February 2020

STORMWATER STRATEGIC PLAN

Green Infrastructure Design & Implementation Guidelines

BLUE PRINT COLUMBUS
Clean streams.
Strong neighborhoods.

THE CITY OF COLUMBUS
ANDREW J. GINTHER, MAYOR

DEPARTMENT OF PUBLIC UTILITIES

DIVISION OF SEWERAGE AND DRAINAGE

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INTRODUCTION

The City of Columbus municipal separate storm sewer system (MS4) permit (Ohio EPA Permit No. 4PI00000*CD) requires the establishment of a Stormwater Management Plan (SWMP) which includes strategies and ordinances for the management of stormwater runoff from new development and redevelopment projects. The City has developed a Stormwater Drainage Manual (SWDM) as its primary mechanism to regulate post-construction runoff for new development and redevelopment projects that disturb more than 10,000 square feet and/or create more than 2,000 square feet of impervious surface. The SWDM includes guidance for the implementation and design of structural water quality best management practices (BMPs) to meet the technical requirements of the Ohio EPA Authorization for Stormwater Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System (NPDES) (Construction General Permit).

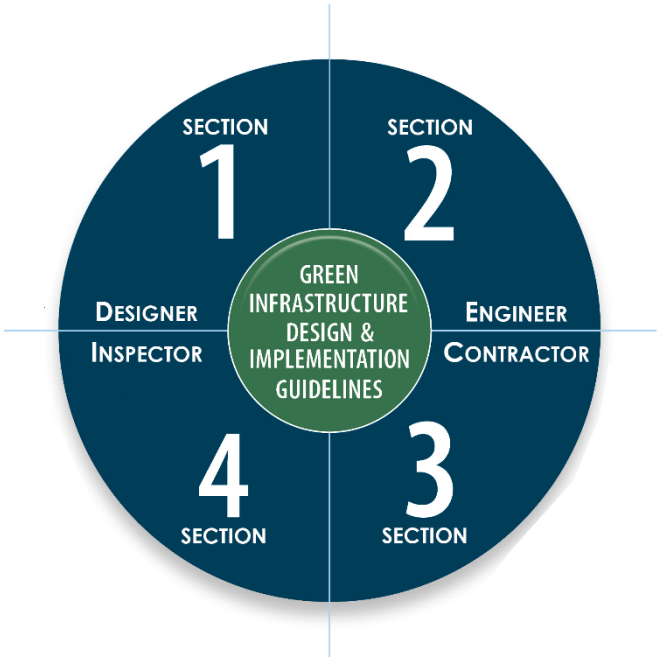
The SWDM promotes a stormwater management philosophy that can be simply summarized as "capture, detain, and release." Use of green infrastructure (GI) for water quantity and quality control methods is encouraged by the City and within the SWDM as an important technique to achieve these goals. Green Infrastructure is defined by the US Environmental Protection Agency as:

> *"… an array of products, technologies, and practices that use natural systems - or engineered systems that mimic natural processes - to enhance overall environmental quality and provide utility services. As a general principal, Green Infrastructure techniques use soils and vegetation to infiltrate, evapotranspirate, and/or recycle stormwater runoff. When used as components of a stormwater management system, Green Infrastructure practices such as green roofs, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these technologies can simultaneously help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits…"*

The City of Columbus has concluded that the SWDM should be supplemented with these *Green Infrastructure Design and Implementation Guidelines* containing site-specific physical and structural components necessary to install a GI facility into the public Right-of-Way (ROW). Users will see that these guidelines incorporate City of Columbus and Ohio standards that are in-place and widely referred to within the public infrastructure community. In addition to City standards, these guidelines reference techniques from numerous other cities that have successfully integrated GI into their communities. The intent of the *Green Infrastructure Design and Implementation Guidelines* (Guidelines) is to provide the user with considerations for the placement, design and construction of GI in ROW and retrofit of existing urban environments. Additionally, the Guidelines provide building blocks for the standard component designs within GI facilities, such as stormwater inlets/outlets, area protection, energy dissipation needs, appropriate landscaping and plant selection, piping and appurtenances, and GI media including permeable surfaces, bioretention soil media and aggregates.

HOW TO USE THE GUIDELINES

The Guidelines are divided into four primary sections intended to target the audience specific to the applicable phase of GI implementation. The beginning of each section includes a "GI Audience & Resource Content Guide" graphic with text describing the resources contained in that section. A brief description of each section, its audience, and how it should be used is provided below.



SECTION 1: GREEN INFRASTURCTURE SITE EVALUATION & DEVELOPMENT

This section is intended to provide the designer with the various City of Columbus resources available for initiating GI design, as well as additional considerations and practices to take into account during the design process. Section 1 discusses the typical steps that are taken in the full GI design process including assembling site information, reviewing local design criteria, designing the GI facility, obtaining approvals, and accounting for designer considerations in construction, inspection and maintenance. This section's intended audience is the GI Designer/Engineer.

SECTION 2: GREEN INFRASTRUCTURE PLACEMENT GUIDELINES AND DESIGN COMPONENTS

This section provides detailed information and placement examples for GI facilities and components specific to City of Columbus requirements discussed in Section 1. Section 2 features the Placement Guidelines showing general considerations in regard to placement of GI within the ROW as well as GI Design Components (DCs) providing standard details and guidance on typical features used in GI. The intended audience for Section 2 is also the GI Designer/Engineer.

SECTION 3: GREEN INFRASTRUCTURE CONSTRUCTION

This section is intended to provide planning tools for GI construction in order to foster a more cohesive construction process and avoid quality issues related to GI. Section 3 identifies some of the differences and unique aspects of GI construction in relationship to typical infrastructure construction and provides guidance relating to the City CMSC, supplemental specifications, and GI Design Components. This section's intended audience is the Contractor.

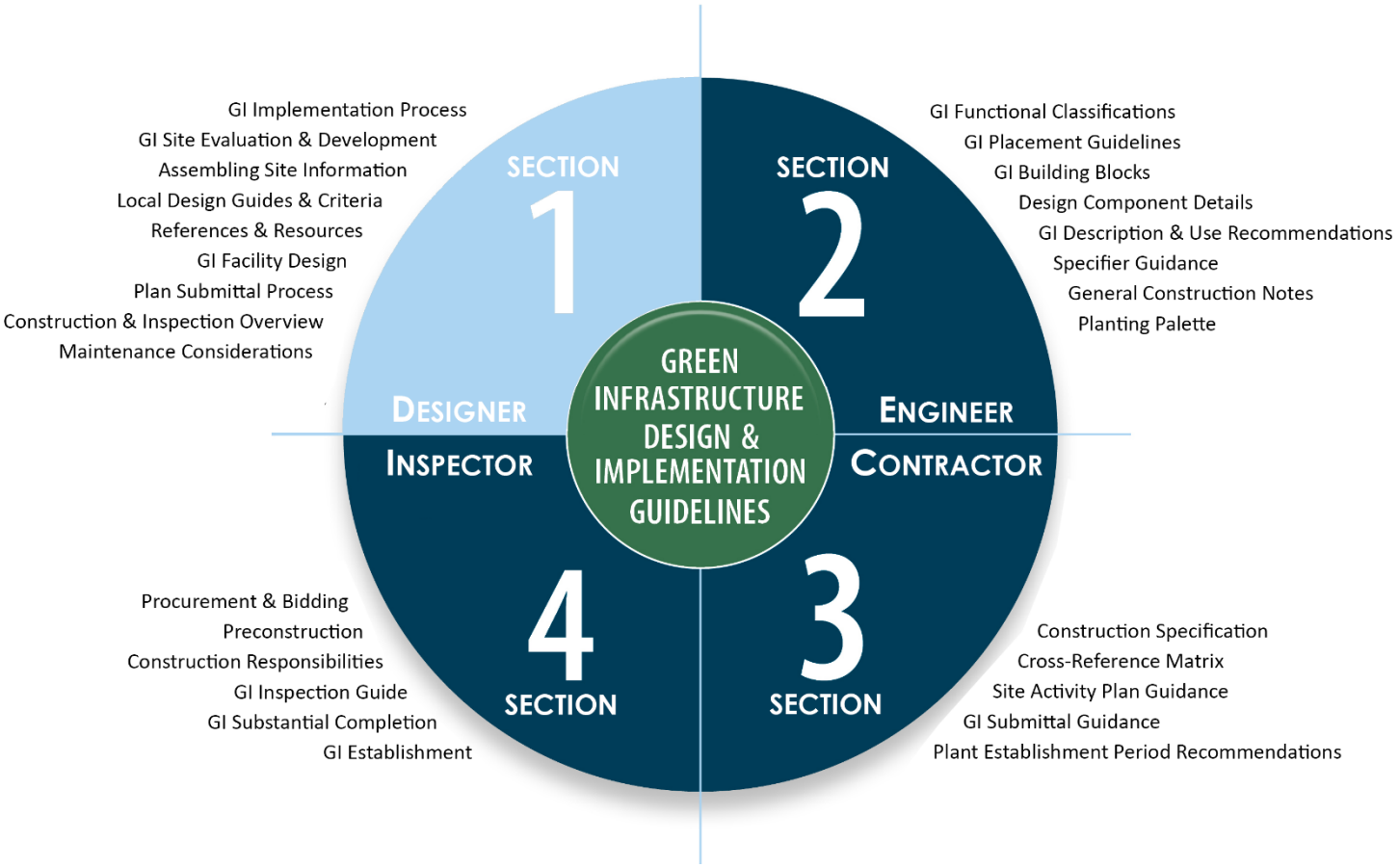
SECTION 4: INSPECTION GUIDANCE FOR GREEN INFRASTRUCTURE CONSTRUCTION

This section provides guidance to be used for procurement and bidding of GI projects as well as the GI inspector's responsibilities during the construction and establishment period. The intended audience for Section 4 is the GI inspector.

SECTION 1

GREEN INFRASTRUCTURE SITE EVALUATION & DEVELOPMENT

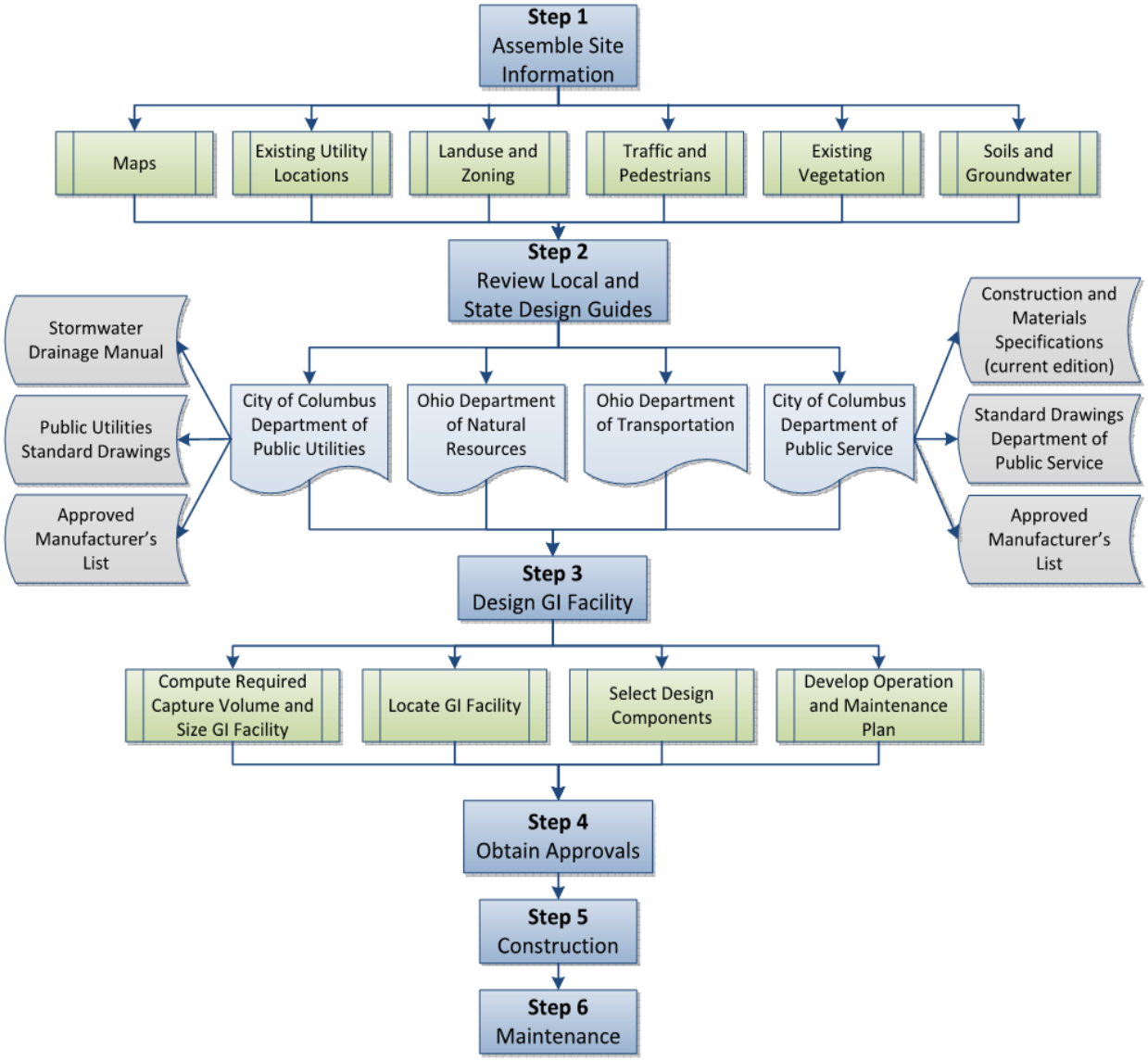
GI Audience & Resource Content Guide



GREEN INFRASTRUCTURE SITE EVALUATION & DEVELOPMENT

Site development and evaluation for a Green Infrastructure (GI) project in the City of Columbus (City) is similar to the development of a traditional public infrastructure retrofit project. The primary purpose of these guidelines is to define the resources available to designers and contractors when planning, designing, constructing, and maintaining GI that is located within the City's Right-of-Way (ROW) or dedicated easement. It is also available as a reference tool for GI projects on private property as part of redevelopment or as a retrofit into an existing drainage system.

These Guidelines will assist the designers in identifying site specific features of their GI application in their projects, such as existing utility locations, land-use and lot sizes, ROW characteristics, and existing vegetation characteristics. It also provides the items to consider during design, review, and implementation. Section 1 of this document describes the GI design and implementation process in a multi-step fashion:



STEP 1 – ASSEMBLE SITE INFORMATION

The first step is to assemble site information. This section provides a quick reference to important sources of site related and background information.

MAPS

Geographic Information System (GIS) maps including ROW limits, parcel and zoning information, and existing building locations are available from the City of Columbus One Stop Shop Zoning website.

Reference maps for street functional classifications can be found on the ODOT maproom website.

EXISTING UTILITY LOCATIONS

GI has the potential to infiltrate stormwater, which may negatively impact existing utilities and infrastructure. All existing utilities in the vicinity of proposed GI should be located and identified per the City of Columbus, Department of Public Utilities *Right-of-Way Plan Routing Manual* and the Department of Public Service *Utilities Manual*. Interference with existing utilities should be avoided whenever possible, and documentation as to the type of utility coordination shall be tracked and provided to the City Project Manager. For relocating existing utilities, coordination with the appropriate City department or private utility company is required. When utilities interfere with or extend through GI installations, a utility sleeve, anti-seep collar or impermeable barrier may be required per DC 7.4 (Anti-Seep Collar/Utility Sleeves) and DC 1.3 (Below Grade Barriers) to protect the existing utility. GI Placement Guidelines and Design Components are discussed further in Section 2. Designer should consider all of the following public and private utilities when implementing GI:

- Public Utilities
    - Regarding proximity of GI to existing utilities, *The Great Lakes—Upper Mississippi River Board 10 States Standards* shall be followed unless otherwise directed by the City.
    - **Storm sewers (swales, gutters, catch basins, inlets, manholes, piping, and outlets):** Existing storm sewer systems may be incorporated in GI design. See DC 2.1 (Retrofit Existing Structures for Inlet) or DC 8.1 (Retrofit Existing Structures for Outlet) for guidance. Design criteria and standards for storm sewer design may be applicable. This guidance shall apply to private storm laterals.
    - **Sanitary and/or combined sewer systems**: It is recommended that GI should be located a minimum of 10 feet horizontally from existing sanitary sewers to minimize potential infiltration and lateral flow into the sanitary sewer. GI may be installed closer than 10 feet with use of impermeable barriers or anti-seep collars per DC 1.3 (Below Grade Barriers) and DC 7.4 (Anti-Seep Collar/Utility Sleeves). This guidance shall apply to private sanitary laterals.
    - **Water mains:** When proposing GI in close proximity to water mains, avoid placing adjacent hydrants. As recommended in *Recommended Standards for Wastewater Facilities*[1], all sewers (including storm sewers) shall be located at least 10 feet horizontally and 18 inches vertically from an existing water main. If these separations cannot be maintained, then both the sewer and water main piping must be constructed of slip-on or mechanical joint pipe. Positioning of potable water valves within the GI feature footprint should be avoided. This guidance shall apply to private water laterals.

[1] Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers

- **Traffic control (signs, poles, conduits, control structures):** Avoid locating GI within close proximity of traffic control features. Stationary signs, such as stop signs, parking signs, etc. may be allowed within a GI feature, so long as the location of the pole does not conflict with the performance of the GI. When proposing GI in close proximity to traffic signals or stop signs, maintain sight distance to the traffic control feature (i.e. line of sight is not obstructed by tall vegetation). The location of underground conduit should be investigated to determine whether the conduit conflicts with the proposed GI feature. Relocation of the conduit or re-positioning of the GI feature may be required. The City of Columbus *Traffic Signal Design Manual* contains additional information for guidelines with respect to traffic signal design and coordination.
- **Street and sidewalk lighting (poles, conduits, control boxes)**: When proposing GI features near utility and/or street light poles, whenever possible maintain offset from the base of the pole. GI features should not be installed in an area with electrical control panels, meter settings or electrical conduit pull boxes.

- Private Utilities

  - **Gas mains and lateral lines:** Avoid locating GI features within 10 feet of gas mains. If a GI intersects a lateral line to a house, the use of a utility sleeve or impermeable barrier with anti-seep collar per DC 1.3 (Below Grade Barriers) and DC 7.4 (Anti-Seep Collar/Utility Sleeves) may be required as permitted by the utility owner.
  - **Electrical (above and below ground and transformers):** GI should not be installed within 10 feet of any underground electrical feature that carries current such as electrical conduit, etc. Electrical crossings are not permitted in GI areas, and it is recommended that the utilities be relocated outside the GI.
  - **Communications (fiber andjunction boxes):** When proposing GI features near buried communications lines, the use of a utility sleeve or impermeable barrier with anti-seep collar per DC 1.3 (Below Grade Barriers) and DC 7.4 (Anti-Seep Collar/Utility Sleeves) may be required.
  - **Utility poles:** When proposing GI features near utility poles, access to the pole by utility workers must be maintained. If utility poles are located within or near a GI facility, the foundation design shall account for the soil properties.

LAND USE AND ZONING

Land use and zoning typically has a direct impact on ROW characteristics which govern where GI can be located. Features that often vary by land use include but are not limited to lot sizes, ROW setbacks, street widths, curb and gutter, sidewalk, driveways, and alleys. Replacement of any existing infrastructure within the public ROW shall conform to the most current *City of Columbus Standard Drawings* and the *Construction and Materials Specifications - City of Columbus* (CMSC). Special consideration should be given to placement of GI per land use in regards to pedestrian access and safety, parking availability, educational benefits, economic development, neighborhood stabilization, and overall community acceptance.

- **Residential**
    - **Curb Bumpouts:** In residential areas, street widths are typically narrow (22 to 26 feet) and include parking areas on both sides of the street. All GI "bumpouts" are to be fixed at 7 feet in width (face-of-curb to face-of-curb). The use of bumpouts is preferred on streets that are 26 feet wide or wider. This arrangement allows for a 7-foot wide bumpout, on-street parking opposite the bumpout and a 12-foot wide travel lane in between. If two-way travel is required on a 26-foot wide street with a bumpout, the area opposite the bumpout shall be a no parking zone. Bumpouts on streets less than 26 feet in width may also be considered to replace a portion of on-street parking or be located opposite a no-parking area such that a minimum 12-foot wide travel lane is maintained at all times. All bumpout locations are subject to the City of Columbus Department of Public Service (DPS) review and approval. No parking/stopping signs shall be specified at the direction of DPS. For all bumpout locations, a parking study shall be performed to determine the impact to parking.
    - **Curb Extensions:** Curb extensions are not preferred by the City of Columbus. The use of curb extensions will require approval from Department of Public Service (DPS) and Department of Public Safety. Designer should evaluate impact of curb extensions to accommodate GI practices to assess impact to turning radii and taper lengths. Provide adequate turning radii, tapers and transitions in accordance with geometric design standards of the ODOT Location and Design manual current volume, the City of Columbus DPS Sight Distance at Intersections Policy and the requirements of the City of Columbus Department of Public Safety. A minimum inside turning radius of 24'-5" shall be provided unless otherwise approved by DPS and the Department of Public Safety.
    - **On-street Parking:** Parking is an important consideration when implementing GI in residential areas. In many residential neighborhoods, properties lack or have limited driveway width and length and, therefore, rely on availability of on-street parking. In these areas, a minimum of one on-street parking space per lot should be maintained, subject to approval by the City of Columbus. In general, an effort should be made to retain some designated on-street parking in all residential areas. When placing GI adjacent to streets with the potential for on-street parking, DPS requires a 2.5-foot minimum operational offset on curbed street sections and 4-foot minimum offset on uncurbed street sections from the front of curb or pavement edge to the edge of the GI installation. This buffer allows for passengers to open vehicle doors and exit vehicles safely.
- **Commercial:** Special considerations should be made when implementing GI in commercial areas with regard to the increased vehicular and pedestrian traffic typical to commercial land uses. Space availability may result in integration of the GI in the sidewalk, which will require area protection for the safety of pedestrians as well as the protection of the GI installation (see Design Components 1.1 At-Grade Barriers, 1.2 Above Grade Barriers, 1.3 Below Grade Barriers). Bus stops are frequent in commercial areas as well. When implementing GI in the vicinity of bus stops, consult *Central Ohio Transit Authority (COTA) Bus Stop Design Guide*, current edition, for design requirements.
- **Industrial:** Special consideration should be made on a case-by-case basis to implementing GI in industrial areas. Wider separations may be required to accommodate heavier and/or longer vehicles. GI recommended for an industrial site should account for the pollutants generated by that particular site.
- **Institutional (schools, churches, public buildings):** Placement of GI around schools can offer an additional educational benefit, though proper area protection should be considered (see DC 1.1 At-Grade Barriers, DC 1.2 Above Grade Barriers, and DC 1.3 Below Grade Barriers). Special consideration should be given to increased volume of pedestrians and increased vehicular site lines near cross walks in general, especially near schools. Installations near elementary and primary educational institutions require more consideration

to account for child visibility and safety. Retaining adequate street widths and curb radii for bus access should also be a consideration near institutional areas.

- **Parks:** Placement of GI around parks can offer additional educational benefit, though proper area protection should again be considered (see DC 1.1 At-Grade Barriers, DC 1.2 Above Grade Barriers, and DC 1.3 Below Grade Barriers). Special consideration should be given to pedestrian and vehicular site lines near cross walks, similar to considerations for institutional land uses. Safety should also be considered for larger centralized GI features that may include permanent pools of water or vertical drops. GI design implementation in parks will require coordination with the City of Columbus Recreation and Parks Department.
- **Vacant or abandoned property**: Vacant property provides unique considerations to design. Vacant properties are ideal locations for GI, as they are typically less restricted by space and existing utilities than GI sites located within the ROW. The main consideration for applicability of GI on a vacant property is its location in the watershed and the ability to convey stormwater to the site. Property acquisition is the other main challenge with vacant or abandoned properties. This will require coordination with the property owner, which could include private owners, the City of Columbus Land Bank, and potentially other City departments depending on the owner and status of the property.

TRAFFIC AND PEDESTRIANS

Above ground barriers such as traffic delineators may be required by the City in order to provide an easily visible and safe barrier between sidewalks or traffic lanes and the GI, as further described in Section 2, DC 1.2 (Above Grade Barriers). Street classifications and design speeds may dictate when and where it is feasible to install GI and should be considered when selecting a site.

Designers should coordinate with DPS to verify that there are no planned sidewalk installation projects at GI locations. If GI is located within the future project area, then space must be made available within or around the GI for addition of sidewalk and curb ramps (if applicable) to be installed at a later date. Traffic and sidewalk separations recommended in these Guidelines are based on City of Columbus Department of Public Service and Ohio Department of Transportation (ODOT) *Location and Design Manual* as well as DPS Sight Distance at Intersection Policy.

EXISTING VEGETATION

It is the policy of the City of Columbus to preserve existing trees as a measure to protect and improve the urban tree canopy. Existing vegetation provides multiple environmental, public, and economical benefits that overall improve the community. The *City of Columbus Executive Order 2015-01* outlines the City's Tree Protection and Mitigation Policy, including measures to be taken to protect trees during construction, and measures for tree replacement based on removed tree trunk diameter. The Executive Order applies to all projects on City property or ROW including a scope of work funded solely by public dollars.

Design professionals should take care to minimize the number of trees disturbed or removed. When removal of trees is necessary, the designer must prepare a replacement plan to be reviewed and approved by the City Forester, in accordance with the City of Columbus Tree Protection and Mitigation Policy. If replacement at the project site is not practical, funding departments shall pay a fee per tree in accordance with the Council of Tree and Landscape Appraiser's *Guide for Plant Appraisal*.

During the construction phase, the contractor should take care not to damage trees within the project boundary. Tree protection is required to prevent damage to existing trees that are to remain after construction (see DC 5.1 Tree Protection for requirements). Incorporation of existing mature trees into new GI installations should also be explored as an alternative option to removing the tree itself. Use of existing trees in GI should

account for the ability of the tree to survive in shallow depressions, and preservation of vegetation within the Critical Root Zone (see Design Component 5.1). The Columbus Recreation and Parks Department provides general standards and planting diagrams related to tree planting that can be applied to preserving existing vegetation.

SOILS AND GROUNDWATER

When implementing GI, site-specific subsurface investigation must be conducted to determine the site's soil characteristics. It is recommended that at least one soil boring or test pit be obtained at each proposed GI facility in order to assess the condition and infiltration capacity of the in situ soils. When multiple GI facilities are proposed relatively near one another, one soil boring may be sufficient, if approved by the City of Columbus. Designers should follow requirements contained in the SWDM and the Ohio Department of Natural Resources (ODNR) *Ohio Rainwater and Land Development Manual* with respect to the need for installation of underdrain piping, and for appropriate separations between the GI feature and groundwater or confining soil layers.

STEP 2 – REVIEW LOCAL DESIGN GUIDELINES & CRITERIA

Installation of GI features will require coordination between designers and City Departments. These GI guidelines have been prepared as a tool to assist planners, designers, contractors and maintenance persons in understanding important attributes of GI features. In situations where conflicts between guidance manuals exist, City requirements take precedence.

Included in these Guidelines are:

- ✓ Placement Guidelines for GI
- ✓ GI Design Components
- ✓ GI Construction
- ✓ Inspection for GI Construction

THESE GUIDELINES SUPPLEMENT EXISTING DESIGN GUIDELINES AND CRITERIA, INCLUDING THE FOLLOWING:

City of Columbus, Department of Building and Zoning

- Document Library contains documents related to general building and zoning requirements including required permits, applications, policies and standards, training and additional information.
    - Engineering Requirements and Applications contains plan requirements, review and approval processes for various types of projects
    - Columbus Development Guide provides information to expedite the development process by providing the City's required submittal and approval process

City of Columbus, Department of Public Utilities (DPU)

- Stormwater Drainage Manual (SWDM)
- Public Utilities Standard Drawings
- Approved Producers and Product List

Ohio Department of Natural Resources (ODNR)

- *Ohio Rainwater and Land Development Manual,* containing information related to construction practices, new development and restoration of Ohio's natural environment.

City of Columbus Department of Public Service (DPS))

- Construction and Material Specifications, current edition
    - City Supplements
    - Supplemental Specifications
    - Special Provisions
- Standard Drawings Department of Public Service
- Approved Producers and Products list
- Sight Distance at Intersections Policy

City of Columbus Recreation and Parks Department (RPD)

- *Columbus Recreation and Parks 2014 Master Plan,* evaluates the City's existing programs, parks, facilities, and services and recommends new or enhanced initiatives that integrate into other City programs.
- *Executive Order 2015-01*, provides the parameters of the City of Columbus' tree protection and mitigation policy for public projects as it relates to both designers and contractors. The policy is comprised of the following parts:
    - *Attachment A, Professional Services Contract Language for Tree Protection and Mitigation During Design*
    - *Attachment B, Construction Contract Language for Tree Protection and Mitigation During Construction*
    - *Attachment C, City of Columbus Tree Protection and Mitigation Policy*
    - *Attachment D, Fees for Tree Replacement*
    - *Attachment E, List of Approved Tree Species for Replacement*
- *Guide for Plant Appraisal* by Council of Tree and Landscape Appraisers is a professional plant appraiser's how-to manual for determining size, species, condition, and location factors that influence the value of plants. The guide can be found at the City of Columbus Department of Recreation, Forestry Section office.
- *American Standard for Nursery Stock* (ANSI Z60.1), plant material guidelines

Ohio Department of Transportation (ODOT)

- *Location and Design Manual, Volume I.*
- The Roadside Safety Landscape Guidelines section within the *Location and Design Manual* contains information related to roadway design criteria for the state of Ohio. This becomes relevant to placement of GI in relation to required offsets from roadways, grading adjacent to roadways, site lines/distances, and more. In instances when the DPS does not specify, the ODOT Location and Design Manual should be consulted and shall be followed unless otherwise approved by DPS.

STEP 3 – DESIGN GI FACILITY

GI design is typically an iterative process between identifying potential sites of GI implementation to achieve the required capture volume, and sizing the GI to maximize the available space while optimizing storage capacity. Once this has been achieved, more detailed GI design commences, including selecting appropriate design components for the GI feature, locating and sizing them appropriately, and accounting for long term operations and maintenance needs.

COMPUTE REQUIRED CAPTURE VOLUME AND SIZE THE GI FACILITY

GI must be designed to the requirements of the given project or, when possible, to capture the volume of runoff tributary to the GI facility that is generated by a water quality rain event, as described in the City of Columbus SWDM.

Sizing will also require a detailed understanding of the underlying soils on the site to assess the need for soil amendments and/or underdrain piping in situations where the in situ soils cannot support the required rates of infiltration and/or where there is insufficient separation between the GI facility and existing structures. Conveyance features shall be sized and designs shall be documented in accordance with SWDM.

LOCATE GI FACILITY

Locating a GI facility must consider the patterns of drainage to a particular site. GI siting must maximize the captured flow and minimize or even eliminate the volume of stormwater runoff flow that bypasses the facility for a defined storm event. Section 3.3.3 (Stormwater Quality Control – Acceptable Methods and Criteria) of the Columbus SWDM should be consulted for additional siting requirements, including building setbacks and accessibility.

Placement Guidelines (Section 2) show general considerations with regard to placement of GI. The Placement Guidelines reflect dimensions and setbacks as required by DPU, DPS, and the SWDM, and as recommended in Section 2 of this document. DPU should be contacted whenever these dimensions or other features cannot be accommodated at a specific site. DPU will work with the designers to achieve an alternative design that meets the objective of the affected GI Guideline. DPU may require a coordination meeting with impacted City Departments to resolve specific design issues.

Consideration should be given for future improvements within the right-of-way. A review of available planning level documents – including but not limited to MORPC's Metropolitan Transportation Plan, Columbus Thoroughfare Plan, City of Columbus Bicentennial Bikeways Plan, Columbus Pedestrian Thoroughfare Plan Handbook, and current versions of the documents listed in Step 2 – shall be completed when siting GI. GI that is sited in areas where improvements have been planned will be approved on a project-by-project basis.

Other siting considerations include:

- Retain existing structures, including sidewalks, driveways, curb, etc. if feasible. Structures that are impacted by the GI installation must be replaced. City approval is required for removal and/or reconstruction of existing public infrastructure.
- Do not locate a GI facility within a floodplain.
- Consider input from adjoining property owners.
- Anticipate field adjustments.

- Limit impacts to existing utilities, considering both existing utility location and depth.

SELECT DESIGN COMPONENTS

Specific components of design included in each GI facility will vary on a case-by-case basis. Each component that is implemented within the GI has its own specifications, placement, and submittal requirements. See Section 2 (Green Infrastructure Design Components) for further details for the following design component features:

- Area protection and right-of-way safety
- Stormwater entrances
- Permeable surfaces (reserved)
- Energy dissipation
- Landscaping
- Storage media
- Piping
- Outlets and overflows
- Monitoring

Note that the GI components contained in this Guidance do not include commercially available manufactured BMPs. Design and placement of manufactured devices must follow the City of Columbus *Policy for Stormwater Treatment Technology Performance and Testing Requirements*, and other requirements contained in the SWDM.

All materials selected must be listed in the most current City of Columbus Approved Producers and Products list. New materials can be submitted for review and receive prior approval by the respective materials approval committees within DPU and DPS.

GI plans should include a plan view, cross sections, and specifications in accordance with each component's design submittal requirements checklist and with other City plan requirements, including the latest Supplemental Specifications for GI.

CONSIDER MAINTENANCE NEEDS

Depending on the type of GI, components used, and specific design, the maintenance needs of a GI facility can vary significantly. Owner's desired long term maintenance level of effort should be considered early on and throughout the design process, to align the designed function of the GI and potential for long-term sustainability.

Because routine inspection and maintenance activities are instrumental to the long term success of GI, a designer should consider maintenance access, frequency and utility/resource needs when siting a GI facility.

STEP 4 – OBTAIN APPROVALS

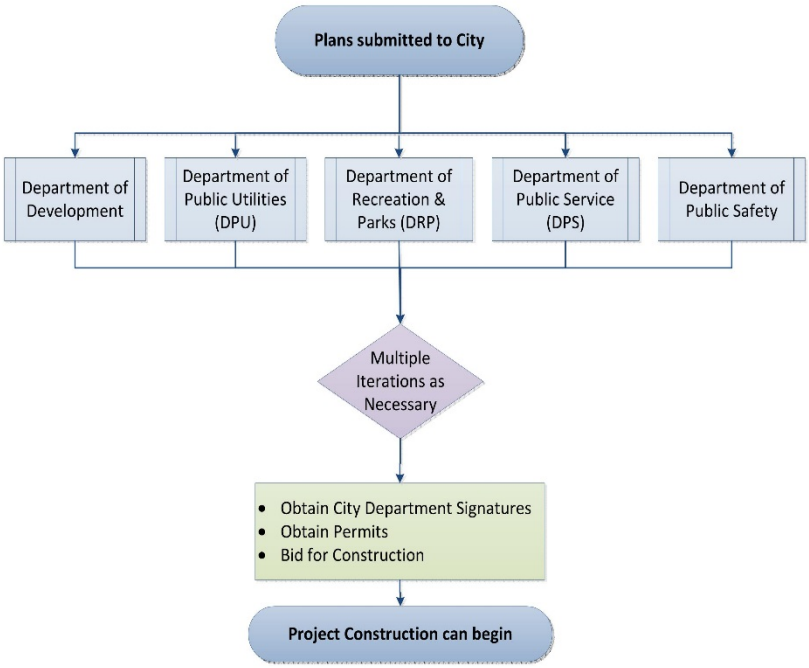
Obtaining approvals and buy-in from both the City and private property and business owners is a necessary step in any project, but is especially important for GI implementation. Because of the high visibility nature of GI projects, it is important to understand how each site will affect the people and businesses that are most exposed to it.

WORKING WITH PROPERTY OWNERS AND BUSINESSES

Designers should work with property and business owners whose property is adjacent to the area being evaluated for GI facilities. This type of stakeholder buy-in can be a critical success factor for GI implementation. GI is a very public display of infrastructure, and its success and function is often measured by its appearance. Designers should plan for time spent on public engagement and coordination efforts throughout the design phases. Public education and engagement during the design process helps to inform the community of the functional and aesthetic improvements and benefits being provided by the GI, and can help with public acceptance and understanding of its importance long-term. Designing GI that is appropriate for the setting will enable the community to see the infrastructure as an amenity, rather than a disruption to their business operations and lives.

CITY APPROVALS AND PERMITS

Because GI facilities are non-traditional infrastructure, designers should plan for extra time to obtain City approvals and required permits (as detailed in Section 6 of the SWDM). The *Columbus Development Guide* should be consulted for the applicable plan review process, required information to be included on plans, required permits, and construction review and approval processes. DPU will convene a multi-department coordination meeting upon submittal of a set of GI plans to discuss the site, the design objectives, and design features. The process diagram to the right depicts the general plan submittal process as a whole.



STEP 5 – CONSTRUCTION & INSPECTION

Proper communication between the designer, contractor, and inspector is instrumental to successful construction of GI facilities. Sections 3 and 4 of the Guidelines provide guidance to contractors and inspectors during construction of GI projects. Section 3 provides information to be conveyed by GI designers to contractors, while Section 4 provides guidance for inspectors. The following lists include items for designers, contractors and inspectors to be prepared to discuss going into the construction process. More detailed information and tools for contractors and inspectors can be found in Sections 3 and 4.

DESIGNERS

- GI functionality
- GI related standard and supplemental specifications included in design
- Prevention of sediment deposition into infiltration zones of GI facility
- Delay of GI facility operation until vegetation is established
- Importance of quality control in planting materials, including planting within seasonally allowable time frames
- Importance of vegetation establishment to prevent invasive plant species from competing with GI installed vegetation

CONTRACTORS

- GI related submittal requirements outlined in SS 1600, Green Infrastructure Submittal Requirements
- Site Activity Plan as outlined in SS 1601, Site Activity Plan for Projects Containing Green Infrastructure Facilities
    - Runoff Management Plan including erosion and sediment control during construction and protection of GI facility until stabilized
    - Site Access Plan and Site Utilization Plan to protect the GI facilities from construction activities while providing site access, haul roads, delivery of materials, and temporary facilities
- Construction schedule including GI sequencing and phasing activities

CONSTRUCTION MANAGERS AND INSPECTORS

- Scope of services
- Pre-bid and pre-construction meeting topics related to GI
- Daily inspection report templates and GI component features for inspection
- Testing and submittal requirements as defined in the CMSC and Supplemental Specifications
- Establishment period monthly and final inspection items

STEP 6 – MAINTENANCE

In conjunction with the operation and maintenance plan, the owner needs to be fully committed to properly maintaining the functionality of the GI facility. Maintenance responsibility, activities, frequencies and funding should be identified early in the design and construction process. Supplemental specification SS 1609 details the maintenance and inspection activities and procedures during the GI Period of Establishment. A general description is provided below for the typical inspection and maintenance categories discussed in Step 3.

TRASH, SEDIMENT & ORGANIC DEBRIS REMOVAL

Any visible trash, sediment, and debris should be removed from all inlets/outlets, forebays, and GI planting bed or media surface areas to allow proper entrance of stormwater into the facility and to avoid clogging of media or GI components. GI media should be inspected to ensure stormwater can move through the facility and drain through the media as intended. Downstream or outlet structures should be inspected to ensure no debris is prohibiting stormwater from exiting the GI. Trash and debris should be hauled off for final recycling or disposal in a landfill, and should not be disposed of in the vicinity of the GI. Extended periods of ponding water indicates that the GI media is unable to infiltrate or discharge and that clogging has occurred. If clogging occurs, additional maintenance or replacement of media may be required.

EROSION & SETTLING INSPECTION/REPAIR

The surface of the BMP should be inspected for indications of settling or compaction of surface materials. This may occur around inlets/outlets, on the side slopes, or within the surface of the GI itself. If settling or minor compaction has occurred, surface material should be broken up using hand tools to increase void space and promote infiltration, if applicable. In planted regions of GI, surface mulch should be refreshed and raked around all plantings. The GIs should be also be inspected for erosion or gullying along the inlet and outlet flow path, including all side slopes or graded channels within the GI. Significant erosion or settling may require regrading of the BMP or replacement of some surface materials over time. Continued erosion within or directly adjacent to the GI may warrant the installation of more permanent erosion control or slope stability measures.

GI DESIGN COMPONENT INSPECTION/REPAIR

All GI design components including area protection, stormwater entrances, permeable surfaces, energy dissipation devices, piping and appurtenances, and outlets should be inspected for physical damage and repair needs. Accessible piping joints should be inspected for cracking, leaking, or disruptions of stormwater flow through the system. Failure to repair a specific GI component upon finding integrity issues can potentially degrade downstream components and negatively impact the function of the GI as whole.

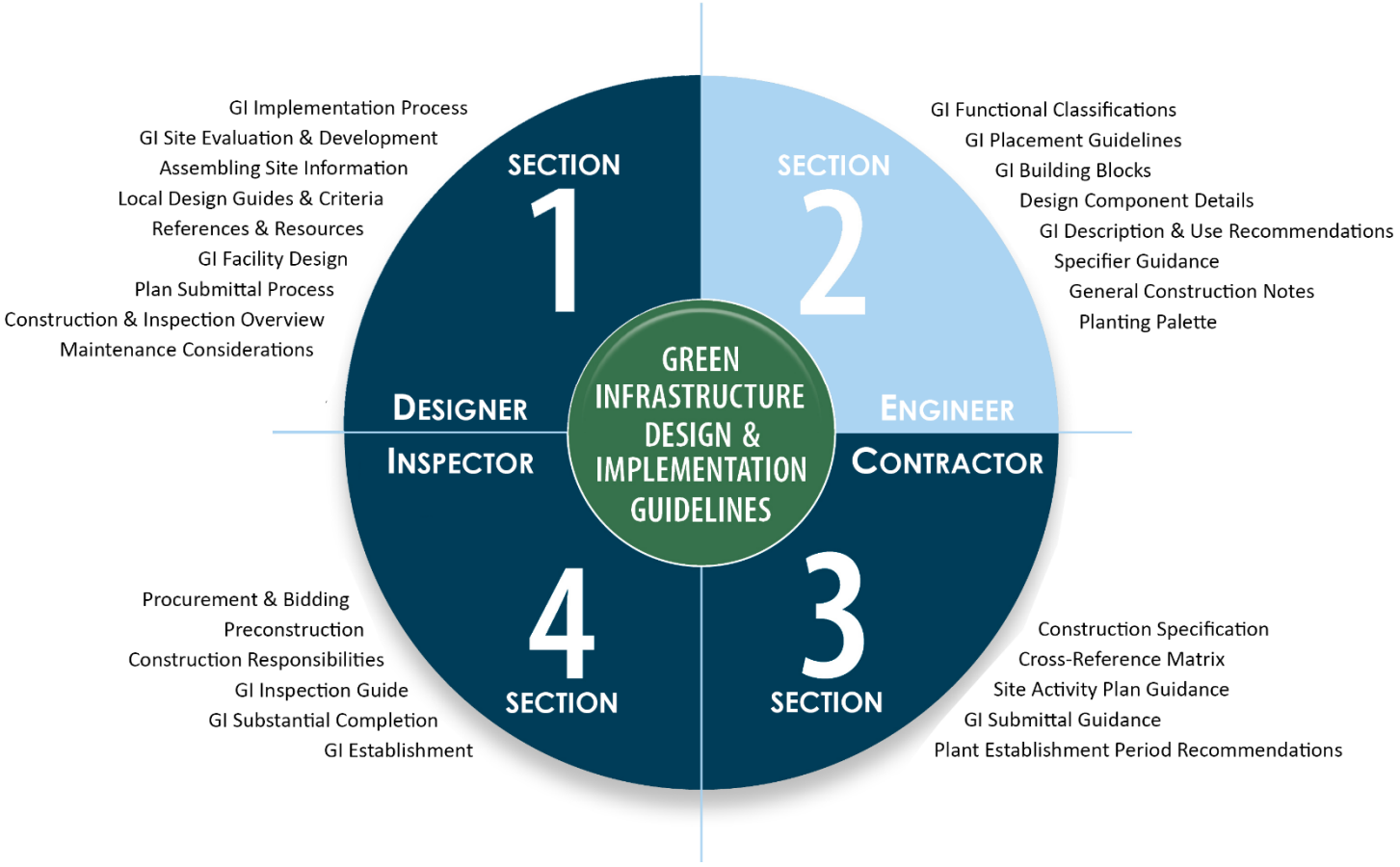
VEGETATIVE MAINTENANCE

Vegetative maintenance needs will vary greatly depending on the type of GI and the landscaping materials incorporated. Primary inspection and maintenance activities consist of removal and replacement of dead/damaged plants, weeding, trimming/pruning, invasive species control, mowing, and irrigation, if needed. Designers should provide a detailed list and photo log of the planting palettes used in each design for the project, to provide maintenance crews tools to decipher between GI plantings and potentially invasive species. DC 5.2 (Planting Palettes) provides a list of the City of Columbus approved plants, example planting plans, as well as photos of all plants.

SECTION 2

GREEN INFRASTRUCTURE PLACEMENT GUIDELINES & DESIGN COMPONENTS

GI Audience & Resource Content Guide



GREEN INFRASTRUCTURE (GI) PLACEMENT GUIDELINES AND DESIGN COMPONENTS

There are two main features included in Section 2: placement guidelines and the design components. The Placement Guidelines section deals with general considerations for placement of GI within the ROW, whereas the GI Design Components section provides guidance on how the most typical components of GI are chosen, implemented, and constructed.

Supplemental specifications specific to GI have also been developed for the City of Columbus and are applicable to the design and construction of certain GI components. GI specific supplemental specifications include the following:

SS 1600	Green Infrastructure Submittal Requirements
SS 1601	Site Activity Plan for Projects Containing Green Infrastructure Facilities
SS 1602	Earthwork for Green Infrastructure Projects
SS 1603	Tree and Vegetative Protection for Green Infrastructure Projects
SS 1604	Bioretention Soils for Green Infrastructure Projects
SS 1609	Green Infrastructure Establishment Activities
SS 1610	Underdrains and Aggregates for Green Infrastructure Facilities

These should be used in conjunction with the existing City of Columbus CMSC and standard drawings, and a comprehensive list of general notes available from DOSD. Designers should carefully consider the site specific features of their GI application in their projects as described in Section 1, while utilizing the placement guidelines and design components.

Supplemental specifications for permeable surfaces are currently under development by DPS and will be available in the future.

PLACEMENT GUIDELINES

The placement guidelines show typical layouts of both vegetated and non-vegetated GI and considerations that should be taken during design of these facilities. The GI displayed on the placement guidelines are meant to represent general GI placement and are in no way restrictive of the type of GI to be implemented in a given location. The designers should refer to the specific design components for requirements for individual GI features.

The placement guidelines reflect dimensions and setback considerations as required by DPU, DPS, SWDM, ODOT, ADA Standards for Accessible Design, as well as other regionally accepted criteria. The designers should use their professional judgment, in coordination with these Guidelines and the City's project specific requirements regarding placement of GI features. The City of Columbus recognizes the challenges of integrating GI into established ROW areas, and in some instances meeting all requirements is not feasible. Deviations from the City requirements and guidelines will be reviewed on a case-by-case basis.

The City of Columbus recognizes the nomenclature shown in the following table to designate various types of stormwater control by their functional classification.

STORMWATER CONTROL FUNCTIONAL CLASSIFICATIONS						
PRIMARY FUNCTION[1]	FEATURE	GI PRACTICE	SECONDARY FUNCTIONS			
			BASINS	FILTERS	INFILTRATORS	SWALES/STRIPS
BASINS	Detention[2]		X		X	
	Underground storage[2]	See Note 6	X		X	
	Rainwater harvesting	X	X			
	Wetland		X	X	X	
	Blue roof		X			
FILTERS	Bioretention [3,4]	X	X	X	X	
	Permeable pavement [3,4]	X	X	X	X	
	Sand and organic filter[3]			X		
	Manufactured filter[2]			X		
	Green roof[2]	X	X	X		
INFILTRATORS	Bioretention [3,5]	X	X		X	
	Permeable Pavement [3,5]	X	X		X	
	Trench (w/ drainage structure)[3]		X	X	X	
SWALES/STRIPS	Vegetated swale			X	X	X
	Grass filter strip[3]			X	X	X

[1] Design of Urban Stormwater Controls, WEF Manual of Practice No. 23, ASCE Manuals and Reports on Engineering Practice No. 87, Water Environment Federation, American Society of Civil Engineers, Environmental and Water Resource Institute, 2012, table 4.2

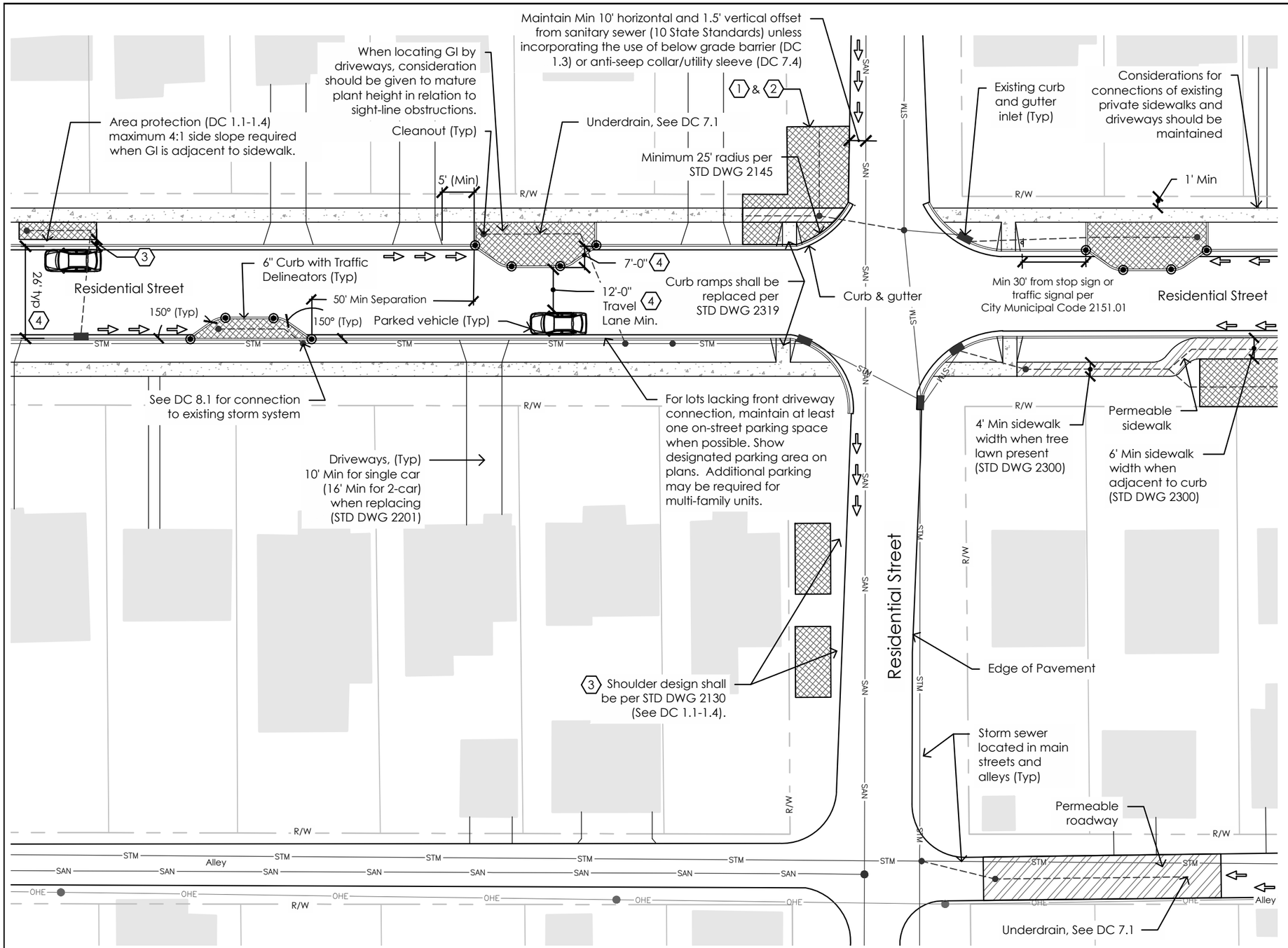
[2] City of Columbus, Department of Public Utilities, Division of Sewerage and Drainage, Stormwater Drainage Manual, 2012

[3] Ohio Department of Natural Resources, Division of Soil and Water Conservation, Rainwater and Land Development Manual, Ohio's Standards for Stormwater Management Land Development and Urban Stream Protection

[4] With engineered drainage structure

[5] Without engineered drainage structure

[6] Stand-alone underground facilities are not considered green infrastructure. Underground storage facilities, however, may be utilized as a component of a GI practice.



Coded Notes

1. Provide adequate turning radii, tapers and transitions in accordance with geometric design standards of the ODOT Location and Design manual current volume, the City of Columbus DPS Sight Distance at Intersections Policy and the requirements of the City of Columbus Department of Public Safety.

2. When proposing GI feature at intersections or adjacent to driveways , mature plant height shall not exceed 2.5' to avoid sight-line obstructions within the sight triangle, as required by the City of Columbus.

3. GI located adjacent to designated on-street parking areas shall maintain a minimum operational offset of 2.5' to allow for exit from vehicles. Uncurbed street sections require a 4' minimum offset from pavement edge to edge of GI. If offset is not feasible given space constraints, alternatives may be evaluated by City of Columbus DPS on a case-by-case basis.

4. All GI "bumpouts" are to be fixed at 7' in width (face-of-curb to face-of-curb). The use of bumpouts is preferred on streets that are 26' wide or wider such that a 12' lane of travel can be maintained at all times when parking is permitted on the opposite side of the street. If two-way travel is required on a 26' wide street with a bumpout, the area opposite the bumpout shall be a no parking zone. Bumpouts on streets less than 26' wide can be considered if the opposite side of the street is a no parking zone. All bumpout locations are subject to DPS review and approval. No parking/stopping signs shall be specified at the direction of DPS. For all bumpout locations, a parking study shall be performed to determine the impact to parking.

General Notes

- This graphic represents generalized conditions and is intended to convey GI siting guidance. Designer is responsible for following all applicable design standards for roadway and infrastructure design. GI locations are subject to review and approval by the City of Columbus.
- When proposing GI feature in close proximity to water mains, avoid placing adjacent to hydrants. Avoid also, positioning valves within GI feature footprint.
- For GI proximity to existing infrastructure, *The Great Lakes - Upper Mississippi River Board 10 States Standards* shall be followed unless otherwise directed by the City.
- Whenever possible, maintain separation from utility poles and/or street light poles. Avoid locating GI feature in an area with electrical control panels, meter settings or electrical conduit pull boxes.
- Avoid where possible, locating a GI facility above underground public and/or private utilities. If unavoidable, utility sleeves, anti-seep collars & below grade barriers may be required. (See DC 7.4 & 1.3)

Legend

DC Design Component

- Sidewalks
- Vegetated GI Facility
- Non-Vegetated GI Facility
- Traffic Delineator
- R/W Right-of-Way Boundary
- STM Storm Sewer
- SAN Sanitary Sewer
- OHE Overhead Electric
- Assumed Drainage Path

THE CITY OF COLUMBUS
ANDREW J. GINTHER, MAYOR
DEPARTMENT OF PUBLIC UTILITIES

Placement Guidelines - 01

Typical Stormwater Green Infrastructure in Right-of-Way
Neighborhood with Curb and Gutter

March 2017

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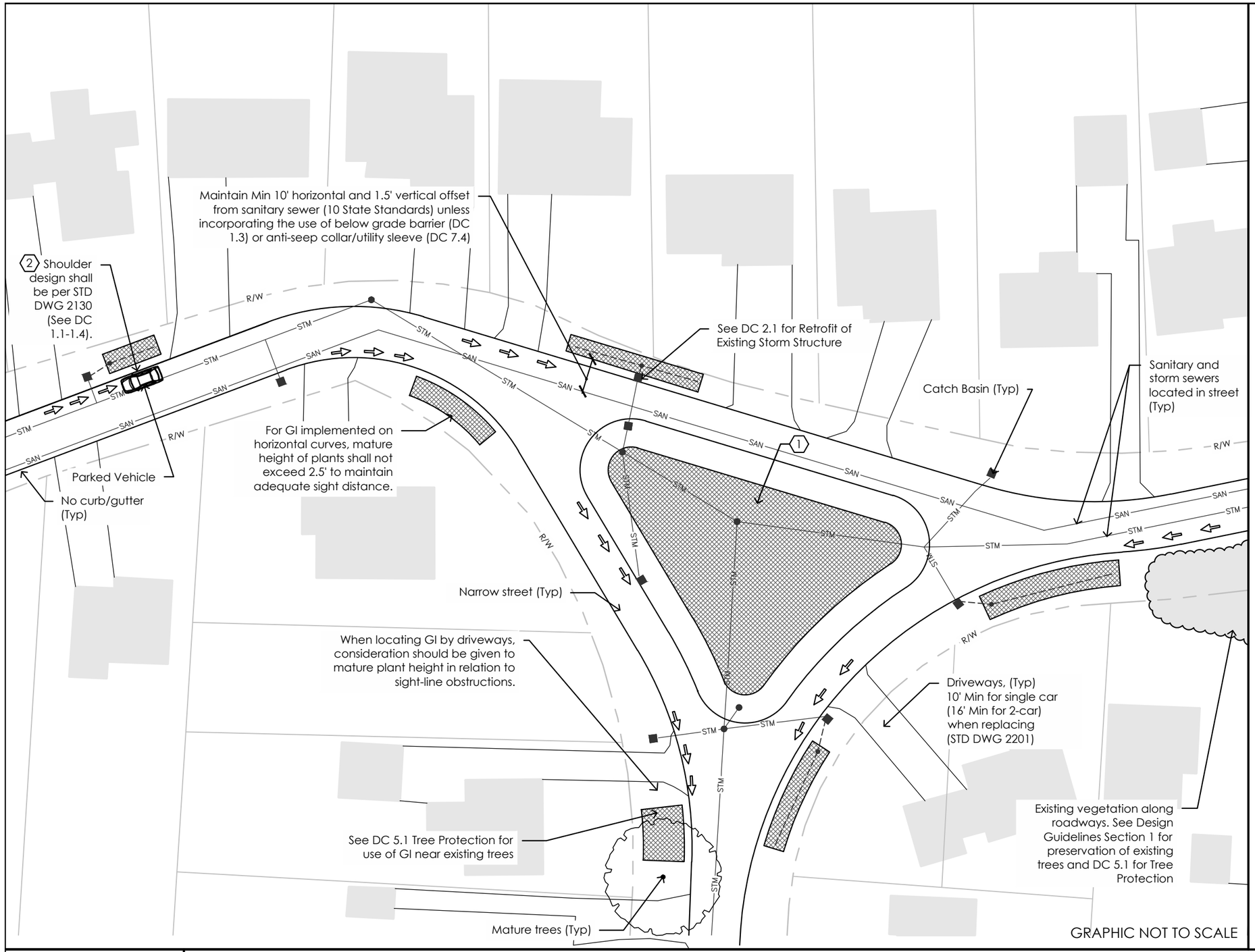
Strong neighborhoods.



Coded Notes

1. When proposing GI feature at intersections or adjacent to driveways, mature plant height shall not exceed 2.5' to avoid sight-line obstructions within the sight triangle, as required by the City of Columbus.

2. GI located adjacent to designated on-street parking areas shall maintain a minimum operational offset of 2.5' to allow for exit from vehicles. Uncurbed street sections require a 4' minimum offset from pavement edge to edge of GI. If offset is not feasible given space constraints, alternatives may be evaluated by City of Columbus DPS on a case-by-case basis.

General Notes

- This graphic represents generalized conditions and is intended to convey GI siting guidance. Designer is responsible for following all applicable design standards for roadway and infrastructure design. GI locations are subject to review and approval by the City of Columbus.
- When proposing GI feature in close proximity to water mains, avoid placing adjacent to hydrants. Avoid also, positioning valves within GI feature footprint.
- For GI proximity to existing infrastructure, *The Great Lakes - Upper Mississippi River Board 10 States Standards* shall be followed unless otherwise directed by the City.
- Whenever possible maintain separation from utility poles and/or street light poles. Avoid locating GI feature in an area with electrical control panels, meter settings or electrical conduit pull boxes.
- Avoid where possible, locating a GI facility above underground public and/or private utilities. If unavoidable, utility sleeves, anti-seep collars & below grade barriers may be required. (See DC 7.4 & 1.3)

Legend

DC	Design Component
	Vegetated GI Facility
	Assumed Drainage Path
R/W	Right-of-Way Boundary
STM	Storm Sewer
SAN	Sanitary Sewer

THE CITY OF COLUMBUS
ANDREW J. GINTHER, MAYOR
DEPARTMENT OF PUBLIC UTILITIES

Placement Guidelines - 02

Typical Stormwater Green Infrastructure in Right-of-Way
Neighborhood with Ditch Section

March 2017

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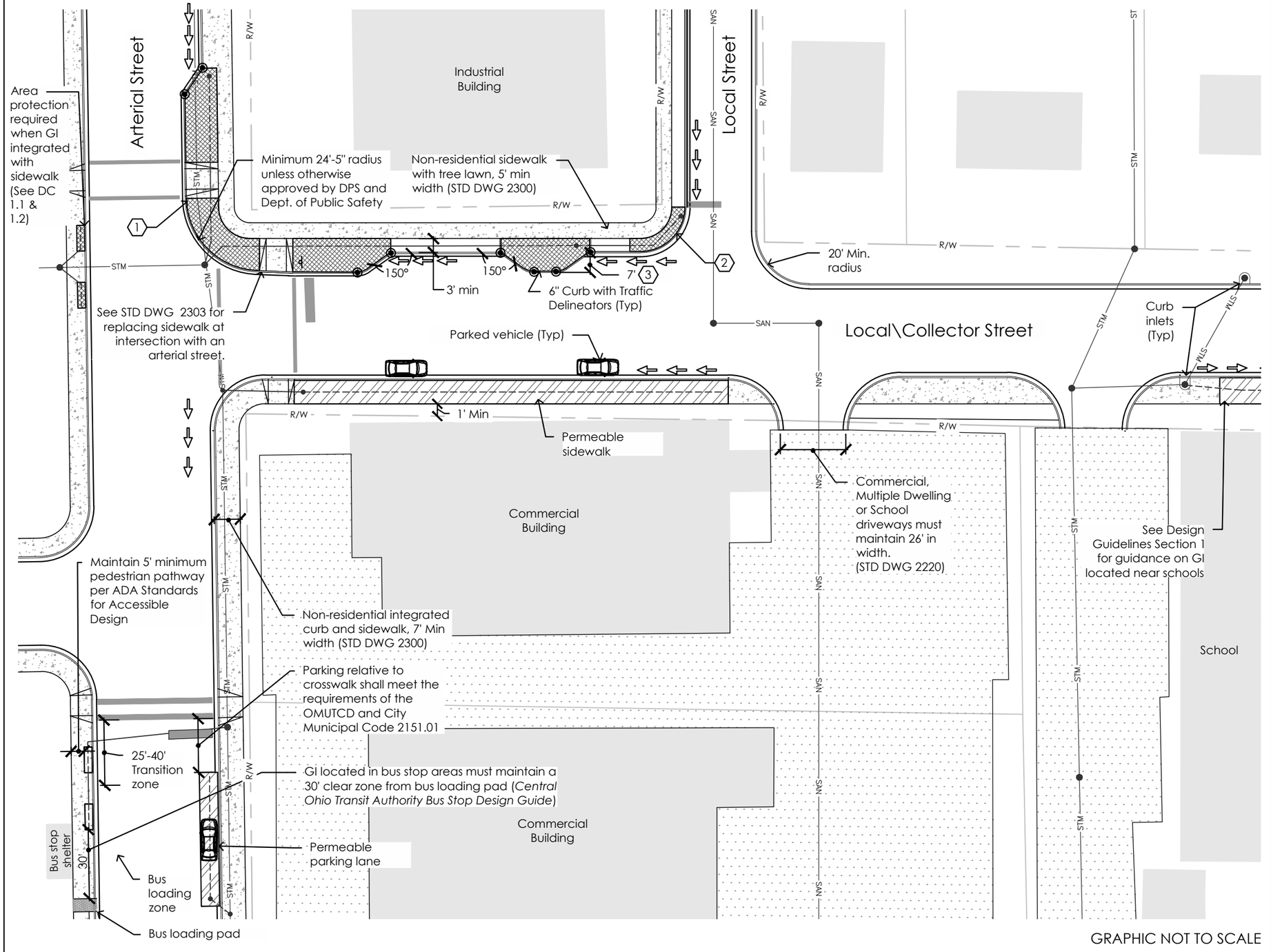

GRAPHIC NOT TO SCALE

Coded Notes

1. Curb extensions are not preferred by the City of Columbus. The use of curb extensions will require approval from DPS and Department of Public Safety. Designer should evaluate impact of curb extensions to accommodate GI practices to assess impact to turning radii and taper lengths. Provide adequate turning radii, tapers and transitions in accordance with geometric design standards of the ODOT Location and Design manual current volume, the City of Columbus DPS Sight Distance at Intersections Policy and the requirements of the City of Columbus Department of Public Safety.

2. When proposing GI feature at intersections, mature plant height shall not exceed 2.5' to avoid sight-line obstructions within the sight triangle, as required by the City of Columbus.

3. All GI "bumpouts" are to be fixed at 7' in width (face-of-curb to face-of-curb). The use of bumpouts is preferred on streets that are 26' wide or wider such that a 12' lane of travel can be maintained at all times when parking is permitted on the opposite side of the street. If two-way travel is required on a 26' wide street with a bumpout, the area opposite the bumpout shall be a no parking zone. Bumpouts on streets less than 26' wide can be considered if the opposite side of the street is a no parking zone. All bumpout locations are subject to DPS review and approval. No parking/stopping signs shall be specified at the direction of DPS. For all bumpout locations, a parking study shall be performed to determine the impact to parking.

General Notes

- This graphic represents generalized conditions and is intended to convey GI siting guidance. Designer is responsible for following all applicable design standards for roadway and infrastructure design. GI locations are subject to review and approval by the City of Columbus.
- When proposing GI feature in close proximity to water mains, avoid placing adjacent to hydrants. Avoid also, positioning valves within GI feature footprint.
- For GI proximity to existing infrastructure requirements, *The Great Lakes - Upper Mississippi River Board 10 States Standards* shall be followed unless otherwise directed by the City.
- Whenever possible maintain separation from utility poles and/or street light poles. Avoid locating GI feature in an area with electrical control panels, meter settings or electrical conduit pull boxes.
- Avoid where possible, locating a GI facility above underground public and/or private utilities. If unavoidable, utility sleeves, anti-seep collars & below grade barriers may be required. (See DC 7.4 & 1.3)

Legend

DC Design Component

- Sidewalks
- Vegetated GI Facility
- Non-Vegetated GI Facility
- Traffic Delineator
- Traffic Sign

R/W Right-of-Way Boundary

STM Storm Sewer

SAN Sanitary Sewer

Assumed Drainage Path

THE CITY OF COLUMBUS
ANDREW J. GINTHER, MAYOR
DEPARTMENT OF PUBLIC UTILITIES

Placement Guidelines - 03

Typical Stormwater Green Infrastructure in Right-of-Way
Non-Residential Land Use

March 2017

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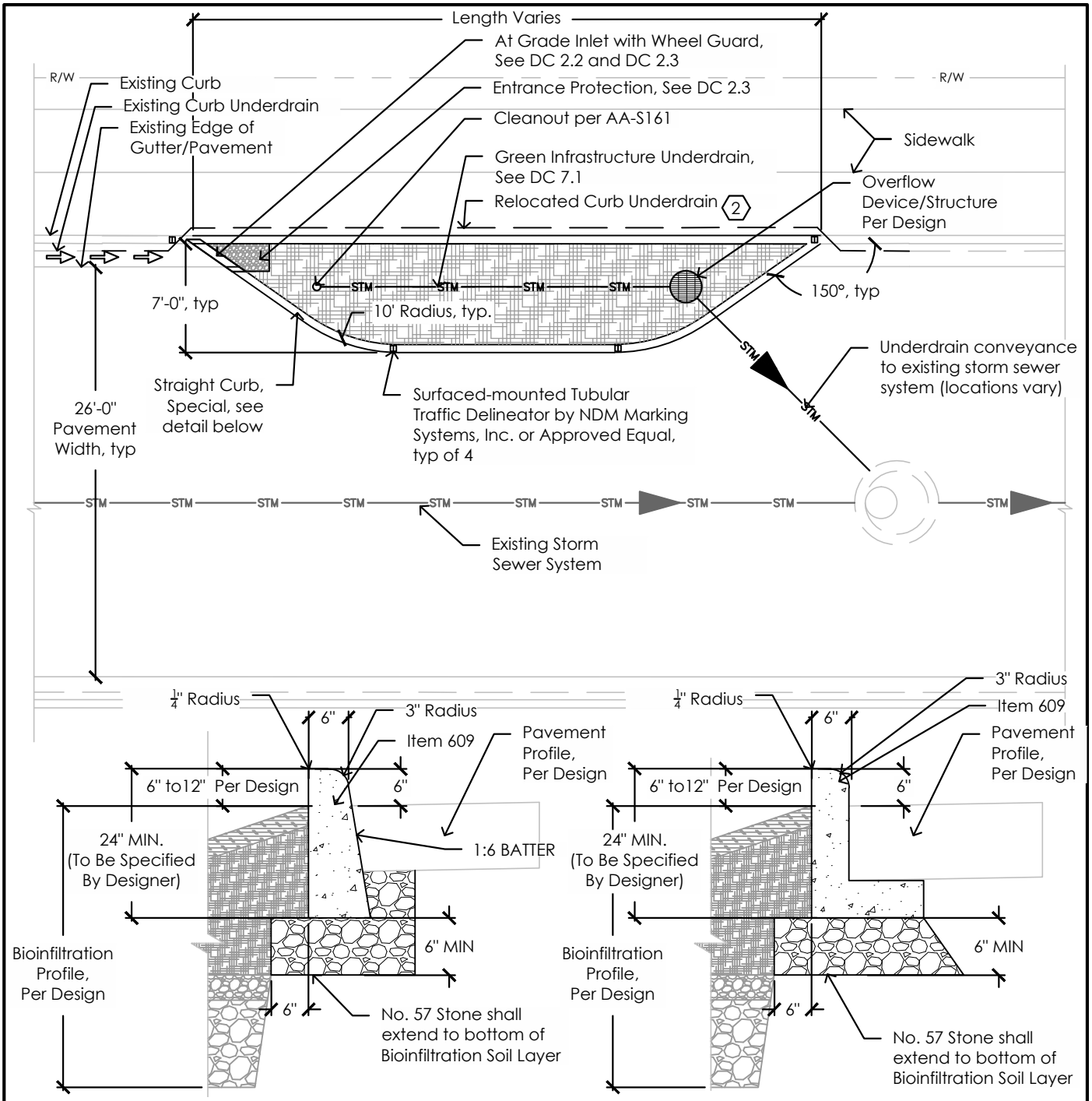

STRAIGHT CURB DETAIL DESIGNS

Coded Notes

1. All GI "bumpouts" are to be fixed at 7' in width (face-of-curb to face-of-curb). The use of bumpouts is preferred on streets that are 26' wide or wider such that a 12' lane of travel can be maintained at all times when parking is permitted on the opposite side of the street. If two-way travel is required on a 26' wide street with a bumpout, the area opposite the bumpout shall be a no parking zone. Bumpouts on streets less than 26' wide can be considered if the opposite side of the street is a no parking zone. All bumpout locations are subject to DPS review and approval. No parking/stopping signs shall be specified at the direction of DPS. For all bumpout locations, a parking study shall be performed to determine the impact to parking.

2. Curb underdrain shall be installed per standard drawing or as required by DPS only when curbing is adjacent to street. Where curb bumpouts interrupt existing underdrains, underdrain shall be re-routed around or behind bumpout to maintain drainage.

3. Straight curb, special is intended to prevent curb overturn. Straight curb, special shall be installed per the requirements of CMSC Item 609.04 for cast-in-place concrete curb. Final design to be determined by Desiger based on GI design and existing pavement conditions.

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Placement Guide - 04
Curb Bumpouts

March 2017

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GREEN INFRASTRUCTURE DESIGN COMPONENTS

The GI Design Components section provides the building blocks for the features required within a GI facility for the design to function. Because every GI design and installation is site specific, not all components will be applicable in every GI system. Instead, the design components provide a standard for each feature that can be applied to GI installations when appropriate. The design components are separated into the following nine categories:

1—AREA PROTECTION AND RIGHT OF WAY SAFETY

2—STORMWATER ENTRANCES

3—PERMEABLE SURFACES (RESERVED)

4—ENERGY DISSIPATION

5—LANDSCAPING

6—STORAGE MEDIA

7—PIPING

8—OUTLETS & OVERFLOWS

9—MONITORING

The guidance for each design component (DC) is divided into these following sections:

DESCRIPTION: A short summary of function and purpose of the individual design component (DC) is presented.

WHERE TO USE: A description of where or when the design component will be required or should be considered. This section also includes a description of complimentary design components, when applicable.

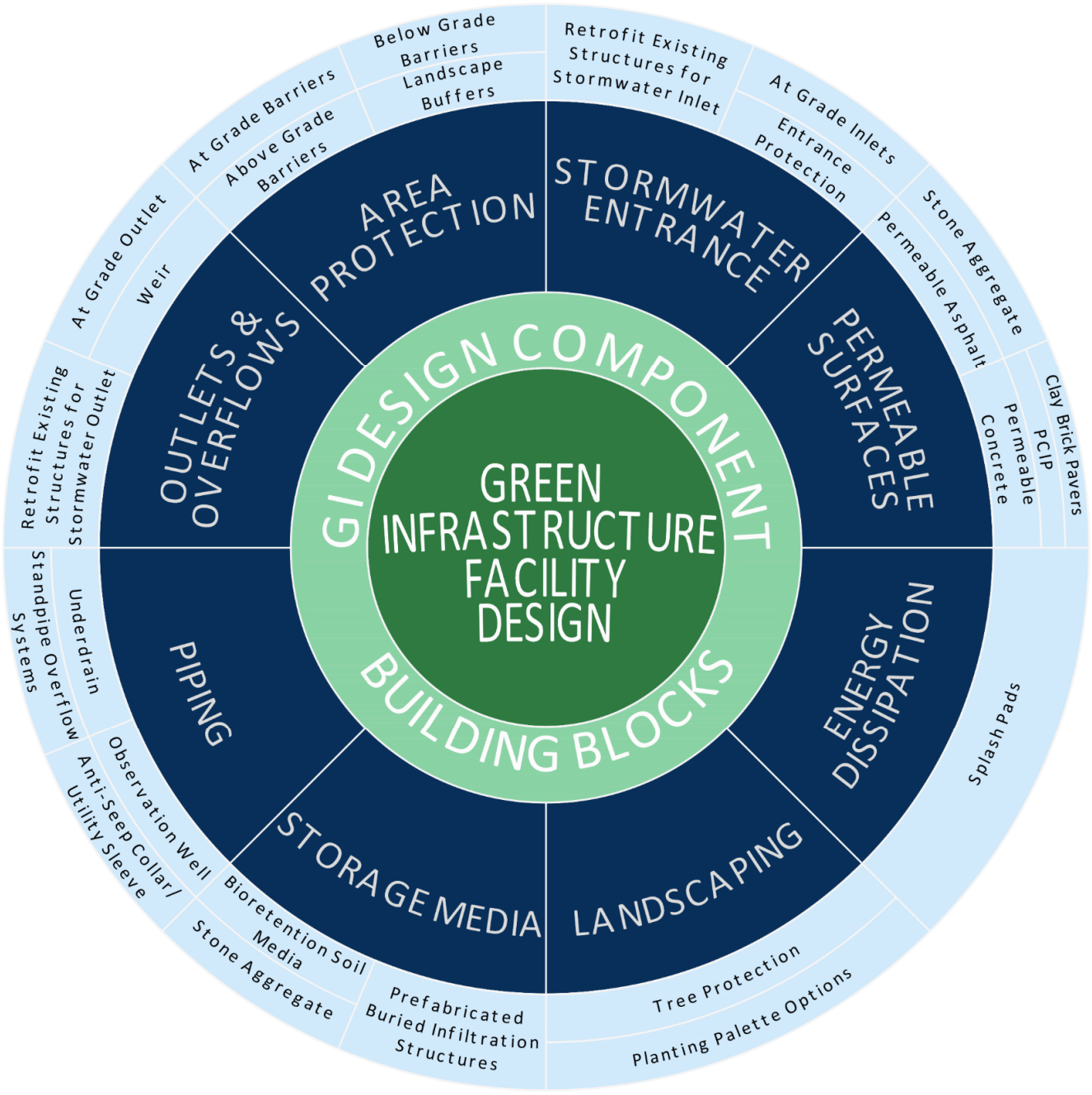
DESIGN CONSIDERATIONS: General material, sizing, placement, offsets, and manufacturer specific detail examples are provided for each individual design component. The section typically includes reference details and refers users to the City standard details, CMSCs, Supplemental Specifications (SS), SWDM, or other pertinent design criteria.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST: A list of required designer submittal documents such as details, plan/profile views, and material/manufacturer certifications for the specific design component is included for reference. SS 1600 Green Infrastructure Submittal Requirements also summarizes GI specific contractor submittal procedures, materials, and testing requirements for GI specific Supplement Specifications. The City or other local agency may require a specification outside of the specific details provided in this section.

DETAILS: Typical design component details are provided to compliment the guidelines outlined in Section 2. Additional detail examples from GI designs in other states are referenced in Appendix A.

ADDITIONAL RESOURCES: Although not part of this manual, the City of Columbus has developed separate resources for the design and construction community to utilize in the implementation of GI. This includes GI specific supplemental specifications, special provisions and general notes, all of which are available from DOSD. The guidance presented in this manual has been developed for the designer to consider when compiling construction plans to convey important GI construction considerations to the contractor.

GREEN INFRASTRUCTURE DESIGN COMPONENTS



1—AREA PROTECTION

DC 1.1—AT GRADE BARRIERS

DESCRIPTION: At-grade barriers are used in areas where Green Infrastructure (GI) is integrated with sidewalk or curb to provide pedestrian safety and protect the GI facility. At-grade barriers are generally solid covers over the GI facility that are in a pedestrian pathway.

WHERE TO USE: At-grade barriers will be required when the vertical drop from the adjacent grade to the top of the GI installation is greater than 6 inches, and no other type of area protection or adequate side slope can be established. The top of the GI is considered to be the highest elevation of the planting bed or soil and at the base of the side slope, if present, as depicted in the example details referenced in Appendix A. See DC 1.2 (Above Grade Barriers) and DC 1.4 (Landscape Buffers) for additional area protection options.

DESIGN CONSIDERATIONS:

Covers

- Cover size, shape, material, and specifications will vary by manufacturer. Covers used shall be in accordance with manufacturer instructions and shall be designed for typical travel loading (pedestrian or vehicular)
- Covers shall be solid, gray iron castings conforming to CMSC 711.12 (ASTM A 48, Class 35B), ductile iron castings conforming to CMSC 711.13 (ASTM A536) or checkered steel plate or better and shall be installed flush with surrounding grade.

Grate (Source: CDM Smith, designed by others)

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Plan view of at-grade barrier placement including offset dimensions.

✓ Detail and section views of cover installation including size, dimensions, and depths.

✓ Manufacturer details including product number, materials, painting specifications, and fastener and frame details.

✓ Additional contractor submittal requirements outlined in SS 1600 or CMSC 711, as applicable.

Cover designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

DC 1.2—ABOVE GRADE BARRIERS

DESCRIPTION: Above Grade Barriers are used as a form of area protection to prevent vehicular or pedestrian traffic through a Green Infrastructure (GI) facility by providing an easily distinguishable separation between travel areas and the GI installation. Above Grade Barriers include traffic delineators, curb reveals, and fencing, if approved.

Curb Reveal (Source: CDM Smith, designed by others)

WHERE TO USE: Barriers should be used when the GI facility is located near areas where pedestrian or vehicular traffic is expected, and no other area protection exists. Specifically, barriers should be implemented when the GI facility side slope adjacent to a sidewalk or uncurbed roadway is steeper than 4:1 (H:V) or if the drop from street or sidewalk to the top of the GI installation is greater than 6 inches (0.5 feet). When GI is adjacent to potential on-street parking areas, provide for 2.5 feet of operational offset to allow for opening of vehicle doors and exiting from the vehicle. See DC 1.4 (Landscape Buffers) for more information. Fencing type barriers should only be used when approved by the City of Columbus.

DESIGN CONSIDERATIONS:

General

- Barrier materials, patterns, shapes, and sizes can vary based on the type of GI system and available space. Typically the type of barrier material should match the existing material for the curb or other barrier that is at the GI facility site, if applicable. Designers should consult with DPS in areas of granite curb to assess whether the granite should be reused or replaced.
- Barriers applied adjacent to streets/roadways should not impair site lines.
- Sidewalk clear zone minimum width of 48 inches must be maintained per ADA requirements around any above grade barrier placed within a sidewalk pedestrian pathway per the City of Columbus Rules and Regulations for Wheelchair Ramp requirements.
- Barriers placed within the roadway clear zone, as defined by the ODOT L&D Manual, Volume 1 Section 600.2 shall be crashworthy as defined by the Ohio Manual of Uniform Traffic Control Devices, or they shall be placed according to the requirements for urban lateral offsets per ODOT L&D Manual, Volume I Section 600.2.2 and operational offsets per 600.2.3. In addition, the City of Columbus requires a 2.5-foot wide minimum operational offset if on-street parking is permitted adjacent to the barrier.
- Site distances shall be provided per the City's Site Distance criteria City Code 3321.05 and the General Policy and Procedures for Sight Distance at Intersections Policy.
- Bollards, permanent or break-away, should not be used as an above-grade barrier.

Curb Reveals

- Curbing shall conform to CMSC 609 – Curbing, Concrete Medians, and Traffic Islands.

- Curbing shall conform to DPS Standard Drawings 2000, 2005, 2010, 2020 with the following exceptions:
    - Maximum exposed curb height facing GI is 18 inches; maximum exposed curb height facing adjacent grade (sidewalk/street) is 6 inches.
    - Curb underdrain shall not be placed within the GI facility and is not required for curbing adjacent to sidewalk. Curb underdrain shall be installed per standard drawing or as required by DPS only when curbing is adjacent to street. Where curb bumpouts interrupt existing underdrains, underdrain shall be re-routed around or behind bumpout to maintain drainage.
    - Mountable combination Curb and Gutter per Standard Drawing 2030 does not provide adequate protection and should not be used for GI adjacent to street pavement.
    - Curbs located on the roadway side of bumpouts shall be designed by a registered engineer to prevent overturn. Design shall account for exposed curb reveal on backside, soil properties, and existing roadway conditions.
- Combination curb and gutter is preferred for proposed curbing on existing curb and gutter section streets. Straight back curb per DPS Standard Drawing 2000 may be used where curb is proposed for existing non curb and gutter street sections, for permeable pavement applications, and for sidewalk abutting the GI.
- When GI is directly abutting the curb reveal on the street side and no landscape buffer is present, curbing must be sufficiently reinforced to sustain off-course vehicular traffic, or design must incorporate a crashworthy barrier/guard rail. Curbing reinforcement must be designed by an engineer licensed in the State of Ohio. Reinforcing materials must comply with CMSC 509 – Reinforcing Steel Material and CMSC 709 – Reinforcing Steel.
- When integrating curb reveal with existing curb, the existing curb shall be removed up to an existing joint, or no closer than 5 feet from an existing joint.
- Granite curbing used for area protection shall conform to DPS Standard Drawing 2005.

Traffic Delineators

- Traffic delineators are intended to prevent unintentional access to GI facilities by making the facilities more visible.
- Traffic delineators shall be provided per CMSC 719 – Delineator Materials. Traffic delineators shall be of a tubular design and provided by NDM Marking Systems, or approved equal.
- Traffic delineators at curb bumpouts shall be surface-mounted on the curb at the front and back taper. Delineators installed along uncurbed streets shall be ground mounted and of a crashworthy design as defined in the OMUTCD.

Fencing (Source: CDM Smith, designed by others)

Fencing, if approved for use

- Fencing shall have a minimum height of 18 inches. If the drop from the adjacent pavement grade to the top of the GI facility is 30 inches or greater, a minimum fence height of 42 inches is required for protection.

- A 1 inch minimum gap must be maintained between the bottom of lowest fence rail and finished grade adjacent to GI system. Fencing rails shall follow line of grade.

- Fence design shall conform to manufacturer specifications and requirements. Post embedment fencing shall be site specific. Posts may be embedded in the sidewalk/curb surrounding the GI, or within a landscape buffer around the GI facility.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Plan view of barrier placement, including offset dimensions.

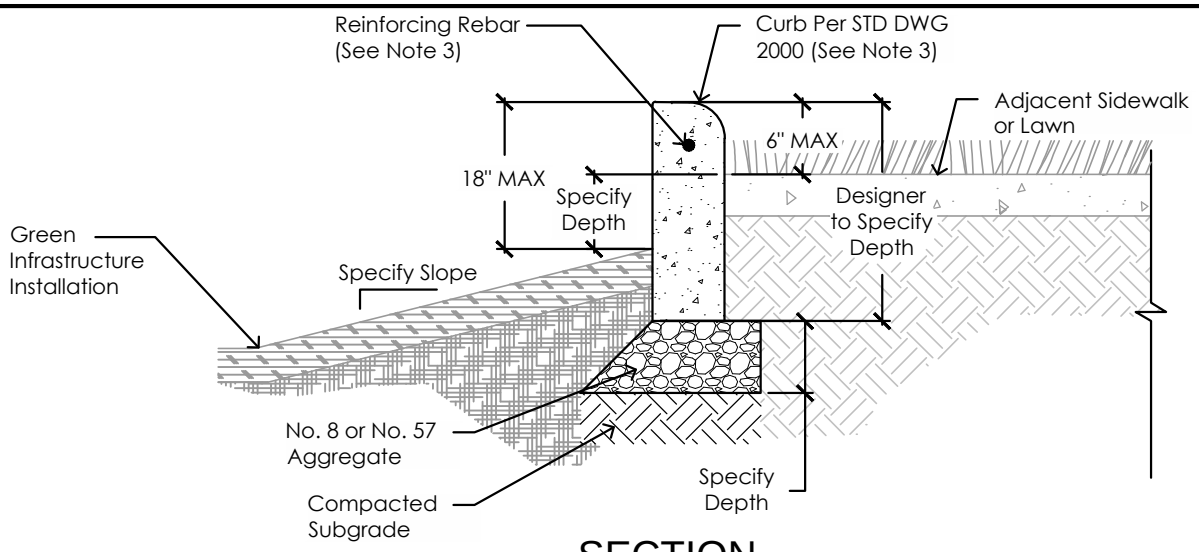
✓ Cross sectional view of barrier including post anchoring and embedment details if applicable. Offset dimensions such as GI side slope and depth from adjacent grade should be specified.

✓ If fabricating area protection, submit mill test reports for structural steel, steel castings, bronze, and sheet lead certified according to CMSC 501.06.

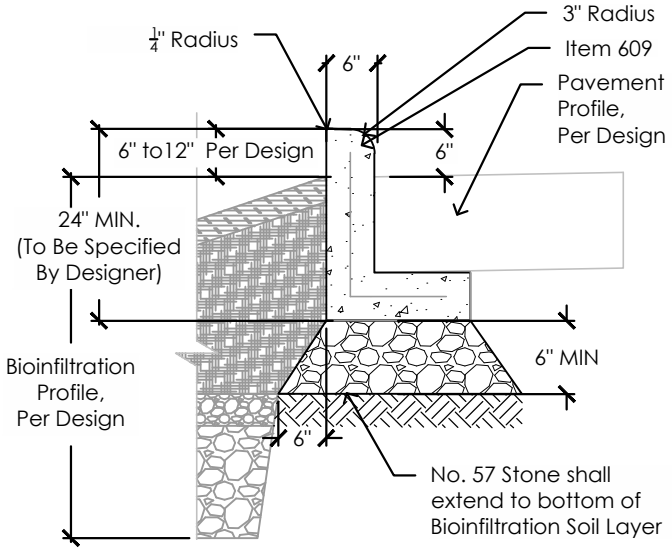
✓ Manufacturer details including product number, materials, painting specifications, fastener details and proposed post anchoring.

✓ Additional contractor submittal requirements outlined in SS 1600, CMSC 501, 509, 609, or 709, as applicable

Area protection designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities and the Department of Public Service.



SECTION
Sidewalk



SECTION
Street

Notes

1. Above grade barriers shall be used in GI adjacent to sidewalk or street when GI has side slopes > 4:1 (H:V) or a > 6" drop from top of pavement to top of GI installation.
2. Concrete curb shall be Class "C" concrete. All exposed surfaces shall have a brushed finish.
3. All curbing for non-street installations shall conform City STD DWG 2000, with the exception of the curb underdrain pipe which does not need to be installed. A curb height of 6" (4" minimum) with 1/2" radius is preferred for curbing adjacent to sidewalk.
4. When back of curb abuts GI, and the GI is located directly adjacent to a roadway, the curb shall be designed to prevent overturn per the detail. The exposed height of the curb facing the GI that is directly adjacent to a roadway shall be limited to 12".
5. Underdrain for curbing to be installed per standard drawings or as required by DPS only when curbing is adjacent to street. Curb underdrain shall not be placed within the GI facility and is not required for curbing adjacent to sidewalk.
6. When GI is applied adjacent to on street parking zones, a grass barrier may be required per DC 1.4 between the back of curb and the edge of the GI.
7. Exposed back of curb should be finished to match the face of curb.
8. Final design to be determined by Desiger based on GI design and existing pavement conditions.

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DEPARTMENT OF PUBLIC UTILITIES

DC 1.2 Above Grade Barrier
Curb Reveal

March 2017

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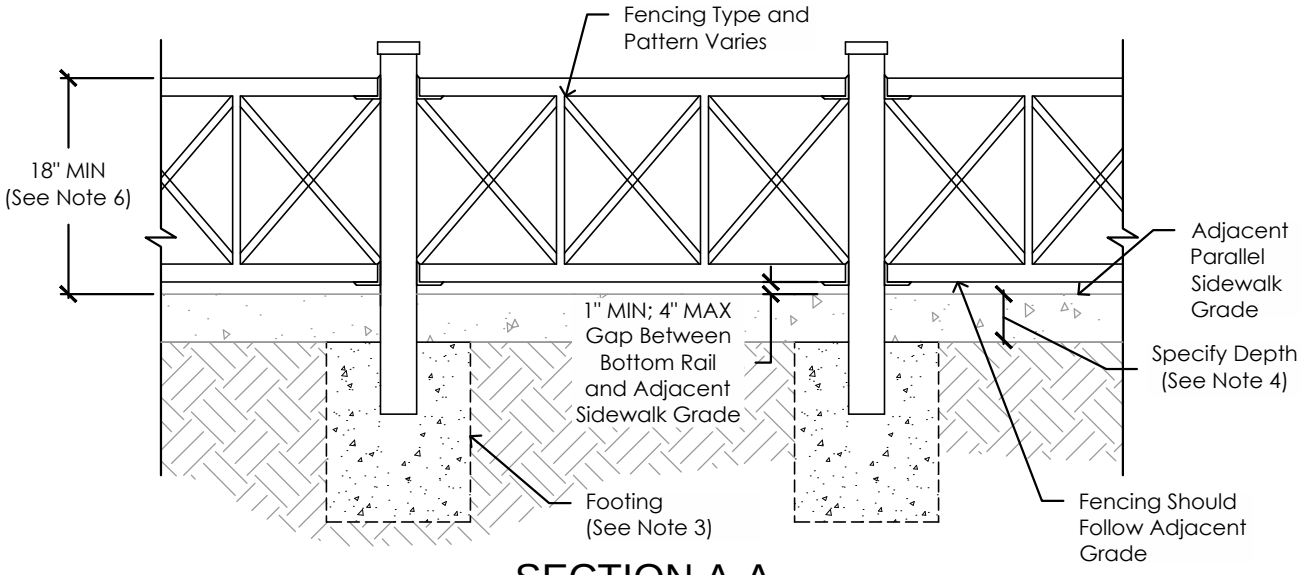
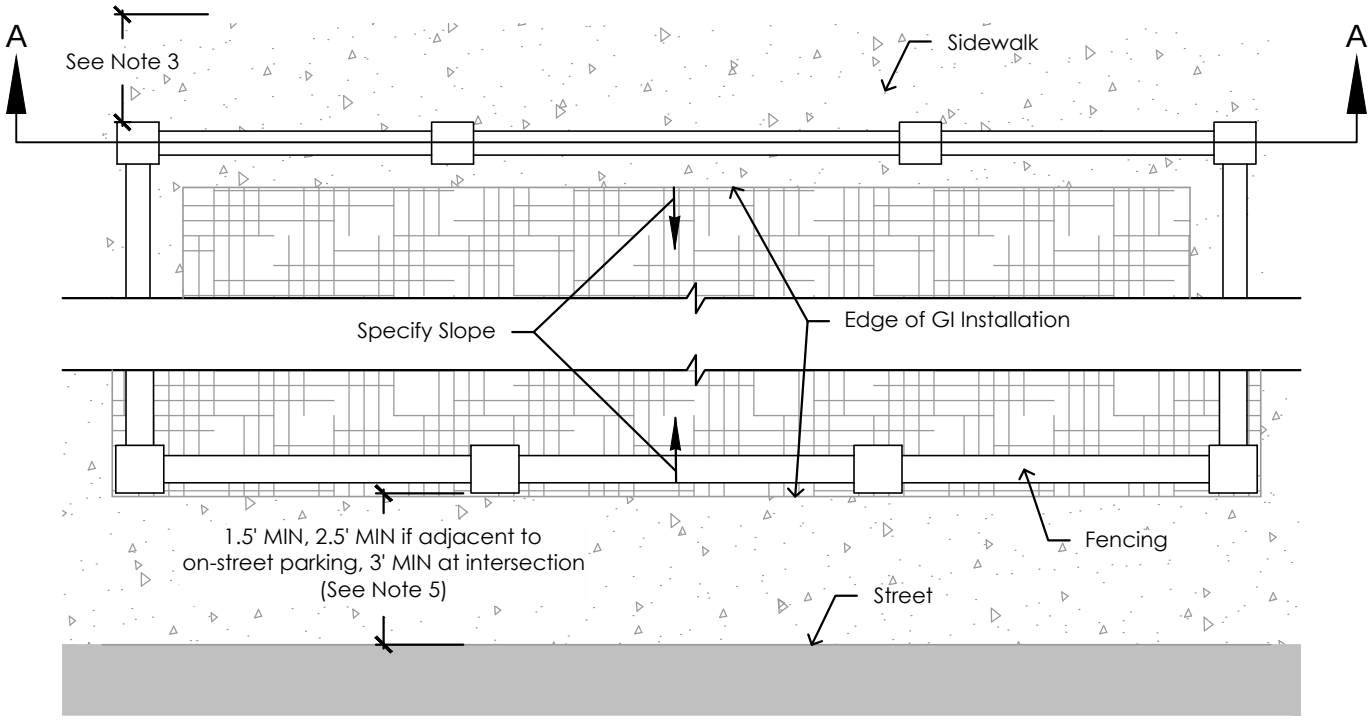


SECTION A-A



PLAN

Notes

1. Above grade barriers shall be used in GI adjacent to sidewalk or street when GI has side slopes > 4:1 (H:V) or a > 6" drop from top of pavement to top of GI installation.
2. Fencing type barriers should only be used when approved by the City of Columbus.
3. Footing shall conform to manufacturer specifications and should extend below frost depth (32"). Posts embedded in pedestrian path must maintain 48" minimum clear zone width for ADA requirements.
4. Sidewalk depth and other features to be installed per STD DWG 2300.
5. Barriers placed within the roadway clear zone, as defined by the ODOT L&D Manual, Volume 1 Section 600.2 shall be crashworthy as defined by the Ohio Manual of Uniform Traffic Control Devices or shall be placed according to the requirements for Urban Lateral Offsets per ODOT L&D Manual Volume I Section 600.2.2 and operational offsets per 600.2.3. In addition, the City of Columbus requires a 2.5-feet minimum operational offset if on-street parking is permitted adjacent to the barrier.
6. If the drop from adjacent pavement to top of GI facility is 30" or greater, a minimum fence height of 42" is required.

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ANDREW J. GINTHER, MAYOR
DEPARTMENT OF PUBLIC UTILITIES

DC 1.2 Above Grade Barrier
Fencing

March 2017

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DC 1.3—BELOW GRADE BARRIERS

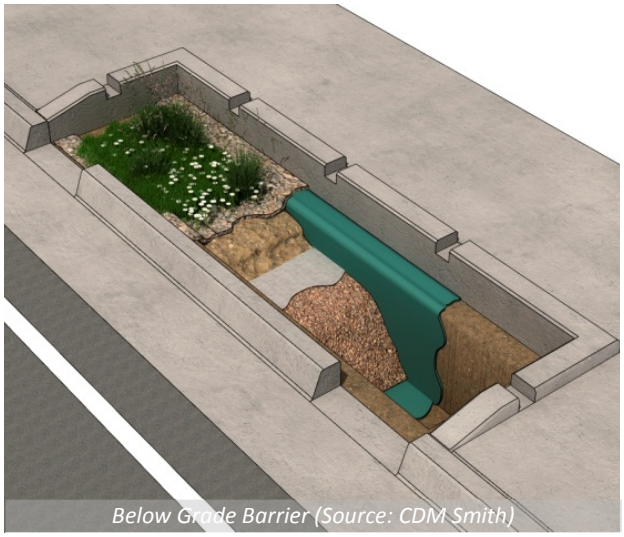
DESCRIPTION: Below grade barriers are used to control or to prevent the movement of materials or stormwater runoff within the subsurface of a Green Infrastructure (GI) facility. Types of barriers used to prevent the movement of soil material include permeable aggregates such as filter stone and permeable geotextile fabrics when approved for use by DPU. Barrier materials used to control the movement of stormwater runoff through a GI facility typically include clay barriers and impermeable geotextile fabrics. Hardscape materials such as concrete may be used for situations where structural support is required.

WHERE TO USE: Permeable below-grade barriers may be installed on the vertical sides of GI media to prevent migration of soils, and as required in the Columbus SWDM. Permeable barriers shall only be used in vertical applications, to avoid clogging potential and decreased infiltration capacity when applied on horizontal media layers. Should a transition layer be needed between GI media and stone aggregate, a stone filter layer may be used. Impermeable barriers shall be installed wherever the potential exists for stormwater runoff to migrate away from the GI facility towards a below grade feature that must be protected from contact with water, such as an underground utility, building foundation, or street/parking lot subgrade. Impermeable barriers may also be appropriate when potential exists for water to migrate into contaminated soil or to prevent leakage when a permanent pool is installed. Permeable and impermeable barriers shall also be installed where specified by the City of Columbus Department of Public Utilities (DPU).

DESIGN CONSIDERATIONS:

Permeable Barriers

- Permeable geotextile, if used, shall be non-woven and meet the requirements of CMSC 712.09. Permeable geotextile liners shall only be used in vertical applications and shall not be placed horizontally between layers or on the bottom of the GI facility due to high clogging potential.
- Permeable media barriers meeting the requirements of CMSC Section 703.01, No. 7 or No. 8 aggregate, may be used in lieu of permeable geotextile where approved by DPU.



Below Grade Barrier (Source: CDM Smith)

Impermeable Barriers

- Impermeable barriers shall be compacted clays, impermeable liners, or other impermeable material as approved by the City. Impermeable barriers shall have a permeability of no more than 1 x 10^{-7} cm/s.
- Recommended soil physical characteristics for compacted clay impermeable barriers include: >50% fines, liquid limit between 35 and 60, and a plasticity index versus liquid limit above the A-line. The Unified Soil Classification System (USCS) soil classification of CH, CL, MH are recommended. Field compaction is required to achieve 95% standard max density as determined by ASTM D 698.
- Geotextile shall be placed according to the requirements of CMSC 204.07, or in accordance with manufacturer's standards and recommendations.
- Adjacent strips of geotextile shall overlap a minimum of 18 inches or per manufacturer specifications, whichever is greater.
- An anti-seep collar (DC 7.4) should be considered for installation at the edge of the GI facility for outlet piping that passes through non-GI areas before connection to the outlet structure.

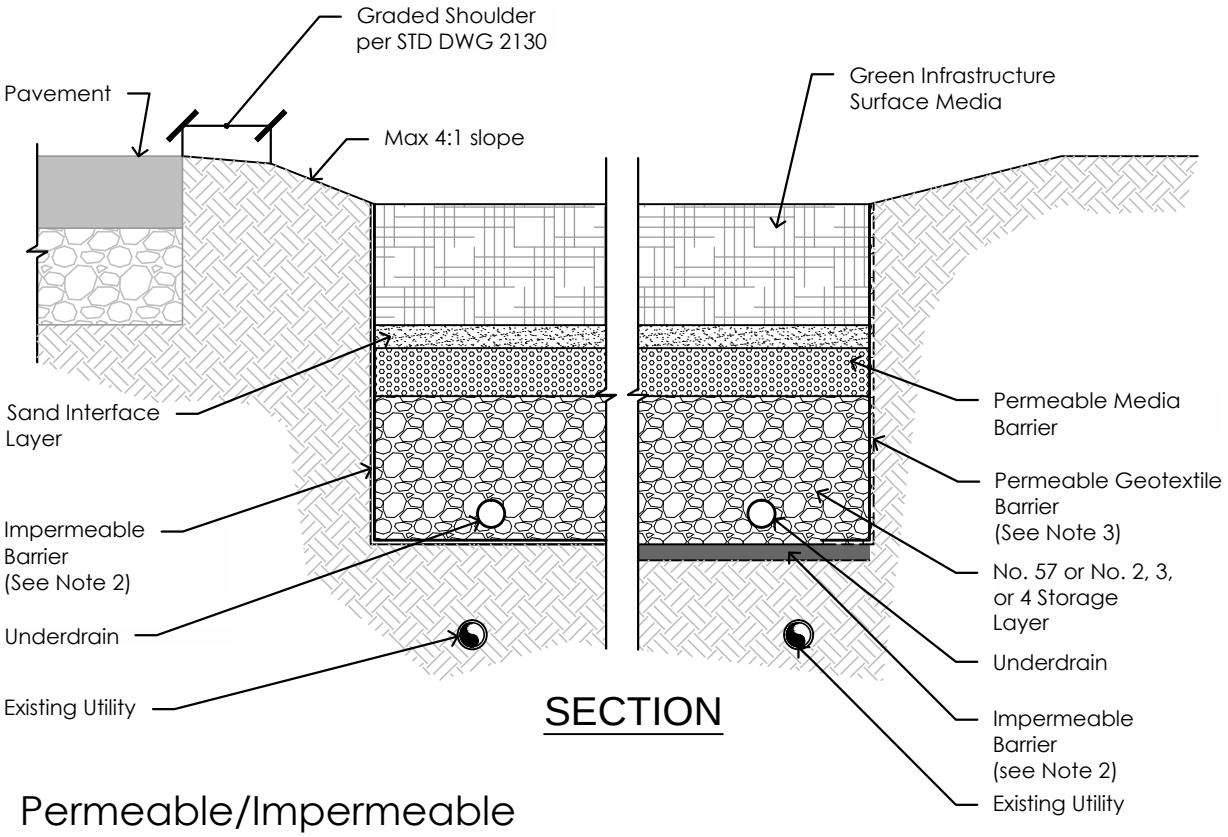
DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Section view of GI facility noting the location, limits, thickness and material specifications of the barrier.

✓ Proposed manufacturer and product details, including product number, material & performance standards.

✓ Additional contractor submittal requirements outlined in SS 1600, 1602, CMSC 703 or 712, as applicable.

Below grade barrier designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.



SECTION

Permeable/Impermeable Layers Legend

- Sand Interface Layer per ASTM C33, Fine Aggregates
- No. 7 or No. 8 Filter Layer per CMSC 703.01
- Permeable Geotextile Liner per CMSC 712.09 (See Note 3)
- Impermeable Clay Barrier to 95% Compaction per ASTM D698
- Impermeable Geotextile Barrier (See Note 2)

Notes

1. Below Grade Barriers are not required for all GI installations. See the "Where to Use" section for DC 1.3, Below Grade Barriers. For different types of media barriers, see DC 3.1 Stone Aggregate for Permeable Surfaces, DC 6.1Bioretention Media, and DC 6.2 Stone Aggregate.
2. Impermeable barriers shall be installed where the potential exists for stormwater to negatively impact existing below grade adjoining infrastructure, such as utilities, structures, or pavement.
3. Specify permeable geotextile liner on the sides of the GI when infiltration into a surrounding subgrade is allowed. Do not use permeable geotextile as a horizontal barrier due to high clogging potential. Permeable geotextile shall be non-woven & meet the requirements of CMSC 712.09.

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DEPARTMENT OF PUBLIC UTILITIES

DC 1.3 Below Grade Barriers
Media and Geotextile Barriers

March 2017

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DC 1.4—LANDSCAPE BUFFERS

DESCRIPTION: Landscape buffers are vegetated areas between the edge of a Green Infrastructure (GI) facility and areas of pedestrian or vehicular traffic used to provide a separation area for safety and to deter entry into the GI facility. Landscape buffers typically consist of a grass buffer or planted buffer strip which provide pretreatment of sheet flow entering the GI.

WHERE TO USE: Landscape buffers shall be required in areas where the GI facility is located directly adjacent to the sidewalk/driveway/road, where the GI facility side slope is steeper than 4:1 or the vertical drop from the adjacent pavement to the top of the GI facility is greater than 6 inches, and where no other area protection is present. See DC 1.1 (At Grade Barriers) and DC 1.2 (Above Grade Barriers) for other area protection options. When GI is applied adjacent to streets with potential for on-street parking, a grass buffer strip may be required by City of Columbus Department of Public Service (DPS) to allow for adequate space to exit vehicles.

DESIGN CONSIDERATIONS:

- For landscape buffers with curbed street sections and parking or at intersections, a 2.5 foot minimum mowable grass buffer between the front of curb and the edge of the GI is preferred. For uncurbed street sections with on-street parking, a 4 foot minimum mowable grass buffer strip is preferred between the edge of pavement and the edge of the GI. Narrower grass buffer strips may be approved by City of Columbus DPS on a case-by-case basis. Concrete or paver strip may be used in place of landscape buffer when applicable. Entrance protection is recommended for locations where concentrated flows through curb cuts could create erosion of the grass buffer.
- Landscape buffers shall have a maximum slope of 4:1, and a preferred slope of 3.13% adjacent to sidewalks per DPS Standard Drawing 2300.
- Any excavation, embankment or grading shall conform to CMSC 203 – Roadway Excavation and Embankment and CMSC 209 – Linear Grading.

Grass Buffer (Source: CDM Smith, Designed by Other)

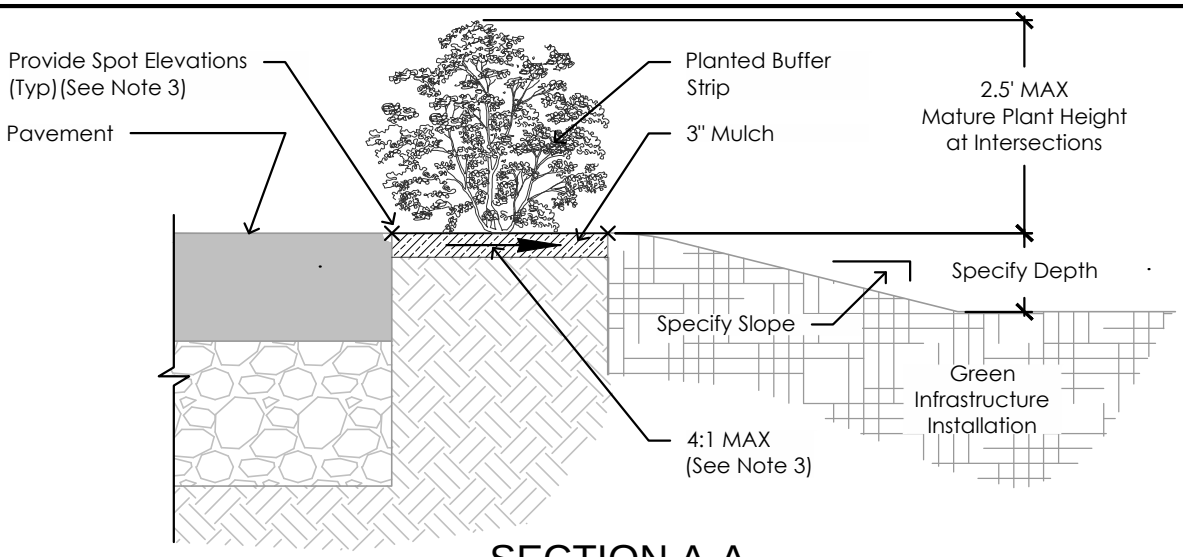
Planted Buffer (Source: CDM Smith, designed by others)

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

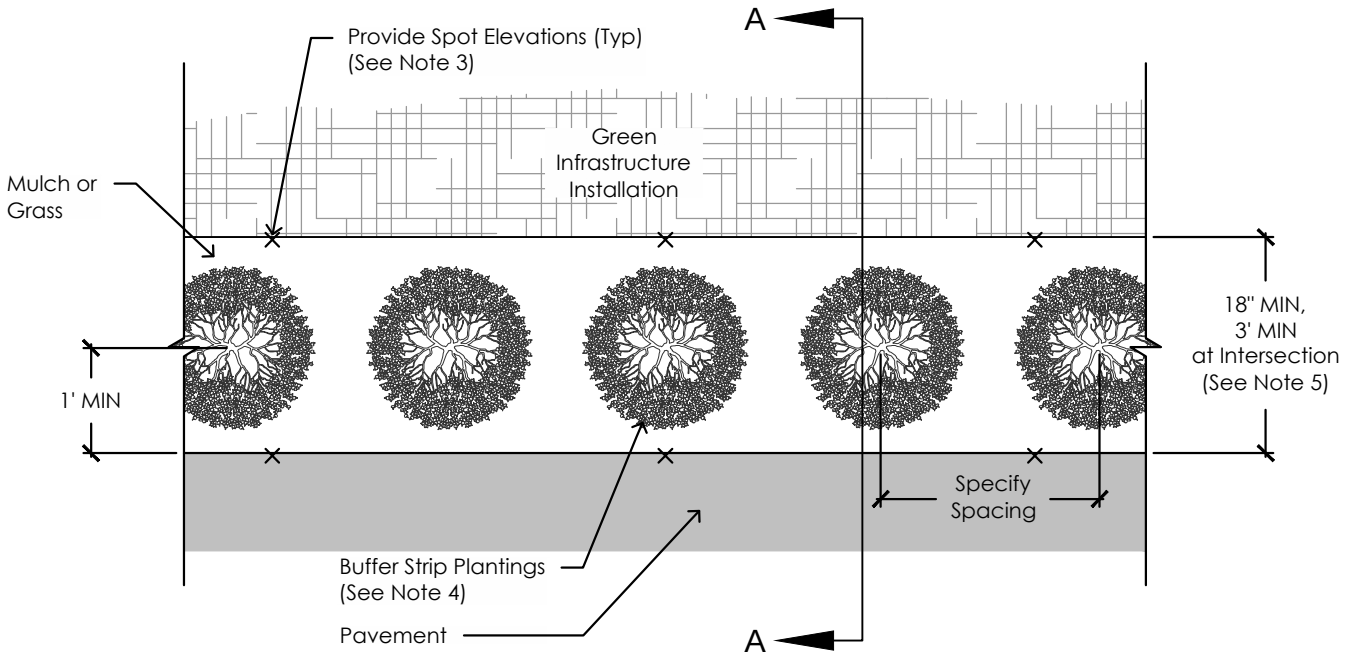
- ✓ Plan view of landscape buffer including grading, spot elevations, and plantings.
- ✓ Profile view of landscape buffer including GI depths and side slopes.
- ✓ Additional contractor submittal requirements outlined in SS 1600, as applicable.

Landscape buffer designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

Grass Buffer (Source: CDM Smith, Designed by Other)



SECTION A-A



PLAN

Notes

1. Landscape buffers shall be used in GI directly adjacent to driveway, or street pavement when GI has side slopes > 4:1 (H:V) or a > 6" drop from top of pavement to top of GI installation, and no other barrier is present (see DC 1.2).
2. Any excavation, embankment or grading shall conform to DPS CMSC 203 and linear grading to DPS CMSC 209.
3. Buffers adjacent to sidewalks shall have a preferred slope of 3.13% and a max slope of 4:1 (H:V) per STD DWG 2300.
4. Plant selection may vary (see DC 5.2). Landscape buffer strip shall be parallel to the longitudinal grade of the adjacent pavement. Non-frangible plantings, as defined by ODOT L&D Manual, Volume I Section 905.2, shall be placed per the requirements of ODOT L&D Manual, Volume I Figures 904-2 and 904-3 unless otherwise approved by the City.
5. When GI is applied adjacent to on street parking zones, a grass buffer may be required between back of curb or edge of pavement and the edge of the GI.

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DEPARTMENT OF PUBLIC UTILITIES

DC 1.4 Landscape Buffers
Planted Buffer Strip

March 2017

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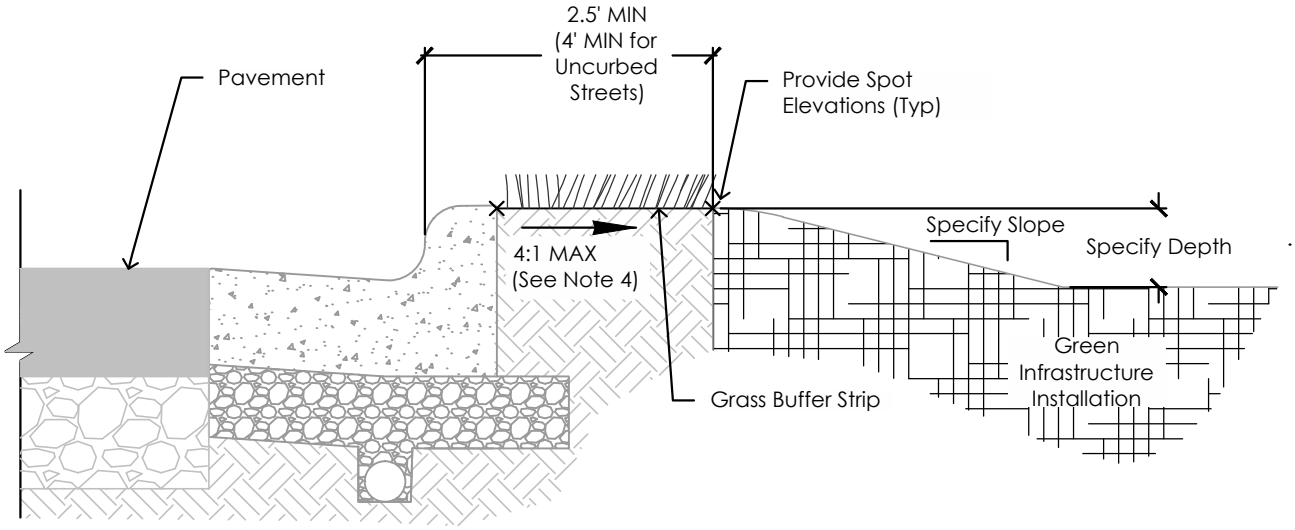
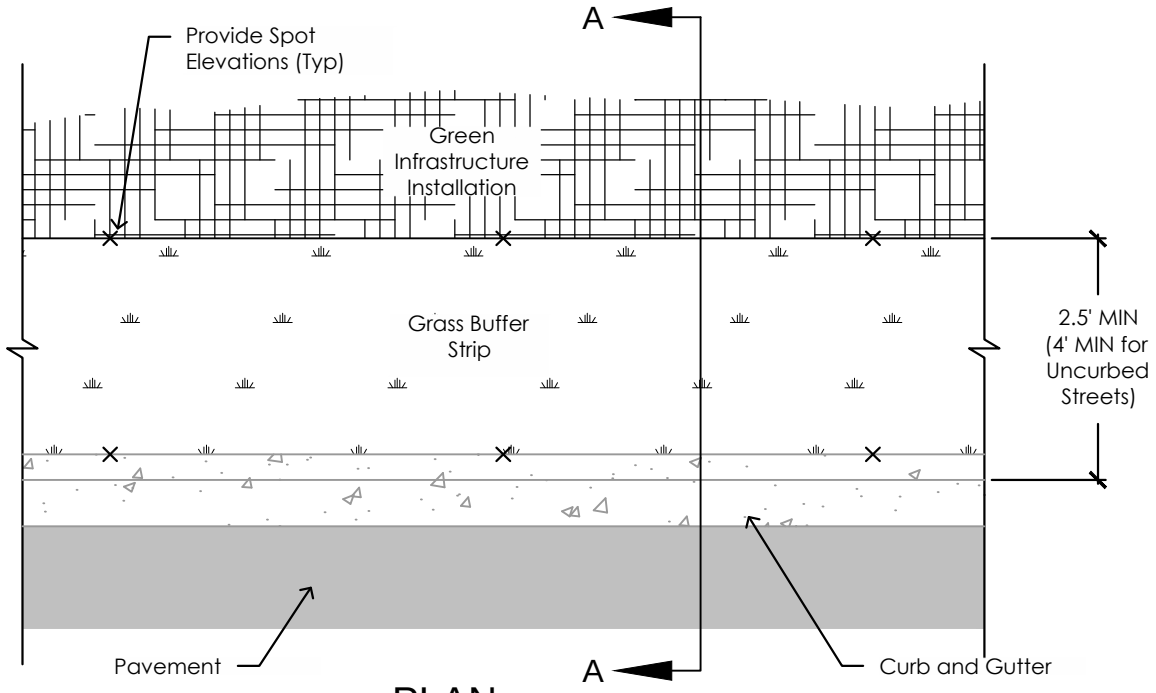


SECTION A-A



PLAN

Notes

1. Grass buffer strip is preferred when potential exists for on street parking.
2. Landscape buffers shall be used in GI directly adjacent to sidewalk, driveway, or street pavement when GI has side slopes > 4:1 (H:V) or a > 6" drop from top of pavement to top of GI installation, and no other barrier is present (see DC 1.2).
3. Any excavation, embankment or grading shall conform to DPS CMSC 203 and linear grading to DPS CMSC 209.
4. Buffers adjacent to sidewalks shall have a preferred slope of 3.13% and a max slope of 4:1 (H:V) per STD DWG 2300.
5. Buffer strip shall be parallel to the adjacent pavement grade.

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DC 1.4 Landscape Buffers
Grass Buffer Strip

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2—STORMWATER ENTRANCES

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DC 2.1—RETROFIT EXISTING STRUCTURES FOR STORMWATER INLET

DESCRIPTION: Retrofit of an existing storm structure includes any modifications made to allow stormwater runoff to enter a Green Infrastructure (GI) facility by directing flow from the existing inlet, catch basin or manhole to the GI system.

WHERE TO USE: An existing curb inlet, catch basin or manhole may be retrofitted in situations where the existing structure is in good condition and at a location adjacent to a GI System, or where specified by the City of Columbus Department of Public Utilities (DPU).

DESIGN CONSIDERATIONS:

- DPU shall provide preliminary determination that the condition and capacity of the inlet/catch basin/manhole is sufficient for GI facility connection.
- An assessment of existing conditions of the inlet, catch basin or manhole shall be conducted prior to a retrofit. Connections to structures of sub-standard condition will not be allowed, as determined by DPU. Consideration should be made to accommodate bypass of peak flows to prevent inundation of the GI. Confirm that stormwater runoff currently flowing through inlet will not interfere with operation of GI facility or discharge from the GI facility.

Retrofit Existing Storm Inlet (Source: CDM Smith)

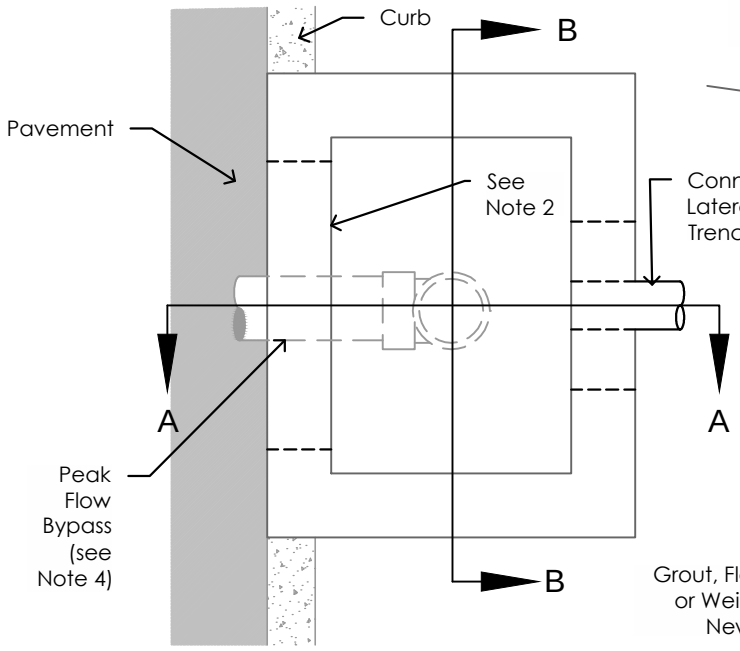
- All connection pipes shall be core-drilled. The connection pipe to the existing manhole shall be grouted and include a waterstop with HDPE installations.
- All materials and installation shall comply with requirements contained in the CMSC Section 604 and 901.
- DPU standard drawings (sewer) should be referenced for structure specific standard details.
- Retrofits of existing structures must not reduce the level of service of the existing conveyance system.
- Entrance velocities should be considered. Use of energy dissipation may be required. See DC 4.1 (Energy Dissipation).

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

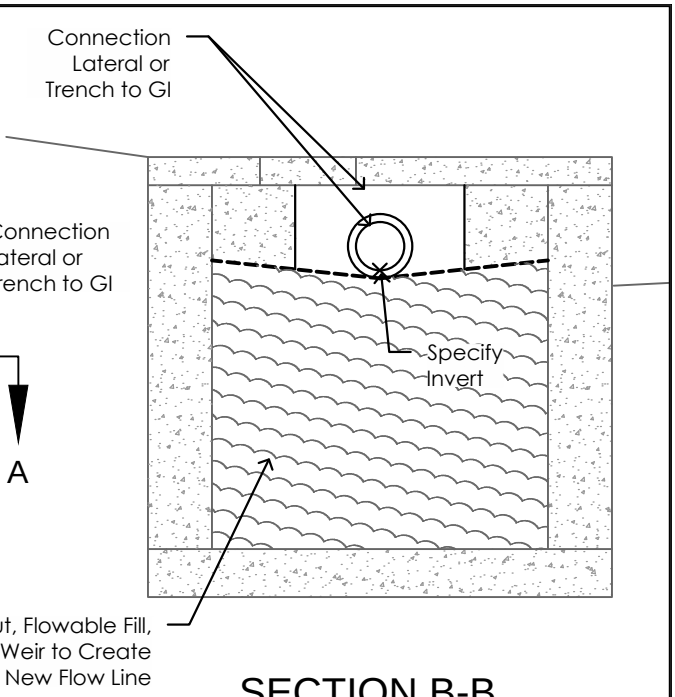
- ✓ Detail of existing inlet, catch basin, or manhole connection.
- ✓ Plan and cross-sectional view of retrofit, including key elevations for new pipe penetrations.
- ✓ Front end documents of the plan set shall require contractor to provide documentation of City of Columbus Utility Contractor License, as required in Director's Rule and Regulation No. 09-05 for retrofit work.
- ✓ Additional contractor submittal requirements outlined in SS 1600, CMSC 604, or 901, as applicable.

Retrofit of existing structure designs and specifications that are outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Utilities.

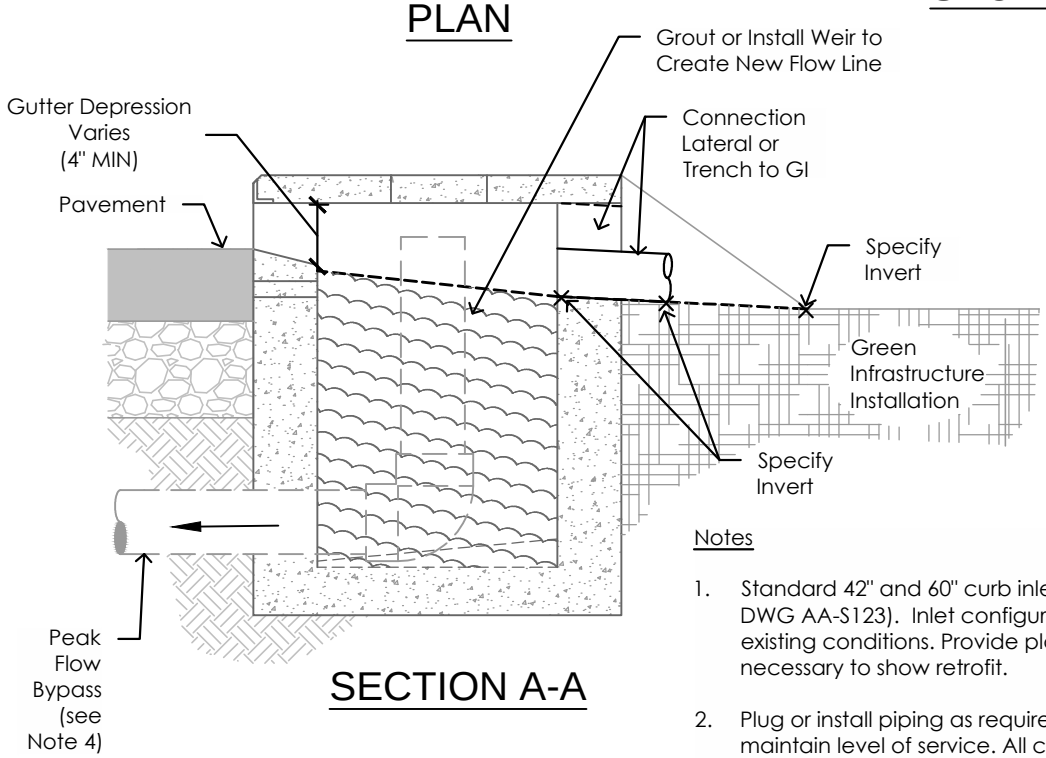
Retrofit Existing Storm Inlet (Source: CDM Smith, designed by others)



PLAN



SECTION B-B



SECTION A-A

Notes

1. Standard 42" and 60" curb inlets shown for reference (STD DWG AA-S123). Inlet configuration will vary based on existing conditions. Provide plan and section views as necessary to show retrofit.
2. Plug or install piping as required to route flow to GI and maintain level of service. All connection pipes must be core-drilled and grouted. HDPE installations shall include a waterstop.
3. Catch basins and manholes with inlet piping that is lower than the GI installation are not suitable for this configuration.
4. This detail may be altered to provide peak flow bypass, subject to approval by DPU.
5. Design for retrofited structures shall include provisions to maintain drainage from underdrains, if applicable.

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DEPARTMENT OF PUBLIC UTILITIES

DC 2.1 Retrofit Existing Structure

Stormwater Inlet

March 2017

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DC 2.2—AT GRADE INLETS

DESCRIPTION: At-grade inlets are used to direct the flow of runoff from a curb and gutter or pavement section into a Green Infrastructure (GI) facility. Types of at-grade inlets include curb openings, gutter aprons, and trench drains. A curb opening with vertical sides is cut into an existing curb to allow stormwater to enter a GI facility located directly behind the back of curb. A curb with a flared entrance is a curb poured with a tapered opening to allow stormwater to enter a GI facility. A gutter apron is a depressed gutter section in front of a GI entrance to increase stormwater capture. A trench drain is a shallow concrete or metal frame trench with a grate to allow stormwater to enter a GI facility. It is recommended that at-grade inlets be coupled with an energy dissipation component or pretreatment to remove coarse materials that could result in scour or clogging of the GI.

WHERE TO USE: At-grade inlets should be used in applications where it is necessary to convey stormwater from the street to the surface of a GI facility, or when specified by the City of Columbus Department of Public Utilities (DPU). In such instances where it is required to convey or intercept stormwater across a path of travel, such as a sidewalk, a trench drain system shall be installed. Special conditions should be considered if at-grade inlets are to be used on cobble or rough brick roads without a concrete curb.

Curb Cut Inlet (Source:CDM Smith, designed by others)

DESIGN CONSIDERATIONS:

- Curb cuts must be saw-cut such that all edges are cut either square or angled and clean. All exposed edges must be beveled and debris must be removed. The horizontal surface of the curb cut must have a positive slope from the gutter to the GI facility.
- Curb cuts shall conform to CMSC Section 202.05 – Pavement, Walks, Steps, Gutters, Curbs, or Traffic Dividers Removed.
- Curbs with side flares shall follow CMSC Section 609.04 – Cast-in-place Concrete Curb and Combination Curb and Gutter.
- Curb cuts that are installed on the street side of a GI facility shall use a wheel guard to prevent the unintentional movement of the vehicle into the curb cut.
- Gutter apron cross slope will be governed by stormwater capture requirements and design entrance velocities. Max slope of apron parallel to curb is 8% per DPU Standard Drawing AA-S125A.

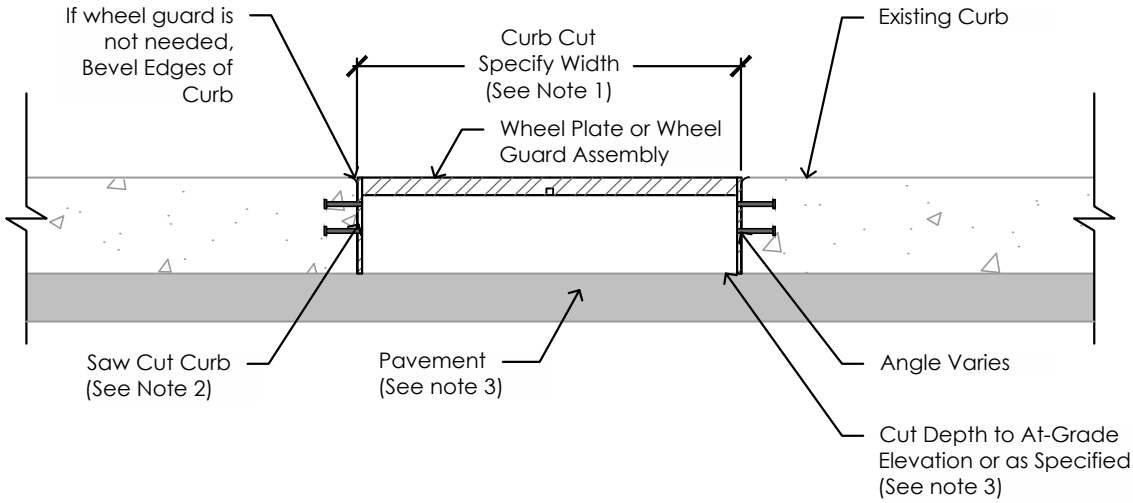
Depressed Curb Inlet (Source: CDM Smith, designed by others)

- Trench drain grate size, shape, material, and specifications will vary by manufacturer or design. Grates used shall be in accordance with manufacturer instructions and shall be designed for typical travel loading (pedestrian or vehicular). If located in a location subject to vehicular travel, the design of the trench drain and grate/cover shall comply with AASHTO H-20.
- Trench drains shall be heavy duty with bolted grate or solid cover. All bolts shall be stainless or galvanized steel or as recommended by manufacturer. Gray or ductile iron castings shall conform to CMSC 711.
- Grates located in walking surfaces shall be solid. Grates not within walking surfaces shall have spaces no greater than ½ inch wide in one direction per ADA standards. Elongated openings should be oriented so that the long dimension is perpendicular to the dominant direction of travel.
- All concrete used for trench drains shall be CMSC Item 499 or 511, Class C Concrete per the City of Columbus Division of Design and Construction specifications.
- Entrance velocities should be considered. Use of energy dissipation may be required. See DC 4.1 (Energy Dissipation).

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

- ✓ Plan and detail view of curb opening including curb elevations, opening size, and base materials with specified depths.
- ✓ Plan and section views of gutter apron including spot elevations, longitudinal, and cross slopes of gutter. Material depths should also be specified.
- ✓ Plan, section, and detail view of trench drains including details for bolt-down connection of trench cover or assembly, spot elevations of trench, and any dimensions/offsets.
- ✓ Manufacturer details including product number, materials, painting specifications, and fastener and frame details.
- ✓ Additional contractor submittal requirements outlined in SS 1600, CMSC 202, 499, 511, 609, or 711, as applicable.

At grade inlet designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.



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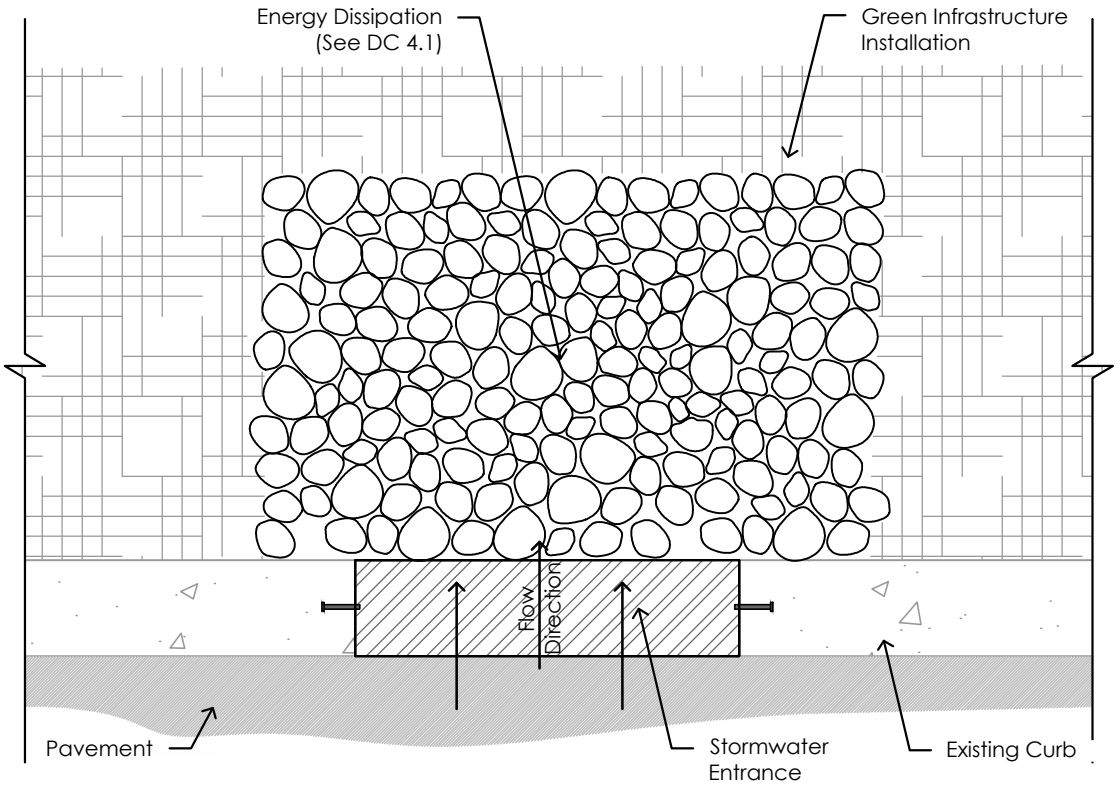

PLAN

Notes

1. A curb cut is a cut in an existing curb. Width and angle of curb cut varies based on site and stormwater capture requirements.
2. Curb cuts must be saw-cut such that all edges are square and edges beveled.
3. Horizontal surface must have positive slope toward GI installation.
4. Curb cuts shall conform to CMSC 202.05 - Pavement, walks, steps, gutters, curbs, or traffic dividers removed.
5. Curb cuts on the street side of a GI facility shall use a wheel plate or wheel guard assembly to prevent the unintentional movement of the vehicle into the curb cut.

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DEPARTMENT OF PUBLIC UTILITIES

DC 2.2 At Grade Inlets
Curb Cut

March 2017

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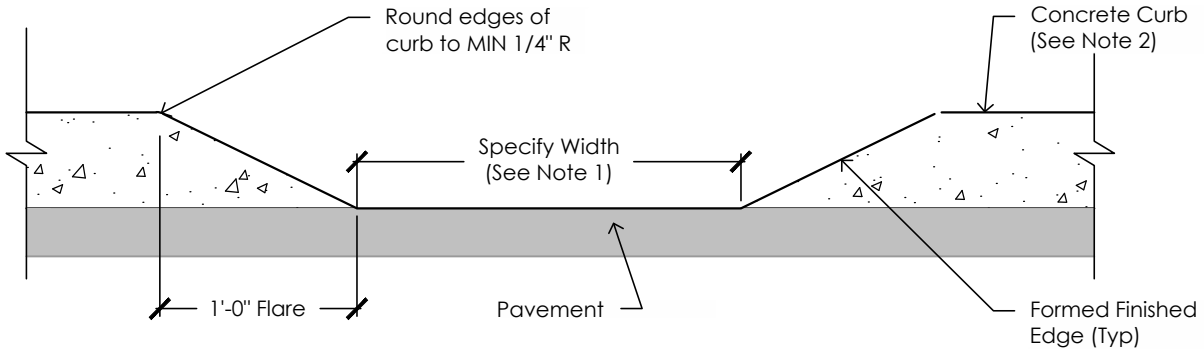
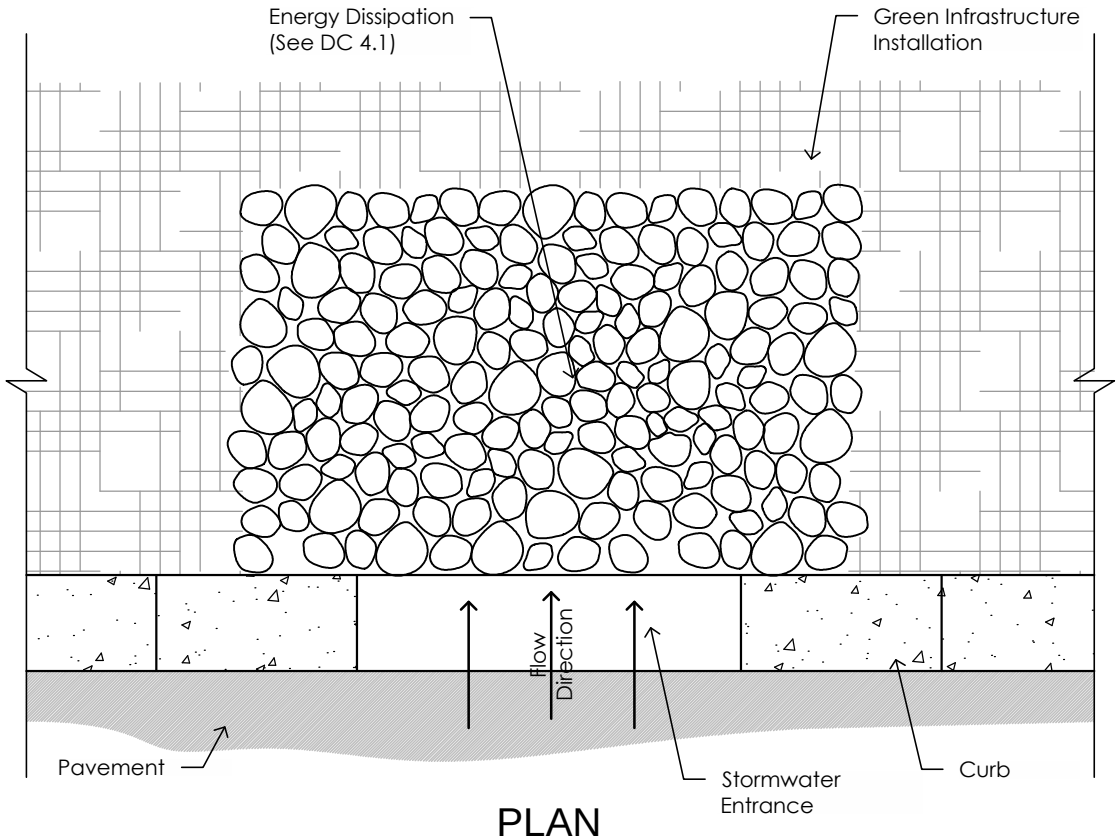


ELEVATION



PLAN

Notes

1. A flared curb is a curb poured in-place with a tapered opening. Width and angle of curb cut vary based on site and stormwater capture requirements.
2. Concrete curb shall be P.C. Concrete Class "C". All exposed surfaces shall have a brushed finish.
3. Flared curb shall transition to typical curb section per STD DWG 2000, 2010, or 2020.
4. Flared curb shall follow CMSC Section 609.04 - Cast in-place concrete curb and combination curb and gutter.

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DEPARTMENT OF PUBLIC UTILITIES

DC 2.2 At Grade Inlets

Flared Curb Entrance

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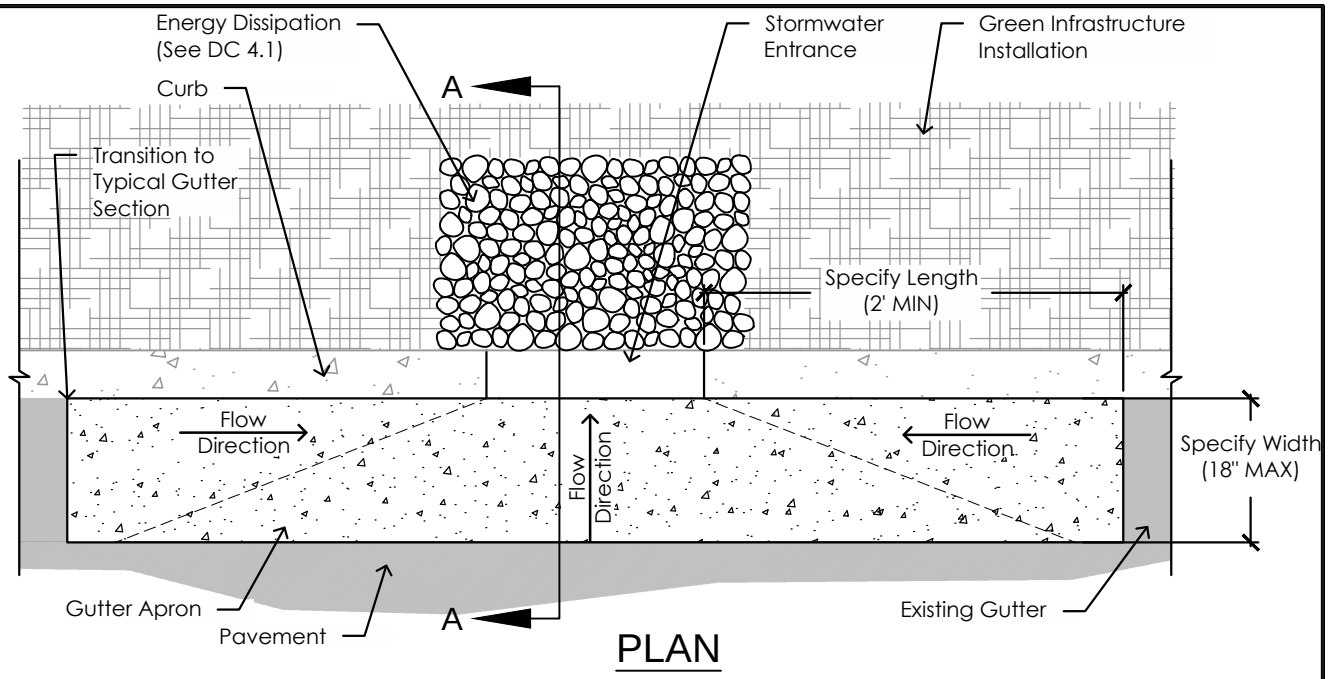

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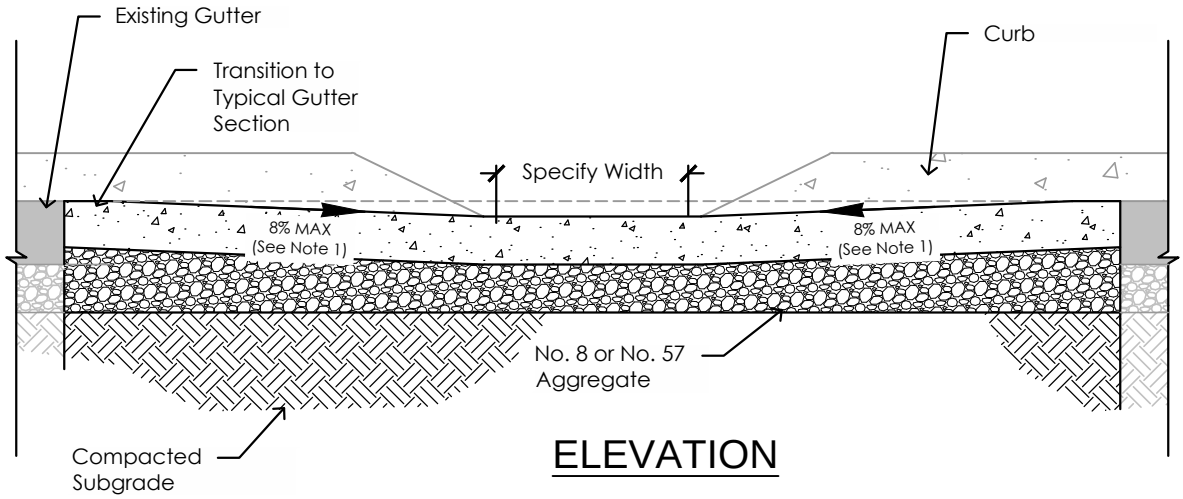

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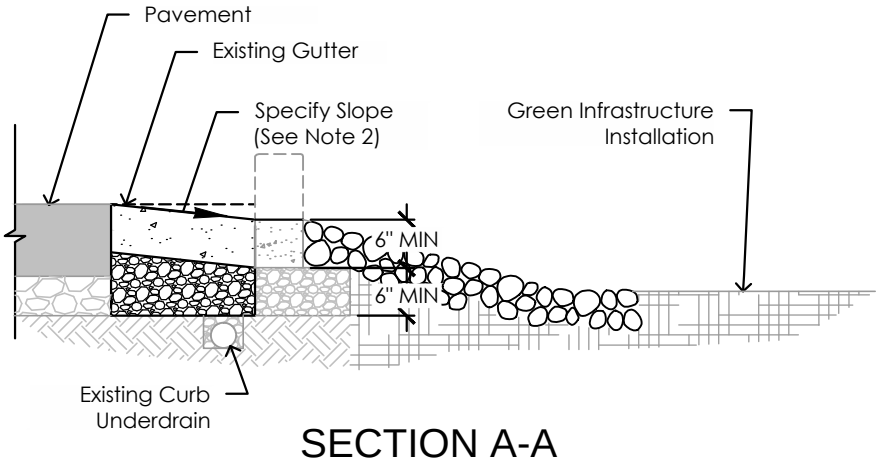

SECTION A-A

Notes

1. Max Slope of apron parallel to the curb is 8% per STD DWG AA-S125A.
2. Gutter apron cross slope will be governed by stormwater capture requirements and entrance velocities.
3. Concrete shall be Class C per CMSC Item 499.

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DC 2.2 At Grade Inlets
Gutter Apron

March 2017

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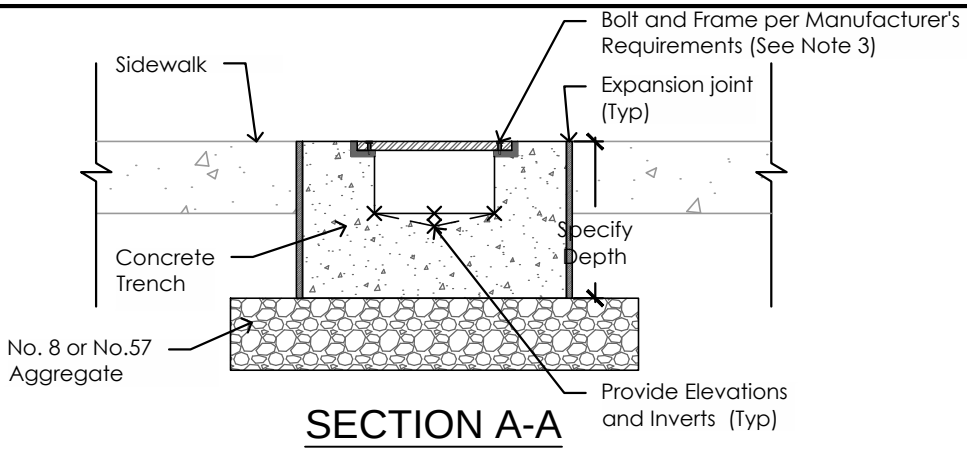
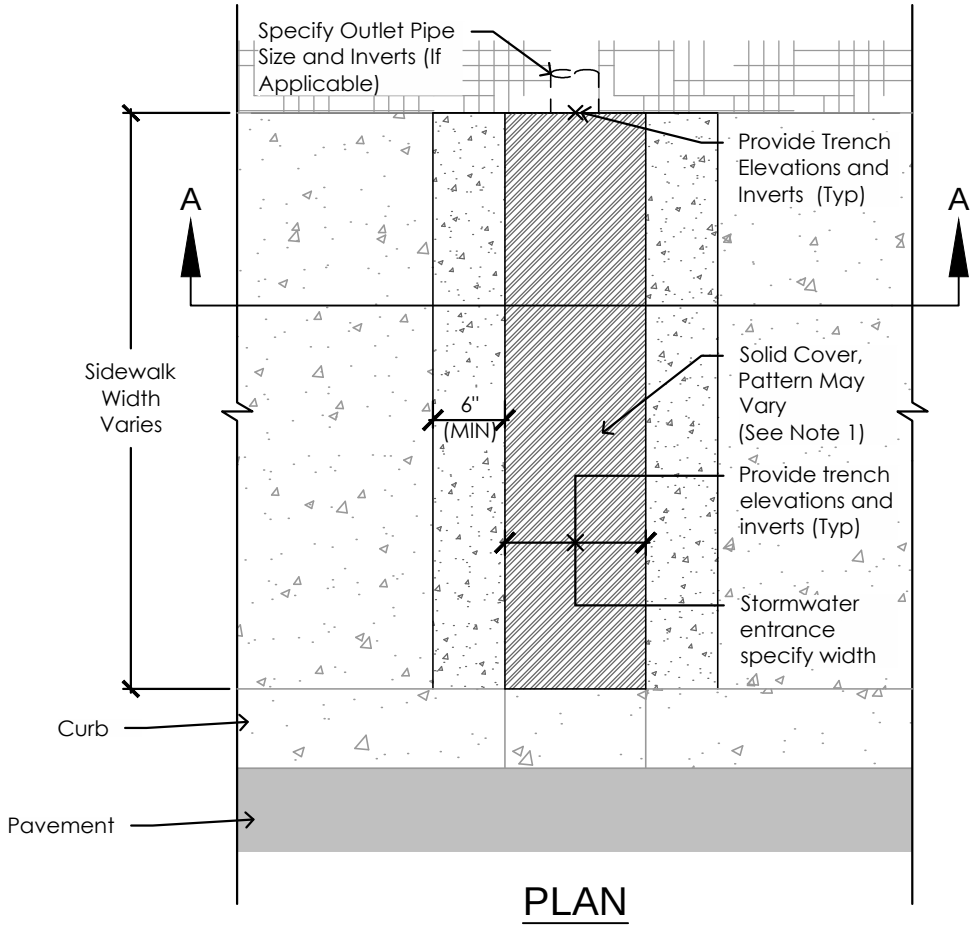


SECTION A-A



PLAN

Notes

1. Grates located in walking surfaces shall be solid. Grates not within walking surfaces shall have openings no greater than 1/2" wide in one direction.
2. If trench cover assembly includes metal frame and channel, install per manufacturer instructions.
3. Cross slope and longitudinal slope of trench channel bottom may vary by design.
4. Bolt down cover/grate and frame is required. All bolts shall be flush with existing grade of the sidewalk.
5. All concrete shall be CMSC Item 499o r 511 Class C concrete per City of Columbus specifications.
6. Trench and cover/grate must be capable of withstanding expected loading required by DPS. If located in a location subject to vehicular travel, the design of the trench and cover/grate shall comply with AASHTO H-20.

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DC 2.2 At Grade Inlets
Trench Channel and Cover/Drain

March 2017

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DC 2.3—ENTRANCE PROTECTION

DESCRIPTION: Entrance protection includes measures to protect at-grade inlets from damage caused by vehicles. Such measures include wheel guard plates or assemblies. Wheel guard assemblies are a pre-cast concrete or steel box that allows water to pass through while providing protection to the entrance.

WHERE TO USE: Entrance protection should be used in areas along concrete curb and gutters where at-grade inlets are used and parking is common along the curb, on high traffic streets, or where specified by the City of Columbus.

DESIGN CONSIDERATIONS:

- Wheel guard plates shall be structural steel plate conforming to ASTM A 709, Grade 50 and meeting the requirements of CMSC 711. Thickness should be designed to withstand the expected loading required by the DPS for a concrete curb, whether from vehicular or pedestrian load.
- Metal wheel guard plates shall be fastened to the concrete curb using concrete anchors that meet the requirements of ASTM A 108. Provide a minimum of two anchors on each side of curb opening to anchor plate to concrete curb.
- Metal wheel guard assemblies shall be per the City of Columbus standard drawing.
- All metal materials shall be hot-dip galvanized in accordance with CMSC 711 and ASTM A 123.

Entrance Protection (Photo Source: CDM Smith, Designed by Others

- Entrance velocities should be considered. Use of energy dissipation may be required. See DC 4.1 (Energy Dissipation).

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Plan/section view of wheel guard including dimensions of plate or assembly.

✓ Endplate and anchor details including dimensions (if applicable), materials, manufacturer, and product number, as applicable.

✓ Additional contractor submittal requirements outlined in SS 1600 or CMSC 711, as applicable.

Entrance protection designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

DC 2.4—DOWNSPOUT CONNECTIONS

DESCRIPTION: Many buildings, especially in commercial districts, have existing buried downspout connections that currently discharge to the curb line or curb and gutter underdrain. These are likely to be intercepted by the GI facility and will need to be reconfigured to route stormwater into the GI facility. Downspout connections may be configured to connect to a perforated pipe below the surface of the GI or to discharge at or above the surface grade of the GI using a piped outfall. Most building downspouts are private pipes, therefore modifications will require coordination with the affected property owner.

WHERE TO USE: Downspout connections can be used anytime it is desired to divert flow to a GI facility from the existing downspout that is discharging to the street or the curb and gutter underdrain. When the existing downspout is shallow enough to discharge at or above the GI surface, flow should be diverted by cutting the existing downspout and re-directing it with pipe fittings, as necessary. When the existing downspout elevation is lower than the proposed GI surface grade, the existing downspout piping should be repaced through the GI facility with new solid downspout piping and bedding. Any downspout connection to the existing sanitary sewer system or roadway underdrain shall be eliminated.

DESIGN CONSIDERATIONS:

Downspout Connection (Source:CDM Smith, designed by others)

- For downspout piping discharging directly to the GI without use of pipe fittings, cut the existing downspout pipe parallel to adjacent grade. Edges shall be deburred and beveled. Install drain grate at downspout outfall to prevent clogging with GI surface material or migrated sediment from stormwater runoff.
- Pipe installation and fittings shall conform to Standard Drawing 2320, CMSC 901 and 915 as well as ASTM F1336.
- Replace curb to nearest joint when downspout piping is disconnected from the curb line. Cap or fill existing downspout connection behind the curb line when discharging to a curb and gutter underdrain.
- Pop-up emitters may be used as an alternative to below grade distribution piping. Design and manufacturer must be approved by the City of Columbus on a case-by-case basis.
- Entrance velocities from downspout connections should be considered. Use of energy dissipation may be required. See DC 4.1 (Energy Dissipation).

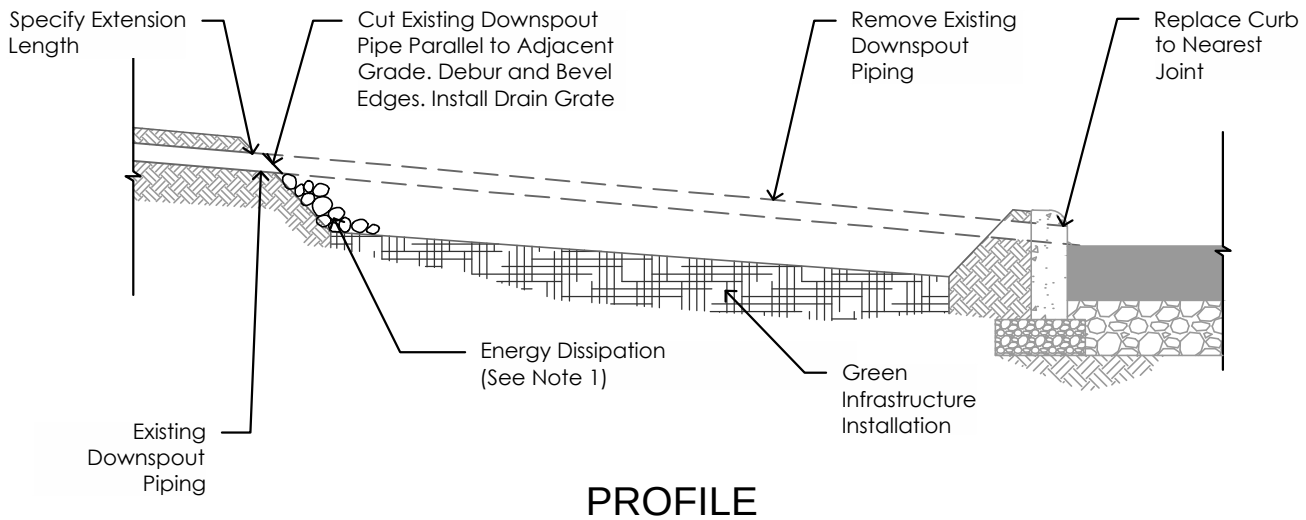
DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Section view of downspout connection specifying pipe invert or depth of pop-up drainage emitter and connection to existing pipe.

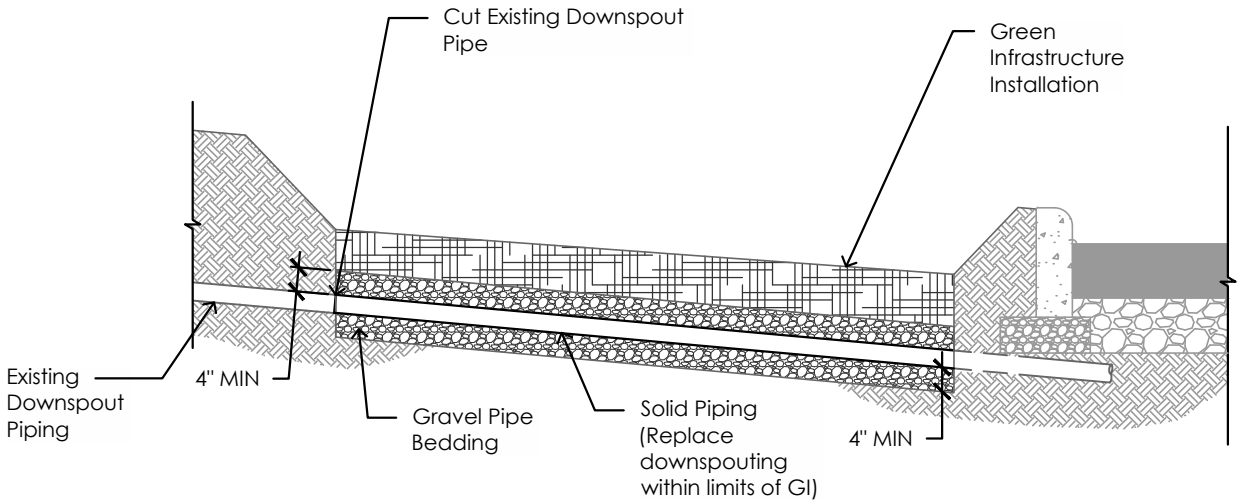
✓ Specify all pipe, fitting material, valves and other appurtenances.

- ✓ Additional contractor submittal requirements outlined in SS 1600, CMSC 703, 720, 901, or 915, as applicable.

Downspout connection designs and specifications outside the parameters of this guideline shall be submitted for review and approval to DPU.



PROFILE
Discharge At Grade



PROFILE
Discharge Below Grade

Notes

1. If entrance velocities from the downspout are expected to exceed the max allowable entrance velocities for the GI surface media, energy dissipation is required (See DC 4.1). Downspout outlet may also be lowered to discharge to surface grade of GI utilizing pipe fittings and a drain grate.
2. Pipe installation and fittings shall conform to ASTM F1336 as well as CMSC 901 and 915.
3. Direct downspout connections to the existing storm sewer shall only be installed if approved by the City of Columbus. Downspout connections to the existing sanitary sewer or roadway underdrain are not permitted by the City of Columbus.

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DC 2.4 Downspout Connections

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3—PERMEABLE SURFACES (RESERVED)

***SPECIFICATIONS FOR PERMEABLE SURFACES ARE CURRENTLY UNDER DEVELOPMENT BY THE CITY OF COLUMBUS.**

4—ENERGY DISSIPATION

4.1—SPLASH PADS

DC 4.1—SPLASH PADS

DESCRIPTION: Energy dissipation is used to reduce velocities and disperse flow of stormwater entering a Green Infrastructure (GI) facility, preventing erosion and scouring of surface materials. Energy dissipation methods include splash pads with rock or brick that may be embedded in concrete at the entrance of the GI facility.

Splash Pad (Source: CDM Smith, designed by others)

WHERE TO USE: Energy dissipation shall be required in instances where concentrated stormwater flows enter a GI facility and may cause erosion of planting media within the GI. This is applicable in GI with surface layers containing soil, mulch, vegetation, or other materials with the potential for erosion.

These devices tend to slow the flow of the stormwater to a velocity that allows for coarser materials to settle, allowing for both energy dissipation and pretreatment of the stormwater. Accessibility and ease of cleaning of these GI devices must be considered to prevent the coarse sediment and other debris from clogging inlets to the GI facility.

For sheet flows with velocities less than 2.5 ft/s, landscape buffers may be used for energy dissipation. See DC 1.4 (Landscape Buffers) for more information. See the table below for allowable entrance velocities per surface material. Concrete should be considered for situations in which the entrance velocity exceeds 6.0 ft/s.

GI Surface Material	Allowable Maximum Entrance Velocity (ft/s)
Sand	2.0
Silt	3.5
Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay	5.0
Graded Loam or Silt to Cobbles	5.0
Coarse Gravel	6.0
Seed Mixtures/Grasses	2.5

Information applied from Columbus SWDM Table 2-17 Maximum Velocities for Channel Lining Materials

DESIGN CONSIDERATIONS:

General

- Widths and lengths of energy dissipation will vary based on type and size of inlet used and velocity of stormwater entering the GI facility. The energy dissipation method shall extend, minimally, the full width of the concentrated flow.
- All concrete to be used shall be mixed, placed and tested in conformance to CMSC 499 – Concrete - General.

- A minimum 3 inches of freeboard between the top of the energy dissipation material and the inlet grade elevation should be provided to allow for sediment accumulation between maintenance events.
- Aggregate used shall conform to requirements of CMSC 703 – Aggregate.
- Splash pads not embedded in concrete shall have surface material conforming to CMSC 601 for slope and channel protection. Loose surface stone may be local washed gravel or river rock that is well graded with the stone sizing ranging between 1 inch and 4 inches, or shall conform to CMSC 703.18 with the exception of RPCC. Splash pad stones that are not embedded in concrete should be surrounded with permanent edging, such as concrete or anchored angle irons, to prevent the materials from migrating into the planting area of the Green Infrastructure.

Energy Dissipation (Source: CDM Smith)

- For brick splash pads, a variation of 4-inch x 2.5-inch x 8-inch and 4-inch x 2.5-inch x 4-inch bricks standing vertically on the 4-inch end shall be placed on a ½-inch thick mortar setting bed. Brick material used shall conform to CMSC 704 – Masonry Units.

Splash Pad Embedded in Concrete

- A 4-inch to 6-inch bedding layer of No. 57 stone with non-woven geotextile fabric on the bottom shall be placed beneath the concrete embedment layer.
- Concrete embedment shall be a minimum of 8 inches thick (min. 4 inches for brick splash pad). Stone splash pad concrete embedment layer shall include welded wire mesh placed in the bottom third of the concrete pad and a 4-inch thick minimum strip of concrete free of stone shall be maintained on all outer sides of the splash pad.
- For stone splash pads embedded in concrete, a 4-inch to 6-inch diameter stone free of jagged edges shall be set into the concrete pad following initial curing of the concrete. Spacing between stones should not exceed 3 inches. Top of stones shall be flush with invert opening.

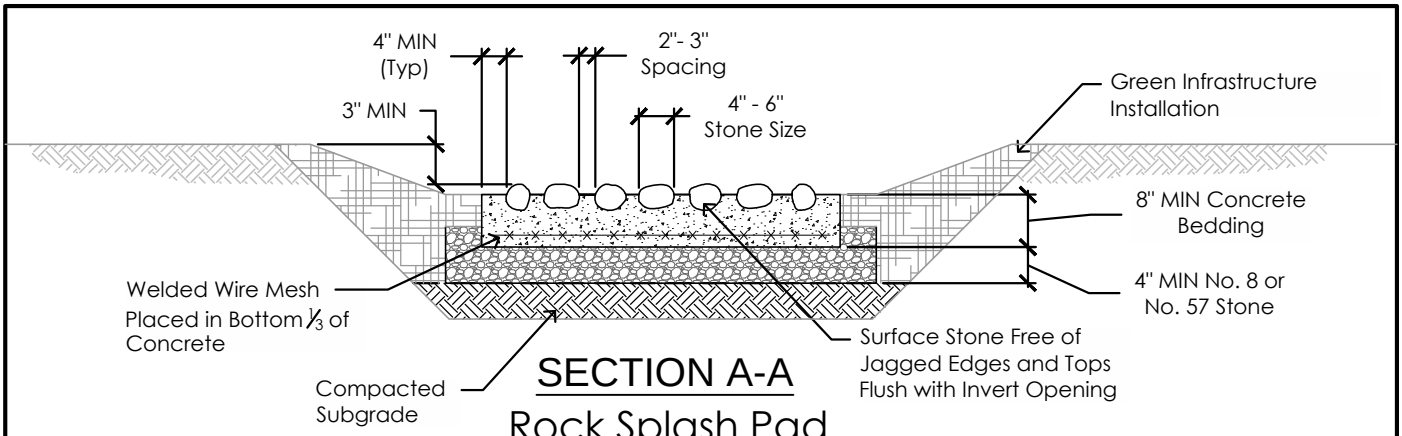
DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Samples of all rock or brick to be used, for approval by the City of Columbus.

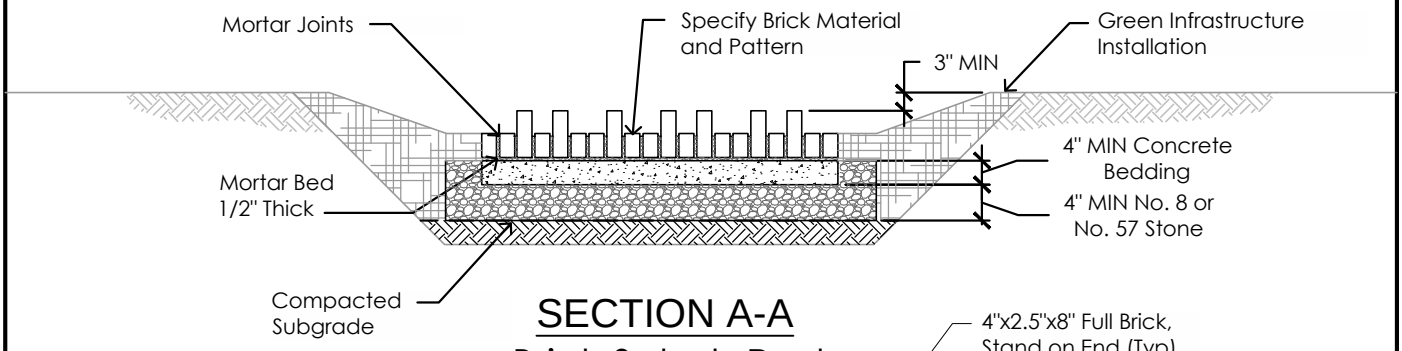
✓ Typical detail of splash pad installation, including definition of placement, length, width, materials, and cross section.

✓ Additional contractor submittal requirements outlined in SS 1600, CMSC 499, 601, 703, and 704, as applicable.

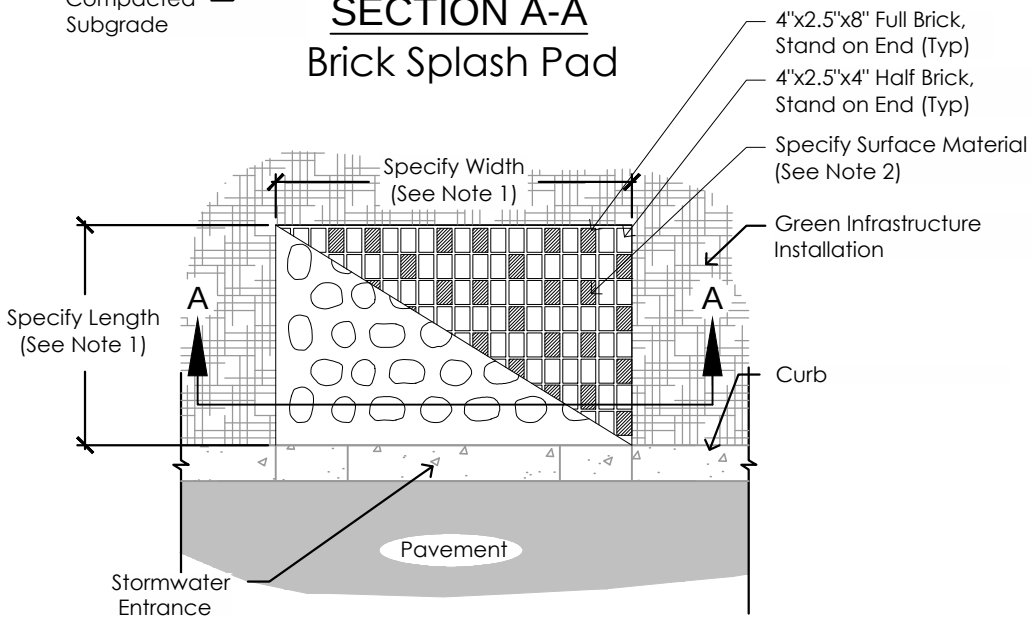
Splash pad designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.



SECTION A-A
Rock Splash Pad Embedded in Concrete



SECTION A-A
Brick Splash Pad



PLAN

Notes

1. Dimensions of splash pad are dependent on inlet size and type used, and the velocity of stormwater entering the GI. Width of splash pad should be equal to or greater than total stormwater entrance width.

2. Surface material of splash pad may vary by design. When surface material is not embedded in concrete as shown on this detail, rock must conform to CMSC 703.18 in accordance with CMSC 601 with the exception of recycled materials.

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DC 4.1 Energy Dissipation
Splash Pad

March 2017

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5—LANDSCAPING

5.1—TREE PROTECTION

5.2—PLANTING PALETTE OPTIONS

DC 5.1—TREE PROTECTION

DESCRIPTION: Tree protection is required to prevent damage to existing trees that are to remain after construction. The preservation of existing trees can aid in mitigating the effect of stormwater runoff through the capture of rainwater within foliage and transpiration into the atmosphere. Public trees will be protected from construction and excavation activities when possible.

WHERE TO USE: Tree protection shall be required for all construction projects on City property or in City ROW that include a scope of work funded solely with public dollars, per City of Columbus Executive Order 2015-01. Tree protection should be applied on all construction projects where construction activity will occur within the drip line or a circular Critical Root Zone (CRZ) around the tree. The CRZ equals 1 foot of radius for each 1 inch of Diameter Breast Height (DBH). DBH is measured 4.5 feet above the ground. Construction activity may be either typical roadway and utility improvements or incorporation of existing trees within proposed Green Infrastructure (GI). CRZ restrictions shall apply to trees of 6 inch DBH and greater, though an effort should also be made to preserve smaller trees when possible. Consider relocation or removal and replacement of trees less than 6-inches DBH if in conflict with proposed GI.

DESIGN CONSIDERATIONS:

Re-Use Existing Trees in GI (Source: CDM Smith, Designed by Others)

- Consult SS 1603 Tree and Vegetation Protection for Green Infrastructure Projects for detailed specifications.
- Conduct an on-site pre-design meeting with representatives of the City Department of Recreation and Parks, Urban Forestry Section to determine suitability of using specific trees within or near GI. Evaluate tree condition, proximity to and within the GI, tolerance for flooding and pruning requirements. Discuss appropriate protective measures for trees where construction activities may encroach the CRZ.
- Provide adequate sub-drainage if incorporating existing trees into GI. Do not allow water to pond in the CRZ for greater than 48 hours. All trees, tree roots, limbs and other vegetation shall be protected unless designated otherwise by the City of Columbus and the Design Professional. The most recent edition of the "American National Standards Institute" (ASI) A300 standards should be followed for tree care practices. Any work involving tree care shall be supervised by an "International Society of Arboriculture" (ISA) certified arborist.
- Do not allow heavy equipment to compact the soil over the CRZ of existing trees. Consider how equipment or construction activity will impact existing trees per SS 1601.
- Where grade change is required within the CRZ, a sufficient residual root zone to provide for the good health of the trees shall remain undisturbed and protected. Use either a tree well or retaining wall for protection if the grade is to be raised or lowered per CMSC 657.
- Construction materials, excavation debris, chemicals, fuel, equipment or vehicles are not to be stockpiled, stored, dumped or parked within the dripline of public trees.

- If tree protection or avoidance is not practical, removed public trees must be replaced in accordance with the City of Columbus Tree Protection and Mitigation Policy, as outlined in Attachment C of Executive Order 2015-01.
    - Replacement trees will have a trunk diameter of at least 2.5-inches in diameter, measured 4 feet up from the base of the tree. Trees must be replaced on a ratio based on the removed tree diameter. This replacement ratio is summarized in the table below.

Existing Tree Removed Diameter	Replacement Ratio
≤ 12”	1:1
> 12 – 18”	2:1
> 18 – 24”	3:1
> 24 – 30”	4:1
> 30”	5:1

    - Tree replacement should occur on the project site, if practical. If not practical, replacement trees may be located on other City-owned properties, or a fee may be paid to the Division of Recreation and Parks to support efforts to increase tree canopy in the City. The fees for tree replacement shall be in accordance with Attachment D of Executive Order 2015-01.
    - Replacement trees shall be in accordance with the List of Approved Tree Species for Replacement, per Attachment E of Executive Order 2015-01.

Tree Protection (Source: CDM Smith)

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Tree protection details on plans.

✓ Tree survey including location, DBH, species, condition of trees and suitability for use in GI if applicable.

✓ Show trees symbols at CRZ size on all plan sheets where trees are shown.

✓ If encroaching the CRZ, provide documentation of meeting with representative of City Department of Recreation and Parks, Urban Forestry Section including agreed upon reduction of CRZ and other protective measures if applicable.

✓ Tree replacement plan, if applicable, showing size and location of tree being removed as well as size and location of replacement trees.

✓ Contractor submittal requirements per SS 1603 Tree and Vegetation Protection for Green Infrastructure Projects.

✓ Additional contractor submittal requirements outlined in SS 1600 and CMSC 657, as applicable.

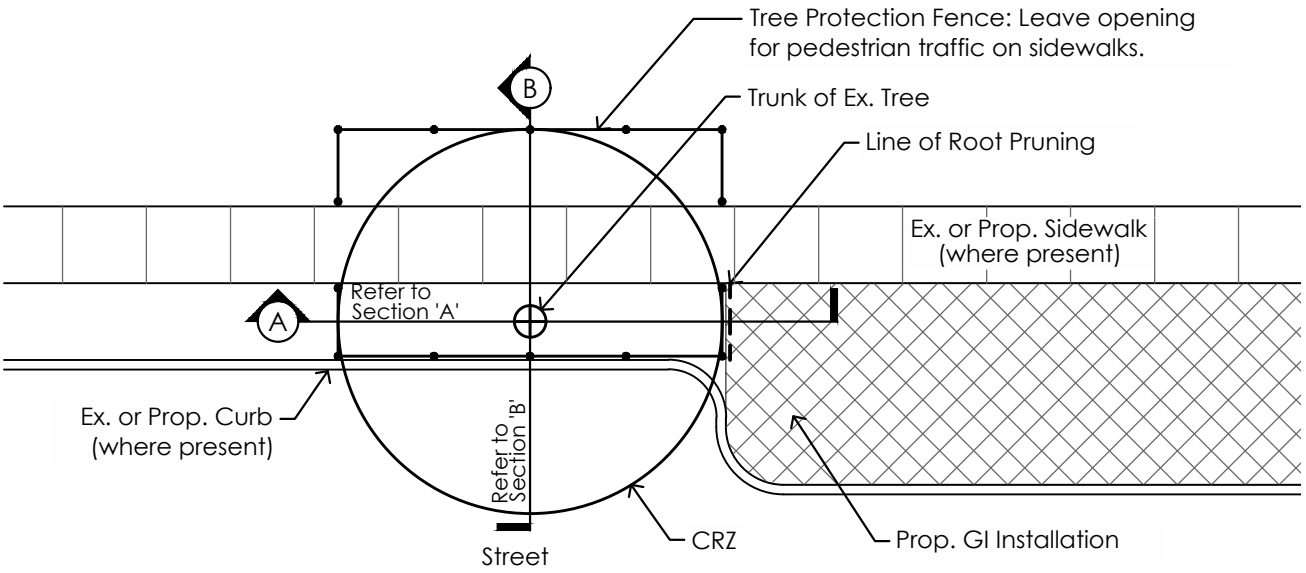
Tree protection designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

ABREVIATIONS

CRZ	Critical Root Zone. Circular area around a tree equal to 1 foot of radius for each 1 inch of DBH or the limit of the tree canopy whichever is greater.
DBH	Diameter Breat Height. The trunk diameter measured 4.5 feet above the ground at the trunk.
GI	Green Infrastructure
ISA	International Society of Arboriculture

NOTES

1. This detail describes the common situation of protecting an existing tree located in a tree lawn. Other situations may exist. Requirements regarding establishment of the CRZ, location of fence, pruning and excavation apply to all trees to be protected.
2. Existing trees to remain shall be protected against unnecessary cutting; breaking or skinning of roots; skinning and bruising of bark; smothering by stockpiling of construction materials or excavated materials; excess foot or vehicular traffic or parking of vehicles within the CRZ.
3. Excavation is not allowed within the established CRZ.
4. Trees to remain shall be protected with a fence. Place fence at limits of CRZ or dripline, as indicated on plan. Fencing shall remain in place and be secured in an upright position during the entire construction period.
5. Wood fence posts shall be 2"x4"x6' long spaced 12' maximum. Install posts a minimum 2' in depth. Provide a "x4" wood stringer along the top of the protection enclosure. Stringers shall be secured to the wood posts.
6. Fence fabric shall be orange nylon or polpropylene.
7. Metal chain link fencing is also acceptable with posts diameters of 2 $\frac{1}{2}$"x6' long. Chain link fence fabric shall be 4' height.
8. Prune roots flush with the edge of the CRZ by cleanly cutting all roots over 1 inch to the depth of the required excavation. Beyond the line of root pruning expose roots with a hydro-vacuum or air-spade to the depth of the required excavation. Cleanly cut roots as close to excavation as possible.
9. Cut roots with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not use a backhoe or other equipment that rips, tears, or pulls roots. Do not paint cut root ends.
10. Cover exposed roots with burlap and water regularly during construction. Cover exposed roots with soil as soon as possible.
11. Prune branches of trees to compensate for root loss caused by damaging or cutting root system or where construction equipment may damage lower branches. Do not remove more than 1/4 of the live foliage or branches. Prune trees according to ANSI A300 (Part 1). Cut branches with sharp pruning instruments; do not break or chop. Do not apply pruning paint to wounds. All pruning shall be performed by an ISA certified arborist.
12. Fertilize trees prior to root pruning. Application rate, method and analysis shall be determined by an ISA certified arborist.
13. Any tree damaged during construction not identified for removal shall be replaced at the Contractor's expense per Executive Order 2015-01.



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DC 5.1 Tree Protection

Plan View

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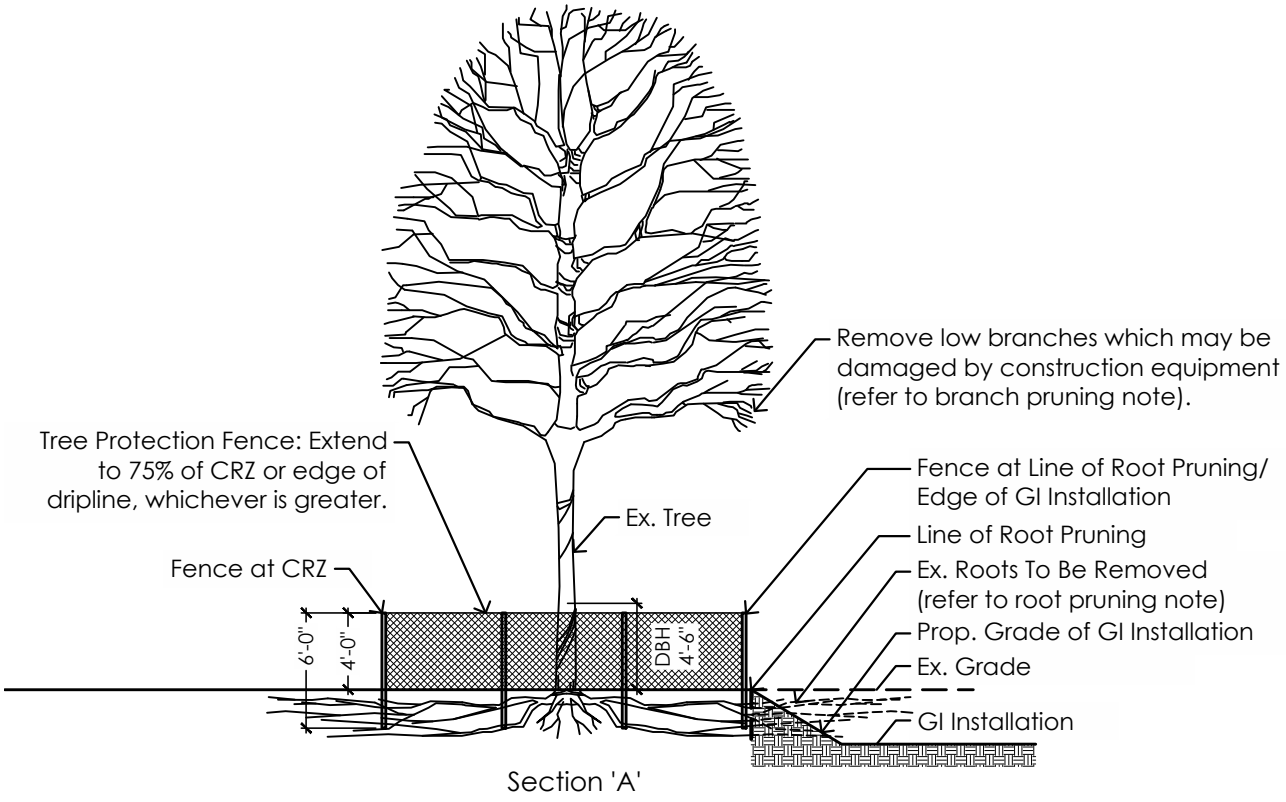
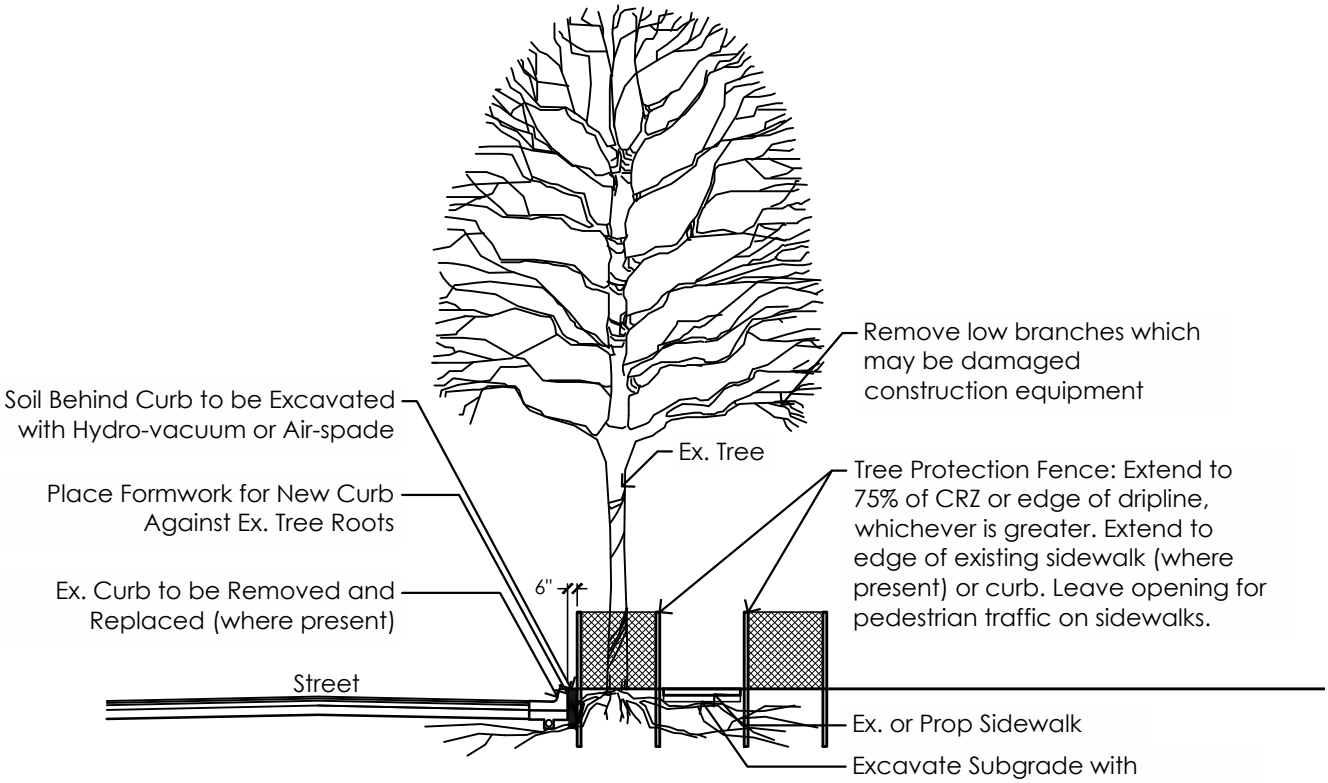


Section 'A'



Section 'B'

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N.T.S

DC 5.1 Tree Protection
Sections

March 2017

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DC 5.2—PLANTING PALETTES

DESCRIPTION: The selection of plants for green infrastructure is critical to the successful performance and aesthetics of the facility. The recommended plants have been selected for use in roadside bioretention basins and rain gardens in the central Ohio region.

WHERE TO USE: These plants are recommended for use in bioretention basins and rain gardens in residential, urban, commercial and industrial settings. Plants in these environments should be at least moderately tolerant of aerial salt spray; be easily maintained at a mature height; be tolerant of dry, hot conditions; not require supplemental irrigation; be native to Ohio, or non-invasive if not native to Ohio; be capable of living in the soil media specified for bioretention basins and rain gardens (see section on soil media); and be commonly available in the local nursery trade.

Planting Palette (Source: CDM Smith, Designed by Others)

DESIGN CONSIDERATIONS:

- Other plants not specifically listed in the planting palette may be suitable and available. The planting palette does exclude non-cultivars and other varieties of plants and grasses. Plants and grasses not specifically listed on the plant palette must be approved by DPU. Planting selection and location must be coordinated with the specifics of each basin and consider local attributes of each basin, such as the size and location of the basin, the grading plan, amount of water received, drawdown time, soil media composition, sun exposure and type of roadway.
- Plant density will vary based on basin size, due to the sizes of plants which are appropriate for different sized basins. The minimum density of plants shall be based on the size of the planted area: Small (<300 sq. ft.) - 1 plant per 12 square feet; Medium (300-1000 sq. ft.) - 1 plant per 16 square feet; Large (>1000 sq. ft.) - 1 plant per 20 square feet. For small basins with many perennials and grasses, planting densities much greater than 1 plant per 12 square feet may be appropriate. Trees, if desired in basins, may be planted at maximum ratio of 1 tree per 50 square feet.
- All plants shall be nursery grown and meet the requirements of CMSC 661.02. Minimum size at installation shall be 18 inches in height for small shrubs; 24 inches in height for large shrubs; 2inch caliper diameter for single stem trees; and 12-feet in height for multi-stem trees. Minimum size at installation for perennials and ornamental grasses shall be #1 container.
- When proposing GI at intersections, mature plant height shall not exceed 2.5 feet to avoid sight-line obstructions within the Clear Vision Triangle, per City of Columbus Code of Ordinances 3321.05 and DPS Sight Distance at Intersections Policy.
- Planting plans for GI shall have a limited variety of species to provide for ease of maintenance. Depending on size of GI 3 to 7 species are recommend with no more than 50 percent of plantings of one species. Plants shall not be placed randomly, but shall be placed in grouping of the same plant. The planting design style, such as formal or informal, may vary based on the neighborhood context.

- All planting areas must be covered with double shredded or triple shredded hardwood mulch to a depth of 3 inches. Mulch shall be natural, undyed; Size Range: 3 inches maximum, 1/2 inch minimum; pH: 5.5 to 7.2; Salinity: less than 3.0 millimhos per centimeter (mS/cm); Carbon: Nitrogen Ratio: less than 36:1. Water all mulch with fine spray immediately following installation to minimize mulch flotation.
- Separate mulched areas of GI from sodded areas with metal or stone block edging.
- Decorative gravel mulch may be used at inflow to GI to minimize wash-out of hardwood mulch, but shall not be used throughout entire planting area. Decorative gravel shall be local, washed, rounded river gravel.
- Comply with the requirements of CMSC 661, except that 661.11 – Backfill Mix, shall be bioretention engineered soil mix, and all plants shall be backfilled with this mix.
- Provide temporary fencing if required to protect GI from traffic through and around the GI. Fence may be similar to tree protection fence in DC 5.1 (Tree Protection).
- Consider both short and long term maintenance requirements and specify, as applicable. For establishment period maintenance specifications, see SS 1609 Green Infrastructure Establishment Activities.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Planting plan and plant schedule for each basin prepared by a landscape architect licensed in the State of Ohio, horticulturist or other qualified landscape professional.

✓ Planting specifications or notes.

✓ Additional contractor submittal requirements outlined in SS 1600, 1609, or CMSC 661, as applicable.

Planting Palette (Source: EMH&T)

Planting palette designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

Planting Palette Options for Right-of-Way Bioretention

Botanical Name	Common Name	Height*	Bloom Time	Bloom Color	Plant Selection Features						Salt Tolerant	Deer Resistant	Substitution
					Shade	Sun	Wet	Ohio Native	Center Spacing	Plant Zone			
Perennials													
Amsonia 'Blue Ice'	Blue Ice Amsonia	1-1.5'	May	Blue		■		■	1.5-2'	B	Unknown	■	*Iris versicolor; Amsonia tabernaemontana 'Storm Cloud'*
Asclepias tuberosa	Butterfly Weed	1-2.5'	Jun-Aug	Orange		■		■	1-1.5'	B	Moderate	■	*Echinacea 'Cheyenne Spirit'*
Echinacea purpurea 'Cheyenne Spirit'	Cheyenne Spirit Purple Coneflower	1-2.5'	Jun-Aug	Mix		■		■	1.5-2'	B		■	*Echinacea purpurea 'PowWow Wild Berry'; Echinacea purpurea 'PowWow White'*
Echinacea purpurea 'PowWow White'	PowWow White Purple Coneflower	2-2.5'	Jun-Aug	White		■		■	1.5-2'	B		■	*Echinacea purpurea 'PowWow Wild Berry'; Echinacea purpurea 'Cheyenne Spirit'*
Echinacea purpurea 'PowWow Wild Berry'	PowWow Wild Berry Purple Coneflower	2-2.5'	Jun-Aug	Pink/Purple		■		■	1.5-2'	B		■	*Echinacea purpurea 'Prairie Splendor'; Echinacea 'Cheyenne Spirit'*
Liatris microcephala	Small-Headed Blazing Star	1.5-2'	Jul	Purple		■			1-1.5'	B	Unknown	■	*Liatris spicata 'Kobold'; Liatris squarrosa*
Phlox subulata 'Emerald Blue'	Emerald Blue Moss Phlox	0.25-0.5'	Mar-May	Pink/Purple		■		■	1-1.5'	B	Moderate	■	*Symphyotrichum ericoides 'Snowflurry'; Phlox subulata 'Snowflake'*
Rudbeckia fulgida 'Goldsturm'	Goldsturm Coneflower	2-2.5'	Jun-Sep	Yellow/Orange		■		■	1.5-2'	B		■	*Echinacea 'Cheyenne Spirit'*
Symphyotrichum ericoides 'Snowflurry'	Snowflurry Heath Aster	0.25-0.5'	Sep-Oct	White		■		■	1-1.5'	B		■	*Phlox subulata 'Emerald Blue'; Phlox subulata 'Snowflake'*
Symphyotrichum novae-angliae 'Purple Dome'	Purple Dome New England Aster	1.5-2'	Aug-Sep	Purple		■	■	■	2.5-3'	A	Moderate	■	*Symphyotrichum novae-angliae 'Vibrant Dome'; Symphyotrichum novae-angliae 'Kickin Lilac Blue'*
Eutrochium dubium 'Baby Joe'	Baby Joe Pye Weed	2-3'	Jul-Sep	Purple	Part	■	■	■	1.5-2'	A/C		■	*Eutrochium maculatum 'Red Dwarf'*
Iris versicolor	Blue Flag Iris	2-2.5'	May-Jun	Purple/Blue	Part	■	■	■	2-2.5'	A/C	■	■	*Iris virginica var. shrevei*
Phlox stolonifera 'Sherwood Purple'	Sherwood Purple Creeping Phlox	0.5-1'	Apr-May	Purple/Blue	Part	■		■	1'	B	■	■	*Phlox stolonifera 'Home Fires'; Asarum canadense*
Pycnanthemum tenuifolium	Slender Mountain Mint	2-3'	Jul-Sep	White	Part	■	■	■	2-3'	A/B/C	■	■	*Iris versicolor; Eutrochium dubium 'Baby Joe'*
Asarum canadense	Wild Ginger	0.5-1'	Apr-May	Purple/Brown	Pt/Full			■	1-1.5'	B		■	*Carex pensylvanica*
Athyrium filix-femina var angustum 'Lady in Red'	Lady in Red Fern	1.5-2.5'	Not Showy		Pt/Full			■	2-2.5'	B		■	*Athyrium filix-femina; Dryopteris marginalis*
Grasses/Sedges													
Panicum virgatum 'Cheyenne Sky'	Cheyenne Sky Switch-Grass	2-3'	Jul-Oct	Red		■	■	■	2-3'	A/B/C	■	■	*Panicum virgatum 'Cape Breeze'*
Sporobolus heterolepis	Prairie Dropseed	2-3'	Aug-Oct	Pink/Brown		■		■	2.5-3'	B	Moderate	■	*Schizachyrium scoparium 'Carousel'; Sporobolus heterolepis 'Tara'*
Carex vulpinoidea	Fox Sedge	1-3'	May-Jul	Green	Part	■	■	■	1.5-2'	A/C	■	■	*Carex stricta; Carex frankii*
Carex pensylvanica	Pennsylvania Sedge	0.5-1'	May	Green	Pt/Full			■	1	B	■	■	*Asarum canadense*
Shrubs													
Aronia melanocarpa 'Morton'	Morton Iroquois Beauty Black Chokeberry	2-3'	May	White	Part	■	■	■	3-4'	A	Moderate	■	*Aronia melanocarpa 'Ground Hog'; Aronia melanocarpa 'Low Scape Mound'*
Cornus sericea 'Kelseyi'	Kelseyi Dwarf Dogwood	2-2.5'	May-Jun	White	Part	■	■	■	2-3'	A/C			*Hypericum kalmianum 'Blue Velvet'; Rhus aromatica 'Grow-Low'*
Hypericum kalmianum 'Blue Velvet'	Blue Velvet St.-John's-Wort	2-3'	Jul-Aug	Yellow	Part	■		■	3-4'	A		Unknown	*Cornus sericea 'Kelseyi'; Rhus aromatica 'Grow-Low'*
Itea virginica 'Sprich' Little Henry	Little Henry Dwarf Sweetspire	1.5-2'	Jun-Jul	White	Part	■	■		2-3'	A/B	Unknown	■	*Hypericum kalmianum 'Gemo'*
Rhus aromatica 'Grow-Low'	Grow-Low Fragrant Sumac	1.5-2'	Apr-May	Yellow	Part	■		■	6'	B	Moderate	■	*Cornus sericea 'Kelseyi'; Hypericum kalmianum 'Blue Velvet'*

Legend

Note:	Designer shall consider long term maintenance requirements when making plant selections.
■	= Suitable Plant
Height	For installations within ROW: ≤2.5' suitable for bioretention bottom or side slopes; ≤3' suitable for bottom of bioretention only * Suitability for ROW basin bottom/slope assumes basin bottom is depressed at least 6" below street centerline; top of plants at maturity within ROW basins shall be ≤2.5' above street centerline grade. Heights and spacing represent typical ranges. Varying site conditions affect plant sizes and should be considered when selecting plants.
Native	= Native to Ohio region or Eastern United States
Wet	= May be suitable for use at locations within the basin near inlets or in basins with large runoff ratios (impervious runoff area to area of basin > 10:1)
Sun	= Plant performs well in full sun to part shade
Shade	= Plant performs well in part shade to full shade

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DC 5.2-1 Planting Palette Options
Right-of-Way Green Infrastructure

February 2020

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Planting Palette Options for Regional Bioretention

Botanical Name	Common Name	Height*	Bloom Time	Bloom Color	Plant Selection Features						Salt Tolerant	Deer Resistant	Substitution
					Shade	Sun	Wet	Ohio Native	Center Spacing	Plant Zone			
Perennials													
Amsonia 'Blue Ice'	Blue Ice Amsonia	1-1.5'	May	Blue		■			1.5-2'	B	Unknown	■	*Iris versicolor; Amsonia tabernaemontana 'Storm Cloud'*
Asclepias tuberosa	Butterfly Weed	1-2.5'	Jun-Aug	Orange		■		■	1-1.5'	B	Moderate	■	*Echinacea 'Cheyenne Spirit'*
Echinacea purpurea 'Cheyenne Spirit'	Cheyenne Spirit Purple Coneflower	1-2.5'	Jun-Aug	Mix		■		■	1.5-2'	B		■	*Echinacea purpurea 'PowWow Wild Berry'; Echinacea purpurea 'PowWow White'*
Echinacea purpurea 'PowWow White'	PowWow White Purple Coneflower	2-2.5'	Jun-Aug	White		■		■	1.5-2'	B		■	*Echinacea purpurea 'PowWow Wild Berry'; Echinacea purpurea 'Cheyenne Spirit'*
Echinacea purpurea 'PowWow Wild Berry'	PowWow Wild Berry Purple Coneflower	2-2.5'	Jun-Aug	Pink/Purple		■		■	1.5-2'	B		■	*Echinacea purpurea 'Prairie Splendor'; Echinacea 'Cheyenne Spirit'*
Liatris microcephala	Small-Headed Blazing Star	1.5-2'	Jul	Purple		■			1-1.5'	B	Unknown	■	*Liatris spicata 'Kobold'; Liatris squarrosa*
Rudbeckia fulgida 'Goldsturm'	Goldsturm Coneflower	2-2.5'	Jun-Sep	Yellow/Orange		■		■	1.5-2'	B		■	*Echinacea 'Cheyenne Spirit'*
Symphyotrichum ericoides 'Snowflurry'	Snowflurry Heath Aster	0.25-0.5'	Sep-Oct	White		■		■	1-1.5'	B		■	*Phlox subulata 'Emerald Blue'; Phlox subulata 'Snowflake'*
Symphyotrichum novae-angliae 'Purple Dome'	Purple Dome New England Aster	1.5-2'	Aug-Sep	Purple		■	■	■	2.5-3'	A		■	*Symphyotrichum novae-angliae 'Vibrant Dome'; Symphyotrichum novae-angliae 'Kickin Lilac Blue'*
Symphyotrichum oblongifolium 'October Skies'	October Skies Aromatic Aster	1.5-2'	Aug-Oct	Blue		■		■	2'	A		■	*Symphyotrichum oblongifolium 'Raydon's Favorite'*
Baptisia australis	Blue False Indigo	1-3'	May-Jun	Purple/Blue	Part	■		■	3-4'	B		■	*Baptisia alba*
Chelone glabra	Turtlehead	2-3'	Aug-Oct	White	Part		■	■	2-2.5'	A/C		■	*Chelone obliqua*
Eutrochium dubium 'Baby Joe'	Baby Joe Pye Weed	2-3'	Jul-Sep	Purple	Part	■	■	■	1.5-2'	A/C		■	*Eutrochium maculatum 'Red Dwarf'*
Iris versicolor	Blue Flag Iris	2-2.5'	May-Jun	Purple/Blue	Part	■	■	■	2-2.5'	A/C	■	■	*Iris virginica var. shrevei*
Lobelia cardinalis	Cardinal Flower	2-4'	Jul-Sep	Red	Part	■		■	1-1.5'	A	■	■	*Lobelia cardinalis 'Black Truffle'*
Pycnanthemum tenuifolium	Slender Mountain Mint	2-3'	Jul-Sep	White	Part	■	■	■	2-3'	A/B/C	■	■	*Baptisia australis; Iris versicolor; Eutrochium dubium 'Baby Joe'*
Athyrium filix-femina var angustum 'Lady in Red'	Lady in Red Fern	1.5-2.5'	Not Showy		Pt/Full			■	2-2.5'	B		■	*Athyrium filix-femina ; Dryopteris marginalis*
Polygonatum biflorum	Solomon's Seal	1-3'	Not Showy		Pt/Full		■	■	1'	B	■		*Carex pensylvanica*
Grasses/Sedges													
Carex pensylvanica	Pennsylvania Sedge	0.5-1'	May	Green	Pt/Full			■	1	B	■	■	*Asarum canadense*
Carex vulpinoidea	Fox Sedge	1-3'	May-Jul	Green	Part	■	■	■	1.5-2'	A/C	■	■	*Carex stricta; Carex frankii*
Deschampsia cespitosa	Tufted Hair Grass	2-3'	Jul-Sep	Purple/Bronze	Part	■	■	■	1.5-2'	A/C	■	■	*Carex pensylvanica; Carex vulpinoidea; Athyrium filix-femina*
Panicum virgatum 'Heavy Metal'	Heavy Metal Switch-Grass	4-5'	Jul-Oct	Red		■	■	■	2-3'	A/B/C	■	■	*Panicum virgatum 'Shenandoah'*
Schizachyrium scoparium 'Standing Ovation'	Standing Ovation Little Bluestem	2-4'	Aug-Oct	Purple/Bronze		■		■	1.5-2'	B	■	■	*Schizachyrium scoparium 'The Blues'; Schizachyrium scoparium 'Smoke Signal'*
Sporobolus heterolepis	Prairie Dropseed	2-3'	Aug-Oct	Pink/Brown		■		■	2.5-3'	B	■	■	*Schizachyrium scoparium 'Standing Ovation'; Sporobolus heterolepis 'Tara'*
Shrubs													
Aronia melanocarpa 'Viking'	Viking Black Chokeberry	3-6'	May	White	Part	■	■	■	6'	A/B	■	■	*Aronia melanocarpa 'Autumn Magic'; Ilex verticillata 'Nana'*
Cornus sericea 'Farrow' Arctic Fire	Farrow Arctic Fire Red Twig Dogwood	3-4'	May-Jun	White	Part	■	■	■	4'	A/C	■	■	*Itea virginica 'Sprich' Little Henry; Itea virginica 'Henry's Garnet'*
Hypericum frondosum 'Sunburst'	Sunburst Golden St.-John's-Wort	3-4'	Jun-Jul	Yellow	Part	■			3-4'	B	Unknown	Unknown	*Itea virginica 'Henry's Garnet'; Itea virginica 'Sprich' Little Henry*
Hypericum kalmianum 'Blue Velvet'	Blue Velvet St.-John's-Wort	2-3'	Jun-Jul	Yellow	Part	■		■	3-4'	B	■	Unknown	*Hypericum kalmianum 'Gemo'; Hypericum frondosum 'Sunburst'*
Ilex verticillata 'Jim Dandy'	Jim Dandy Winterberry	3-6'	Jun-Jul	White	Part	■	Low pH	■	6-8'	A/B/C	■	■	*Itea virginica 'Henry's Garnet'; Aronia melanocarpa 'Viking'*
Ilex verticillata 'Nana'	Nana Red Sprite Winterberry	2.5-3'	Jun-Jul	White	Part	■	Low pH	■	4'	A/B/C	■	■	*Itea virginica 'Henry's Garnet'; Aronia melanocarpa 'Viking'*
Itea virginica 'Henry's Garnet'	Henry's Garnet Sweetspire	3-4'	May-Jun	White	Pt/Full	■	■		4'	A/B	■	■	*Itea virginica 'Sprich' Little Henry; Cornus sericea 'Farrow' Arctic Fire*
Physocarpus opulifolius 'Seward' Summer Wine	Summer Wine Ninebark	4-6'	May-Jun	Pinkish White	Part	■		■	4-6'	B	Moderate	Unknown	*Physocarpus opulifolius 'Tiny Wine'; Hypericum frondosum 'Sunburst'*

Legend

Note:	Designer shall consider long term maintenance requirements when making plant selections.
■	= Suitable Plant
Height	For installations within ROW: ≤2.5' suitable for bioretention bottom or side slopes; ≤3' suitable for bottom of bioretention only * Suitability for ROW basin bottom/slope assumes basin bottom is depressed at least 6" below street centerline; top of plants at maturity within ROW basins shall be ≤2.5' above street centerline grade. Heights and spacing represent typical ranges. Varying site conditions affect plant sizes and should be considered when selecting plants.
Native	= Native to Ohio region or Eastern United States
Wet	= May be suitable for use at locations within the basin near inlets or in basins with large runoff ratios (impervious runoff area to area of basin > 10:1)
Sun	= Plant performs well in full sun to part shade
Shade	= Plant performs well in part shade to full shade

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DC 5.2-2 Planting Palette Options
Regional Green Infrastructure

February 2020

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See Note 1

EXAMPLE PLANT SCHEDULE

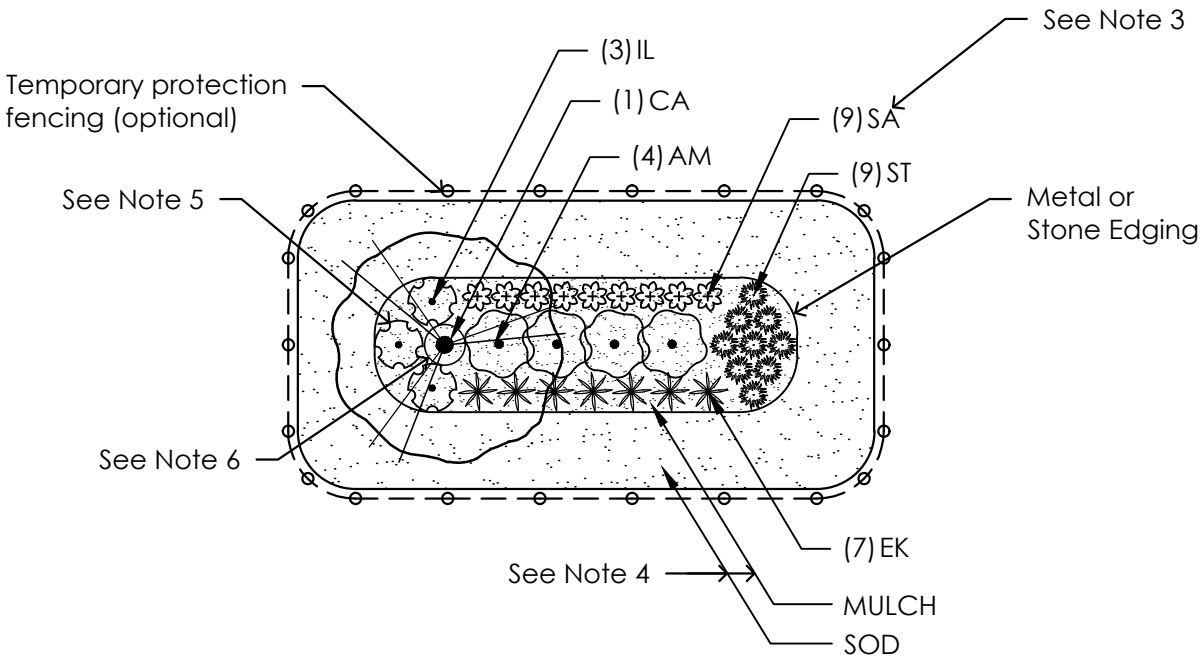
TREES	QTY	BOTANICAL NAME	COMMON NAME	SIZE	CONDITION
CA	1	Cercis canadensis `Appalachian Red`	Appalachian Red Redbud	2" Cal.	B&B
SHRUBS	**QTY**	**BOTANICAL NAME**	**COMMON NAME**	**SIZE**	**CONDITION**
AM	4	Aronia melanocarpa `Morton`	Iroquis Beauty Black Chokeberry	24" Ht.	B&B
IL	3	Itea virginica `Little Henry`	Little Henry Dwarf Sweetspire	18" Ht.	Cont.
GRASSES	**QTY**	**BOTANICAL NAME**	**COMMON NAME**	**SIZE**	**CONDITION**
ST	9	Sporobolus heterolepis `Tara`	Dwarf Prairie Dropseed	#1	Cont.
PERENNIALS	**QTY**	**BOTANICAL NAME**	**COMMON NAME**	**SIZE**	**CONDITION**
EK	7	Echinacea purpurea `Kim`s Knee High`	Kim`s Knee High Coneflower	#2	Cont.
SA	9	Sedum spectabile `Autumn Joy`	Autumn Joy Stonecrop	#2	Cont.
GROUND COVERS	**QTY**	**COMMON NAME**			
MULCH	146 sf	Shredded Hardwood Mulch	← See Note 2		
SOD	296 sf	Tall Fescue Sod			

ABREVIATIONS

B&B	Balled and burlap root ball
Cont.	Container grown root ball
#1, #2	Container size per ANSI Z60.1

Notes

1. Include a schedule with Code, Quantity, Botanical and Common Names, Installed size and root condition.
2. Include mulch and sod in schedule or quantify elsewhere in plans.
3. Label quantity and unique code for each plant.
4. Label mulch, sod and other materials if specified.
5. Use unique symbols for each plant species.
6. Do not plant directly above tree rootballs with shrubs, perennials or grasses.



EXAMPLE PLANTING PLAN

1" = 10' - 0"

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DC 5.2 Planting Palette Options

Example Planting Plan

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Acer rubrum
Red Maple

Betula nigra 'Dura Heat'
Dura Heat River Birch

Nyssa sylvatica 'Wildfire'
Wildfire Black Gum

Platanus occidentalis
American Sycamore

Taxodium distichum
Bald Cypress

Amelanchier laevis 'Cumulus'
Cumulus Serviceberry

Cercis canadensis
'Appalachian Red'
Appalachain Red Redbud

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DC 5.2 Planting Palette Options

Plant Photos: Trees

March 2017

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Panicum virgatum 'Cheyenne Sky'
Cheyenne Sky Switch Grass

Sporobolus heterolepis 'Tara'
Dwarf Prairie Dropseed

Carex morrowii 'Ice Dance'
Ice Dance Sedge

Calamagrostis x acutiflora
'Karl Foerster'
Karl Foerster Feather
Reed Grass

Panicum virgatum 'Heavy Metal'
Heavy Metal Switch Grass

Schizachyrium scoparium
'The Blues'
The Blues Little Bluestem

Sporobolus heterolepis
Prairie Dropseed

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DC 5.2 Planting Palette Options
Plant Photos: Grasses

March 2017

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Amsonia x 'Blue Ice'
Blue Ice Amsonia

Asclepias tuberosa
Butterfly Weed

Echinacea purpurea
'Kim's Knee High'
Kim's Knee High
Purple Coneflower

Liatris microcephala
Small-headed
Blazing Star

Rudbeckia fulgida var. sullivantii 'Goldsturm'
Black-eyed Susan

Sedum spectabile 'Autumn Joy'
Autumn Joy Stonecrop

Solidago x 'Solar Cascade'
Solar Cascade Goldenrod

Polygonatum odoratum 'Variegatum'
Variegated Solomon's Seal

Boltonia asteroides 'Snowbank'
False Aster

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DC 5.2 Planting Palette Options

Plant Photos: Perennials

March 2017

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Aronia melanocarpa 'Morton'
Iroquois Beauty Black Chokeberry

Cornus sericea 'Kelseyi'
Kelsey Dwarf Dogwood

Hypericum kalmianum
'Blue Velvet'
Blue Velvet St. John's Wort

Rhus aromatica 'Gro-Lo'
Gro-Lo Fragrant Sumac

Hypericum frondosum 'Sunburst'
Golden St. John's Wort

Itea virginica
'Little Henry'
Little Henry Dwarf
Sweetspire

Aronia melanocarpa
'Viking'
Viking Black
Chokeberry

Ilex verticillata
'Red Sprite'
Red Sprite
Winterberry

Spiraea nipponica 'Snowmound'
Snowmound Spirea

Itea virginica 'Henry's Garnet'
Henry's Garnet Sweetspire

Ribes alpinium 'Green Mound'
Green Mound Alpine Currant

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DC 5.2 Planting Palette Options
Plant Photos: Shrubs

March 2017

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6—STORAGE MEDIA

6.1—STONE AGGREGATE

6.2—BIORETENTION SOIL MEDIA

6.3—PREFABRICATED BURIED INFILTRATION STRUCTURES

DC 6.1—STONE AGGREGATE

DESCRIPTION: Stone aggregate is used to provide void space for water storage in GI systems. Stone aggregate materials include no. 2, no. 3, no. 4, no. 8, and no. 57 stone.

WHERE TO USE: Use stone aggregate under engineered soil in GI such as bioretention basins. Use no. 8 size aggregate immediately below the engineered soil as a filter layer above a no. 57 size storage layer. The no. 8 filter layer is used to keep the fine particles of the engineered soil layer from entering the no. 57 storage layer. A no. 2, 3 or 4 size storage layer can be placed below the no. 57 layer if additional storage capacity is required below the underdrain located within the no. 57 layer. Void space in open graded no. 57 and no. 2, 3 or 4 aggregate ranges from 30% to 40%. This void space is available for water storage.

DESIGN CONSIDERATIONS:


Stone Aggregate (Source: EMH&T)

- All stone aggregate must be clean, washed and free of fines.
- See SS 1602 Earthwork for Green Infrastructure Projects for excavation and placement of aggregate material specifications and SS 1610 Underdrains and Aggregates for Green Infrastructure Facilities for material specifications.

No. 8 Filter Layer

- Narrowly graded mixture of washed, crushed stone or crushed gravel in accordance with CMSC 703.01.
- Coarse-aggregate grading size 8 with 100 percent passing a ½ inch (12.5-mm) sieve and 0 to 5 percent passing a no. 16 (1.18-mm) sieve.

No. 57 Storage Layer

- Narrowly graded mixture of washed, crushed stone or crushed gravel in in accordance with CMSC 703.01.
- Coarse-aggregate grading size 57 with 100 percent passing a 1-½ inch (37.5-mm) sieve and 0 to 5 percent passing a no. 8 (2.36-mm) sieve.

No. 2, 3, or 4 Storage Layer

- Narrowly graded mixture of washed, crushed stone or crushed gravel in accordance with CMSC 703.01
- Coarse-aggregate grading size 2 with 100 percent passing a 3 inch (100-mm) sieve, 0 to 5 percent passing a ¾ inch (19-mm) sieve, and less than 2 percent passing the no. 200 sieve.
- Course-aggregate grading size 3 with 100 percent passing the 2-½ inch (63 mm) sieve, 0 to 5 percent passing a ½ inch (12.5 mm) sieve, and less than 2 percent passing the no. 200 (75 um) sieve
- Course-aggregate grading size 4 with 100 percent pass the 2 inch (50 mm) sieve, 0 to 15 percent passing the ¾ inch (19 mm) sieve, and less than 2 percent passing the no. 200 (75 um) sieve.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

- ✓ Cross-Section of storage media within GI system.
- ✓ Specified requirement for sieve analysis of all aggregates.
- ✓ Storage media designs outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.
- ✓ Additional contractor submittal requirements outlined in SS 1600, 1602, or CMSC 703, as applicable.

Stone Aggregate (Source: CDM Smith)

DC 6.2—BIORETENTION SOIL MEDIA

DESCRIPTION: Bioretention soil media is a blended soil consisting of four components: planting soil, sand, organic amendment and topsoil. The bioretention soil allows for pollutant filtration and controlled exfiltration into the storage media, as well as providing an organic, moisture-retentive, and chemically suitable growing medium for the required plants.

WHERE TO USE: Bioretention soil media shall be used in bioretention basins and rain gardens above the stone aggregate storage layer.

DESIGN CONSIDERATIONS:

- Consult SS 1604 Bioretention Soil for Green Infrastructure Projects for details specifications.
- Gradation of the bioretention soil mix shall be determined by a qualified laboratory using the USDA *Soil Survey Laboratory Methods Manual*.
- Existing native soil may be used if the soil meets the testing requirements indicated for bioretention soil media.
- See SS 1602 Earthwork for Infrastructure Projects for excavation and placement of material specifications.

Bioretention Soil Media (Source: EMH&T)

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

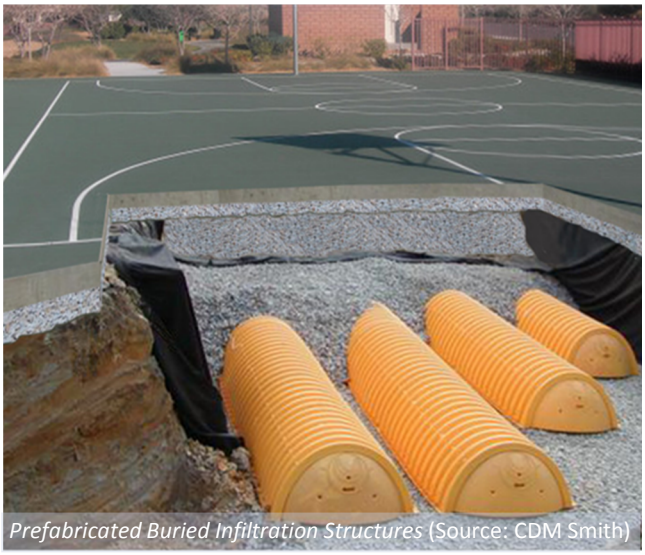
- ✓ Plan, section, and detail drawings showing extents and depth of bioretention soil media.
- ✓ Specification and contractor submittal requirements per SS 1604 Bioretention Soils for Green Infrastructure Projects.
- ✓ Additional contractor submittal requirements outlined in SS 1600 and 1602, as applicable.

Bioretention soil media designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

DC 6.3—PREFABRICATED BURIED INFILTRATION STRUCTURES

DESCRIPTION: Prefabricated buried infiltration structures can be used to provide void space for water storage. These structures may be installed in combination with bioretention basins, permeable pavements and other green infrastructure practices. Systems vary greatly by manufacturer, but generally can be open-bottom arch shapes or rectangular shapes and may be made of plastic or concrete material. Systems should be designed to promote infiltration where underlying soils allow. This specification does not include solid wall storage structures such as pipes and box culverts. Buried infiltration structures are generally not considered injection wells if the length of the system exceeds the depth.

WHERE TO USE: May be applied in parking lots, parks or other private property settings with the permission of the property owner, but are not permitted for use within the ROW unless otherwise approved by the City. Use for greater water storage capacity than can be provided by stone aggregate. Void space in prefabricated materials can often be greater than 90%. By comparison, the void space available in stone aggregate ranges from 30 to 40%. Can be used under permeable pavement as a mechanism to transfer water from the stone storage bed to an outlet structure and used in lieu of perforated underdrains. These types of systems have been approved by Ohio EPA as an alternative stand-alone BMP when standard BMPs are not feasible due to various constraints. Ohio EPA requires a proven pretreatment mechanism and maintenance plan to protect the long term functionality of the product.



Prefabricated Buried Infiltration Structures (Source: CDM Smith)

DESIGN CONSIDERATIONS:

- Specifications and details related to materials, aggregate, geotextiles, sizing, installation and maintenance are manufacturer specific. Follow all manufacturer specifications, details and recommendations for use.
- Meet the ASTM requirements of F 2787, Standard Practice for Structural Design of Thermoplastic Corrugated Wall Stormwater Collection Chambers
- Meet the ASTM requirements of F 2418 (polypropylene chambers) and F 2922 (polyethylene chambers). Meet the soil-structure interaction design standards of the AASHTO LRFD Bridge Design Specification, Section 3 and Section 12.
- Systems designed for use under pavement must be capable of supporting a vehicle load up to AASHTO H-20 rating.
- Design and placement of manufactured devices must follow the City of Columbus Policy for Stormwater Treatment Technology Performance and Testing Requirements, and other requirements contained in the Stormwater Drainage Manual.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

- ✓ Design plan views and foundation cross-sections, including storage media material for the area surrounding unit and for subgrade beneath it.
- ✓ Complete design of system, including details and specifications of proposed system including end treatment, discharge weir and system bypass when unit is full.
- ✓ Soil report identifying the seasonal ground water table levels.
- ✓ Infiltration testing protocol and results.
- ✓ Recommended maintenance method and interval.
- ✓ For stone bedding surrounding and beneath the structure: aggregate type, source, grading, dry-rodded unit weight, and void content.
- ✓ Construction procedures, and quality control plan.
- ✓ Additional contractor submittal requirements outlined in SS 1600, as applicable.

Prefabricated buried infiltration structure designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

7—PIPING

DC 7.1—UNDERDRAIN

DESCRIPTION: Underdrains are perforated pipes used to intercept, collect, and convey stormwater from the storage or subsurface layers of a Green Infrastructure (GI) installation.

WHERE TO USE: Underdrain systems are required in all GI facilities unless results of infiltration testing show that in-situ soils are adequate for infiltration within the required drawdown time of the GI. Underdrains may also be installed as an overflow mechanism and/or when specified by the City of Columbus Department of Public Utilities. GI facilities designed without an underdrain system must be approved by the City on a case-by-case basis. Underdrain systems may require anti-seep collars to prevent migration of stormwater runoff away from the GI facility; see DC 7.4 (Anti-Seep Collar/Utility Sleeve).

DESIGN CONSIDERATIONS:

- Underdrains shall be a minimum 6 inches in diameter according to requirements contained in the Columbus SWDM. Six inch to 8 inch diameter underdrain piping can also be used to compensate for freeze-thaw effects, site hydraulics, and maintenance. Under certain circumstances, underdrain piping size may be increased to provide additional temporary hydraulic storage, as approved by the City of Columbus.
- Polyvinyl chloride (PVC) plastic pipe shall be in accordance with CMSC 720.07. Corrugated high density polyethylene (HDPE) or high density polypropylene (HDPP) pipe used shall be in conformance with CMSC 720.12 and 720.13.
- Perforated underdrains shall have a minimum of four rows of perforations. Perforations should be pre-drilled and free of shavings.
- Underdrains shall be solid when passing through areas where stormwater needs to be conveyed without exfiltration from the pipe, such as from the extents of the GI system to the existing drainage system or outfall point. Anti-seep collars, per DC 7.4 (Anti-Seep Collar/Utility Sleeve) shall be installed when transitioning from perforated to solid pipe.
- An anti-seep collar should be considered for installation at the edge of the GI facility for outlet piping that passes through non-GI areas before connection to the outlet structure.
- All underdrains shall be capable of withstanding the expected loading applied above it, whether vehicular or pedestrian. The designed flow rate through underdrains shall exceed the infiltration rates of the soil media layers.
- Aggregates shall comply with material quality, handling, and testing requirements of CMSC 703.
- Unless otherwise shown on the design, bedding and granular backfill shall consist of durable AASHTO No. 57 aggregate in accordance with CMSC 703.01, shall extend a minimum of 4 inches beyond the outside diameter of the underdrain, and shall extend the entire length of the underdrain.
- Sites expected to produce greater fine particles in runoff should use a filter layer between the GI media and the underdrain aggregate. Bedding and filter aggregate shall be double washed prior to installation to reduce suspended solids and reduce the potential for clogging.

- Underdrain shall have a minimum grade of 0.5 percent per the Columbus SWDM.
- Upstream ends of an underdrain pipe shall include cleanout per STD DWG AA-161. Cleanouts shall consist of an elbow connected to a vertical pipe extended to 6 inches above the surface of the GI facility. The vertical pipe shall be connected to a junction box or capped with a screw cap. Cleanouts shall also be installed in underdrain systems at a minimum interval of every 50 feet, unless otherwise approved by DPU. Junction boxes or capped cleanouts in paved areas in ROW shall be fitted with heavy duty casting and lid per DPU standard drawings.
- Underdrains shall drain to an existing drainage system, such as an existing inlet or other suitable stable outlet having positive drainage. Prior to exiting the GI, a mechanism to control discharge from the underdrain, such as a valve, orifice, or upturned elbow, shall be installed. An access cleanout or structure is required at this location to provide maintenance access to the mechanism.
- Provide all fittings conforming to the applicable CMSC, ASTM, AASHTO, and manufacturer's specifications.
- See SS 1610 Underdrains and Aggregates for Green Infrastructure Facilities for additional underdrain specifications.
- Signs to be placed within a green infrastructure facility shall be placed prior to installation of underdrains. see DC 7.1, Sign Post Installation.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Plan view of underdrain placement, including offset dimensions.

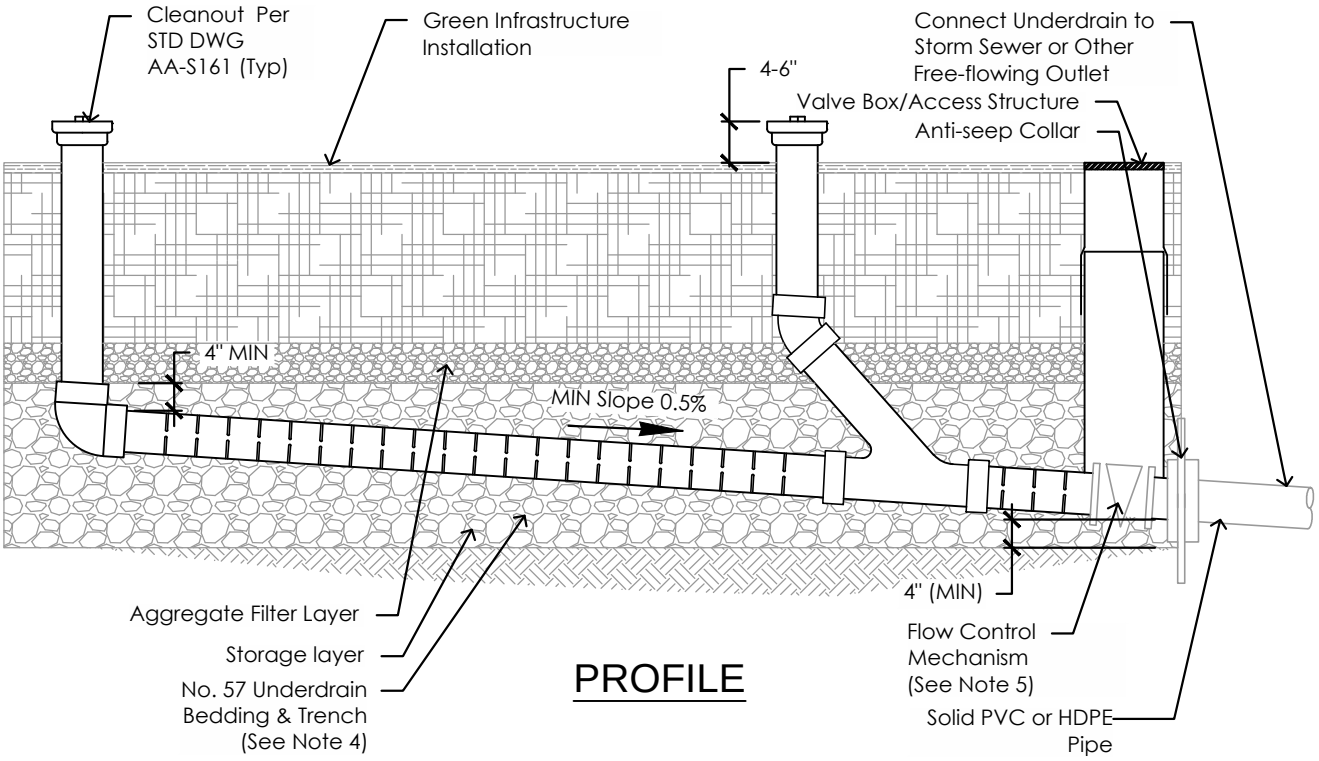
✓ Cross-sectional view of underdrain including details of all materials and fittings.

✓ Detail of existing drainage system connection or outlet, as well as discharge control mechanisms to be used.

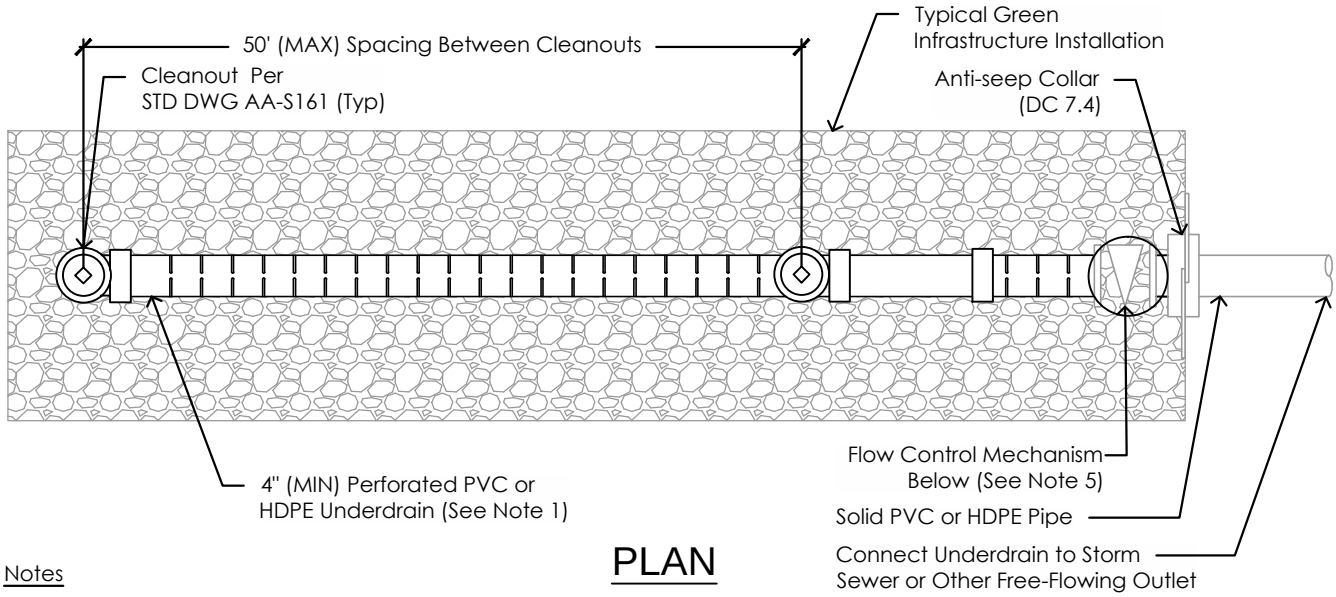
✓ Specification and contractor submittal requirements per SS 1602 Earthwork for Green Infrastructure Projects.

✓ Additional contractor submittal requirements outlined in SS 1600, as applicable.

Underdrain piping designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.



PROFILE



PLAN

Notes

1. Underdrains shall be a minimum of 4" diameter. 6" or 8" diameter preferred.
2. PVC or HDPE underdrains shall conform to CMSC sections 720.07, 720.12 & 720.13. A minimum of 4 rows of perforations required.
3. Lateral or parallel underdrains may be installed if necessary depending on size slope of GI. Intersecting underdrains shall be installed such that flow enters the pipe run in the downstream direction.
4. Underdrain bedding trench must maintain a minimum offset of 4" from the outside diameter of the underdrain. Trench sides may be vertical or sloped.
5. A flow control mechanism such as a valve, orifice, or upturned elbow shall be installed on the downstream end of underdrains to control discharge from the GI. If a valve is used for flow control, it shall be operable from above grade. Provide valve box or access vault for valve. Flow control elbows and orifices shall be accessible for regular cleaning. Provide access vault.

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DC 7.1 Underdrain

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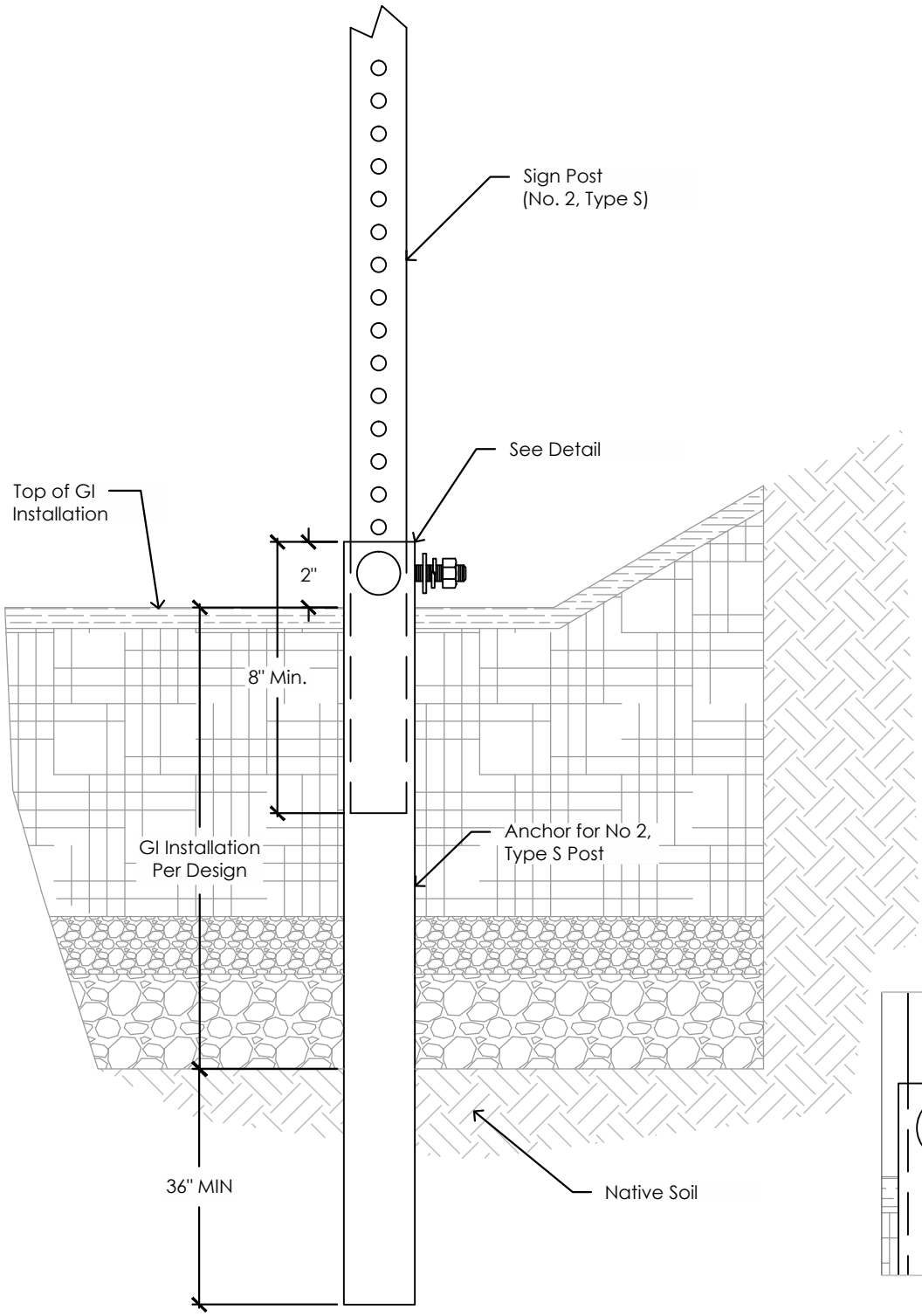
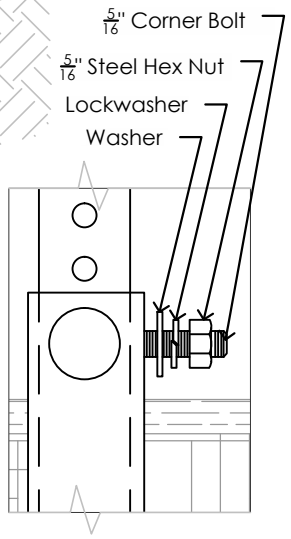


SECTION



DETAIL

Notes

1. Yielding post design shall comply with ODOT Standard Drawing TC-41.20, Typical Square Post Anchor Base Installation except as modified per this detail. The anchor post shall be installed prior to installation of the underdrain, aggregates and bioretention soil.

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DC 7.1 Underdrain
Sign Installation Detail

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DC 7.2—STANDPIPE OVERFLOW SYSTEMS

DESCRIPTION: Overflow systems include measures to convey stormwater runoff above the design ponding elevation back into an existing stormwater system. The systems consist of a dome- or flat-shaped grate located within a GI system and mounted on top of a vertical riser pipe, which is connected to a lateral drain pipe.

WHERE TO USE: An overflow system shall be used when ponding within the GI facility needs to be controlled, or when specified by the City of Columbus Department of Public Utilities (DPU). A standpipe overflow device is the preferred device per the Columbus SWDM, 2012. Standpipe bypass flow will be routed to an existing inlet or manhole, or connect directly to an existing stormwater pipe.

DESIGN CONSIDERATIONS:

- The overflow system shall be sized to remove water from the GI facility above a specified ponding depth. This will maximize effectiveness of the GI facility by preventing short circuiting and not overloading the receiving storm sewer.
- An anti-seep collar should be considered for installation at the edge of the GI facility for outlet piping that passes through non-GI areas before connection to the outlet structure.
- The riser grate size shall be a minimum of 12 inches in diameter and be of a locking type. The overflow system shall be one of the following DPU Standard Drawings or as approved by DPU:
    - AA-S130 “Catch Basin – 12 inch Diameter”
    - AA-S132 “Catch Basin – 42 inch Diameter”
    - AA-S133A “Standard Catch Basin (21 inch Diameter and Smaller Pipe)”
    - AA-S133B “Standard Catch Basin (24 inch to 42 inch Pipe)”
    - AA-S134 “Standard Catch Basin – 24 inch Side Inlets”
    - AA-S135 “Precast Rectangular Catch Basins”
    - AA-S136 “Rectangular Concrete Catch Basin (48 inch Inlet)”
    - AA-S138 “Grating for 24 inch and 42 inch Diameter Catch Basins”
    - AA-S139 “Light Duty Grate and Angle Frame for Standard Catch Basin”
    - AA-S140 “Rectangular Cast Iron Inlet Frame and Grating”
    - AA-S141 “Heavy Duty Grate and Frame for Standard Catch Basin”

Overflow SYstem(Source: CDM Smith, designed by others)

- Riser piping shall be made of soil-tight seals and fittings and shall conform to CMSC 901.15 – Pipe Joints.

- Frames, grates and covers shall meet the requirements of CMSC 604.02.
- Vegetation in the vicinity of the overflow should be planted with sufficient distance from the overflow to prevent plant debris from clogging outlet.
- Alternative riser pipe designs are acceptable provided that the functional intent is the same, and that ease of maintenance is provided.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Standard riser detail.

✓ Manufacturer details for all products used, including product number, materials, painting specifications, and fastener and frame details.

✓ A plan view of the GI facility showing all overflow pathways and elevations confirming that overflows are maintained on public property and do not flow onto private property or into any structure.

✓ Additional contractor submittal requirements outlined in SS 1600 or CMSC 901, as applicable.

Riser pipe overflow designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

DC 7.3—OBSERVATION WELL

DESCRIPTION: An observation wells is a vertical pipe that extends through a Green Infrastructure (GI) facility and allows for measurement of the sub-surface water level. Observation wells are used to assess the performance of the GI over time, in order to monitor functionality of GI surface layers.

WHERE TO USE: Observation wells shall be used in all GI facilities that are designed for infiltration and/or storage or when deemed necessary by the City of Columbus Department of Public Utilities (DPU).

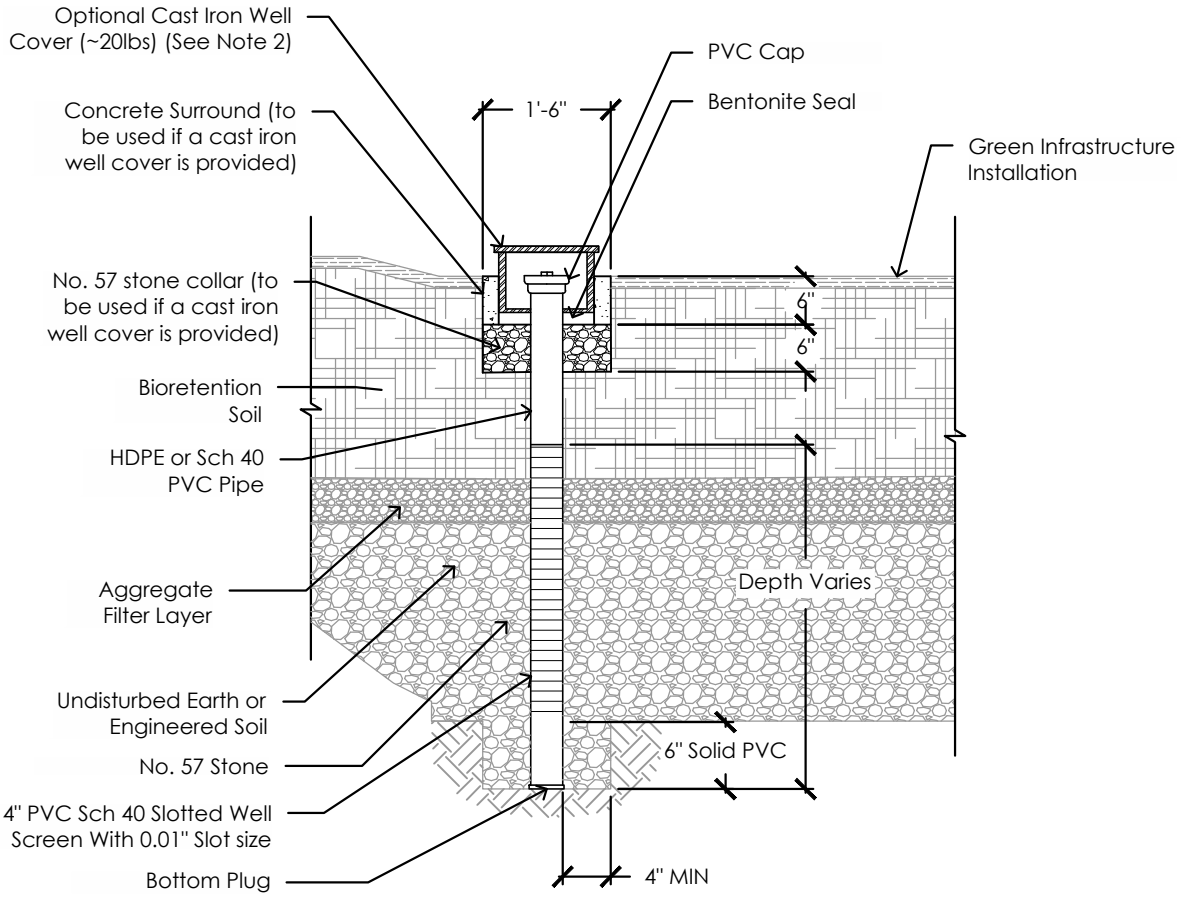
DESIGN CONSIDERATIONS:

- Observation wells located within the pavement, curb and gutter, or sidewalks shall conform to CMSC 604 – Manholes, Catch Basins, Inlets, Inspection Wells, Junction Chambers, Precast Reinforced Concrete Outlets, or Monuments.
- Covers for observation wells shall be screw-cap type and clearly marked with a unique identification number, to be provided by DPU.
- The area surrounding the solid well section shall be restored in kind with the adjoining area. Any geotextile filter fabric that the observation well must penetrate shall be cut and wrapped to a height of 6 inches upward along the solid well section.
- The solid well cover shall be secured into a 1 foot-6 inch diameter concrete frame, unless the well is secured by surface restoration. The solid well section shall extend into the frame enough that a bentonite/grout seal can be placed around the well within the frame, and a solid bolt-down cap can be fitted onto the pipe end.
- See SS 1602 Earthwork for Green Infrastructure Projects for additional observation well specifications.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

- ✓ Plan view of the placement in the GI system and a section view of the proposed observation well.
- ✓ Manufacturer details including product number, materials, painting specifications, and fastener and frame details.
- ✓ Additional contractor submittal requirements outlined in SS 1600, as applicable.

Observation well designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.



SECTION

Notes

1. If observation well is located in pavement, it shall conform to DPS CMSC Section 604.
2. Cast iron well cover shall be bolt-down type and clearly marked with a unique ID number provided by DPU. Well covers shall be secured in concrete surround if not secured in pavement surface restoration. Well covers in pavement shall be flush with finished grade.
3. Area surrounding well shall be restored in kind with the adjoining area. Any geotextile filter fabric penetrated during installation shall be cut and wrapped to a height of 6" upward along the solid well section.

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DC 7.3 Observation Well

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DC 7.4—ANTI-SEEP COLLAR/UTILITY SLEEVE

DESCRIPTION: An anti-seep collar or utility sleeve is installed on utility connections or other service piping that passes through or is directly adjacent to the GI facility to protect the utility from stormwater runoff and to prevent stormwater from laterally seeping along the GI. Anti-seep collars or utility sleeves may also be installed on GI outlet piping that passes through edge of the GI facility to prevent the washout and/or bypassing of stormwater along the piping. Typical anti-seep collars consist of a collar, clamp, and/or bands connected to and surrounding a pipe to prevent seepage of stormwater runoff along the outside of the pipe as it enters and exits the GI. Utility sleeves consist of total enclosure of the utility or service piping within an impermeable material.

WHERE TO USE: Anti-seep collars shall be required at storm pipes that enter or exit a GI system. This is also applicable where a perforated pipe transitions to a solid pipe through which stormwater runoff needs to be conveyed without exfiltration from the GI facility when passing through the outside boundaries of a GI system. Utility sleeves may be used in place of anti-seep collars. Either anti-seep collars or utility sleeves may be used to protect existing utilities that bisect a GI facility. Anti-seep collars in conjunction with an impermeable barrier per DC 1.3 (Below Grade Barriers) or utility sleeves may also be used to reduce the required horizontal offset from existing sanitary sewers as approved by DPU.

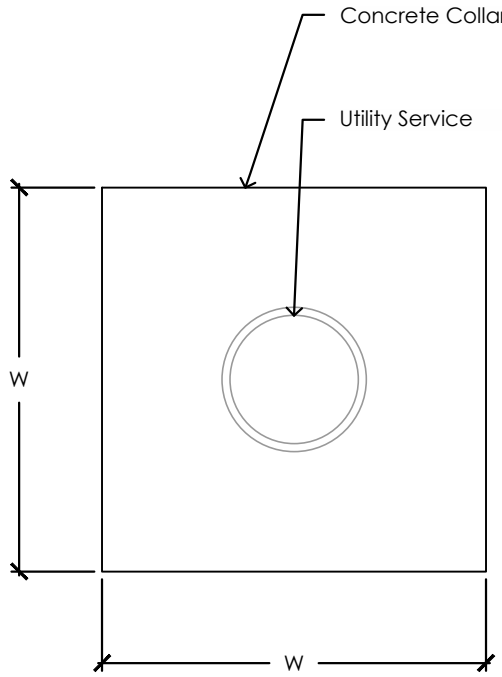
DESIGN CONSIDERATIONS:

- All anti-seep collars shall be constructed with material that provides a watertight connection to the pipe and is compatible to the pipe.
- Anti-seep collars shall be installed on the utility piping at the upstream and downstream edge of the GI. Anti-seep collars shall also be installed on all utility piping joints, bends, and splices that are within the GI.
- All anti-seep collars, fittings and seals shall be installed and tested according to manufacturer specifications for a water-tight seal.
- Utility sleeves shall be of watertight construction and sealed at each end using non-shrink grout or sealant. Utility sleeves shall include installation of anti-seep collars at both the upstream and downstream end of the sleeve.
- Utilities that have in-place geotextiles or liners that interfere with the anti-seep collars may be minimally cut to allow for the collar and then sealed within the external sheets of the anti-seep collar.
- Hydrophilic water stops may be an allowable substitute for anti-seep collars for situations where the utility or other piping passes through a concrete structure, with approval from DPU.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

- ✓ Detail of proposed configuration and details of all proposed sleeves and collars.
- ✓ Manufacturer details including product number, materials, painting specifications, and fastener and frame details.
- ✓ Additional contractor submittal requirements outlined in SS 1600, as applicable.

Anti-seep collar/utility sleeve designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.



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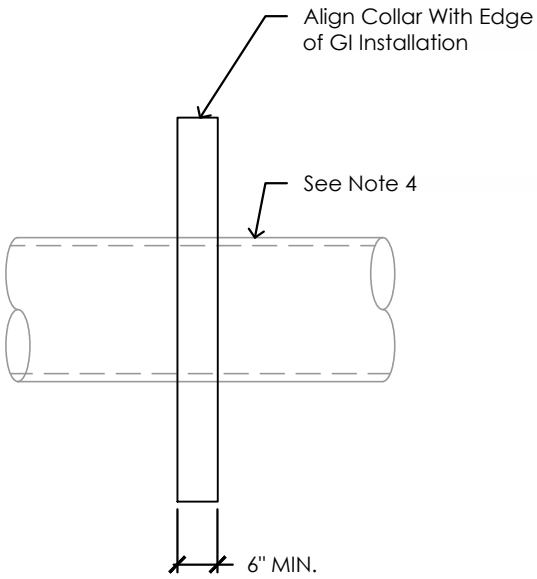

SECTION

Notes

1. Anti-seep collar shall be used in conjunction with utility sleeve.
2. 'W' shall be 3' for pipes 12" and smaller. Refer to ODOT Std. Dwg WQ-1.2 for size requirements for larger pipes.
3. Collar shall be constructed of 4000 psi compressive strength concrete or other material approved by the City.
4. Pipe material and sizing will vary by function.

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DC 7.4 Anti-Seep Collar

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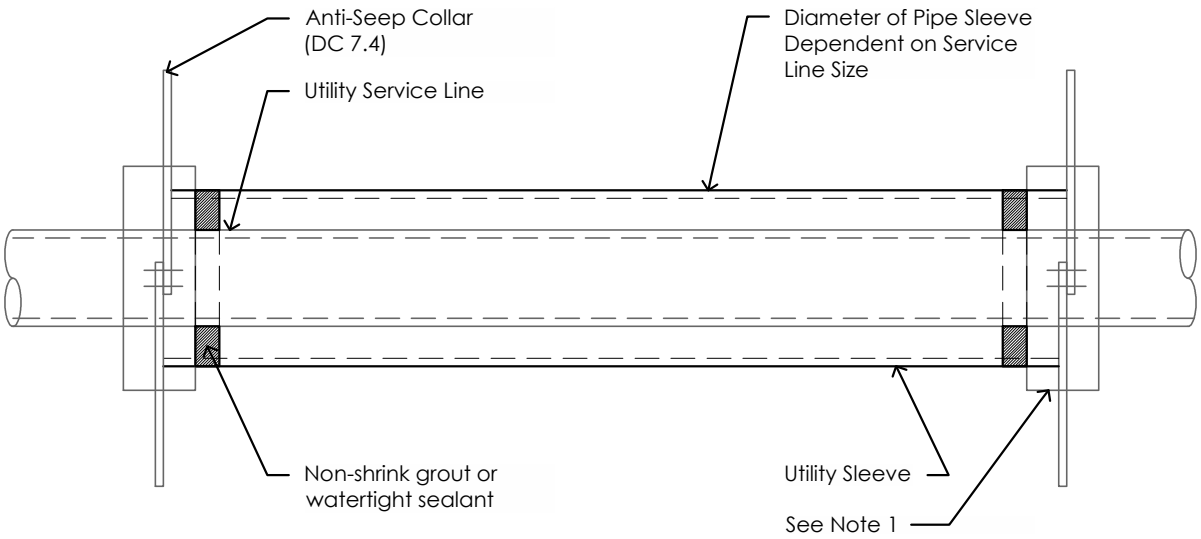

Notes

1. Seal surface of utility, utility sleeve and anti-seep collar (if necessary) with non-shrink grout or other sealant.

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DC 7.4 Utility Sleeve

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8—OUTLETS AND OVERFLOWS

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8.1—RETROFIT EXISTING STRUCTURES FOR STORMWATER OUTLET

8.2—AT GRADE OUTLET

8.3—WEIR

DESIGN COMPONENTS

DC 8.1—RETROFIT EXISTING STRUCTURES FOR STORMWATER OUTLET

DESCRIPTION: The retrofit of an existing storm structure for outlet purposes includes making modifications to allow the overflow from a Green Infrastructure (GI) facility to re-enter the existing sewer at the downstream end of the GI system via an existing inlet, catch basin or manhole.

Overflow (Source: CDM Smith, designed by others)

WHERE TO USE: An existing curb inlet, catch basin or manhole shall be retrofitted in situations where the existing structure is in good working condition and at a location adjacent to a GI System, or where specified by the City of Columbus Department of Public Utilities (DPU).

DESIGN CONSIDERATIONS:

- An assessment of existing conditions of the inlet, catch basin or manhole shall be conducted prior to a retrofit. Connections to structures of sub-standard condition will not be allowed, as determined by DPU.
- Confirm that additional stormwater flow from the GI will not interfere with operation of existing structure.
- All connection pipes shall be core-drilled, and the connection pipe to the existing manhole shall be grouted and include a waterstop with HDPE installations. An anti-seep collar should be considered for installation at the edge of the GI facility for outlet piping that passes through non-GI areas before connection to the outlet structure.
- All materials and installation shall comply with requirements contained in the CMSC 604 and 901.
- Refer to DPU standard drawings (sewer) for structure specific standard details.
- DPU shall provide preliminary determination that the condition and capacity of the inlet/catch basin/manhole is sufficient for connection to the GI facility.
- Retrofits of existing structures must not negatively impact the existing conveyance system level of service.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

- ✓ Detail of connection to the existing inlet/manhole/catch basin. Plan and cross-sectional view of retrofit, including key elevations for new pipe penetrations.
- ✓ A plan view of the GI facility showing all overflow pathways and elevations, which confirms that overflows are maintained on public property and do not flow onto private property or into any structure.
- ✓ City of Columbus Utility Contractor License as required in Director's Rule and Regulation No. 09-05 for retrofit work.
- ✓ Additional contractor submittal requirements outlined in SS 1600, CMSC 604, or 901, as applicable.

Retrofit designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

DC 8.2—AT GRADE OUTLET

DESCRIPTION: At-grade outlets are used to provide for the safe release of excess flow greater than the water quality volumes from a Green Infrastructure (GI) facility. At grade outlets include curb openings with or without side flares. Curb openings with vertical sides are used in existing curbs to allow stormwater to exit a GI facility located directly behind the back of curb. A curb with side flares is a curb poured with a tapered opening to allow stormwater to exit a GI system. All at-grade outlets must be higher than the GI surface to prevent short circuiting of the GI facility.

WHERE TO USE: At grade outlets shall be required in applications where it is necessary to allow stormwater to exit the GI facility to the street as an overflow mechanism, or where specified by the City of Columbus Department of Public Utilities (DPU).

DESIGN CONSIDERATIONS:

- Curb cuts must be saw-cut such that all edges are cut square and clean. All exposed edges must be beveled and debris must be removed.
- Curb cuts shall conform to CMSC 202.05 – Pavement, Walks, Steps, Gutters, Curbs, or Traffic Dividers Removed.
- Curb openings with side flares shall conform to DPS CMSC 609.04 – Cast-in-place Concrete Curb and Combination Curb and Gutter.
- For curb cuts installed on the street side of a GI facility, the use of a wheel guard should be considered for preventing the unintentional movement of the vehicle into the curb cut.

Curb Cut Outlet (Source: CDM Smith, design by others)

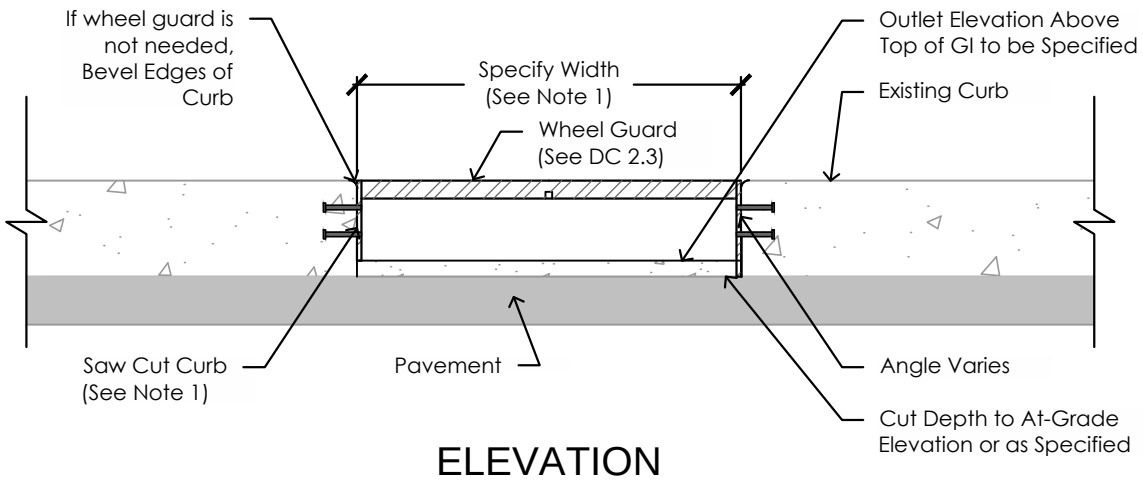
DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

✓ Plan and detail view of curb opening including curb elevations, opening size, and base materials with specified depths.

✓ A plan view of the GI facility showing all overflow pathways and elevations that confirm that overflows are maintained on public property and do not flow onto private property or into any structure.

✓ Additional contractor submittal requirements outlined in SS 1600, CMSC 202 or 609, as applicable.

At grade outlet designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.



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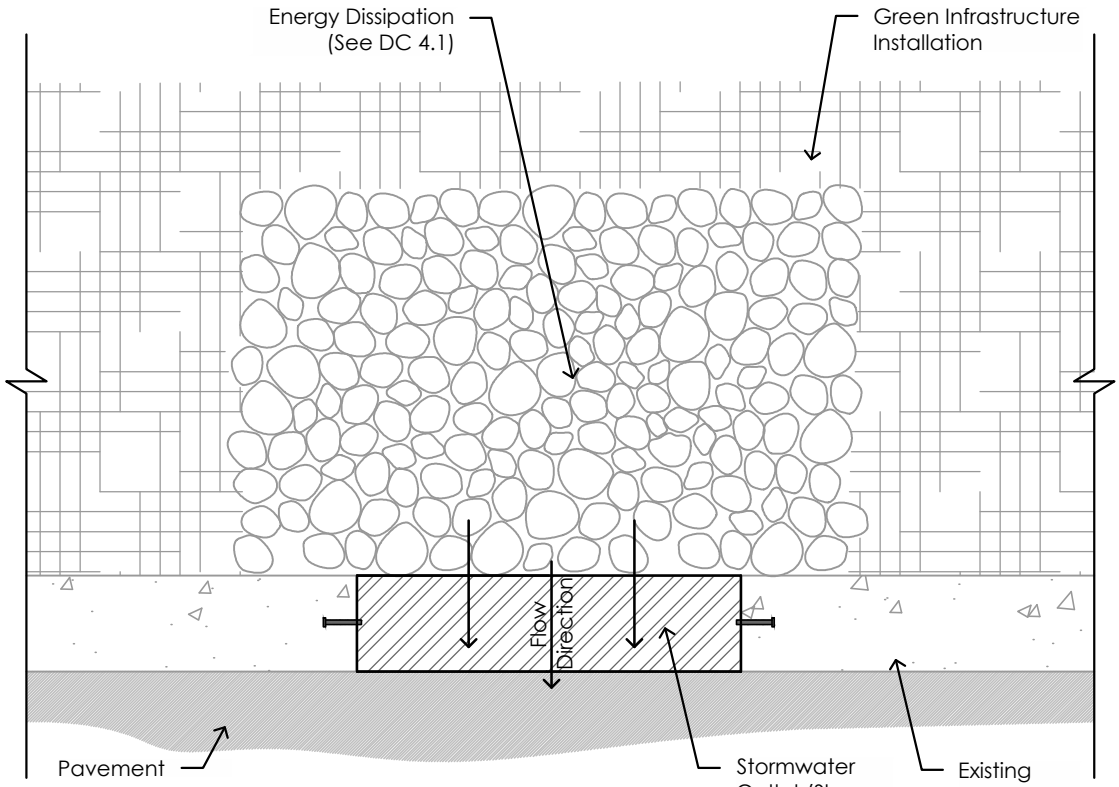

PLAN

Notes

1. A curb cut outlet is a cut into an existing curb. Width and angle of curb cut varies based on site and stormwater release requirements.
2. Curb cuts must be saw-cut such that all edges are square and edges beveled.
3. Curb cuts shall conform to CMSC 202.05 - Pavement, walks, steps, gutters, curbs, or traffic dividers removed.
4. Curb cuts on the street side of a GI facility shall use a wheel guard (DC 2.3) to prevent the unintentional movement of the vehicle into the curb cut.

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DC 8.2 At Grade Outlet
Curb Cut

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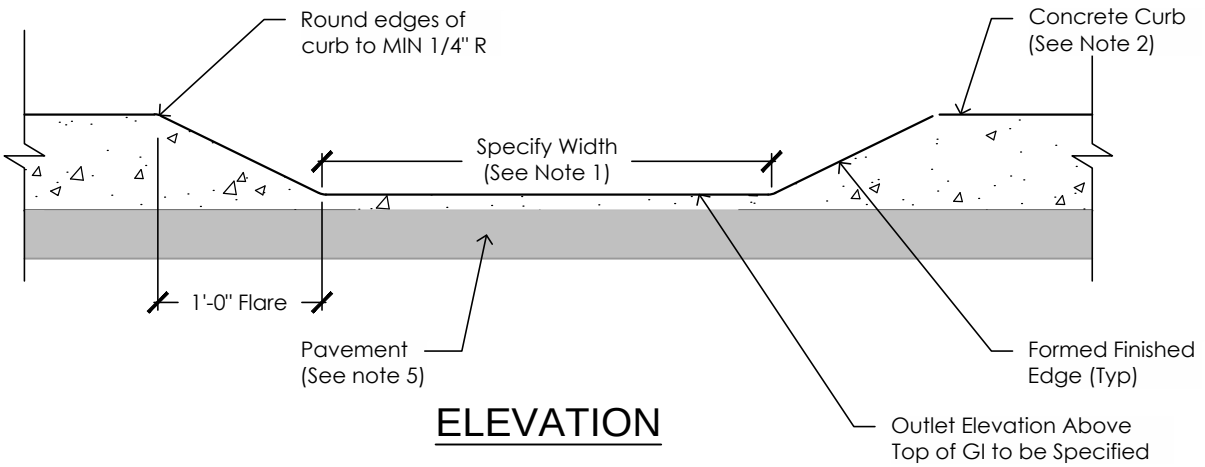

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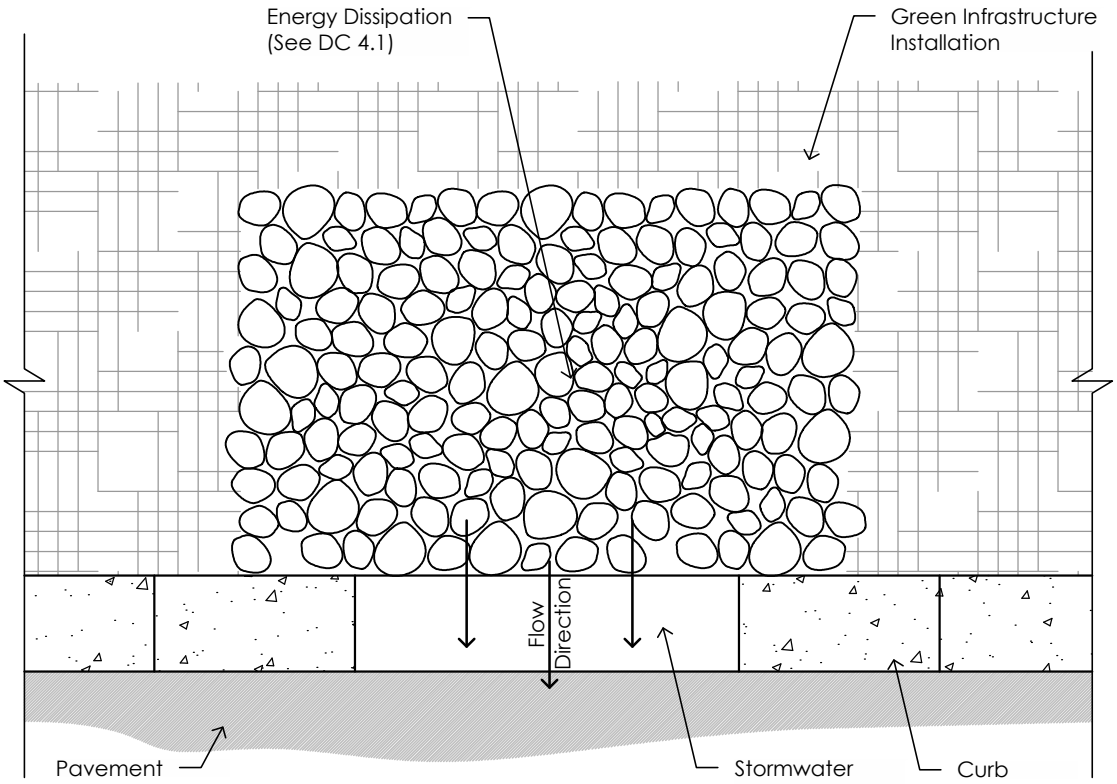

PLAN

Notes

1. A flared curb is a curb poured in-place with a tapered opening. Width and angle of curb cut vary based on site and stormwater release requirements.
2. Concrete curb shall be P.C. Concrete Class "C". All exposed surfaces shall have a brushed finish.
3. Flared curb shall transition to typical curb section per STD DWG 2000, 2010, or 2020.
4. Flared curb shall follow CMSC Section 609.04.
5. Horizontal surface must have positive slope from GI facility towards the gutter.

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DC 8.2 At Grade Outlet

Flared Curb Outlet

March 2017

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DC 8.3—WEIR

DESCRIPTION: The purpose of an overflow weir is to provide for the safe release of excess flow greater than the design volumes from a Green Infrastructure (GI) facility.

WHERE TO USE: A weir shall be required in applications where it is necessary to control stormwater runoff in the GI facility by releasing excess water at a specified elevation into the street, to a second tier GI system, or existing storm system, or where specified by the City of Columbus Department of Public Utilities (DPU).

DESIGN CONSIDERATIONS:

- The weir shall be sized to convey excess water from the GI system above a specified ponded depth. This will maximize the effectiveness of the GI facility and manage excess flow back to the existing sewer system.
- Weirs used in a second-tier system should be sized to optimize the multi-tier GI system including the inlet and outlet conditions.
- The weir may be integrated with the surrounding embankment or barrier (i.e. curb) and must be strong enough to withstand the expected forces for the design storm specified and the expected velocities as in DC 4.1 (Energy Dissipation).

Weir (Source: CDM Smith, design by others)

- Weirs may be the top of berm at the edge of a GI facility or be a separate structure, such as a wooden weir, rock dam, or concrete curb/reveal. In some instances, a curb cut with a shallow notch located downstream of the GI facility may act as a weir.
- The weir should be located at a low point within the GI facility and be located adjacent to a roadway, swale, gutter, ditch, etc. that has positive drainage away from the GI facility and towards a downstream storm sewer drainage system.
- The top of the weir must be located at or above the GI facility treatment volume level.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

- ✓ Plan and section view of weir including material, elevations, dimensions, and base materials with specified depths.
- ✓ A plan view of the GI facility showing all overflow pathways and elevations that confirm that overflows are maintained on public property and do not flow onto private property or into any structure.
- ✓ Additional contractor submittal requirements outlined in SS 1600, as applicable.

Weir designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

9—MONITORING

9.1—MONITORING STATION

DC 9.1 MONITORING STATIONS

DESCRIPTION: Monitoring equipment can be positioned in the outlet piping of a GI facility to create features that aid in the flow monitoring or sampling of stormwater discharges. Not all GI facilities are required to install these features; monitoring stations should be installed those GI facilities that have been designated for post-construction monitoring. The purpose of this guideline is to establish the features of the monitoring station that must be constructed as part of a GI facility.

WHERE TO USE: Monitoring components should be installed on inlet, outlet or overflow piping of the GI for stormwater inflow and outflow monitoring. The type of monitoring station selected will be based on site conditions. Sites with sufficient depth should install a manhole for the purpose of housing the equipment and providing access to sensors and sample collection devices. The equipment should be housed in an above-ground or below ground shelter at sites with insufficient depth. PVC piping should be installed to house cable connections between the equipment shelter and the point of flow monitoring and/or data collection. An oversized observation well may be installed to aid in the installation of the sensors and sample collection devices.

DESIGN CONSIDERATIONS:

Monitoring (Photo Source: CDM Smith, Designed by Others

- An assessment of existing conditions of the inlet, catch basin or manhole shall be conducted prior to creating a connection between a monitoring station and existing piping, catch basin or manhole. Connections to structures of sub-standard condition will not be allowed, as determined by DPU.
- A minimum depth of three feet is required for the installation of a manhole-style monitoring station.
- Monitoring manholes and other access portals should be installed with locking lids to prevent equipment vandalism.
- Monitoring stations must be located such that equipment is accessible for the purpose of maintenance and data collection. Installation at the edge of a GI facility is allowable only if the monitoring station does not decrease the required storage capacity.
- Below ground manholes or vaults cannot be located in a traffic lane, but are allowable in a parking lane, tree lawn, or sidewalk. Below ground vaults located within the ROW must be based on current DPU allowable structures, such as a Type E manhole (STD DWG AA-S104), or a medium duty traffic control/electrical pullbox (STD DWG 4021) or other vault approved for below ground installation within the City of Columbus Right-of-Way.
- Above ground monitoring stations must be installed in tree lawns within the ROW.
- All connection pipes shall be core-drilled and have a minimum diameter of 4 inches. The connection pipe to the existing manhole shall be grouted and include a waterstop. An anti-seep collar shall be installed at the edge of the GI facility.

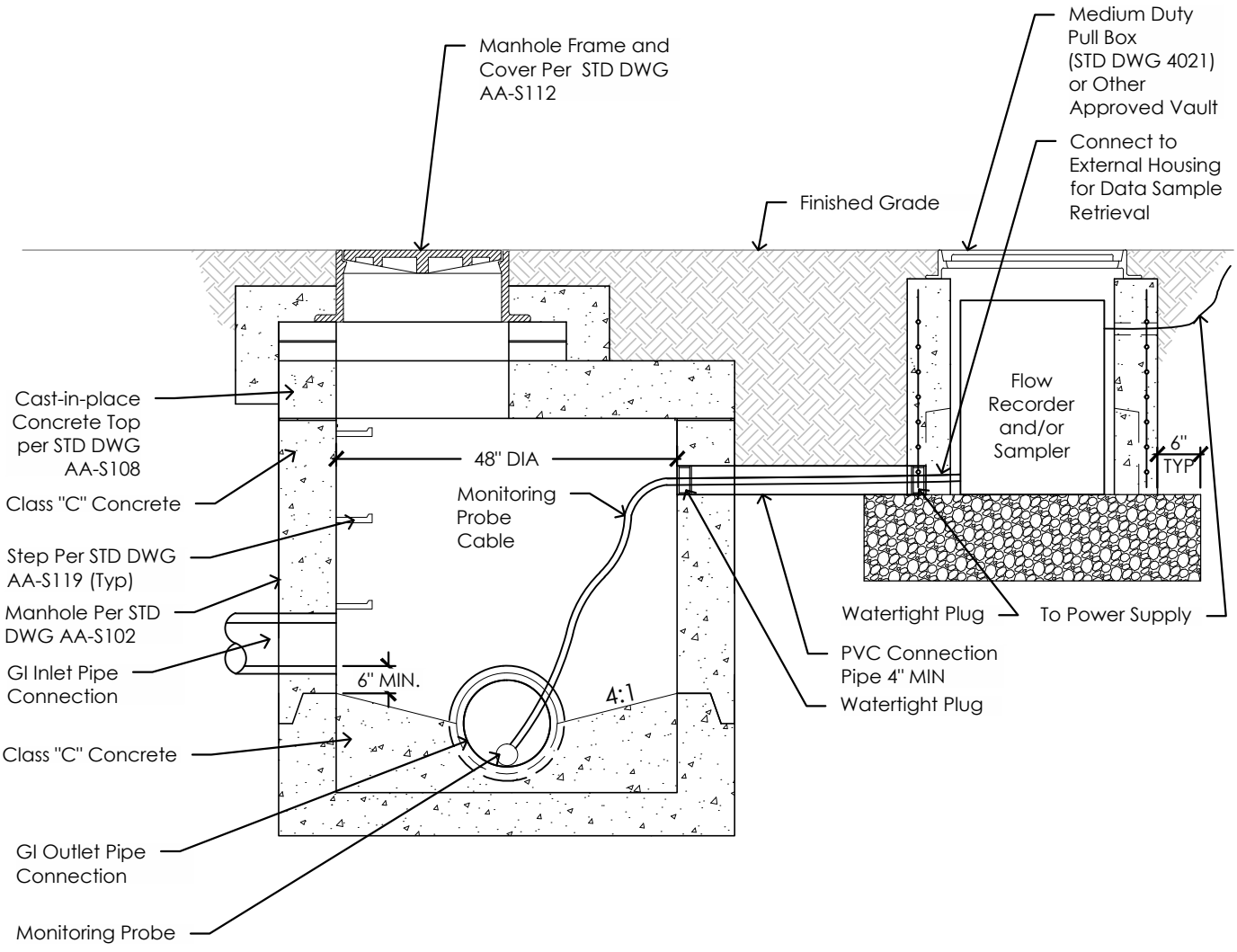
- Bedding and granular backfill shall consist of durable AASHTO no. 57 aggregate in accordance with CMSC 703.01.
- Provide fittings conforming to the applicable CMSC, ASTM, AASHTO, and manufacturer's specifications.
- Prefabricated monitoring manholes may be reviewed and approved by the DPU on a case-by-case basis.
- When monitoring pipe inflow, use flumes or weirs for measurements and avoid use of acoustic devices for better accuracy and ease of maintenance, if possible.
- Monitoring sites should include instruments for recording precipitation and other meteorological data at the site, such as a rain gauge, radar, or satellite, or a combination of these measures.
- Observation wells should be nested, with at least one screened in the GI media and one screened below the GI. If possible, include wells upgradient and downgradient from the GI to provide data for groundwater mounding that is occurring.
- Power supply during cold temperatures should be taken into consideration to avoid equipment freezing or failure.
- Stations shall be placed in accordance with the Urban Lateral Offsets per ODOT L&D Manual Volume I Section 600.2.2 and operational offsets per 600.2.3. In addition, the City of Columbus requires a 2.5-feet minimum operational offset if on-street parking is permitted adjacent to the barrier.

DESIGN SUBMITTAL REQUIREMENTS CHECKLIST:

- ✓ Monitoring station detail.
- ✓ Monitoring plans, including type of monitoring being implemented, frequency of monitoring, and responsible parties for completion of monitoring activities.
- ✓ Plan view of monitoring station placement, including offset dimensions.
- ✓ Cross sectional view of monitoring station, including details of all materials and fittings.
- ✓ Manufacturer details including product number, materials, and frame details.

Monitoring station designs and specifications outside the parameters of this guideline shall be submitted for review and approval to the City of Columbus Department of Public Utilities.

Monitoring (Photo Source: CDM Smith, Designed by Others



Notes

1. Grout all openings in pre-cast structures per CMS 604.06 and CMS 602.03.
2. Flow Recorder, Sampler, and Typical Monitoring Probe shown for illustrative purposes only.

THE CITY OF COLUMBUS
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DC 9.1 Monitoring Station Manhole

External Data Retrieval Housing

March 2017

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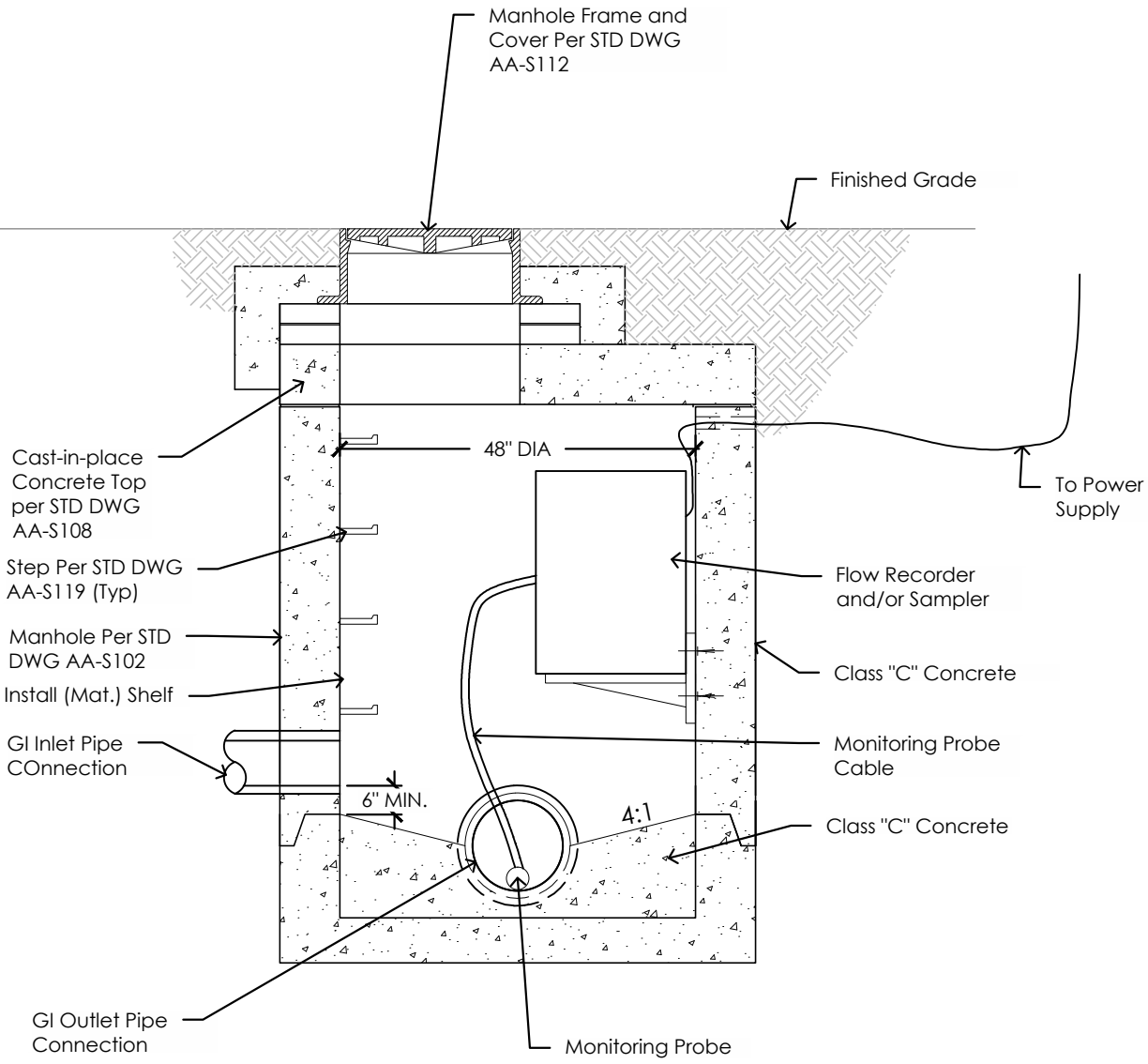
Clean streams. Strong neighborhoods.



Notes

1. Grout all openings in pre-cast structures per CMS 604.06 and CMS 602.03.
2. Flow Recorder, Sampler, and Typical Monitoring Probe shown for illustrative purposes only.

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DC 9.1 Monitoring Station Manhole

Internal Data Retrieval Housing

March 2017

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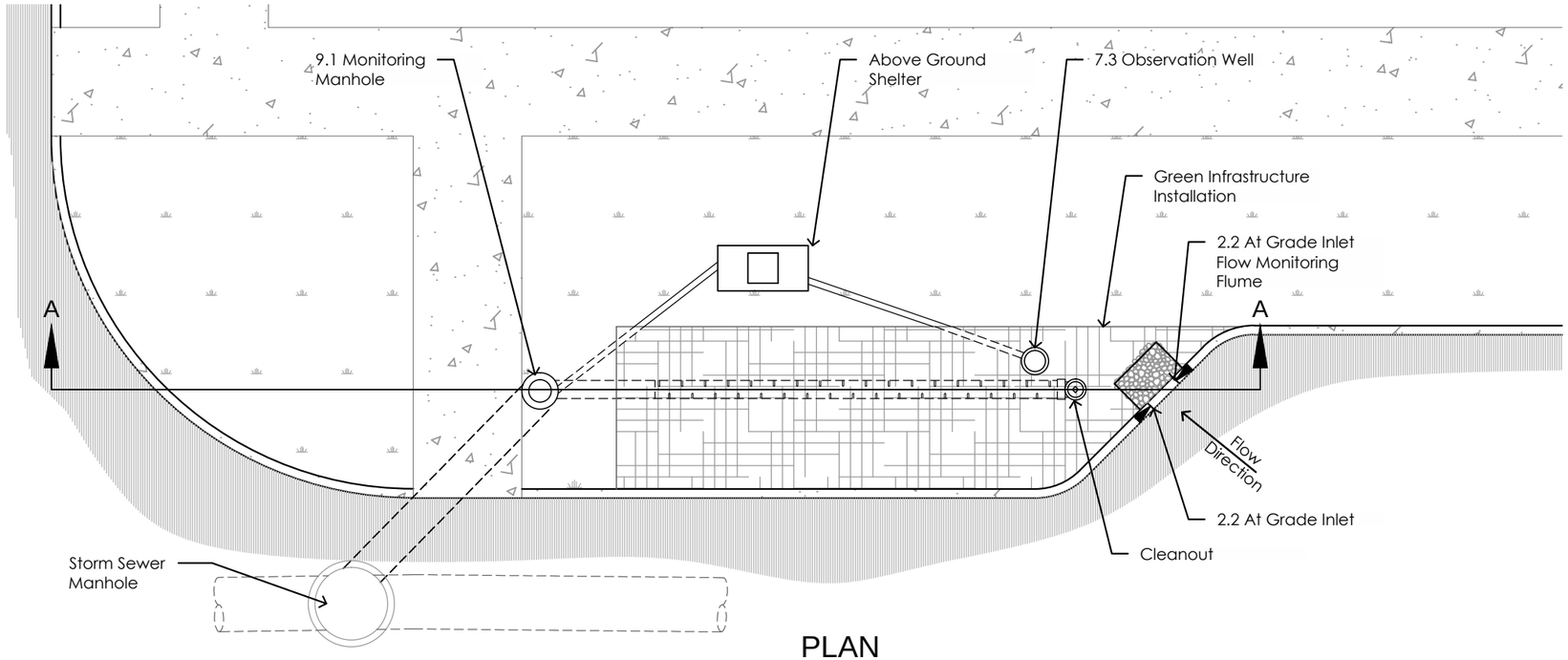
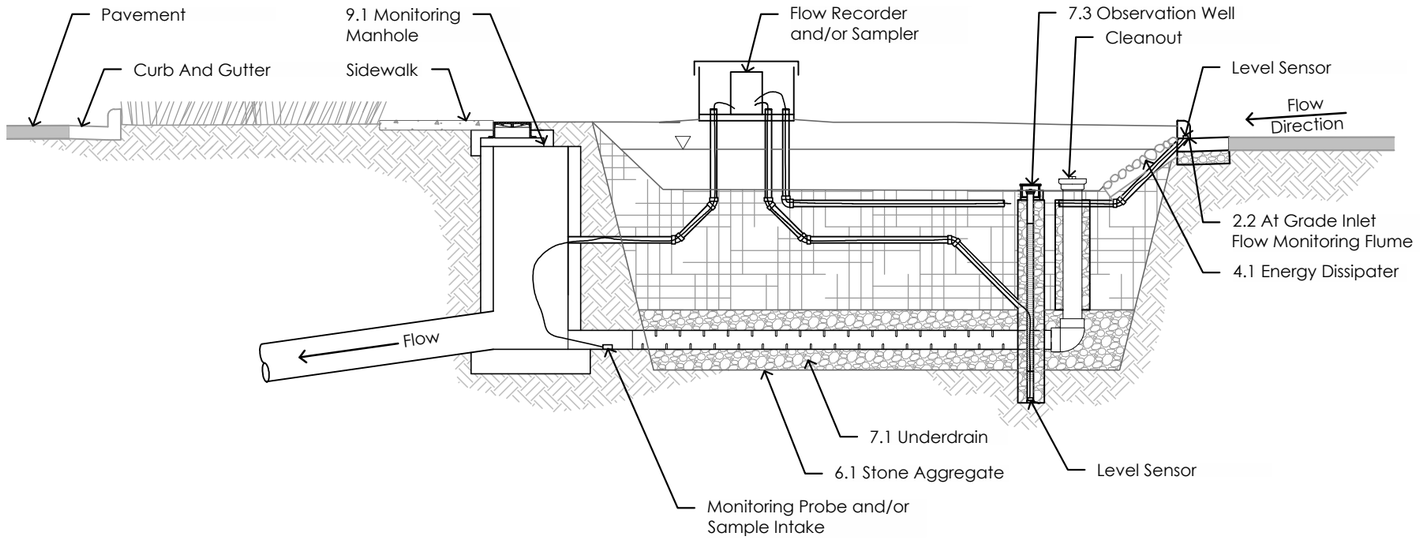


PLAN



SECTION A-A

Notes

1. Flow Recorder, Sampler, Level Sensor and Typical Monitoring Probe shown for illustrative purposes only.
2. Above ground equipment box shall be provided with secure clasp and lock.
3. Above grade shelters must be no taller than 2.5 feet when located within the Sight Distance Triangle as determined by the procedures set in the City of Columbus Sight Distance at Intersections Policy, January 1, 2014.
4. Stations shall be placed in accordance with the Urban Lateral Offsets per ODOT L&D Manual Volume I Section 600.2.2 and operational offsets per 600.2.3. In addition, the City of Columbus requires a 2.5-feet minimum operational offset if on-street parking is permitted adjacent to the barrier.

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DEPARTMENT OF PUBLIC UTILITIES

N.T.S

DC 9.2 Monitoring Station Placement Diagram

Above Grade Equipment Shelter

March 2017

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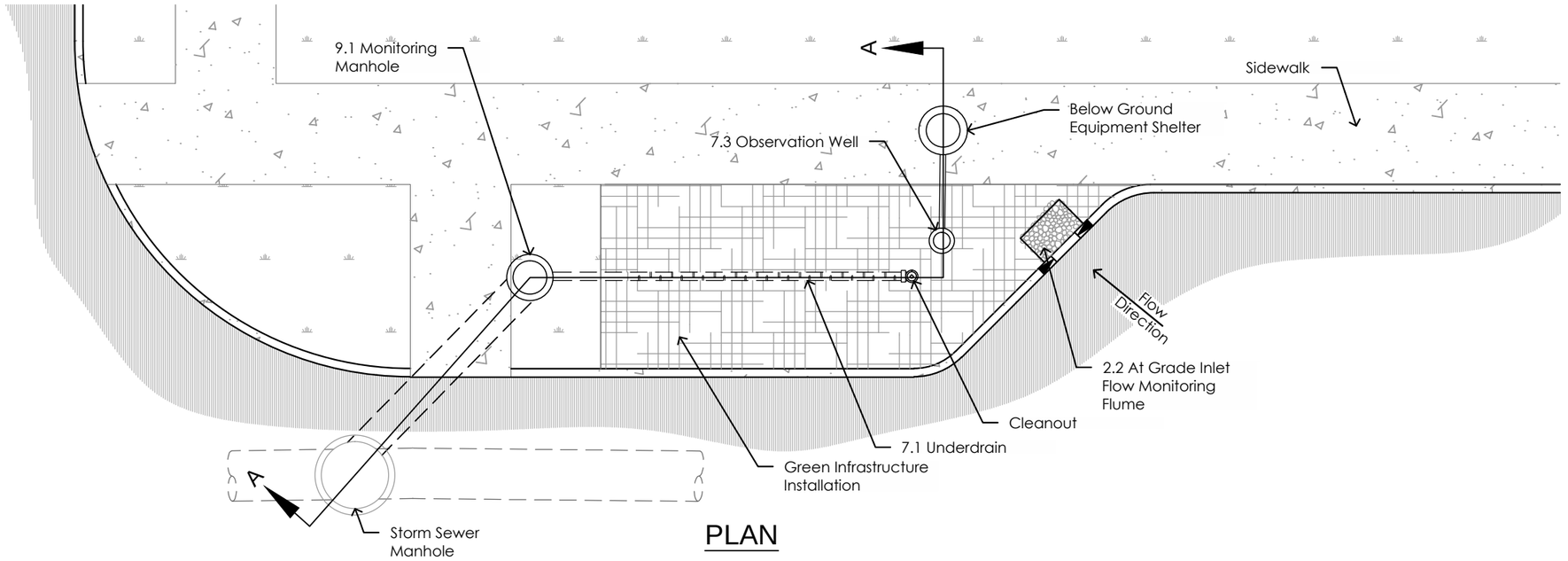
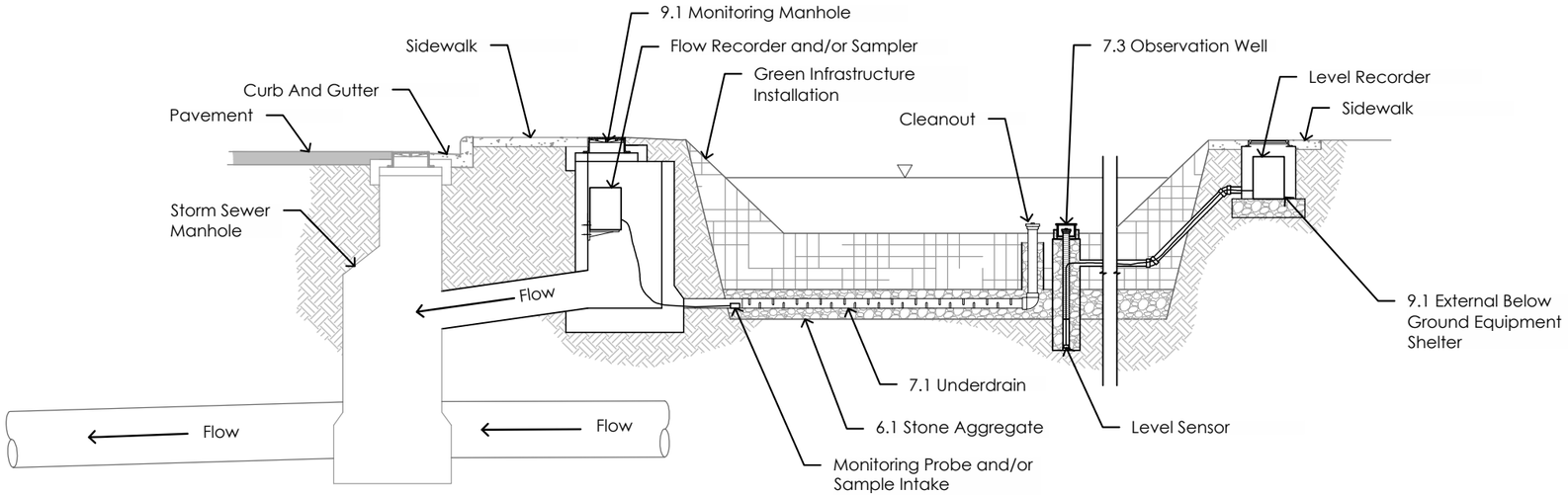


PLAN



SECTION A-A

Notes

1. Flow Recorder, Sampler, Level Sensor and Typical Monitoring Probe shown for illustrative purposes only.
2. Below ground monitoring manhole and vaults shall be provided with locking lids.

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N.T.S

DRAFT

DC 9.2 Monitoring Station Placement Diagram

Below Grade Equipment Shelter

March 2017

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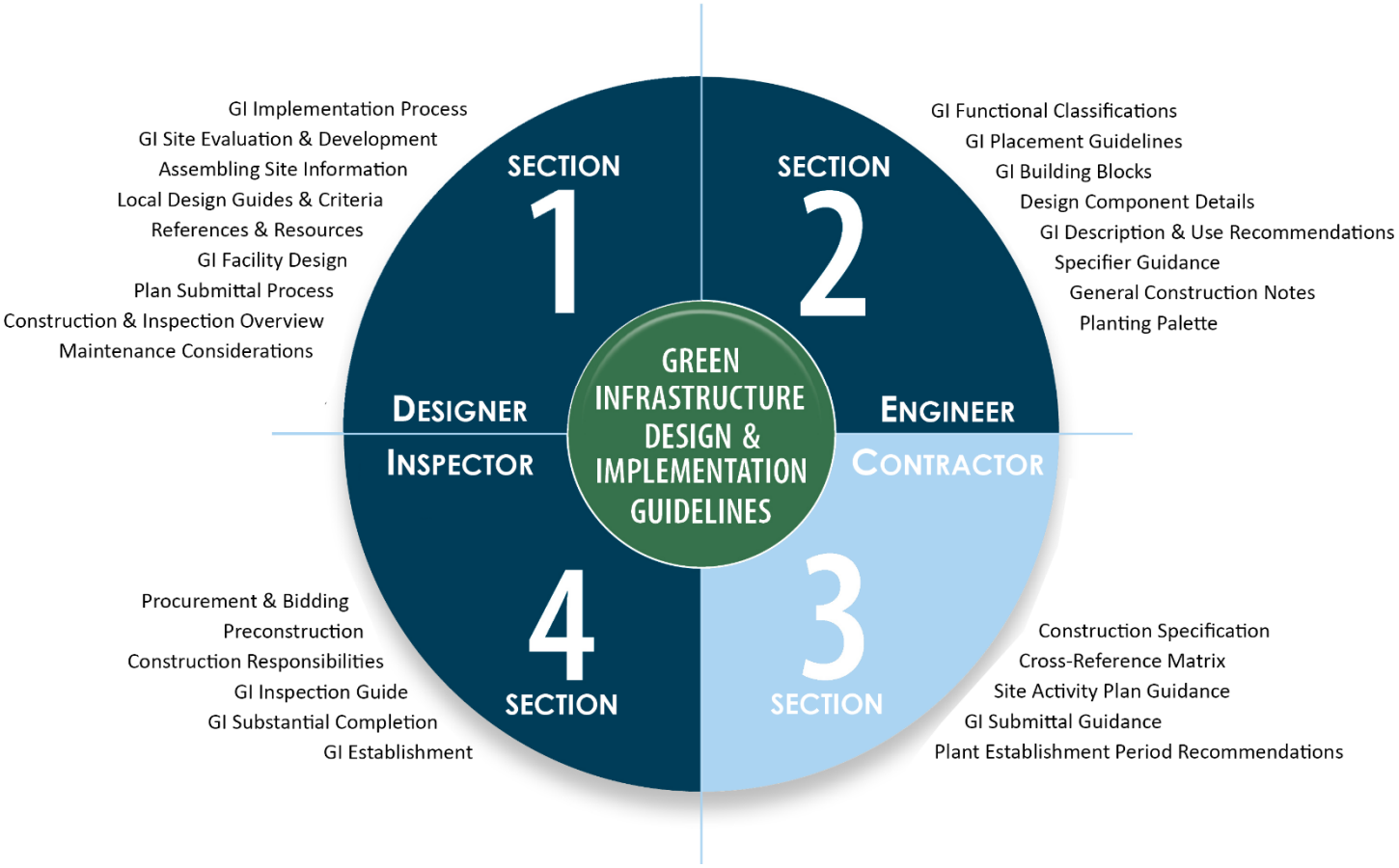
SECTION 3

GREEN INFRASTRUCTURE CONSTRUCTION

GI Audience & Resource Content Guide



GREEN INFRASTRUCTURE CONSTRUCTION

Why the Construction Approach is Important to the Success of Green Infrastructure:

This section of the *Green Infrastructure Design Implementation Guidelines* provides critical sequencing and construction technique guidance for contractors to follow in implementing BluePrint Columbus projects, as well as for all GI installed throughout Columbus. Section 3 provides the necessary planning tools for contractors to use to help identify key components of GI construction in order to prevent unnecessary problems during construction. Each of these tools are a quick reference to City of Columbus requirements.

There are many parallels between traditional construction and GI construction in public rights-of-way, because the features are often the same: pavements, curbing, sidewalks, green spaces, trees, and plantings. The primary difference is that traditional infrastructure in public rights-of-way is designed to rapidly drain the runoff away from the roadway, while GI uses permeable and vegetated surfaces to slow down and reduce runoff.

Contractors have found that applying traditional infrastructure construction approaches to GI can lead to problems such as water ponding, frequent repairs, additional maintenance, and even facility failure. Successful GI involves the following key principles, summarized here and described in more detail in this section:

- Early evaluation by the contractor to develop staging and construction techniques that take into account utility conflicts, site constraints, and existing trees, and accommodate public access to buildings, sidewalks, and streets.
- Establishing a construction sequence and schedule that minimizes the period of excavation and grading, employs erosion and sediment controls during soil disturbance, stabilizes the site as soon as feasible, and meets the scheduling requirements of the contract.
- Directing runoff away from or around infiltration areas during construction.
- Providing field staff (laborers, supervisors, inspectors, and equipment operators) educated on the intent of GI.
- Proper selection, inspection, and storage of materials, including plants, geotextiles, soils, etc.
- Use of equipment that does not compact or improperly mix the soils.
- Management of runoff during construction through implementation of proper dewatering or redirection of runoff to prevent degradation of the GI facility before it is fully constructed.

SPECIFIC GUIDANCE FOR CONTRACTORS

CITY OF COLUMBUS SUPPLEMENTAL SPECIFICATIONS AND SPECIAL PROVISIONS FOR GREEN INFRASTRUCTURE PROJECTS

Green Infrastructure requires the installation of special materials and the utilization of specific construction practices that are necessary for the successful infiltration of stormwater runoff. For this reason, Supplemental specifications and special provisions specific to GI have also been developed for the City of Columbus and are applicable to the design and construction of GI components. GI-specific supplemental specifications include the following:

SUPPLEMENTAL SPECIFICATIONS

SS 1600 Green Infrastructure Submittal Requirements

SS 1601 Site Activity Plan for Projects Containing Green Infrastructure Facilities

SS 1602 Earthwork for Green Infrastructure Projects

SS 1603 Tree and Vegetative Protection for Green Infrastructure Projects

SS 1604 Bioretention Soils for Green Infrastructure Projects

SS 1605 *Aggregates for Permeable Pavements - Reserved*

SS 1606 *Permeable Clay Brick Pavers - Reserved*

SS 1607 *Permeable Concrete Pavers - Reserved*

SS 1608 *Permeable Concrete - Reserved*

SS 1609 Green Infrastructure Establishment Activities

SS 1610 Underdrain and Aggregates for Green Infrastructure Facilities

SPECIAL PROVISIONS

SP-20 Period of Establishment Year 2, Reduction of Performance Bond

SP-21 Green Infrastructure Period of Establishment Season 2 Retainage

SP-22 Permeable Clay Brick Pavers and Permeable Concrete Pavers

SP-23 Permeable Concrete

SP-24 Green Infrastructure Period of Establishment Season 1, Green Infrastructure Period of Establishment Season 2, and Warranty

These should be used in conjunction with the existing City of Columbus CMSC and standard drawings, and a comprehensive list of general notes available from DOSD.

CMSC / SUPPLEMENTAL SPECIFICATION / DESIGN COMPONENT CROSS REFERENCE MATRIX

Appendix C-1 contains a reference of the Columbus Department of Public Utilities (DPU) and Department of Public Services (DPS) specifications that apply to the Green Infrastructure components contained in this Guide. Each design component contained in Section 2 is cross-referenced with existing CMSC and/or Green Infrastructure Supplemental Specifications.

Instructions for Contractors:

- Contractors should use this matrix to determine the pre-existing Columbus specifications that apply to each unique GI component.
- Drawings and contract documents prepared for a specific project may include additional specifications that are not referenced on this matrix. The matrix is intended to supplement the information provided in the Contract Documents.

SITE ACTIVITY PLAN

SS 1601, Site Activity Plans requires contractors to prepare and package the Site Activity Plan and to check that all the information required by the Contract Documents has been included. The table below is a quick summary of the detailed information that is required for each project specific Site Activity Plan.

Instructions for Contractors:

- The contractor shall use the Site Activity Plan to demonstrate an understanding of the contract documents and to show that the work has been thoroughly planned.
- When preparing the Site Activity Plan, special attention should be paid to sequencing, protecting, and constructing green infrastructure facilities which may require non-traditional construction methods, special materials, or experience outside of the contractor's typical work. Each of these items should be reflected in the various components of the Plan.
- Contractors are required to create a Site Activity Plan that details the project's schedule and shows coordination between overlapping activities that can occur in the small footprint of GI construction areas.

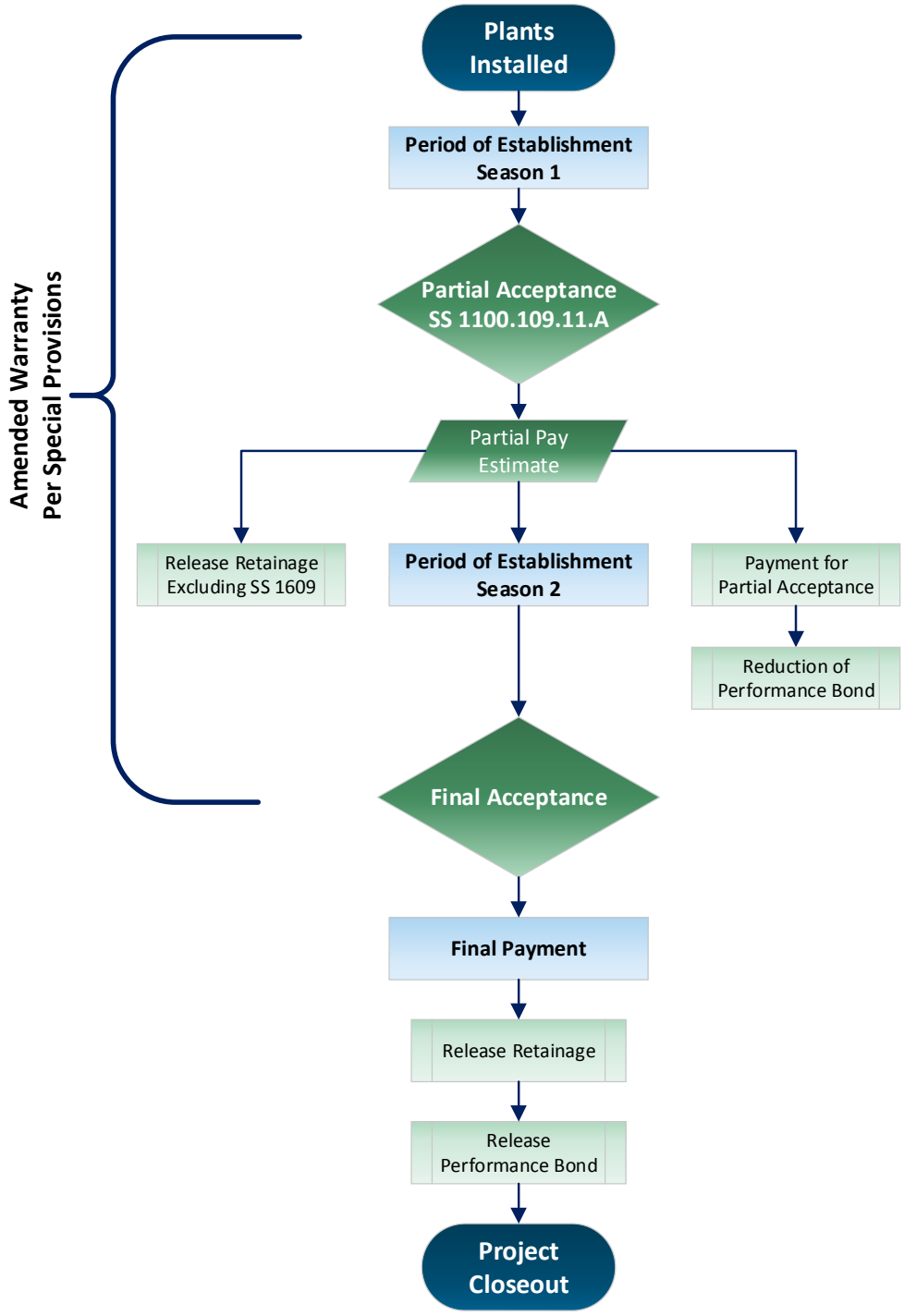
SITE ACTIVITY PLANS FOR GREEN INFRASTRUCTURE REQUIRED CONTENT		
SITE ACTIVITY PLAN	**REQUIRED ADDITIONAL CONTENT FOR GI PROJECTS**	**SPECIFICATION REFERENCE**
Construction Schedule	GI material procurement schedule, including planting materials, lead times, and storage.	1601.02 CMSC 108.03
	Installation and completion schedule for all components of GI facility	
	Diversion of flow timeline	
	Plant establishment schedule	
	Site stabilization schedule	
Runoff Management Plan	Erosion and sediment control per CSMC 207	1601.03 CMSC 207
	Approach to runoff management that does not use the GI facility for runoff collection or storage	
	Techniques to promptly remove sedimentation and re-scarify subgrade	
	Approach to ensure that contributing drainage areas are stabilized before installing GI components	
	Statement acknowledging that the engineer's authorization required before introducing runoff into completed GI facility	
Site Access Plan	Illustration of access for non-construction pedestrian, bicycle, and vehicle traffic to and around site	1601.04 1603 CMSC 105, 106, 614, 615
	Illustration of access for construction vehicles, equipment, materials to site	
	Map of haul roads for heavy and large equipment access to site	
	Statement acknowledging that permanent roads with permeable pavers cannot be used for haul roads	
	Contractor's plan for de-compacting area within GI footprint, where authorized	
	Description and map of material delivery and storage procedures	
Site Utilization Plan	Description of protection of open areas	1601.05 1603 CMSC 105, 106, 107, 207
	Description of private property protection	
	Description of protection of structures and utilities	
	Description of tree and vegetation protection	
	Description of how flows in sewers and water courses will be maintained during construction	
	Map of location of material storage areas, laydown areas, and temporary facilities	
	Description of protection of stored materials	
	Description of material disposal methods	
	Description of equipment and materials used to backfill that prevent compaction of subgrade or backfill materials if approved for use within footprint of GI Facility	

SUBMITTALS LIST

SS 1600 compiles all the submittals required by the various GI supplemental specifications into a single location. This specification can be referenced to plan ahead for the required materials, procedural, and testing submittals that will be required as specified in the various GI supplemental specifications. The submittals list is intended to supplement the information provided in and required by the Contract Documents. In the event that a Supplemental Specification for Green Infrastructure conflicts with this Section, then the Supplemental Specification will take precedence.

PLANT ESTABLISHMENT PERIOD

SS 1609 details the activities and procedures that the Contractor must follow after Green Infrastructure (GI) components have been completed, and shall be in effect until the project has received Final Acceptance by the City. Activities include, but are not limited to, plant establishment, temporary protections, site stabilization and trash collection, repair/replacement, and inspections/reporting. In addition to the establishment requirements included in CMSC 661 and SS 1609, the special provisions will contain changes to the warranty, retainage, and performance bond requirements and procedures. The following flow chart illustrates, in simplified form, the changes made to these items within the contract documents.



Instructions for Contractors:

- Contractors are responsible for maintaining the GI facility and establishing plant material through the end of the plant establishment period. This may include activities beyond the plant establishment period, as outlined in project specific contract documents.

A quick reference of required activities is listed below:

Monthly Activity (April through November)

- Watering (weekly)
- Excess sediment removal
- Trash removal and disposal
- Leaf and tree debris removal and disposal
- Weed removal
- Removal and replacement of dead and diseased plants
- Plant stakes and guys re-set or replaced
- Detailed monthly report of activities submitted to City

Quarterly Inspection Item

- Inspection of plants by certified arborist

Annual and Semi-Annual Inspection Items

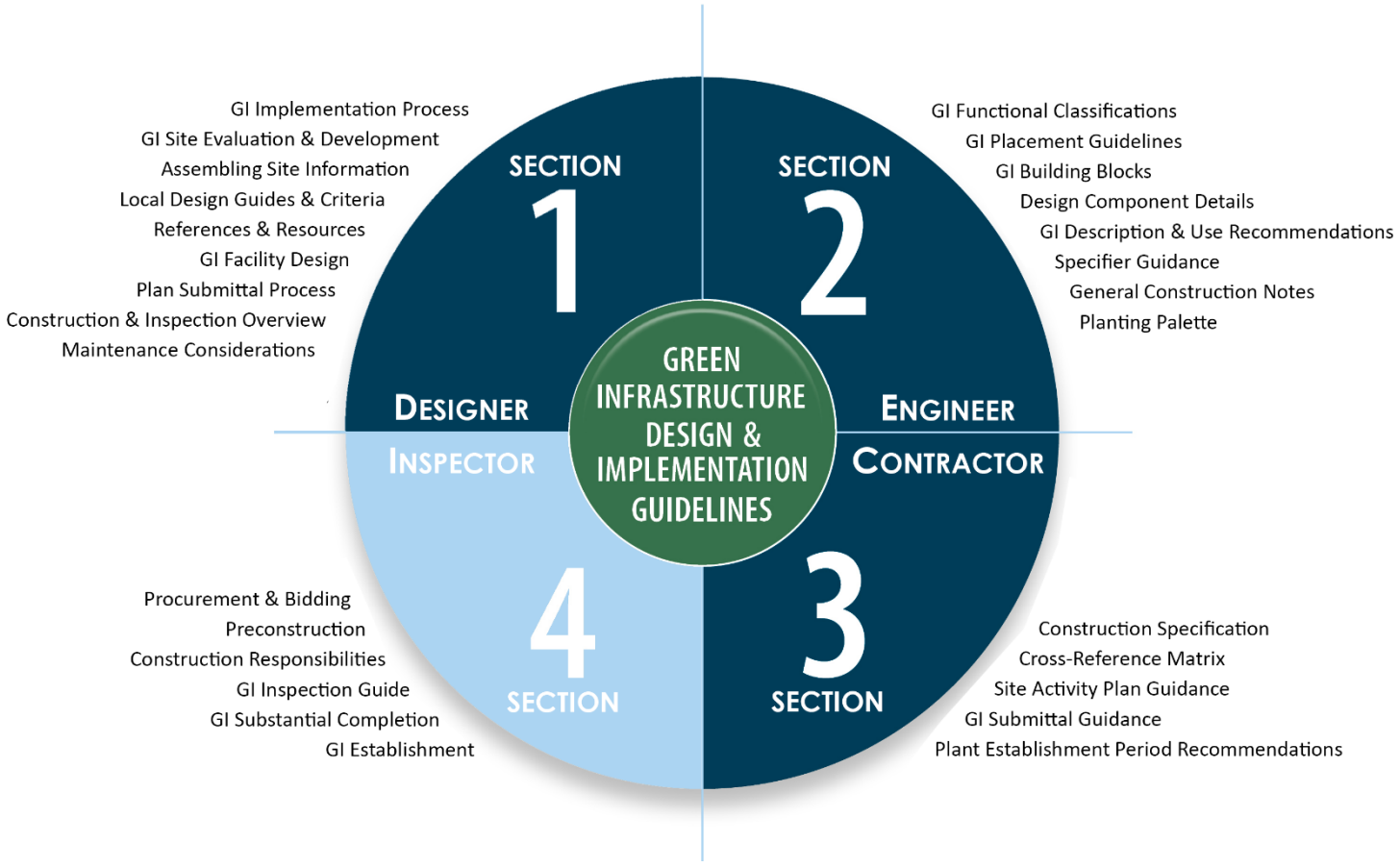
- March/April: spring clean-up
- March: trees and shrubs pruning
- April: spring plant survival inspection
- April: bioretention soil replacement in areas that have eroded or settled; mulch added to maintain 3-inch depth
- May and November: structures inspected and maintained to be free of debris and properly operating
- October/November: fall clean-up
- Fall: plant survival inspection
- November: perennials pruning

- Monthly report submitted to City should include all activities conducted throughout the previous month to document work completed.

SECTION 4

INSPECTION GUIDANCE FOR GREEN INFRASTRUCTURE CONSTRUCTION PROJECTS

GI Audience & Resource Content Guide



INSPECTION GUIDANCE FOR GREEN INFRASTRUCTURE CONSTRUCTION PROJECTS

Successful public infrastructure construction projects, including Green Infrastructure (GI) retrofit projects, integrate the expertise of four critical partners: the City, engineers, contractors, and inspectors. Each section of this manual provides in-depth information and tools for each of these partners: Section 2 of this Manual supports GI design; Section 3 provides guidance to be conveyed from GI designers to contractors; and Section 4 provides guidance for inspectors. For the purpose of this Section, "inspector" may refer to City personnel and/or contractors who are hired for the purpose of administering and/or inspecting the construction of a GI facility.

GUIDANCE FOR PROCUREMENT AND BIDDING OF GI PROJECTS

During the procurement phase, the City may hire an inspector or engineer to help administer the GI construction project and inspect the contractor's work on behalf of the City. The inspector should be familiar with both Department of Public Utilities and Department of Public Services documents and requirements, including the Standard Specifications for Construction, Standard Details, Special Provisions and Supplemental Specifications.

GI TOPICS FOR PRE-BID MEETING

The pre-bid meeting is the first opportunity for the City staff and inspectors to communicate the features that comprise GI construction as well as how construction, testing, measurement and payment of GI construction varies from traditional construction practices. The following GI specific topics are recommended for conversation during the pre-bid meeting, at the discretion of the construction manager:

Site Activity Plan for GI Construction (SS 1601)

- Requirements in SS 1601 are intended to supplement, not replace, other CMSC Site Activity requirements.
- Contractor is required to thoroughly plan construction sequencing, site preparation, installation, and establishment of GI facilities.
- Site Activity Plan sections include Construction Schedule, Runoff Management Plan, Site Access Plan, and Site Utilization Plan
- The Site Activity Plan must be submitted and approved before beginning field activities.
- Measurement and payment shall be spread among various bid items associated with GI facility construction

Earthwork for GI Projects (SS 1602)

- Objective is to preserve infiltration capacity of soils by using lightweight construction equipment and methods for excavation and backfill.
- GI areas should be field marked to protect them from compaction before excavation. Vehicles not allowed to travel across marked area. No material storage is allowed.
- During excavation and backfilling, the contractor should place equipment adjacent to excavation areas to prevent compaction of GI subgrade and/or, if approved, use low ground contact pressure equipment.
- Underdrains, aggregate, and bioretention soil should not be installed until contributing drainage area is stabilized, so that soils will not erode into bioretention areas.
- Measurement and payment is based on the cubic yard volume of the GI excavation.

Tree Protection for GI Projects (SS 1603)

- Trees are to be protected in accordance with most current City of Columbus Tree Protection Policy.
- Tree protection should be installed before any other activity or concurrently with temporary erosion and sediment control. Tree protection must remain in place until all construction is complete.
- For projects with limited space only, vehicle access under tree canopy is allowed ONLY if tree roots are protected with temporary paving materials.
- Trees damaged by the contractor must be trimmed and pruned or replaced at the contractor's expense.
- Measurement and payment is based on the linear footage of fence installed.

Bioretention Soils for GI Projects (SS 1604)

- Purpose is to specify special materials required for GI facilities, including soil, mulch, topsoil, and edging.
- Engineer will inspect and approve the bioretention facility prior to the facility being put into service.
- Measurement and payment is based on the cubic yard volume of soil and mulch placed and the linear feet of edging installed.

Aggregates for Permeable Surface (SS 1605) - Reserved

Permeable Clay Brick or Concrete Pavers (SS 1606 or SS 1607) – Reserved

Permeable Concrete Pavement (SS 1608) - Reserved

Green Infrastructure Establishment (SS 1609)

- Purpose is to fully establish the GI plant material. Plant establishment required in CMSC 661 is extended from one growing season to two full growing seasons.
- Work includes general clean-up, weeding, watering, pruning, dead or diseased plant replacement, repair of eroded areas, replacement of mulch, and replacement of soil as necessary.
- Monthly reports shall be provided to the City during growing seasons.
- Contractor or subcontractor is required to demonstrate previous experience in GI maintenance.
- Measurement and payment for the first growing season is included in CMSC 661 bid item. Second growing season payment will be based on the lump sum bid item.

GI INSPECTOR RESPONSIBILITIES DURING CONSTRUCTION

Extra planning and coordination provides distinct benefits to GI construction projects. During the pre-construction meeting the City, contractors, engineers and inspectors will discuss preliminary plans for staging, hauling routes, material deliveries, construction sequencing, traffic control (pedestrians, bicycles, and vehicles), erosion and sediment control, permits, communication protocols and project schedule (as defined in the Site Activity Plan).

The following tools are intended to provide quick references and checklists that an inspector may use to ensure that construction complies with both the Special Provisions for Green Infrastructure and other requirements of this Manual.

GI TOPICS FOR PRE-CONSTRUCTION MEETING

During the pre-construction meeting, the City, engineer, contractor and inspector will have the opportunity to discuss detailed contractual requirements and other issues that are critical for successful GI construction. At the meeting the contractor should be prepared to discuss components of the Site Activity Plan (Supplemental Specification 1601) including Construction Schedule, Runoff Management Plan, Site Access Plan and Site Utilization Plan. At the meeting the inspectors and contractors should also be prepared to discuss the following GI specific submittals and/or procedural issues that are unique to GI construction:

Site Activity Plan for GI Projects (SS 1601)

- Requirements in SS 1601 are intended to supplement, not replace, other CMSC Site Activity requirements.
- Construction Schedule includes:
  - ✓ Plant and planting materials procurement lead time and storage
  - ✓ Installation and completion of each GI component
  - ✓ Flow diversion
  - ✓ Plant establishment
  - ✓ Site stabilization
- Runoff Management Plan outlines the contractor's runoff management:
  - ✓ GI facility cannot be used for collection or conveyance of stormwater until site is stabilized.
  - ✓ Upstream drainage areas must be stabilized before the installation of GI components.
  - ✓ Sediment accumulation in GI must be promptly removed.
  - ✓ Engineer must authorize discharge of runoff into completed GI facility.
- Site Access Plan additional content includes:
  - ✓ Access to and around site for construction access AND for non-construction pedestrians, bicycles, and vehicles
  - ✓ Haul route map
  - ✓ Material delivery and storage procedures and locations

- Site Utilization Plan includes:
  - ✓ Open excavation equipment and methods utilized to prevent compaction of GI subgrade
  - ✓ Private property protection methods
  - ✓ Tree and vegetation protection methods
  - ✓ Areas designated for material storage, laydown areas, and temporary facilities
  - ✓ Material storage protection methods
  - ✓ Material disposal methods
  - ✓ Backfill equipment and methods utilized to prevent compaction of subgrade

Earthwork for GI Projects (SS 1602)

- Use equipment and methods as approved in Site Activity Plan.
- Green Infrastructure excavation areas shall be field marked before excavation.
- Excavation requirements:
  - ✓ Excavation areas shall be protected from heavy equipment to prevent the compaction of soils within the Green Infrastructure footprint.
  - ✓ Compaction must be corrected by tilling methods to a depth of 12 inches.
  - ✓ Sides and bottom of excavated areas must be scarified to depth of 2 inches to 3 inches before backfilling.
  - ✓ Elevations are to be verified before final grading of subgrade.
  - ✓ All debris, soil clods, vegetative material, stones, polluted soils must be removed from the subgrade.
  - ✓ Vegetation should only be removed mechanically or by hand.
- Compaction requirements
  - ✓ Compact only as allowed on drawings using lightweight equipment.
- Geotextile requirements
  - ✓ Vertically placed impermeable geotextiles are to be used to protect utilities and structures from infiltration.
  - ✓ Horizontally placed geotextiles are not allowed within green infrastructure footprint.
- Fill and backfill requirements
  - ✓ Begin placement of materials and backfill after upgradient areas are stabilized.
  - ✓ Fill and backfill are to be placed in lifts to suit line and grades on drawings.
- Grading requirements
  - ✓ Excess materials are to be temporarily stockpiled in approved areas.
- Notify Engineer 24-hours in advance of:
  - ✓ Excavation completion
  - ✓ Installation of underdrains, observation wells, and clean-outs
  - ✓ Placement of aggregate or bedding layers
  - ✓ Placement of bioretention soils
  - ✓ Placement of mulch
  - ✓ Installation of edging

Tree Protection for GI Projects (SS 1603)

- Trees shall be protected in accordance with most current City of Columbus Tree Protection Policy.
- Tree protection shall be installed before any field activity, or concurrent with installation of E&SC.
- Tree protection shall consist in substantial fencing and shall remain in place until construction is complete.
- Pruning of interfering branches is allowed with approval of City Forester.
- Stockpiling of materials, debris, etc. under trees is not allowed.
- Operation of heavy equipment under trees is allowed only if roots are protected AND if approved by the engineer.
- Open trenches through the root zone are not acceptable.
- Root zone shall be protected by wall or tree well if grade is to be raised or lowered.

Bioretention Soils for GI Projects (SS 1604)

- A sample of the soil mixture and lab analysis shall be submitted 1-month before installation.

  ✓ Bioretention soil mixture consists of 2% to 5% organic material plus sand and topsoil.
  ✓ Bioretention soil mixture must comply with pH, phosphorus, and salt content requirements.

- Contractor shall coordinate with trades and subcontractors to prevent vehicle travel across bioretention footprint.
- Bioretention cells will be put into service after site stabilization is complete and approved by the engineer.
- Soils shall be placed in 8-inch to 12-inch lifts. The top of each lift shall be watered lightly to encourage settling and shall be scarified before placing next lift.
- Allow soil to settle for 24-hours before placing mulch and/or plants.
- Mulch must be shredded hardwood placed to a depth of 3-inches.
- Engineer approval is required to put bioretention cell into service. Up gradient erosion and sediment control devices can be removed after bioretention cell is put into service.

Aggregates for Permeable Surfaces (SS 1605) - Reserved

Permeable Clay Brick or Concrete Pavers (SS 1606 or SS 1607) - Reserved

Permeable Concrete Pavement (SS 1608) – Reserved

Plant Establishment Period (SS 1609)

- Submittals shall include material data, testing results, certifications that has been updated or as needed for new plants and materials.
- Contractor shall prepare schedule of anticipated site visits, spring cleanup and fall cleanup.
- Use of chemicals is not allowed unless, requested by contractor and approved by City.

- All plants and trees must be protected during entire establishment period.
- Monthly activities during growing season include watering (weekly), clean-up, debris and litter removal, sediment removal, weeding.
- Quarterly inspection by certified arborist is required.
- Annual activities include spring and fall plant viability inspection, structure inspection, pruning, repair of erosion, replacement of soils, replacement of mulch.
- Monthly reports are required

Underdrains and Aggregates for Green Infrastructure Facilities (SS 1610)

- Submittals shall include material data and gradation reports.
- Contractor shall coordinate with trades and subcontractors to prevent vehicle travel across bioretention footprint.
- Confirm the underdrain has a positive grade from upstream to downstream.

GREEN INFRASTRUCTURE INSPECTION GUIDE

This guide is intended to provide a quick reference of submittals, materials, and execution requirements related to the GI components contained in this Design Guide and is included in this Guide as Appendix D-1.

Use this guide as reference for specific requirements contained in the Green Infrastructure Supplemental Specifications. Refer to CMSC specifications for submittal, inspection and execution requirements for the gray infrastructure components including as sidewalks, curb and gutter, storm sewers, etc.

INSPECTOR'S SUBSTANTIAL OR FINAL COMPLETION CHECKLIST FOR GI CONSTRUCTION

The Substantial or Final Completion Inspection form is a checklist for the inspector to use at the stage of the project when the construction is complete. At this stage the inspector is responsible for checking whether all requirements have been completed and whether the project – or in the case of substantial completion, components of the project – is ready to be turned over from the Contractor to the City. Items in the checklist are directly related to Supplemental Specifications for GI Construction and to other requirements in these guidelines.

GI Submittals (SS 1600)

- Have all delinquent submittals been provided by the contractor?

Earthwork for GI Projects (SS 1602)

- Have all stockpiled, excess, and/or excavated materials been removed and disposed?
- Are inlet and outlets cleared of debris?

Tree Protection (SS 1603)

- Has all temporary tree protection been removed and cleared from project site?
- Is there no contractor damage to trees?
- Has the City Forester inspected and approved all tree pruning?

Bioretention Soils (SS 1604)

- Does the surface have a positive grade from inlet to outlet?
- There are no depressions or settled areas?
- Are all bioretention soils uniformly covered with mulch?
- Have all stockpiled, excess, and/or excavated materials been removed and disposed?
- Are all bioretention soils uniformly covered with mulch?
- Has edging been installed in areas adjacent to lawns and other grassed areas?
- Is the top of edging a uniform 1 inch above finished grade?
- Has permanent erosion prevention been installed?
- Is temporary sedimentation control removed and properly disposed?

Aggregates for Permeable Pavements (SS 1605) - Reserved

Permeable Pavers (SS 1606 and SS 1607) - Reserved

Permeable Concrete Pavement (SS 1608) - Reserved

Green Infrastructure Establishment (SS 1609)

- Has all debris been removed and properly disposed?
- Have all plant supports, temporary fencing, plant stakes been removed and properly disposed?
- Have all outstanding monthly inspection deficiencies been corrected?
- Are all monthly reports from the contractor complete and on file?

GI INSPECTOR RESPONSIBILITIES DURING ESTABLISHMENT PERIOD

GI ESTABLISHMENT PERIOD MONTHLY INSPECTION

During the Plant Establishment Period, the contractor will be responsible for the ongoing operation, maintenance, and repair of the GI facility as defined in the Contract Documents, CMSC 659 and SS 1609. It is suggested that the City's inspector will need to visit the site a minimum of once each month during the Warranty Periods. Inspectors should use the following list to ensure that the contractor is conducting all required Establishment Period activities:

Monthly Inspection Item (April through November)

- Sediment has not accumulated?
- Has trash been removed and properly disposed?
- Has leaf and tree debris been removed and properly disposed?
- Have weeds been removed?
- Have dead and diseased plants been removed and replaced?
- Has the contractor provided proof that planted areas have been watered once each week?
- Has a detailed monthly report of activities been provided by the contractor?
- Have plant stakes and guys been maintained?

Quarterly Inspection Item

- Is it confirmed that a certified arborist has inspected the site within the past 3-months?

Spring Annual Inspection Items

- March/April: Was a spring clean-up conducted?
- March: Have trees and shrubs been pruned?
- April: Was a spring plant survival inspection conducted?
- April: Has bioretention soil that has eroded or settled been replaced?
- April: Is mulch depth maintained at 3 inches?
- May: Are structures in good condition, free of debris, and operating properly?

Fall Annual Inspection Items

- October/November: Was a fall clean-up conducted?
- Fall: Was a plant survival inspection conducted?
- November: Have perennials been pruned?
- November: Are structures in good condition, free of debris, and operating properly?

GI ESTABLISHMENT PERIOD FINAL INSPECTION

The inspection at the completion of the Plant Establishment Period serves to document that the contractor has completed all work. Its purpose is to document that the GI facility is complete, that plant establishment is complete per the Contract Documents, and that the Contract can be closed. The majority of the contract work should have been certified as complete if a Partial or Substantial Completion inspection was conducted. Additionally, the monthly reports and inspections during the Plant Establishment Period provide sufficient documentation that the work was conducted as required. Therefore, this inspection serves to wrap up final documentation and other loose ends such as completion of record drawings and final invoices, removal of temporary erosion and sediment controls, and final clean-up. The following list of final inspection items is based on the project completion requirements of SS 1609:

- ✓ Has the contractor provided revised or updated record drawings?
- ✓ Are all quantities reconciled with contractor invoices?
- ✓ Are all conditions of permits met?
- ✓ Are temporary fencing, stakes, wrappings and other protections removed?
- ✓ Are all Plant Establishment Period deficiencies resolved?
- ✓ Have all warranty requirements been satisfied?

APPENDIX A

REFERENCES & ADDITIONAL RESOURCES

COLUMBUS AND STATE OF OHIO STANDARDS

- City of Columbus Department of Public Utilities, Stormwater Drainage Manual, current edition.
- City of Columbus Department of Public Service Construction and Materials Specifications, current edition.
- City of Columbus Department of Public Utilities Standard Drawings, current edition.
- City of Columbus, Erosion and Sediment Pollution Control Regulation, June 1994.
- City of Columbus Recreation and Parks Department, Tree Planting Standards.
- Ohio Department of Transportation Location and Design Manual, Volume 1, current edition.
- Ohio Department of Natural Resources, Rainwater and Land Development Manual, Chapter 2.
- City of Columbus Executive Order 2015-01, Attachment B Columbus Recreation and Parks Department Tree Protection Program and Tree Replacement Policy.
- City of Columbus Executive Order 2015-01, Attachment D Fee Schedule for Tree Replacement.
- City of Columbus Department of Public Service, Non-Residential Street Pavement Design Policy.
- City of Columbus Department of Public Service, Residential Street Pavement Design Policy.
- City of Columbus Department of Public Service, Sight Distance at Intersections Policy

GREEN INFRASTRUCTURE DETAILS FROM OTHER STATES

- Philadelphia Green Streets Design Manual, 2014.
  http://www.phillywatersheds.org/img/GSDM/GSDM_FINAL_20140211.pdf
  http://www.phillywatersheds.org/img/GSDM/GSDM_. Appendix_20141014.pdf
- City of New York Standards for Green Infrastructure, 2014.
  http://www.nyc.gov/html/dep/pdf/green_infrastructure/bioswales-standard-designs.pdf
- District of Columbia Department of Transportation, Greening DC Streets, 2014
  http://ddot.dc.gov/publication/greening-dc-streets
- City of Raleigh Standard Detail Drawings; Stormwater, and Parks and Recreation
  http://www.raleighnc.gov/business/content/PlanDev/Articles/DevServ/DrawingsStandardDetailsIndex.html
- City of Portland Environmental Services 2014 Stormwater Management Manual, Appendix G.
  http://www.portlandoregon.gov/bes/64040
- American Association of State Highway and Transportation Officials (AASHTO), Guide for the Development of Bicycle Facilities. 1999. http://safety.fhwa.dot.gov/ped_bike/docs/b_aashtobik.pdf

PERMEABLE PAVEMENT REFERENCES (RESERVED)

TREES AND PLANTS REFERENCES

- Iles, J and Gleason, M. (2008). Sustainable Urban Landscapes – Understanding the Effects of Flooding on Trees, Iowa State University, University Extension.
- Jull, L. (Undated). The Effects of Flooding on Plants and Woody Plants Tolerant to Wet Soil. University of Wisconsin-Madison.
- The National Arbor Day Foundation. Tree City USA Bulletins #7, 9, 20 and 35.
- Seattle Public Utilities and Herrera Environmental Consultants (2008). The Effects of Trees on Stormwater Runoff.
- Shaughnessy, D. (1999). Protecting Trees During Construction – HGIC1002. Clemson Cooperative Extension.
- USDA Forest Service, Northeastern Area (Undated). Flooding and its Effects on Trees.
- ANSI Z60.1, American Standard for Nursery Stock.
- The National Virtual Arboretum and Regional Ornamental Plant Database, maintained by Steve Foltz, Director of Horticulture at Cincinnati Zoo & Botanical Garden. http://www.plantplaces.com/
- City of Columbus Green Infrastructure Design and Implementation Guidelines Revisions to Planting Palette Options Technical Memorandum by Coldwater Consulting, LLC dated 1/20/2017

APPENDIX B

ACRONYMS

ACRONYMS USED IN THESE GUIDELINES:

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
COTA	Central Ohio Transit Authority
CRZ	Critical Root Zone
CMSC	Construction and Materials Specifications, City of Columbus Department of Public Service
DBH	Diameter Breast Height
DPS	Columbus Department of Public Service
DPU	Columbus Department of Public Utilities
E&SC	Erosion and Sediment Control
EPA	Environmental Protection Agency
GI	Green Infrastructure
GIS	Geographic Information System
HDPE	High Density Polyethylene
HDPP	High Density Polypropylene
LRFD	Load and Resistance Factor Design (for bridge specifications)
mS	Millimhos
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
PVC	Polyvinyl Chloride
ROW	Right-of-Way
SWDM	2012 Stormwater Drainage Manual, City of Columbus Department of Public Utilities
SP	Special Provisions
SS	Supplemental Specifications

APPENDIX C

GI CONTRACTOR MATERIALS

MATERIALS IN APPENDIX C:

C-1 Columbus Specifications Cross Reference

Appendix C-1

City of Columbus Specifications for GI Construction

COLUMBUS SPECIFICATIONS REQUIRED FOR GI CONSTRUCTION				
GI Component	**Material / Activity**	**Columbus CMSC**	**Supplemental Spec.**	**Columbus Standard Drawing**
1—Area Protection and Right of Way Safety				
1.1—At Grade Barriers	Curb Removal	CMSC 202 (Removal of Structures and Obstructions)		
	Concrete curb	CMSC 609 (Curbing, concrete medians, and traffic Islands)		
	Grate and frame (including tree grates)	CMSC 711 (Structural Steel)		
1.2—Above Grade Barriers - Curb Reveal	Curb Removal	CMSC 202 (Removal of Structures and Obstructions)		
	Concrete curb	CMSC 609 (Curbing, concrete medians, and traffic Islands)		DWG 2000, 2005, 2010, 2020
	Rebar (for curb)	CMSC 509 (Reinforcing steel materials) or CMSC 709 (Reinforcing steel)		
	Aggregate base	CMSC 609 (Curbing, concrete medians, and traffic Islands)		
1.2—Above Grade Barriers - Fencing	Fencing	CMSC 501 (Structures - General - testing)		DWG 2300 (sidewalk)
		CMSC 607 (Fence)		
		CMSC 710 (Fence and Guardrail Materials)		
	Concrete footing	CMSC 607 (Fence)		
1.3—Below Grade Barriers	Geotextile - permeable	CMSC 712 (Miscellaneous)		
	Geotextile - impermeable	CMSC 712 (Miscellaneous)		
	Clay barrier	CMSC 911 (Compacted backfill)	1602 (Excavation and Grading for Green Infrastructure Projects)	
	Filter aggregate layer	CMSC 703 (Aggregate)		
	Sand interface layer	CMSC 703 (Aggregate)		

GI Component	Material / Activity	Columbus CMSC	Supplemental Spec.	Columbus Standard Drawing
1—Area Protection and Right of Way Safety (Continued)				
1.4—Landscape Buffers - Grass	Grass - seeding	CMSC 659 (Seeding and Mulching)		DWG 2300 (sidewalk)
	Grass - sodding	CMSC 660 (Sodding)		
	Topsoil/loam	CMSC 653 (Topsoil Furnished and Placed)		
1.4—Landscape Buffers - Plants	Plants	CMSC 661 (Planting Trees, Shrubs and Vines)		DWG 2300 (sidewalk)
	Mulch	CMSC 659 (Seeding and Mulching)		
	Planting Media	CMSC 661 (Planting Trees, Shrubs and Vines)		
2—Stormwater Entrances				
2.1—Retrofit Existing Structure for Stormwater Inlet	Curb inlet	CMSC 604 (Manholes, Catch Basins, Inlets, Inspection Wells, Junction Chambers, Precast Reinforced Concrete Outlets or Monuments) or 609 (Curbing, Concrete Medians, and Traffic Islands)		DWG AA-S123 (CHECK)
	Grout, flowable fill	CMSC 613 (Flowable Controlled Density Fill)		
	MH connection	CMSC 901 (Pipe Sewers Complete)		
2.2—At Grade Inlets - Curb Cut	Curb cut	CMSC 202 (Removal of Structures and Obstructions)		
2.2—At Grade Inlets - Flared Curb Entrance	Concrete curb	CMSC 609 (Curbing, Concrete Medians, and Traffic Islands)		DWG 2000, 2010, 2020
2.2—At Grade Inlets - Gutter Apron	Gutter apron	CMSC 499 (Concrete, General)		DWG AA-S125A
	Aggregate base	CMSC 703 (Aggregate)		
2.2—At Grade Inlets - Trench Channel and Cover/Drain	Concrete trench	CMSC 499 (Concrete, General)		
		CMSC 511 (Structural Concrete)		
	Trench grate and frame	CMSC 711 (Structural Steel)		
2.3—Entrance Protection - Wheel Guard	Wheel guard (plate)	CMSC 711 (Structural Steel)		

GI Component	Material / Activity	Columbus CMSC	Supplemental Spec.	Columbus Standard Drawing
2—Stormwater Entrances (Continued)				
2.4—Downspout connections	Fittings	CMSC 915 (Wyes, fittings and cleanouts)		DWG 2320
	Piping	CMSC 901 (Pipe Sewers Complete) or CMSC 901.15 (Pipes, Sewers Complete in Place)		
	Backfill	CMSC 901 (Pipe Sewers Complete)		
	Valves	CMSC 802 (Valves and Appurtenances)		
	Concrete curb	CMSC 609 (Curbing, concrete medians, and traffic Islands)		
4—Energy Dissipation				
4.1—Splash Pads	Bedding layer	CMSC 703 (Aggregate)		
	Geotextile - nonwoven	CMSC 712 (Miscellaneous)		
	Concrete bedding	CMSC 499 (Concrete)		
	Welded wire mesh	CMSC 701 (Reinforcing Steel)		
	Rock	CMSC 703 (Aggregate)		
		CMSC 601 (Slope and Channel Protection)		
	Mortar bedding	CMSC 602 (Masonry)		
	Brick	CMSC 602 (Masonry)		
5—Landscaping				
5.1—Tree Protection	General	CMSC 657 (Tree Protection)	1602 (Tree and Vegetation Protection for GI Projects)	
	Fencing - temporary		1602 (Tree and Vegetation Protection for GI Projects)	
	Pruning, trimming	CMSC 666 (Pruning Existing Trees)	1602 (Tree and Vegetation Protection for GI Projects)	
	Excavation around tree roots		1602 (Tree and Vegetation Protection for GI Projects)	

GI Component	Material / Activity	Columbus CMSC	Supplemental Spec.	Columbus Standard Drawing
5—Landscaping (Continued)				
5.2—Planting Palette	Trees	CMSC 661 (Planting Trees, Shrubs and Vines)		
	Shrubs	CMSC 661 (Planting Trees, Shrubs and Vines)		
	Perennials	CMSC 661 (Planting Trees, Shrubs and Vines)		
	Grasses	CMSC 659 (Seeding and Mulching)		
	Watering	CMSC 662 (Landscape Watering)		
	Fencing - temporary			
	Metal edging		1604 (Bioretention for GI Projects)	
	Stone edging		1604 (Bioretention for GI Projects)	
	Mulch	CMSC 659 (Seeding and Mulching)	1604 (Bioretention for GI Projects)	
	Sod / seed	CMSC 659 (Seeding and Mulching) CMSC 660 (Sodding)		
	Topsoil/loam	CMSC 659 (Seeding and Mulching)	1604 (Bioretention for GI Projects)	
6—Storage Media				
6.1—Stone Aggregate	Aggregate	CMSC 703 (Aggregates)	1610 (Underdrains and Aggregates for Green Infrastructure Projects)	
6.2—Bioretention Soil Media	BSM mix	CMSC 703 (Aggregates)	1604 (Bioretention Soils for GI Projects)	
	Embankments between bioretention cells	CMSC 203 (Roadway Excavation and Grading) CMSC 204 (Subgrade Compaction)	1602 (Excavation and Grading for Green Infrastructure Projects)	
	BSM excavation, placement and grading		1602 (Excavation and Grading for Green Infrastructure Projects)	

GI Component	Material / Activity	Columbus CMSC	Supplemental Spec.	Columbus Standard Drawing
7—Piping				
7.1—Underdrain	General	CMSC 605 (Underdrains)	1610 (Underdrains and Aggregates for Green Infrastructure Projects)	
	Cleanout	CMSC 915 (Wyes, fittings and cleanouts)	1610 (Underdrains and Aggregates for Green Infrastructure Projects)	DWG AA-S161
		CMSC 914 (Six-inch diameter pipe risers)	1610 (Underdrains and Aggregates for Green Infrastructure Projects)	
	Solid PVC or HDPE piping	CMSC 901 (Pipe Sewers Complete)		
	Perforated PVC piping	CMSC 720 (Plastic Pipe)	1610 (Underdrains and Aggregates for Green Infrastructure Projects)	
	Bedding and Filter Material	CMSC 703 (Aggregates)	1610 (Underdrains and Aggregates for Green Infrastructure Projects)	
	Geotextile	CMSC 712 (Miscellaneous)		
	Valve	CMSC 802 (Valves and Appurtenances)		
7.2—Standpipe Overflow Systems	Grate and frame	CMSC 604 (Manholes, Catch Basins, Inlets, Inspection Wells, Junction Chambers, Precast Reinforced Concrete Outlets or Monuments)		AA-S130, AA-S132, AA-S133A, AA-S133B, AA-S134, AA-S135, AA-S136, AA-S138, AA-S139, AA-S140, AA-S141
	Concrete ring	CMSC 499 (Concrete)		
	Welded wire mesh	CMSC 701 (Cementitious Materials)		
	PVC	CMSC 720 (Plastic Pipe)		
	Piping, seals and fittings	CMSC 901 (Pipes, Sewers Complete in Place)		
		CMSC 914 (Six-inch diameter pipe risers)		
	Bedding layer	CMSC 703 (Aggregates)	1610 (Underdrains and Aggregates for Green Infrastructure Projects)	

GI Component	Material / Activity	Columbus CMSC	Supplemental Spec.	Columbus Standard Drawing
7—Piping (Continued)				
7.3—Observation Well	Observation well	CMSC 720 (Plastic Pipe)		DWG AA-S174
	Well cover	CMSC 604 (Manholes, Catch Basins, Inlets, Inspection Wells, Junction Chambers, Precast Reinforced Concrete Outlets or Monuments)		
	Concrete surround	CMSC 499 (Concrete)		
	Riser	CMSC 914 (Six-inch diameter pipe risers)	1610 (Underdrains and Aggregates for Green Infrastructure Projects)	
	Bedding layer	CMSC 703 (Aggregates)	1610 (Underdrains and Aggregates for Green Infrastructure Projects)	
7.4—Anti-Seep Collar	HDPE collar			
	Bolts			
	Sealant			
7.4—Utility Sleeve	Pipe sleeve	CMSC 701 (Cementitious Materials)		
	Sealant	CMSC 720 (Plastic Pipe)		

GI Component	Material / Activity	Columbus CMSC	Supplemental Spec.	Columbus Standard Drawing
8—Outlets & Overflows				
8.1—Retrofit Existing Structures for Stormwater Outlet	MH connection	CMSC 604 (Manholes, Catch Basins, Inlets, Inspection Wells, Junction Chambers, Precast Reinforced Concrete Outlets or Monuments) CMSC 901 (Pipes, Sewers Complete in Place)		
	Flowable fill	CMSC 613 (Flowable Controlled Density Fill)		
8.2—At Grade Outlet - Curb Cut	Curb cut	CMSC 202 (Removal of Structures and Obstructions)		
8.2—At Grade Outlet - Flared Curb Outlet	Concrete curb	CMSC 609 (Curbing, concrete medians, and traffic Islands)		DWG 2000, 2010, 2020
8.3—Weir	Weir - general			
	Concrete Weir	CMSC 499 (Concrete) CMSC 511 (Structural Concrete) CMSC 609 (Curbing, concrete medians, and traffic Islands)		
	Aggregate Weir	CMSC 703 (Aggregate)		
	Metal Weir	CMSC 711 (Structural Steel)		

APPENDIX D

GI INSPECTOR MATERIALS

MATERIALS IN APPENDIX D:

D-1 GI Inspector's Guide

Appendix D-1

Green Infrastructure Inspector's Guide

GENERAL RESPONSIBILITIES FOR GI INSPECTORS	
Frequency / Timing	**Activity**
Daily after start of construction	Inspect on-site during construction, document activity in daily report.
As required	Check content of contractor submittals against specification requirements. Return to contractor if insufficient information is provided. Forward to Engineer if sufficient information is provided.
As required	Inspect materials on-site and off-site. Maintain file of materials, certifications, and test results. Accept material samples and coordinate testing with City laboratory.
Monthly through the end of the contract	Review contractor invoice against daily reports. Check delivery tickets. Review other documentation for compliance. Submit invoice to City.
Once at end of construction phase	Observe contractor bringing GI facility on-line. Record observations on Daily Inspection Sheet. Note and communicate deficiencies.
Once at end of construction phase	Inspect and document substantial completion prior to Plant Establishment Period. Develop Contractor punch list. Communicate deficiencies with contractor and City. Certify substantial completion of work and establish start of Plant Establishment Period.
Monthly for first and second growing season of Plant Establishment period.	Inspect site and record observations during Plant Establishment Period. Accept or reject level of maintenance. Communicate itemized list of deficiencies with contractor.
Monthly during plant establishment period	Review contractor invoices and monthly report during Plant Establishment Period. Submit invoice to City.
Each Fall and April during Plant Establishment Period	Conduct Fall survival inspection with contractor and develop Spring plant replacement list. Conduct April survival inspection and revise replacement list as needed.
Once at end of Plant Establishment Period	Inspect at completion of Plant Establishment Period and record observations. Communicate deficiencies with contractor and City. Certify final acceptance of work.

INSPECTOR REFERENCES	
Reference Title	**Link**
Contract Administration Forms	https://columbus.gov/Templates/Detail.aspx?id=65235
Construction Document Library	https://columbus.gov/publicservice/Document-Library/
Qualified Products List	https://columbus.gov/WorkArea/DownloadAsset.aspx?id=70624
Stormwater Drainage Manual	https://columbus.gov/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=53681
Stormwater Erosion and Sediment Pollution Control Regulation	https://columbus.gov/uploadedFiles/Public_Utilities/Document_Library/Publications/Sewer/Manuals/StormwaterErosionControlManual%20.pdf
Procedures & Standards for Creation and Submittal of Sewer Drawing Plans	https://columbus.gov/Templates/Detail.aspx?id=66553
ODNR Rainwater and Land Development Manual	http://water.ohiodnr.gov/water-use-planning/stormwater-management#RAI
ASTM Test Methods	http://www.astm.org/
AASHTO Test Methods	http://www.transportation.org/Pages/Default.aspx
OSHA Standards	https://www.osha.gov/
National Ready Mix Concrete Assn. Pre-Construction Conference Checklist	http://www.nrmca.org/aboutconcrete/cips/32p.pdf
American Standard for Nursery Stock, ANSI 860.1	http://americanhort.org/documents/ANSI_Nursery_Stock_Standards_AmericanHort_2014.pdf

INSPECTOR ACTIVITY FROM GI SUPPLEMENTAL SPECIFICATIONS AND GREEN INFRASTRUCTURE DESIGN GUIDELINES					
GI COMPONENT	**SUBMITTALS**	**MATERIALS**	**EXECUTION**	**SUPPLEMENTAL SPEC.**	**CMSC**
1—Area Protection and Right of Way Safety					
1.1—At Grade Barriers *Tree Grates*	* Plan and section view consistent with drawings? * Anchor details provided and approved by Engineer? * Manufacturer information provided?	* Frame material same as grate material? * Grate opening 1/2-inch or less? * Elongated openings oriented correctly? * Tree grates are two sections and bolted?	* Subbase properly prepared before installation of frame? * Seat of frame clean before installation of grate? * Frame and grates are level and flush with surrounding surface? * Grate sections bolted on underside? * Exposed hardware flush with surrounding surface?		609, 711
1.2—Above Grade Barriers *Curb Reveals, Fencing*	* Cross sectional view of barriers including anchoring details and embedment details submitted to Engineer for approval? * Mill test reports for structural steel, steel casting, bronze and sheet lead for fabricated fencing provided? * Manufacturer information, contact information, and product number, painting specs, fastener details and post anchoring provided?		* Fastening and anchoring installed according to manufacturer recommendations?		501, 509, 607, 609, 626, 710
1.3—Below Grade Barriers *Clay Barrier*	* Description of equipment, placement, and compaction methods? * Name and contact information for laboratory that tests / certifies materials provided? * Clay material source and certifications provided?	* Berm material is USCS CH, CL or MH and has permeability no less than 1×10^{-7} cm/sec?	* Infiltration areas protected during placement and compaction of berm materials? * Materials and subgrade are not saturated or frozen during placement? * Materials placed according to location and elevation on drawings? * Clay compacted to 95% Standard Maximum Density?		203, 204, 703, 911
1.3—Below Grade Barriers *Geotextiles*	* Geotextile manufacturer and product details including contact information, material thickness, product number and performance standards provided?		* Geotextiles overlap a minimum of 18-inches? * Anti-seep collar installed at edge of GI facility?		703, 712, 911
1.4—Landscape Buffers *Grass*			* Maximum cross slope of landscape buffer is 4:1 [H:V]?		659, 661
1.4—Landscape Buffers *Grasses and Plants*	* Written proof that specified plant cannot be obtained, whenever needed? * Certificates of inspection for each shipment of plants provided with invoices? * Location and source of plant material and/or grass seed provided and complete?	* Plants are nursery grown, certification provided?	* Plant type and planting density in accordance with drawings? * Plants not installed above tree roots? * Mulch areas separated from grass areas by metal or stone edging? * Plants covered with 3-inches of double or triple shredded hardwood mulch? * Mulch not touching plant stems? * Plants watered immediately after installation? * Planting beds surrounded with temporary fencing?		653, 660, 659, 661
1.4—Landscape Buffers *Plant Establishment Period*	* Contractor provides qualification documentation? * Product data information and certificates provided for all materials, plants, etc. utilized during Plant Establishment Period? * List of anticipated site dates including spring clean-up, fall clean-up and monthly growing season visits is provided by Contractor? * Written maintenance schedule? * Monthly report submitted? * Chemical application request and operator license submitted for each chemical application?	* Replacement plants conform with plant specified in original drawings?	* Structures, grates, underdrains, observation ports, cleanouts kept free of debris and litter? * Vegetative debris, litter, and other waste properly disposed? * Planting beds kept free of weeds? * Chemicals applied only after written approval by City? * Sources of erosion are stabilized? * Planting areas are watered weekly? * Monthly activities include removal of sediment, trash, leaf and tree debris, weed removal, and dead/disease plant removal? * Quarterly activities include inspection by certified arborist? * Semi-annual activities include plant survival inspections and structure inspections? * Annual activities include pruning, soil replacement, mulch replacement?	1609	659, 660, 661, 662, 666

INSPECTOR ACTIVITY FROM GI SUPPLEMENTAL SPECIFICATIONS AND GREEN INFRASTRUCTURE DESIGN GUIDELINES					
GI COMPONENT	**SUBMITTALS**	**MATERIALS**	**EXECUTION**	**SUPPLEMENTAL SPEC.**	**CMSC**
2—Stormwater Entrances					
2.1—Retrofit Existing Structure for Stormwater Inlet	* DPU provided preliminary determination of condition of inlet/catch basin/manhole? * Contractor provides documentation of Columbus Utility Contractor License?		* All connections are pre-drilled? * All installation complies with CMSC 901? * Concrete pipe connection is grouted? * HDPE pipe connection is installed with waterstop?		609, 613, 901
2.2—At Grade Inlets *Depressed Curb, Gutter Apron*			* Saw cut edges are beveled, and cleaned? * Gutter apron cross-slope maximum is 8% and sloped towards Green Infrastructure? * New concrete curb replaced to nearest existing joint?		202, 499, 609, 703
2.2—At Grade Inlets *Trench Drain*	* Plan and section view consistent with drawings? * Anchor and bolt down details provided and approved by Engineer? * Manufacturer information provided?	* Grades in streets designed for travel loading? * Grades in pedestrian areas heel safe and slip resistant? * Frame material same as grate material? * Grate opening 1/2-inch or less? * Elongated openings oriented correctly? * Grate sections lockable? * Frame and cover approved by DPU?	* Concrete trench box properly installed and cured before installation of frame? * Seat of frame clean before installation of grate? * Frame and grates are level and flush with surrounding surface? * Exposed hardware flush with surrounding surface and bolted on the underside? * Frame and grate installed per manufacturer recommendations?		499, 511, 711
2.3—Entrance Protection *Wheel Guard*	* Plan and section views properly dimensioned? * Endplate and anchor details developed and approved by Engineer? * Manufacturer information provided?	* Material is structural steel at least 1/4-inch in thickness? * Materials are hot-dipped galvanized? * Bolts are galvanized or stainless steel? * Materials according to CMSC requirements and manufacturer information?	* Wheel guard plate extends at least 8-inches beyond curb opening on both sides? * Anchors or bolts are at least 2-inches from edge of plate and edge of concrete opening? * Profile of box-style castings match top and face of curb?		711
2.4—Downspout Connections			* Downspout edges cut parallel to existing grade? * Edges are beveled and deburred? * Concrete curb replaced to nearest existing joint? * Check valves installed per manufacturer recommendations?		609, 703, 720, 711, 802, 901, 915
4—Energy Dissipation					
4.1 — Splash Pads	* Samples of rock materials provided and submitted to Engineer for approval? * Submittals in accordance with CMSC requirements provided?	* Loose stone is washed, well graded, and between 1-inch and 4-inches? * Stones to be embedded in concrete are 4-inch to 6-inch diameter, washed, and free of jagged edges. * Materials according to CMSC requirements and manufacturer information?	* Splash pad stones not embedded in concrete surrounded by permanent edging? * Bricks installed standing vertically on the 4-inch end and placed on 1/2-inch thick mortar setting bed? * Stones embedded in concrete spacing does not exceed 3-inches?		499, 601, 602, 701, 703, 704, 712

INSPECTOR ACTIVITY FROM GI SUPPLEMENTAL SPECIFICATIONS AND GREEN INFRASTRUCTURE DESIGN GUIDELINES					
GI COMPONENT	**SUBMITTALS**	**MATERIALS**	**EXECUTION**	**SUPPLEMENTAL SPEC.**	**CMSC**
5—Landscaping					
5.1—Tree Protection	* No submittals required	* Wooden fence posts? * Fabric 4-ft high safety fence fabric?	* Tree protection installed before Erosion and Sediment Control? * Post spacing no greater than 12-feet? * Posts installed a minimum of 2-feet in depth? * Posts connected with 1-inch by 4-inch stringer along top of enclosure. * Fencing installed at or beyond Critical Root Zone? * Construction materials, vehicles, etc. not stored within CRZ? * Tree roots pruned flush with edge of CRZ? * Exposed roots covered with burlap and watered regularly during construction? * Pruning of damaged branches approved by City Forester and performed by ISA certified arborist? * For limited access area, tree roots are protected with temporary paving materials? * No open trenches within CRZ?	1603	201, 657, 666
5.2—Planting Palette *Grasses, plants, shrubs, and trees*	* Written proof that specified plant cannot be obtained, whenever needed? * Certificates of inspection for each shipment of plants provided with invoices? * Location and source of plant material and/or grass seed provided and complete? * Submittals in accordance with CMSC requirements provided?	* Plants are nursery grown, certification provided? * Materials according to CMSC requirements and manufacturer information?	* Plant type and planting density in accordance with drawings? * Plants not installed above tree roots? * Mulch areas separated from grass areas by metal or stone edging? * Plants covered with 3-inches of double or triple shredded hardwood mulch? * Mulch not touching plant stems? * Plants watered immediately after installation? * Planting beds surrounded with temporary fencing?		653, 659, 660, 661, 662
5.2—Planting Palette *Plant Establishment Period*	* Contractor provides qualification documentation? * Product data information and certificates provided for all materials, plants, etc. utilized during Plant Establishment Period? * List of anticipated site dates including spring clean-up, fall clean-up and monthly growing season visits is provided by Contractor? * Written maintenance schedule? * Monthly report submitted? * Chemical application request and operator license submitted for each chemical application?	* Replacement plants conform with plant specified in original drawings?	* Structures, grates, underdrains, observation ports, cleanouts kept free of debris and litter? * Vegetative debris, litter, and other waste properly disposed? * Planting beds kept free of weeds? * Chemicals applied only after written approval by City? * Sources of erosion are stabilized? * Planting areas are watered weekly? * Monthly activities include removal of sediment, trash, leaf and tree debris, weed removal, and dead/disease plant removal? * Quarterly activities include inspection by certified arborist? * Semi-annual activities include plant survival inspections and structure inspections? * Annual activities include pruning, soil replacement, mulch replacement?	1609	659, 660, 661, 662, 666

INSPECTOR ACTIVITY FROM GI SUPPLEMENTAL SPECIFICATIONS AND GREEN INFRASTRUCTURE DESIGN GUIDELINES					
GI COMPONENT	**SUBMITTALS**	**MATERIALS**	**EXECUTION**	**SUPPLEMENTAL SPEC.**	**CMSC**
6—Storage Media					
6.1—Stone Aggregate	* Sieve analysis and void content for each type of aggregate? * 3-lb sample of all aggregates provided and submitted to City lab for testing? * Contractor submitted list of all materials, suppliers and locations for all aggregate?	* Aggregate clean, washed and free of fines? * Aggregates handled and stored in a manner that prevents accumulation of fines and prevents material segregation?	* NA	1610	703
6.2—Bioretention Soil Media *Excavation and Grading*	* Description of equipment and methods used for excavation and backfill provided as part of SS 1601?	* Materials per SS 1605 and SS1604.	* GI excavation areas marked and protected from heavy equipment and material storage? * Low ground-contact pressure equipment utilized to minimize compaction? * Areas adversely compacted are tilled to depth of 12-inches? * Sides and bottom scarified to depth of 2- to 3-inches? * Subgrade clear of pollution, debris, poor soils, debris, trash, clods, roots, brush, foreign material? * Vegetation on side slopes removed mechanically or by hand? * Adjacent pavements and structure protected? * Geotextiles installed per drawings, only? Geotextiles not installed in horizontal layers? * Compaction limited to embankments and other areas designated on drawings, only? * Upgradient areas stabilized before materials installed? * Materials installed in lifts and lightly compacted per drawings? * Contractor notifies Engineer 24 hours in advance of key operations?	1602	106, 203, 204, 603, 703, 712, 901, 1601, 1604, 1605
6.2—Bioretention Soil Media *Placement*	* Name and contact information provided for laboratory used to test/certify materials? * Contractor provided description of equipment and methods for soil mixing, placement and compaction? * Delivery and placement schedule provided? * Five gallon sample of soil mixture provided and delivered to City lab for testing? * Material source(s) provided? * Supplier's soil mix and mulch report provided? * Laboratory certification of material requirements provided? * Manufacturer information, product number and specifications for steel edging provided? * Documentation of contractor qualifications?	* Steel edging black coated and 3/16-inch by 4-inch? * Mulch is coarse shredded hardwood?	* Infiltration areas protected from vehicle traffic for entire construction period prior to grading? * Weather conditions not frozen and dry within the previous 48 hours? * Contractor uses low ground-pressure equipment for placement and compaction? * Soil mixes protected in areas of high traffic? * Materials placed according to location and elevation on drawings and approved contractor site activity plan? * 24-hour settling period prior to grading? * Maximum compaction is 85% density? * Soil media protected from wind and rain until mulch is installed? * Engineer verifies completion before Bioretention Cell put into operation? * Excess material, equipment and tools removed immediately after grading is complete? * Edging installed per drawings?	1604	601, 659, 661, 720, 703, 901, 1602
6.3—Prefabricated Buried Infiltration Structures	* Manufacturer material specifications and testing results provided? * Construction procedures provided? * Pre-infiltration testing results provided?	* Vault materials meet ASTM requirements of F-2787, F-2418, and F-2922?	* Placement follows City Policy for Stormwater Treatment Technology Performance and Testing Requirements? * Excavation and placement per 1602? * Post-infiltration testing results provided?	1602	

INSPECTOR ACTIVITY FROM GI SUPPLEMENTAL SPECIFICATIONS AND GREEN INFRASTRUCTURE DESIGN GUIDELINES					
GI COMPONENT	**SUBMITTALS**	**MATERIALS**	**EXECUTION**	**SUPPLEMENTAL SPEC.**	**CMSC**
7—Piping					
7.1—Underdrain	* Laboratory contact information provided? * Manufacturer information, product number and specifications for control structure provided? * Laboratory certification of bedding and filter aggregate provided?	* Perforations are pre-drilled and free of shavings?	* Underdrains below non-infiltration areas of GI are solid? * Underdrain installed with minimum grade of 0.5 %? * Mechanism to control discharge installed per manufacturer recommendations and per drawings? * Bottom rototilled before placement of underdrain bedding? * Minimum of 24-inches of filter material over top of underdrain piping?	1610	605, 703, 720, 712, 802, 901, 915, 1602
7.2—Standpipe Overflow	* Manufacturer information including product number, materials, painting specifications and frame details provided?	* Riser grate is 12-inch in diameter or greater and is locking type?	* Sufficient separation between overflow grate and vegetation to prevent plant debris from clogging grate? * Standpipe is secured into 4-inch concrete ring? * Grate elevation is set according to drawings and at or above the top of the GI?		499, 701, 703, 901, 914
7.3—Observation Well	* Contractor provided configuration details consistent with drawings? * Manufacturer product information provided?	* Well covers are screw-type and clearly marked? * Wells in pavement conform to CMSC 604?	* Wells are installed 6-inches into pervious material of GI facility? * Surrounding area restored to pre-construction condition? * Well extends into cover frame? * Solid well cover is secured into 1.5-ft concrete surround? * Bentonite clay or grout seal placed around the well within the frame? * Observation well placed prior to placement of aggregates. * Aggregates are of the same type as surrounding GI facility and are not over-compacted? * Depth of slotted segment of well is screened and extends through full depth of pervious material?		499, 604, 701, 703, 720
7.4—Anti-Seep Collars and Utility Sleeves	* Contractor provided configuration details consistent with drawings? * Manufacturer product information provided?	* Utility sleeves Schedule 80 PVC? * Utility sleeves a minimum of 1-inch greater in diameter than utility being protected? * Anti-seep collar consists of 1/4-inch thick HDPE? * Anti-seep collar bolt material is Type 304 stainless steel? * Bentonite seals and grout as required in specifications? * Height of anti-seep collar is at least 3 times the diameter of the utility service, sleeve or pipe?	* Spacers used to center utility piping within utility sleeve? * Utility sleeves sealed at each end of sleeve with anti-seep collar or other approved method? * Collars aligned vertically and with edge of GI installation? * Existing geotextiles surrounding utilities minimally cut to accommodate Utility Sleeve and Anti-Seep Collars? * Collars are tested in accordance with manufacturer's specifications?		701, 720
8—Outlets & Overflows					
8.1—Retrofit Existing Structure for Stormwater Outlet	* DPU provided preliminary determination of condition of inlet/catch basin/manhole? * Contractor provides documentation of Columbus Utility Contractor License? * Submittals in accordance with CMSC requirements provided?		* All connections are pre-drilled? * All installation complies with CMSC 901? * Concrete pipe connection is grouted? * HDPE pipe connection is installed with waterstop?		609, 613, 901
8.3—At Grade Outlet			* Saw cut edges are beveled, and cleaned? * New concrete curb replaced to nearest existing joint?		202, 499, 609, 703
8.3—Weir	* Plan and section details provided by contractor include location, elevations, dimensions, bolt locations and anchor details? * Manufacturer information provided?	* Metal weir plates a minimum of 1/4-inch thick structural steel plate? * Weir plate materials hot dipped galvanized? * Weir plate anchors are Type 316 stainless steel? * Concrete weirs consistent with CMS Columbus sections 499 and 511? * Aggregate weir materials Type C or D per CMS Columbus 703.18?	* Top elevation of weir set per drawings and located at the low point of the GI installation? * Weir elevation is plumb? * Metal weir plates fastened to concrete using concrete anchors? * Weirs installed in dry conditions? * Aggregate weir materials hand-placed? * Engineer confirmed stability of aggregate weirs?		499, 511, 609, 703, 711

INSPECTOR ACTIVITY FROM GI SUPPLEMENTAL SPECIFICATIONS AND GREEN INFRASTRUCTURE DESIGN GUIDELINES					
GI COMPONENT	**SUBMITTALS**	**MATERIALS**	**EXECUTION**	**SUPPLEMENTAL SPEC.**	**CMSC**
9—Monitoring Stations					
9.1—Monitoring Stations	* Manufacturer information provided for fittings, frames, castings, and other materials?		* All connections are pre-drilled? * Waterstops installed on all connections? * All installation complies with CMSC 703 and 901? * Concrete pipe connection is grouted? * HDPE pipe connection is installed with waterstop?		604, 703, 901,
X—Other					
X.3—Erosion Prevention and Sediment Control			* Devices maintained until upgradient areas stabilized? * Areas not in active construction for 21 days are stabilized within 7 days of active construction? Or 2 days for sites within 50 feet of water body? * Street cleaned by contractor as directed by Engineer?		207, 670, 671