Urban Bioretention

Description: Urban bioretention is similar to traditional bioretention practices, except that the urban bioretention is fit into concrete-sided containers within urban landscapes, such as planter boxes or tree planters. Captured runoff is treated by filtration through an engineered soil medium, and is then either infiltrated into the subsoil or exfiltrated through an underdrain.

Advantages/Benefits:

- Reduced runoff volume
- Reduced peak discharge rate
- Reduced Total Suspended Solids (TSS)
- Reduced pollutant loading
- Reduced runoff temperature
- Groundwater recharge (if soils are sufficiently permeable)
- Habitat creation
- Enhanced site aesthetics
- Reduced heat island effect

Disadvantages/Limitations:

- Problems with installation can lead to failure
- Minimum 2 foot separation from groundwater and bedrock is required for applications without an impermeable bottom
- Suitable for pollution hotspots only with underdrain and liner

Selection Criteria:

40% Runoff Reduction Credit

Land Use Considerations:

- [x] **Residential**
- [x] **Commercial**
- [x] **Industrial**

Maintenance:

- Regular maintenance of landscaping to maintain healthy vegetative cover
- Irrigation when necessary during first growing season
- Periodic trash removal

M **Maintenance Burden**
L = Low M = Moderate H = High

SECTION 1: DESCRIPTION

Urban bioretention practices are similar in function to regular urban bioretention practices except they are adapted to fit into "containers" within urban landscapes. Typically, urban bioretention is installed within an urban streetscape or city street Right of Way (ROW), urban landscaping beds, tree planters, and plazas. Urban bioretention is not intended for large commercial areas. Urban bioretention is intended to be incorporated into small fragmented drainage areas such as shopping or pedestrian plazas within a larger urban development.

Urban bioretention features hard edges, often with vertical concrete sides, as contrasted with the more gentle earthen slopes of regular urban bioretention. If these practices are outside of the ROW, they may be open-bottomed, to allow some infiltration of runoff into the sub-grade, but they generally are served by an underdrain. Each urban bioretention variant is planted with a mix of trees, shrubs, and grasses as appropriate for its size and landscaping context.

SECTION 2: PERFORMANCE

The runoff reduction function of an urban bioretention area is described in **Table 2.1**.

Table 2.1. Runoff Volume Reduction Provided by Urban bioretention Basins

Stormwater Function	Level 1 Design
Runoff Volume Reduction (RR)	40%
Treatment Volume (Tv) Multiplier*	1.0

*Incorporated into LID Site Design Tool calculations
Sources: CSN (2008) and CWP (2007)

SECTION 3: TYPICAL DETAILS

See Appendix 1-B and 1-C for required standard notes and applicable details for use in construction plans.

SECTION 4: PHYSICAL FEASIBILITY & DESIGN APPLICATIONS

Urban bioretention can be applied in most soils or topography, since runoff simply percolates through an engineered soil bed and can be returned to the stormwater system if the infiltration rate of the underlying soils is low. Key considerations with urban bioretention include the following:

Infiltration/Soils. Infiltration is a key component of Low Impact Development (LID) design. Infiltration testing may be required for some urban bioretention applications (see **Section 5.1**). Soil conditions do not constrain the use of urban bioretention but can affect the design requirements. Hydrologic Soil Groups (HSG) should be determined from NRCS soil data. For more information on soil types go to: http://websoilsurvey.nrcs.usda.gov/app/. Alternative HSG classifications will be considered when supporting reports from a licensed soil scientist or geotechnical engineer are provided.

Available Space. A prime advantage of urban bioretention is that it requires minimal additional space at a new development or redevelopment site, which can be important for tight sites or areas where land prices are high.

Accessibility. Urban bioretention facilities require periodic maintenance and must be accessible to various types of equipment. A path of travel for equipment no less than twelve feet in width with a maximum slope of 3:1 must be provided for the urban bioretention facility. The path of travel shall be along no less than 50% of the perimeter of the urban bioretention area and must be accessible by common equipment and vehicles at all times.

Subsurface Constraints. Urban bioretention perimeters typically consist of vertical constraints such as retaining walls, structures, or other impermeable barriers that comprise greater than 50% of the perimeter (≤50% see **GIP-01**). Urban bioretention subgrade shall always be separated from the water table and bedrock. Groundwater intersecting the filter bed can lead to possible groundwater contamination or failure of the urban bioretention facility. A separation distance of 2 feet is required between the bottom of the excavated urban bioretention area and the seasonally high ground water table and/or bedrock unless an impermeable liner is used.

Utilities. Designers must ensure that future tree canopy growth in the urban bioretention area will not interfere with existing overhead public utility lines. Public underground utilities and associated easements shall not be located within the urban bioretention footprint. Local utility design guidance shall be consulted in order to determine clearances required between stormwater infrastructure and other dry and wet utility lines. Private utilities should not be located within the urban bioretention area when possible.

Contributing Drainage Area. Urban bioretention is limited to 2,500 sq. ft. of drainage area. However, this is considered a general rule; larger drainage areas may be allowed with sufficient flow controls and other mechanisms to ensure proper function, safety, and community acceptance. The drainage areas in these urban settings are typically considered to be 100% impervious. While multiple planters or swales can be installed to maximize the treatment area in ultra-urban watersheds, urban bioretention is not intended to be used as treatment for large impervious areas (such as parking lots).

Hotspot Land Uses. Runoff from hotspot land uses should not be treated with infiltrating urban bioretention without appropriate pretreatment and MWS staff approval. For additional information on stormwater hotspots, please consult **Section 6.3**.

Floodplains. Urban bioretention areas shall be constructed outside the limits of the 100-year floodplain. Flood waters from the 100-year event or smaller shall be prohibited from entering the urban bioretention underdrain or overflow system.

Irrigation or Baseflow. The planned urban bioretention area shall not receive baseflow, chlorinated wash-water or other such non-stormwater flows, except for irrigation as necessary during the first growing season for the survival of plantings within the urban bioretention area (Consult the maintenance guidance outlined in **the main bioretention design specification (GIP-01) Section 9.2**).

Setbacks. To avoid the risk of seepage, a licensed professional engineer should be consulted to determine the appropriate setbacks necessary to prevent urban bioretention infiltration from compromising structural foundations or pavement.

Applications. Urban bioretention is typically used in medium to high density commercial, institutional and residential sites. It should be noted that special care must be taken to provide adequate pretreatment for urban bioretention cells in space-constrained high traffic areas. Typical locations for urban bioretention could include stormwater planters, green street swales, etc.

- **Green Street swales and planters** are installed in the sidewalk zone near the street where urban street trees are normally installed. ROW applications require an underdrain and an impermeable liner along the roadside to protect the roadway subgrade. This is a ROW application that requires MPW approval.

- **Stormwater planters** take advantage of limited space available for stormwater treatment by placing a soil filter in a container located above ground or at grade in landscaping areas between buildings and roadways with liner protection.

SECTION 5: DESIGN CRITERIA

5.1 Soil Infiltration Rate Testing

If infiltration is utilized, one must measure the infiltration rate of subsoils at the subgrade elevation of the urban bioretention area. If the infiltration rate exceeds 0.5 inch per hour, an underdrain should not be utilized. If the infiltration rate of subsoils is greater than 0.1 inch per hour and less than or equal to 0.5 inch per hour, underdrains will be required. On-site soil infiltration rate testing procedures are outlined in **Appendix 1-A**. The number of soil tests varies base on the size of the urban bioretention area:

- < 1,000 ft^2 = 2 tests
- 1,000 – 10,000 ft^2 = 4 tests
- >10,000 ft^2 = 4 tests + 1 test for every additional 5,000 ft^2

A separation distance of 2 feet is required between the bottom of the excavated urban bioretention area and the seasonally high ground water table and/or bedrock, unless an impermeable liner is used.

5.2 Sizing of Urban Bioretention Practices

5.2.1 Stormwater Quality

Sizing of the surface area (SA) for urban bioretention practices is based on the computed Treatment Volume (T_v) of the contributing drainage area and the storage provided in the facility. The required surface area (in square feet) is computed as the Treatment Volume (in cubic feet) divided by the equivalent storage depth (in feet). The equivalent storage depth is computed as the depth of media, gravel, and surface ponding (in feet) multiplied by the accepted porosity (see **Table 2.2**). All layer depths shall be uniform with regard to surface area. The filter bed surface should generally be flat so the urban bioretention area fills up like a bathtub. A maximum surface slope of 3% is permitted. See **Section 5.5** for material specifications.

Table 2.2 Urban Bioretention Typical Section for Water Quality Calculations

Layer	Depth (inches)	Porosity Value (n)
Ponding	6	1.0
Surface Cover*	3	N/A
Media	24-48	0.25
Choker	3	0.40
Reservoir	9	0.40

* Cannot be used in De and surface area calculations.

The equivalent storage depth is therefore computed as:

Equation 1.1. Urban Bioretention Design Storage Depth

$$\text{Equivalent Storage Depth} = D_E = n_1(D_1) + n_2(D_2) + \cdots$$

$$D_E = (2 \text{ to } 4 \text{ ft.} \times 0.25) + (1 \text{ ft} \times 0.40) + (0.5 \times 1.0) = 1.4 \text{ to } 1.9 \text{ ft.}$$

Where n_1 and D_1 are for the first layer, etc.

Therefore, the Urban Bioretention Surface Area (SA) is computed as:

Equation 1.3. Urban Bioretention Design Surface Area

$$SA\ (sq.\ ft.) = (T_v - \text{the volume reduced by an upstream SCM}) / D_E$$

Where:

SA = Minimum surface area of bioretention filter (sq. ft.)

D_E = *Equivalent Storage Depth (ft.)*

T_v = Treatment Volume (cu. ft.) = [(1.0 in.)(R_v)(A)*3630]

5.2.2 Stormwater Quantity

It is recommended that rain events larger than the 1-inch storm bypass urban bioretention areas to prevent additional maintenance burden. However, if designed with sufficient volume and appropriate outlet structures, peak attenuation control may be provided by the urban bioretention area. Hydrologic calculations utilizing the SCS method may be necessary to demonstrate pre versus post peak flow rates.

Subsurface Storage. Designers may be able to create additional subsurface storage for flow attenuation by increasing the subsurface volume without necessarily increasing the urban bioretention footprint. Additional volume can be provided by increasing the depth of media, stone, or approved proprietary storage products. Subsurface storage will not be allowed without sufficient infiltration (see **Section 5.1**).

Adjusted CN. With infiltration rates greater than 0.5 inch per hour (see **Section 5.1**), the removal of volume by urban bioretention changes the runoff depth entering downstream flood control facilities. An approximate approach to accounting for the removal of volume is to calculate an "effective SCS curve number" (CN_{adj}), which is less than the actual curve number (CN). CN_{adj} can then be used in hydrologic calculations and in routing. This method is detailed in Volume 5 Section 3.2.5.

5.3 Pretreatment

Pretreatment facilities must always be used in conjunction with urban bioretention to remove floatables and sediment to prevent clogging and failure. Every green infrastructure practice must include pretreatment techniques, although the nature of pretreatment practices depends on the type of flow received. Pretreatment measures should be designed to evenly spread runoff across the entire width of the urban bioretention area. Several pretreatment measures are feasible, depending on the scale of the urban bioretention practice and whether it receives sheet flow, shallow concentrated flow or deeper concentrated flows. The number and type of acceptable pretreatment techniques needed for the types of receiving flow are found in **Table 2.3**.

Table 2.3. Required Pretreatment Elements for Infiltration Practices

Flow Type	
Point/Concentrated	*1 technique* • *Outlet protection* • *Proprietary structure (such as a trash rack, MWS approval required)*
Sheet	*Gravel diaphragm*
Upstream GIP	*Outlet protection required at upstream GIP outfall*

5.4 Conveyance and Overflow

An overflow structure should always be incorporated into on-line designs to safely convey larger storms through the urban bioretention area. Common overflow systems within urban bioretention practices consist of an outlet structure(s) and/or emergency spillway in compliance with the Stormwater Management Manual, Volume 2, Section 8.

5.5 Urban Bioretention Material Specifications

Table 2.4 outlines the standard material specifications used to construct urban bioretention areas.

Table 2.4 Bioretention Material Specifications

Material	Specification	Notes
Mulch Layer	• Shredded hardwood • Hardwood bark • River stone • Coir or jute matting	Lay a 3-inch layer on the surface of the filter bed in order to suppress weed growth & prevent erosion. Stone shall not comprise more than 50% of the surface area.
Filter Media Composition	• 70% - 85% sand; • 10%-30% silt + clay, with clay ≤ 10%; and • 5% to 10% organic matter	The volume of filter media based on 110% of the plan volume, to account for settling or compaction. Minimum media infiltration rate 1 in/hr. Contact staff for testing procedures.
Geotextile	Use a non-woven geotextile fabric with a flow rate of > 110 gal./min./ft² (e.g., Geotex 351 or equivalent)	Apply only to the sides and above the underdrain (2'-4' wide strip). AASHTO M288-06, ASTM D4491 & D4751
Choker Layer	#8 or #89 clean washed stone	Meet TDOT Construction Specifications.
Reservoir Layer	#57 clean washed stone	Meet TDOT Construction Specifications.
Underdrain	6-inch dual wall HDPE or SDR 35 PVC pipe with 3/8-inch perforations at 6 inches on center	AASHTO M 252 Place perforated pipe at base of reservoir layer.
Cleanout	6-inch SDR 35 PVC pipe with vented cap	Provide cleanouts at the upper end of the underdrain.
Observation Well	6-inch SDR 35 PVC pipe with vented cap and anchor plate	Number of wells equals the number of test pits required for infiltration testing (see Appendix 2-A)

5.6 Urban Bioretention Planting Plans

A landscaping plan must be provided for each urban bioretention area. Minimum plan elements shall include the proposed planting plan for the surface area of the urban bioretention, the list of planting stock, sources of plant species, sizes of plants, and the planting sequence along with post-nursery care and initial maintenance requirements. The planting plan must address 100% of the planting area and achieve a surface area coverage of at least 75% in the first two years. Native plant species are preferred over non-native species, but some ornamental species may be used for landscaping effect if they are not aggressive or invasive. **Appendix 1-D** lists native plant species suitable for use in urban bioretention. Landscaping in the ROW should be designed to limit visual obstructions for pedestrian and vehicular traffic.

The planting plan must be prepared by a qualified Landscape Architect. The Landscape Architect shall certify the planting plan with certification statement, located on the urban bioretention planting plan. Standard certification statement can be found in **Appendix 2-B**.

SECTION 6: SPECIAL CASE DESIGN ADAPTATIONS

6.1 Shallow Bedrock and Groundwater Connectivity

Many parts of Nashville have shallow bedrock, which can constrain the application of urban bioretention areas (utilizing infiltration). In such settings, other GIPs may be more applicable. For more information on bedrock depths download the GIS data set from: http://water.usgs.gov/GIS/metadata/usgswrd/XML/regolith.xml.

6.2 Karst

Karst regions are found in much of Middle Tennessee, which complicates both land development and stormwater design. Infiltrative practices shall not be used in any area with a high risk of sinkhole formation. Urban bioretention areas must use an impermeable liner in these areas.

6.3 Hotspots

Stormwater hotspots are operations or activities that are known to produce higher concentrations of stormwater pollutants and/or have a greater risk for spills, leaks or illicit discharges. Urban Bioretention designs utilizing infiltration shall not be used in any area with a hotspot designation without appropriate pretreatment, impermeable barriers, and MWS staff approval. Designs that meet separation distance requirements (2 feet) and possess an impermeable bottom liner and an underdrain are suited for certain hotspots. Staff may also require additional treatment for runoff from hotspots.

SECTION 7: CONSTRUCTION

7.1 Construction

Construction Stage Erosion and Sediment Controls. Urban bioretention areas should be fully protected by silt fence and construction fencing to prevent sedimentation and compaction. Ideally, urban bioretention should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment.

Excavation. The proposed site should be checked for existing utilities prior to any excavation. It is very important to minimize compaction of both the base of the urban bioretention area and the required backfill. When possible, excavators should work from the sides of the urban bioretention area to remove original soil. Compaction will significantly contribute to design failure.

7.2 Urban Bioretention Installation

Construction should take place during appropriate weather conditions. The following is a typical construction sequence to properly install an urban bioretention basin. These steps may be modified to reflect different urban bioretention applications or expected site conditions:

Step 1. The designer and the installer should have a preconstruction meeting, checking the boundaries of the contributing drainage area and the actual inlet elevations to ensure they conform to original design. Since other contractors may be responsible for constructing portions of the site, it is quite common to find subtle differences in site grading, drainage and paving elevations that can produce hydraulically important differences for the proposed urban bioretention area. The designer should clearly communicate, in writing, any project changes determined during the preconstruction meeting to the installer and the plan review/inspection authority.

Step 2. Ensure that the entire contributing drainage area has been stabilized prior to urban bioretention construction. Otherwise, use EPSC measures as outlined in **Section 7.1**.

Step 3. Excavation of the urban bioretention area should follow the guidelines found in **Section 7.1**.

Step 4. It may be necessary to rip the bottom soils to a depth of 6 to 12 inches to promote greater infiltration.

Step 5. Install all layers, components, and landscaping of the urban bioretention per plans. Media shall be tested per MWS standards. Irrigate plantings as needed.

Step 6. Conduct the final construction inspection (see **Section 8**). Then log the GPS coordinates for each urban bioretention facility and submit them to MWS.

SECTION 8: AS-BUILT REQUIREMENTS

After the urban bioretention area has been constructed, the owner/developer must have an as-built certification of the urban bioretention area conducted by a registered Professional Engineer. The as-built certification verifies that the GIP was installed per the approved plan. The following items shall be provided in addition to the as-built requirements found in SWMM Volume 1.

1. Landscape Architect letter certifying that the SCM plantings have been installed in general conformance with the approved grading plans and, with proper maintenance, should achieve 75% coverage within the first two years.
2. The Engineer shall include a copy of the GIP summary table found in Appendix 2-E.
3. Supporting documents such as invoices, photos, and media test results should be included in the submittal package.

SECTION 9: MAINTENANCE

Routine operation and maintenance are essential to gain public acceptance of highly visible urban bioretention areas. Weeding, pruning, the removal and replacement of dead vegetation and trash removal should be done as needed to maintain the aesthetics necessary for community acceptance. During drought conditions, it may be necessary to water the plants, as would be necessary for any landscaped area. Maintenance shall be the responsibility of the property owner as outlined in Volume 1, Appendix C.

To ensure proper performance, installers should check that stormwater infiltrates properly into the soil within 24 hours after a storm. If excessive surface ponding is observed, corrective measures include inspection for soil compaction and underdrain clogging. Consult the maintenance guidance outlined in **the main bioretention design specification (GIP-01)**.

SECTION 10: COMMUNITY & ENVIRONMENTAL CONCERNS

The following is a list of some community and environmental concerns that may arise when infiltration practices are proposed:

Nuisance Conditions. Poorly designed infiltration practices can create potential nuisance problems such as basement flooding, poor yard drainage and standing water. In most cases, these problems can be minimized through proper adherence to the setback, soil testing and pretreatment requirements outlined in this specification.

Mosquito Risk. Infiltration practices have some potential to create conditions favorable to mosquito breeding, if they clog and have standing water for extended periods. Proper installation and maintenance of the urban bioretention area will prevent these conditions from occurring.

Figure 2.1 Portland State University street planters.
(Photo: Martina Keefe)

Figure 2.2 Deaderick Street planters.

SECTION 11: REFERENCES

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VADCR. 2013. Stormwater Design Specification No. 9, *Appendix 9-A: Urban bioretention / Stormwater Planters / Expanded Tree Planters / Stormwater Curb Extensions, version 1.7. Virginia Department of Conservation and Recreation.*

APPENDIX 2-A
INFILTRATION SOIL TESTING PROCEDURES

I. Test Pit/Boring Procedures

1. The number of required test pits or standard soil borings is based on proposed infiltration area:
   - < 1,000 ft^2 = 2 tests
   - 1,000 – 10,000 ft^2 = 4 tests
   - >10,000 ft^2 = 4 tests + 1 test for every additional 5,000 ft^2
2. The location of each test pit or standard soil boring should correspond to the location of the proposed infiltration area and be performed in in situ soils.
3. Excavate each test pit or penetrate each standard soil boring to a depth at least 2 feet below the bottom of the proposed infiltration area.
4. If the groundwater table is located within 2 feet of the bottom of the proposed facility, determine the depth to the groundwater table immediately upon excavation and again 24 hours after excavation is completed.
5. Determine the USDA or Unified Soil Classification system textures at the bottom of the proposed infiltration area and at a depth that is 2 feet below the bottom. All soil horizons should be classified and described.
6. If bedrock is located within 2 feet of the bottom of the proposed infiltration area, determine the depth to the bedrock layer.
7. Test pit/soil boring stakes should be left in the field to identify where soil investigations were performed.

II. Infiltration Testing Procedures

1. The number of required infiltration tests is based on proposed infiltration area:
   - < 1,000 ft^2 = 2 tests
   - 1,000 – 10,000 ft^2 = 4 tests
   - >10,000 ft^2 = 4 tests + 1 test for every additional 5,000 ft^2
2. The location of each infiltration test should correspond to the location of the proposed infiltration area.
3. Install a test casing (e.g., a rigid, 4 to 6-inch diameter pipe) to a depth 2 feet below the bottom of the proposed infiltration area. Record the testing elevation.
4. Remove all loose material from the sides of the test casing and any smeared soil material from the bottom of the test casing to provide a natural soil interface into which water may percolate. If desired, a 2-inch layer of coarse sand or fine gravel may be placed at the bottom of the test casing to prevent clogging and scouring of the underlying soils. Fill the test casing with clean water to a depth of 2 feet, and allow the underlying soils to presoak for 24 hours.
5. After 24 hours, refill the test casing with another 2 feet of clean water and measure the drop in water level within the test casing after one hour. Repeat the procedure three (3) additional times by filling the test casing with clean water and measuring the drop in water level after one hour. A total of four (4) observations must be completed.
6. The infiltration rate of the underlying soils may be reported either as the average of all four observations or the value of the last observation. The infiltration rate shall be reported in terms of inches per hour along with the elevations and locations of the test pits. Locations shall be shown on site map.
7. Infiltration testing may be performed within an open test pit or a standard soil boring. After infiltration testing is completed, the test casing should be removed, and the test pit or soil boring should be backfilled and restored.

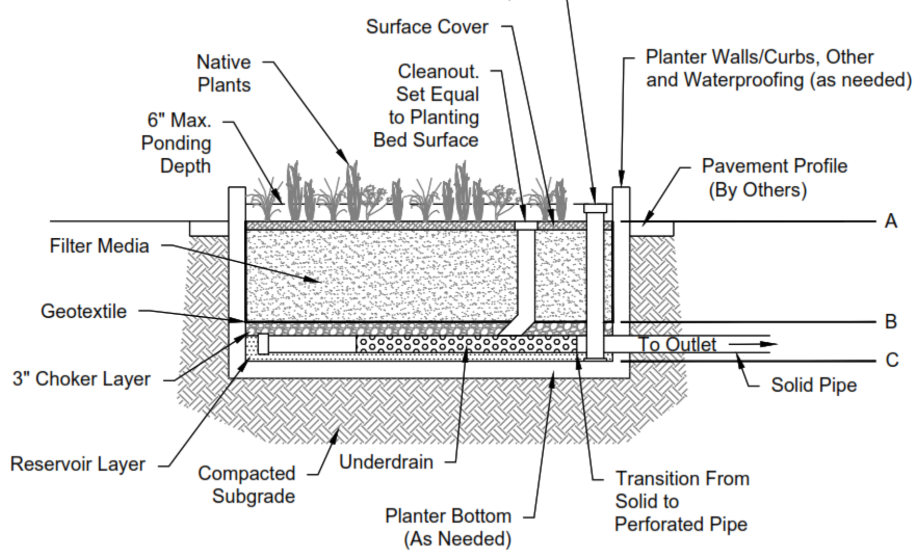
APPENDIX 2-B
STANDARD NOTES

Required Urban bioretention Notes:

- Contractor, Engineer, or Owners Representative shall notify MWS NPDES staff at least 48 hours prior to the installation of the planting soil filter bed. At the completion of installation, the above referenced person will collect one sample per urban bioretention bed for analysis and confirmation of the soil characteristics as defined by GIP-01. Media testing not required when using a certified media product.
- I hereby certify that this urban bioretention planting plan is in keeping with the requirements listed in GIP-02 Section 5.6. Only native species and/or non-invasive species of plants were used in the design of this urban bioretention planting plan. This plan will achieve at least 75% surface area coverage within the first two years.
- Vehicular and equipment traffic shall be prohibited in an infiltrating urban bioretention area to prevent compaction and sediment deposition.

APPENDIX 2-C
STANDARD DETAILS

GIP - 02A
URBAN BIORETENTION
WITH UNDERDRAIN



GIP - 02B
URBAN BIORETENTION
WITHOUT UNDERDRAIN

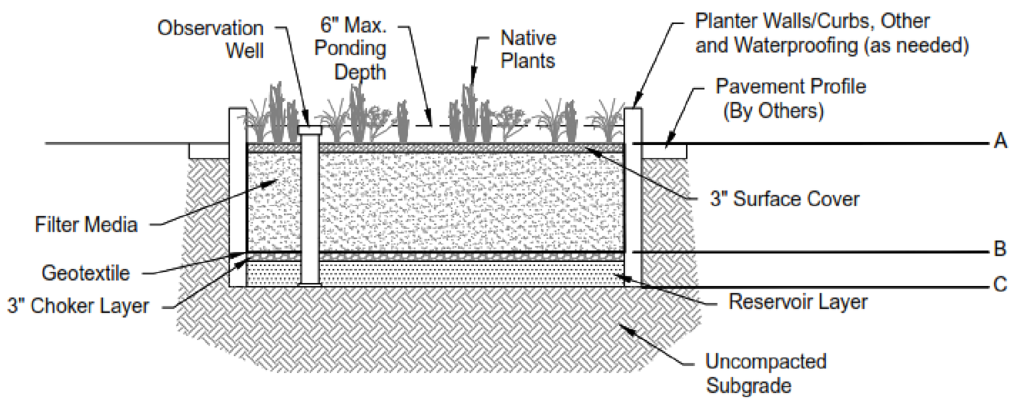


Figure 2.3. Design Details

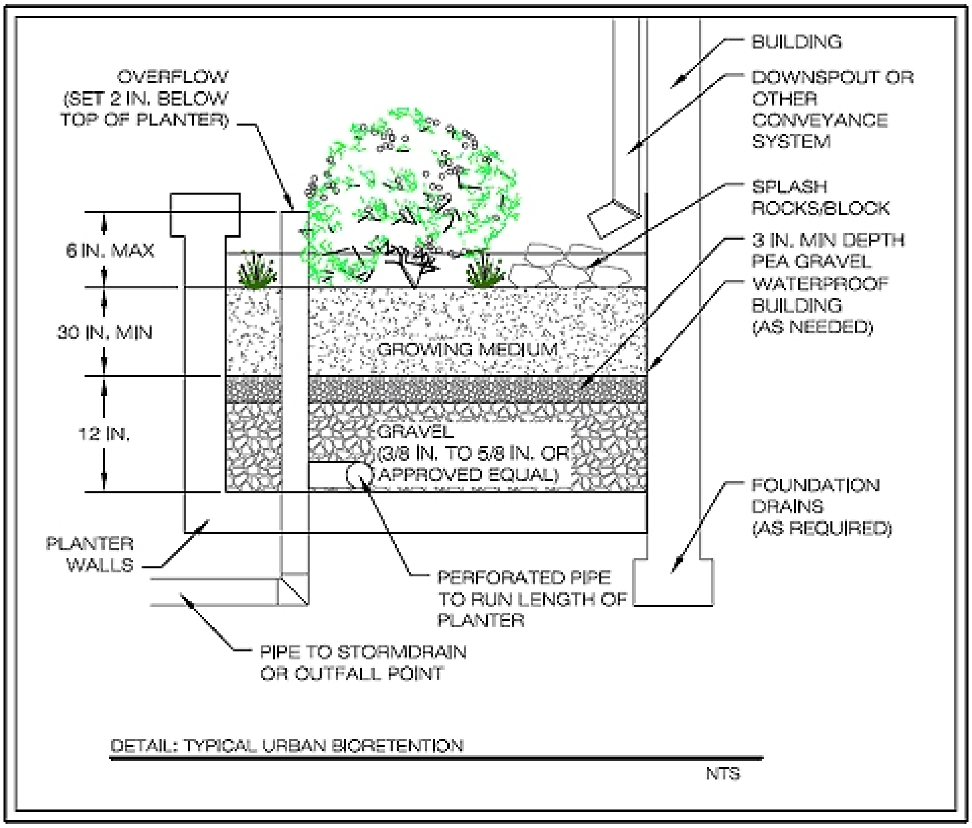


Figure 2.4. Stormwater Planter Cross-Section (source: VADCR, 2010)

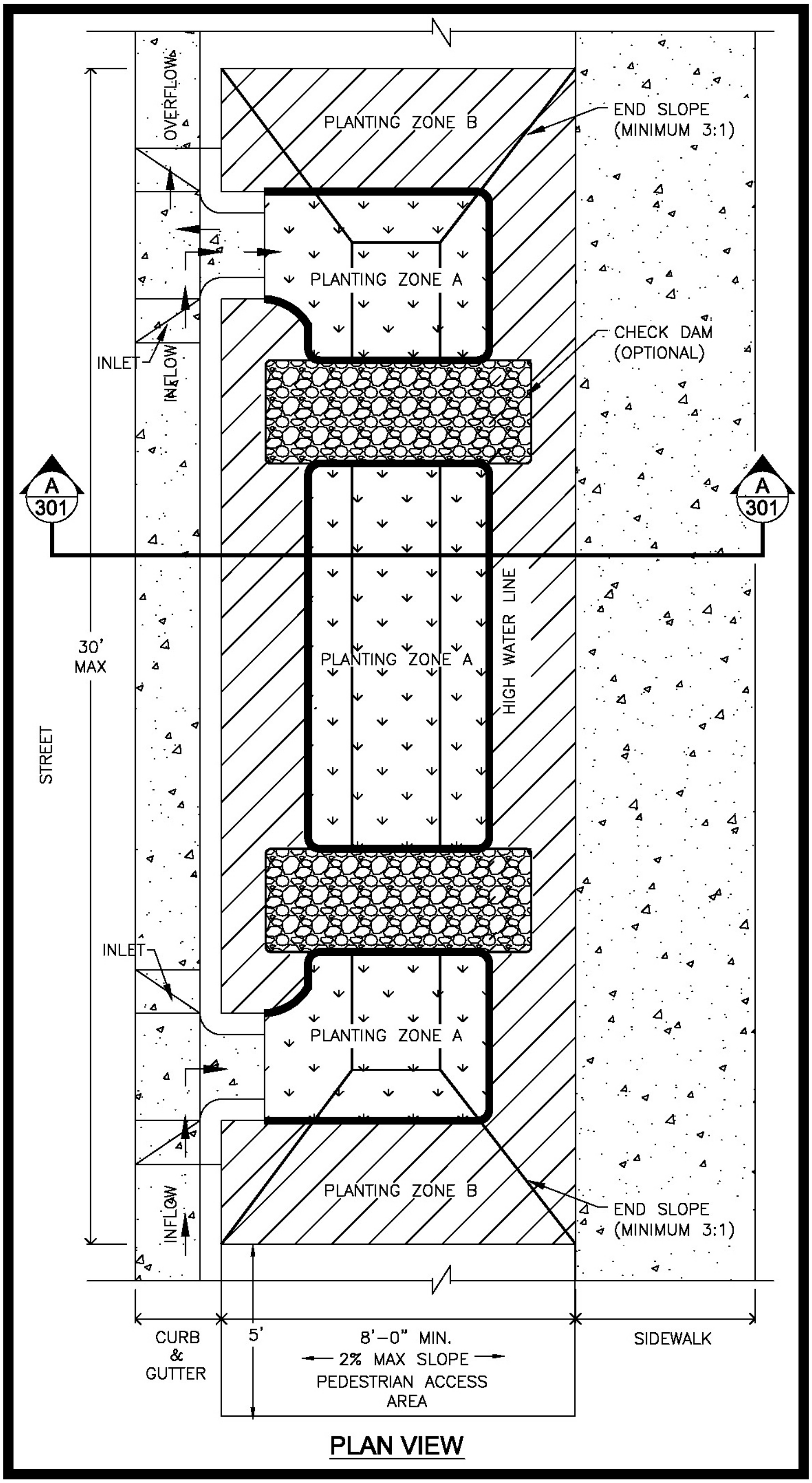


Figure 2.5. Green Streets Swale Plan View (source: Portland, 2011)

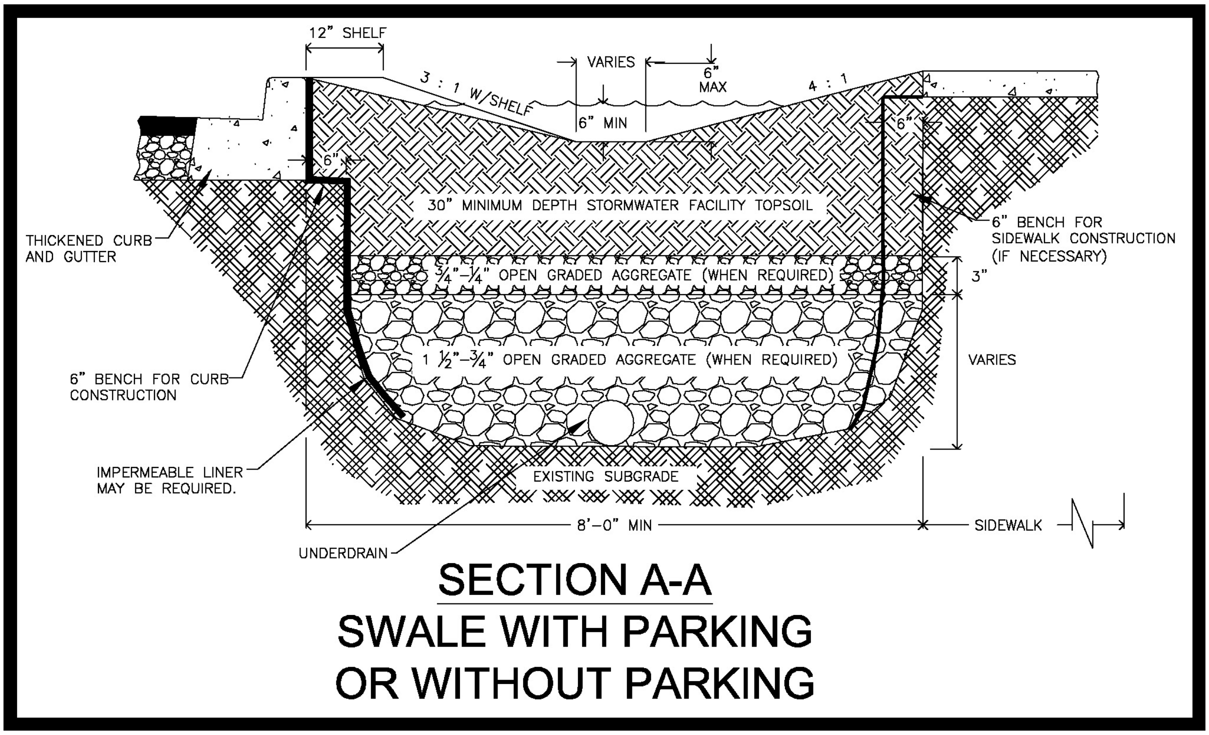


Figure 2.6. Green Streets Swale Section View (source: Portland, 2011)

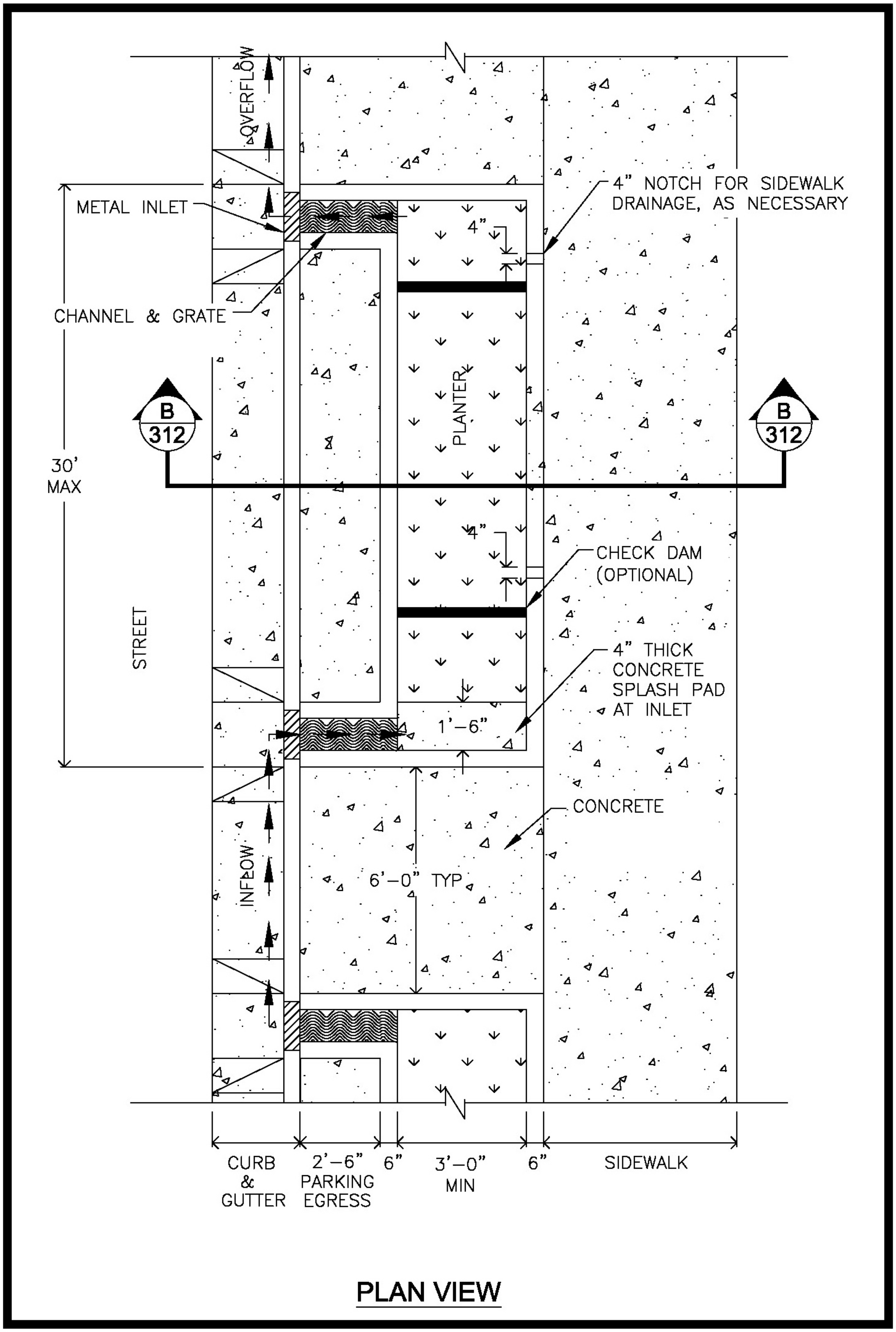


Figure 2.7. Green Streets Planter Plan View With Parking (source: Portland, 2011)

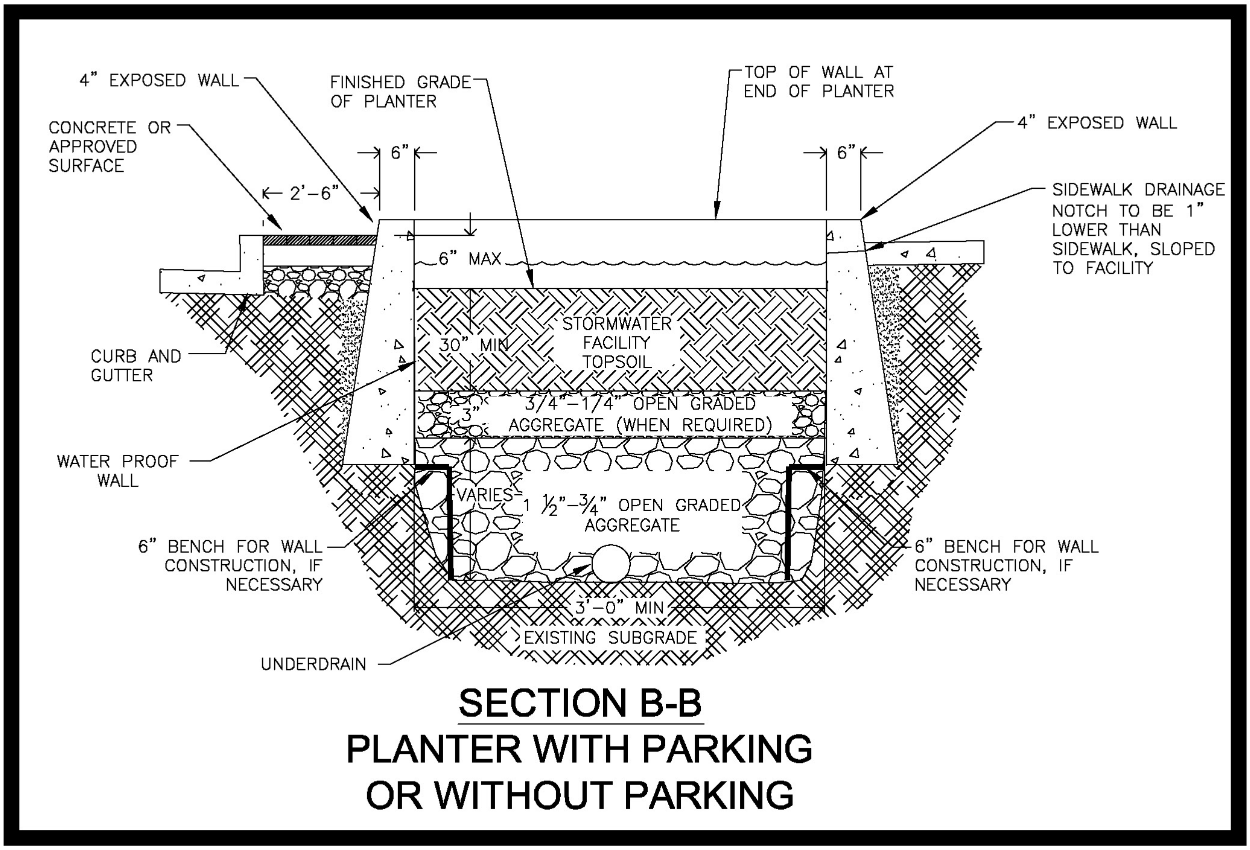


Figure 2.8. Green Streets Planter Section View With or Without Parking (source: Portland, 2011)

APPENDIX 2-D
NATIVE PLANTINGS

Popular Native Perennials for Urban Bioretention – Full Sun						
Latin Name	**Common Name**	**Size**	**Spacing**	**Moisture**	**Color**	**Height**
Asclepias incarnate	Marsh milkweed	Plugs – 1 gal.	1 plant/24" o.c.	Wet	Pink	3-4'
Asclepias purpurescens	Purple milkweed	Plugs – 1 gal.	1 plant/18" o.c.	Moist	Purple	3'
Asclepias syriaca	Common milkweed	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Orange	2-5'
Asclepias tuberosa	Butterfly milkweed	Plugs – 1 gal.	1 plant/18" o.c.	Dry-moist	Orange	2'
Asclepias verdis	Green milkweed	Plugs – 1 gal.	1 plant/18" o.c.	Moist	Green	2'
Asclepias verdicillata	Whorled milkweed	Plugs – 1 gal.	1 plant/18" o.c.	Moist	White	2.5'
Aster laevis	Smooth aster	Plugs – 1 gal.	1 plant/18" o.c.	Moist	Blue	2-4'
Aster novae-angliae	New England aster	Plugs – 1 gal.	1 plant/24" o.c.	Wet-moist	Blue	2-5'
Aster sericeus	Silky aster	Plugs – 1 gal.	1 plant/18" o.c.	Dry	Purple	1-2'
Chamaecrista fasciculata	Partridge pea	Plugs – 1 gal.	1 plant/18" o.c.	Dry	Yellow	1-2'
Conoclinium coelestinum	Mist flower	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Blue	1-2'
Coreopsis lanceolata	Lance-leaf coreopsis	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Yellow	6-8'
Echinacea pallida	Pale purple coneflower	Plugs – 1 gal.	1 plant/18" o.c.	Dry	Purple	2-3'
Echinacea purpurea	Purple coneflower	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Purple	3-4'
Eupatorium perfoliatum	Boneset	Plugs – 1 gal.	1 plant/24" o.c.	Wet	White	3-5'
Eupatorium purpureum	Sweet Joe-Pye Weed	Plugs – 1 gal.	1 plant/24" o.c.	Wet-moist	Purple	3-6'
Iris virginica	Flag Iris	Plugs – 1 gal.	1 plant/18" o.c.	Moist-Wet	Blue	2'
Liatris aspera	Rough blazingstar	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Purple	2-5'
Liatris microcephalla	Small-headed blazingstar	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Purple	3'
Liatris spicata	Dense blazingstar	Plugs – 1 gal.	1 plant/24" o.c.	Wet-moist	Purple	1.5'
Liatris squarrulosa	Southern blazingstar	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Purple	2-6'
Lobelia cardinalis	Cardinal flower	Plugs – 1 gal.	1 plant/18" o.c.	Wet-moist	Red	2-4'
Monarda didyma	Bee balm	Plugs – 1 gal.	1 plant/24" o.c.	Wet-moist	Red	3'
Monarda fistulosa	Wild bergamot	Plugs – 1 gal	1 plant/18" o.c.	Moist	Purple	1-3'
Oenethera fruticosa	Sundrops	Plugs – 1 gal	1 plant/18" o.c.	Moist-dry	Yellow	
Penstemon digitalis	Smooth white	Plugs – 1 gal	1 plant/24" o.c.	Wet	White	2-3'
Penstemon hirsutus	Hairy beardtongue	Plugs – 1 gal	1 plant/18" o.c.	Dry	White	1-3'
Penstemon smallii	Beardtongue	Plugs – 1 gal	1 plant/18" o.c.	Moist	Purple	1-2'
Pycanthemum tenuifolium	Slender mountain mint	Plugs – 1 gal	1 plant/18" o.c.	Moist	White	1.5-2.5'
Ratibida piñata	Gray-headed coneflower	Plugs – 1 gal	1 plant/18" o.c.	Moist	Yellow	2-5'
Rudbeckia hirta	Black-eyed Susan	Plugs – 1 gal	1 plant/18" o.c.	Moist-dry	Yellow	3'
Salvia lyrata	Lyre-leaf sage	Plugs – 1 gal	1 plant/18" o.c.	Moist	Purple	1-2'
Solidago nemoralis	Gray goldenrod	Plugs – 1 gal.	1 plant/18" o.c.	Dry	Yellow	2'
Solidago rugosa	Rough-leaved goldenrod	Plugs – 1 gal.	1 plant/18" o.c.	Wet	Yellow	1-6'
Veronacastrum virginicum	Culver's root	Plugs – 1 gal.	1 plant/24" o.c.	Dry	White	3-6'
Veronia veboracensis	Tall ironweed	Plugs – 1 gal.	1 plant/24" o.c.	Wet-moist	Purple	3-4'

Plant material size and grade to conform to "American Standards for Nursery Stock" American Association of Nurserymen, Inc. latest approved revision, ANSI Z-60-1

Popular Native Perennials for Urban Bioretention – Shade						
Latin Name	**Common Name**	**Size**	**Spacing**	**Moisture**	**Color**	**Height**
Aquilegia canadensis	Wild columbine	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Pink	1-2.5'
Athyrium filix-femina	Lady Fern	1 gal.	1 plant/18" o.c.	Moist	Green	3'
Arisaema triphyllum	Jack-in-the-pulpit	Plugs – 1 gal.	1 plant/18" o.c.	Moist	Green	1.5-2.5'
Arisaema dricontium	Green dragon	Plugs – 1 gal.	1 plant/18" o.c.	Wet-moist	Green	3'
Asarum canadense	Wild ginger	Plugs – 1 gal.	1 plant/18" o.c.	Wet-moist	Red-brown	0.5-1'
Aster cardifolius	Blue wood aster	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Blue	1-3'
Aster novae-angliae	New England aster	Plugs – 1 gal.	1 plant/24" o.c.	Moist-dry	Blue/ purple	3-4'
Aster oblongifolius	Aromatic Aster	Plugs – 1 gal.	1 plant/24" o.c.	Moist-dry	Blue/ purple	1.5-3'
Coreopsis major	Tickseed coreopsis	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Yellow	3'
Dryopteris marginalis	Shield Fern	1 gal.	1 plant/18" o.c.	Moist	Green	2-3'
Geranium maculatum	Wild geranium	Plugs – 1 gal.	1 plant/18" o.c.	Moist	Pink	2'
Heuchera americana	Alumroot	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Purple	1'
Iris cristata	Dwarf crested iris	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Purple	4"
Lobelia siphilicata	Great blue lobelia	Plugs – 1 gal.	1 plant/18" o.c.	Wet-moist	Blue	1.5-3'
Lobelia cardinalis	Cardinal flower	Plugs – 1 gal.	1 plant/18" o.c.	Wet-moist	Red	2-4'
Mertensia virginica	Virginia bluebells	Plugs – 1 gal.	1 plant/18" o.c.	Moist	Blue	1.5'
Osmunda cinnamomea	Cinnamon Fern	1 gal.	1 plant/24" o.c.	Wet-moist	Green	3-4'
Phlox divericata	Blue phlox	Plugs – 1 gal.	1 plant/18" o.c.	moist	Blue	0.5-2'
Polemonium reptans	Jacob's ladder	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Blue	15"
Polystichum acrostichoides	Christmas fern	Plugs – 1 gal.	1 plant/24" o.c.	Moist-dry	Evergreen	2'
Stylophoru diphyllum	Wood poppy	Plugs – 1 gal.	1 plant/18" o.c.	Wet -moist	Yellow	1.5'

Plant material size and grade to conform to "American Standards for Nursery Stock" American Association of Nurserymen, Inc. latest approved revision, ANSI Z-60-1.

Popular Native Grasses and Sedges for Urban Bioretention						
Latin Name	**Common Name**	**Size**	**Spacing**	**Moisture**	**Color**	**Height**
Carex grayi	Gray's Sedge	1 gal.	1 plant/24" o.c.	Moist	Green	3'
Carex muskingumensis	Palm Sedge	1 gal.	1 plant/24" o.c.	Moist	Green	3'
Carex stricta	Tussock Sedge	1 gal.	1 plant/24" o.c.	Moist	Green	3-4'
Chasmanthium latifolium	Upland Sea Oats	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Green	4'
Equisetum hyemale	Horsetail	Plugs – 1 gal.	1 plant/18" o.c.	Wet	Green	3'
Juncus effesus	Soft Rush	Plugs – 1 gal.	1 plant/24" o.c.	Wet-dry	Green	4-6'
Muhlenbergia capallaris	Muhly Grass	1 gal.	1 plant/24" o.c.	Moist	Pink	3'
Panicum virgatum	Switchgrass	1-3 gal.	1 plant/48" o.c.	Moist-dry	Yellow	5-7'
Schizachyrium scoparium	Little Blue Stem	1 gal.	1 plant/24" o.c.	Moist-dry	Yellow	3'
Sporobolus heterolepsis	Prairie Dropseed	1 gal.	1 plant/24" o.c.	Moist-dry	Green	2-3'

Plant material size and grade to conform to "American Standards for Nursery Stock" American Association of Nurserymen, Inc. latest approved revision, ANSI Z-60-1.

Popular Native Trees for Urban Bioretention							
Latin Name	**Common Name**	**DT-FT**	**Light**	**Moisture**	**Notes**	**Flower Color**	**Height**
Acer rubrum	Red Maple	DT-FT	Sun-shade	Dry-wet	Fall color		50-70'
Acer saccharum	Sugar Maple		Sun-pt shade	Moist	Fall color		50-75'
Ameleanchier Canadensis	Serviceberry		Sun-pt shade	Moist-wet	Eatable berries	White	15-25'
Asimina triloba	Paw Paw		Sun-pt shade	Moist	Eatable fruits	Maroon	15-30'
Betula nigra	River Birch	FT	Sun-pt shade	Moist-wet	Exfoliating bark		40-70'
Carpinus caroliniana	Ironwood		Sun-pt shade	Moist		White	40-60'
Carya aquatica	Water Hickory	FT-DT	Sun	Moist	Fall color		35-50'
Cercus Canadensis	Redbud	DT	Sun-shade	Moist	Pea-like flowers, seed pods	Purple	20-30'
Chionanthus virginicus	Fringetree		Sun-pt shade	Moist	Panicled, fragrant flowers	White	12-20'
Cladratis lutea	Yellowwood	DT	Sun	Dry-moist	Fall color	White	30-45'
Cornus florida	Flowering Dogwood		Part shade	Moist	Red fruit, wildlife	White	15-30'
Ilex opaca	American Holly	DT	Sun-pt shade	Moist	Evergreen	White	30-50'
Liquidambar styraciflua	Sweetgum	DT-FT	Sun-pt shade	Dry-moist	Spiny fruit		60-100'
Magnolia virginiana	Sweetbay Magnolia		Sun-pt shade	Moist-wet	Evergreen	White	10-60'
Nyssa sylvatica	Black Gum		Sun-Shade	Moist	Fall color		35-50'
Oxydendrum arboretum	Sourwood		Sun-pt shade	Dry-moist	Wildlife	White	20-40'
Platanus occidentalis	Sycamore	FT	Sun-pt shade	Moist	White mottled bark		70-100'
Quercus bicolor	Swamp White Oak	DT	Sun-pt shade	Moist-wet	Acorns		50-60'
Quercus nuttalli	Nuttall Oak	DT	Sun	Dry-moist	Acorns		40-60'
Quercus lyrata	Overcup Oak	FT	Sun	Moist	Acorns		40-60'
Quercus shumardii	Shumard Oak	DT	Sun	Moist	Acorns		40-60'
Rhamnus caroliniana	Carolina Buckthorn		Sun	Moist	Black fruit		15-30'
Salix nigra	Black Willow	FT	Sun-pt shade	Moist-wet	White catkins	Yellow	40-60'
Ulmus americana	American Elm	DT-FT	Sun-pt shade	Moist			
Salix nigra	Black Willow	FT	Pt shade	Moist-wet	White catkins	Yellow	40-60'

Size: min. 2" caliper if not reforestation. DT: Drought Tolerant FT: Flood Tolerant
Plant material size and grade to conform to "American Standards for Nursery Stock" American Association of Nurserymen, Inc. latest approved revision, ANSI Z-60-1.

Popular Native Shrubs for Urban bioretention								
Latin Name	**Common Name**	**DT-FT**	**Light**	**Moisture**	**Spacing (0 C)**	**Notes**	**Flower Color**	**Height**
Aronia arbutifolia	Red Chokeberry	FT	Sun-pt shade	Dry-wet	4’	Red berries, wildlife	White	6-12’
Buddleia davidii	Butterfly Bush	DT	Sun-pt shade	Dry-moist	4’	Non-native	Blue	5’
Callicarpa Americana	American Beautyberry	DT	Sun-pt shade	Dry-wet	5’	Showy purple fruit	Lilac	4-6’
Cephalanthus occidentalis	Button Bush	FT	Sun-shade	Moist-wet	5’	Attracts wildlife	White	6-12’
Clethra alnifolia	Sweet Pepper Bush		Sun-pt shade	Dry-moist	3’	Hummingbird	White	5-8’
Cornus amomum	Silky Dogwood		Sun-shade	Moist-wet	6’	Blue berries, wildlife	White	6-12’
Corylus americana	American Hazelnut		Sun-pt shade	Dry-moist	8’	Eatable nuts, wildlife	Yellow	8-15’
Hamemelis virginiana	Witch-hazel		Sun-pt shade	Dry-moist	8’	Winter bloom	Yellow	10’
Hibiscus moscheutos	Swamp Mallow	FT	Sun	Moist-wet	30”	Cold-hardy	White – red	4-7’
Hydrangea quercifolia	Oakleaf Hydrangea	DT	Pt shade – shade	Moist	4’	Winter texture	White	3-6’
Hypericum frondosum	Golden St. John’s Wort	DT	Sun-pt shade	Dry-moist	30”	Semi-evergreen	Yellow	2-3’
Hypericum prolificum	Shrubby St. John’s Wort	DT	Sun-pt shade	Dry-moist	3’	Semi-evergreen	Yellow	3’
Ilex decidua (dwarf var.)	Possumhaw Viburnum	DT	Sun-pt shade	Moist	4-6’	Red berries		6-14’
Ilex glabra	Inkberry	DT	Sun-pt shade	Moist-wet	3’	Evergreen		4-8’
Ilex verticillata	Winterberry Holly	FT	Sun-pt shade	Moist-wet	3’	Red berries		10’
Itea virginica	Virginia Sweetspire	DTFT	Sun-shade	Moist-wet	4’	Fall color	White	4-8’
Lindera benzoin	Spicebush	DT	Pt shade – shade	Moist-wet	8’	Butterflies, wildlife	Yellow	6-12’
Viburnum dentatum	Arrowwood Viburnum		Sun-shade	Dry-wet	6’	Wildlife	White	6-8’

Size: minimum 3 gal. container or equivalent. DT: Drought Tolerant FT: Flood Tolerant
This list provides plant species; there are multiple varieties within each species.
Plant material size and grade to conform to “American Standards for Nursery Stock” American Association of Nurserymen, Inc. latest approved revision, ANSI Z-60-1.

Popular Plants Suitable for Tree Planters in Metro Nashville

Popular Native Perennials Suitable for Tree Planters – Full Sun						
Latin Name	**Common Name**	**Size**	**Spacing**	**Moisture**	**Color**	**Height**
Asclepias tuberosa	Butterfly milkweed	Plugs – 1 gal.	1 plant/18" o.c.	Dry-moist	Orange	2'
Aster novae-angliae	New England aster	Plugs – 1 gal.	1 plant/24" o.c.	Wet-moist	Blue	2-5'
Coreopsis lanceolata	Lance-leaf coreopsis	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Yellow	6-8'
Eupatorium purpureum	Sweet Joe-Pye Weed (Dwarf)	Plugs – 1 gal.	1 plant/24" o.c.	Wet-moist	Purple	3-6'
Iris virginica	Flag Iris	Plugs – 1 gal.	1 plant/18" o.c.	Moist-Wet	Blue	2'
Liatris spicata	Dense blazingstar	Plugs – 1 gal.	1 plant/24" o.c.	Wet-moist	Purple	1.5'
Penstemon digitalis	Smooth white beardtongue	Plugs – 1 gal	1 plant/24" o.c.	Wet	White	2-3'
Salvia lyrata	Lyre-leaf sage	Plugs – 1 gal	1 plant/18" o.c.	Moist	Purple	1-2'

Popular Native Perennials Suitable for Tree Planters – Shade						
Latin Name	**Common Name**	**Size**	**Spacing**	**Moisture**	**Color**	**Height**
Aquilegia canadensis	Wild columbine	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Pink	1-2.5'
Aster novae-angliae	New England aster	Plugs – 1 gal.	1 plant/24" o.c.	Moist-dry	Blue/ purple	3-4'
Aster oblongifolius	Aromatic Aster	Plugs – 1 gal.	1 plant/24" o.c.	Moist-dry	Blue/ purple	1.5-3'
Coreopsis lanceolata	Tickseed coreopsis	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Yellow	3'
Heuchera americana	Alumroot	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Purple	1'

DT: Drought Tolerant
FT: Flood Tolerant

Popular Native Grasses and Sedges Suitable for Tree Planters						
Latin Name	**Common Name**	**Size**	**Spacing**	**Moisture**	**Color**	**Height**
Carex muskingumensis	Palm Sedge	1 gal.	1 plant/24" o.c.	Moist	Green	3'
Chasmanthium latifolium	Upland Sea Oats	Plugs – 1 gal.	1 plant/18" o.c.	Moist-dry	Green	4'
Equisetum hyemale	Horsetail	Plugs – 1 gal.	1 plant/18" o.c.	Wet	Green	3'
Juncus effesus	Soft Rush	Plugs – 1 gal.	1 plant/24" o.c.	Wet-dry	Green	4-6'
Muhlenbergia capallaris	Muhly Grass	1 gal.	1 plant/24" o.c.	Moist	Pink	3'
Panicum virgatum	Switchgrass	1-3 gal.	1 plant/48" o.c.	Moist - dry	Yellow	5-7'
Schizachyrium scoparium	Little Blue Stem	1 gal.	1 plant/24" o.c.	Moist-dry	Yellow	3'
Sporobolus heterolepsis	Prairie Dropseed	1 gal.	1 plant/24" o.c.	Moist-dry	Green	2-3'

Popular Native Trees Suitable for Tree Planters							
Latin Name	**Common Name**	**DT-FT**	**Light**	**Moisture**	**Notes**	**Flower Color**	**Height**
Acer rubrum	Red Maple	DT-FT	Sun-shade	Dry-wet	Fall color		50-70'
Betula nigra	River Birch	FT	Sun-pt shade	Moist-wet	Exfoliating bark		40-70'
Carpinus caroliniana	Ironwood		Sun-pt shade	Moist		White	40-60'
Carya aquatica	Water Hickory	FT-DT	Sun	Moist	Fall color		35-50'
Cercus Canadensis	Redbud	DT	Sun-shade	Moist	Pea-like flowers, seed pods	Purple	20-30'
Liquidambar styraciflua	Sweetgum (fruitless)	DT-FT	Sun-pt shade	Dry-moist			60-100'
Nyssa sylvatica	Black Gum		Sun-Shade	Moist	Fall color		35-50'
Platanus occidentalis	Sycamore	FT	Sun-pt shade	Moist	White mottled bark		70-100'
Quercus nuttalli	Nuttall Oak	DT	Sun	Dry-moist	Acorns		40-60'
Quercus lyrata	Overcup Oak	FT	Sun	Moist	Acorns		40-60'
Quercus shumardii	Shumard Oak	DT	Sun	Moist	Acorns		40-60'
Ulmus americana	American Elm	DT-FT	Sun-pt shade	Moist			

Popular Native Shrubs Suitable for Tree Planters							
Latin Name	**Common Name**	**DT-FT**	**Light**	**Moisture**	**Notes**	**Flower Color**	**Height**
Clethra alnifolia	Sweet Pepper Bush (Dwarf)		Sun-pt shade	Dry-moist	Hummingbirds	White	5-8'
Hydrangea quercifolia	Oakleaf Hydrangea (Dwarf)	DT	Pt shade – shade	Moist		White	3-6'
Hypericum frondosum	Golden St. John's Wort	DT	Sun-pt shade	Dry-moist	Semi-evergreen	Yellow	2-3'
Ilex glabra	Inkberry (Dwarf)	DT	Sun-pt shade	Moist-wet	Evergreen		4-8'

DT: Drought Tolerant
FT: Flood Tolerant

APPENDIX 2-E
AS-BUILT REQUIREMENTS

A printer friendly version of this table can be found on the MWS Development Services website or by request.

Urban Bioretention Number:

	Design	As-Built
Treatment Volume (Tv), CF		
Surface Area, SF		
Top of Bank Elevation		
Emergency Spillway Elevation*		
Overflow (TOC) Elevation*		
(A) GIP Surface Elevation		
(B) Top of Stone Elevation		
Underdrain Invert*		
Outlet Elevation*		
(C) Subgrade Elevation		
* N/A if not required		
ALL Elevation shall be NAVD88		