques.

4. PLACEMENT AND SETTLING OF ENGINEERED SOIL MIXTURE

a. Placement and Settling of Engineered Soil - The following apply:

1. Prior to placement in the rain garden strategy, the engineered soil mixture shall be premixed and the moisture content shall be low enough to prevent clumping and compaction during placement. OWNER shall review the engineered soil mixture upon completion of premixing and before delivery to the site. No onsite mixing of soils shall be allowed. Only approved tested material shall be delivered to the site.
2. As approved by OWNER, steps may be taken to induce mild settling of the engineered soil bed as needed to prepare a stable planting medium and to stabilize the ponding depth. Vibrating plate-style compactors shall not be used to induce settling.
3. The entire soil planting bed shall be mulched prior to planting vegetation to help prevent compaction of the planting soil during the planting process. Mulch shall be pushed aside for the placement of each plant.

5. NOTIFICATION

a. CONTRACTOR shall notify OWNER following the excavation of rain garden areas prior to installation of engineered soil media. CONTRACTOR shall only proceed with the installation of the engineered soil media with approval of the OWNER.

D. PAYMENT

Except as noted otherwise hereinafter payment for the work in this Section will be based on the quantities and unit bid prices for each of the individual bid items for the rain garden green infrastructure strategy. Payment will be made at the unit prices stated in the Bid. The unit prices shall constitute full compensation for all labor, equipment, materials, and incidentals necessary for the satisfactory completion of the work.

* * * * * *

02839 POROUS PAVEMENT GREEN INFRASTRUCTURE STRATEGY

[NTS: This specification is intended to be used as part of the Milwaukee Metropolitan Sewerage District's Green Solutions Program for implementation of green infrastructure strategies into Contract Documents by local municipalities or other entities. The specification is also intended to be used in conjunction with the Green Infrastructure Sizing Calculator and the Green Infrastructure Typical Details developed for the Green Solutions Program. The specification is considered to be a technical guidance document to assist users with the design of green infrastructure strategies. It is the responsibility of the local municipality or design engineer to make revisions to the specification as needed for specific design projects. It is recommended the documents are reviewed by a licensed professional engineer before releasing for construction. Note that the specification was last updated by the District in 2016.]

A. SCOPE

This Section covers the work necessary to furnish and install porous pavement green infrastructure strategies, including the porous pavement surface, bedding aggregate layer, base course aggregate layer, stormwater storage aggregate layer, underdrain piping, cleanouts, and observation wells.

1. GENERAL

[NTS: Update language of this Section as necessary based on applicable references to front-end specifications.]

See CONDITIONS OF THE CONTRACT, and Division 1, GENERAL REQUIREMENTS, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

2. RELATED WORK

[NTS: The list below may not be fully inclusive depending upon the specifics of each individual project. Update language of this Section as necessary based on applicable references to other technical specification sections.]

The applicable requirements, materials and workmanship specified in the following Sections are included by reference in this Section. The list below is from the Wisconsin Department of Transportation (WisDOT) Standards and Specifications for Highway and Structure Construction, latest edition.

Section 201 Clearing and Grubbing
Section 205 Roadway and Drainage Excavation
Section 301 General Requirements for Base Aggregates
Section 501 Concrete
Section 601 Concrete Curb and Gutter
Section 612 Underdrains
Section 628 Erosion Control

Section 645 Geotextile Fabrics

In addition to the WisDOT Standards and Specifications for Highway and Structure Construction, latest edition, the American Concrete Institute (ACI) Specification for Pervious Concrete Pavement (ACI 522.1-08) is also included by reference.

3. SUBMITTALS

a. SUBMITTALS REQUIRED PRIOR TO BID OPENING

Prebid approval of materials is not required. Suppliers and products have been identified as a means of establishing quality, but not for purposes of limiting competition.

b. SUBMITTALS DURING CONSTRUCTION

[NTS: Update language of this Section as necessary based on applicable references to front-end specifications.]

Submittals during construction shall be made in accordance with Section 01300 in Division 1, GENERAL REQUIREMENTS. In addition, the following specific information shall be provided:

1. CONTRACTOR's Qualifications: CONTRACTOR shall submit information showing conformance with qualification requirements listed in specifications. Submit CONTRACTOR Qualifications to OWNER for review prior Notice to Proceed.

2. Porous Pavement Surface: CONTRACTOR shall submit drawings and documentation for the porous pavement surface in accordance with the respective industry standards, including:

   a. ACI Specification for Pervious Concrete or the recommendations of the Wisconsin or National Ready Mixed Concrete Associations for pervious concrete. Only one test panel, as described in ACI 522.1-1.5.3.4, shall be required to be placed. If total proposed pervious concrete area is less than the required 225 square feet for a test panel, the test panel shall be the entire proposed pervious concrete area;

   b. Wisconsin or National Asphalt Pavement Associations for porous asphalt;

   c. Concrete Pavement Institute, Brick Industry Association, or National Concrete Masonry Association for permeable interlocking pavers and permeable blocks.

CONTRACTOR may submit drawings and documentation conforming to other industry standard sources for review by OWNER. OWNER will review and inform CONTRACTOR in writing that drawings and documentation conforming to industry standards not specifically mentioned here are either approved or not approved. Only those approved in writing by OWNER will be accepted.

Submit shop drawings to OWNER for review and approval prior to installation.

3. Bedding Aggregate Layer, Base Course Aggregate Layer, Stormwater Storage Aggregate Layer: CONTRACTOR shall submit sieve analysis by a qualified testing laboratory and other documentation necessary showing conformance with specifications for each aggregate layer. Submit sieve analysis and other documentation to OWNER for review and approval prior to installation.

4. Underdrain Piping: CONTRACTOR shall submit shop drawings of underdrain piping showing conformance with specifications. Submit shop drawings to OWNER for review and approval prior to installation.

5. Porous Pavement Surface Performance Infiltration Testing: CONTRACTOR shall submit results of surface infiltration testing completed in accordance with applicable standards to OWNER for review and approval prior to final acceptance.

4. SUBSTITUTION OF MATERIALS

The use of manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired only. Products of other manufacturers will be considered in accordance with GENERAL CONDITIONS.

5. SHOP DRAWINGS, MATERIAL REVIEW AND SAMPLES

a. Porous Pavement Surface

b. Bedding Aggregate Layer

c. Base Course Aggregate Layer

d. Stormwater Storage Aggregate Layer

e. Underdrain Piping

6. CONTRACTOR QUALIFICATIONS

The CONTRACTOR shall have five years' experience (minimum) and shall have completed green infrastructure work similar in material, design, and extent to that indicated for this Project. CONTRACTOR must provide five or more successful installations of green infrastructure projects.

7. TOLERANCES

Tolerances for porous pavement green infrastructure strategy construction and materials shall conform to the requirements hereinafter specified. The finished surface elevation of the porous pavement green infrastructure strategy shall be as required by the respective industry standards referenced in the specification. If tolerance for surface elevations are not discussed in industry standard specifications, elevations shall be within 0.06 feet (+/-) of the finished elevations as specified in the drawings. Subgrade elevations shall be within 0.12 feet (+/-) of the finished elevations as specified in the drawings.

B. MATERIALS

1. GENERAL

All porous pavement green infrastructure strategies shall meet the requirements of the following specifications. The OWNER reserves the right to take samples of materials whenever deemed necessary.

2. POROUS PAVEMENT SURFACE

The porous pavement surface shall conform to the following specifications:

a. Pervious concrete shall conform with all requirements of ACI 522.1, "Specification for Pervious Concrete Pavement," published by the ACI, Farmington Hills, Michigan, except as modified by these Specifications

b. Porous asphalt shall conform with all requirements of the Wisconsin or National Asphalt Pavement Associations, except as modified by these Specifications.

c. Permeable interlocking pavers and permeable blocks shall conform with all requirements of the Concrete Pavement Institute, Brick Industry Association, or National Concrete Masonry Association, except as modified by these Specifications.

d. All porous pavement green infrastructure strategy surface treatments shall have a percent voids less than 25 percent and meet the porous pavement surface performance requirements listed in Section C.1 of this

specification.

3. BEDDING AGGREGATE LAYER/JOINT FILL AGGREGATE

Bedding aggregate layer is intended to provide a suitable surface on which to place the permeable interlocking pavers and permeable blocks. The bedding aggregate layer is not required for pervious concrete or porous asphalt. The minimum depth of the bedding aggregate layer shall be 5 inches for permeable interlocking pavers and permeable blocks. Aggregate shall be provided in accordance with ASTM C-33 and size No. 8, 89, 9, or 57 aggregate. Aggregate shall be kept sediment-free during storage and handling and placed to avoid segregation of aggregate.

If required by drawings, joint fill aggregate shall be provided between the joints of the permeable interlocking pavers and permeable blocks. Joint fill material depth can be included to meet the total depth for bedding aggregate layer for the permeable interlocking pavers or permeable blocks so long as the total combined depth of the two layers is 5 inches. Aggregate shall be provided in accordance with ASTM C-33 and size No. 8, 89, 9, or 57 aggregate. Aggregate shall be kept sediment-free during storage and handling and placed to avoid segregation of aggregate.

4. BASE COURSE LAYER

Base course layer is required for permeable interlocking pavers. Base course layer shall be installed to depth shown on the drawings and a minimum of 4 inches in depth. Aggregate shall be provided in accordance with ASTM C-33 and size No. 57 aggregate. Base course aggregate conforming to these specifications may be considered part of the aggregate storage depth. Aggregate shall be kept sediment-free during storage and handling and placed to avoid segregation of aggregate.

5. STORAGE LAYER

The storage layer below the porous pavement surface is intended for temporary storage of stormwater runoff. Storage layer shall be installed to depth shown on the drawings and a minimum of 12 inches in depth. The storage layer shall consist of aggregate that shall conform to the following specifications:

a. The aggregate shall be open graded consisting of crushed stone or crushed gravel with no greater than 5 percent passing the No. 200 sieve.

b. Aggregate shall have a minimum porosity of 30 percent in accordance with ASTM C29 Standard Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate.

c. Aggregate shall be in accordance with soundness, wear, and fracture requirements listed in WisDOT Standards and Specifications for Highway and Structure Construction Section 301.2.4.5 - Aggregate Base Physical Properties.

d. Aggregate shall be kept sediment-free during storage and handling and placed to avoid segregation of aggregate.

6. UNDERDRAIN PIPING

The underdrain pipe shall conform to the following specifications:

a. The underdrain pipe shall have a minimum diameter of 4 inches and be made of SDR-35 PVC or other material approved by the OWNER. The pipe shall be capable of withstanding expected traffic loads over portions of the pipe extending beyond the soil planting bed.

b. The underdrain orifice shall be restricted as necessary so that the design infiltration rate plus the underdrain rate equals the design draw down rate. The restriction shall be achieved by using an adjustable restrictor plate or valve. The restriction device shall be accessible for adjustment.

c. The total opening area of all perforation holes combined shall be sufficient to allow the underdrain pipe to discharge at full capacity, as would occur if there were no orifice restriction. The amount of perforations shall be increased to provide a margin of safety but shall not be so great as to compromise structural integrity of the pipe material. The size of the perforations shall be small enough to prevent surrounding aggregate material from traveling through the perforations. A minimum of three rows of perforations shall be used.

d. The underdrain pipe shall be protected from clogging by use of a cover of pea gravel. The pea gravel shall conform to the following specifications:

1. Pea gravel - The pea gravel layer shall be at least 4 inches thick on all sides of the underdrain. Pea gravel shall be washed. Pea gravel shall be large enough to prevent its falling through the perforations of the underdrain pipe. The pea gravel shall be sized in accordance with AASHTO No. 8 aggregate (size number according to AASHTO M43) to meet the following gradation requirements:

Sieve Size	Percent Passing by Weight
1/2-inch	100
3/8-inch	85 to 100
No. 4	10 to 30
No. 8	0 to 10
No. 16	0 to 5

e. The underdrain pipe shall have a vertical, connecting standpipe to serve as a clean-out port for the underdrain pipe. The pipe shall be rigid, non-perforated SDR-35 PVC pipe, a minimum of 6 inches in diameter and covered with a watertight cap. Watertight cap shall be installed flush with porous pavement surface. Watertight cap assembly shall be southern code countersunk brass screw plug with 6 inch ASTM D3034 PVC gasketed adapter (to accept PVC pipe) fitted with cast iron top, which is internally threaded.

7. OBSERVATION WELLS

If there is no underdrain or the underdrain is located above the bottom of the storage layer, an observation well shall be installed to monitor drainage from the porous pavement green infrastructure strategy. If the porous pavement green infrastructure strategy exceeds one acre, one additional observation well shall be installed per additional acre. The observation wells shall conform to the following specifications:

a. The observation well shall be a minimum 6 inch diameter slotted SDR 35 PVC pipe from the bottom of the storage layer to the top of the storage layer and then solid wall PVC pipe from the top of the storage layer to the porous pavement surface, anchored vertically to a footplate at the bottom of the storage layer. Observation well shall be covered with a watertight cap. Watertight cap shall be installed flush with porous pavement surface. Watertight cap assembly shall be southern code countersunk brass screw plug with 6 inch ASTM D3034 PVC gasketed adapter (to accept PVC pipe) fitted with cast iron top, which is internally threaded.

b. Foot plate shall be 24 inch by 24 inch by 3/8 inch thick HDPE sheet with PVC cap to match dimension of the observation well pipe and shall be anchored to the HDPE sheet with four 3/8 inch stainless steel bolts and washers to prevent movement and rotation. Observation well PVC pipe shall be connected to PVC cap in accordance with manufacturer's recommendations.

8. NON-WOVEN GEOTEXTILE FILTER FABRIC

Porous pavement green infrastructure strategy shall include non-woven geotextile filter fabric as shown on drawings. Non-woven geotextile fabric shall be in accordance with WisDOT Standards and Specifications for Highway and Structure Construction Section 645 - Geotextile Fabrics.

9. CONCRETE CURB

Porous pavement green infrastructure strategy shall be surrounded by concrete curb in accordance with WisDOT Type "A" Concrete Curb without deformed tie bars. Concrete curb shall be provided in accordance with WisDOT Standards and

Specifications for Highway and Structure Construction Section 601 - Concrete Curb and Gutter. Concrete curb shall be installed to elevations shown on the drawings.

C. WORKMANSHIP

1. POROUS PAVEMENT SURFACE PERFORMANCE

a. CONTRACTOR shall complete testing of installed porous pavement green infrastructure strategies to determine the surface infiltration rate upon completion of installation is a minimum of 100 inches/hour. Porous pavement green infrastructure strategies not meeting this criteria will not be accepted. Porous pavement green infrastructure strategies shall be tested in accordance with the following criteria:

1. Pervious concrete shall be tested in accordance with ASTM C1701 - Standard Test Method for Infiltration Rate of In Place Pervious Concrete.

2. Porous asphalt shall be tested in accordance with ASTM D6390 - Standard Test Method for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures.

3. Permeable interlocking pavers and permeable blocks shall be tested in accordance with ASTM C1781 - Standard Test Method for Surface Infiltration Rate of Permeable Unit pavement Systems.

2. STORAGE LAYER INSTALLATION

a. Aggregate shall be installed in accordance with WisDOT Standards and Specifications for Highway and Structure Construction Section 301.3.

3. CONSTRUCTION SITE STABILIZATION

a. CONTRACTOR shall not construct porous pavement strategies until all of the contributing drainage areas are stabilized to the satisfaction of the OWNER. Do not use the porous pavement strategies as temporary sediment control facilities during construction. It is the responsibility of the CONTRACTOR to sequence the construction of the porous pavement strategies in a manner such to prevent sediment from entering the porous pavement strategies as a result of construction activities.

b. Construction site runoff from disturbed areas shall not be allowed to discharge onto the surface of the porous pavement. CONTRACTOR shall use sediment control measures as necessary to prevent construction site runoff from discharging onto the surface of the porous pavement. Sediment control measures indicated on design drawings are not

intended to limit the CONTRACTOR in the manner and techniques to control erosion. It is the responsibility of the CONTRACTOR to control erosion from this site during construction.

c. Sediment that discharges onto the surface of the porous pavement during construction as a result of construction activities shall be removed by the CONTRACTOR at no cost to the OWNER. In circumstances where, in the opinion of the OWNER, sediment significantly impacts the functionality of the underdrains, observation wells, aggregate materials, or porous pavements, these items shall be completely replaced by the CONTRACTOR at no cost to the OWNER.

d. CONTRACTOR shall not store any equipment or materials within the perimeter of the porous pavement area.

4. SUITABLE WEATHER

a. Construction of the porous pavement strategies shall be suspended during periods of rainfall or snowmelt. Construction shall remain suspended if ponded water is present or if residual soil moisture contributes significantly to the potential for soil smearing, clumping, or other forms of compaction within the porous pavement strategies. CONTRACTOR shall inspect and maintain all sediment control measures protecting both the porous pavement strategies and the entire project site following periods of rainfall or snowmelt.

5. COMPACTION AVOIDANCE

a. Compaction and smearing of the soils beneath the floor and sides of the porous pavement area shall be minimized. During site development, the area dedicated to the porous pavement area shall be cordoned off to prevent access by heavy equipment. Acceptable equipment for constructing the porous pavement strategy includes excavation hoes, light equipment with turf type tires, marsh equipment or wide-track loaders.

b. If compaction occurs at the base of the porous pavement strategy, the soil shall be refractured to a depth of at least 12 inches. Additional base or subbase may be required along with additional compaction of these materials to reduce the risk of surface settlement. CONTRACTOR shall provide OWNER with plan for reducing compaction of over-compacted soils prior to completion of the work for acceptance by OWNER. Refracturing shall not be used by CONTRACTOR in lieu of proper compaction avoidance techniques.

6. SUBGRADE PREPARATION

a. The slope of the subgrade shall be as flat as possible. In no case shall the subgrade slope be greater than 2 percent. A series of aggregate storage reservoir cells can be designed and constructed to prevent seepage through downgradient portions of the permeable pavement surface, if necessary.

7. POST-CONSTRUCTION CLEANING

a. Following substantial completion of the Project, CONTRACTOR and OWNER shall inspect the porous pavement green infrastructure strategy surface. If OWNER determines the surface requires cleaning before final acceptance, CONTRACTOR shall clean the surface of the porous pavement green infrastructure strategy in accordance with industry recommended methods. These methods include items such as regenerative air or vacuum sweeping.

8. NOTIFICATION

a. CONTRACTOR shall notify OWNER following the excavation of porous pavements, prior to installation of underdrains, observation wells, storage layer, base course layer, bedding layer, and porous pavement surface mixture. CONTRACTOR shall only proceed with the installation of these items with approval of the OWNER.

D. PAYMENT

Except as noted otherwise hereinafter payment for the work in this Section will be based on the quantities and unit bid prices for each of the individual bid items for the porous pavement green infrastructure strategy. Payment will be made at the unit prices stated in the Bid. The unit prices shall constitute full compensation for all labor, equipment, materials, and incidentals necessary for the satisfactory completion of the work.

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02840 EXTERIOR PLANTS (NATIVE LANDSCAPING AND STORMWATER TREES) GREEN INFRASTRUCTURE STRATEGIES

[NTS: This specification is intended to be used as part of the Milwaukee Metropolitan Sewerage District's Green Solutions Program for implementation of green infrastructure strategies into Contract Documents by local municipalities or other entities. The specification is also intended to be used in conjunction with the Green Infrastructure Sizing Calculator and the Green Infrastructure Typical Details developed for the Green Solutions Program. The specification is considered to be a technical guidance document to assist users with the design of green infrastructure strategies. It is the responsibility of the local municipality or design engineer to make revisions to the specification as needed for specific design projects. It is recommended the documents are reviewed by a licensed professional engineer before releasing for construction. Note that the specification was last updated by the District in 2016.]

A. SCOPE

This Section covers the work necessary to furnish and install native landscaping and stormwater tree green infrastructure strategies, including preparation of plant beds, exterior plants (trees, shrubs, plant plugs and perennials).

1. GENERAL

[NTS: Update language of this Section as necessary based on applicable references to front-end specifications.]

See CONDITIONS OF THE CONTRACT, and Division 1, GENERAL REQUIREMENTS, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

2. RELATED WORK

[NTS: The list below may not be fully inclusive depending upon the specifics of each individual project. Update language of this Section as necessary based on applicable references to other technical specification sections.]

The applicable requirements, materials and workmanship specified in the following Sections are included by reference in this Section. The list below is from the Wisconsin Department of Transportation (WisDOT) Standards and Specifications for Highway and Structure Construction, latest edition.

Section 627 Mulching
Section 628 Erosion Control
Section 630 Seeding
Section 631 Sodding
Section 645 Geotextile Fabrics

The following specifications as developed for the Milwaukee Metropolitan Sewerage

District's Green Solutions Program may also include related work.

a. Section 02837 Bioretention / Bioswale Green Infrastructure Strategy
b. Section 02838 Rain Garden Green Infrastructure Strategy
c. Section 02841 Soil Amendment Green Infrastructure Strategy

3. DEFINITIONS

a. **Balled and Burlapped Stock:** Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size is subject to meeting ANSI Z60.1 limitations for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum-laced as recommended by ANSI Z60.1.

b. **Balled and Potted Stock:** Exterior plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is subject to meeting ANSI Z60.1 limitations for type and size of tree or shrub required.

c. **Container Stock:** Healthy, vigorous, well-rooted exterior plants grown in a container with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.

d. **Finish Grade:** Surface or elevation of soil remaining after topsoil has been spread to the specified depth on drawings.

e. **Subgrade:** Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

f. **Growing Season:** Period of time approximately between March and November, during which rainfall and temperature are conducive to plant growth.

4. SUBMITTALS

a. Product Data: For each type of product indicated.

b. Samples for Verification: 1/2 lb. of mulch specified placed in labeled plastic bag.

c. Product Certificates: For each type of manufactured product, signed by product manufacturer, and complying with the following:
   1. Manufacturer's certified analysis for standard products.
   2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists,

where applicable.

d. Qualification Data: Statement of landscape installer's qualifications in performing native landscape installations and complying with the following:
   1. A minimum of 5 years' experience.
   2. Proof of five or more successful native landscape examples to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, photographs of completed projects, names and address of architects and owners, and other information specified. See "Quality Assurance" article in this section for additional contractor requirements.

e. Material List: Provide list of each landscape material (trees, shrubs, perennials, plugs) and identify intended type, size, and nursery source.

f. Planting Schedule: Indicate expected delivery and installation dates for each type of landscape work, during seasons identified for such work.

g. Planting Plan: CONTRACTOR to develop planting plan that shows conformance with planting plan and planting schedule shown on drawings. Prior to staking tree locations, shrub locations, groundcover locations, and plug beds, CONTRACTOR to schedule meeting with OWNER to review planting plan.

h. Maintenance Instructions: Typewritten recommended seasonal procedures to be provided by CONTRACTOR to OWNER for maintenance of exterior plants during a calendar year. Include recommendations for care of trees and shrubs to promote healthy, vigorous growth and avoid susceptibility to disease. Submit before expiration of required maintenance periods.

i. Tree Certification: Signed statement by nursery certifying that plants conform to specified requirements.

j. Photographs of Trees: Submit images within fourteen days of proposed field inspections of each plant species of each size and each quality grade clearly showing the full range of variations between the grades.
   1. Scale: Include a yardstick in each photograph to provide scale.
   2. Background: Ensure form and condition of plant is clear from background.
   3. Identification: Provide the following information:
      a. Name of Project and OWNER.
      b. Name and address of grower.
      c. Date photograph was taken.
      d. Species name and quality grade.

k. Topsoil Analysis: Contractor shall furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand,

silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of topsoil. A minimum of two samples from each different soil area and type and from each imported soil source is required.

1. Report suitability of topsoil for plant growth. State-recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce a satisfactory topsoil for each planting type (turf, perennials, woody plant material, etc.).
2. Soil analysis requirement applies to all soils and conditions within this project, including import soils and on-grade soils.

5. DEPARTURES FROM PLANS AND SPECIFICATIONS

Submit in writing to the OWNER for review, details of any proposed departures from these Contract Documents, and the reasons therefor. Submit such requests as soon as practicable after the Notice to Proceed. Make no such departures without prior written acceptance of the OWNER.

6. QUALIFICATIONS / QUALITY ASSURANCE

a. Nursery Qualifications: A company specializing in growing and cultivating the plants with three years' experience. Plant materials shall be free of disease and hazardous insects.

b. Installer Qualifications: A qualified landscape installer with five years' experience (minimum) who have completed native landscape work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment. Qualified landscape installer must provide five or more successful native landscape installations. Installer's Field Supervision: CONTRACTOR shall provide an experienced full-time supervisor on project site when exterior planting is in progress.

c. Provide consistent quality, size, genus, species, and variety of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, "American Standard for Nursery Stock."

d. Tree and Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches (150 mm) above ground for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

e. Observation: OWNER may observe trees and shrubs either at place of growth or at site before planting for compliance with requirements for genus, species, variety, size, and quality. OWNER retains right to observe trees and shrubs further for size and condition of balls and root systems,

insects, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site. Notify OWNER of sources of planting materials 14 days in advance of delivery to site.

f. Allowance for losses: Grow additional plants to ensure that the contract quantities shall be achieved after normal production losses from natural causes, breakage, natural random non- conformities, transplant shock and/or delivery damage. Replace any plants that are damaged, fail or are rejected.

B. MATERIALS

1. TREE MATERIAL

a. General: Furnish nursery-grown trees and shrubs complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, mold, insects, eggs, larvae, prematurely opened buds, and defects such as crooked leader, abrasion of bark, knots, sun scald, injuries, abrasions, and disfigurement. All of the above are cause for rejection.
   1. Single stem trees should have one main straight leader limbed to the height specified in the planting schedule, a well-balanced crown, and height and caliper as indicated in planting schedule. Trees not meeting these requirements will be rejected.
   2. Branching Height: One-third to one-half of tree height, minimum of 5 feet.
   3. Source location: Plant material should be selected from material grown in like hardiness zone to the project.

b. Grade: Provide trees of sizes and grades complying with ANSI Z60.1 for type of trees required. Trees of a larger size may be used if acceptable to OWNER, with a proportionate increase in size of roots and root ball upon review and approval by OWNER.

c. Label at least one tree of each variety and caliper with a securely attached, waterproof tag bearing legible designation of botanical and common name.

d. Tree Root Union: Trees will not be accepted if the Tree Root Union has been buried. Trees must be harvested that have had the tree root union uncovered prior to digging. Root ball size must meet ANSI Z60.1 standards; shaving off excess soil from root ball after digging of tree will not be accepted. Failure to comply with this requirement is cause for rejection of affected plant material. Provide balled and burlapped trees.

2. SHADE AND FLOWERING TREES

a. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.
   1. Provide balled and burlapped trees.
   2. Branching Height: One-third to one-half of tree height, 5 feet minimum.

b. Small Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:
   1. Stem Form: as noted on the drawings.
      a. Single Stem.
      b. Multistem, clump with two or more stems.
      c. Multistem shrub, with multiple stems.
   2. Provide balled and burlapped trees.

c. Multistem Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:
   1. Stem Form: Clump.
   2. Provide balled and burlapped trees.

d. No species or size shall be substituted without approval by OWNER.

3. DECIDUOUS SHRUBS

a. Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub. Provide balled and burlapped shrubs.

b. Label at least one shrub of each variety with a securely attached, waterproof tag bearing legible designation of botanical and common name.

c. No species or size shall be substituted without approval by OWNER.

4. PLUGS

a. Plugs shall have a minimum size of 2-inch diameter or 2-inch-by 2-inch square and 3-inch depth. Plugs shall be thoroughly rooted through the container.

b. No species or size shall be substituted without approval of OWNER.

c. Plugs shall be inoculated with VAM (Vesicular Arbusular Mycorrhizae) endomycorrhizal fungi as provided by plug supplier.

d. Plugs shall be healthy, free from disease and pests at time of delivery. Plugs must be well developed and fully rooted into growing cell container.

e. For plug species, see planting schedule.

5. PLANTS

a. Perennials and Grasses: See pot sizes specified in plant schedule. Provide healthy, field- grown plants from a commercial nursery, of species and variety shown on plan.

6. TOPSOIL

a. A loamy, friable mineral soil essentially free from heavy or stiff clay lumps, stones, cinders, concrete, brick, roots, sticks brush, litter, plastics, metals, refuse or other deleterious materials in accordance with ASTM D 5286-92. The soil shall be free of herbicides, petroleum-based materials or other substances of a hazardous or toxic nature which may inhibit plant growth. The soil shall be free of noxious weeds, seeds or vegetative parts of weedy plants that cannot be selectively controlled in the planting.

b. The soil shall be taken from the a horizon of a well-drained site and have a USDA soil texture classification of a clay loam or loam. The topsoil shall have the following particle size distribution:

USDA particle name	size (mm)	allowable limit
gravel	2.00 - 4.75	less than 5%
sand	0.05 - 2.00	25 - 45 %
silt	0.002 - 0.05	25 - 40 %
clay	minus 0.002	15 - 30 %

c. The topsoil component shall meet the following specifications. Perform the following tests and submit test reports showing the following criteria are met:
   1. The particle size analysis as defined above.
   2. The pH shall be 5.5 to 7.8
   3. The soluble salts shall be less than 1.5 mmoh/cm
   4. The organic matter content shall be 3.0 to 6.0%

d. Provide certification from the supplier that the topsoil does not contain any toxic substances harmful to plant growth.

e. Off-site (borrow) topsoils meeting the criteria shown above must be used for the planting mix and their source or location communicated to the landscape architect.

f. Soil nutrient/ pH analysis to be performed by an agronomic soil testing agency; apply and incorporate any recommended fertilizers or soil amendments to achieve proper growing conditions. Testing for topsoil

suitability to meet these specifications is the responsibility of the contractor. Results to be supplied to landscape architect and owner.

g. Topsoil from the site may be used if it meets the above requirements. Additional topsoil shall be provided as required by drawings and specifications.

7. INORGANIC SOIL AMENDMENTS

a. Lime: ASTM C 602, agricultural limestone containing a minimum 80% calcium carbonate equivalent and as follows: Any application of lime recommended by CONTRACTOR must be substantiated by lab test results and reviewed by OWNER.
   1. Class: Class T, with a minimum 99% passing through No. 8 (2.36-mm) sieve and a minimum 75% passing through No. 60 (0.25-mm) sieve.
   2. Class: Class O, with a minimum 95% passing through No. 8 (2.36-mm) sieve and a minimum 55% passing through No. 60 (0.25-mm) sieve.
   3. Provide lime in form of dolomitic limestone.

b. Sulfur: Granular, biodegradable, containing a minimum of 90% sulfur, with a minimum 99% passing through No. 6 (3.35-mm) sieve and a maximum 10% passing through No. 40 (0.425-mm) sieve.

c. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 30 to 35% iron and 30 to 50% sulfur and supplied by a commercial fertilizer supplier.

d. Aluminum Sulfate: Commercial grade, unadulterated.

e. Perlite: Horticultural perlite, soil amendment grade.

f. Agricultural Gypsum: Finely ground, containing a minimum of 90% calcium sulfate.

g. Sand: Clean, washed, natural or manufactured, free of toxic materials.

h. Diatomaceous Earth: Calcined, diatomaceous earth, 90% silica, with approximately 140% water absorption capacity by weight.

i. Zeolites: Mineral clinoptilolite with at least 60% water absorption by weight.

j. Hydrogel: "Soil Moist"(tm) Hydro by JRM Chemical Inc. (1-800-962-4010) or approved equal. Applied and mixed according to manufacturer's recommendations.

8. ORGANIC SOIL AMENDMENTS

a. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55% by weight; 100% passing through 3/4-inch (19-mm) sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   1. Organic Matter Content: 50% of dry weight.
   2. Source: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste. Leaf humus compost, manure composts, peat, peat-humus and mushroom compost products are not acceptable.

b. Peat: Sphagnum peat moss, partially decomposed, finely divided or granular texture, with a pH range of 3.1 to 5.0.

c. Peat: Finely divided or granular texture, with a pH range of 6 to 7.5, containing partially decomposed moss peat, native peat, or reed-sedge peat and having a water-absorbing capacity of 1100 to 2000%.

d. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture, free of chips, stones, sticks, soil, or toxic materials.
   1. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with at least 0.15 lb (2.4 kg) of ammonium nitrate or 0.25 lb (4 kg) of ammonium sulfate per cubic foot (cubic meter) of loose sawdust or ground bark.

e. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25% by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

9. FERTILIZER

a. Do not apply any fertilizer other than compost to any area to be installed with bioretention soil mix.

b. Containing fifty percent of the elements derived from organic source; of proportion necessary to eliminate and deficiencies of topsoil, as indicated in analysis.

c. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4% nitrogen and 20% phosphoric acid.

d. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20% available phosphoric acid.

e. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50% derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

f. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50% water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.
   2. Pre-approved slow-release fertilizer: Davey Arbor Green Pro or approved equal.

g. Calcium nitrate: Agricultural grade containing 15-1/2% nitrogen.

10. HERBICIDE

a. Preemergent Herbicide: Granular type, Treflan or equal, to be applied at a rate per manufacturer's recommendation.

b. Do not apply pre-emergent herbicide to areas where seeding will be installed.

c. Glyphosate herbicide applied to areas where plugs will be installed. See Preparation section in this specification.

11. MULCHES

a. Double-shredded hardwood mulch, well composted, free from deleterious materials, locally harvested and produced, and suitable as a top dressing of trees and shrubs.

b. All trees planted in a seeded area shall have a 6-foot diameter double-shredded hardwood mulch ring 2 inches thick.

c. All shrub beds, with and without trees, shall have a 2-inch layer of double-shredded hardwood mulch.

d. All rain gardens shall have a 2-inch layer of double-shredded hardwood mulch. Erosion Control Matting materials are required and specified for these areas.

12. STAKES AND GUYS

a. Trees are not required to be staked unless called out on plans or if environmental conditions require them to keep a tree straight and upright. If CONTRACTOR sees the need for stakes due to environmental conditions, consult OWNER prior to installing stakes.

b. Trees are to be planted straight. During the maintenance period if, trees have not maintained trueness, CONTRACTOR is to stake trees as needed.

c. Cable, Wire, Eye Bolts: Noncorrosive, of sufficient strength to withstand wind pressure and resulting movement of plant life.

13. MISCELLANEOUS PRODUCTS

a. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

b. Tree guard: High density, UV stabilized polyethylene with heavy duty 3/8-inch by 3/8-inch mesh by Tenax (product: Hardware Net) or approved equal. Tenax Hardware Net is available from Eads Fencing Company, www.eadsfence.com.

C. WORKMANSHIP

1. DELIVERY, STORAGE, AND HANDLING

a. Deliver exterior plants freshly dug from nursery. Deliver trees and shrubs after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set exterior plants and trees in shade, protect from weather, wildlife and mechanical damage, and keep roots moist.
   1. Bare root material shall be harvested and handled according to American Nurseryman Standards, which include but are not limited to: Maintain moist root mass at all times, deliver and store in a manner to retard bud development until time of planting.
   2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
   3. Do not remove container-grown stock from containers before time of planting.
   4. Water root systems of exterior plants stored on-site with a fine-mist spray and as often as necessary to maintain root systems in a moist condition.

b. Do not prune trees and shrubs before delivery, except as approved by OWNER. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape.

Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery.

c. Handle planting stock by root ball while supporting the stem.

d. Package Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site.

2. PROJECT CONDITIONS

a. Coordinate excavation and plant installation with location of above grade and underground utilities, which will avoid damage.
   1. Hand excavate as required.
   2. Maintain grade stakes until removal is mutually agreed upon by parties concerned. CONTRACTOR is liable for the repair of any utility damaged by his work at no additional costs to OWNER.

b. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify project OWNER before planting.

c. Erosion Control: All erosion control matting to be installed immediately after seed is placed. See drawings and specification for all sediment and erosion control.

d. Utilities: Determine location of above ground and underground utilities and perform work in a manner which will avoid damage. Hand excavate as required. Maintain grade stakes until removal is mutually agreed upon by parties concerned. CONTRACTOR is liable for the repair of any utility damage by CONTRACTOR's work at no additional cost.

e. Landscaped areas shall be kept free of trash, litter, and weeds at all times during construction.

3. ENVIRONMENTAL CONDITIONS

a. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

b. Do not install plant life when ambient temperatures may drop below 35°F or rise above 90°F.

4. COORDINATION

a. Planting Installation Schedule: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required

maintenance until date of Substantial Completion.

1. Deciduous and Evergreen Material: April 1 to May 30 or August 15 to November 15.
2. Herbaceous Material: April 1 to May 30 or August 15 to October 15.
3. Bulbs: October 15 to November 15.
4. Plugs: April 1st to May 30 and August 15 to October 15.
5. Other planting times may be considered with prior approval; if the plant material is dormant, or if plant material has been dug during dormancy and has been maintained in a holding area for at least 2 weeks and not more than 6 weeks without signs of wilting, scorching or other signs of stress.

b. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit. Planting will not be permitted if sufficient soil moisture is absent or if ground is frozen.

c. Coordination with Seeding: Plant trees and shrubs after finished grades are established and before installing turf-sod and seeded areas, unless otherwise acceptable to OWNER. When planting trees and shrubs after turf-sod and seeded areas, protect turf-sod and seeded areas and promptly repair damage caused by planting operations.

d. Coordination with Erosion Control Material (ECM): Plant plugs after finished grades are established and after ECM has been placed and installed over planting beds. Plugs are not to be planted before placement of ECM.

e. Coordinate planting operations with the locations of underground utilities; CONTRACTOR is to contact the utility location service. CONTRACTOR is to coordinate work with other trades and with the general contractor to protect private underground utilities in the area. CONTRACTOR is responsible for the repair or replacement of any utilities.

f. CONTRACTOR is responsible for verifying all required topsoil is in place before the planting operation commences. Plant material may have to be removed due to insufficient topsoil for no additional cost.

g. Special Requirements for Plug Installation in Biosoil Areas: All seeded areas or disturbed areas outside of the biosoil footprint must have sufficient coverage prior to planting vegetation in biosoil.

h. Unless noted, tree locations, shrub, groundcover and plug bed locations are approximate. CONTRACTOR shall stake as indicated below:

1. Trees: Stake out all tree locations in field using colored flags for each different tree species for review by OWNER prior to excavation. OWNER reserves the right to adjust plants to exact location in the field.
2. Shrubs, groundcover and plug beds: Bed layouts shall be staked for review by OWNER prior to installation. OWNER reserves the right to

adjust plants to exact location in the field. Do not disturb root zones or existing trees for planting bed preparation.

5. EXAMINATION

a. Examine areas to receive exterior plants for compliance with requirements and conditions affecting installation and performance. Proceed with installation only after unsatisfactory conditions have been corrected.

6. SITE PREPARATION

a. Protect structures, utilities, sidewalks, pavements, and other facilities, and lawns and existing exterior plants from damage caused by planting operations.

b. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

c. Lay out individual tree and shrub locations and areas for multiple exterior planting. Stake locations, outline areas, adjust locations when requested, and review with OWNER before planting. Make minor adjustments as required. Unless noted, tree locations on drawings are approximate. CONTRACTOR shall stake out all tree locations in the field using colored flags for each different tree species for review by OWNER prior to excavation. OWNER reserves the right to adjust plants to exact location in field.

d. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage to protect during digging, handling, and transportation. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

7. PREPARATION OF TREE, SHRUB AND PERENNIAL AREAS

a. Prepare subsoil to eliminate uneven areas. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas. Roll and rake, remove ridges, and fill depressions to meet finish grades.

b. Remove foreign materials, weeds and undesirable plants and their roots. Ensure weeds are non-existent before any planting occurs. Remove contaminated subsoil. Remove stones larger than 1 inch in any dimension. Remove sticks, roots, rubbish, and other extraneous matter and legally dispose of them off the OWNER's property.

c. Scarify subsoil to a depth of 8 inches where plants are to be placed. Repeat

cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.

d. Finish grades of all landscape areas shall be 1 inch below adjacent curb or pavement. In areas where 2 inches of mulch are to be applied, finish soil grades shall be 2 inches below adjacent curb or pavement, mulch surface shall be flush with adjacent curb or pavement.

e. Spread topsoil to the depth indicated on drawings and not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy or excessively wet. Spread approximately one-half the thickness of topsoil over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of topsoil.

f. After topsoil is spread, apply soil amendments and fertilizer on surface and thoroughly blend topsoil.
   1. Delay mixing fertilizer with topsoil if planting will not proceed within a few days.
   2. Mix lime (if needed) with dry soil before mixing fertilizer.

g. Apply pre-emergent herbicide to all planting beds prior to plant installation. Follow manufacturer's recommendations on application. Do not apply pre-emergent herbicide to areas where plugs or seeding will be installed.

h. Restore planting beds if eroded or otherwise disturbed after finish grading and before planting.

i. Finish Grading: Grade planting beds to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

8. PREPARATION OF PLANT PLUG AREAS

a. Prepare subsoil to eliminate uneven areas. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas. Rake, remove ridges, and fill depressions to meet finish grades.

b. Completely remove foreign materials, existing vegetation, and the existing soil seed bank prior to planting plugs. Remove contaminated subsoil. Remove stones larger than 1 inch in any dimension. Remove sticks, roots, rubbish, and other extraneous matter and legally dispose of them off OWNER's property.

c. Scarify subsoil outside of rain gardens to a depth of 8 inches where plants are to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.

d. In areas outside of the biosoil, spread topsoil to the depth indicated on drawings and not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
   1. Do not apply pre-emergent herbicide to areas where bioretention soil mix is installed.

e. If vegetation exists after soil preparation, apply a 2% glyphosate herbicide at least four weeks prior to installation on all actively growing vegetation. Verify that a good kill has resulted from the herbicide application prior to planting.

f. Do not apply any fertilizer other than compost.

g. Restore planting beds if eroded or otherwise disturbed after finish grading and before planting.

h. Erosion Control Material (ECM) as specified and shown on drawings must be placed after finish grading and before plug planting.

i. Special Requirements for Plug Installation in Biosoil Areas: All seeded areas or disturbed areas outside of the biosoil footprint must have sufficient coverage prior to planting vegetation in biosoil.

9. TREE AND SHRUB BALLED AND BURLAPPED AND CONTAINER STOCK INSTALLATION

a. Excavation
   1. Pits and Trenches: Excavate circular pits with sides sloped inward. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation.
      a. Excavate approximately three times as wide as ball diameter for balled and burlapped and/or container-grown stock.
      b. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
      c. If drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.
   2. Subsoil removed from excavations may be used as backfill if it meets specified requirements for topsoil.
   3. Obstructions: Notify OWNER if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
   4. Drainage: Notify OWNER if subsoil conditions show evidence of unexpected water seepage or retention in tree or shrub pits.

b. Planting
   1. Plant Placement: Plant spacing is as indicated on drawing unless

otherwise noted. It is the CONTRACTOR's responsibility to provide full coverage in all planting areas as specified in the plant schedule remarks. Align and equally space in all directions all trees, shrubs, groundcover, bulbs and plugs as noted in the drawings.

2. Set balled and burlapped stock and container stock plumb and in center of pit or trench with top of root crown 2 inch (50 mm) above adjacent finish grades.
    a. Remove burlap, rope, container and/or wire baskets from top one-third of root balls and partially from sides, but do not remove from burlap from under root balls.
    b. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
    c. Place topsoil around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of topsoil.
3. Dish and tamp top of backfill to form a 3 inch high saucer around the rim of the pit. Do not cover top of root ball with backfill.
4. Plants will be rejected if the rootball has been disturbed or damaged prior to or during planting.

c. Pruning: Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Unless otherwise indicated by OWNER, do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are sizes after pruning.

10. PLUG INSTALLATION

a. Install Erosion Control Material (ECM) as specified prior to plug installation in all areas as indicated on plan.

b. Install plugs by slitting ECM 6 inches in a north/south/east/west pattern to install plug into soil below mat. Plant plugs 18 inches on center (or as indicated in Plant Schedule) as shown on detail.

c. Plant plugs level with existing soil grade. Be certain that soil is placed around the plugs and firmed into place. Do not fill around plugs with mulch.

d. Thoroughly soak plugged area with water until soil is moist to a depth of 4 inches.

e. Plugs to be installed in all areas indicated on plans and planting schedule.

f. Early post planting, once plants have had the opportunity to be watered and begin new root establishment, apply Barricade pre-emergent (or approved

equal) per label instructions.

11. CLEANUP AND PROTECTION

a. During exterior planting, keep adjacent paving and construction work area clean and in an orderly condition.

b. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Protect exterior plants from wildlife damage. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged exterior planting. Install tree guards immediately after tree installation to protect from deer damage.

12. OBSERVATION AND ACCEPTANCE

a. Observation: Field observation may be completed by the OWNER for performance of landscape work defined by Contract Documents. Observation visits may be made by OWNER at any time throughout the landscape installation.

b. Plant Plugs Acceptance:
   1. Plugs shall exhibit vigorous growth and be thoroughly rooted by the end of first growing season.
   2. Maximum acceptable loss is 10% of total number of installed plugs. Replace plugs that are dead or in an unhealthy condition at end of warranty period as determined by OWNER.

13. DISPOSAL

a. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off OWNER's property.

14. MAINTENANCE

a. Trees and Shrubs: Maintenance for trees and shrubs shall be through the growing season and up until Substantial Completion as specified below. OWNER will accept responsibility for maintenance at Substantial Completion.
   1. Watering: watering and rainfall shall supply a minimum of 1 inch of water per week.
   2. Weeding: monthly or more frequently as needed to remove invasive or exotic plants.
   3. Pruning: once at initial planting or as needed
   4. Spraying: monthly or as needed to keep trees and shrubs free of insects and disease.
   5. Tightening/ Repairing Tree Stakes and Vertical Adjustment: as needed

to maintain trees and shrubs growing in an upright vertical position
6. Replanting/ Replacement: as needed to replace dead or damaged plant material
7. Trash/ Litter Removal: weekly or as needed to remove trash and litter

b. Special Landscape Areas: Maintenance for special landscape areas shall be through the growing season and up until Substantial Completion as specified below. Maintenance must be on an approximate monthly basis or more frequently if needed for certain tasks like watering. Contractor to submit maintenance schedule to OWNER before acceptance of initial planting by OWNER. OWNER will accept responsibility for maintenance at Substantial Completion.
1. Special Landscape Areas include:
   a. Bioretention Areas.
   b. Plug Areas.
   c. Perennials and Grasses Areas.
2. Maintenance items during this period are as specified below:
   a. Watering: watering and rainfall shall supply a minimum of 1 inch of water per week.
   b. Weeding: monthly or more frequently as needed to remove invasive or exotic plants to less than 5% of vegetative cover.
3. Pruning/ Cut-back Perennials: as needed
4. Replanting/ Replacement: as needed to replace dead or damaged plant material
5. Control of Erosion or Gullies: monthly or as needed
6. Trash/ Litter Removal: weekly or as needed to remove trash and litter

c. All plant material shall be maintained in a healthy and growing condition and must be replaced with plant material of similar variety and size if damaged, destroyed or removed.

d. Plug Maintenance: In addition to the general requirements above for plant material, the following maintenance requirements are specific to plug installations: Pull weeds of the following species deemed detrimental to native plug plantings. The species include but are not limited to: Canada Thistle, Queen Anne's Lace, Sweet Clover, Johnson Grass, Nutsedge, Barnyard Grass.

e. For all maintenance areas, CONTRACTOR is responsible for watering. Watering and rainfall shall supply a minimum of 1 inch of water per week.

f. After the specified period for which CONTRACTOR is responsible for maintenance as specified above, OWNER will assume maintenance responsibility. CONTRACTOR to provide OWNER with 30-day notice before the end of the period for which their maintenance will end.

15. WARRANTY

a. Special Warranty: Warrant the following exterior plants, for the warranty period indicated, against defects including death and unsatisfactory growth.
   1. Warranty Period for Trees and Shrubs: Two years from date of Substantial Completion.
   2. Warranty Period for Plugs and Perennials: Two years from date of Substantial Completion.

b. Remove dead exterior plants immediately. Replace immediately unless required to plant in the succeeding planting season.

c. Replacement plants shall be the same size and species as specified with a new warranty commencing on date of replacement.

d. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

e. There will be no exceptions to the warranty. CONTRACTOR accepts responsibility for all materials specified.

D. PAYMENT

Furnishing and installation of exterior plants are paid for at the unit price bid per item. Payment will be made at the unit prices stated in the Bid. The unit prices shall constitute full compensation for all labor, equipment, materials, and incidentals necessary for the satisfactory completion of the work.

* * * * * *

02841 SOIL AMENDMENT GREEN INFRASTRUCTURE STRATEGY

[NTS: This specification is intended to be used as part of the Milwaukee Metropolitan Sewerage District's Green Solutions Program for implementation of green infrastructure strategies into Contract Documents by local municipalities or other entities. The specification is also intended to be used in conjunction with the Green Infrastructure Sizing Calculator and the Green Infrastructure Typical Details developed for the Green Solutions Program. The specification is considered to be a technical guidance document to assist users with the design of green infrastructure strategies. It is the responsibility of the local municipality or design engineer to make revisions to the specification as needed for specific design projects. It is recommended the documents are reviewed by a licensed professional engineer before releasing for construction. Note that the specification was last updated by the District in 2016.]

A. SCOPE

This Section covers the work necessary to furnish and install soil amendment green infrastructure strategies, including the incorporation of compost into the existing soil and soil stabilization following incorporation.

1. GENERAL

[NTS: Update language of this Section as necessary based on applicable references to front-end specifications.]

See CONDITIONS OF THE CONTRACT, and Division 1, GENERAL REQUIREMENTS, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

2. RELATED WORK

[NTS: The list below may not be fully inclusive depending upon the specifics of each individual project. Update language of this Section as necessary based on applicable references to other technical specification sections.]

The applicable requirements, materials and workmanship specified in the following Sections are included by reference in this Section. The list below is from the Wisconsin Department of Transportation (WisDOT) Standards and Specifications for Highway and Structure Construction, latest edition.

Section 201 Clearing and Grubbing
Section 627 Mulching
Section 628 Erosion Control
Section 630 Seeding

The following specification as developed for the Milwaukee Metropolitan Sewerage District's Green Solutions Program may also include related work.

3. SUBMITTALS

a. SUBMITTALS REQUIRED PRIOR TO BID OPENING

Prebid approval of materials is not required. Suppliers and products have been identified as a means of establishing quality, but not for purposes of limiting competition.

b. SUBMITTALS DURING CONSTRUCTION

[NTS: Update language of this Section as necessary based on applicable references to front-end specifications.]

Submittals during construction shall be made in accordance with Section 01300 in Division 1, GENERAL REQUIREMENTS. In addition, the following specific information shall be provided:

1. Compost Analysis: CONTRACTOR shall submit compost analysis by a qualified soil-testing laboratory showing conformance with compost specifications. Submit compost analysis to OWNER for review and approval prior to installation.

4. DEPARTURES FROM PLANS AND SPECIFICATIONS

Submit in writing to the OWNER for review, details of any proposed departures from these Contract Documents, and the reasons therefor. Submit such requests as soon as practicable after the Notice to Proceed. Make no such departures without prior written acceptance of the OWNER.

5. SHOP DRAWINGS, MATERIAL REVIEW AND SAMPLES

a. Compost Analysis

6. TOLERANCES

Tolerances for soil amendment green infrastructure strategy construction and materials shall conform to the requirements hereinafter specified. The depths of roto-tilling shall be within 0.25 feet (+) and 0.08 feet (-) and the depths of compost shall be within 0.08 feet (+) and 0.04 feet (-) of the depths specified in the drawings.

B. MATERIALS

1. GENERAL

All soil amendment green infrastructure strategies shall meet the requirements of the

following specifications. The OWNER reserves the right to take samples of materials whenever deemed necessary.

2. COMPOST

The compost shall conform to the following specifications:

a. The compost shall meet the requirements of Wisconsin Department of Natural Resources Specification S100, Compost, as follows:

1. Particle Size – 98% of the compost shall pass through a 0.75-inch screen.
2. Physical Contaminants – Less than 1% combined glass, metal and plastic.
3. Organic Matter/Ash Content – At least 40% organic matter; less than 60% ash content.
4. Carbon to Nitrogen Ratio – 10-20:1 C:N ratio.
5. pH – Between 6 and 8.
6. Soluble Salt – Electrical conductivity below 10 dS m^{-1} (mmhos cm^{-1})
7. Moisture Content – Between 35% and 50% by weight.
8. Maturity – The compost shall be resistant to further decomposition and free of compounds, such as ammonia and organic acids, in concentrations toxic to plant growth.
9. Residual Seeds & Pathogens – Pathogens and noxious seeds shall be minimized.
10. Pathogens – The compost shall meet the Class A requirements for pathogens as specified in s. NR 204.07(6)(a), Wis. Adm. Code.
11. Other Chemical Contaminants – The compost shall meet the high quality pollutant concentrations as specified in s. NR 204.07(5)(c), Wis. Adm. Code.

C. WORKMANSHIP

1. CONSTRUCTION SITE STABILIZATION

a. CONTRACTOR shall not construct soil amendment strategies until all of the contributing drainage areas are stabilized to the satisfaction of the OWNER. Do not use the soil amendment strategies as temporary sediment control facilities during construction. It is the responsibility of the CONTRACTOR to sequence the construction of the soil amendment strategies in a manner such to prevent sediment from entering the soil amendment strategies as a result of construction activities.

b. Construction site runoff from disturbed areas shall not be allowed to enter the soil amendment strategies. CONTRACTOR shall use sediment control measures as necessary to prevent construction site runoff from entering the soil amendment strategies. Sediment control measures indicated on design

drawings are not intended to limit the CONTRACTOR in the manner and techniques to control erosion. It is the responsibility of the CONTRACTOR to control erosion from this site during construction.

c. Sediment that enters the soil amendment strategies during construction as a result of construction activities shall be removed by the CONTRACTOR at no cost to the OWNER. In circumstances where, in the opinion of the OWNER, sediment significantly impacts the functionality of the soil amendment strategy, 1 inch of additional composts shall be added and rototilled into the soil in accordance with the drawings. Reconstruction of soil amendment strategy shall be completed by the CONTRACTOR at no cost to the OWNER.

d. CONTRACTOR shall not store any equipment or materials within the perimeter of the soil amendment strategy area.

2. SUITABLE WEATHER

a. Construction of the soil amendment strategies shall be suspended during periods of rainfall or snowmelt. Construction shall remain suspended if ponded water is present or if residual soil moisture contributes significantly to the potential for clumping or other forms of compaction within the soil amendment strategies. CONTRACTOR shall inspect and maintain all sediment control measures protecting both the soil amendment strategies and the entire project site following periods of rainfall or snowmelt.

3. COMPACTION AVOIDANCE

a. Compaction of the soils in the area the soil amendment strategy shall be minimized. During site development, the area dedicated to the soil amendment strategy shall be cordoned off to prevent access by heavy equipment. Acceptable equipment for constructing the soil amendment strategy includes light equipment with turf type tires, marsh equipment, or wide-track loaders.

b. If compaction of the soil amendment strategy occurs, additional roto-tilling shall be completed to the satisfaction of the OWNER. Additional roto-tilling shall not be used by CONTRACTOR in lieu of proper compaction avoidance techniques.

4. INSTALLATION OF SOIL AMENDMENT STRATEGY

a. Installation of Soil Amendment Strategy - The following apply:

1. The 4 inches of subsoil below the 8 inches of the soil amendment layer shall be scarified or loosened by CONTRACTOR by roto-tilling prior to placement of compost. If soil is too dense for use of

roto-tiller, soil should first be loosened using soil ripper then roto-till.

2. CONTRACTOR shall roto-till soil amendment strategy to a depth of 8 inches. If soil is too dense for use of roto-tiller, soil should first be loosened using soil ripper then roto-tilled.
3. CONTRACTOR shall evenly distribute 2 inches of compost over the entire, loosened surface of the soil amendment strategy.
4. Following distribution of the compost, CONTRACTOR shall roto-till the entire soil amendment strategy area several times to incorporate soil amendment compost. Roto-tilling passes shall be completed in the perpendicular direction to the previous pass.
5. After roto-tilling has been completed and accepted by OWNER, CONTRACTOR shall water or hand roll soil amendment strategy area for compaction and rake to fine grade to match existing ground surface.
6. CONTRACTOR shall seed and mulch soil amendment strategy area in accordance with the drawings. If seeding and mulching is not shown on drawings (unless specifically noted that area is not to be seeded), CONTRACTOR shall completing seeding in accordance with WisDOT Standards and Specifications for Highway and Structure Construction Section 630 - Seeding and complete straw mulching in accordance with WisDOT Standards and Specifications for Highway and Structure Construction Section 627 - Mulching.

5. NOTIFICATION

a. CONTRACTOR shall notify OWNER following the loosening or scarifying of subsoil, prior to placement of compost, prior to roto-tilling of compost, and prior to watering or hand rolling for compaction. CONTRACTOR shall only proceed with the installation of placement of compost, roto-tilling of compost, and watering or handrolling for compaction of the soil amendment strategy with approval of the OWNER.

D. PAYMENT

Except as noted otherwise hereinafter payment for the work in this Section will be based on the quantities and unit bid prices for each of the individual bid items for the soil amendment green infrastructure strategy. Payment will be made at the unit prices stated in the Bid. The unit prices shall constitute full compensation for all labor, equipment, materials, and incidentals necessary for the satisfactory completion of the work.

* * * * * *

Appendix C

Inspection and Maintenance Checklists

Evaluation Date:_____
Name:_____
Data Entry Date:_____

Inspection and Maintenance Checklist

Bioretention / Bioswale
Rain Garden
Stormwater Tree
Native Landscaping
Soil Amendment

Property/Project Name: _____

Property Address: _____

Property Owner Present?: ☐ Yes ☐ No

Owner/Representative Name: _____ Fax # or Email: _____

Type of Strategy: ☐ Bioretention / Bioswale ☐ Rain Garden ☐ Stormwater Tree ☐ Native Landscaping ☐ Soil Amendment ☐ Other

Last Rain Event Date: _____ Last Rain Event Duration: _____

Last Rain Event Amount (in.): _____ Location of Rain Gauge: _____

Current Weather Conditions: _____

GI Element	Inspection Item	Yes, No, N/A	Comments
Contributing Drainage Area	Excessive trash, debris, sediment, landscape waste, or yard clippings		
	Bare/exposed soil		
	Evidence of erosion		
Pretreatment, if applicable	Excessive trash/debris/sediment		
	Evidence of clogging		
	Evidence of erosion		

GI Element	Inspection Item	Yes, No, N/A	Comments
Pretreatment, if applicable	Vegetation appears unhealthy		
	DRY WEATHER: Evidence of standing water or noticeable odors		
	WET WEATHER: Ponding water depth	----------	
Stormwater Entry Points to Feature	Evidence of flow impediment		
Vegetation	Plant cover less than 90% (3+ years after installation)		
	Dead plants (Include percentage of plant mortality, if appropriate)		
	Excessive growth of one plant species (overtaking other species)		
	Invasive plants and/or weeds		
Soil Media	Exposed/bare soil		
	Evidence of erosion		
	Excessive trash/debris/sediment		
	DRY WEATHER: Evidence of standing water or noticeable odors		
	WET WEATHER: Ponding water depth	----------	
Underdrain, if applicable	Evidence of flow impediment		
Outlet/ Overflow Spillway	Evidence of flow impediment		
	Excessive trash/debris/sediment at outlet(s)		
	Evidence of erosion at/around outlet(s)		

OVERALL CONDITION OF FACILITY:

- ☐ **Poor**: Immediate need for repair or replacement
- ☐ **Fair**: Poorly maintained, routine maintenance and repair needed
- ☐ **Good**: Adequately maintained, routine maintenance needed
- ☐ **Excellent**: Well maintained, no action required

GENERAL COMMENTS:

Items for consideration NOT evaluated during this site visit. Should be determined by a certified professional:

- Topsoil is in poor condition, the pH level is not 6-7, the composition is inappropriate
- The composition of soil media is inconsistent with design specifications
- Soil media depth is too low or is over-compacted

Evaluation Date:_____
Name:_____
Data Entry Date:_____

Inspection and Maintenance Checklist
POROUS PAVEMENT

Property/Project Name: _____

Property Address: _____

Property Owner Present?: ☐ Yes ☐ No

Owner/Representative Name: _____ Fax # or Email: _____

Type of Pervious Pavement: ☐ Concrete ☐ Asphalt ☐ Pavers

Last Rain Event Date: _____ Last Rain Event Duration: _____

Last Rain Event Amount (in.): _____ Location of Rain Gauge: _____

Current Weather Conditions: _____

GI Element	Inspection Item	Yes, No, N/A	Comments
Contributing Drainage Area	Excessive trash, debris, sediment, landscape waste, or yard clippings		
	Bare exposed soil		
	Evidence of erosion		
	Visible evidence of chemicals and/or automotive fluids		
Pervious Pavement Surface	Visible evidence of chemicals and/or automotive fluids		
	Standing water		
	Visible evidence of sediment accumulation or clogging		
	Visible evidence of pavement deterioration or failure (including rutting, rippling, cracking, chipping, etc.)		

BMP Element	Inspection Item	Yes, No, N/A	Comments
Underdrain, if applicable	Evidence of flow impediment		
Outlet, if applicable	Evidence of flow impediment		
	Excessive trash, debris, or sediment accumulation at outlet(s)		
	Evidence of erosion at/around outlet(s)		

OVERALL CONDITION OF FACILITY:

- ☐ **Poor**: Immediate need for repair or replacement
- ☐ **Fair**: Poorly maintained, routine maintenance and repair needed
- ☐ **Good**: Adequately maintained, routine maintenance needed
- ☐ **Excellent**: Well maintained, no action required

GENERAL COMMENTS:

Appendix D

Tree and Plant Lists

Table D-1 Stormwater Tree Species Considerations

SCIENTIFIC NAME	COMMON NAME	HEIGHT (FT)	SPREAD (FT)	SOIL CONDITIONS	DROUGHT TOLERANT	SALT TOLERANT	NATIVE TO SE WISC	BEST FOR TOUGH SITES
Large-Sized Trees								
Carya ovata	Shagbark hickory	60-80	35-50	Adaptable	Y	Y	Y	
Ginko Biloba	Ginko	50-80	34-40	Adaptable	Y	Y	N	Y
Gleditsia triacanthos	Honey locust	30-70	30-70	Adaptable	Y	Y	Y	Y
Gymnocladus dioicus "Stately Manor"	Fruitless Kentucky coffee Tree	50-70	30-50	Adaptable	Y	Y	Y	Y
Quercus macrocarpa	Bur Oak	70-80	70-80	Adaptable	Y	Y	Y	
Quercus rubra	Northern Red Oak	60-75	60-75	Well drained-sandy	Y	Y	Y	
Quercus x schuetti	Hybrid swamp X Bur Oak	60-75	60-70	Adaptable	Y	Y	M	Y
Sophora japonica	Japanese Pagoda Tree	50-75	50-75	Well drained, tolerates alkaline soils	N	Y	N	
Plantanus occidentalis	Sycamore	75-100	75-100	Moist, well-drained	Y	N	Edge	
Quercus imbricaria	Shingle oak	50-60	50-60	Adaptable	Y	Y	Edge	
Medium-Sized Trees								
Betula nigra	River birch	40-70	40-60	Moist, well drained, acidic	Y	Y	No	
Celtis occidentalis	Hackberry	40-60	40-60	Rich moist, withstands alkaline	Y	Y	Yes	Y
Crataegus crus-galli	Cockspur hawthorn	18-25	18-25	Adaptable	Y	Y	N	Y
Juniperus virginiana	Eastern Red Cedar	40-50	10-20	Adaptable	Y	Y	Y	Y

Table D-2 Small Size Trees and Shrubs for Rain Gardens

SCIENTIFIC NAME	COMMON NAME	HEIGHT (FT)	SPREAD (FT)	SOIL CONDITIONS	DROUGHT TOLERANT	SALT TOLERANT	NATIVE TO SE WISC	BEST FOR TOUGH SITES
Amelanchier spp.	Service berry, juneberry	10-20	10-20	Prefers slightly acid	N	Y	Y	
Aronia arbutifolia	Red Chokeberry	6-10	3-5	Adaptable, prefers acid	Y	Y	Y	Y
Aronia melanocarpa	Black Chokeberry	3-6	3-6	Adaptable, Prefers acid soil	Y	Y	Y	Y
Clethera alnifolia	Summersweet Clethra	4-8	4-10	Prefers slightly acid, and moist	Y	Y	Y	Y
Cornus amonum	Silky dogwood	6-10	6-10	Adaptable	Y	N	Y	
Cornus sericea or stolonifera	Red-osier dogwood	7-10	8-10	Adaptable	Y	N	Y	
Dirca palustris	Leatherwood	2-5	2-5	well drained, tolerates alkaline	N	Y	Y	
Hypericum prolificum	Shrubby St. Johnswort	3-4	3-4	Adaptable	Y	Y	Y	Y
Ilex verticilata	Winterberry	6-9	6-9	Needs a consistently wet site	N	N	Y	
Juniperus communis	Common juniper	5-10	8-15	Adaptable	Y	Y	Y	Y
Myrica pensylvanica	Bayberry, northern bayberry	6-12	6-12	Adaptable, prefers slightly acid soils	Y	Y	Y	
Potentila fruticosa	Shrubby Cinquefoil, potentilla	2-4	2-4	Very adaptable	Y	Y	Y	Y
Physocarpus opulifolius	Ninebark	5-10	5-10	Tolerates alkaline soil	Y	N	Y	
Rhus aromatic – "grow low"	Fragrant sumac	3-8 ft	6-10	Adaptable, prefers acid	Y	Y	Y	
Syringa reticulata	Japanese Tree Lilac	20-30	15-25	Well drained, slightly acidic	N	Y	N	
Viburnum dentatum	Arrowwood Viburnum	6-12	6-12	Adaptable, prefers slightly acid soils	Y	Y	Y	
Viburnum lentago	Nannyberry	10-30	6-12	Well drained	Y	Y	Y	

Table D-3 Perennials for Rain Gardens and Native Landscaping

SCIENTIFIC NAME	COMMON NAME	HEIGHT (FT)	LIGHT	SOIL CONDITIONS	DROUGHT TOLERANT	SALT TOLERANT	NATIVE TO SE WISC	RELIABLE, LOW MAINT.
Asclepias tuberosa	Butterfly weed	2	Sun/ Pt. Shade	Well drained	Y		Y	Y
Aquilegia Canadensis	Columbine	2	Sun/ Pt. Shade/ Shade	Well drained	Y		Y	Y
Baptisia bracteata	Cream False Indigo	2	Sun/ Pt. Shade	Well drained	Y		Y	
Liatris cylindracea	Dwarf blazing star	1	Sun/ Pt. Shade	Well drained	Y		Y	
Campanula rotundifolia	Harebell	1	Sun/ Pt. Shade	Well drained	Y		Y	
Zizia aptera	Golden Alexanders	2	Sun/ Pt. Shade	Well drained	Y		Y	Y
Coreopsis lanceolata	Sand coreopsis	2	Full sun	Well drained	Y		Y	
Aster ericoides	Heath aster	2	Sun/ Pt. Shade	Well drained	Y		Y	Y
Echinacea angustifolia	Narrow-leaved coneflower	2	Full sun	Well drained	Y		Y	
Penstemon pallidus	Pale beardtongue	1	Full sun	Well drained	Y	Y	Y	
Tradescantia bracteata	Prairie Spiderwort	1	Full sun	Well drained				
Aster sericeus	Silky aster	1	Sun/ Pt. Shade	Well drained	Y			
Liatris squarrosa	Scaly blazing star	2	Sun/ Pt. Shade	Well drained	Y			
Dodecatheon amethystinum	Amethyst shooting star	1	Sun/ Pt. Shade	Adaptable	Y		Y	
Agastache foeniculum	Anise hyssop	3	Sun/ Pt. Shade	Adaptable	Y		Y	
Rudbeckia hirta	Black-eyed susan	2	Sun/ Pt. Shade	Adaptable	Y		Y	Y
Rudbeckia fulgida	Orange coneflower	3	Sun/ Pt. Shade	Adaptable	Y		Y	
Gentiana andrewsii	Bottle gentian	3	Sun/ Pt. Shade	Adaptable	Y		Y	
Nepeta faassenii	Catmint	2	Full sun	Well drained	Y	Y	N	Y
Pycnanthemum virginianum	Virginia mountain mint	3	Sun/ Pt. Shade	Adaptable	N		Y	
Helianthus occidentalis	Ox-eye Sunflower	3	Full sun	Well drained	Y		Y	Y
Aster azureus	Sky-blue aster	3	Sun/ Pt. Shade	Adaptable	Y	Y	Y	Y
Penstemon tubiflorus	Tube beardtongue	3	Sun/ Pt. Shade	Adaptable	Y	Y	Y	
Mertensia virginica	Virginia Bluebells	2	Pt shade/ Shade	Moist	N		Y	
Solidago flexicaulis	Zig-zag goldenrod	3	Pt shade/ Shade	Adaptable	Y		Y	Y

Table D-3 Perennials for Rain Gardens and Native Landscaping (Continued)

SCIENTIFIC NAME	COMMON NAME	HEIGHT (FT)	LIGHT	SOIL CONDITIONS	DROUGHT TOLERANT	SALT TOLERANT	NATIVE TO SE WISC	RELIABLE, LOW MAINT.
Huechera richardsonii	Prairie alumroot	2-3	Pt shade/ Shade	Adaptable	N	Y	Y	
Aster macrophyllus	Big-leaved aster	1	Shade	Adaptable	Y		Y	Y
Amemonella thalictroides	Rue Anemone	6”	Shade	Adaptable	N		Y	
Aster lateriflorus	Calico Aster	1-3	Shade	Adaptable	Y		Y	Y
Polemonium reptans	Jacob’s ladder	1	Shade	Adaptable	Y		Y	
Aster drummondii	Drummond’ s Aster	3	Shade	Adaptable	Y		Y	Y
Achillea millefolium	Common yarrow	2	Sun	Adaptable	Y	Y	Y	Y
Physostegia virginiana	Obedient plant	3-4	Sun	Well drained	Y	Y	Y	Y
Grasses / Sedges								
Sporobolus heterolepis	Prairie/nort hern dropseed	3	Sun/ Pt. Shade	Adaptable	Y	N	Y	
Carex gravida	Long-awned sedge	2-3	Sun	Adaptable	Y	N	Y	
Schizachyrium scoparium	Little bluestem	3	Sun/ Pt. Shade	Adaptable	Y	Y	Y	Y
Bouteloua curtipendula	Side-oats gamma	2	Sun/ Pt. Shade	Well drained	Y			
Carex pensylvanica	Penn/Oak sedge	8”	Sun/ Pt. Shade/ Shade	Adaptable	Y	N	Y	
Carex bebbii	Bebb’s Oval Sedge	3	Sun	Moist	N	N	Y	Y
Hierochloe odorata	Sweet grass	2	Sun/ Pt. Shade	Moist	N	N	Y	
Elymus villosus	Silky Wild Rye	3	Pt Shade	Dry-moist	Y	N	Y	
Carex brevior	Plains oval sedge	1	Pt Shade	Dry-moist	Y	N	Y	
Carex eburnean	Ivory sedge	6”	Shade	Dry-med	Y	N	Y	
Carex davisii	Awned graceful sedge	2-3	Shade	Med-moist	N	N	Y	
Carex sprengelii	Long-beaked sedge	2	Shade	Dry-moist	Y	N	Y	
Carex interior	Prairie Star Sedge	2	Shade	Med-wet	N	N	Y	
Chasmanthium latifolium	Northern sea-oats	5	Sun/ Pt. Shade/ Shade	Adaptable	Y	Y	Y	Y