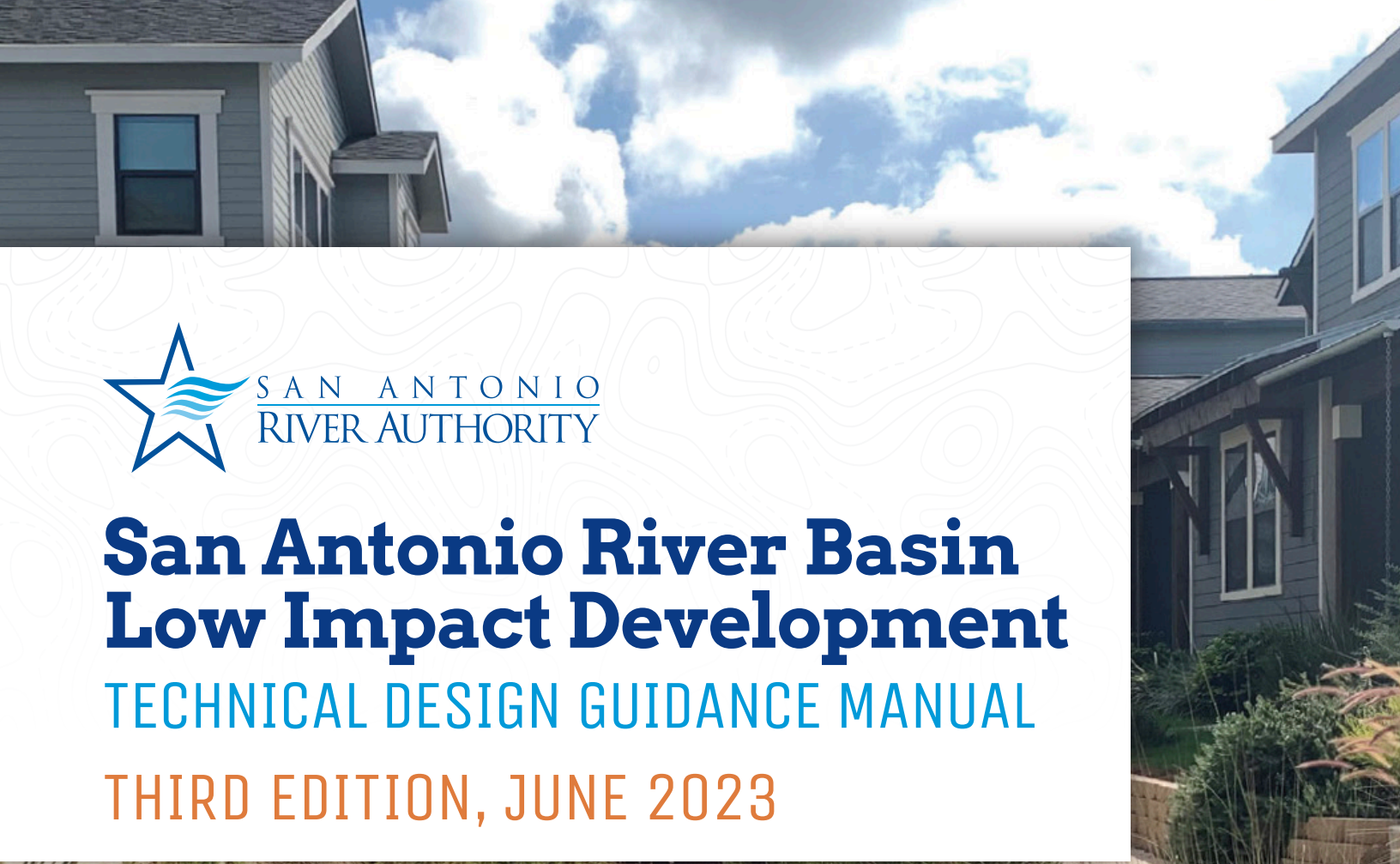

SAN ANTONIO RIVER AUTHORITY

San Antonio River Basin Low Impact Development

TECHNICAL DESIGN GUIDANCE MANUAL

THIRD EDITION, JUNE 2023

Acknowledgements

Special thanks go to Kali Bronson of Bernalillo County, New Mexico for granting the San Antonio River Authority authorization to incorporate select renderings developed by Bernalillo County.

This manual was prepared with contributions of:

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Table of Contents

Introduction

TRADITIONAL STORMWATER MANAGEMENT

Traditional engineering approaches to stormwater management convey runoff rapidly from developed surfaces into drainage systems, discharging large volumes of stormwater and pollutants to downstream receiving waters. As a result, stormwater runoff from developed land is a significant source of many water quality, stream morphology, and ecological impairments (USEPA 1999). In addition, the infrastructure's purpose is strictly related to volume control. It provides little to no water quality benefits.

REASONS TO CONSIDER LOW IMPACT DEVELOPMENT

This manual is tailored for design professionals who seek to use low impact development (LID) to

- incorporate water quality function into their projects.
- reduce and/or extend the peak flow.
- store stormwater for future use.
- receive the City of San Antonio's credit/offset and/or fee-based incentives under Unified Development Code (UDC) Chapter II, Section 35-210. (See UDC for the design storm requirements.)
- meet the requirements of City of San Antonio UDC Chapter 35, Section 673.

MANUAL CONTENT OVERVIEW

The manual addresses the design, specifications, and details of individual LID best management practices (BMPs). Since future maintenance should be considered during the design process, preferably by incorporating maintenance staff into the planning and design process, the manual also includes maintenance guidance. The manual provides guidance both on design considerations influenced by maintenance and on general maintenance practices for each BMP.

The manual also provides a segment on treatment trains, showing three different popular configurations of BMPs working in sequence for enhanced performance. Multiple treatment processes in either individual or multiple BMPs are called a treatment train. Treatment trains maximize the treatment of pollutants within the runoff. For example, vegetated filter strips designed to convey runoff from a road may be directed into an infiltrating bioretention cell that is designed to capture pollutants and provide volume reduction. Another example is the use of manufactured products for pre-treatment, filtering, trash removal, and oil and grease removal as the first structural BMP in a treatment train. Developer flexibility is enhanced by the many treatment train BMP combinations that can be designed.

LID OVERVIEW

LID is a site-specific approach to development that strives to replicate predevelopment and natural hydrologic processes and to reduce the disruptive effects of urban development on runoff patterns. LID strategies reduce and/or disconnect impervious cover from regional stormwater conveyance systems and utilize infiltration, filtration, stormwater storage, and stormwater conveyance coupled with native or improved soils, native vegetation, and bioengineering.

COMPENSATING FOR INCREASED IMPERVIOUS COVER AND MAINTAINING NATURAL FUNCTION

As the imperviousness of development sites increases, runoff also increases, with each acre of impervious cover producing approximately 27,150 gallons of stormwater for each inch of rainfall. Predevelopment runoff, measured as a runoff coefficient or the ratio of runoff volume to the total amount of rainfall, can be maintained through planning and design by compensating for increases in impervious areas, soil compaction, and the loss of abstraction.

The area of development ideally should be in less sensitive locations with respect to hydrologic function and should be outside protected areas and areas containing setback regulations, easements, and utilities.

Introduction

Site fingerprinting refers to site clearing and development with minimal disturbance of existing vegetation and soils. Such techniques include reducing paving and compaction of highly permeable soils, minimizing the size of construction easements and material storage areas, site clearing and grading to avoid tree removal, delineating and flagging the smallest site disturbance area possible, and maintaining existing topography to the extent possible. The figure below illustrates the use of orange construction fencing to preserve the natural features, drainage pathways, and maintain infiltration on suitable soils at the example site as identified in previous steps.

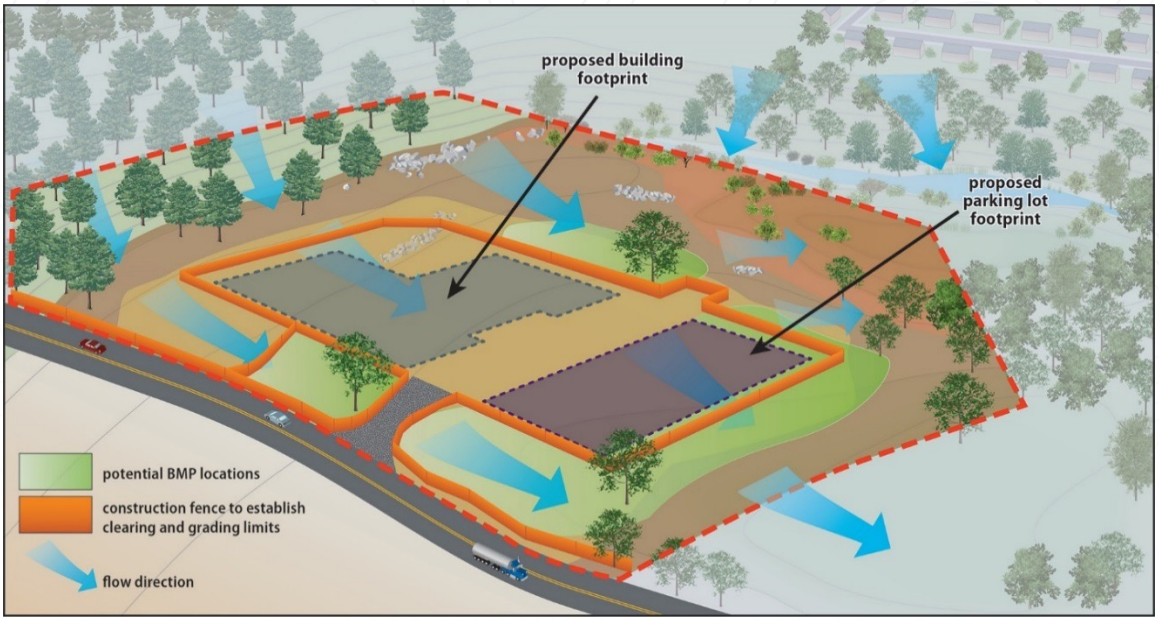


Figure IN-1. Establish grading envelope to protect natural areas and infiltrating soils

LID AND FLOOD VOLUME

LID can improve localized flooding but is not intended to replace traditional stormwater infrastructure, which focuses on managing flood volume. Rather, LID supplements traditional stormwater infrastructure by providing the stormwater quality benefits that traditional practices lack and mitigating the erosion that traditional practices have on receiving streams and infrastructure.

LID AND THE EDWARDS AQUIFER RECHARGE AND CONTRIBUTING ZONES

No retention facilities or pervious pavement without an impermeable liner is allowed over the Edwards Aquifer recharge zone to discourage the infiltration of pollutants. Refer to Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices (2005) to ensure compliance with the Edwards rules.

LID PERFORMANCE CURVES

Refer to Appendix J, for performance curves on the following BMPs: bioretention, bioswale, permeable pavement, planter box, green roof, sand filter, stormwater wetland, stormwater cistern, extended detention basin, vegetated swale, and vegetated filter strip.

Introduction

FOUR PRIMARY FUNCTIONS

The LID BMPs in this manual perform one or more of the following functions: infiltration, filtration, storage, and conveyance. The BMPs will be organized in this manual by the primary function they serve. Additional functions will be identified.

Infiltration BMPs

Infiltration BMPs filter out sediments, take up stormwater pollutants, and provide volume reduction. As stormwater percolates into the ground, the soil captures dissolved and suspended material in stormwater. Infiltration BMPs cannot be used in all locations. Native soils must be tested to determine if the infiltration rates of the soils are acceptable for infiltration. Where they are not, amendment of soils is an option if infiltration BMPs are the preferred BMP. Infiltration BMPs are not applicable at locations where ground water is close to the surface or where ground water pollution potential is high because of high pollution loads. LID practices addressed in this manual that use infiltration are bioretention, street-side bioretention, bioswales, stormwater bump-outs, permeable pavement, and street-side tree wells.

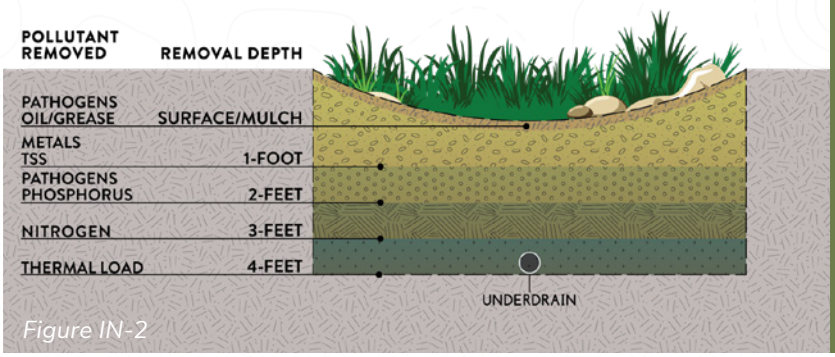


Figure IN-2

Proper construction sequencing is extremely important to reduce the risk of disturbing and clogging infiltration BMPs. Exposed soils within BMPs should be limited; imported BMP media should not be added until the site is stable; and soil media should not be installed until at least the first course of road and parking lot pavement has been set to minimize the washing of fines into the BMP.

Filtration BMPs

Filtration BMPs are versatile and have been widely used due to their moderate physical requirements. They can be incorporated into a wide range of landscapes including roadway corridors, rights-of-way, sidewalks, and areas with limited space. Most filtration LID techniques are designed to treat only a portion of a storm event, usually based on volume- or flow- based designs. Filtration LID techniques are not intended to infiltrate runoff into subsoils. Planter boxes, green roofs, and sand filters as well as the proprietary BMPs high-flow media, hydrodynamic separators, and cartridge membrane filters are the filtration BMPs addressed in this manual.

Storage BMPs

With the goal of reducing the total runoff volume washed into the traditional stormwater conveyance system, stormwater wetlands, stormwater cisterns, extended detention basins, and batch detention are especially effective and are addressed in this manual. Once captured, the stormwater is slowly released between storm events and can be used for irrigation. The controlled release from cisterns reduces peak storm volumes and, therefore, reduces runoff and erosion potential.

Conveyance and Pre-treatment BMPs

Conveyance and pretreatment LID BMPs are well suited for runoff from roads, highways, small parking lots, and other impervious surfaces. They can remove particles and constituents from runoff. Vegetated swales, vegetated filter strips, and vegetated stream buffers are the examples of conveyance and pre-treatment BMPs addressed in this manual.

***Note that local regulatory design criteria governs if more stringent than design criteria in this manual.**

USEPA (U.S. Environmental Protection Agency). 1999. Preliminary Data Summary of Urban Storm Water Best Management Practices. EPA.821-R-99-012. Office of Water, Washington, DC.

Bioretention

PURPOSE:

Capture and infiltration of stormwater runoff for treatment, with temporary storage to extend peak storm.

APPLICATION:

Site development and landscaping, road rights of way, parking lots

GENERAL DESCRIPTION:

Bioretention areas, also commonly known as rain gardens, are landscaped, shallow depressions that capture, infiltrate, and temporarily store stormwater runoff, regulating discharge rates and improving water quality (Figures BR-1 - BR-5). The depressed area is planted with small- to medium-sized vegetation including trees, shrubs, and groundcover that can withstand urban environments and tolerate periodic inundation and dry periods. Plantings also provide habitat beneficial for pollinators and aesthetic benefits for stakeholders and can be customized to attract butterflies or particular bird species.

Bioretention is the most commonly implemented LID technique because it mimics hydrologic conditions and enhances water quality. It can be incorporated into both new and existing development. Bioretention is well suited to the San Antonio River Basin because it can be adapted to a variety of site constraints. A benefit of bioretention areas is that they can be used for the dual purpose of stormwater treatment and landscaping or be integrated into the existing landscape.

Figure BR-1
Bioretention at LPA Studio.

Figure BR-2
Bioretention collecting roof runoff at the San Antonio River Authority Guenther Offices.

Bioretention

DESIGN CONSIDERATIONS:

SIZING:

- The bioretention footprint should be calculated after the desired ponding depth and soil media depth have been selected. Bioretention areas should be sized to fully capture the treatment volume from Appendix J.
- Available stormwater storage in the subsurface soil media and gravel drainage layer should be determined based on the laboratory-measured porosity of current soils or materials that will be installed on-site.
- Bioretention areas are intended to drain to below the surface in less than 24 hours, however, it is recommended that they be designed to drain in 12 hours or less as a safety factor.

SITING:

- Address sub-surface utility conflicts during design.
- Bioretention is well-suited for distributed control of stormwater throughout the site, including in landscaped areas.

FUNCTION & MATERIALS:

- Underdrains will be required if a bioretention cell is lined, adjacent to a steep slope, or if the subsoil infiltration rate is less than 0.5 in per hour.
- If gravel bed is open graded, the gravel should be encapsulated in a filter fabric to reduce the migration of fines into the open spaces of the gravel bed.
- Soil media should consist of a loamy sand and meet the specifications listed in Appendix B, Bioretention Areas, Table B-3. Bioretention soil media specifications (Hunt et. al. 2012).
- Include a temporary irrigation system for plant establishment.
- Some form of edging that allows for the easy removal of stolons and extends up to 6 inches deep to impede the spread of rhizomes may be necessary to discourage non-native turf grasses from encroaching into the feature.
- Limits of uncompacted soil should be reviewed by the Design Team to not impact grade supported structures or features.

ESTABLISHMENT & MAINTENANCE:

- Efforts to avoid soil compaction during construction should be made to preserve infiltration.

REFERENCE:

- Materials information is often available from suppliers or quarries.
- See specifications, details (on the following pages) and LID calculation sheets for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- Bioretention flow volume performance curves are found on page 340; Bacteria, Residential on page 343; Bacteria, Commercial/Industrial/Transportation on page 346; CBOD on page 349; Sediment on page 352; Total-N on page 355; Total-P on page 358; Total-Pb on page 361; and Total-Zn on page 364 of Appendix J.
- Refer to Appendix G: Operations & Maintenance for more information.
- See Plant List, Appendix E.

See Appendix B for Additional BMP-Specific Design Guidance.

Hunt, W.F., A.P. Davis, and R.G. Traver. 2012. Meeting hydrologic and water quality goals through targeted bioretention design. Journal of Environmental Engineering 138(6):698– 707.

Bioretention

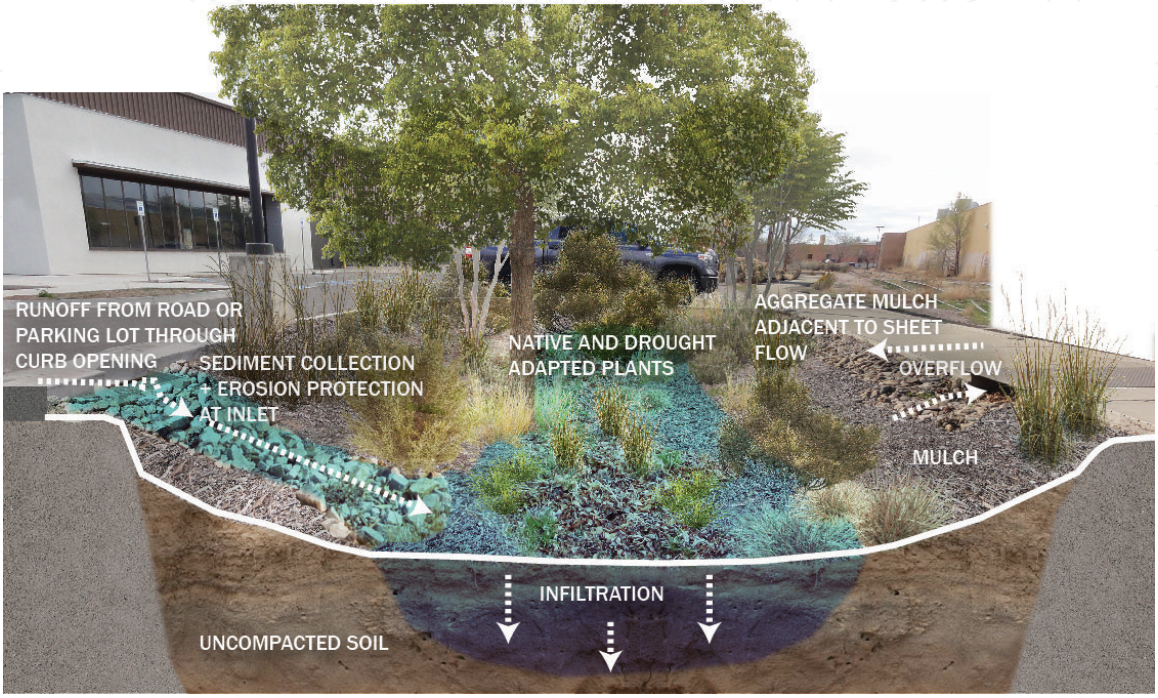


Figure BR-3
Bioretention conceptualization, courtesy of Bernalillo County.

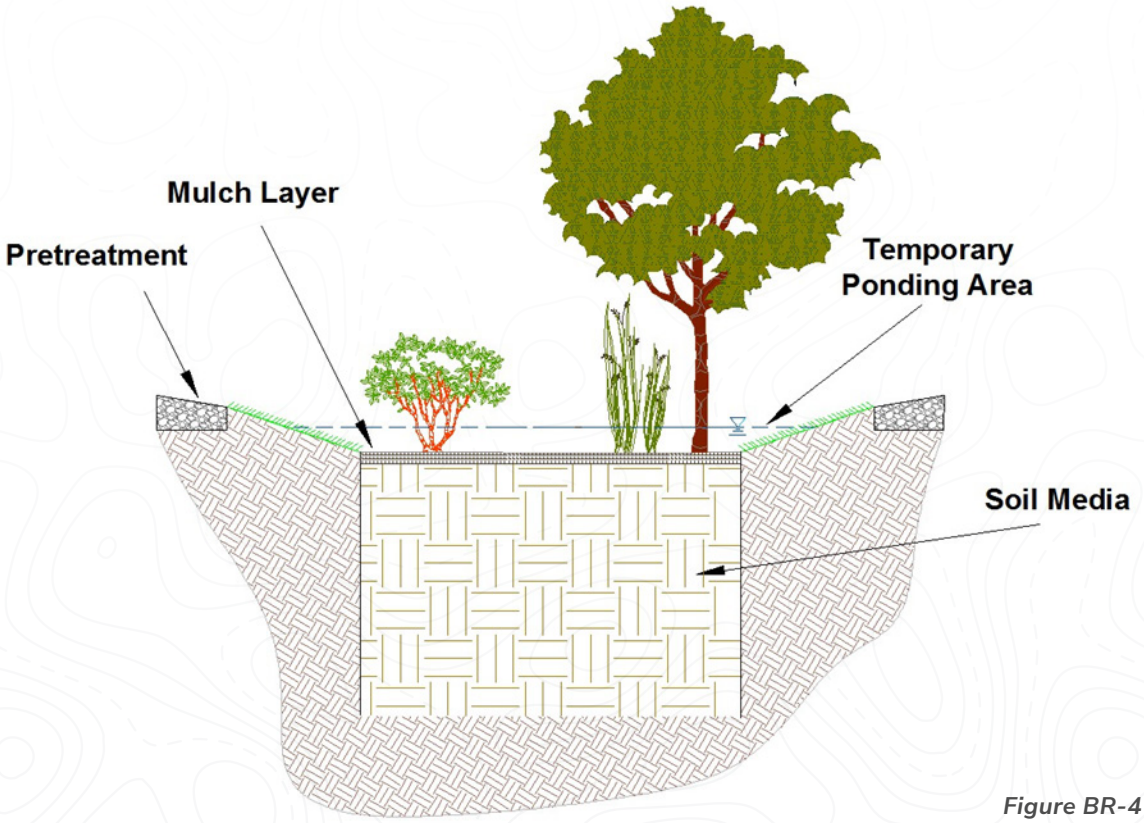


Figure BR-4
Schematic of Bioretention without underdrain

Bioretention, Street-side

PURPOSE:

Stormwater collection and treatment from small pavement areas.

APPLICATION:

Parking lot boundaries and medians. Street edges and medians along run of the street.

GENERAL DESCRIPTION

Street-side bioretention areas are structures adjacent to streets or other impervious cover that improve stormwater runoff quality by capturing, storing, and treating runoff. Street-side bioretention usually consist of pits with imported soil and organic material, a gravel layer, vertical concrete sides and sealed bottoms. They are located adjacent to impervious cover and are designed to capture and treat runoff.

Figure BR-5
Street-side bioretention planter located in New York.
Source: National Association of City Transportation Officials.

Bioretention, Street-side

DESIGN CONSIDERATIONS:

SIZING:

- Design positive overflow pathways for storms greater than the design storage volume within the facility.
- Design inflow forebays to reduce erosivity into the facility.

SITING:

- Address sub-surface utility conflicts during design.
- Consider easement requirements for location of street-side bioretention.

FUNCTION & MATERIALS:

- Choose vegetation that is tolerant of prolonged saturated environments and well-drained soil.

ESTABLISHMENT & MAINTENANCE:

- Provide temporary irrigation during establishment or extreme drought.
- Include adequate access to BMP for mulch replacement and trash removal as needed.
- Design curb cut inflow sections so that sediment can be easily shovelled and removed after large storms.

REFERENCE:

- If using a manufactured system, check manufacturer's sizing guides and requirements.
- Check that manufacturer's sizing recommendation will provide adequate treatment to meet local regulations.
- See specifications, details (on the following pages), and LID calculation sheets for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- Refer to Appendix G: Operations & Maintenance for more information.

See Appendix B for Additional BMP-Specific Design Guidance.

SECTION 33 46 64

Bioretention

33 46 64.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Bioretention Basin as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. Bioretention Basins are landscaped, shallow depressions that capture and temporarily store stormwater runoff.*

33 46 64.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Bioretention Basin. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 - Channel Excavation

Item 107 – Embankment

SARA Items:

Section 31 05 19.13 – Geotextile Separation Layer

Section 31 23 13.1 – Subgrade Preparation (Infiltrating Soil)

Section 32 46 82 – Sand Filter Layer

Section 32 91 13.16 – Mulch

Section 32 93 94 – Vegetation

Section 33 41 16.19 – Underdrain Piping and Underdrain Cleanout

Section 33 41 44 – Bioretention Infiltration Media

Section 33 46 81 – Impervious Liner

ASTM Items:

ASTM #57 – Graded Aggregate #57 Stone

ASTM #8 – Graded Aggregate Choker Stone

33 46 64.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 64.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. **Basin Inlet:** Contractor to install energy dissipation at the basin inlet to reduce resuspension of accumulated sediment or scouring of mulch and bioretention soil media. Energy dissipators to be specified on plans.

B. **Media Layers:** The following media layer depths shall be installed according to plan set: Mulch, Bioretention Soil Media, Sand Layer, Choker Stone and Drainage Layer (#57 Stone).

C. **Vegetation:** Contractor to install vegetation in basin as specified by Designer.

D. **Impervious Liner:** Impermeable liner, if required, to be installed according to plan set.

E. **Ponding Depth:** Contractor to provide ponding depth, vertical elevation between top of mulch and inflow invert, as specified by Engineer.

33 46 64.5 MEASUREMENT: This Item will be measured as individual components of each Bioretention Basin, to include, excavation, embankment, subgrade preparation, geotextile separation layer, soil media layer, mulch, vegetation, underdrain piping and underdrain cleanouts, graded aggregate #57 stone, graded aggregate choker stone, impervious liner, sand filter layer, etc.

33 46 64.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for the below bid items. This price shall be full compensation for all equipment described under this item and all associated items listed below.

33 46 64.7 BID ITEM:

Item 33 46 64.1 – Excavation – per cubic yard

Item 33 46 64.2 – Embankment – per cubic yard

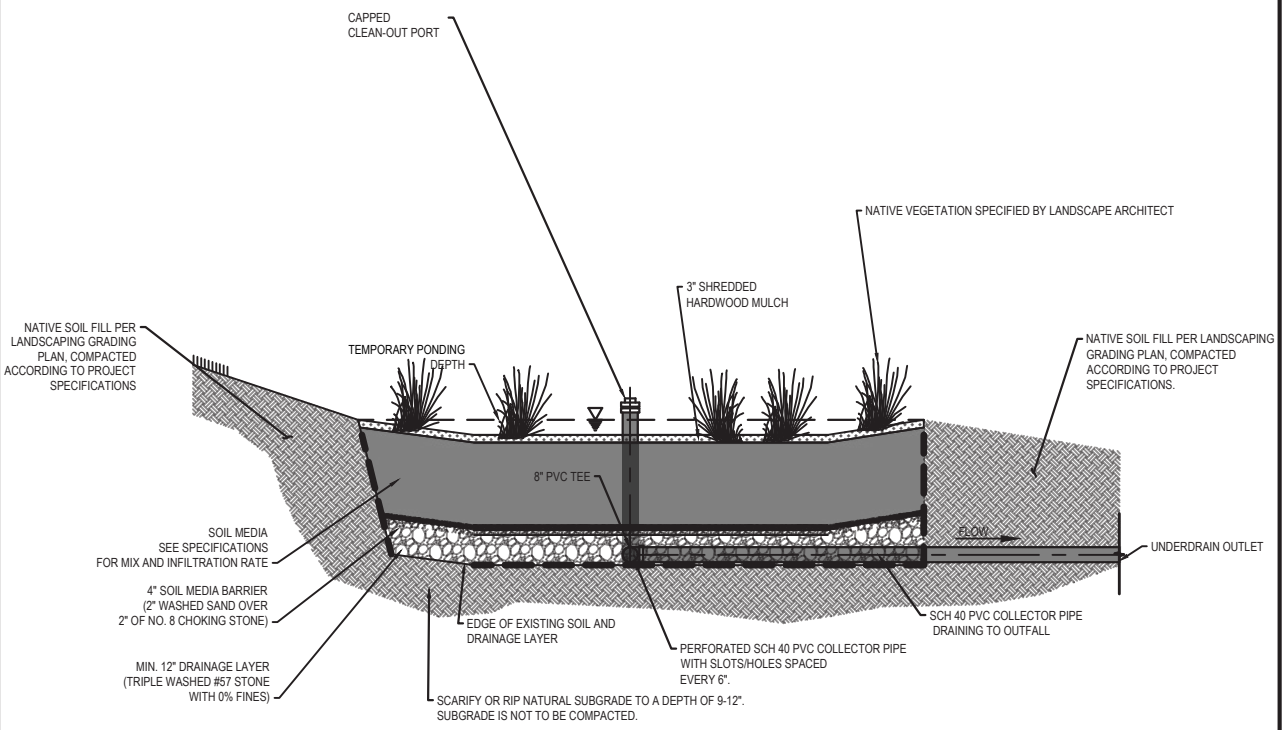
Item 33 46 64.3 – Subgrade Preparation (Infiltrating Soil) – per cubic yard

Item 33 46 64.4 – Geotextile Separation Layer – per square yard

Item 33 46 64.5 – Bioretention Infiltration Media – per cubic yard

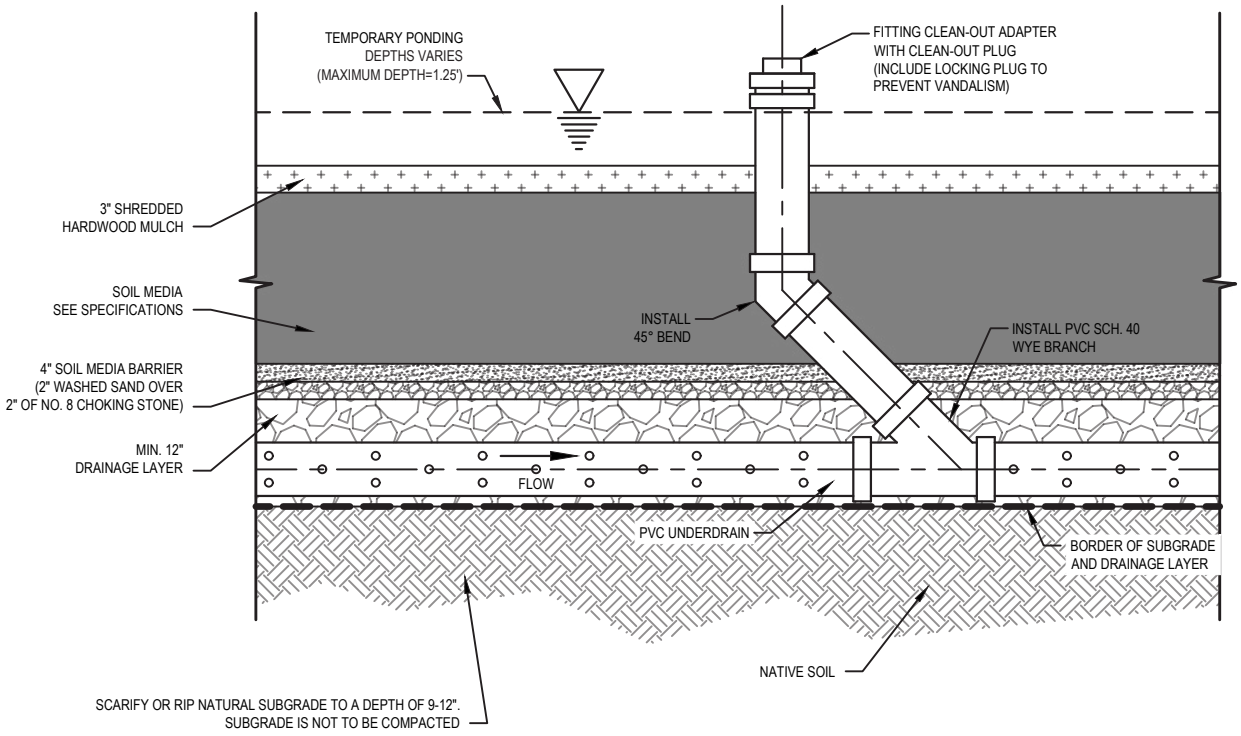
Item 33 46 64.6 – Mulch – per cubic yard

Item 33 46 64.7 – Vegetation – per each



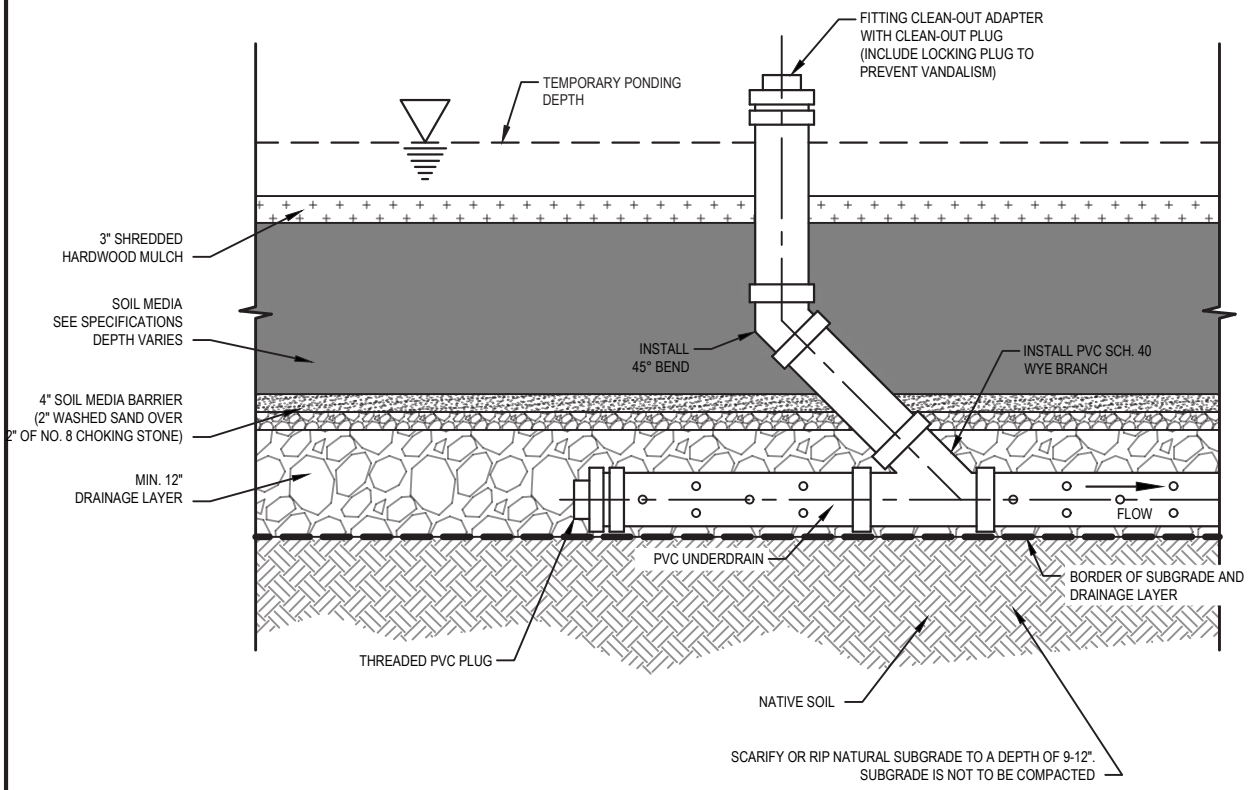
BIORETENTION TYPICAL SECTION

SAN ANTONIO RIVER AUTHORITY	BIORETENTION CONSTRUCTION DETAIL	APPROVED	REVISED
		BR–1	SHEET 1 OF 3



CLEANOUT - MIDSTREAM

SAN ANTONIO RIVER AUTHORITY	BIORETENTION CONSTRUCTION DETAIL	APPROVED	REVISED
		BR–2	SHEET 2 OF 3



BIORETENTION AREA CLEANOUT - UPSTREAM END

SAN ANTONIO RIVER AUTHORITY	BIORETENTION CONSTRUCTION DETAIL	APPROVED	REVISED
		BR–3	SHEET 3 OF 3

Bioswale

PURPOSE:

Stormwater collection and treatment from impervious areas.

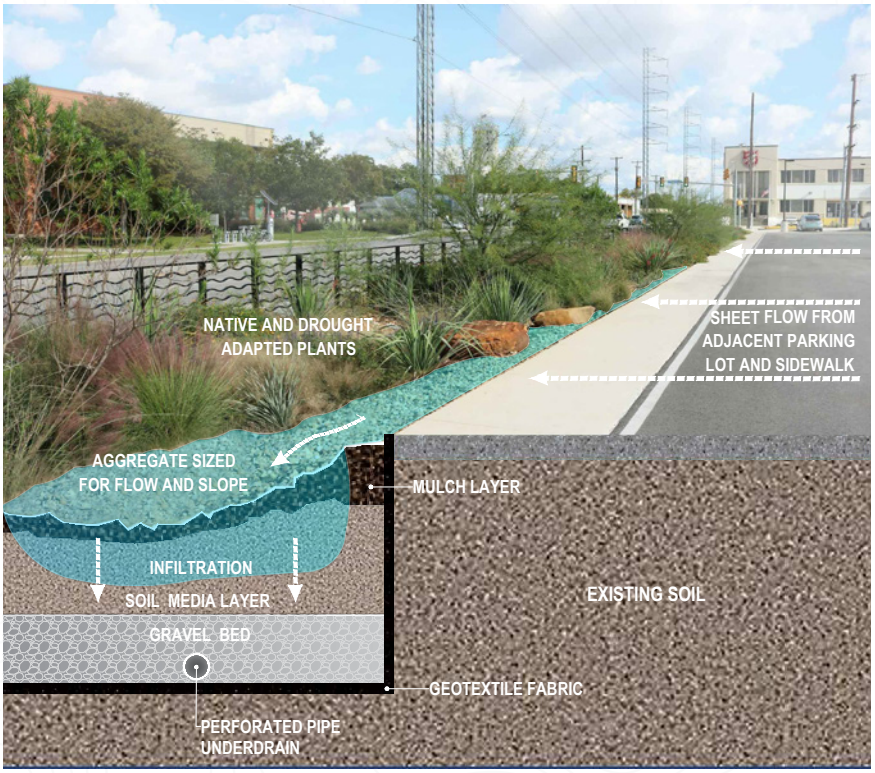
APPLICATION:

Parking and roadway edges and margins, transition zones.

GENERAL DESCRIPTION:

Bioswales are shallow, narrow vegetated features designed to improve stormwater runoff quality by slowing, treating, and conveying runoff; allows pollutants to settle out and promotes infiltration (Figures BS-1 - BS-3). Appropriate plant material improves infiltration through root development and cycles out the captured pollutants through physiological processes.

Bioswale effectiveness in part depends on stormwater retention time, with longer retention times generally resulting in higher removal efficiency. Bioswales can, however, serve as conveyance for stormwater and can be used in place of traditional curbs and gutters. Bioswales vary significantly in design configuration and can be constructed with or without check dams, subsurface storage media, and underdrains. Soil media can be added to a bioswale to improve water quality, reduce the runoff volume, and modulate the peak runoff rate, while also providing conveyance of excess runoff. Supplemental irrigation is required until plants are established.



Figures BS-1 and BS-2
Bioswale at City of San Antonio Development Services' Employee Parking Lot; bioswale overflow shown at right.

Bioswale

DESIGN CONSIDERATIONS:

SIZING:

- Size and place erosion protection as needed for design storm velocity and slope stabilization.

SITING:

- Address sub-surface utility conflicts during design.
- Groundwater table or bedrock separation of 10-ft; less separation needed with an underdrain.
- Consider the need for a safety barrier, such as a fence, either because of depth or proximity to hardened components for public safety.

FUNCTION & MATERIALS:

- Recommend infiltration rate greater than 0.5 inch/hour or consider an underdrain system.
- To maximize infiltration, do not compact bottom during construction.
- If gravel bed is open graded, the gravel bed should be encapsulated in a filter fabric to reduce the migration of fines into the open spaces of the gravel bed.
- Where soils permit, bioswales allows captured runoff to fully or partially infiltrate into underlying soils; where infiltration is restricted (such as in the Edwards Aquifer Recharge Zone, karst, or near building foundations), permeable pavement can be lined with an impermeable membrane and used as detention systems.
- Place plants according to inundation zone and transect. Use appropriate drought tolerant plant material capable of tolerating occasional periods of temporary inundation.
- Include a temporary irrigation system for plant establishment.
- Limits of uncompacted soil should be reviewed by the Design Team to not impact grade supported structures or features.

ESTABLISHMENT & MAINTENANCE:

- Inappropriate plant material choices will result in unhealthy conditions where the plants may never achieve optimum growth potential, may require replacement, may be less capable of deterring encroachment of undesirable vegetation, and may require additional supplemental irrigation to thrive. These conditions may affect aesthetics, reduce long-term function, and increase maintenance.

REFERENCE:

- See specifications, details (on the following pages) and LID calculation sheets for more information.
- Refer to Appendix G: Operations & Maintenance for more information.
- See Plant List, Appendix E.
- Bioswale flow volume performance curves are found on page 340; Bacteria, Residential on page 343; Bacteria, Commercial/Industrial/Transportation on page 346; CBOD on page 349; Sediment on page 352; Total-N on page 355; Total-P on page 358; Total-Pb on page 361; and Total-Zn on page 364 of Appendix J.

See Appendix B for Additional BMP-Specific Design Guidance.

Bioswale

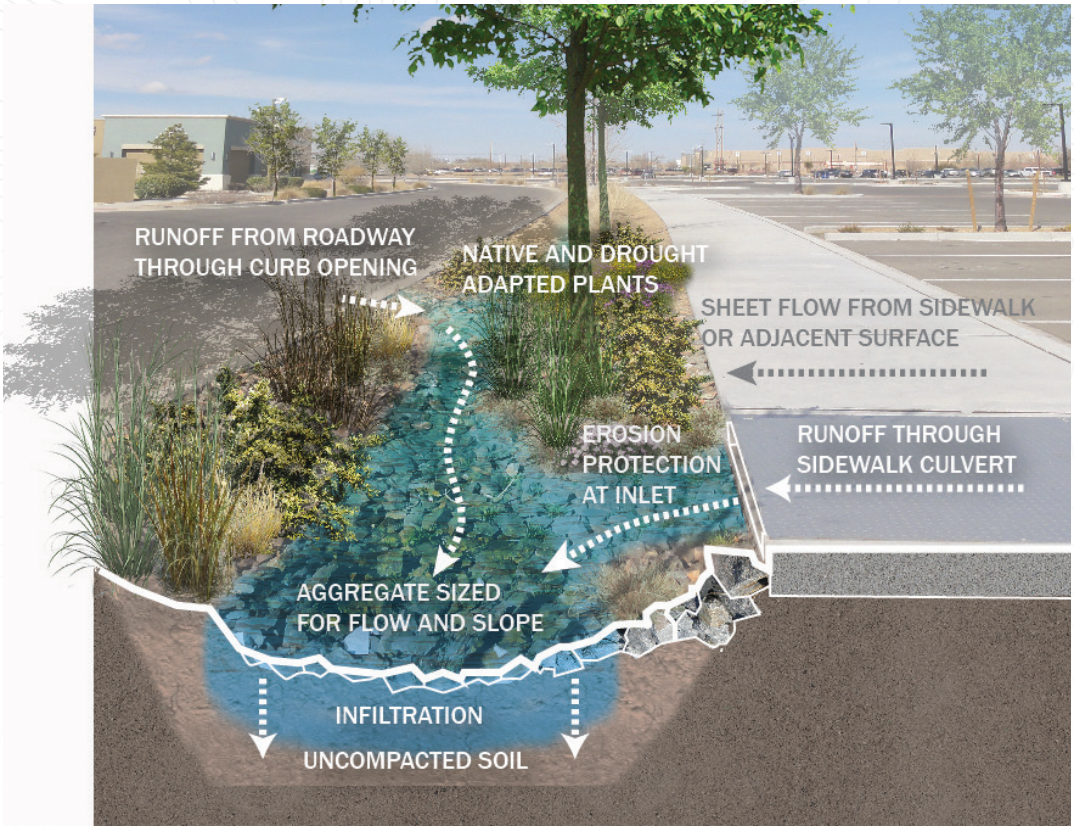


Figure BS-3
Bioswale conceptualization, courtesy of Bernalillo County.

SECTION 33 46 66

Bioswale

33 46 66.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Bioswale as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. Bioswales are shallow, narrow, vegetated channels, often referred to as linear bioretention, that are designed to treat runoff primarily by vertical filtration of runoff through soil media and infiltration into underlying soils.*

33 46 66.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Bioswale. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 - Channel Excavation

Item 107 – Embankment

Embankment

SARA Items:

Section 31 05 19.13 – Geotextile Separation Layer

Section 31 23 13.1 – Subgrade Preparation (Infiltrating Soil)

Section 32 46 82 – Sand Filter Layer

Section 32 91 13.16 – Mulch

Section 32 93 94 – Vegetation

Section 33 41 16.19 – Underdrain Piping and Underdrain Cleanout

Section 33 41 44 – Bioretention Infiltration Media

Section 33 46 81 – Impermeable Liner

ASTM Items:

ASTM #57 – Graded Aggregate #57 Stone

ASTM #8 – Graded Aggregate Choker Stone

33 46 66.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 66.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. Basin Inlet: Contractor to install energy dissipation at the basin inlet to reduce resuspension of accumulated sediment or scouring of mulch and bioretention soil media. Energy dissipators to be specified on plans.

B. Media Layers: The following media layer depths shall be installed according to plan set: Mulch, Bioretention Soil Media, Sand Layer, Choker Stone and Drainage Layer (#57 Stone).

C. Vegetation: Contractor to install vegetation in basin as specified by Designer.

D. Impervious Liner: Impermeable liner, if required, to be installed according to plan set.

E. Check Dams: Check damn to be installed as directed by Engineer in plan set.

F. Ponding Depth: Contractor to provide ponding depth, vertical elevation between top of mulch and inflow invert, as specified by Engineer.

33 46 66.5 MEASUREMENT: This Item will be measured as individual components of each Bioswale, to include, excavation, embankment, subgrade preparation, geotextile separation layer, soil media layer, mulch, vegetation, underdrain piping and underdrain cleanouts, graded aggregate #57 stone, graded aggregate choker stone, impervious liner, sand filter layer, etc.

33 46 66.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for the below bid items. This price shall be full compensation for all equipment described under this item and all associated items listed below.

33 46 66.7 BID ITEM:

Item 33 46 64.1 – Excavation – per cubic yard

Item 33 46 64.2 – Embankment – per cubic yard

Item 33 46 64.3 – Subgrade Preparation (Infiltrating Soil) – per cubic yard

Item 33 46 64.4 – Geotextile Separation Layer – per square yard

Item 33 46 64.5 – Bioretention Infiltration Media – per cubic yard

Item 33 46 64.6 – Mulch – per cubic yard

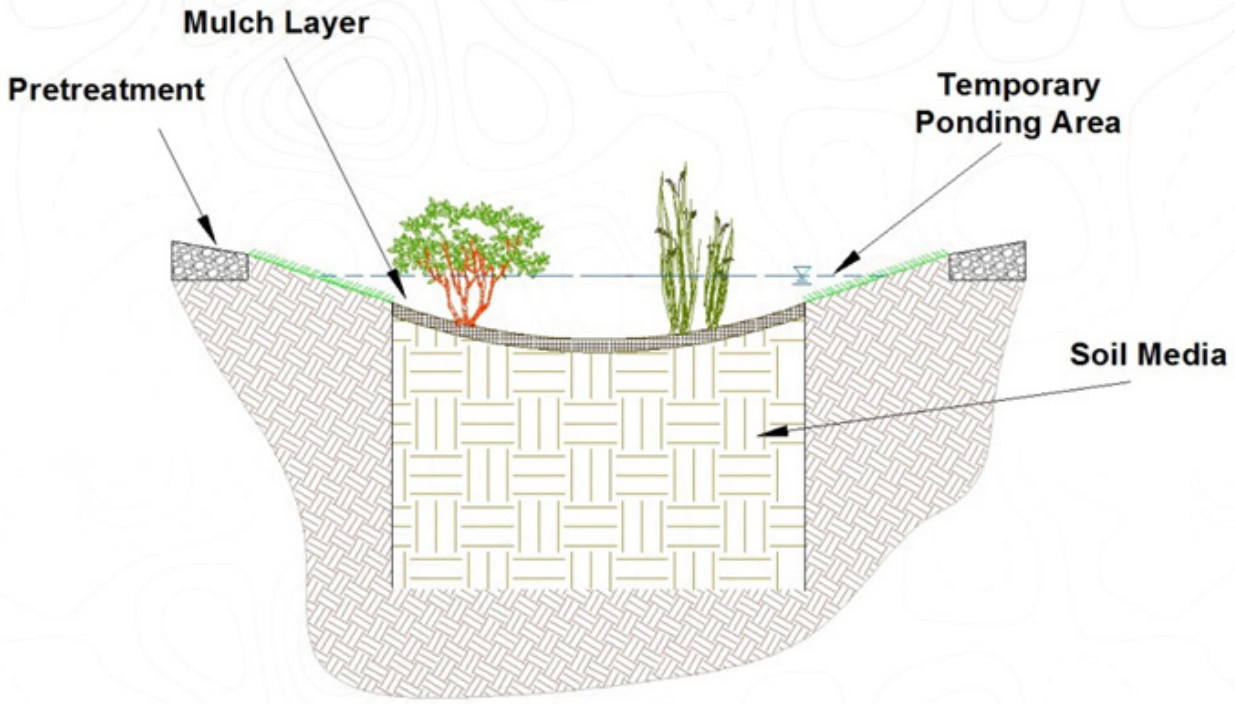
Item 33 46 64.7 – Vegetation – per each

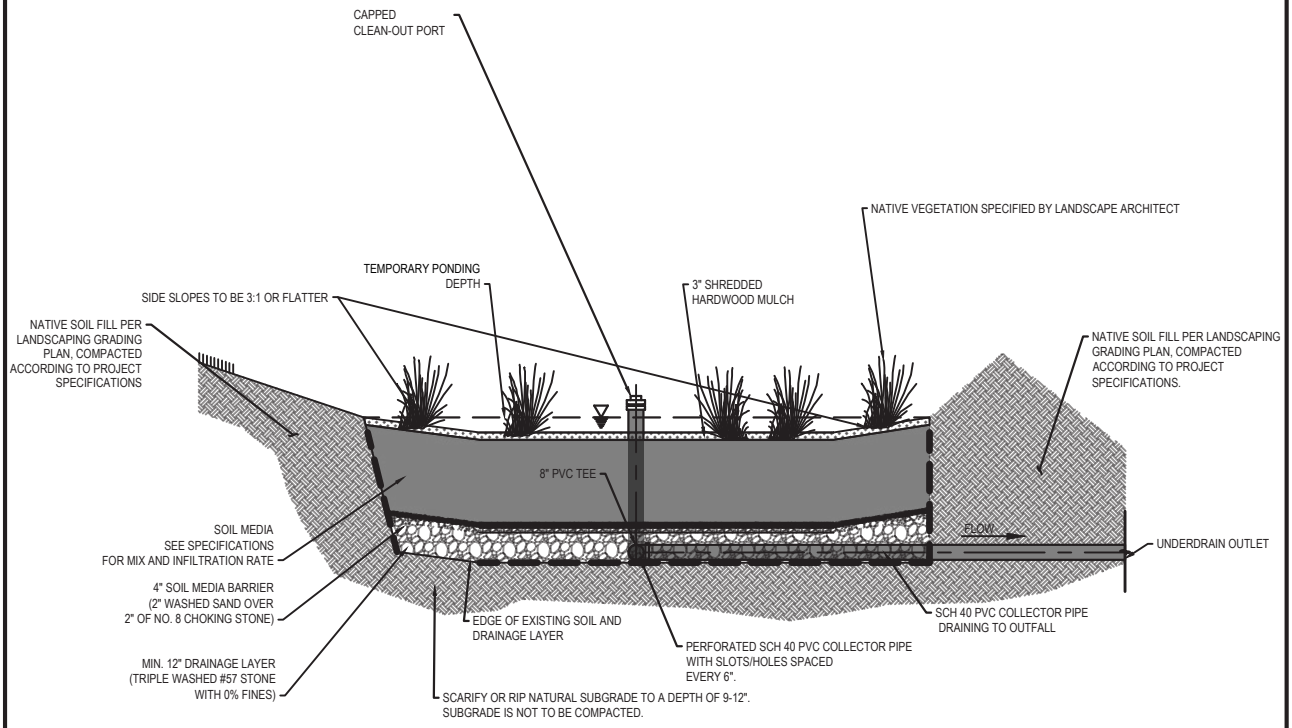
Item 33 46 64.8 – Underdrain Piping and Underdrain Cleanouts – per linear foot

Item 33 46 64.9 – Graded Aggregate #57 Stone – per cubic yard

Item 33 46 64.10 – Impervious Liner – per square yard

Item 33 46 64.11 – Sand Filter Layer – per cubic yard





BIOSWALE TYPICAL SECTION

NOTES:

1. THIS DETAIL DISPLAYS KEY CONCEPTS FOR A BIOSWALE AND MAY NOT PROVIDE ALL NECESSARY DESIGN INFORMATION FOR INDIVIDUAL SITES.
2. SLOPE OF SWALE BOTTOM SHALL BE LESS THAN 3%.
3. BIOSWALES SHALL BE WELL VEGETATED USING NATIVE PLANT SPECIES
4. REFERENCE BIORETENTION DETAILS BR–2 AND BR–3 FOR ADDITIONAL UNDERDRAIN CROSS SECTIONS

SAN ANTONIO RIVER AUTHORITY	BIOSWALE CONSTRUCTION DETAILS	APPROVED	REVISED
		BS–1	SHEET 1 OF 1

Notes:

Permeable Pavement

PURPOSE:

Paving material that allows stormwater to move through the pavement's surface to a storage layer below, allowing infiltration into the underlying soil. Provides both water quality and water storage benefits. Includes, but is not limited to, pervious concrete, porous asphalt, plastic grid pave systems, permeable grid pavers and interlocking concrete pavers.

APPLICATION:

Following is a list of settings in which permeable pavement can be incorporated to meet more than one project-level or watershed-scale objective:

- Parking lots
- Bike lanes
- Parking lanes in rights-of-way along roads
- Sidewalks and pedestrian plazas
- Alleyways, access roads, and shoulders.
- Permeable pavement systems are appropriate in retrofit applications to provide onsite detention where existing drainage infrastructure is undersized.

GENERAL DESCRIPTION:

Permeable pavement is a highly versatile stormwater LID strategy because it can effectively reduce pollutants and be integrated into site plans with various configurations and components (Figures PP-1 – PP-4).

Permeable pavement allows streets, parking lots, sidewalks, and other typically impervious surfaces to retain the infiltration capacity of underlying soils while maintaining the structural and functional features of the materials they replace. Permeable pavement has small voids or aggregate-filled joints that allow water to drain through to an aggregate reservoir. Permeable pavement systems can be designed to operate as underground detention. Permeable pavement systems can be designed to operate as underground storage if the native soils do not have sufficient infiltration capacity or if infiltration is precluded by aquifer protection, hotspots, or adjacent structures. Retrofit applications can provide storage where existing drainage infrastructure is undersized.

Several types of permeable pavement are available: pervious concrete, porous asphalt, permeable interlocking concrete pavers, concrete grid pavers, and plastic grid pave systems, among others. Each type of pavement has advantages and disadvantages, so factors such as cost, pavement use (parking area, driveway, sidewalk, fire lane, etc.) and maintenance requirements should be considered on a site-by-site basis. Permeable pavement can be developed using modular paving systems (e.g., permeable interlocking concrete pavers, concrete grid pavers, or plastic grid pave systems) or poured in place solutions (e.g., pervious concrete or porous asphalt). Some pervious concrete systems can also be precast. In many cases, especially where space is limited, permeable pavement is a cost-effective solution relative to other LID practices because it doubles as both transportation infrastructure and a LID strategy.

Permeable Pavement

DESIGN CONSIDERATIONS:

SIZING:

- Peak flow rates for the design storm should be calculated so that the inlet and pretreatment can be accordingly sized and flow attenuation can be considered.

SITING:

- Address sub-surface utility conflicts during design.
- Adjacent landscape areas that drain to the permeable pavement area should be stabilized and maintained to inhibit sediment migration to the system.
- Where soils permit, permeable pavement allows captured runoff to fully or partially infiltrate into underlying soils; where infiltration is restricted (such as in the Edwards Aquifer Recharge Zone, karst, or near building foundations), permeable pavement can be lined with an impermeable membrane and used as detention systems.

FUNCTION & MATERIALS:

- Verify selected permeable product can withstand vehicular weight and traffic frequency, including required maintenance equipment (vacuum truck), and wheel turning anticipated on the site.
- Permeable pavement systems are designed to reduce surface runoff by allowing stormwater to infiltrate the pavement surface. While the specific design can vary, most permeable pavements have a similar structure consisting of a surface course layer and an underlying stone aggregate reservoir layer. Modular storage units, chambers, and pipes can also be integrated for additional subsurface storage.
- If non-infiltrating (per geotechnical investigation), use impermeable clay liner, geomembrane, or concrete further described in Appendix A, Common Design Elements,
- Use concrete or geomembrane to restrict lateral flows to adjacent subgrades, foundations, or utilities.
- If using underdrain and if infiltration is feasible, elevate the outlet to create a sump to enhance infiltration and treatment.
- If design is fully infiltrating with no underdrain, ensure that subgrade compaction is minimized.
- Seal coating is not appropriate for pervious pavements.
- Gravel filler material for plastic grid pave systems should be a triple-washed material free of fines.

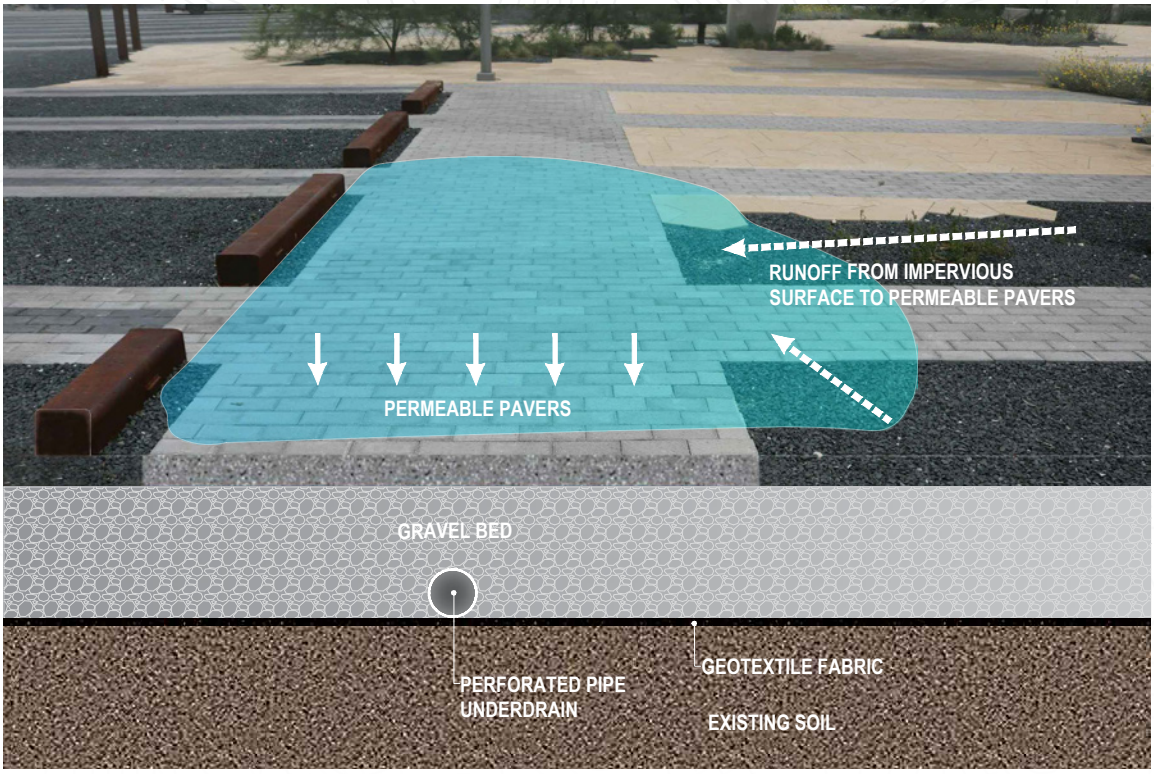
ESTABLISHMENT & MAINTENANCE:

- Design should ensure access for underdrain inspection and replacement, plant maintenance, and other maintenance activities and equipment, including vacuum truck.
- Tree and plant selections near permeable pavement systems should consider future impacts on maintenance. Small-leaved, deciduous trees and vegetation that shed throughout the year may result in more frequent system cleaning to keep pore spaces from clogging.

REFERENCE:

- See specifications, details (on the following pages) and LID calculation sheets for more information.
- See Specifications to ensure adherence to ADA requirements for heel gaps and bumps.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- Permeable pavement flow volume performance curves are found on page 341; Bacteria, Residential on page 344; Bacteria, Commercial/Industrial/Transportation on page 347; CBOD on page 350; Sediment on page 353; Total-N on page 356; Total-P on page 359; Total-Pb on page 362; and Total-Zn on page 365 of Appendix J.
- Refer to Appendix G: Operations & Maintenance for more information.

Permeable Pavement



Figures PP-1 and PP-2
Permeable parking installations at Confluence Park, San Antonio, TX (top) and at the San Antonio River Authority Guenther St. Offices (bottom)

Permeable Pavement

Figures PP-3
Schematic courtesy of Bernalillo County, New Mexico.

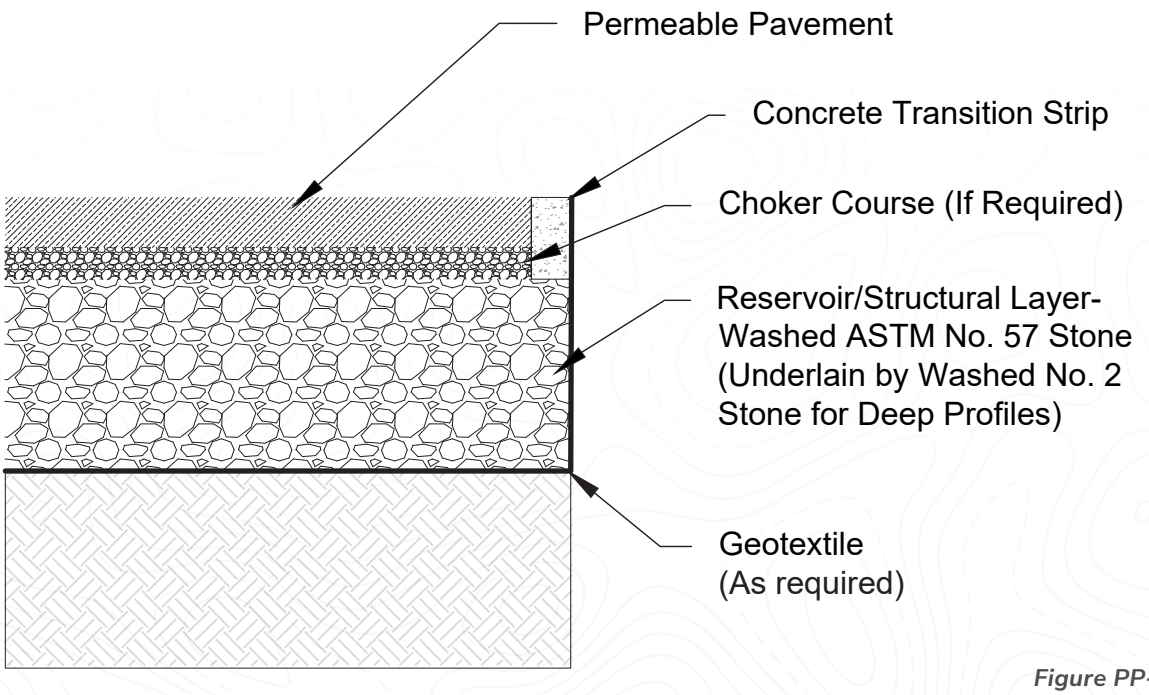


Figure PP-4
Typical porous asphalt cross section.

See Appendix B for Additional BMP-Specific Design Guidance.

SECTION 32 14 43

Permeable Pavement

32 14 43.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational Permeable Pavement as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. A variety of permeable pavement surfaces are available and while the specific design may vary, all permeable pavements have a similar structure, consisting of a permeable surface pavement layer, an underlying stone aggregate reservoir layer and a filter layer or fabric installed on the bottom.*

32 14 43.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of Permeable Pavement. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 - Channel Excavation

Item 107 – Embankment

Item 300 – Concrete

Item 301 – Reinforcing Steel

Item 304 – Expansion Joint Materials

Item 305 – Membrane Curing

Item 500 – Concrete Curb, Gutter, and Concrete Curb and Gutter

SARA Items:

Section 33 41 16.19 – Underdrain Piping and Underdrain Cleanout

Section 33 46 81 – Impervious Liner

ASTM Items:

ASTM #57 – Graded Aggregate #57 Stone

ASTM #8 – Graded Aggregate Choker Stone

32 14 43.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

32 14 43.5 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. **Drainage Layer Stone:** Drainage layer rock procured for project will meet the requirements of the ASTM #57 Stone Specification and be triple washed prior to delivery to site.
B. **Choker Stone Layer:** Choker stone layer procured for project will meet the requirements of the ASTM #8 Stone Specification.
C. **Installation:** Permeable pavement systems should be installed according to manufacturer specifications. This includes instructions on installation, cutting, patching, etc.
D. **Accessibility**: Permeable pavement system shall be ADA compliant where required by Engineer. Brick spacers shall be ½" or less to ensure a safe heel gap when brick pavers are utilized.

32 14 43.6 MEASUREMENT: This Item will be measured as individual components of each Permeable Pavement System, to include, excavation, embankment, subgrade preparation, concrete curb installation, #57 Stone installation, impervious liner installation, permeable pavement installation (including any filler aggregate), Underdrain Piping and Underdrain Cleanout, etc.

32 14 43.7 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for each item below. This price shall be full compensation for all equipment described under this item.

32 14 43.8 BID ITEM:

Item 32 14 43.1 – Excavation – per cubic yard

Item 32 14 43.2 – Embankment – per cubic yard

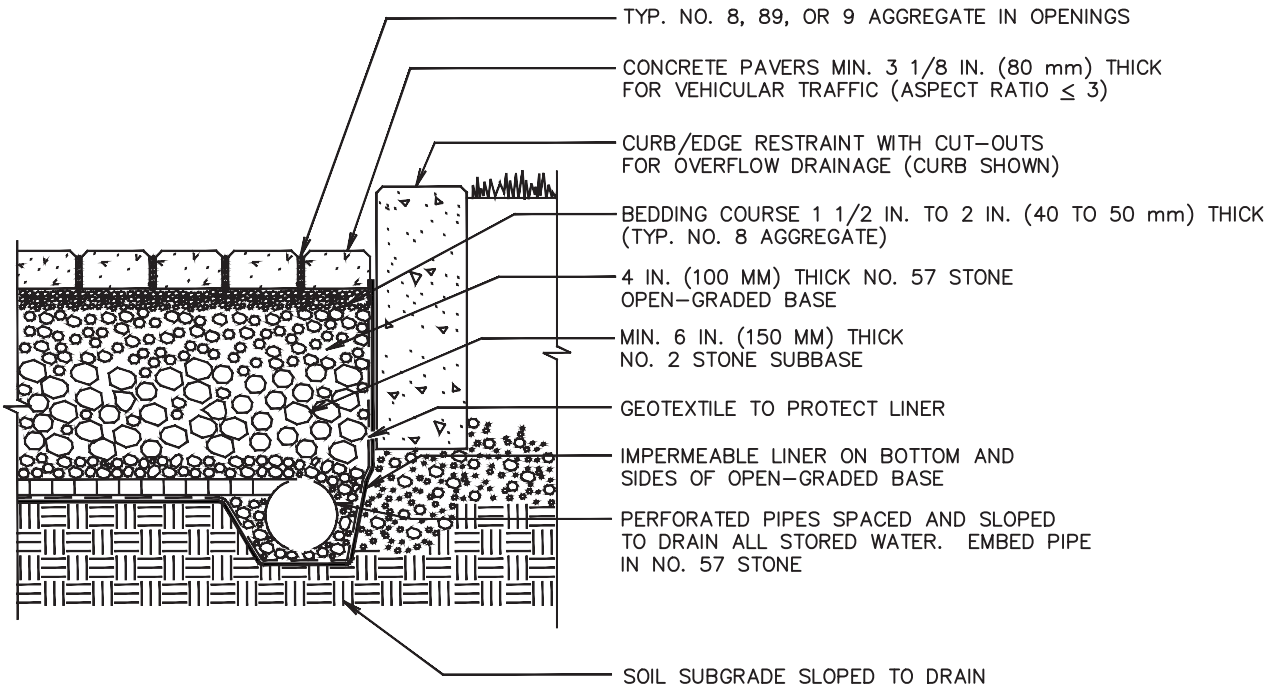
Item 32 14 43.3 – Concrete Curb – per linear foot

Item 32 14 43.4 – Graded Aggregate #57 Stone – per cubic yard

Item 32 14 43.5 – Impervious Liner – per square yard

Item 32 14 43.6 – Permeable Pavement – per square yard

Item 32 14 43.7 – Underdrain Piping and Underdrain Cleanouts – per linear foot



NOTES:

1. THIS DETAIL DISPLAYS KEY CONCEPTS FOR PERMEABLE PAVEMENT AND MAY NOT PROVIDE ALL NECESSARY DESIGN INFORMATION FOR INDIVIDUAL SITES.
2. THIS DETAIL IS FOR CONCRETE PAVERS BUT SETUP FOR ALTERNATIVE SOLUTIONS (I.E. PLASTIC PAVERS, PERMEABLE CONCRETE, ETC ARE SIMILAR IN NATURE).
3. REFERENCE SURFACE MATERIAL MANUFACTURER'S SPECIFICATIONS AND DETAIL

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Notes:

Stormwater Bump-out*

PURPOSE:

Provides water quality and volume benefits through interception and infiltration of runoff before it reaches traditional drainage infrastructure.

APPLICATION:

Use street-side, in parking lots, and in residential developments; often used as traffic-calming devices or to reduce pedestrian travel distance.

GENERAL DESCRIPTION:

Bump-outs are bioretention areas created when the curb and gutter is moved into the portion of the roadway normally reserved for parking. Bump-outs can be designed for intersections or mid-block.

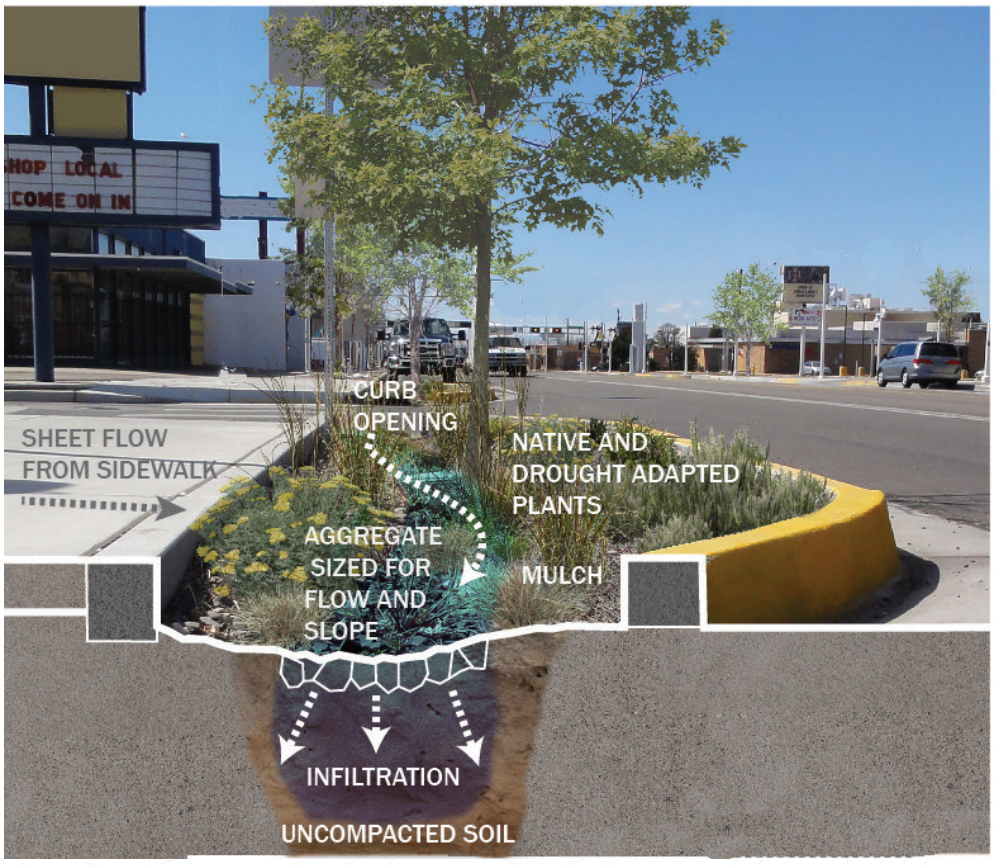


Figure SB-1
Schematic courtesy of Bernalillo County, New Mexico.

**(also known as bulbouts or chicanes)*

Stormwater Bump-out

DESIGN CONSIDERATIONS:

SIZING:

- Size and place erosion protection as needed for design storm.

SITING:

- Consider sub-surface utility conflicts during design.
- Storm drain inlet location and direction of stormwater flow dictate bump-out placement.
- Can be used to retrofit existing projects, as well as constructed with new projects. Retrofit application will require sawcut and removal of existing curb, gutter, and pavement.
- Line and pipe the bioretention cell to the storm drain to prevent extension of runoff into roadway during large storm events.

FUNCTION & MATERIALS:

- Place sediment trap at inlet.
- Place plants according to inundation zone and transect.
- Ensure gutter and bump-out curb opening are aligned.
- If gravel bed is open graded, the gravel bed should be encapsulated in a filter fabric to reduce the migration of fines into the open spaces of the gravel bed.
- Limits of uncompacted soil should be reviewed by the Design Team to not impact grade supported structures or features.

Figure SB-2
Bioretention curb bump-out, Portland Oregon. Source: Tetra Tech.

ESTABLISHMENT & MAINTENANCE:

- Include a temporary or permanent irrigation system for plant establishment.
- Select heat and drought tolerant plants to minimize replacement need.
- Select plants that, once at mature size, allow for vehicle clearances and sight lines.

REFERENCE:

- When placing and designing stormwater bump-outs adjacent to travel ways, check the American Association of State Highway and Transportation Officials Roadside Design Guide for safety requirements including roadway markings on the bump-out.
- Green Stormwater Infrastructure, Low Impact Development, Bernalillo County, New Mexico. 2021
- See specifications and details (on the following pages) and LID calculation sheets for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- Refer to Appendix G: Operations & Maintenance for more information.
- See Plant List, Appendix E.

See Appendix B for Additional BMP-Specific Design Guidance.

SECTION 33 46 84

Stormwater Bumpout

33 46 84.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Stormwater Bumpout (bioretention) as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. Stormwater Bumpouts are landscaped, shallow depressions that capture and temporarily store stormwater runoff from adjacent roadways.*

33 46 84.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Stormwater Bumpout. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 – Channel Excavation

Item 107 – Embankment

Item 300 – Concrete

Item 301 – Reinforcing Steel

Item 307 – Concrete Structures

SARA Items:

Section 31 05 19.13 – Geotextile Separation Layer

Section 31 23 13.1 – Subgrade Preparation (Infiltrating Soil)

Section 32 46 82 – Sand Filter Layer

Section 32 46 83 – Soil Media Layer

Section 32 91 13.16 – Mulch

Section 32 93 94 – Vegetation

Section 33 41 16.19 – Underdrain Piping and Underdrain Cleanout

Section 33 41 44 – Bioretention Infiltration Media

Section 33 46 81 – Impervious Liner

33 46 84.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 84.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. **Basin Inlet:** Contractor to install energy dissipation at the basin inlet to reduce resuspension of accumulated sediment or scouring of mulch and bioretention soil media. Energy dissipators to be specified on plans.

B. **Media Layers:** The following media layer depths shall be installed according to plan set: Mulch, Bioretention Soil Media, Sand Layer, Choker Stone and Drainage Layer (#57 Stone).

C. **Vegetation:** Contractor to install vegetation in basin as specified by Designer.

D. **Impervious Liner:** Impermeable liner, if required, to be installed according to plan set.

E. **Concrete Walls:** Contractor to install concrete walls as specified by Engineer's plan set.

F. **Ponding Depth:** Contractor to provide ponding depth, vertical elevation between top of mulch and inflow invert, as specified by Engineer.

33 46 84.5 MEASUREMENT: This Item will be measured as individual components of each Stormwater Bumpout, to include, excavation, embankment, subgrade preparation, concrete structures, geotextile separation layer, soil media layer, mulch, vegetation, underdrain piping and underdrain cleanouts, graded aggregate #57 stone, graded aggregate choker stone, impervious liner, sand filter layer, etc.

33 46 84.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the below bid items. This price shall be full compensation for furnishing, hauling and placing all materials, for all water required and for all labor, tools, equipment and incidentals necessary to complete the work.

33 46 84.7 BID ITEM:

Item 33 46 84.1 – Excavation – per cubic yard

Item 33 46 84.2 – Embankment – per cubic yard

Item 33 46 84.3 – Subgrade Preparation (Infiltrating Soil) – per cubic yard

Item 33 46 84.4 – Geotextile Separation Layer – per square yard

Item 33 46 84.5 – Soil Media Layer – per cubic yard

Item 33 46 84.6 – Mulch – per cubic yard

Item 33 46 84.7 – Vegetation – per each

Item 33 46 84.8 – Underdrain Piping and Underdrain Cleanouts – per linear foot

Item 33 46 84.9 – Graded Aggregate #57 Stone – per cubic yard

Item 33 46 84.10 – Impervious Liner – per square yard

Item 33 46 84.11 – Sand Filter Layer – per cubic yard

Item 33 46 84.12 – Concrete Structures – per cubic yard

Notes:

Street-side Tree Well

PURPOSE:

Stormwater collection and treatment from small pavement areas.

APPLICATION:

Install adjacent to ground-level impervious cover, such as in parking lot boundaries and medians; also along street edges and medians where sight line obstructions are not an issue.

GENERAL DESCRIPTION

Street-side tree wells are tree wells built adjacent to streets and parking lots and designed to improve stormwater runoff quality through filtration and biological processes. Individual stormwater tree wells have a relatively low storage capacity, however, connecting multiple wells in series using continuous soil trenches and drains can increase the effectiveness of treatment and further reduce volume in the downstream surface drainage systems. Tree wells can be designed with open bottoms where infiltration rates are adequate or with closed bottoms and underdrains to convey water to other stormwater infrastructure. Supplemental irrigation is recommended until plants are established and may be necessary in times of extended drought.

Figure TW-1
Filterra Street Side Tree Well. Shown implemented in edge of parking lot.
Source: Contech Engineered Solutions LLC.

Street-side Tree Well

DESIGN CONSIDERATIONS:

SIZING:

- Treatable drainage areas are typically small for each tree well, use multiple installations to treat larger areas.

SITING:

- Consider local street tree requirements where appropriate.
- Be cognizant of maximum growth potential of tree.
- Ensure trees will not create visual obstructions for pedestrians, bicyclists, drivers, and other roadway users.
- Address sub-surface utility conflicts during design.
- Consider easement requirements for location of tree well.

FUNCTIONS & MATERIALS:

- Choose vegetation that is tolerant of prolonged saturated environments and well-drained soil.

ESTABLISHMENT & MAINTENANCE:

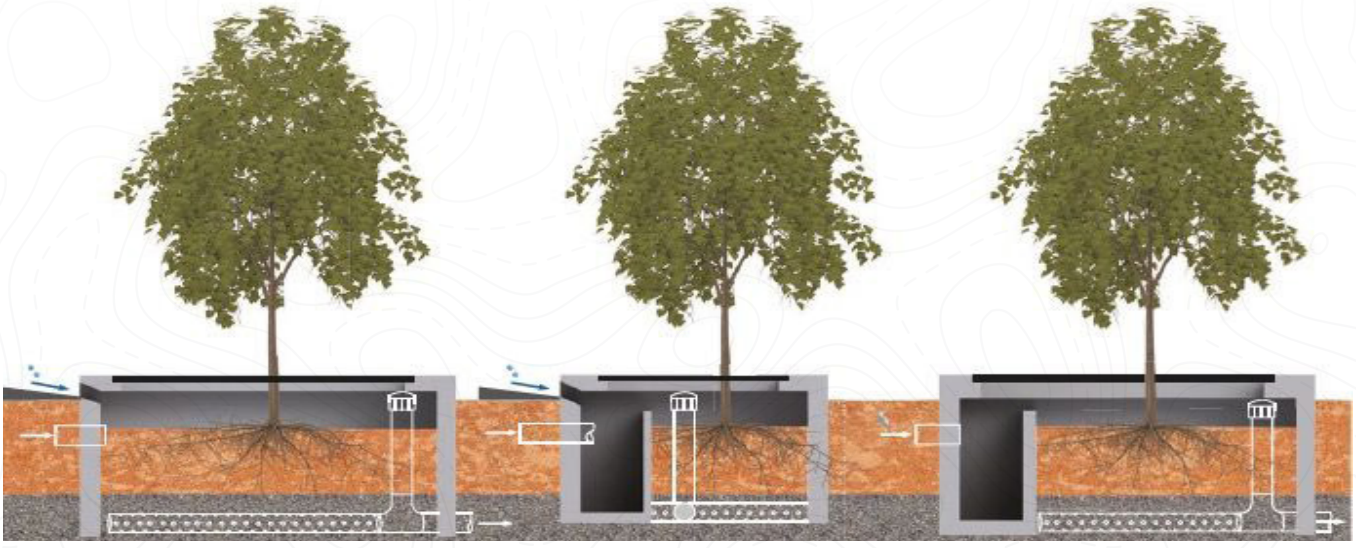
- Provide temporary irrigation during establishment or extreme drought.
- Include adequate access to BMP for mulch replacement and trash removal as needed.
- Deciduous trees will likely require more maintenance due to excess leaf litter.
- Provide root barriers to prevent damage to pavement subgrade and sidewalks.
- Appropriate vegetation should be selected based on the specific site conditions and recommendations by local horticulturalists and tree well manufacturers with consideration given to mature plant characteristics including height, width, and root structure.

REFERENCE:

- Check tree well manufacturer's sizing guides, soil media recommendations, and other requirements.
- Check that manufacturer's sizing recommendation will provide adequate treatment to meet local regulations.
- See specifications, details (on the following pages), and LID calculation sheets for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.

See Appendix B for Additional BMP-Specific Design Guidance.

Figure TW-2
StormTree® typical configuration diagram.
Source: StormTree®



SECTION 33 46 68

Street-Side Tree Well

33 46 68.1 DESCRIPTION: *Construct Furnish, install, test, and make fully operational a Street-Side Tree Well as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. Street-side tree wells are typically pre-cast or cast-in-place concrete boxes that contain typical bioretention layers that capture and immobilize pollutants. Stormwater runoff flows through the media and into an underdrain system at the bottom of the container, where the treated water is discharged.*

33 46 68.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Street-Side Tree Well. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 – Channel Excavation

Item 107 – Embankment

Item 300 – Concrete

Item 301 – Reinforcing Steel

Item 307 – Concrete Structures

SARA Items:

Section 31 05 19.13 – Geotextile Separation Layer

Section 31 23 13.1 – Subgrade Preparation (Infiltrating Soil)

Section 32 46 82 – Sand Filter Layer

Section 32 46 83 – Soil Media Layer

Section 32 91 13.16 – Mulch

Section 32 93 94 – Vegetation

Section 33 41 16.19 – Underdrain Piping and Underdrain Cleanout

Section 33 41 44 – Bioretention Infiltration Media

Section 33 46 81 – Impervious Liner

33 46 68.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 68.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. Set precast vault on crushed rock base material that has been placed in maximum 6-inch lifts, loose thickness, and compacted to at least 95-percent of the maximum dry density as determined by the standard Proctor compaction test, ASTM D698, at moisture content of +/- 2% of optimum water content.

B. Inlet and outlet pipes shall be attached to provided couplers or grouted in and connected to precast or cast-in-place concrete vault according to Engineer's requirements and specifications. All connections to be water tight.

C. All throat and grate protection covers shall remain in place until the system is activated

D. Contractor to cast-in-place throat inlet to convey stormwater into bioretention system according to Engineer's requirements and specifications.

E. If media is shipped separately from vault, Manufacturer or a Manufacturer's certified representative shall install media into the vault or be present tosupervise installation in order to ensure proper installation.

F. The bioretention system shall not be placed in operation (activated) until the project site is clean and stabilized (construction erosion control measures no longer required). The project site includes any surface that contributes storm drainage to the system. All impermeable surfaces shall be clean and free of dirt and debris. All catch basins, manholes and pipes shall be free of dirt and sediment. Activation shall be provided by Manufacturer, authorized supplier, or contractor if unit is cast-in-place.

33 46 68.5 MEASUREMENT: This Item will be measured as individual components of each Street-Side Tree Well to include, excavation, embankment, concrete structure, subgrade preparation, geotextile separation layer, soil media layer, mulch, vegetation, underdrain piping and underdrain cleanouts, graded aggregate #57 stone, graded aggregate choker stone, impervious liner, sand filter layer, etc.

33 46 68.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the below bid items. This price shall be full compensation for all equipment described under this item and all associated items listed below.

33 46 68.7 BID ITEM:

Item 33 46 68.1 – Exacavation – per cubic yard

Item 33 46 68.2 – Embankment – per cubic yard

Item 33 46 68.3 – Subgrade Preparation (Infiltrating Soil) – per cubic yard

Item 33 46 68.4 – Geotextile Separation Layer – per square yard

Item 33 46 68.5 – Soil Media Layer – per cubic yard

Item 33 46 68.6 – Subgrade Preparation (Infiltrating Soil) – per cubic yard

Item 33 46 68.7 – Geotextile Separation Layer – per square yard

Item 33 46 68.8 – Soil Media Layer – per cubic yard

Item 33 46 68.9 – Mulch – per cubic yard

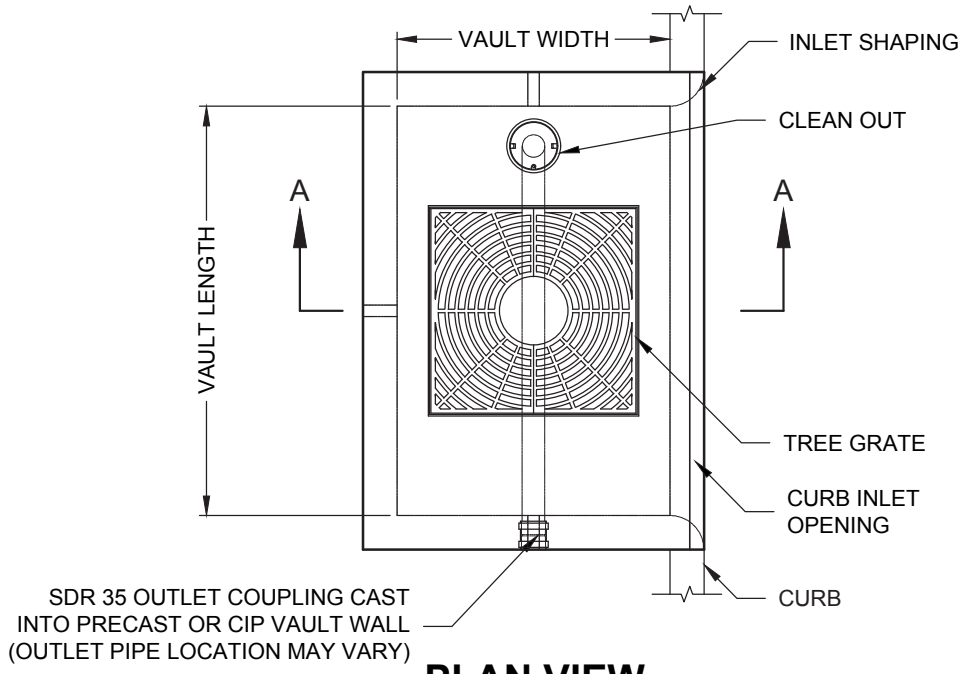
Item 33 46 68.10 – Vegetation – per each

Item 33 46 68.11 – Underdrain Piping and Underdrain Cleanouts – per linear foot

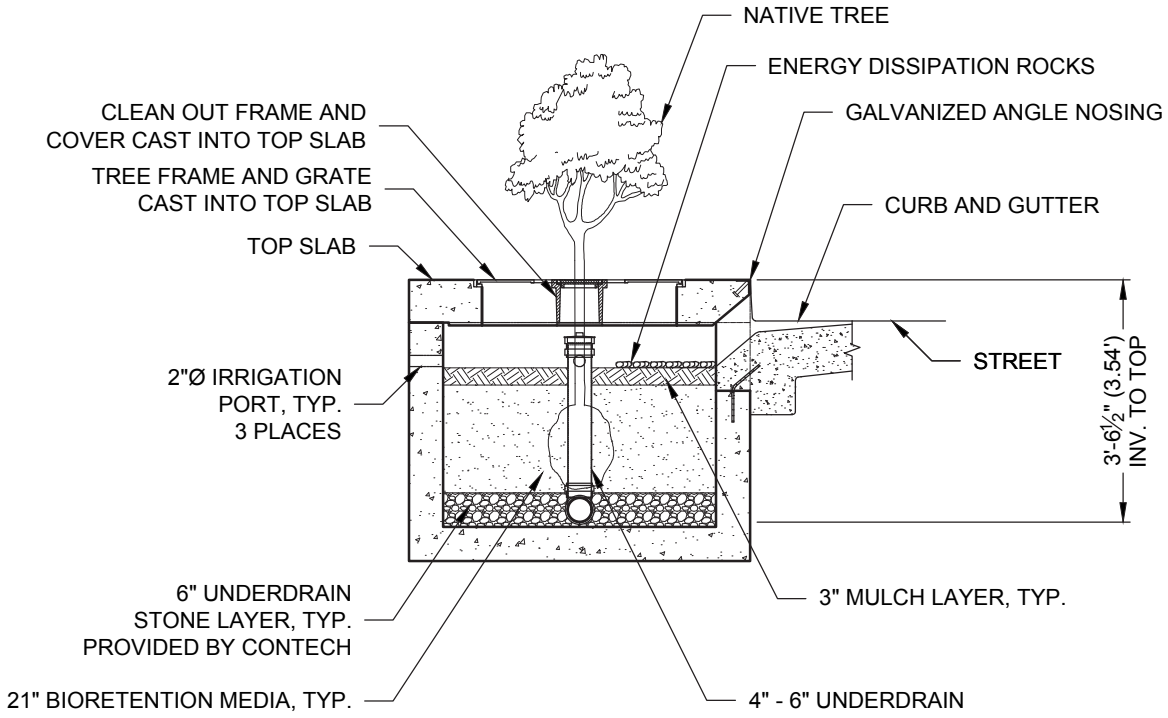
Item 33 46 68.12 – Graded Aggregate #57 Stone – per cubic yard

Item 33 46 68.13 – Impervious Liner – per square yard

Item 33 46 68.14 – Sand Filter Layer – per cubic yard

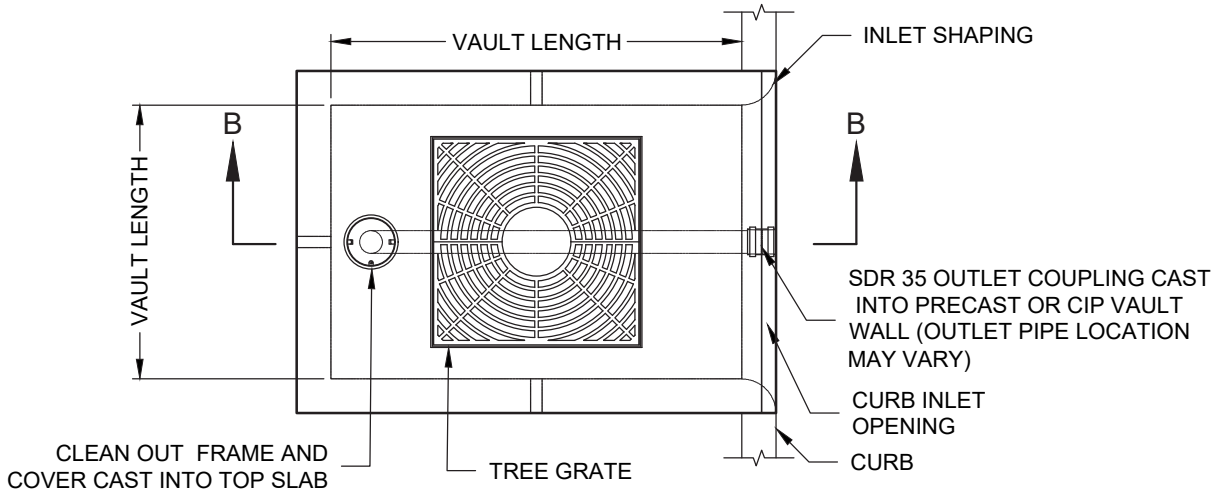


PLAN VIEW

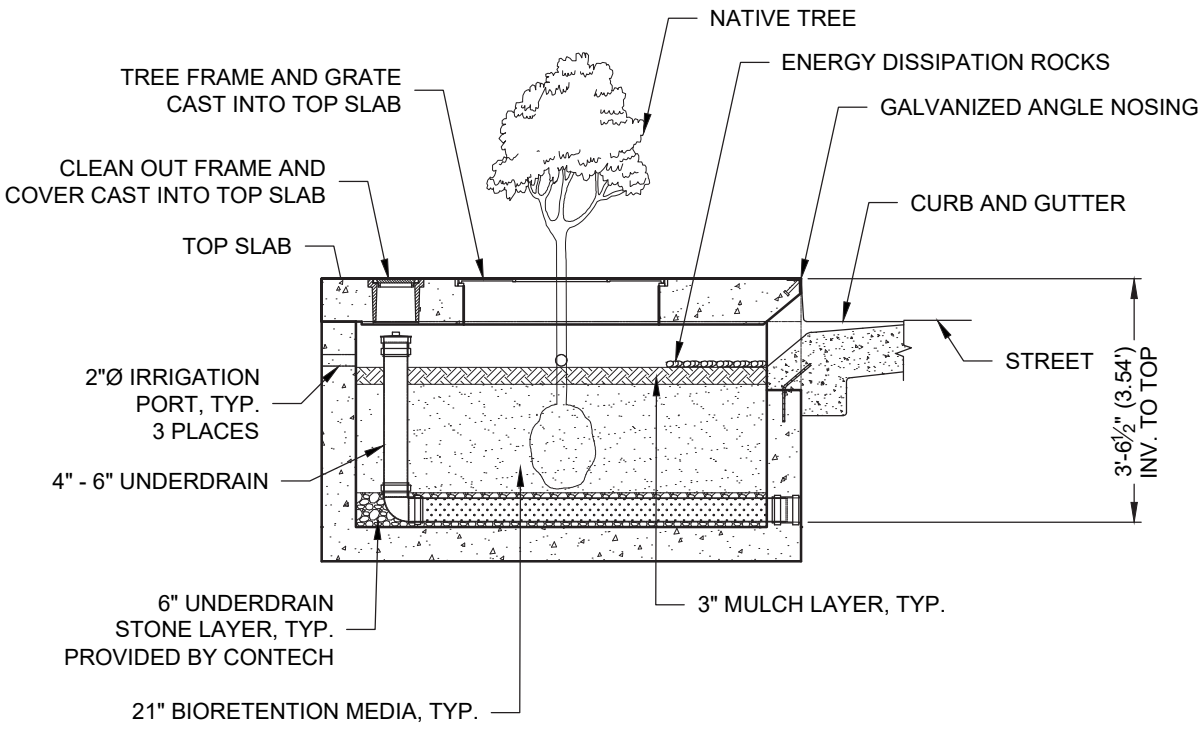


SECTION A-A

SAN ANTONIO RIVER AUTHORITY	STREET–SIDE TREE WELL CONSTRUCTION DETAILS	APPROVED	REVISED
		TW–1	SHEET 1 OF 3

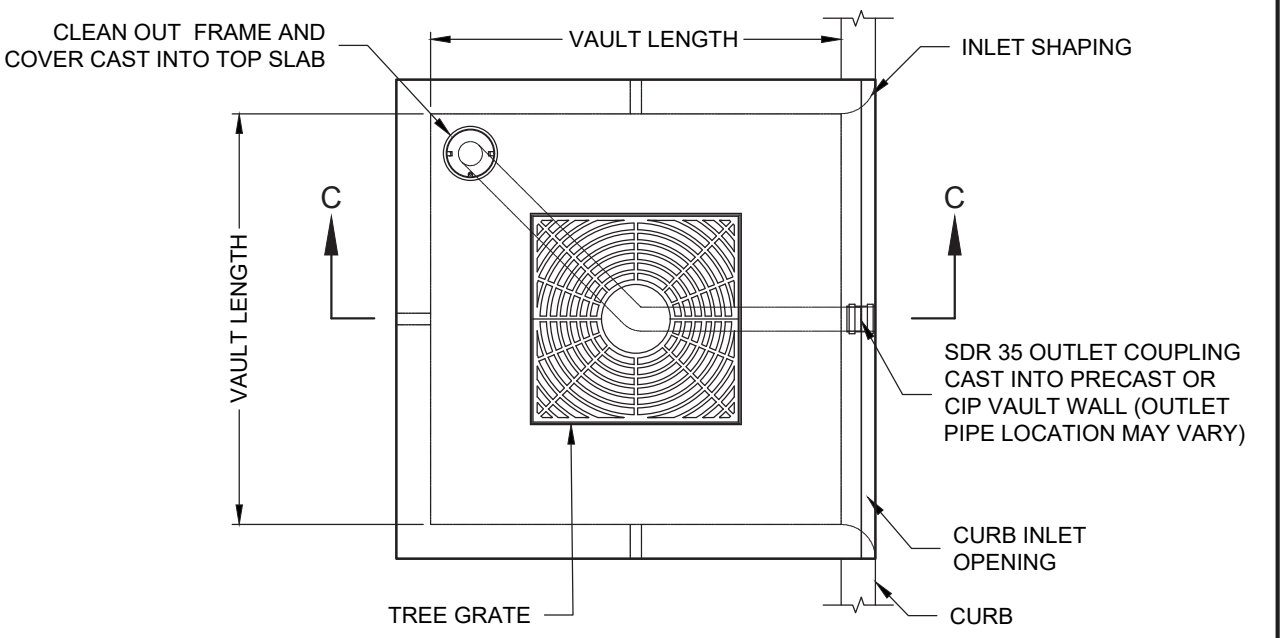


PLAN VIEW

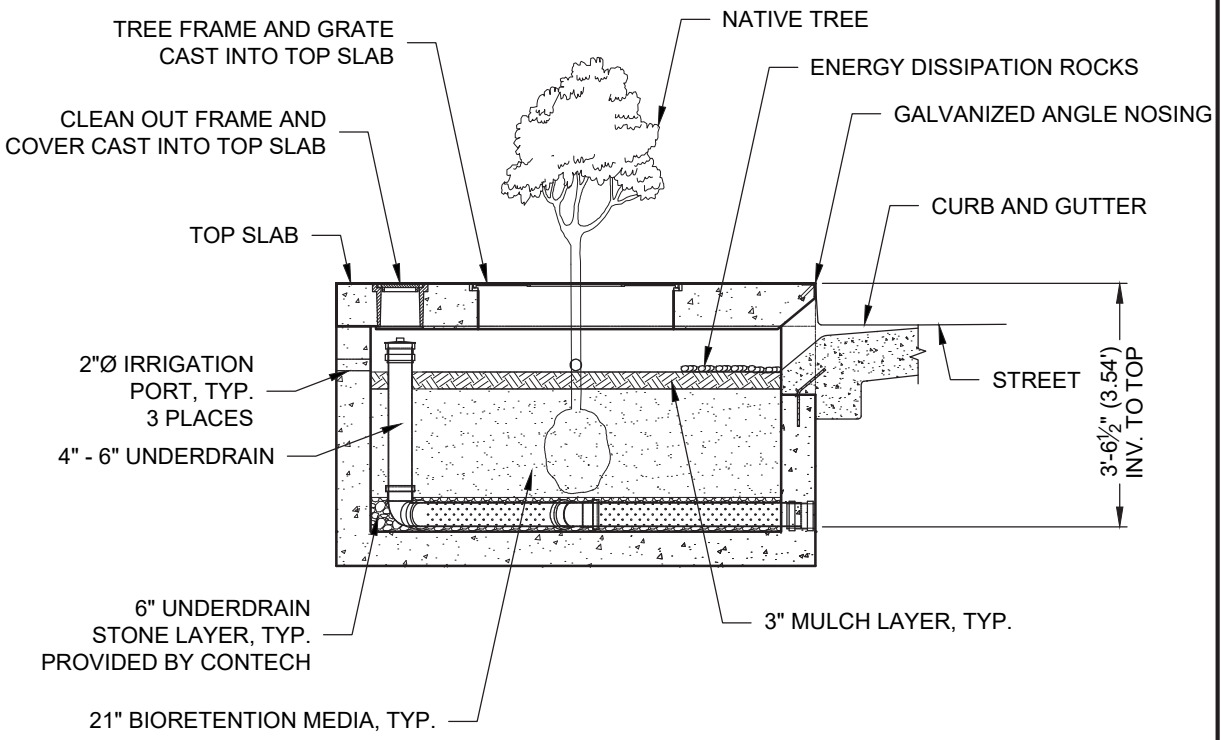


SECTION B-B

SAN ANTONIO RIVER AUTHORITY	STREET–SIDE TREE WELL CONSTRUCTION DETAILS	APPROVED	REVISED
		TW–2	SHEET 2 OF 3



PLAN VIEW



SECTION C-C

SAN ANTONIO RIVER AUTHORITY	STREET–SIDE TREE WELL CONSTRUCTION DETAILS	APPROVED	REVISED
		TW–3	SHEET 3 OF 3

Planter Box

PURPOSE:

Functions similarly to a small bioretention area but is a completely lined concrete box that must have an underdrain; capable of consistent, high pollutant removal for sediment, metals, and organic pollutants (e.g., hydrocarbons).

APPLICATION:

In highly urbanized areas around paved streets, parking lots, and buildings to provide initial stormwater detention and treatment of runoff and to minimize directly connected impervious cover; based on available space, incorporate along the perimeter of buildings, along the roadway right-of-way, or near the outlet of a green roof or cistern.

GENERAL DESCRIPTION:

Planter boxes are vegetated and mulched or grassed shallow depressions within a concrete box that capture, temporarily store, and filter stormwater runoff before directing the filtered stormwater toward a stormwater conveyance system or other BMP via underdrain pipes. The captured runoff infiltrates through the bottom of the depression and a soil media layer approximately 2 to 4 feet deep that has an infiltration rate capable of draining the planter box (to the bottom of the soil media) within a specified design drawdown time. Planter boxes are typically planted with grasses, shrubs, and trees that can withstand short periods of saturation followed by longer periods of drought.

Planter boxes are volume-based BMPs intended primarily for water quality treatment yet can provide limited peak-flow reduction for the water quality or design storm and volume reduction. Planter boxes should be used only in place of bioretention where geotechnical conditions do not allow for infiltration. Although planter boxes do not allow for infiltration into the subsoils, they still provide functions considered fundamental for LID practices.

Figure PB-1
Planter box inlet configuration, San Diego, California.
Photo source: Tetra Tech; Rendering components: San Antonio River Authority.

Planter Box

DESIGN CONSIDERATIONS:

SIZING:

- The planter box must be sized to fully capture the desired or required design storm volume and filter it through the soil media.

SITING:

- Planter boxes provide similar function to a bioretention area but can be used to provide treatment where geotechnical limitations or vertical constraints prevent infiltration.
- Contained planter boxes can be designed close to buildings and other structural foundations without affecting structural stability if underdrain outflow and overflow are routed in a safe direction.
- Planter boxes can be perched above grade on structures and/or be placed in series along a grade (tiered systems) to take advantage of vertical structures.
- Planter boxes can be designed as offline or online systems. (Off-line systems have external bypass and online systems have an internal bypass.) Planter boxes designed in the right-of-way should be designed as offline systems.
- Coordinate design and location with building foundation including existing crawl spaces, underfloor access, and other building features.
- Outlets should be designed to discharge safely towards a stormwater conveyance system or other BMP.
- The structural engineer of record should determine if the existing foundation will tolerate the new load created by the planter box.

FUNCTION & MATERIALS:

- Planter boxes have the same drainage requirements as bioretention but are typically hydraulically isolated from subsoils, so underdrains are always required.
- The overflow system will typically include a vertical riser in both online or offline systems.
- Planter boxes have the same sizing, inlet, media standards, and mulch and vegetation requirements as a bioretention area.
- Planter boxes in the right-of-way should be sized and vegetated to comply with sight distance requirements.
- Depending on the weight of the planter box, above ground systems might require a gravel or concrete footer to distribute the load.

ESTABLISHMENT & MAINTENANCE:

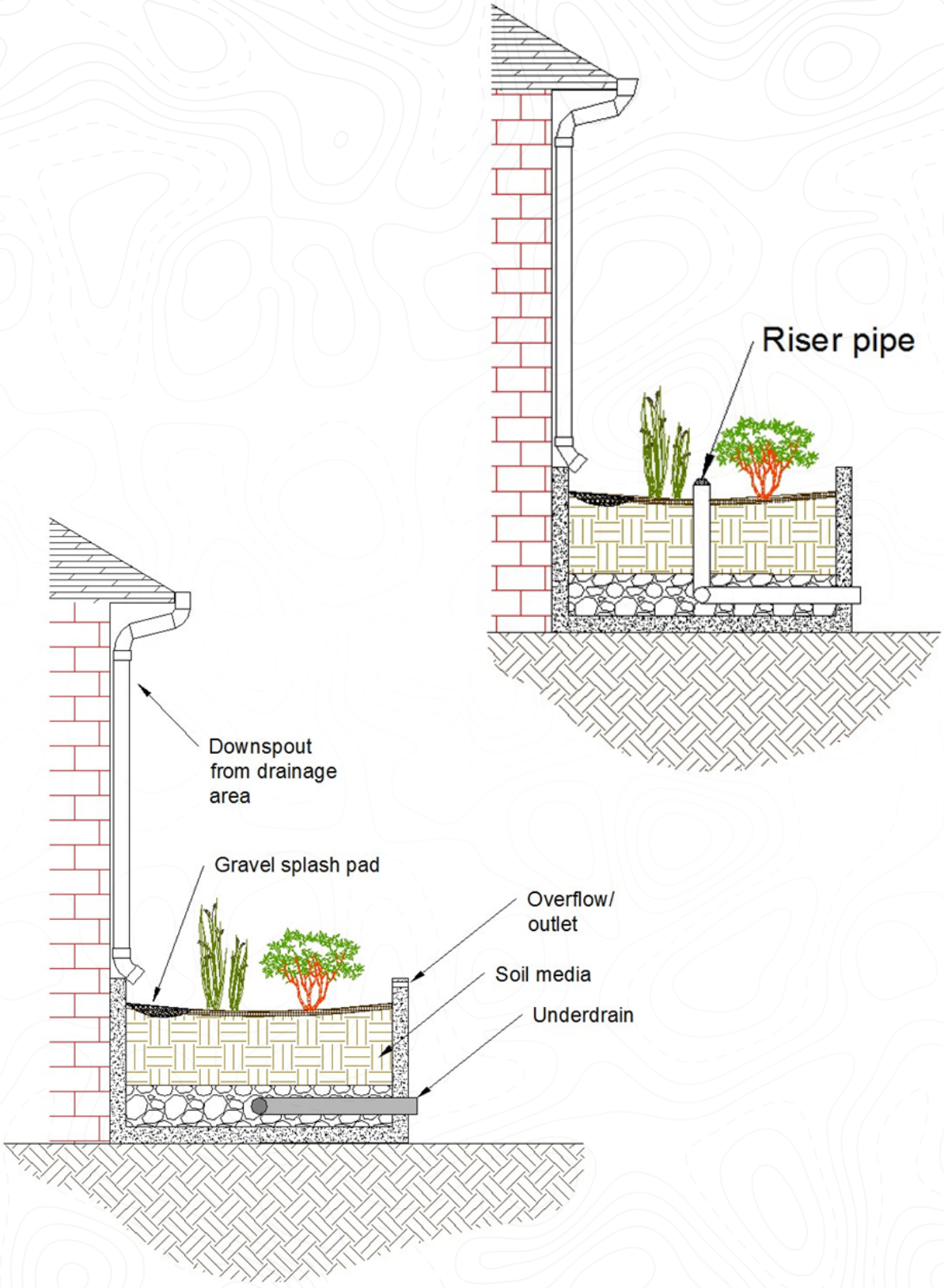
- Designs should specify shade-tolerant plants if the planter box will be shaded by surrounding structures.
- Ensure designs provide access for equipment for maintenance and future repairs.

REFERENCE:

- See specifications, details (on the following pages) and LID calculation sheets for more information.
- Planter box flow volume performance curves are found on page 342; Bacteria, Residential on page 345; Bacteria, Commercial/Industrial/Transportation on page 348; CBOD on page 351; Sediment on page 354; Total-N on page 357; Total-P on page 360; Total-Pb on page 363; and Total-Zn on page 366 of Appendix J.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- See Plant List, Appendix E.

See Appendix B for Additional BMP-Specific Design Guidance.

Planter Box



Figures PB-2 and PB-3
Left to Right: Schematics of planter box inlet configuration and vertical riser pipe.

SECTION 33 46 67

Planter Box

33 46 67.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Planter Box as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. Planter boxes are landscaped, shallow depressions that typically capture and temporarily store stormwater runoff from rooftops.*

33 46 67.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Planter Box. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 – Channel Excavation

Item 107 – Embankment

Item 300 – Concrete

Item 301 – Reinforcing Steel

Item 307 – Concrete Structures

SARA Items:

Section 31 05 19.13 – Geotextile Separation Layer

Section 32 46 82 – Sand Filter Layer

Section 32 91 13.16 – Mulch

Section 33 41 16.19 – Underdrain Piping and Underdrain Cleanout

Section 33 41 44 – Bioretention Infiltration Media

Section 33 46 81 – Impervious Liner

33 46 67.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 67.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. **Basin Inlet:** Contractor to install energy dissipation at downspout locations to reduce resuspension of accumulated sediment or scouring of mulch and bioretention soil media. Energy dissipators to be specified on plans.

B. **Media Layers:** The following media layer depths shall be installed according to plan set: Ponding Depth, Mulch, Bioretention Soil Media, Sand Layer, Choker Stone and Drainage Layer (#57 Stone).

C. **Vegetation:** Contractor to install vegetation in planter box as specified by Designer.

D. **Impervious Liner:** Impermeable liner, if required, to be installed according to plan set.

E. **Concrete Walls:** Contractor to install concrete walls as specified by Engineer's plan set.

33 46 67.5 MEASUREMENT: This Item will be measured as individual components of each Planter Box, to include, excavation, embankment, subgrade preparation, concrete structures, geotextile separation layer, soil media layer, mulch, vegetation, underdrain piping and underdrain cleanouts, graded aggregate #57 stone, graded aggregate choker stone, impervious liner, sand filter layer, etc.

33 46 67.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the below bid items. This price shall be full compensation for furnishing, hauling and placing all materials, for all water required and for all labor, tools, equipment and incidentals necessary to complete the work.

33 46 67.7 BID ITEM:

Item 33 46 67.1 – Excavation – per cubic yard

Item 33 46 67.2 – Embankment – per cubic yard

Item 33 46 67.3 – Geotextile Separation Layer – per square yard

Item 33 46 67.4– Soil Media Layer – per cubic yard

Item 33 46 67.5 – Mulch – per cubic yard

Item 33 46 67.6 – Shrubs – per each

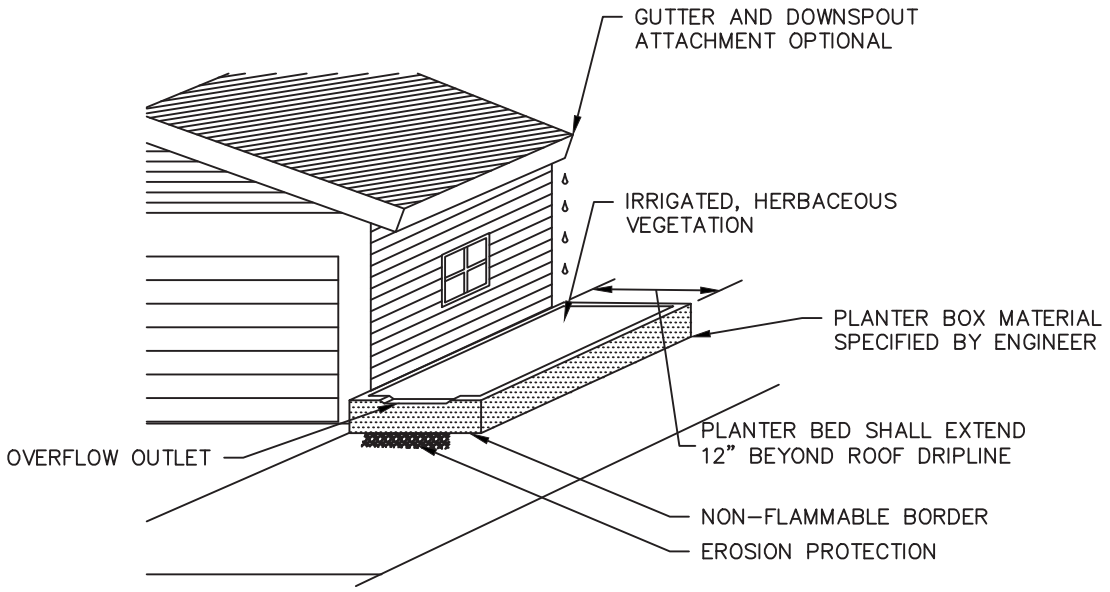
Item 33 46 67.7 – Underdrain Piping and Underdrain Cleanouts – per linear foot

Item 33 46 67.8 – Graded Aggregate #57 Stone – per cubic yard

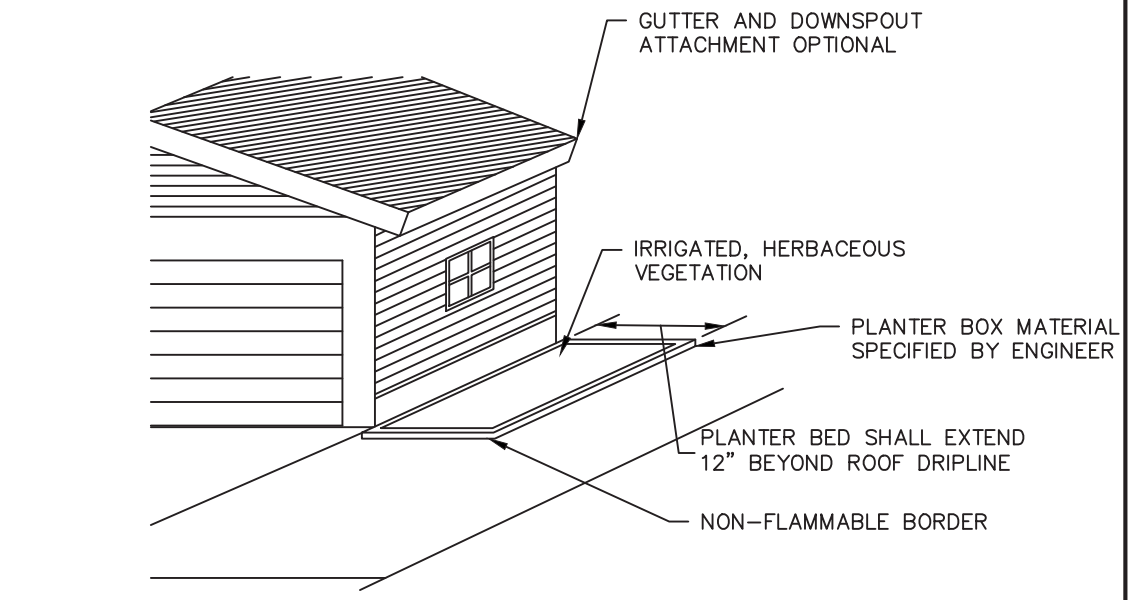
Item 33 46 67.9 – Impervious Liner – per square yard

Item 33 46 67.10 – Sand Filter Layer – per cubic yard

Item 33 46 67.11 – Concrete Structures – per cubic yard



RAISED PLANTER BOX



AT GRADE PLANTER BOX

SAN ANTONIO RIVER AUTHORITY	PLANTER BOX DETAIL	APPROVED	REVISED
		PB-1	SHEET 1 OF 1

Notes:

Green Roof

PURPOSE:

Green roofs provide significant rainfall volume retention and reduced peak discharge from rooftops by intercepting rainfall in a layer of rooftop growing media.

APPLICATION:

Green roofs are highly effective at reducing or eliminating rooftop runoff from small to medium storm events, which can reduce downstream pollutant loads. Green roofs do not typically improve the quality of captured rainwater. Since green roofs are not infiltration BMPs, design as part of treatment train with bioretention or bioswale for water quality treatment.

GENERAL DESCRIPTION:

Rainwater captured in rooftop media evaporates or is transpired by plants into the atmosphere. Rainwater exceeding the media capacity is detained in a drainage layer before flowing to roof drains and downspouts. Green roofs can be designed as shallow-media systems or deep-media systems depending on the design goals, roof structural capacity, and available funding. In addition to providing stormwater volume reduction, green roofs offer an array of benefits including reduced energy use, new habitats for birds and insects, and opportunities for recreation (Figure GR-1).

Green roofs may be extensive or intensive. Extensive green roofs have shallow growing media (4" to 6"), small, drought-tolerant vegetation, and no irrigation needed (Figure GR-3). Intensive green roofs have more than 6" of growing media, deeper rooted vegetation, and require regular irrigation (Figure GR-1). A qualified professional with experience designing intensive green roofs is recommended.

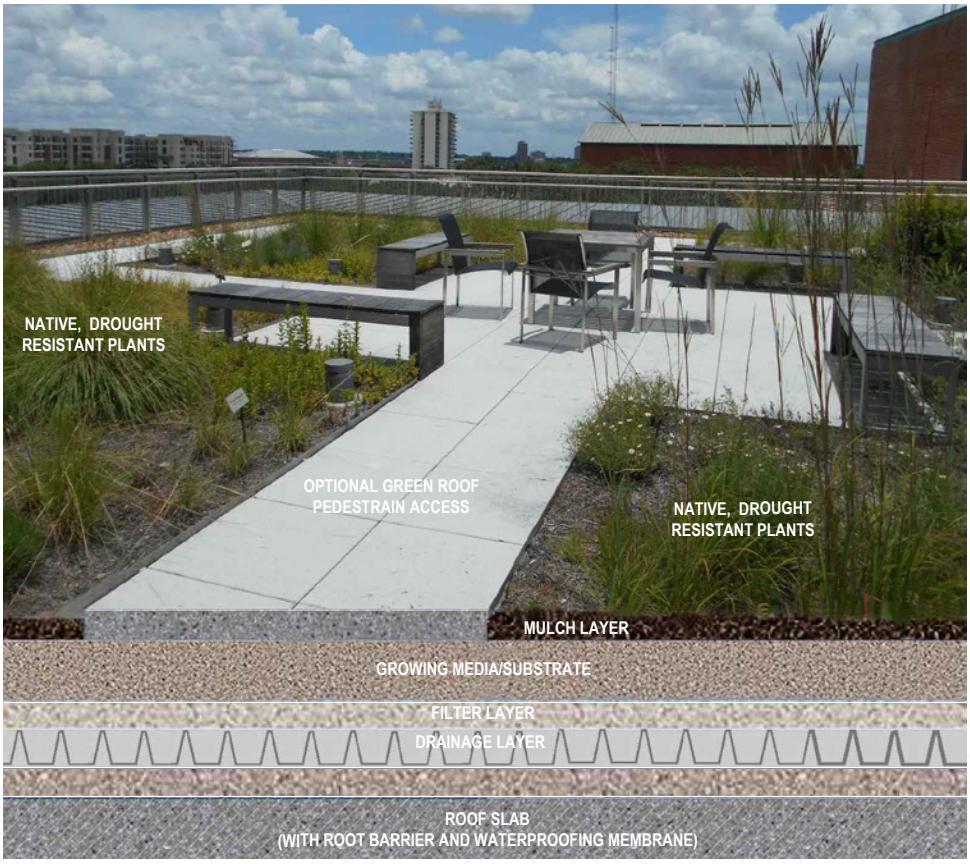


Figure GR-1
Intensive green roof at Trinity University, San Antonio, Texas.

Green Roof

DESIGN CONSIDERATIONS:

SIZING:

- The sizing methodology presented in Bioretention can be used to design the system to capture a specific design volume.

SITING:

- Green roof design is largely dependent on structural constraints of the building. Evaluate the proposed or existing building and roof structure to determine additional dead and live load capacity available to accommodate green roof installation.

FUNCTION & MATERIALS:

- Select waterproof liner. Conventional roof waterproofing tar is typically sufficient but can be supplemented with waterproof geomembranes if desired.
- Select root barrier. Geomembranes used as waterproof liners can sometimes double as root barriers.
- Geotextile fabric should be installed between the media and the aggregate.
- Provide roof drains or scuppers consistent with local building code requirements. Surround outlets with minimum 12 inches of high-porosity drainage material (washed ASTM No. 57 stone or comparable).
- Media should consist of a well-drained, high-porosity mix of primarily lightweight aggregate (preferred media is site specific, but expanded mineral materials are typically specified for intensive green roofs).
- Soil media for green roofs should have the following characteristics:

  - o Well drained and aerated
  - o High porosity
  - o High nutrient holding capacity (cation exchange capacity)
  - o Permanent (non-biodegrading)
  - o Lightweight
  - o Windproof
  - o Stable (must support plants)

- Supplemental irrigation may be necessary ensuring survival and full roof coverage during plant establishment period.
- Where public access is provided for recreation or other purposes, consider barriers to mitigate fall risk.
- If desired, include features to enhance recreational opportunities, habitat, aesthetics, and energy savings.

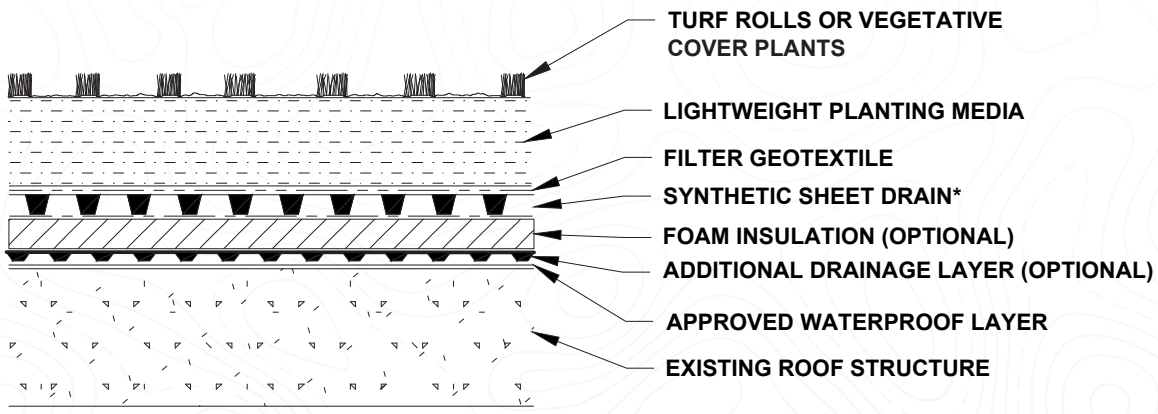


Figure GR-2
Schematic of green roof

Green Roof

ESTABLISHMENT & MAINTENANCE:

- Appropriate vegetation should be selected based on the specific site conditions and recommendations by local horticulturalists and green roof manufacturers with consideration given to mature plant characteristics including height, width, and root structure.
- Provide access for installation, inspection, and maintenance of the green roof, including adequate areas at the building perimeter for material and equipment staging.
- Design should include adequate physical access to the roof and accommodations for transporting media, plants, and other maintenance materials to the rooftop.

REFERENCE:

- See specifications, details (on the following pages) and LID calculation sheets for more information.
- See Specifications to ensure adherence to ADA requirements for heel gaps and bumps.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- Green roof flow volume performance curves are found on page 342; Bacteria, Residential on page 345; Bacteria, Commercial/Industrial/Transportation on page 348; CBOD on page 351; Sediment on page 354; Total-N on page 357; Total-P on page 360; Total-Pb on page 363; and Total-Zn on page 366 of Appendix J.
- Refer to Appendix G: Operations & Maintenance for more information.
- See Plant List, Appendix E.

See Appendix B for Additional BMP-Specific Design Guidance.

Figure GR-3
Extensive green roof, Hipolito F. Garcia Federal Building and United States Courthouse, San Antonio. Source: Joss Growers

SECTION 33 46 69

Green Roof

33 46 69.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Green Roof as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. Green Roofs are a layer of vegetation planted over a waterproofing system and installed on top of a flat or slightly-sloped roof. This specification does not cover structural or architectural elements of the building design.*

33 46 69.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Green Roof. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

SARA Items:

Section 33 41 44 – Bioretention Infiltration Media

33 46 69.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 69.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. General: Install green roof system in strict accordance with manufacturer's instructions and in proper relationship with adjacent materials and the following.
   a. Protection layer: Install the Protection Mat butt jointed above a root proof waterproofing. The protection mat shall be taken above the bioretention media along edges and at roof penetrations. Cut the protection mat in situ at roof penetrations. Protection layer to be specified by Engineer.
   b. Drainage Layer: Install the drainage elements above the protection layer according to manufacturer specifications. Cut the drainage element in situ at roof penetrations and along edges.
   c. Separation Fabric: Install the separation fabric underneath all areas of bioretention infiltration media. Fabric must be durable and have resiliency from clogging and degradation. The fabric must be root-permeable to allow the roots to use the total system depth. Fabric must be made of non-woven geotextile fabric.

d. Bioretention Infiltration Media: Install the bioretention infiltration media layer above the drainage layer to depth specified by Engineer. Check the depth in several places to ensure a continuous thickness.
e. Vegetation Layer: Install vegetation mats, seeding, mature plants, or cuttings as specified by Engineer and/or Landscape Architect. Avoid delivery and installation of vegetation during periods of frost or hot weather conditions. Water and fertilize plants as required by the specific plans lists and local climate.

B. All roof layers, membranes and/or members below the protection layer are to be specified by the Structural Engineer and/or Architect.

33 46 69.5 MEASUREMENT: This Item will be measured as individual components of each Green Roof, to include, vegetation, bioretention infiltration media, drainage layer, protection layer, and separation fabric.

33 46 69.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the below bid items. This price shall be full compensation for all equipment described under this item and all associated items listed below.

33 46 69.7 BID ITEM:

Item 32 93 44.1 – Vegetation (Grasses) – per each

Item 32 93 44.2 – Vegetation (Shrubs) – per each

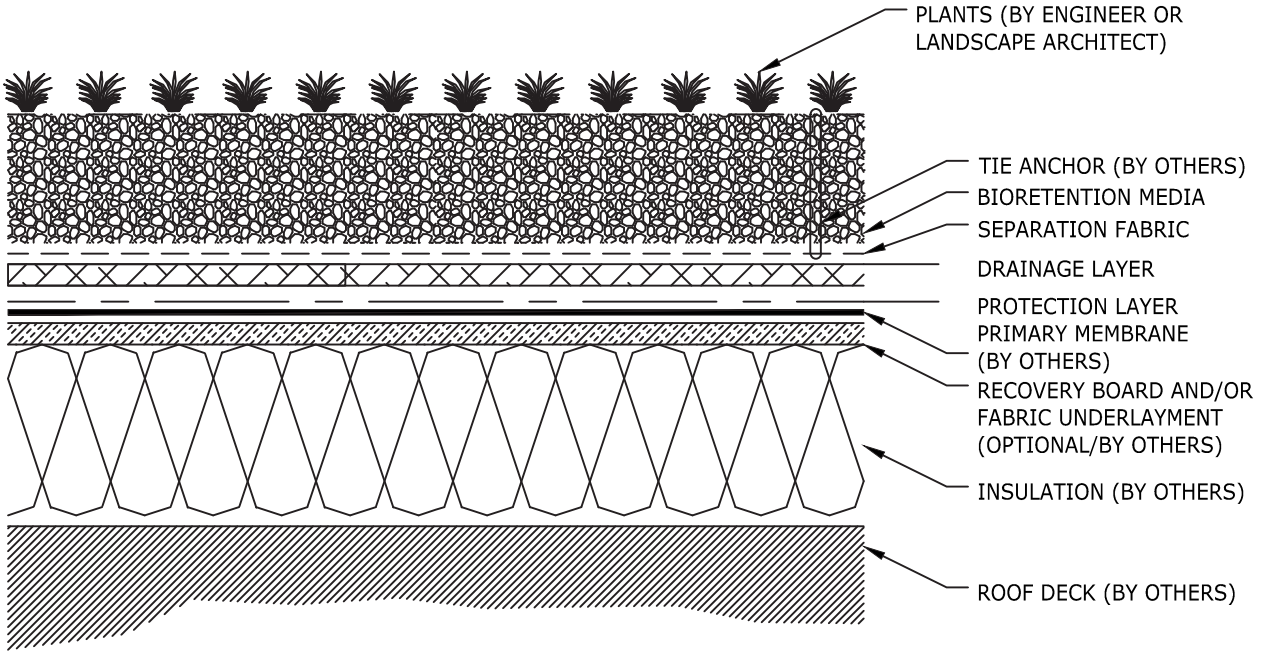
Item 32 93 44.3 – Vegetation (Trees) – per each

Item 33 41 44.1 – Bioretention Infiltration Media – per cubic yard

Item 33 46 69.1– Drainage Layer – per square yard

Item 33 46 69.2 – Protection Layer – per cubic yard

Item 33 46 69.3 – Separation Fabric– per square yard



SAN ANTONIO RIVER AUTHORITY	GREEN ROOF DETAILS	APPROVED	REVISED
		GR–1	SHEET 1 OF 1

Sand Filter

PURPOSE:

Designed primarily for water quality enhancement; however, surface sand filters can store a substantial volume of water and be used for peak flow attenuation.

APPLICATION:

Generally applied to land uses with a large fraction of impervious surfaces; require less space than many BMPs and are typically used in parking lots or other highly impervious areas; because sand filters can be implemented underground, they can also be used in areas with limited surface space.

GENERAL DESCRIPTION:

Sand filters are a flow-through system designed to improve water quality from impervious drainage areas by slowly treating runoff through sedimentation and filtration chambers. With increased detention time, the sedimentation chamber allows smaller particles to settle in the chamber.

For design flexibility, one large sand filter or multiple units dispersed throughout a large site may be incorporated. Two strategies are available for incorporating sand filters into the site design:

- An open basin or above ground design that allows sunlight penetration to enhance pathogen removal;
- A closed basin or below ground design that requires very little space in a site but has reduced pollutant-removal capabilities.

In many cases, sand filters are contained within enclosed concrete or block structures with underdrains; therefore, only minimal volume reduction occurs via evaporation as stormwater percolates through the filter to the underdrain.

Because sand filters rely on filtration as the primary function for pollutant reduction, infiltration rates could be higher than what is recommended for a bioretention area, allowing a greater volume to pass through the media in a short time. That requires less surface area of the BMP to treat the same volume with a lower performance for some pollutants.

Figure SF-1
Surface sand filter at Remington Oaks, San Antonio. Source: Bender Wells Clark Design.

Sand Filter

DESIGN CONSIDERATIONS:

SIZING:

- The sand filter must be sized to fully capture the desired or required design storm volume and filter it through the soil media.
- The sand filter should be oversized by 20 percent to accommodate the sediment accumulation in the surface of the sand filter, which reduces design volume (Barrett 2005).
- Ponding depth limits are not based on vegetation concerns. Depth is determined by the ability of the sand filter to completely drain within 48 hours and, therefore, is a function of the surface area and infiltration rate of the sand media.
- Ponding depth should not exceed 8 feet as a safety precaution, and it should be shallower near residential areas, parks, and schools. When surface sand filters feature deep ponding depths, safety precautions consistent with conventional ponds (shallow water safety shelves, fencing, etc.) should be specified in the design.

SITING:

- Sand filters can be designed as online or offline systems, but offline configurations are typically preferred to preserve the functional life of the filter media.
- A filter strip or swale may be paired with above ground systems.
- Surface sand filters can be integrated into the site plan as recreational facilities such as open space or volleyball courts.

FUNCTION & MATERIALS:

- Sand filters should be designed as infiltrating practices whenever practicable. Refer to Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices (2005) to ensure compliance with the Edwards rules on liner requirements.
- Sand filters have many of the same design elements as bioretention, including geotechnical testing and drainage requirements, but are typically not planted and do not have constraints imposed by vegetation.
- Sand filter performance can be improved if subsoil infiltration rate is sufficiently high (e.g. infiltration rates of greater than 0.5 in/hour).
- Erosive velocities and high sediment loads can be detrimental to sand filters. Both above ground and below ground sand filters require some type of pretreatment before stormwater contacts the filter media.
- Flows entering sand filters should be diffused by passing over a level spreader before contacting the filter media to reduce velocity, minimize filter media erosion, and distribute the flow over a larger surface area.

ESTABLISHMENT & MAINTENANCE:

- It is important to distribute the flow across the surface area of the sand filter as much as possible to prevent the inflow from concentrating in one area, causing erosion and increased maintenance.
- Care should be taken during design to allow for ease of maintenance access. Refer to local guidance for appropriate ramp slope and placement.
- The underdrain system should be designed so that it can be flushed and cleaned as needed.

Barrett, M.E. 2005. Complying with the Edwards Aquifer Rules. Technical Guidance on Best Management Practices. RG-348. Prepared for Texas Commission on Environmental Quality, Field Operations Division, Austin, TX.

Hunt, W.F., C.S. Apperson, and W.G. Lord. 2005. Mosquito Control for Stormwater Facilities. Urban Waterways.

Sand Filter

REFERENCE:

- See specifications, details *(on the following pages)* and LID calculation sheets for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- Refer to Appendix G: Operations & Maintenance for more information.
- Sand filter flow volume performance curves are found on page 342; Bacteria, Residential on page 345; Bacteria, Commercial/Industrial/Transportation on page 348; CBOD on page 351; Sediment on page 354; Total-N on page 357; Total-P on page 360; Total-Pb on page 363; and Total-Zn on page 366 of Appendix J.

See Appendix B for Additional BMP-Specific Design Guidance.

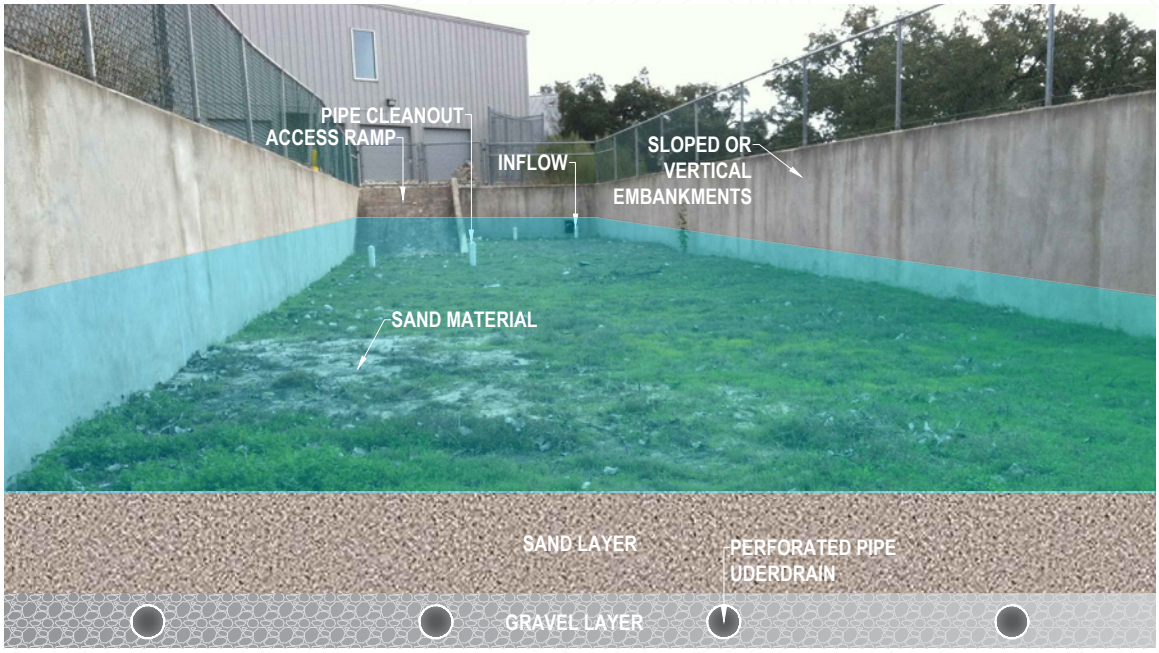


Figure SF-2
Rendering illustrating sand filter geometry and profile.

SECTION 33 46 70

Sand Filter

33 46 70.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Sand Filter as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. A sand filter treatment system works by using a two-component clarification system: the first is a sediment forebay for settling large particles and the second is a horizontal layer of coarse grained soil that acts as a screen.*

33 46 70.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Sand Filter. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 - Channel Excavation

Item 107 - Embankment

Item 300 - Concrete

Item 301 - Reinforcing Steel

Item 307 - Concrete Structures

Item 401 - Reinforced Concrete Pipe

SARA Items:

33 46 81 – Impervious Liner

33 46 70.3 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. Provide sufficient maintenance access according to local code.

B. Absolutely no runoff is to enter the sand filter until all contributing drainage areas have been stabilized. Sand filters may be used as temporary sediment basins during construction but must be cleaned and restored to original condition before use as permanent feature.

C. Surface of filter bed is to be level.

D. Sand filter side walls or slopes to be constructed according to plan design.

33 46 70.4 MEASUREMENT: This Item will be measured as individual components of each Sand Filter to include, excavation, embankment, subgrade preparation, hydromulching, outflow piping, trash rack, concrete work, overflow structures, any necessary velocity dissipators, sand media layer, etc.

33 46 70.5 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Sand Filter":

33 46 70.6 BID ITEM:

Item 106.1 – Excavation – per cubic yard

Item 107.1 – Embankment (Final) – per cubic yard

Item 520.1 – Hydromulching – per square yard

Item 401.1 – Reinforced Concrete Pipe – per linear foot (Class _) (_inches dia.)

Item 33 46 70.1 – Trash Rack – per each

Item 307.2 – Concrete Structure – per cubic yard

Item 33 46 70.2 – Overflow Structure – per each

Item 33 46 70.3 – Velocity Dissipators – per cubic yard

Item 32 46 82.1 – Sand Media Layer – per cubic yard

Item 33 46 81.1 – Impervious Liner – per square yard

SAN ANTONIO RIVER AUTHORITY

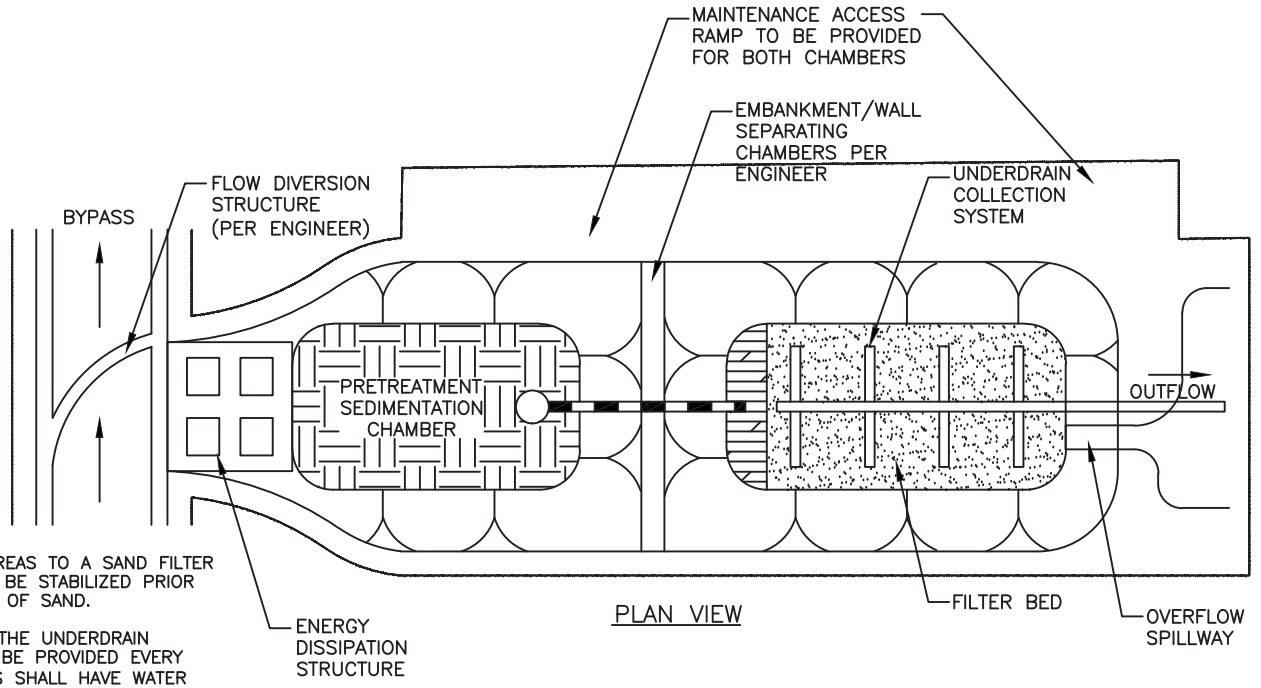
SAND FILTER DETAIL

SF – 1

APPROVED

REVISED

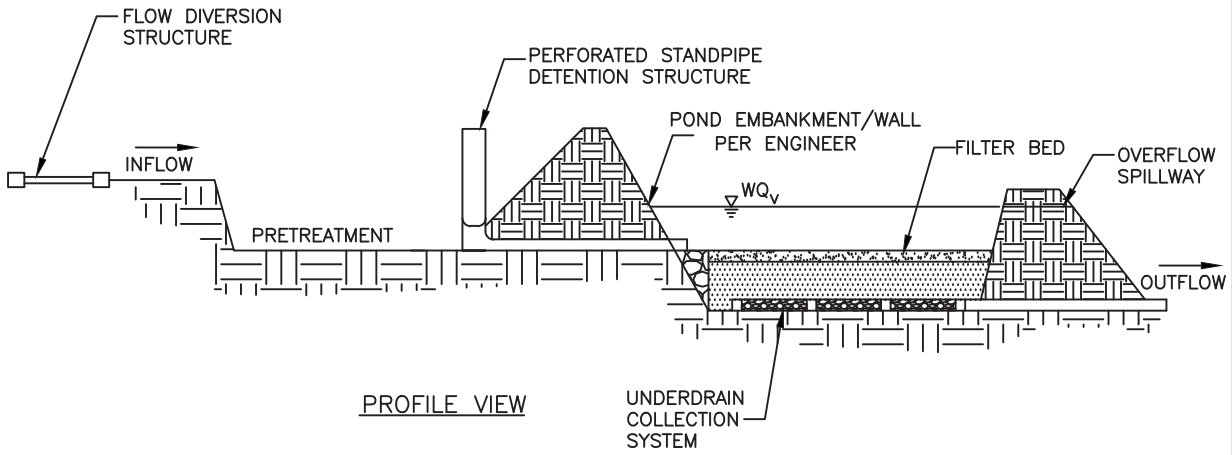
SHEET 1 OF 1



PLAN VIEW

NOTES:

1. ALL DRAINAGE AREAS TO A SAND FILTER FACILITY ARE TO BE STABILIZED PRIOR TO INSTALLATION OF SAND.
2. CLEAN OUTS IN THE UNDERDRAIN SYSTEM ARE TO BE PROVIDED EVERY 50'. CLEAN OUTS SHALL HAVE WATER TIGHT, VANDAL PROOF CAPS AND EXTEND 6" ABOVE THE SURFACE.



PROFILE VIEW

Stormwater Wetland

PURPOSE:

Stormwater quality improvement through physicochemical and biological processes and flood control benefits through temporary storage and slow release of stormwater.

APPLICATION:

Commonly implemented in low-lying areas, stormwater wetlands are well suited to large drainage areas along river corridors where water tables are higher.

GENERAL DESCRIPTION:

Stormwater wetlands are engineered, shallow-water ecosystems designed to treat stormwater runoff. Sediment and nutrients are efficiently reduced by stormwater wetlands by means of sedimentation, chemical and biological conversions, and uptake. Stormwater wetlands provide flood control benefits by storing water and slowly releasing it. Runoff enters stormwater wetlands and is stilled in a forebay where large solids and debris are captured. The design volume then fills the wetland to a depth of 12 inches or less and drains over two to five days through a drawdown orifice installed at the elevation of the permanent pool. Runoff in excess of the design volume can bypass to the downstream stormwater network or can be detained using a riser structure or weir.

Although stormwater wetlands can mitigate peak discharge, they are not designed for volume reduction. Infiltration is discouraged to ensure that permanent pools are maintained for plant survival and aesthetic purposes.

The configuration of the stormwater wetland can be adapted to the available space and desired functions. Long, linear wetlands can be installed along the perimeter of sites, smaller pocket wetlands can be distributed throughout a development, or larger wetlands can be installed at the downstream end of a catchment.

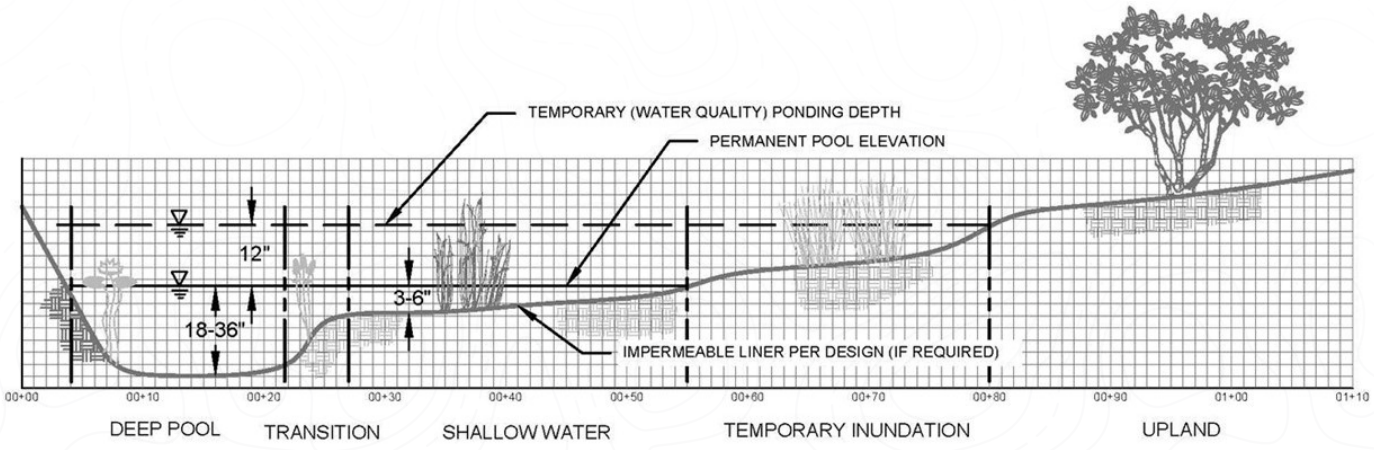


Figure SW-1
The four wetland zones.

Stormwater Wetland

DESIGN CONSIDERATIONS:

SIZING:

- The wetland should be oversized by 20 percent to accommodate the sediment accumulation in the wetland, which reduces design volume (according to Barrett 2005).
- One of the most common causes of wetland plant die-off is designing the shallow water zone too deep; depths greater than six inches will reduce plant survival rates and encourage the encroachment of invasive plant monocultures which can, in turn, harbor mosquito habitat. (Hunt et al. 2005).
- Outlets should be designed such that the water level in the wetland can be varied for establishment periods and maintenance using a variable outlet control like shown in Figure SW-4.

SITING:

- Address sub-surface utility conflicts during design.
- Constructed stormwater wetlands are typically constructed in the lowest area of a site such that runoff can be conveyed by gravity flow and so that excavation is minimized.
- The stormwater wetland location should provide adequate elevation difference, typically three feet or more, to discharge water to the existing stormwater network without the need for pumps.
- Where seasonally low groundwater elevations intersect with the wetland features, groundwater resources might be sufficient to supply enough water to ensure plant survival.
- Unlike many stormwater BMPs, stormwater wetlands are not intended to infiltrate runoff. Thus, the subsoil conditions must be investigated to determine in situ infiltration rates, depth to seasonal high groundwater table, and underlying geology, including proximity to Edwards Aquifer Recharge, Contributing, and Transition zones.

Figure SW-2
Sinuous pattern increases flow path in a stormwater wetland, Wilmington, North Carolina. Source: Tetra Tech.

Figure SW-3
A downturned inlet pipe with an orifice extends into a deep pool in a small stormwater wetland, Raleigh, North Carolina. Source: Tetra Tech.

Barrett, M.E. 2005. Complying with the Edwards Aquifer Rules. Technical Guidance on Best Management Practices. RG-348. Prepared for Texas Commission on Environmental Quality, Field Operations Division, Austin, TX.

Hunt, W.F., C.S. Apperson, and W.G. Lord. 2005. Mosquito Control for Stormwater Facilities. Urban Waterways.

Stormwater Wetland

FUNCTION & MATERIALS:

- A stormwater wetland's function relies on the wetland retaining an adequate supply of water between storm events.
- In areas where an impermeable liner is incorporated into the wetland design, a water balance evaluation should be conducted to determine if the necessary water will be retained in the deep pools.
- A rock-lined forebay stills incoming runoff and allows larger particles to settle.
- Designing the internal wetland features, zones, and footprint is an iterative process. The design must balance storage volume requirements with existing site grading and desired flow length ratios.
- The flow length through the wetland should be maximized to improve residence time and treatment. This can be done by incorporating a sinuous flow path (see Figures SW-2) or by using berms to form racetrack style configurations.
- As with other BMPs, stormwater wetlands can be designed as online or offline systems. Regardless of the configuration, mechanisms are required to draw down water in the wetland basin between storm events.
- A non-clogging orifice should be designed to draw down the water quality design volume in two to five days.

ESTABLISHMENT & MAINTENANCE:

- A trash rack, like the one shown in Figure SW-5, can be used to minimize and limit clogging.
- Draw down orifice mechanisms are required for maintenance.

REFERENCE:

- See specifications, details *(on the following pages)* and LID calculation sheets for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- Stormwater wetland flow volume performance curves are found on page 341; Bacteria, Residential on page 344; Bacteria, Commercial/Industrial/Transportation on page 347; CBOD on page 350; Sediment on page 353; Total-N on page 356; Total-P on page 359; Total-Pb on page 362; and Total-Zn on page 365 of Appendix J.
- Refer to Appendix G: Operations & Maintenance for more information.
- See Plant List, Appendix E.

See Appendix B for Additional BMP-Specific Design Guidance.

Figure SW-4 and SW-5

Left to Right: Outlet elevation varied with weir boards. Source: Tetra Tech. Outlet with trash rack. Source: North Carolina State University Department of Biological and Agricultural Engineering.

SECTION 33 46 71

Stormwater Wetland

33 46 71.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Stormwater Wetland as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. Stormwater wetlands are wetland systems designed to maximize the removal of pollutants from stormwater runoff through settling and both uptake and filtering by vegetation. Constructed stormwater wetlands temporarily store runoff in relatively shallow pools that support conditions suitable for the growth of wetland plants.*

33 46 71.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Stormwater Wetland. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 - Channel Excavation

Item 107 – Embankment

Item 300 - Concrete

Item 301 - Reinforcing Steel

Item 307 - Concrete Structures

Item 401 - Reinforced Concrete Pipe

33 46 71.3 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. Once the stormwater wetland volume has been excavated, the wetland should be graded to create the major internal features (pool, safety ledge, marshes, etc.).

B. After the mulch or topsoil has been added, the stormwater wetland needs to be graded to its final elevations. All wetland features above the normal pool should be stabilized temporarily.

C. After grading to final elevations, the pond drain should be closed and the pool allowed to fill. No mowing, equipment operation, etc. shall be allowed in the stormwater wetland area for six to nine months, unless directed by the landscape architect.

D. Erosion controls should be strictly applied during the standing and planting periods. All vegetated areas above the normal pool elevation should be stabilized during the standing period, usually with hydroseeding.

E. The stormwater wetland should be de-watered at least three days before planting since a dry wetland is easier to plant than a wet one.

F. Reference design plans for velocity dissipators for pipe inflow to stormwater wetland and downstream outfall.

33 46 71.4 MEASUREMENT: This Item will be measured as individual components of each Stormwater Wetland, to include, excavation, embrankment, subgrade preparation, hydromulching, outflow piping, trash rack, concrete work, overflow structures, any necessary velocity dissipators, etc.

33 46 71.5 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the below bid items. This price shall be full compensation for all equipment described under this item.

33 46 71.6 BID ITEM:

Item 106.1 – Excavation – per cubic yard

Item 107.1 – Embankment (Final) – per cubic yard

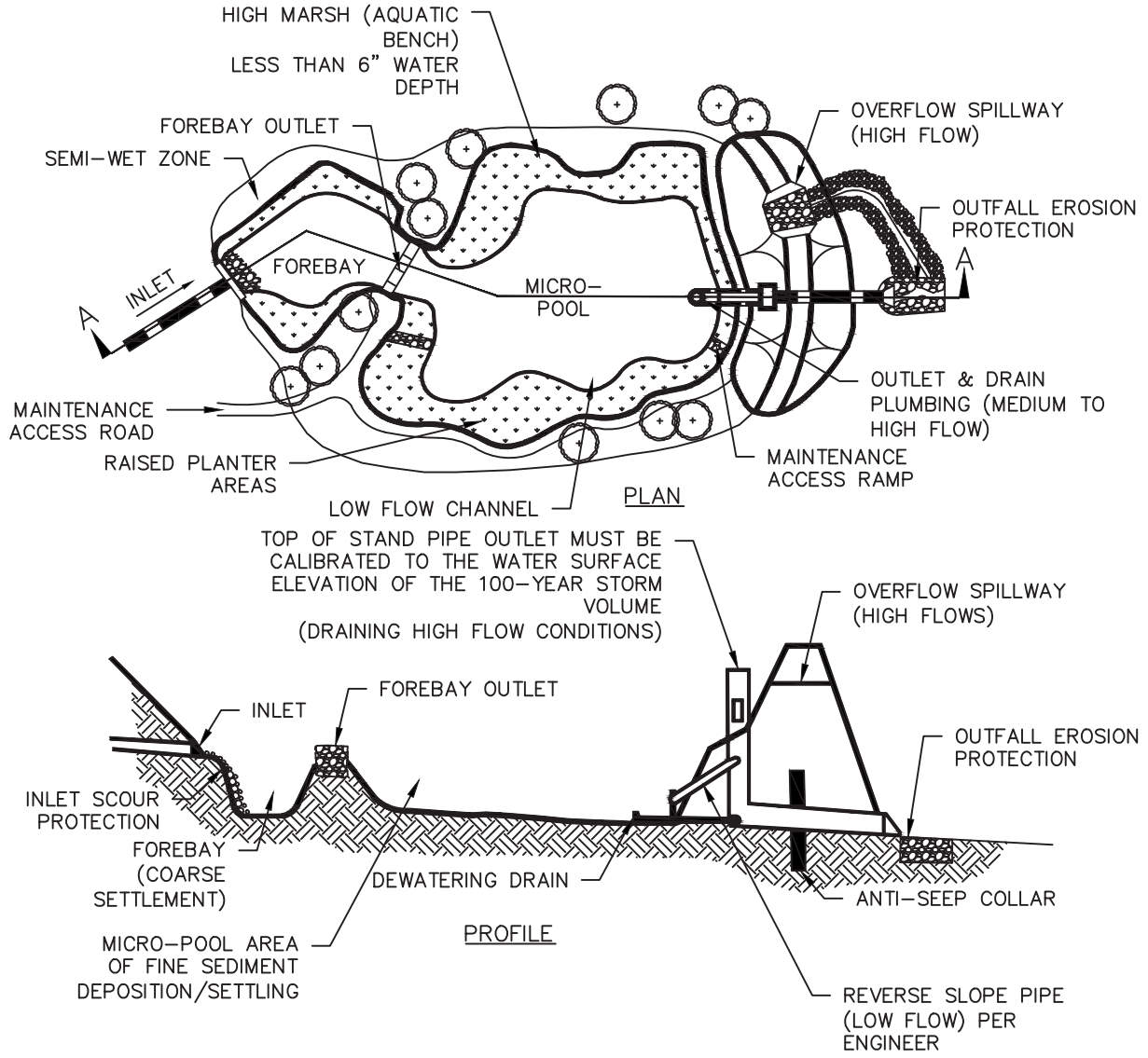
Item 520.1 – Hydromulching – per square yard

Item 401.1 – Reinforced Concrete Pipe – per linear foot (Class _) (_inches dia.)

Item 33 46 71.1 – Trash Rack – per each

Item 307.2 – Concrete Structure – per cubic yard

Item 33 46 71.2 – Velocity Dissipators – per cubic yard



SAN ANTONIO RIVER AUTHORITY	STORMWATER WETLAND DETAILS	APPROVED	REVISED
		SW-1	SHEET 1 OF 1

Stormwater Cistern

PURPOSE:

Stormwater cisterns capture and reduce the amount of site runoff contributing to the peak storm volume.

APPLICATION:

Stormwater cisterns primarily provide control of stormwater volume from rooftops and other impervious areas where site constraints limit the use of other LID techniques. However, water quality improvements can be achieved when cisterns used to capture roof runoff are used in a treatment train with BMPs such as bioretention areas.

GENERAL DESCRIPTION:

Stormwater cisterns are self-contained above ground or below ground container systems that store runoff typically collected from rooftops. Below ground systems often require a pump for water removal. A cistern typically holds several hundred to several thousand gallons of rainwater that can be used in a variety of residential, commercial, governmental, and industrial applications, including non-potable water for irrigation, toilet flushing, cooling system makeup, and equipment and vehicle washing.

Figure SC-1
Stormwater cisterns at the San Antonio River Authority Euclid location.

Stormwater Cistern

DESIGN CONSIDERATIONS:

SIZING:

- Cisterns, which will typically be part of a treatment train that includes other BMPs such as bioretention or pervious pavement, can be incorporated to reduce the size of another BMP.

SITING:

- Ensure a structural engineer reviews the cistern footprint adjacent to the facility foundation.
- Overflow systems should direct water away from any structural foundations.
- Do not direct cistern outfalls towards fences, buildings, or adjacent properties.

FUNCTION & MATERIALS:

- Screen all tank openings including inlets and overflow pipes, and ensure gaps are sealed to prevent mosquito breeding (Hunt, Gee 2021).
- Water in cisterns or rain barrels can be controlled by permanently open outlets or operable valves depending on project specifications.
- The outlet of the cistern should be designed to release the volume of captured runoff at a rate below the design storm rate at its maximum capacity.
- The outlet of the cistern should be directed to a bioretention area or other pervious surface with enhanced infiltration capacity.
- Select opaque and dark cistern tank colors for algae control.

ESTABLISHMENT & MAINTENANCE:

- Consider cistern and/or large tree placement to reduce leaf litter and other debris collected in the gutter system.
- It is possible for some sediment and debris to accumulate in the bottom of the cistern. Access to the cistern should be provided for visual inspections.
- Protect overflow area from erosion by using rock riprap or other stabilizing material.

Figure SC-2
Large below ground cistern under construction, Confluence Park, San Antonio. Source: San Antonio River Foundation.

Stormwater Cistern

REFERENCE:

- See specifications, details *(on the following pages)* and LID calculation sheets for more information.
- See San Antonio plumbing code (City of San Antonio 2009); additional resources are at Texas Commission on Environmental Quality (2011), Texas Water Development Board (2005), and Texas Agrilife Extension Services (2013).
- Stormwater cistern flow volume performance curves are found on page 342; Bacteria, Residential on page 345; Bacteria, Commercial/Industrial/Transportation on page 348; CBOD on page 351; Sediment on page 354; Total-N on page 357; Total-P on page 360; Total-Pb on page 363; and Total-Zn on page 366 of Appendix J.
- Refer to Appendix G: Operations & Maintenance for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.

See Appendix B for Additional BMP-Specific Design Guidance.

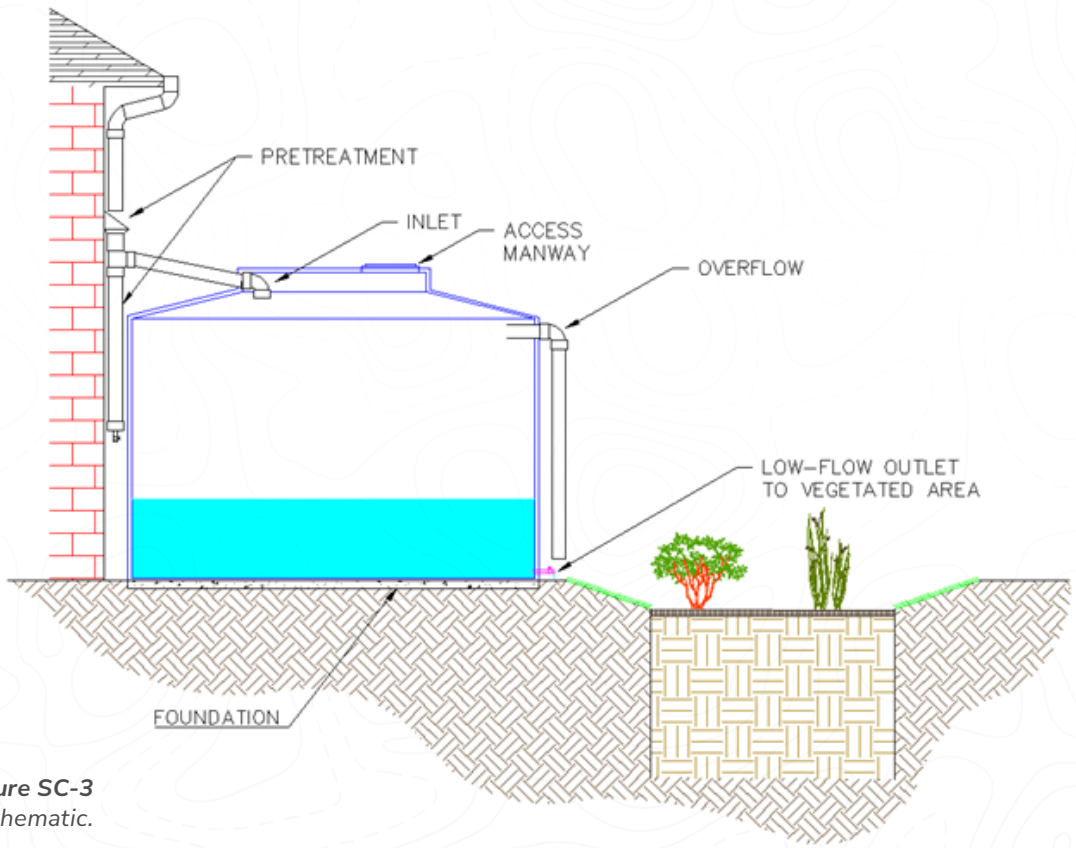


Figure SC-3
Cistern schematic.

City of San Antonio. 2009. Appendix C, Gray Water Recycling Systems and Reclaimed/Recycled Water Systems. 2009 International Plumbing Code and 2009 International Fuel Gas Code/Local Amendments. San Antonio, TX.

Hunt, B., and K. Gee. 2021. Mosquito Control for Rainwater Harvesting Systems. Urban Waterways. North Carolina State Extension, Raleigh, NC. https://content.ces.ncsu.edu/show_ep3_pdf/1630419974/25034/

TCEQ (Texas Commission on Environmental Quality). 2011. Rainwater Harvesting with Rain Barrels. A "Take Care of Texas" Guide. GI-383. Austin, TX.

Texas Water Development Board. 2005. The Texas Manual on Rainwater Harvesting. Third Edition. Austin, TX.

Texas A&M AgriLife Extension Service. 2013. Rainwater Harvesting (online). Accessed 20 June 2013 at http://rainwaterharvesting.tamu.edu/.

SECTION 33 46 39

Stormwater Cistern

33 46 39.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Stormwater Cistern as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. Stormwater Cisterns are self-contained aboveground or belowground container systems that store runoff typically collected from rooftops.*

33 46 39.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Stormwater Cistern. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 300 – Concrete

Item 301 – Reinforcing Steel

Item 307 – Concrete Structures

Item 311 – Concrete Surface Finish.

33 46 39.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 39.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. Cistern tank(s) supplied shall be of the size(s) specified by Engineer.
B. All tanks shall be similar in appearance, finish, and shall be provided by a single manufacturer. Four (4) copies of shop drawings for each individual tank shall be submitted for approval prior to fabrication. Shop drawings shall indicate the types and grades of all materials; tank sizes and dimensions; mounting or assembly instructions; sizes and orientation of basket inlet, overflow, and outlet piping. Ensure maximum height of tank from top of slab to peak is installed according to plan. Each tank is to be mounted to a foundation as shown on plans.
C. Tank sidewalls shall be constructed from 20 gauge galvanized steel or opaque plastic of a similar width with tops 22 gauge or heavier. Tank interiors are to have an epoxy painted liner or approved alternative. Tanks will not be used for potable

water storage. Tanks shall be equipped with one 12" min. observation hatch in the roof assembly positioned for pumped cleanouts; one each 6" diameter overflow outlet pipe; 2" bulkhead 2" diameter lockable ball valve for hose or spigot discharge.

D. Each tank with attached mounting brackets is to be secured to the reinforced concrete base slab with a minimum of three brackets. Each bracket secured to the concrete with two (2) each 0.5-inch "Red Head" - type expandable concrete anchors. If mounting brackets are not physically attached to the tank itself, a minimum of three (3) each 6-inch long, galvanized angle brackets approximately 5" x 7" x 38 " are to be provided and shall be secured to the base slab tightly against the tank to prevent sliding. Two each 0.5-inch "Red Head" – type concrete anchors are to be used to secure each galvanized bracket in place.

E. Tanks shall be similar to those as manufactured by Texas Tanks, Contain Water Systems, RainHarvest Systems, or approved substitute. The tank manufacturer shall have continuously manufactured tanks similar to those specified for no less than four (4) years. Each cistern top shall be provided with a top fitted with an access hatch and screen basket; overflow port and downspout, drain line with valve, and level monitoring port, with mounting brackets, complete.

33 46 39.5 MEASUREMENT: This Item will be measured as individual components of each Stormwater Cistern, to include, concrete pad, stormwater cistern tank, accessories and fittings, and PVC piping and fittings.

33 46 39.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for the below bid items. This price shall be full compensation for furnishing, hauling and placing all materials, for all water required and for all labor, tools, equipment and incidentals necessary to complete the work.

33 46 39.7 BID ITEM:

Item 302.1 – Metal for Structures – per pound

Item 307.2 – Concrete Structure – per cubic yard

Item 311.2 – Concrete Surface Finish – Concrete Paint Finish– per square yard

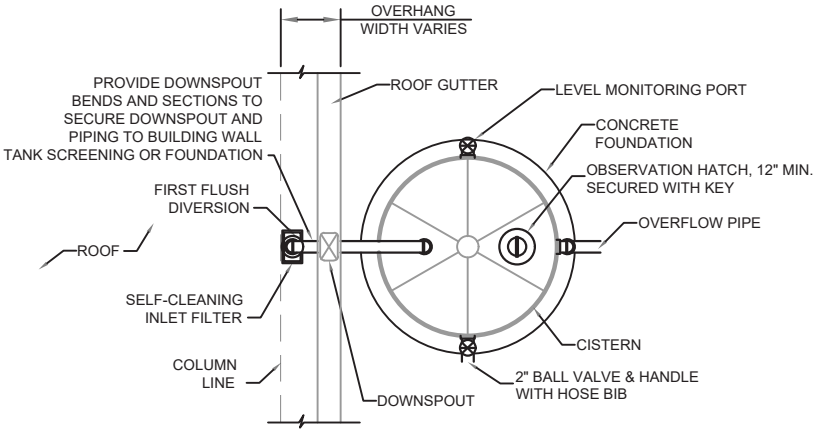
Item 33 46 39.5 – Stormwater Tank – per each

Item 33 46 39.6 – Stormwater Tank Accessories and Fittings – per each

Item 33 46 39.7 – PVC piping and fittings – per linear foot

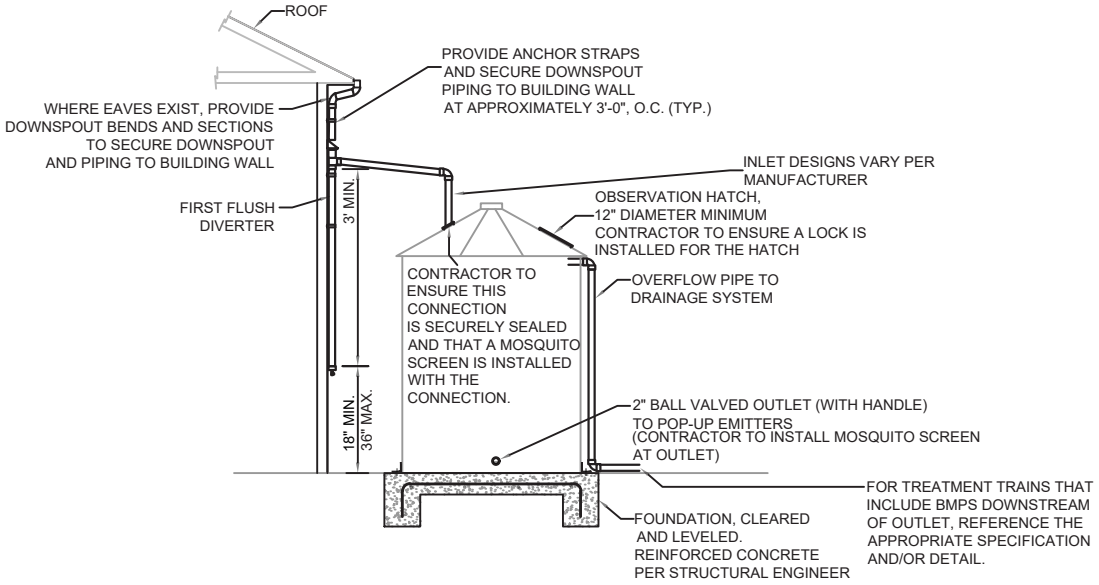
Item 33 46 39.6 – Stormwater Tank Accessories and Fittings – lump sum

Item 33 46 39.7 – PVC piping and fittings – per linear foot



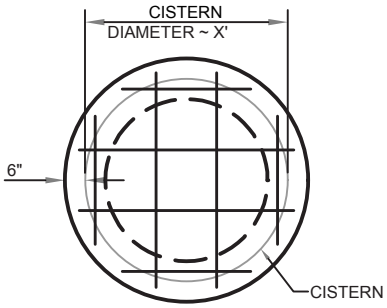
CISTERN PLAN VIEW (TYP.)

NOTE:
PAINT ALL EXPOSED PVC PIPE.
COORDINATE COLOR WITH ARCHITECT.

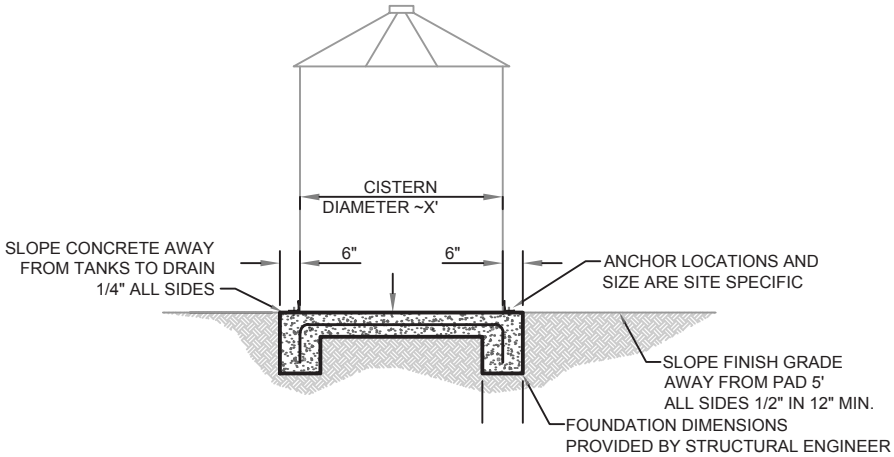


CISTERN PROFILE

SAN ANTONIO RIVER AUTHORITY	STORMWATER CISTERN DETAILS	APPROVED	REVISED
		SC–1	SHEET 1 OF 3



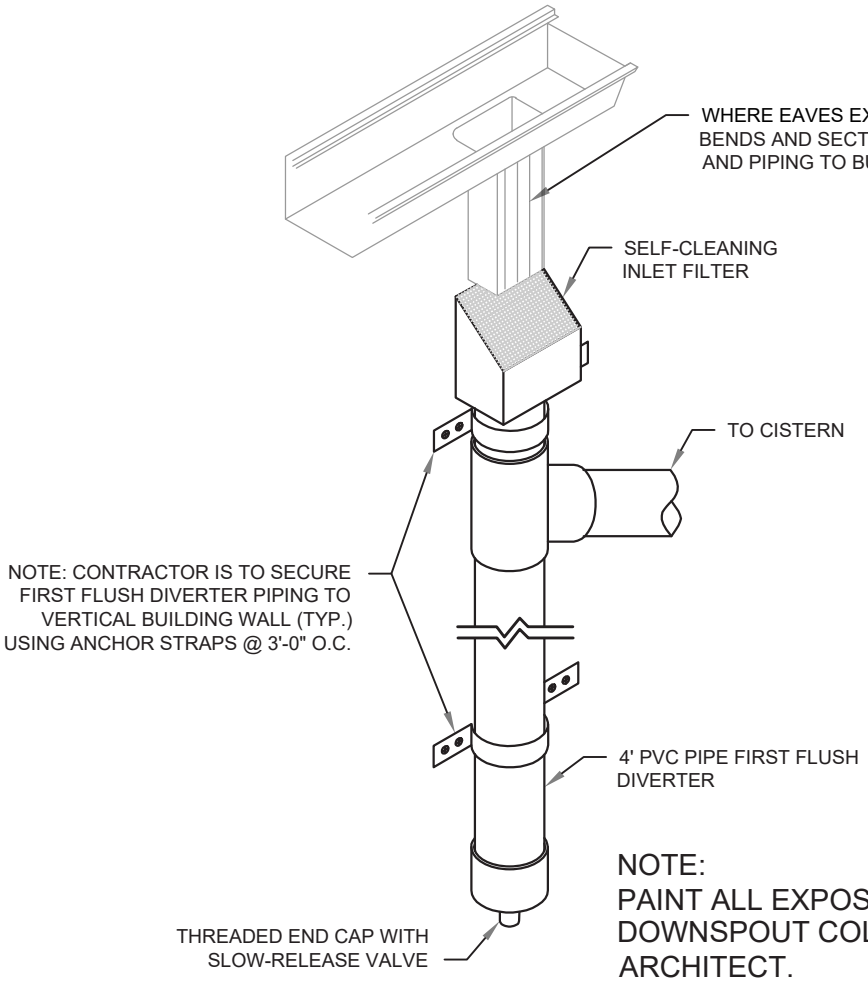
PLAN VIEW



SECTION VIEW

CISTERN CONCRETE SLAB

SAN ANTONIO RIVER AUTHORITY	STORMWATER CISTERN DETAILS	APPROVED	REVISED
		SC–2	SHEET 2 OF 3



NOTE:
PAINT ALL EXPOSED PVC PIPE TO MATCH DOWNSPOUT COLOR. COORDINATE WITH ARCHITECT.

PRETREATMENT DETAIL

SAN ANTONIO RIVER AUTHORITY	STORMWATER CISTERN DETAILS	APPROVED	REVISED
		SC-3	SHEET 3 OF 3

Notes:

Extended Detention Basin

PURPOSE:

Peak stormwater runoff discharge reduction, water quality storage, sediment and particulate matter settling, UV sunlight treatment, and erosion protection to downstream receiving waters.

APPLICATION:

Most often used in residential neighborhoods, commercial areas, and industrial sites, but can also be used for roads and parking lots. Can be retrofitted from stormwater detention basins and roadway stormwater outfalls. (See Figure EDB-2.) Well-suited for sites that are in mandatory detention areas or for sites that have been identified to require detention on site. May be applied for water quality only, even if sites do not otherwise require detention. Particularly effective for water quality when incorporated into a treatment train with other BMPs, such as bioretention.

GENERAL DESCRIPTION:

Extended detention basins (EDBs) are dry detention or sedimentation basins that discharge the design water quality volume of stormwater runoff over an extended period, usually from 24 to 48 hours. EDBs function similarly to flood control detention basins but include the extended holding period to encourage settling of sediment and particulate matter, exposure to UV sunlight, and other processes that treat pollutants before discharge.

EDBs are sized to detain volume for the purpose of water quality, rather than sized for flood control. However, EDBs may be used for both water quality and water quantity control in stacked detention systems where the discharge rate is separated and the water quality basin drains slower.

EDBs include a variety of designs and may be designed as part of a treatment train with other BMPs, such as bioretention, to improve water quality performance. Double-stage EDBs incorporate small wetland marshes, ponding areas, or micro-pools at the downstream section of the basin to promote biological uptake, thus promoting soluble pollutant removal. EDBs that lack large designed permanent pools do not comply with this manual.

Figure EDB-1
Extended Detention Basin, Grant Ranch, Colorado. Photo source: Urban Drainage Flood Control District; Rendering components: San Antonio River Authority.

Extended Detention Basin

DESIGN CONSIDERATIONS:

SIZING:

- The water quality volume should be increased by a factor of 20% to accommodate reductions in the available storage volume due to deposition of solids between full-scale maintenance activities (Barrett 2005).
- The project area must have sufficient area to hold the design water quality volume and hydraulic head.

SITING:

- Address sub-surface utility conflicts during design.
- EDBs work best for watersheds larger than five acres. The orifice design may be prone to clogging when used in smaller watersheds due to the smaller orifices being more prone to clogging.
- Rapidly percolating soils may require minor design adjustments, and the EDB base should not intersect the water table.

FUNCTION & MATERIALS:

- The rate of release is established by the outlet control structure, usually an orifice structure designed at a specific size to control basin discharge.
- EDBs must include an overflow outlet to control the discharge rate and location of discharge of volumes exceeding the design storage volume.
- Energy dissipation is required at the basin inlet to reduce suspension of accumulated sediment. Rock riprap or another velocity reducing system must be placed at the basin inlet to reduce velocities to less than 3 feet per second.
- Trickle channels prevent shallow ponding in front of the structure, providing vector control.

ESTABLISHMENT & MAINTENANCE:

- Sediment forebays and trash racks are design components that will decrease future routine maintenance time.
- Temporary irrigation may be necessary until plants are established.
- Ensure designs provide access for equipment for maintenance and future repairs.

REFERENCE:

- See specifications, details *(on the following pages)* and LID calculation sheets for more information.
- Refer to Appendix G: Operations & Maintenance for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.

See Appendix B for Additional BMP-Specific Design Guidance.

Figure EDB-2
Extended Detention Basin before and after retrofit. Crosspointe and Fairfax County, VA.

Barrett, M.E. 2005. Complying with the Edwards Aquifer Rules. Technical Guidance on Best Management Practices. RG-348. Prepared for Texas Commission on Environmental Quality, Field Operations Division, Austin, TX.

SECTION 33 46 72

Extended Detention Basin

33 46 72.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational an Extended Detention Basin as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. Extended Detention (dry) Basins (EDBs) are detention or sedimentation basins that discharge the design water quality volume of stormwater runoff over an extended period, usually from 24 to 48 hours.*

33 46 72.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of an Extended Detention Basin. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 - Channel Excavation

Item 107 – Embankment

Item 520 – Hydromulching

33 46 72.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper prosecution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 72.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. Basin Geometry: - Contractor to construct basin as directed by Engineer's plan set.

B. Basin Inlet: Contractor to install energy dissipators as specified by Engineer's plan set.

C. Outflow Structure: Contractor to install outflow piping and valves as specified on Engineer's plan set.

D. Vegetation: Reference plan set for direction on how the basin will be stabilized with vegetation.

E. Outfall Erosion Protection: Contractor to install outfall erosion protection as specified on plan set.

F. Sediment Forebay: Sediment forebay shall be constructed according to the Engineer's plan set.

G. Trash Rack: Contractor to install trash rack as specified by Engineer's plan set.

33 46 72.5 MEASUREMENT: This Item will be measured as individual components of each Extended Detention Basin, to include, excavation, embrankment, subgrade preparation, hydromulching, outflow piping, trash rack, concrete work, overflow structures, any necessary velocity dissipators, etc.

33 46 72.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the below bid items. This price shall be full compensation for all equipment described under this item.

33 46 72.7 BID ITEM:

Item 106.1 – Excavation – per cubic yard

Item 107.1 – Embankment (Final) – per cubic yard

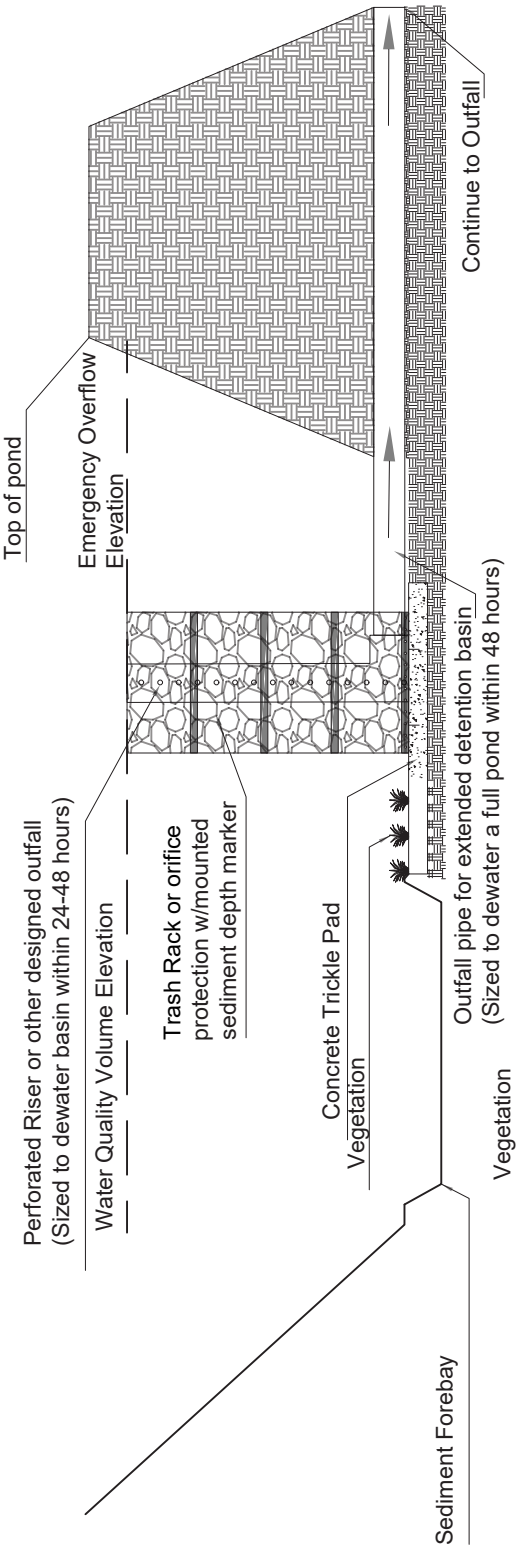
Item 520.1 – Hydromulching – per square yard

Item 401.1 – Reinforced Concrete Pipe – per linear foot (Class _) (_inches dia.)

Item 33 46 72.1 – Trash Rack – per each

Item 307.2 – Concrete Structure – per cubic yard

Item 33 46 72.2 – Velocity Dissipators – per cubic yard



SAN ANTONIO RIVER AUTHORITY	EXTENDED DETENTION BASIN CONSTRUCTION DETAILS	APPROVED	REVISED
		EDB–1	SHEET 1 OF 1

Notes:

Batch Detention

PURPOSE:

Sediment and particulate pollutant removal, peak stormwater runoff discharge reduction, UV sunlight treatment, and erosion protection to downstream receiving waters.

APPLICATION:

Most often used in residential neighborhoods, commercial areas, and industrial sites, but can also be used for roads and parking lots. Can be retrofitted from stormwater detention basins and roadway stormwater outfalls. Requires less space than extended detention basins.

Particularly well-suited for, but not limited to, use where land availability for below grade installation is restricted and there is little elevation head available. Use where Hazardous Material Trap is required.

GENERAL DESCRIPTION:

A batch detention is primarily used to remove particulate pollutants and to mimic predevelopment hydrology. A valve on the outlet is used to detain the produced stormwater runoff for a fixed amount of time and then release it. These devices require less surface area and hydraulic head than sand filters and provide similar, or better, TSS removal. The batch detention basins may be berm-encased areas, excavated basins, or buried tanks, although the latter are not preferred in most situations. (TCEQ 2017).

Batch detention functions include an extended holding period to promote settling of sediment and particulate matter from the full first flush event. Batch detention basins discharge by valve and automated controller instead of by orifice. Thus, unlike the extended detention basin, they can be used in watersheds less than 5 acres without concern of clogging. (TCEQ 2017).

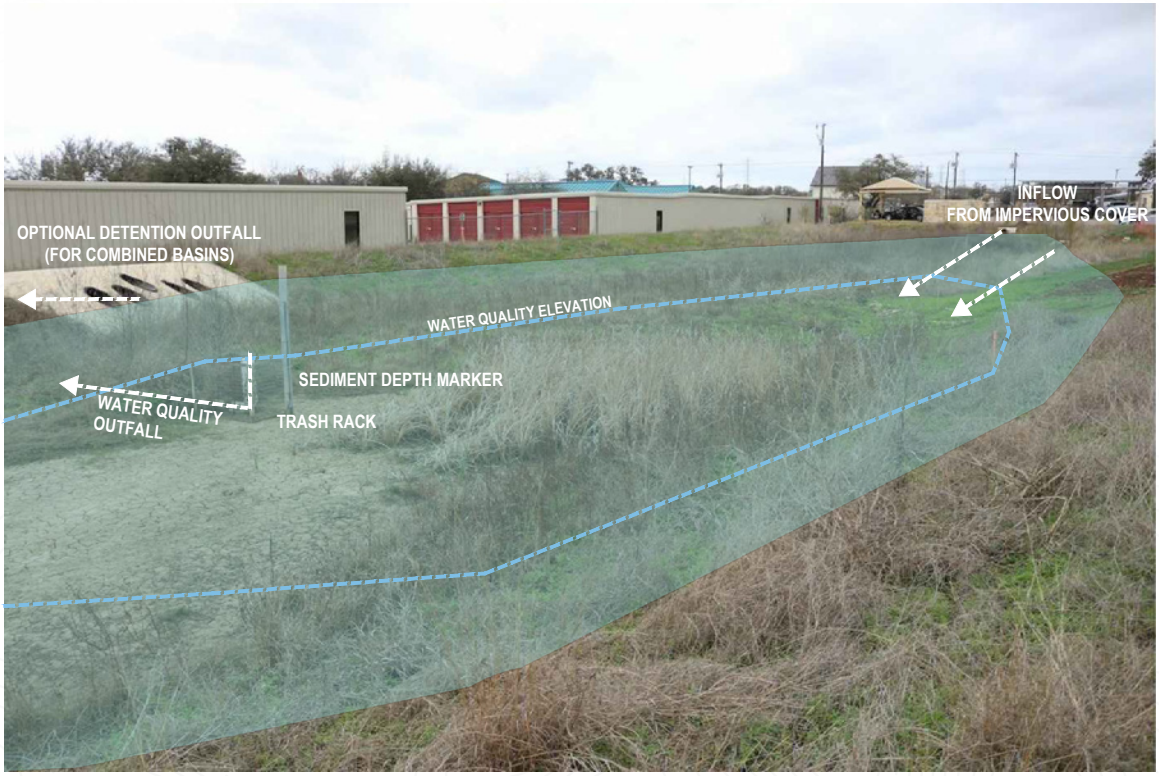


Figure BD-1
Batch detention rendering showing water quality elevation and outfall.

Batch Detention

DESIGN CONSIDERATIONS:

SIZING:

- The water quality volume should be increased by a factor of 20% to accommodate reductions in the available storage volume due to deposition of solids between full-scale maintenance activities (Barrett 2005).

SITING:

- Off-line structures are preferred, though batch detention basins may be constructed either on-line or off-line. (Barrett 2005)

FUNCTION & MATERIALS:

- A non-clogging outflow structure, such as an orifice protected by trash rack, or a perforated riser pipe protected by rip rap, is typically part of the design.
- A fixed vertical sediment depth marker should be installed in the batch detention basin to indicate when sediment accumulation reaches a required removal depth of 6 inches.
- For online basins, a stilling basin at the outfall location may be required to reduce flow velocities from the primary spillway to non-erosive velocities. (TCEQ 2017).
- Solar panel and/or grid-connected power supply will be the primary electric source. An electrical backup power supply shall be installed to ensure proper function of the system and dewatering of the basin.

ESTABLISHMENT & MAINTENANCE:

- Ensure design accommodates an access ramp and clearance for heavy equipment for maintenance and future repairs.

REFERENCE:

- See specifications and details (on the following pages) and LID calculation sheets for more information, including information in the Batch Detention Basin Control System specification regarding solar power system, if incorporated into the design.
- Refer to Appendix G: Operations & Maintenance for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.

See Appendix B for Additional BMP-Specific Design Guidance.

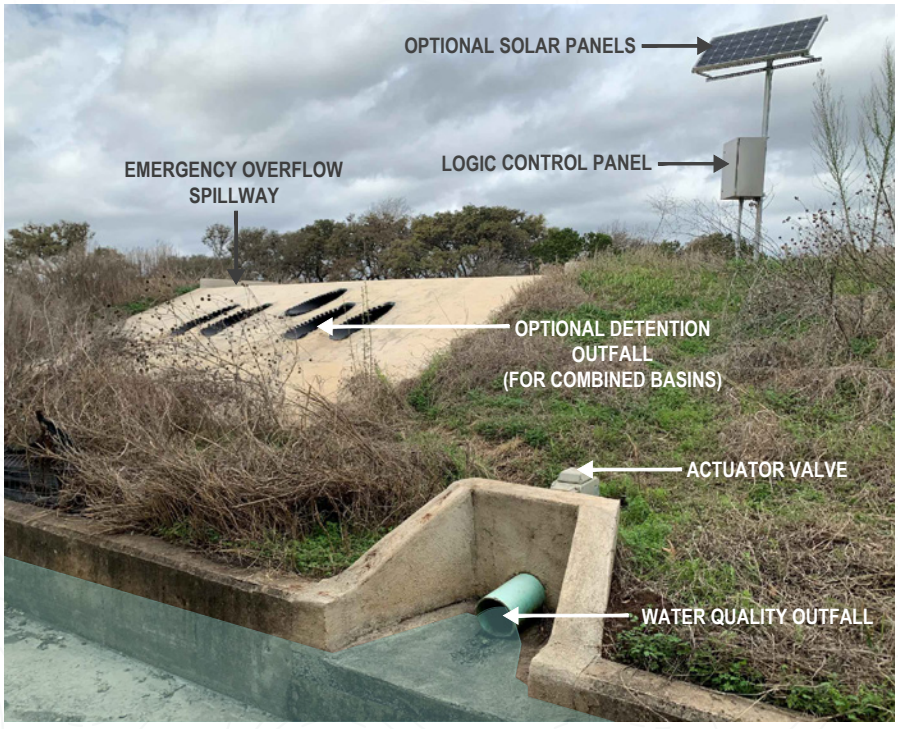


Figure BD-2
Example of configuration combining flood and water quality.

Batch Detention

Figure BD-3
Example of outlet with combined valve and solar panel components. Photo courtesy of Construction Eco Services.

Figure BD-4
Batch detention perforated trash rack riser. Photo courtesy of Construction Eco Services.

Texas Commission on Environmental Quality (TCEQ). (2017). Addendum Sheet: Complying with the Edwards Aquifer Rules Technical Guidance on Best Management Practices RG-348 (Revised July 2005). https://www.tceq.texas.gov/assets/public/comm_exec/pubs/rg/rg348/addendum.pdf

Barrett, M.E. 2005.Complying with the Edwards Aquifer Rules. Technical Guidance on Best Management Practices. RG-348. Prepared for Texas Commission on Environmental Quality, Field Operations Division, Austin, TX.

SECTION 33 46 77

Batch Detention Basin

33 46 77.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Batch Detention Basin as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. A batch detention basin is a facility constructed through filling and/or excavation that provides temporary storage of stormwater runoff using an automated controller and valve outflow.*

33 46 77.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Batch Detention Pond. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 - Channel Excavation

Item 107 - Embankment

Item 300 - Concrete

Item 301 - Reinforcing Steel

Item 307 - Concrete Structures

Item 401 - Reinforced Concrete Pipe

SARA Items:

Section 33 46 78 – Batch Detention Pond Control System

33 46 77.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper prosecution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 77.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. **Basin Geometry**: - Contractor to construct basin as directed by Engineer's plan set.

B. **Basin Inlet:** Contractor to install energy dissipators as specified by Engineer's plan set.

C. **Outflow Structure:** Contractor to install outflow piping and valves as specified on Engineer's plan set.
D. **Vegetation:** Reference plan set for direction on how the basin will be stabilized with vegetation.
E. **Outfall Erosion Protection:** Contractor to install outfall erosion protection as specified on plan set.

33 46 77.5 MEASUREMENT: This Item will be measured as individual components of each Batch Detention Basin, to include, excavation, embankment, subgrade preparation, hydromulching, outflow piping, trash rack, concrete work, overflow structures, any necessary velocity dissipators and associated batch detention basin control system.

33 46 77.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Batch Detention Basin". This price shall be full compensation for all equipment described under this item and Item 117 – Batch Detention Basin Control System.

33 46 77.7 BID ITEM:

Item 106.1 – Excavation – per cubic yard

Item 107.1 – Embankment (Final) – per cubic yard

Item 520.1 – Hydromulching – per square yard

Item 401.1 – Reinforced Concrete Pipe – per linear foot (Class _) (_inches dia.)

Item 33 46 77.1 – Trash Rack – per each

Item 307.2 – Concrete Structure – per cubic yard

Item 33 46 77.2 – Velocity Dissipators – per cubic yard

Item 33 46 78.1 – Batch Detention Basin Control System – per each

SECTION 33 46 78

Batch Detention Basin Control System

33 46 78.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a Batch Detention Basin Control System as specified by Engineer with appurtenances included hereafter at designated locations as shown on the plans. Approved equipment shall provide the functionality and monitoring functions as specified below. For each solar power system, if proposed, located at each project site submit electrical load calculations, structural load calculations, drawings, and details. Include the structural connection details for solar panels, control panel, and battery enclosure to poles. Structural calculations shall be sealed by a licensed structural engineer in the state of Texas. Provide equipment data sheets, details, and specifications.*

33 46 78.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

33 46 78.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper prosecution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 78.4 CONSTRUCTION:

A. Installation. Provide equipment that utilizes the latest available techniques for design and construction with a minimum number of parts, subassemblies, and modules to maximize standardization and commonality.

B. System Configuration. Configure and fully integrate the equipment to provide a fully operational system.

C. General. Furnish and install all materials, including support, calibration and test equipment, to ensure an operating and functional solar power system. Install power and data cables, power grounding and lightning suppression systems. Prior to beginning installation, inspect each site to verify suitability of the design for installation, grounding and lightning protection.

D. Configure and setup the solar power system, if proposed, to assure connection and electric power delivery to the field equipment as indicated in the plans. Locate and mount all equipment as detailed in the plans and as directed by the Engineer.

E. Wiring. Provide wiring that meets the requirements of the NEC. Provide wires that are cut to proper length before assembly. Provide cable slacks to facilitate removal

and replacement of assemblies, panels, and modules. It is not acceptable to "double-back" wire to take up slack. Lace wires neatly with nylon lacing or plastic straps. Secure cables with clamps. Provide service loops at connections. All wiring, conduit, cables, conductors, and overall electrical setup shall be designed by an Engineer licensed in the State of Texas.

F. Poles. Mount all PV units and cabinets on poles as shown on plans. Provide poles as shown on plans for the height specified. Coordinate location of PV system pole with location of batch outlet structure. Ensure poles are located a maximum of 100m (330ft) from batch outlet structure.

G. Testing. Test the system at the factory and in the field to assure proper function operation.

33 46 78.5 MEASUREMENT: This Item will be measured as each Batch Detention Basin Control System with control system installed, fully integrated and tested.

33 46 78.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Batch Detention Basin Control System". This price shall be full compensation for all equipment described under this item, all conduit, cables, and connectors, all documentation and testing, and furnishing all labor and equipment necessary to complete the work.

33 46 78.7 BID ITEM:

Item 33 46 78.1 – Batch Detention Basin Control System – per each

BATCH DETENTION CONSTRUCTION NOTES:

1. CONTRACTOR TO CONSTRUCT POND OUTFLOW PIPES FROM DOWNSTREAM TO UPSTREAM.
2. CONTRACTOR TO ENSURE LOGIC BOARD IS INSTALLED WITHIN 100 FEET OF THE ACTUATOR VALVE, BE ACCESSIBLE BY PEDESTRIANS, AND BE LOCATED ON THE TOP OF THE POND EMBANKMENT.
3. A MANUAL RELEASE TEST OF THE ACTUATOR VALVE WILL BE PERFORMED WITH THE ENGINEER AND PROPERTY OWNER PRIOR TO FINAL ACCEPTANCE.
4. ACTUATOR VALVE SHALL BE SET TO A 12-HOUR TIMER, TO ACTIVATE ONCE THE FLOAT SYSTEM SENSOR ACTIVATES, TO BEGIN DEWATERING THE BASIN.
5. CONTRACTOR TO ENSURE PROPER VEGETATION ESTABLISHMENT PRIOR TO PROJECT ACCEPTANCE.
6. DEWATERING ORIFICE(S) FOR THE BATCH DETENTION BASIN SHALL INCLUDE A TRASH RACK AND/OR OTHER DEBRIS CATCHING STRUCTURE TO PROTECT DEWATERING ORIFICE(S).

SAN ANTONIO RIVER AUTHORITY	BATCH DETENTION CONSTRUCTION NOTES	APPROVED	REVISED
		BD-1	SHEET 1 OF 2

SAN ANTONIO RIVER AUTHORITY

BATCH DETENTION CONSTRUCTION DETAILS

APPROVED	REVISED

BD–2

SHEET 2 OF 2

Notes:

Vegetated Swale

PURPOSE:

Pretreatment for other stormwater BMPs or in a treatment train; typically should not be installed as standalone practices for water quality improvement.

APPLICATION:

Vegetated swales are LID alternatives to traditional curbs and gutters. They are well suited for runoff from roads, highways, small parking lots, and other impervious surfaces.

GENERAL DESCRIPTION:

These shallow, open, often grass-lined channels (Figure VS-1) are designed to convey runoff while providing limited sedimentation removal and horizontal filtration through vegetation. Swales are effective for pretreatment of concentrated flows before discharge to a downstream BMP. Vegetated swales should not be confused with bioswales which rely on vertical filtration of runoff through subsurface bioretention media. Compared with other LID practices, vegetated swales have a relatively low construction cost, a moderate maintenance burden, and require only a moderate amount of surface area.

Figure VS-1
Vegetated swale in institutional setting at James Madison High School Agriscience Building. Source: Bender Wells Clark Design.

Vegetated Swale

DESIGN CONSIDERATIONS:

SIZING:

- The flow capacity of a vegetated swale is a function of the longitudinal slope (parallel to flow), the resistance to flow (e.g., Manning's roughness), and the cross-sectional area.
- The flow capacity of vegetated swales should be such that the design water quality flow rate will not exceed a flow depth of two-thirds the height of the vegetation in the swale or 4 inches at the peak of the water quality design storm intensity.
- If the swale is too long to fit in the site, the design parameters can be adjusted to provide the flow velocity required to meet the recommended residence time. Additionally, a sinuous pattern can be used to increase total swale length (and decrease bed slope) over a distance (Figure VS-2).

SITING:

- Vegetated swales are often designed as online systems that convey flows higher than the design storm flow but can be designed as offline systems incorporating a high-flow bypass or diversion structure upstream of the swale inlet.

FUNCTION & MATERIALS:

- The cross section is normally approximately trapezoidal, and the area is a function of the bottom width and side slopes.
- Although longitudinal slope is often determined by site conditions, the slope should not exceed 2-5% for optimum water quality performance.
- It is desirable to have the design velocity as low as possible, both to improve treatment effectiveness and to reduce swale length requirements.
- The residence time in a swale should be at least 10 minutes to optimize pretreatment and sediment removal, although this is not always feasible given certain site constraints.
- The swale area must be appropriately vegetated with a mix of erosion-resistant plant species that effectively bind the soil.

Figure VS-2
Vegetated swale at Trinity University

- Swales should be designed to drain within 48 hours.
- Check dams can be used to reduce the effective slope of a swale (see Bioswales in Appendix B for check dam design information). While not required, spreadsheet or computer-based models with "goal seek" functions can assist with this analysis.
- Check dams (if present) should be designed to control and distribute flow evenly across the swale.

ESTABLISHMENT & MAINTENANCE:

- Vegetation should be planned to be dense enough for filtration while protecting the underlying soils from erosion.
- The swale should be designed to convey the design storm without the threat of erosion.

REFERENCE:

- See specifications, details *(on the following pages)* and LID calculation sheets for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- See Plant List, Appendix E.

See Appendix B for Additional BMP-Specific Design Guidance.

SECTION 33 46 73

Vegetated Swale

33 46 73.1 DESCRIPTION: *This Item shall govern the construction of a vegetative swale on the areas designated on the plans, to the lines and grades specified, or as directed by the Engineer. Vegetated swales are typically shallow, open, often -grass lined channels designed to convey runoff while providing limited sediment removal.*

33 46 73.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Vegetated Swale. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 – Channel Excavation

Item 107 – Embankment

Item 520 – Hydromulching

33 46 39.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 73.4 CONSTRUCTION: Prevent damage to existing vegetation, slopes, utilities, structures, and other amenities.

33 46 73.5 MAINTENANCE: Inspect the vegetated swale at regular intervals to ensure proper functioning. Vegetation height should be maintained above 4 inches to ensure proper treatment and soil stabilization.

Check for damage by equipment and vehicles. In newly planted areas, check the progress of germination and plant growth, and arrange for organic fertilizing, if needed, to enhance growth and establishment.

33 46 73.6 MEASUREMENT: Measurement of acceptable "Vegetated Swale," complete in place, will be for each square yard of vegetation establishment and cubic yardage of excavation and embankment.

Measurement by the square yard is a plans quantity measurement. The quantity to be paid for is the quantity shown in the proposal unless modified by the Engineer.

Additional measurements or calculations will be made if adjustments of quantities are required.

Measurement for grading is further defined for payment by the cubic foot of volume for excavation and embankment in the completed and accepted final plan.

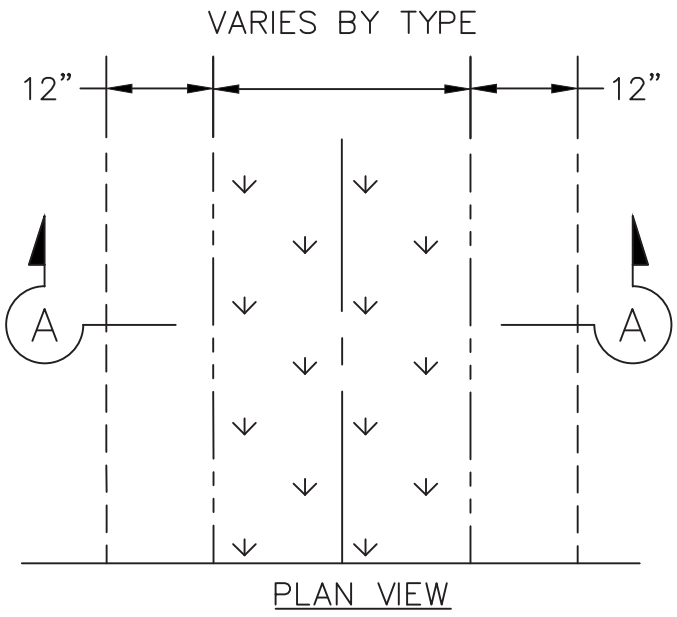
33 46 73.7 PAYMENT: "Vegetated Swale," measured as provided above, will be paid for at the contract unit price bid per SY for vegetation and CY of grading, which price shall be full compensation for furnishing, hauling and placing all materials, for all water required and for all labor, tools, equipment and incidentals necessary to complete the work.

33 46 73.8 BID ITEM:

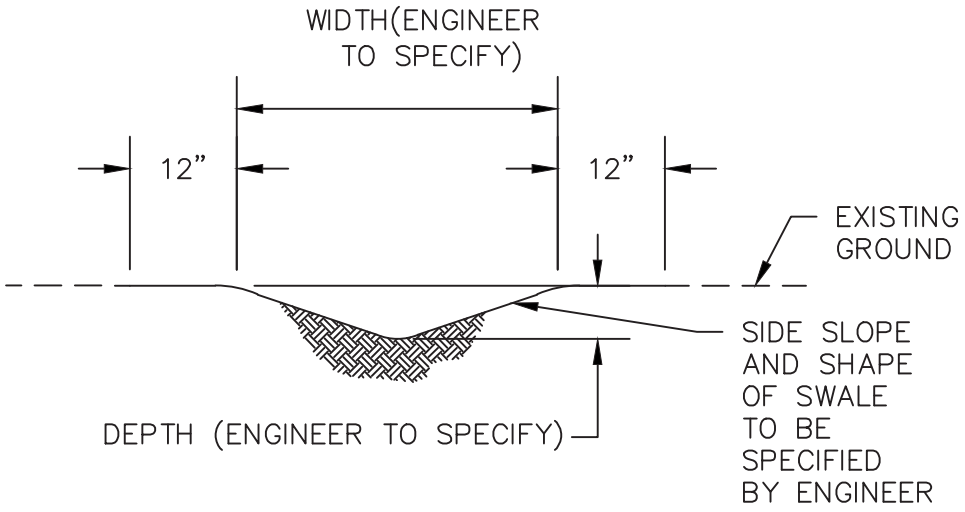
Item 106.1 – Excavation – per cubic yard

Item 107.1 – Embankment (Final) – per cubic yard

Item 520.1 – Hydromulching – per square yard



PLAN VIEW



(A–A) VEGETATED SWALE DETAIL

SAN ANTONIO RIVER AUTHORITY	VEGETATED SWALE DETAIL	APPROVED	REVISED
		VS–1	SHEET 1 OF 1

Notes:

Vegetated Filter Strip

PURPOSE:

Maintains sheet flow of runoff across a vegetated area for pretreatment and energy dissipation; should be installed as pretreatment for other BMPs or in a treatment train; typically should not be installed as standalone practices for water quality improvement.

APPLICATION:

Vegetated filter strips are bands of dense, permanent vegetation with a uniform slope, designed to provide pretreatment of runoff generated from impervious areas before flowing into another BMP as part of a treatment train. Vegetated filter strips are commonly used in the landscape designs of residential, commercial, institutional, and roadway applications and are well suited for pretreating runoff from roads, highways, driveways, roof downspouts, parking lots, and other impervious surfaces.

GENERAL DESCRIPTION:

Vegetated filter strips are bands of dense, permanent vegetation with a uniform slope designed to pretreat runoff generated from impervious areas before flowing into another BMP as part of a treatment train. Vegetated filter strips are often used as pretreatment devices for other, larger-capacity BMPs such as bioretention and permeable pavement. They filter sediment and associated pollutants, prevent clogging, and reduce maintenance requirements for larger capacity BMPs. Vegetated filter strips on highly permeable soils can also provide infiltration, helping to mimic predevelopment conditions.

Vegetated filter strips are flow-based BMPs intended for achieving water quality treatment. As water sheet flows across the vegetated filter strip, the vegetation filters and settles the particulates and constituents, especially in the initial flow of stormwater. Depending on site slope and soil conditions, they can provide some volume reduction and can increase a site's time of concentration. However, vegetated filter strips are not intended to act as a standalone, primary BMP for meeting volume-reduction objectives. Because of their limited ability to provide peak attenuation and their ability to decrease sediment loads, vegetated filter strips are often used as a pretreatment for other BMPs.

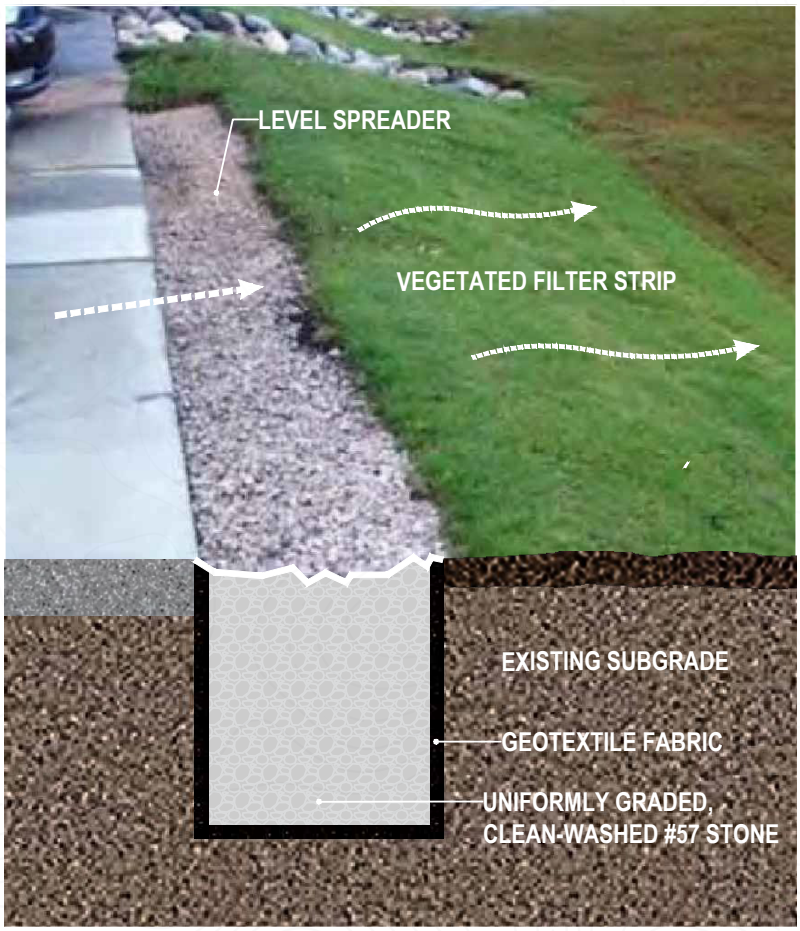


Figure VFS-1

Vegetated filter strip conveying stormwater runoff from a parking lot into a bioretention cell, Raleigh, North Carolina. Photo source: Tetra Tech, Inc.; Rendering components: San Antonio River Authority.

Vegetated Filter Strip

DESIGN CONSIDERATIONS:

Figure VFS-2
Vegetated filter strip between parking lot and stream, San Gravel fringe and vegetated filter strip pretreatment, Louisburg, North Carolina. Source: North Carolina State University Department of Biological and Agricultural Engineering. Source: Tetra Tech

SIZING:

- The flow associated with the water quality design storm should be calculated according to information provided in Appendix H, San Antonio Unified Development Code, or San Antonio River Basin Regional Modeling Standards for Hydrology and Hydraulic Modeling.
- In addition to being designed for the water quality design flow, the filter strip should be designed to safely convey the 25-year storm event.
- Hydraulically, filter strips should be designed according to two primary criteria: maximum depth of flow and maximum flow velocity.

SITING:

- Runoff should enter vegetated filter strip under sheet flow conditions
- Vegetated filter strips must be adjacent to the impervious areas they are intended to treat.

FUNCTION & MATERIALS:

- Vegetated filter strips may not be suitable for industrial sites or large drainage areas because a large footprint may be required for sufficient treatment.
- Removal efficiency often depends on the slope, length, gradient, and biophysical condition of the vegetation in the system.
- The primary mechanism of failure for filter strips is the development of concentrated flow, which results in erosion and the formation of rills. Vegetated filter strips should thus be carefully graded to prevent concentration of flow, and level spreaders (if used) should be completely level.

ESTABLISHMENT & MAINTENANCE:

- Monitor sediment deposit depth and re-level surface to maintain sheet flow over the vegetated filter strip.
- It is important to specify installation of signage so that the vegetated filter strip is properly maintained. Signage should label the practice as a stormwater BMP, prohibit foot traffic, and instruct maintenance crews to maintain vegetation at a height of approximately 4 inches—this will ensure maximum treatment and soil stabilization.

REFERENCE:

- See specifications, details *(on the following pages)* and LID calculation sheets for more information.
- Vegetated filter strip flow volume performance curves are found on page 342; Bacteria, Residential on page 345; Bacteria, Commercial/Industrial/Transportation on page 348; CBOD on page 351; Sediment on page 354; Total-N on page 357; Total-P on page 360; Total-Pb on page 363; and Total-Zn on page 366 of Appendix J.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.
- Refer to Appendix G: Operations & Maintenance for more information.
- See Plant List, Appendix E.

See Appendix B for Additional BMP-Specific Design Guidance.

Texas Commission on Environmental Quality (TCEQ). (2017). Addendum Sheet: Complying with the Edwards Aquifer Rules Technical Guidance on Best Management Practices RG-348 (Revised July 2005). https://www.tceq.texas.gov/assets/public/comm_exec/pubs/rg/rg348/addendum.pdf

Barrett, M.E. 2005.Complying with the Edwards Aquifer Rules. Technical Guidance on Best Management Practices. RG-348. Prepared for Texas Commission on Environmental Quality, Field Operations Division, Austin, TX.

SECTION 33 46 74

Vegetated Filter Strip

33 46 74.1 DESCRIPTION: *This Item shall govern the construction of a vegetated filter strip on the areas designated on the plans, to the lines and grades specified, or as directed by the Engineer.*

33 46 74.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for t he installation of a Vegetated Filter Strip. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 – Channel Excavation

Item 107 – Embankment

Item 520 – Hydromulching

SARA Items:

33 46 76 – Level Spreader

33 46 74.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 74.4 CONSTRUCTION: Prevent damage to existing vegetation, slopes, utilities, structures, and other amenities.

Ensure that the vegetated filter strip is constructed at the proper slope and length specified on the plans.

A. Level Spreader: Contractor to install level spreader upstream of vegetated filter strip areas where applicable (i.e. adjacent to parking lots, sidewalk, and other impervious areas).

33 46 74.5 MAINTENANCE: Inspect the vegetated filter strip at regular intervals to ensure proper functioning.

Check for damage by equipment and vehicles. In newly planted areas, check the progress of germination and plant growth, and arrange for organic fertilizing, if needed, to enhance growth and establishment.

33 46 74.6 MEASUREMENT: Measurement of acceptable "Vegetated Filter Strip," complete in place, will be for each square yard of vegetation establishment and cubic yardage of excavation and embankment.

Measurement by the square yard is a plans quantity measurement. The quantity to be paid for is the quantity shown in the proposal unless modified by the Engineer. Additional measurements or calculations will be made if adjustments of quantities are required.

Measurement for grading is further defined for payment by the cubic foot of volume for excavation and embankment in the completed and accepted final plan.

33 46 74.7 PAYMENT: "Vegetated Filter Strip," measured as provided above, will be paid for at the contract unit price bid per SY for vegetation, CY of grading and linear foot of level spreader, which price shall be full compensation for furnishing, hauling and placing all materials, for all water required and for all labor, tools, equipment and incidentals necessary to complete the work.

33 46 74.8 BID ITEM:

Item 106.1 – Excavation – per cubic yard

Item 107.1 – Embankment (Final) – per cubic yard

Item 520.1 – Hydromulching – per square yard

Item 33 46 76.1 – Level Spreader – per linear foot

SECTION 33 46 76

Level Spreader

33 46 76.1 DESCRIPTION: *This Item shall govern the construction of level spreaders on the areas designated on the plans, to the lines and grades specified, or as directed by the Engineer.*

33 46 76.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a Vegetated Filter Strip. Provide materials that comply with the details shown on the plans .

33 46 76.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 76.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. **Constructed Trench:** Contractor to excavate trench to the dimensions specified by designer. Contractor to ensure a 1-2" elevation drop from edge of pavement to top of level spreader gravel surface.
B. **Stone:** Contractor to utilize uniformly graded, clean-washed coarse aggregate (ASTM #57 Stone) in constructed trench for level spreader.
C. **Non-woven Geotextile Fabric:** Contractor to utilize non-woven geotextile fabric to line the sides and bottom of constructed trench for level spreader prior to filling with washed stone.

33 46 76.5 MAINTENANCE: Inspect the level spreader at regular intervals to ensure proper functioning.

Level spreaders require at least yearly maintenance to remove trees and shrubs that begin to grow on the level spreader or that impede flow just downslope of the level spreader. Any debris and sediment that build up in the level spreader should be removed annually and after storms greater than or equal to a 2-year storm. If possible, the vegetation immediately downslope of the level spreader lip should be mowed regularly to encourage low, dense growth and to facilitate inspection. The use of perennial, dense, low-growing ground covers downslope of the lip may help to maintain diffuse flow. These issues should be addressed immediately to restore proper function. If erosion is apparent, corrective action must be taken, such as installing erosion control matting and possibly regrading.

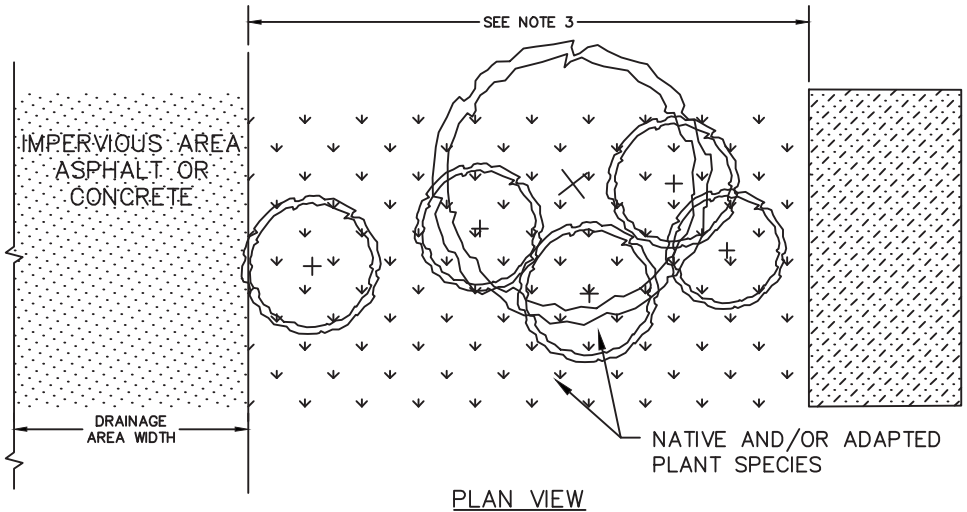
33 46 76.6 MEASUREMENT: Measurement of acceptable "Level Spreader," complete in place, will be for linear footage of level spreader.

Measurement by the linear foot is a plans quantity measurement. The quantity to be paid for is the quantity shown in the proposal unless modified by the Engineer. Additional measurements or calculations will be made if adjustments of quantities are required.

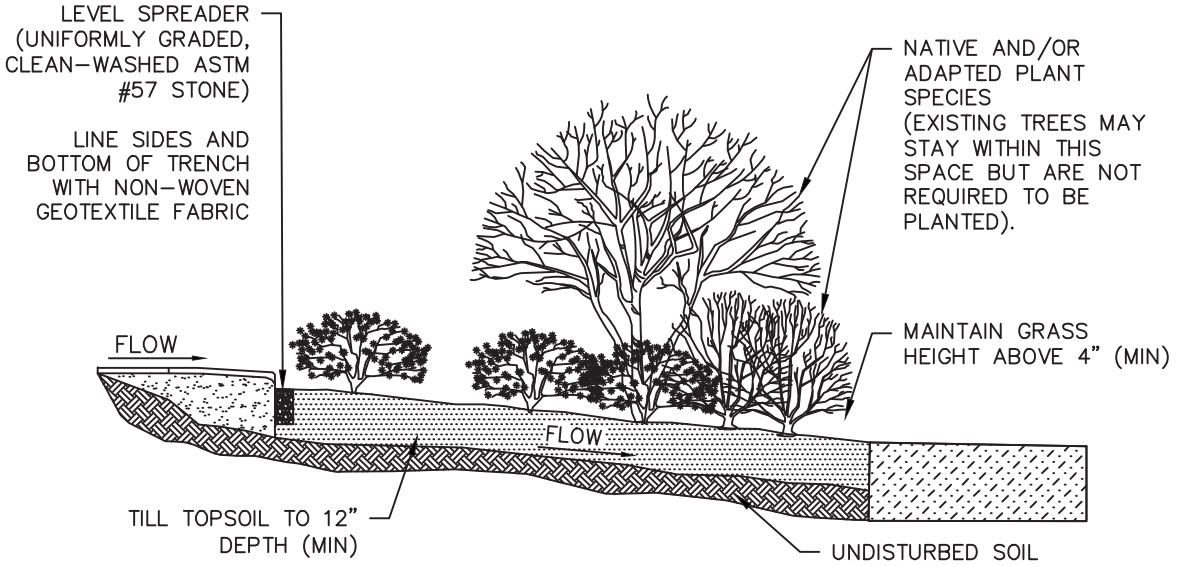
33 46 76.7 PAYMENT: "Level Spreader," measured as provided above, will be paid for at the contract unit price bid per LF of level spreader, which price shall be full compensation for furnishing, hauling and placing all materials, and for all labor, tools, equipment and incidentals necessary to complete the work.

33 46 76.8 BID ITEM:

Item 33 46 76.1– Level Spreader – per linear foot



PLAN VIEW



SECTION VIEW

NOTES:

1. THIS DETAIL DISPLAYS KEY CONCEPTS FOR A VEGETATED FILTER STRIP AND MAY NOT PROVIDE ALL NECESSARY DESIGN INFORMATION FOR INDIVIDUAL SITES.
2. AVOID SITING FILTER STRIPS ON SLOPES GREATER THAN 5%.
3. FILTER STRIP WIDTH SHALL BE 15' (MIN.).

SAN ANTONIO RIVER AUTHORITY	VEGETATED FILTER STRIP DETAIL	APPROVED	REVISED
		VFS–1	SHEET 1 OF 1

Notes:

Vegetated Stream Buffer

PURPOSE:

Stormwater treatment, stream enhancement and protection.

APPLICATION:

Stream banks, riparian areas, sensitive features, and wetlands for all drainage areas.

GENERAL DESCRIPTION

Vegetated buffers are areas of vegetation along streams and other sensitive features that serve as a buffer to pollutants entering them via surface runoff, aid in reducing stream erosion and reduce surface water temperatures through shading. Effectiveness depends on buffer width, soil and vegetation conditions within the buffer. Preserving existing buffers reduces cost for planting and establishment. Established healthy stream buffers provide stronger bank protection and a full soil profile that improves water quality treatment. For preserved or restored streams, buffers extending to both stream banks with shallow overland slopes and high infiltration capacity (Hydrologic Soil Groups A and B) provide the greatest effectiveness in reducing nitrogen in downstream systems through denitrification and plant uptake. Runoff contact time with the vegetated buffer is a key metric to predict buffer effectiveness. To maintain effectiveness, vegetated buffers should be protected against concentrated runoff, compaction, loss of vegetation, and stream incision.

Figure VSB-1
No-Mow sign posted near BMP to protect natural vegetation. Sign text should be tailored to site conditions.
Source: San Antonio River Authority.

Figure VSB-2
Vegetated stream buffer on Leon Creek, Northern Bexar County, Texas.
Source: Halff Associates, Inc.

Vegetated Stream Buffer

DESIGN CONSIDERATIONS:

SIZING:
- Maximize vegetated stream buffer width when possible, width is primary characteristic controlling effectiveness of buffer.

SITING:
- Consider implementing stream buffers downstream of detention facilities or other LID facilities to maximize stream protection.
- Consider easement requirements for location of stream buffer.

FUNCTIONS & MATERIALS:
- To maximize infiltration, avoid compacting soils within stream buffer during construction.

ESTABLISHMENT & MAINTENANCE:
- Avoid concentrated flow entering and flowing across stream buffer; the flow through the vegetated stream buffer should be spread as evenly as possible.
- Use Natural Channel Design Protocol to prevent erosion.

REFERENCE
- Coordinate stream buffer requirements with local tree and floodplain ordinance requirements.
- See specifications and details (on the following pages) and LID calculation sheets for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.

See Appendix B for Additional BMP-Specific Design Guidance.

Figure VSB-3
Thick brush forms vegetated stream buffer on banks of the Nueces River. Source: Texas Riparian Association.

SECTION 33 46 75

Vegetated Stream Buffer

33 46 75.1 DESCRIPTION: *This Item shall govern the construction of vegetative stream buffers on the areas designated on the plans, to the lines and grades specified, or as directed by the Engineer.*

33 46 75.2 MATERIALS: For vegetative stream buffers to function properly as stormwater treatment or as a stream protection measure, vegetation selection is crucial. Appropriate vegetation shall consist of live, native, growing plants secured from sources where the soil is fertile. All vegetation shall have a healthy, virile root system and the Contractor shall not use vegetation that is thinned or has been dried out by exposure to air and sun to such an extent as to damage its ability to grow when transplanted. The vegetation shall be free from noxious weeds or other matter deleterious to its growth or which might affect its subsistence or hardiness when transplanted. Sources from which vegetation is to be obtained shall be subject to approval by the Engineer.

A. **Stream Buffer Vegetation.** Native plant species or hardy cultivars that are not invasive and do not require chemical inputs are recommended to be used to the maximum extent practicable.

Plant materials must be tolerant of summer drought, extreme heat, and saturated soil conditions.

1. **Trees.** Trees shall be of the specified height and crown to the last division of the terminal leader and diameter. The height shall be measured from the root crown. The diameter shall be measured 6 inches above the root crown. Shade trees should be free of branches for the bottom 1/3 of their total height, if located adjacent to pedestrian areas, and lines of sight must be maintained when planting along roadways. Tree height and placement should consider overhead utilities.
2. **Shrubs.** Shrubs shall be of the specified type and size.
3. **Herbaceous Groundcover.** Groundcover shall be of the specified type and size. If turfgrass is specified, seeding is preferred over sod installation for increased pollutant removal.

B. **Rejection or removal of Plants.** Plants with any of the following characteristics are subject to rejection or removal:

- Disease or insect infestation, including eggs and larvae;
- Dried or damaged root system or crown;

- Excessive abrasion of the bark;
- Prematurely opened or damaged buds;
- Disfiguring knots;
- Evidence of heat, freeze, or wind burn, mold, sun scald, or similar conditions;
- Damaged, pruned, crooked, or multiple leaders, unless multiple leaders are specified or are normal for the species;
- Cut limbs over ¾ inches in diameter that have not completely callused;
- Dry, soggy, loose, cracked, broken, misshapen, or undersized root balls;
- Processed balled roots (bench balled);
- Root balls encased in impervious material;
- Overgrown or root-bound plants;
- Undersized or unsound containers;
- Stock not well established in containers;
- Containers with less than ¾ planting medium depth;
- An abnormal balance between height and spread for the species;
- Missing or broken serialized locking tags, when specified
- Any conditions that does not conform to the plans or nursery stock standards; or
- Conditions that would prevent thriving growth or cause an unacceptable appearance.

33 46 75.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 75.4 CONSTRUCTION: Prevent damage to existing vegetation, slopes, utilities, structures, and other amenities.

A. **Soil Preparation**. Unless otherwise directed by the landscape architect, prepare all seedbeds by adequately loosening to a minimum depth of 4 inches by ripping and/or disking. In areas where ripping and/or disking cannot be safely conducted, prepare compacted seedbeds by roughening, either by hand scarifying or by equipment,

depending on-site conditions. If seeding is done immediately following construction, seedbed preparation may not be required except on compacted, polished or freshly cut areas.

B. **Existing Invasive Species Removal.** Contractor shall remove all vegetation within the stream buffer area that is non-native to Texas. Reference Texasinvasives.org for a list of non-native plants.

C. **Plant Approval Before Delivery.** Plants are subject to inspection at the nursery or location of collection. Provide and use serialized locking tags on plants selected by the Engineer as directed.

D. **Plant Delivery.** Notify the Designer or Landscape Architect at least 48 hours before delivering plants to the worksite. Coordinate with the Engineer for inspection and approval of materials upon delivery. Remove rejected plants from the worksite and replace as directed.

E. **Plant Inspection.** All plants will be inspected prior to planting, including plants previously approved at the nursery.

F. **Mark Plant Locations.** Provide and install coded markings, such as wooden stakes, to mark the location and type of plants. Obtain approval of the plant locations before excavation begins.

G. **Plant Pit Excavation.** Excavate pits for container, balled and burlapped (B&B), and fabric bag grown sock to the depth shown on the plans or at least the depth of the root ball. Excavate pits for bare root plants equal to the depth of the root system. Excavate pits on slopes using measurements shown on the plans or at least the depth of the root ball based on the uphill side of the pit. Excavate the receiving pits for mechanically transplanted plants with the same type and size equipment used to dig the plants.

   Provide a minimum horizontal dimension of 12 inches between the root ball and pit walls for the following, unless otherwise shown on the plans:

   - 15-gallon or larger pots,
   - 14-inch or larger boxes, and
   - Larger than 14-inch root balls of B&B and fabric bag grown plants.

   Provide a minimum horizontal dimension of 2 times the root ball diameter across the pit for the following, unless otherwise shown on the plans:

   - Less than 15-gallon pots, and

- 14-inch or smaller root balls of B&B and fabric bag grown plants.

Provide a minimum pit diameter for bare root plants that permits the roots to spread without crowding or curving around the walls of the pit.

H. Plant Installation. Install plants within 24 hours of excavating plant pits. Scarify the walls of the pits as plant installation begins. Center all plants in a pit, except those mechanically collected, backfill in lifts, each lift 1/3 of the depth of the root ball, and fill the pit with water after each lift to remove air pockets. Prune protruding roots, from the root ball, for mechanically collected plants, to a point even with the cutting blades. Place the plant in the pit and work soil media between the pit walls and the root ball with water until the soil media fills all the cavities. If equipment is necessary, operate equipment adjacent to the facility. Equipment operation within the facility should be avoided to prevent soil compaction. If machinery must operate in the facility, use lightweight, low ground-contact pressure equipment.

I. Watering. Coordinate the planting work to ensure that an irrigation system, when specified, operates properly to meet the watering requirements. Apply water to plants or planting areas at the rate and frequency specified for an irrigation system or for the application method shown on the plans. Keep the ground and backfill moist at least 12 inches around the entire root ball if a watering rate and frequency are not specified.

J. Plant Support Installation. Install plant supports such as staking, guying, and bracing as shown on the plans. Support and keep plants in a vertical position or as directed.

K. Plant Replacement. Remove and dispose of dead and damaged plants from the worksite as directed. Replace plants as originally specified within 10 days of notification.

L. Erosion Control. Erosion and sediment control practices during construction should be employed to protect the downstream watershed from construction activity. The following practices shall be followed for this reason:

1. Provide erosion control in the contributing drainage areas to the vegetative stream buffer and stabilize upstream areas.
2. Provide erosion control downstream of the proposed construction activity area to protect the downstream watershed.

M. Boundary Markers: Bollards, boulders, wooden posts and/or metal signs shall be used to delineate the boundary of the vegetative stream buffer.

33 46 75.5 MAINTENANCE: Inspect the buffer strip at regular intervals to ensure proper functioning.

Check for damage by equipment and vehicles. (Planted ground should not be used for a sediment trap until the vegetation is well established.) Make sure that water flowing through the buffer strip is not causing additional erosion nearby and not forming ponds due to erosion within the buffer strip.

Buffer strips in natural vegetation do not generally require maintenance; however, on some sites it may be necessary to remove sediments and replant on a regular basis. Promptly repair any damage from equipment, vehicles, or erosion.

33 46 75.6 MEASUREMENT: Measurement of acceptable "Vegetative Stream Buffer," complete in place, will be for each plant and square footage of grading work.

Measurement by the square foot is a plans quantity measurement. The quantity to be paid for is the quantity shown in the proposal unless modified by the Engineer. Additional measurements or calculations will be made if adjustments of quantities are required.

Measurement for grading is further defined for payment by the square foot of surface area in the completed and accepted final plan.

Measurement of boundary features is further defined as the number of bollards, boulders, and/or metal signs that are used to delineate the boundary of the vegetative stream buffer.

33 46 75.7 PAYMENT: "Vegetative Stream Buffer," measured as provided above, will be paid for at the contract unit price bid per SF, which price shall be full compensation for furnishing, hauling and placing all materials, for all water required and for all labor, tools, equipment and incidentals necessary to complete the work.

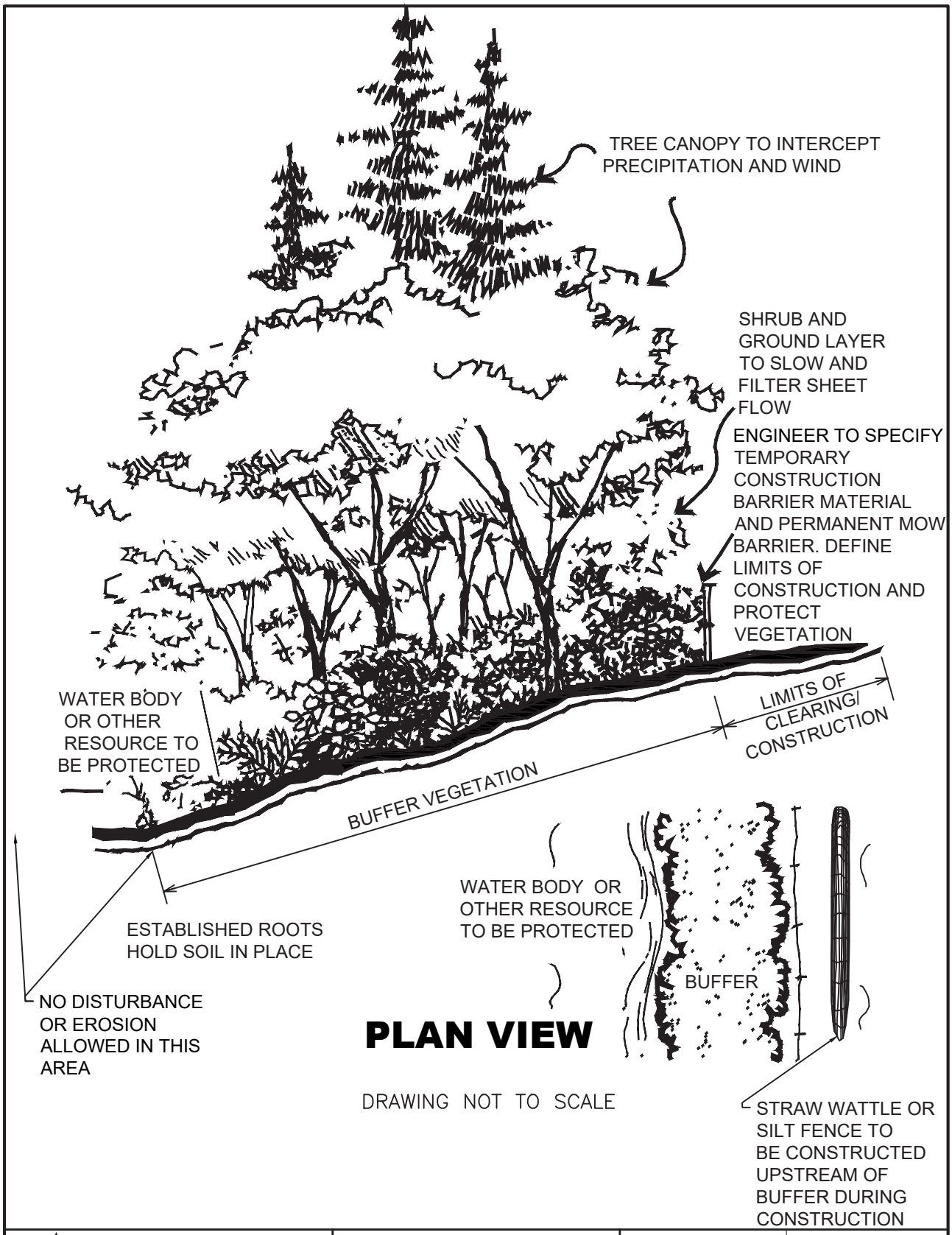
33 46 75.8 BID ITEM:

Item 33 46 75.1– Vegetation (Grasses) – per SY

Item 33 46 75.2 – Vegetation (Shrubs) – per each

Item 33 46 75.3 – Vegetation (Trees) – per each

Item 33 46 75.4 – Boundary Features – per each



SAN ANTONIO RIVER AUTHORITY	VEGETATIVE STREAM BUFFER DETAILS	APPROVED	REVISED
		VSB–1	SHEET 1 OF 1

High-flow Media

PURPOSE:

Stormwater treatment from impervious areas using filtration media designed for higher flow rates; typically greater than 6 inches per hour. High flow rates allow for smaller footprints leading to more flexibility in retrofit applications or along streets.

APPLICATION:

Small footprint locations where surface or sub-surface stormwater can be conveyed to be treated. May or may not include surface landscaping features.

GENERAL DESCRIPTION

High-flow Media BMPs are structures containing a mixture of media designed to act as a filtration device. Like membrane filters, high-flow media is capable of removing suspended solids in water, but may also be able to treat stormwater for soluble metals and nutrients if loading rates are low.

Performance of high-flow media filters is dependent on gradation of media and hydraulic loading rates applied to the filter. Finer gradations of media can remove more pollutants at the cost of lower flow rates. Media filters can be designed to incorporate surface level vegetation, enhancing treatment in the BMP through natural biological (plant uptake) and physical (evapotranspiration) processes. Designing high-flow media BMPs with larger footprints will generally reduce maintenance requirements throughout the life of the filter.

Figure HFM-1
High-flow Media BMP including surface vegetation adjacent to street in San Antonio.
Source: Halff Associates, Inc.

High-flow Media

DESIGN CONSIDERATIONS:

SIZING:

- Desired flow rate through media and pollutant removal will influence required footprint.
- Proprietary media design information to be provided by manufacturer.

SITING:

- Consider easement requirements for location of filter media BMP vault or footprint.
- Address sub-surface utility conflicts during design.

FUNCTIONS & MATERIALS:

- Surface level vegetation in media can serve as landscaping feature on site.
- Consider using locally available media in BMP to manage cost.

ESTABLISHMENT & MAINTENANCE:

- Include temporary irrigation for establishment of any included surface vegetation.
- Consider maximizing footprint when available in order to reduce required maintenance frequency.
- Ensure access for maintenance personnel and equipment.

REFERENCE

- See specifications and details (on the following pages) for more information
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.

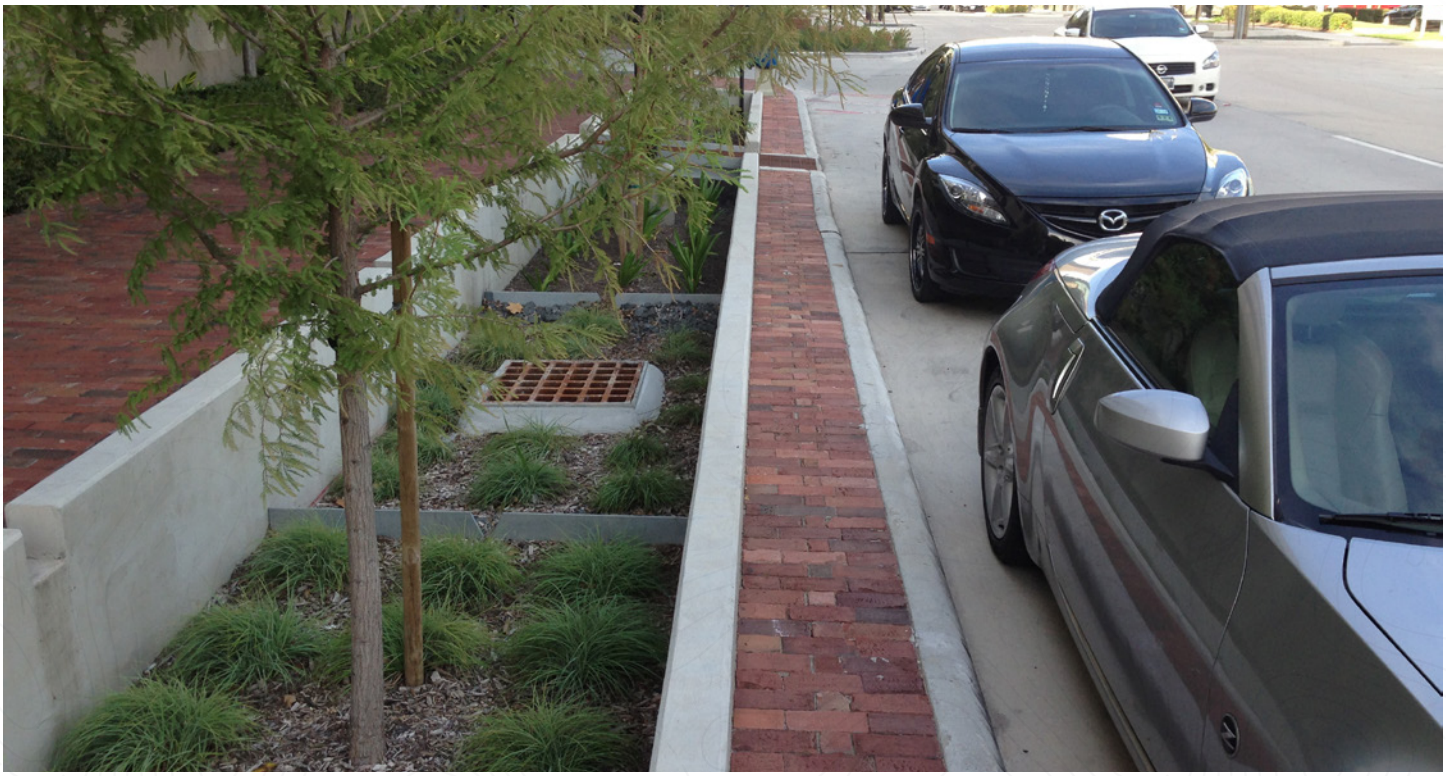


Figure HFM-2
High-flow Media BMP including surface vegetation adjacent to street in San Antonio. • Source: Halff Associates, Inc.

SECTION 33 46 82

High Flow Media Basin

33 46 82.1 DESCRIPTION: *Construct, furnish, install, test, and make fully operational a High Flow Media Basin as specified below or an engineer approved equal with appurtenances included hereafter at designated locations as shown on the plans. High Flow Media Basins are landscaped, shallow depressions that capture and temporarily store stormwater runoff. High Flow Media Basins are structures containing a mixture of media designed to act as a filtration device.*

33 46 82.2 MATERIALS: Furnish materials that meet the requirements of the Engineer's plans and specifications.

Provide all materials necessary for the installation of a High Flow Media Basin. Provide materials that comply with the details shown on the plans, and the requirements of this Item along with the following Item(s):

COSA Items:

Item 105 - Channel Excavation

Item 107 – Embankment

SARA Items:

Section 31 05 19.13 – Geotextile Separation Layer

Section 31 23 13.1 – Subgrade Preparation (Infiltrating Soil)

Section 32 91 13.16 – Mulch

Section 32 93 94 – Vegetation

Section 33 41 16.19 – Underdrain Piping and Underdrain Cleanout

Section 33 41 16.20 – Structural Underdrain

Section 33 46 81 – Impervious Liner

Section 33 46 83 – High Flow Media

ASTM Items:

ASTM #8 – Graded Aggregate Choker Stone

33 46 82.3 EQUIPMENT: Provide the machinery, tools and equipment necessary for proper execution of the work. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

33 46 82.4 CONSTRUCTION: Prevent damage to existing pavement, vegetation, slopes, utilities, structures, and other amenities.

A. **Bridging Stone:** Contractor to utilize ASTM #8 stone as bridging stone between high flow media and structural underdrain.
B. **Impervious Liner:** Contractor to utilize non-woven geotextile fabric, as directed by Engineer on plans.
C. **Walls and slopes:** High flow media basin wall material or slopes to be specified by Engineer. (i.e. concrete, earthen, etc).

33 46 82.5 MEASUREMENT: This Item will be measured as individual components of each High Flow Media Basin, to include, excavation, embankment, subgrade preparation, geotextile separation layer, high flow media layer, mulch, vegetation, underdrain piping and underdrain cleanouts, bridging stone, impervious liner, etc.

33 46 82.6 PAYMENT: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the below bid items. This price shall be full compensation for all equipment described under this item and all associated items listed below.

33 46 82.7 BID ITEM:

Item 106.1 – Excavation – per cubic yard

Item 107.1 – Embankment (Final) – per cubic yard

Item 33 46 82.1 – High Flow Media Layer – per cubic yard

Item 33 46 82.2 – Mulch – per cubic yard

Item 33 46 75.1– Vegetation (Grasses) – per SY

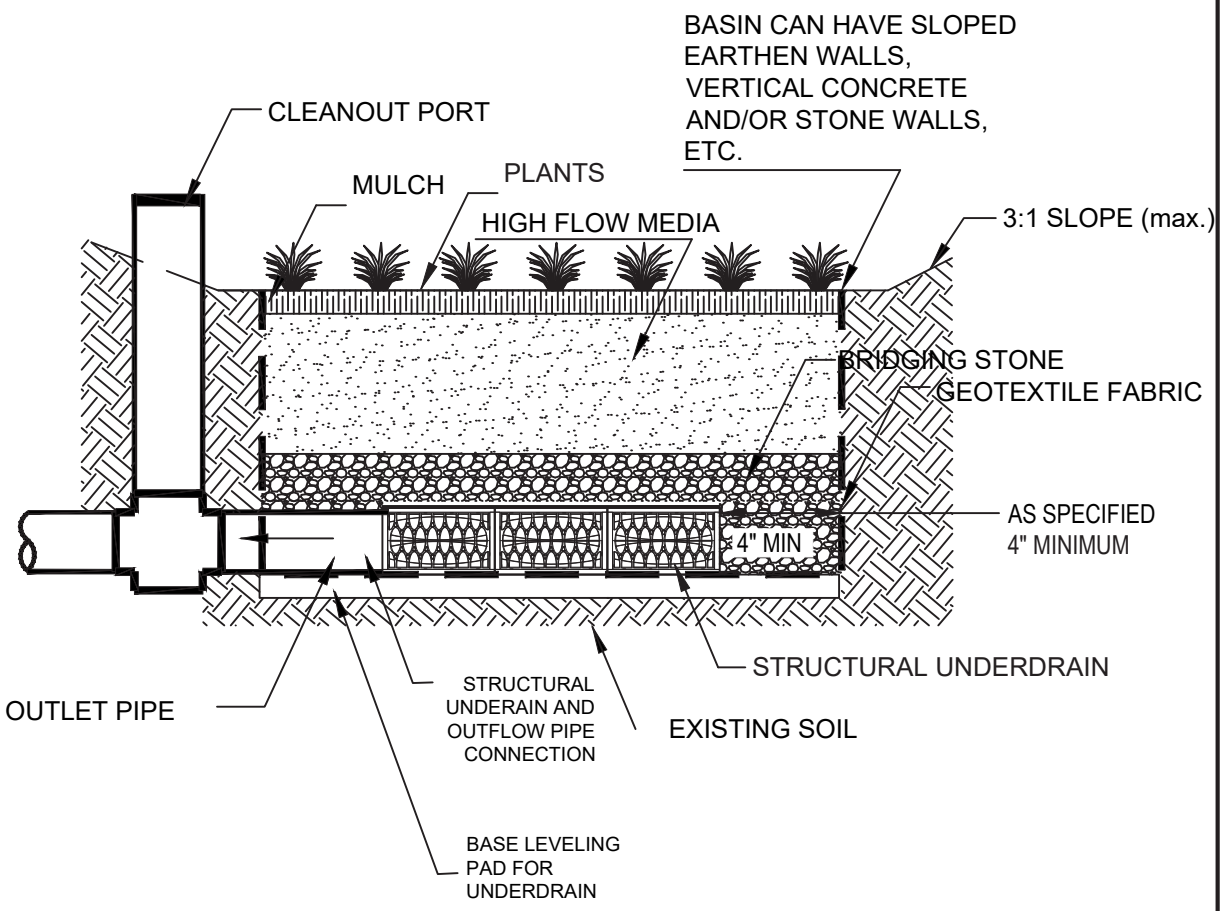
Item 33 46 75.2 – Vegetation (Shrubs) – per each

Item 33 46 75.3 – Vegetation (Trees) – per each

Item 33 41 16.19.1 – Underdrain Piping and Underdrain Cleanouts – per linear foot

Item 33 46 82.3 – Bridging Stone – per cubic yard

Item 33 46 81.1 – Impervious Liner – per square yard



SAN ANTONIO RIVER AUTHORITY	HIGH FLOW MEDIA CONSTRUCTION DETAILS	APPROVED	REVISED
		HFM–1	SHEET 1 OF 1

Notes:

Hydrodynamic Separator

PURPOSE:

Stormwater treatment from impervious areas when available footprint is severely limited. Treats stormwater for sediments and some include trash removal chambers. May be used for pre-treatment in a treatment train.

APPLICATION:

Small footprint locations where surface or sub-surface stormwater can be conveyed to be treated. Also as pretreatment in treatment trains to capture sediment and floatables.

GENERAL DESCRIPTION

Hydrodynamic separators (HDS) are flow through structures that utilize the energy in flowing water to allow sediment to efficiently separate, typically through a swirling action or indirect filtration. Hydrodynamic separators are effective at removing heavy particles and floatables but are less effective at removing dissolved solids or solids with poor settleability. HDS units are typically proprietary systems with design and treatment guidance provided by the manufacturer.

Hydrodynamic separators do not require frequent maintenance but must be cleaned out via a vacuum truck when the unit fills to capacity of captured sediment. Designer will need to consult manufacturer's recommendations.

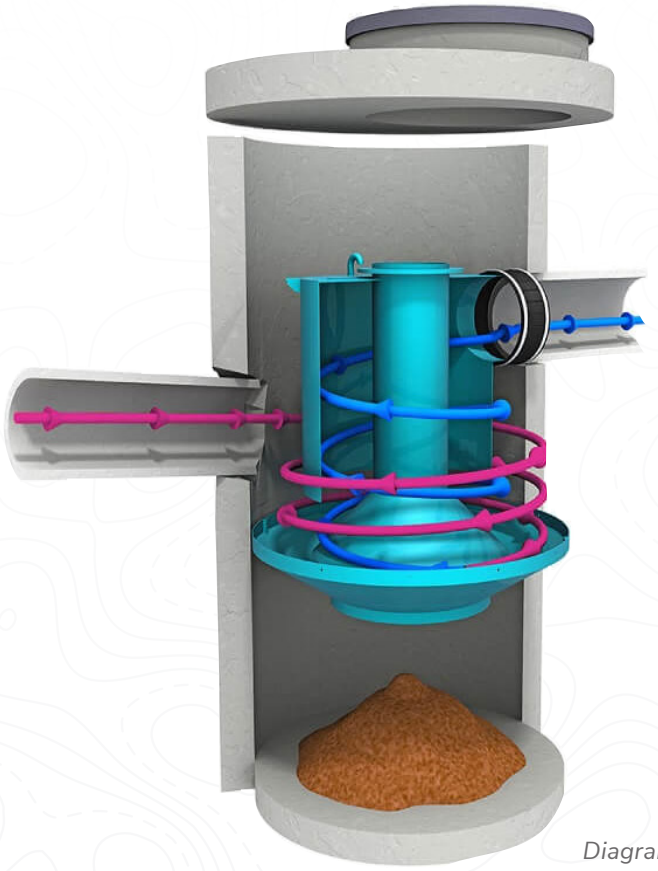


Figure HDS-1
Diagram of Hydrodynamic Separator and function.
Source: Hydro International UK Ltd.

Hydrodynamic Separator

DESIGN CONSIDERATIONS:

SIZING:

- Sizing information to be provided by manufacturer.
- Ensure HDS is sized for correct inflow flow rate.
- Required level of treatment and desired flow rate influence sizing factors.

SITING:

- Address sub-surface utility conflicts during design.
- Consider easement requirements for location of HDS unit.
- Coordinate with municipality regarding placement of separators and potential traffic impacts during maintenance.

FUNCTIONS & MATERIALS:

- Check if HDS has minimum velocity requirement for effective sediment separation.

ESTABLISHMENT & MAINTENANCE:

- Ensure available access for vacuum truck which is necessary for maintenance.
- Trash generation levels of upstream area will influence required maintenance frequency.

REFERENCE:

- HDS manufacturers will have sizing guides and requirements.
- Check that manufacturer's sizing recommendation will provide adequate treatment to meet local regulations.

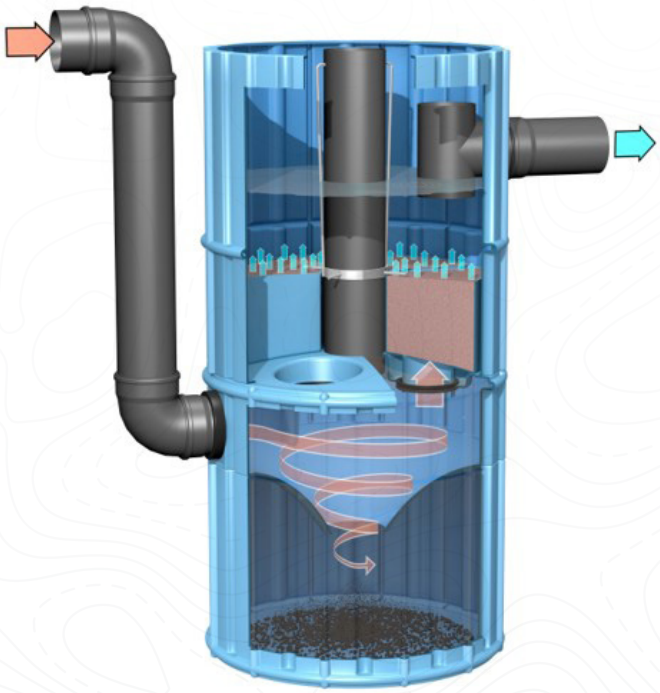


Figure HDS-2
Diagram of Hydrodynamic Separator and function.
Source: Sustainable Technologies, LLC

Cartridge Membrane Filter

PURPOSE:

Stormwater treatment from impervious areas; primarily in high density or retrofit applications.

APPLICATION:

Small footprint locations where stormwater runoff can be conveyed for treatment. Can be effective in areas with specific target pollutants, such as dissolved metals.

GENERAL DESCRIPTION

Cartridge membrane filters are manufactured BMPs which use membrane filters to remove pollutants from stormwater. Porous membranes are typically installed in the form of removable cartridges below ground in a concrete box or manhole. Flow enters the system and passes through the membrane where suspended solids, some nutrients, and other pollutants are physically filtered from the flow stream.

Cartridge membrane filter performance depends on the surface area of the filter membrane. A larger filter surface area may be installed when high design flow rates must be accommodated, while a smaller filter may be used when lower flow rates are acceptable. Manufacturers typically provide siting and design guidance along with test data on performance.

Figure CMF-1
Cartridge Membrane Filter (shown removed from vault).
Source: Halff Associates, Inc.

Cartridge Membrane Filter

DESIGN CONSIDERATIONS:

SIZING:

- Sizing information to be provided by manufacturer.
- Design flow rate will influence required membrane surface area.

SITING:

- Consider outfall elevation and ensure adequate drop to nearest downstream connection.
- Address sub-surface utility conflicts during design.
- Consider easement requirements for location of filter vault.
- Coordinate with municipality regarding placement of filters and potential traffic impacts during maintenance.

FUNCTIONS & MATERIALS:

- Consider target pollutants when choosing from available filtration membranes.

ESTABLISHMENT & MAINTENANCE:

- Higher surface area filters will require less frequent maintenance than lower surface area filters for the same flow rate.
- Maintenance access and equipment required may limit applicability or require third party maintenance agreement.

REFERENCE:

- Proprietary system manufacturer will have sizing guides and requirements. Check that manufacturer's sizing recommendation will provide adequate treatment to meet local regulations.
- Provide manufacturer with target pollutant type for proper membrane selection.

Figure CMF-2
Example of membrane filter cartridges.
Source: Halff Associates, Inc.

Treatment Trains

PURPOSE:

Combining BMPs in series to increase stormwater benefits, maximize efficiency, increase developer flexibility, and potentially reduce cost.

APPLICATION:

Sites where a singular BMP cannot be sized or sited to achieve all stormwater quality and/or quantity goals.

GENERAL DESCRIPTION

Using multiple LID BMPs in series is called a treatment train. Treatment trains can be designed to combine BMPs which utilize different unit processes to create design flexibility for sites while maximizing treatment. Using the same type of BMP multiple times in series tends to provide lower overall removal efficiency compared to using diverse BMPs in series (TCEQ 2005).

The combination of BMPs allows the designer to maximize pollutant removal while also providing flow and volume reduction. The benefits of combining several BMPs into a treatment train for a developer include increased flexibility for laying out BMPs within a development, incorporating smaller BMPs where space is limited, and maximizing treatment efficiency. Pre-treatment BMPs (screening, hydrodynamic separators) may also be used to decrease maintenance costs by protecting downstream infiltration and filtration BMPs from sediment and litter.

Adding small BMPs in series to green areas already included in the land plan (filter strips in medians, bioretention in parking lot islands, rain barrels in planter beds, etc.) can allow the overall treatment goal to be achieved without modifying the land plan to accommodate a single large BMP.

Although there are many configurations of treatment trains to address various sites' needs, this manual presents three common combinations:

- Cistern to Bioretention
- Hydrodynamic Separator to Bioretention
- Vegetated Filter Strip to Bioretention

Where design considerations are consistent among these three treatment trains, they are provided immediately below. Where they differ, the manual provides a tailored discussion of the three featured treatment train BMPs after the shared design considerations below.

TCEQ (Texas Commission on Environmental Quality). 2005. Complying with the Edwards Aquifer Rules—Technical Guidance on Best Management Practices. RG-348 (Revised) with Addendum. Texas Commission on Environmental Quality, Austin, TX http://www.tceq.texas.gov/field/eapp.

Treatment Trains

GENERAL DESIGN CONSIDERATIONS:

SIZING:

- Identify required or target water quality volume during the master development phase of a project to develop and optimize treatment train locations.

SITING:

- Consider combination of cistern and bioretention in treatment train when available bioretention footprint is limited.
- Consider easement requirements of municipality when designing treatment trains.
- When retrofitting a treatment train design consider placing within existing drainage easements or in areas with limited utility conflicts.
- Identify existing local drainage pathways when siting BMPs to limit unnecessary grading.

FUNCTIONS & MATERIALS:

- Consider infiltration rate of in-situ soils beneath bioretention component; include liners or underdrains when appropriate.

ESTABLISHMENT & MAINTENANCE:

- Include irrigation for vegetation establishment and cases of extreme drought when appropriate.
- Include access to BMPs for maintenance activities where required.

REFERENCE:

- Check any manufacturer sizing recommendations / requirements for BMPs implemented in treatment train.
- See specifications and details (on the following pages) and LID calculation sheets for more information.
- For sizing, and whether volume-based or flow-based, please see the LID Calculation Sheet.

SPECIFIC DESIGN CONSIDERATIONS:

Cistern to Bioretention

APPLICATION:

Sites with impervious roof cover near landscaped areas; roof drainage can be captured in cistern which can then feed bioretention in landscaped area.

DESIGN CONSIDERATIONS:

SIZING:

- Maximize treatment of system by optimizing cistern storage for available footprint; lower release rate from cistern allows smaller bioretention footprint.

ESTABLISHMENT & MAINTENANCE:

- Foundation / flatwork for cistern should be designed by a structural engineer.

Figure TTCB-1
Treatment Train with Cistern Flowing into Bioretention at River Authority headquarters. Source: Halff Associates, Inc.

SPECIFIC DESIGN CONSIDERATIONS:

Hydrodynamic Separator to Bioretention

APPLICATION:

Sites with impervious ground cover near landscaped areas; impervious cover drainage can be captured and conveyed to the HDS which can then drain to bioretention in landscaped area. Retrofit applications with existing storm drains that carry high trash and sediment loads.

SPECIFIC DESIGN CONSIDERATIONS:

ESTABLISHMENT & MAINTENANCE:

- HDS units require vacuum truck access.

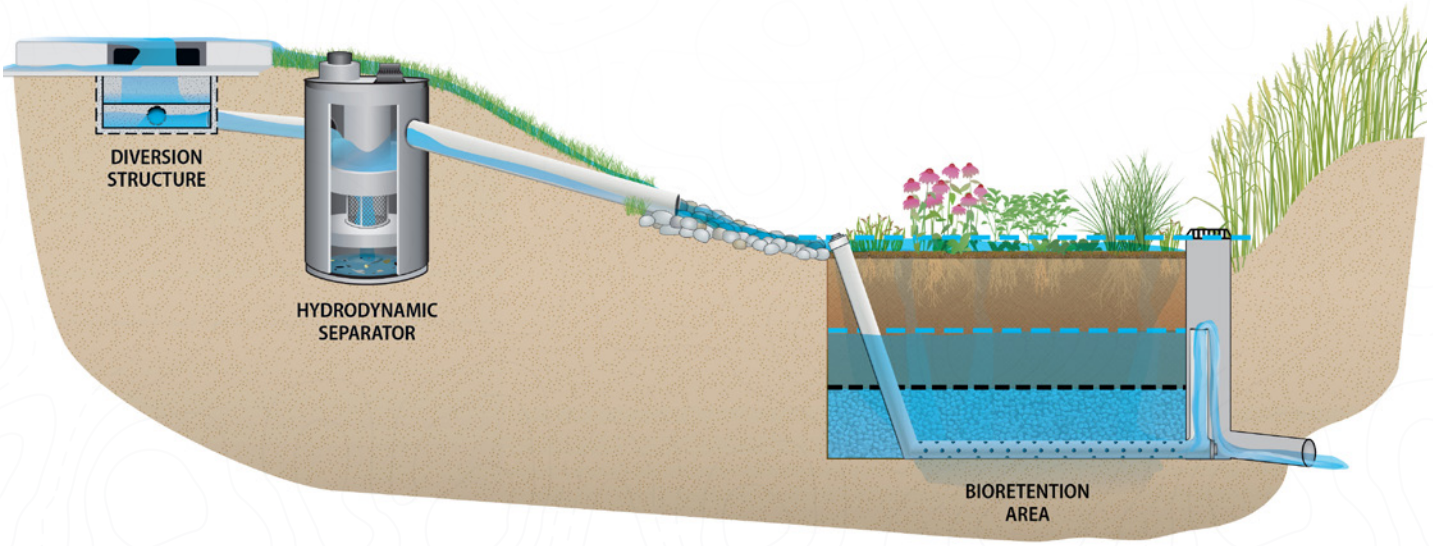


Figure TTHSB-1
Treatment Train diagram with hydrodynamic separator flowing into bioretention.
Source: TetraTech, Inc.

SPECIFIC DESIGN CONSIDERATIONS:

Vegetated Filter Strip to Bioretention

PURPOSE:

The vegetated filter strip provides pre-treatment and reduces pollutant loading rates entering the bioretention area.

APPLICATION:

Sites with impervious area that shares perimeter with bioretention areas. Vegetated filter strips can be installed along perimeter between impervious area and bioretention to reduce sediment and pollutant loads before entering the bioretention area potentially reducing long term maintenance within the facility.

SPECIFIC DESIGN CONSIDERATIONS:

SITING:

- Consider designing vegetated filter strips on the upstream side of the bioretention facility and utilize as primary inflow mechanism into bioretention facility to control and reduce entrance velocities.

FUNCTION & MATERIALS:

- Consider mowing width and slope when designing vegetated filter strips.
- Consider utilizing weed fabric barriers or landscaping edging to separate the vegetated filter strips and bioretention facilities to reduce grassing of bioretention facility if not desired.
- Provide maintenance entrance to both vegetated filter strip area and bioretention facility.

Figure TTVFSBR-1
Vegetated filter strip surrounding a bioretention area in a parking lot, Raleigh, North Carolina. Source: TetraTech, Inc.

Notes:

Glossary

Aquatic bench – A shallow area inside the perimeter of the normal pool that promotes growth of aquatic plants and can also serve as a safety feature in stormwater wetlands and other aquatic BMPs.

Best management practices (BMPs) – Nonpoint Source BMPs are specific practices or activities used to reduce or control impacts to water bodies from nonpoint sources, most commonly by reducing the loading of pollutants from such sources into storm water and waterways. (TCEQ)

Bioretention (rain gardens) – A stormwater management technique that typically uses parking lot islands, planting strips, or swales to collect and filter urban stormwater. The cells include grass and sand filters, loamy soils, mulch, shallow ponding and native trees and shrubs.

Bridging stone – A separation layer of stone which utilizes the concept of "bridging" to separate the biofiltration media from the underdrain without the use of geotextile fabrics.

Chicanes – A horizontal diversion of vehicular traffic designed to reduce speed and increase safety for pedestrians, bicyclists and motorists.

Contributing zone (Edwards Aquifer) – Located on the Edwards Plateau, the contributing zone is the upstream-most zone of the Edwards Aquifer drainage area. Rainfall infiltrates to recharge the water table aquifer or runs off overland to the recharge zone.

Conveyance systems – Stormwater management systems designed to efficiently convey runoff from a site or watershed into a receiving stream. Systems are typically comprised of impervious segments such as driveways, streets, closed pipes, lined channels and engineered earthen channels.

Curbs – A concrete barrier on the margin of a road or street that is used to direct stormwater runoff to an inlet, protect pavement edges, and protect lawns and sidewalks from encroachment by vehicles.

Detention – A stormwater management approach that temporarily holds back water and releases it at a rate slower than the maximum inflow rate. Detention is not typically designed to reduce the total volume of runoff.

Development - Any manmade change in improved and unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or, drilling operations or storage of equipment or materials (Municipal Code Corporation 2006).

Drainage pathways – Natural or designed routes on the land surface that drain stormwater to BMPs or downstream water bodies.

Easements – An easement is defined as a right, privilege or advantage in real property, existing distinct from the ownership of the land. Most commonly, an easement entails the right of a person (or the public) to use the land of another in a certain manner such as electric, cable, drainage, gas and water easements.

Erosion – The wearing away of land surface by wind or water. Erosion occurs naturally from weather or runoff but can be intensified by increased runoff and land-clearing practices related to farming, residential or industrial development, road, building, or timber cutting.

Evapotranspiration – The combined loss of water from a given area, and during a specified period of time, by evaporation from the soil surface and transpiration from plants into the atmosphere.

Floatables – Any foreign matter that may float or remain suspended in the water column and includes plastic, aluminum cans, wood products, bottles, and paper products.

Geotextile fabric – Permeable textile material used to provide soil stabilization, erosion control and/or aid in drainage. Geotextile fabric can also be used to prevent soil migration from one subgrade section to another.

Groundwater – Water stored underground that fills the spaces between soil particles or rock fractures. A zone underground with enough water to withdraw and use for drinking water or other purposes is called an aquifer.

Hotspot (Stormwater Hotspot) – Areas where infiltration into native soils should be restricted due to risk of contamination. Areas include, but are not limited to: fueling stations, vehicle/equipment maintenance and wash facilities, solid waste facilities, and trucking/railroad facilities.

Hydraulic loading – Flow rate of stormwater divided by surface area.

Glossary

Hydrology – Is the science that encompasses the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle.

Impervious cover – Any surface which cannot be effectively penetrated by water. Examples include roads, parking areas, buildings, pools, patios, sheds, driveways, public and private sidewalks, and other impermeable construction covering the natural land surface.

Infiltration – The downward entry of water into the surface of the soil, as contrasted with percolation which is movement of water through soil layers.

Interception – The capture and storage of water on leaves, grass and buildings that are above the ground surface.

Karst – A landscape formed from the dissolution of soluble rocks including limestone, dolomite and gypsum. It is characterized by sinkholes, caves, and underground drainage systems.

Low impact development – A stormwater management and land development strategy that emphasizes conservation and the use of on-site natural features integrated with engineered, small-scale hydrologic controls to more closely reflect pre-development hydrologic functions.

Peak flow reduction – A stormwater management approach that focuses on limiting peak flow during design storms (water quality, flood control or combination) to a target usually set by existing or pre-development conditions.

Popup emitter –Irrigation drain that opens by the gravity produced pressure of water captured in a drainage system, releases the water in water-safe locations, and remains closed during dry periods.

Precipitation –A method of causing contaminants that are either dissolved or suspended in solution to settle out of solution as a solid precipitate, which can then be filtered or otherwise separated from the liquid portion. Chemical precipitation is a widely used, proven technology for the removal of metals and other inorganics, suspended solids, fats, oils, greases, and some other organic substances from wastewater, drinking water, and occasionally in wastewater.

Predevelopment– The description of land cover, soil profile, hydrologic characteristics and water movement within a site or study area that would exist without human disturbance.

Recharge zone (Edwards Aquifer) – The recharge zone is directly downstream from the contributing zone and consists of highly fractured limestone. Rainfall and runoff directly recharge the confined Edwards Aquifer through deep networks of fissures, faults, and sinkholes.

Retention – A stormwater management technique that captures water permanently and reduces volume and flow rate. The captured water is reused for irrigation or allowed to naturally infiltrate and evapotranspire.

Right-of-way – Right of way is a general term denoting land, property or interest therein, usually in a strip, acquired for or devoted to a highway for the construction of the roadway. Right of way is the entire width of land between the public boundaries or property lines of a highway.

Soil compaction – The process where soil particles are pressed together, reducing pore space between them. Compacted soils typically contain few large pores and have a reduced rate of both water infiltration and drainage from the compacted layer. Soil compaction is a result of equipment, vehicle and pedestrian traffic.

Stormwater bump-out – Extension of the street curb designed to treat stormwater with an inlet or curb cut directing runoff into the structure where it can be stored, infiltrated, filtered and/or absorbed by plants and media, depending on the design.

Time of concentration – The time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet.

Transition zone (Edwards Aquifer) – Located between the recharge zone and the artesian zone, this area features both deep infiltration and artesian springs.

Treatment train – A stormwater technique in which several treatment types (filtration, infiltration, retention, evaporation) are used in conjunction with one another and are integrated into a comprehensive runoff management system.

Wattle –Erosion control material typically consisting of natural fiber filled tubes used for stormwater runoff and sediment control and installed in a manner to interrupt and slow sheet flow.

Municipal Code Corporation and the City of San Antonio. 2006. Code of Ordinances. Chapter 35 (Unified Development Code). Appendix H. Chapter 19. San Antonio, TX https://library.municode.com/tx/san_antonio/codes/unified_development_code