

STORMWATER TREE SYSTEM DESIGN GUIDE

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CITY of BOSTON



City of Boston
Green Infrastructure

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1 PURPOSE

1.1 INTRODUCTION

A Stormwater Tree System is a type of Green Infrastructure (GI) technique which uses a nature-based approach to filter and infiltrate stormwater. The Stormwater Tree System Design Guide (the Guide) was developed as a companion to existing design manuals to help the City of Boston design and maintain greener, healthier, and more resilient tree systems. The Guide is a tool to assist with the design process given specific stormwater objectives, site context, aesthetics, tree health, and maintenance capabilities. It is not intended to be prescriptive or one-size-fits-all, but rather to encourage a creative, multi-functional design approach specific to each project's needs, goals, and budget.

Guidance pertaining to regulatory requirements, sizing criteria, and construction details specific to the practice are not included in this Guide. Refer to the [Green Infrastructure Right-of-Way](#) and Green Infrastructure Open Space Details (forthcoming) from the City of Boston Office of Green Infrastructure, the [Boston Complete Streets Design Guidelines](#), the [Boston Parks and Recreation Department Tree Standards](#), the [Boston Parks and Recreation Department Green Stormwater Infrastructure Design and Implementation Guide](#), the [Boston Water and Sewer Commission Green Infrastructure Planning and Design Handbook](#), and the [Massachusetts Department of Environmental Protection Stormwater Management Handbook](#), as well as other regulatory documents and resources for specific design and maintenance requirements. Registered professionals knowledgeable in both the design and installation of GI, landscape design, and tree health should be consulted to ensure all goals, objectives, and requirements are met.



HARD AT WORK

A vegetated Stormwater Tree System with curb cuts manages stormwater runoff from a parking lot.

1.2 HOW DOES IT WORK?

Stormwater Tree Systems are designed to mimic nature and use the natural filtration properties of soil and plants to remove pollutants from stormwater runoff. Stormwater Tree Systems rely on the following six basic steps and the associated components to function properly:

1. **COLLECT** | INLETS
2. **CAPTURE** | FOREBAYS
3. **MOVE** | WEIRS & CHECK DAMS
4. **FILTER & STORE** | SURFACE & SUBSURFACE MATERIALS
5. **EXPAND & ABSORB** | ROOT ZONE
6. **OVERFLOW** | OUTLETS

These components will be referenced throughout this Guide. If one of these steps does not function properly, the entire system could be compromised and the GI practice itself could contribute to more frequent maintenance burden, unhealthy trees, and localized flooding, possibly requiring costly repairs.

A Stormwater Tree System can include variations of different GI practices designed to filter or infiltrate stormwater as well as add trees to the landscape, such as Bioretention Areas, Bioswales/Rain Gardens, Stormwater Planters, Tree Box Filters, and Constructed Stormwater Wetlands. For the purposes of this Guide, we have simplified the practices into two basic types:

- **SURFACE STORMWATER TREE SYSTEM**

Stormwater enters the feature from the surface. The feature provides stormwater filtration through an amended soil media as well as infiltration and groundwater recharge at sites with well-drained subsoils. A stone storage layer may be added.

- **SUBSURFACE STORMWATER TREE SYSTEM**

Stormwater enters the feature through a catch basin, area drain, or equivalent. The feature provides stormwater storage in a stone layer, as well as filtration through an amended soil media, infiltration, and groundwater recharge at sites with well-drained subsoils.

Surface Stormwater Tree Systems may be desired when more surface space is available to capture and treat stormwater. These types of systems serve as visible infrastructure which may aid in the frequency of maintenance and offer educational opportunities for the public. In addition, they may provide additional ecological benefits through the inclusion of native vegetation. While Subsurface Stormwater Tree Systems can likewise include native vegetation and associated ecological benefits when surface space is available, they may additionally be used when surface space is limited in compact urban areas. In these situations, the systems make the underlying infrastructure less visible, often only providing

clues through a surface drain or inlet. Subsurface systems necessitate a stone storage layer, while surface systems may include this layer to accommodate additional water storage.



INFRASTRUCTURE CAMOUFLAGED

The Subsurface Stormwater Tree Systems including porous paving in Central Square help to manage stormwater while discreetly blending into the urban fabric.

1.3 HOW TO USE THIS GUIDE

The Guide provides a basic understanding of the different components of a Tree System and information to assist design decisions specific to each project's location and objectives. The Guide starts with an initial introduction to Trees and Good Practices and is then divided into two sections which provides more detailed design information on the two Stormwater Tree System types (surface and subsurface). Under each type are the following four subsections:

COMPONENTS

This section describes the six basic components for each tree system type: Collect, Capture, Move, Filter & Store, Expand & Absorb, and Overflow. The design and location of each component may vary depending on specific site constraints and design choices.

DESIGN MATRIX

Understanding the various options available for each component is important to selecting the one that best fits a specific application and context. The Design Matrix provides a quick view of the construction and maintenance costs, clogging tendency, maintenance effort, durability, infiltration or permeability, and ecological value for each design option. These criteria and a key for their symbols in the Design Matrix are explained in greater detail on **page 8**.

COMPONENT IMAGES & MORE INFORMATION

Detailed design and maintenance information as well as photos of each component type are included in this section to supplement the synthesized information found in the Design Matrix.

TYPICAL LAYOUT

Typical Stormwater Tree System layout options are provided for each system type to illustrate how the components fit together and their adaptability to various applications. These layouts are not intended to be the only options. Layout variations can be developed to create a unique tree system that fits a site's specific needs.

2 TREES & GOOD PRACTICES

2.1 TREE BENEFITS

Healthy and mature trees provide a wide array of health, safety, environmental, and economic benefits within our communities. The design of these practices should take into consideration the growth and health of the tree to maximize these long-term benefits. Trees intercept rainfall, “absorb” stormwater runoff, filter pollutants, and provide water storage, thereby acting as a GI system unto themselves. They also provide the following additional benefits beyond stormwater management:

- Add shade and urban tree canopy
- Mitigate the urban heat island effect
- Absorb carbon dioxide from the air and release oxygen
- Remove various pollutants from the atmosphere through absorption and adhesion
- Create context and frame views
- Provide a physical and visual connection to nature
- Create and enhance habitat
- Provide traffic calming benefit within streetscapes, and increase pedestrian comfort
- Improve property values

2.2 SITE CONTEXT

Considering the benefits trees provide, a Stormwater Tree System should be carefully designed to create an environment where trees will thrive. This requires careful review of the intended location to determine if the site conditions are appropriate. When starting the design process it is important to review the project area and consider the following questions:

1. Is there enough room for the tree roots?
2. Is there enough room for the tree canopy?
3. Are there any site constraints that will affect tree growth?
4. Will the tree need to be removed or replaced?



SHADE, FILTRATION, AND BEAUTY

Suspended pavement surface Stormwater Tree System creating a cool and shady plaza at the Christian Science Center.

ROOTS

Stormwater Tree Systems should be designed to include adequate root space for trees to grow to full maturity and ensure longevity. The exact volume varies per tree species. In the Northeast, trees need approximately 2 cubic feet (cu ft) of soil per square foot of canopy area. Following this guideline, below is a list of minimum soil volumes recommended for certain tree canopy diameters expected at maturity:

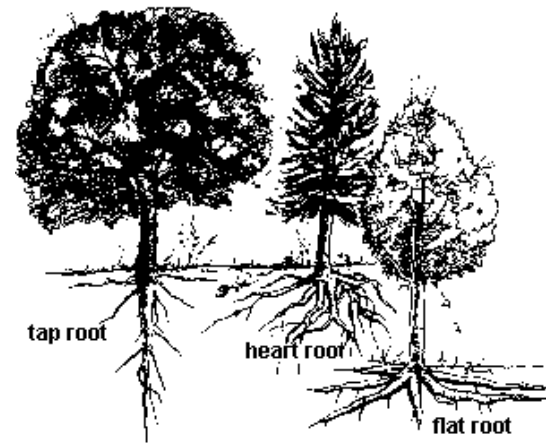
- **25' canopy** = 982 cu ft
- **35' canopy** = 1925 cu ft
- **45' canopy** = 3181 cu ft

The first few inches of soil depth are the most important for the root system and should be prioritized. Most roots typically do not utilize soil beyond a 3-foot depth, therefore volume below this depth is not as critical in the design.

To reach the recommended minimum sizes a linear tree system will frequently be close to the length of the tree canopy, depending on its width. Refer to the [Boston Complete Streets](#) report for additional guidance on street tree planting dimensions. Ensure the subsurface opening is large enough to accommodate the root ball. Include an expanded root zone as necessary to achieve the recommended soil volumes described above.

The growing form of the root system should also be considered. There are generally three types of root forms, tap root, heart root, and flat root. The root system may vary depending on site constraints, but generally some of the species for these types are:

- **Tap root:** Hickory, Walnut, Butternut, White Oak, Hornbeam
- **Heart root:** Red Oak, Honey Locust, Linden (Basswood), Sycamore, Pines
- **Shallow root:** Birch, Fir, Spruce, Sugar Maple, Cottonwood, Silver Maple, Hackberry



VARIED ROOT SYSTEMS

Image and species per root type provided by Iowa State University Forestry Extension.

In general, trees that are tap or heart rooted have less expansive root zones and are best for tree trenches with hardscape, and are less likely to clog up systems.

EXPANDED ROOT ZONE OPTIONS

If site constraints do not allow for the proposed root system area/volume, consider expanding the available root zone area with one of the following options:

- Reducing the amount of surrounding hardscape,
- Connecting to adjacent open spaces, or
- Utilizing suspended pavements, soil cell products, or sand-based structural soil under paved surfaces.

These practices are included within the Design Matrix. Soil cells and some sand-based structural soil mixes are proprietary products, and several resources are available for their design and installation.

Depending on the site-specific constraints and design, it may make sense to locate the tree outside of the inundation/ponding area, to allow the roots to take advantage of the excess water and growing space while reducing the stress of continual inundation, as demonstrated in the Typical Layout section.

CANOPY SPACE

Consider the size of the canopy from when the tree is planted to full growth. Are there structures or overhead utilities in the immediate area that the canopy might grow into? Is there an adjacent walkway or roadway that may be affected by lower branches? Selecting the right tree for the location will help prevent future harm to the branches.

To maximize shade and urban canopy creation and urban heat island reduction, expected canopy diameter at maturity should match the project tree spacing. This will allow for the creation of a continuous canopy.

SITE CONSTRAINTS

Consider existing or proposed site conditions that may affect tree health such as the following:

- Targeted stormwater pollutants or receiving water impairments
- Roadway maintenance (salt & snow storage)
- Underground infrastructure
- Depth to groundwater
- Stored stormwater drawdown time
- Soil type
- Circulation – pedestrian and vehicular
- Contamination of soil or groundwater from previous land uses

2.3 SELECTING SPECIES

Along with the site constraints listed above, tree characteristics and requirements should be considered during plant selection such as sun/ shade tolerance, soil pH, and drought/urban stress tolerance. Additionally, tree selection should include consideration for additional benefits for the surrounding environment such as shade, human health, traffic calming, and wildlife habitat.

Many resources are available to help select tree species that are appropriate for a specific site. Some of the available local sources include:

- [Boston Parks and Recreation Department Recommended Public Street Trees](#) (use for all Right-of-Way and Park spaces)
- City of Boston Office of Green Infrastructure Right-of-Way Green Infrastructure Plant Palette (forthcoming)
- [EPA Stormwater Trees Technical Memorandum](#)

The multi-functional benefits of planting and protecting trees should not be overlooked. Opportunities to preserve and enhance the urban tree canopy should be identified early during the site analysis and design process.

3 SURFACE STORMWATER TREE SYSTEM

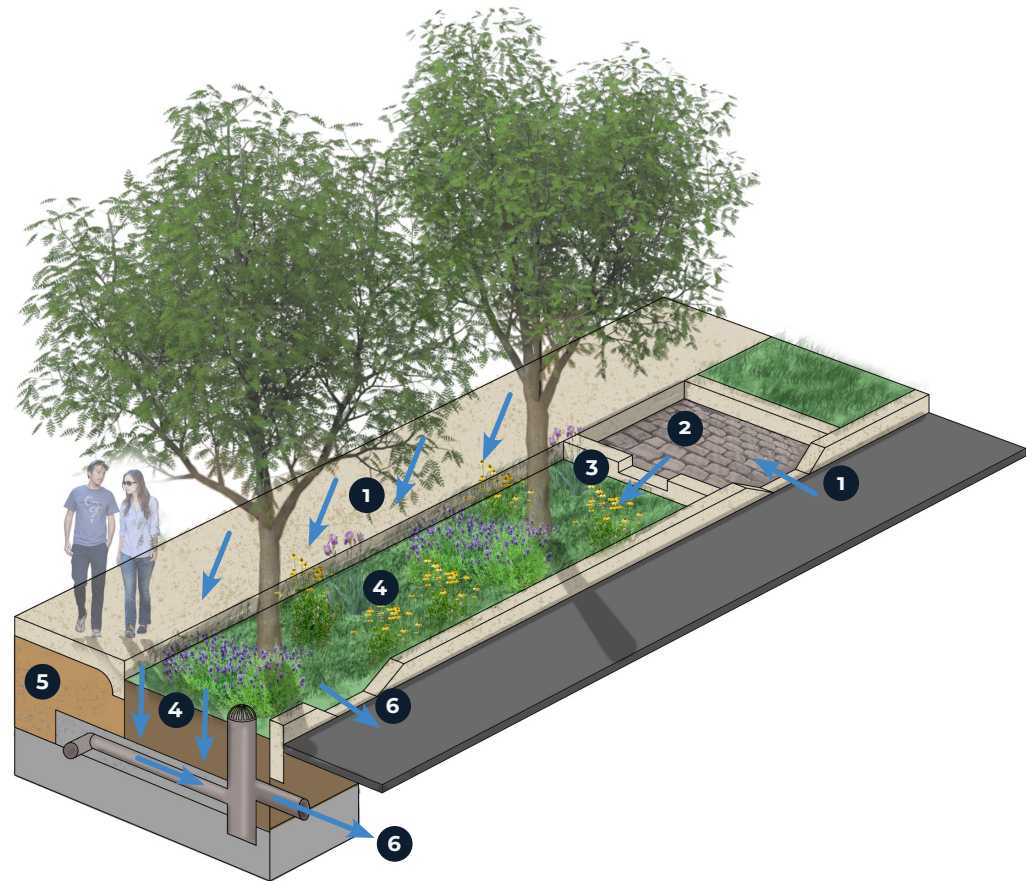
A Surface Stormwater Tree System provides stormwater filtration and irrigation through an amended soil media as well as infiltration and groundwater recharge at sites with well-drained subsoils.

USE WHEN:

- Surface space is available
- Visible infrastructure is desired for maintenance / educational value
- Ecological benefits are desired

3.1 COMPONENTS



- 1 COLLECT**
Stormwater runoff enters the treatment system through an inlet at street level, or through sheet flow from adjacent paved surfaces such as a sidewalk.
- 2 CAPTURE**
The collected runoff is directed to a sediment forebay, which slows the water down with a check dam, allowing debris and sediment to settle out.
- 3 MOVE**
The runoff then overflows into the filter area.
- 4 FILTER & STORE**
The runoff is filtered through soil and root zones to remove pollutants and provide watering.
- 5 EXPAND & ABSORB**
The stormwater continues into an expanded root zone which allows more growing space for roots, greater infiltration and stormwater storage, and prevents clogging.
- 6 OVERFLOW**
The filtered stormwater exits the system through subsurface infiltration providing groundwater recharge or via the outlet structure for larger storm events.



3.2 DESIGN MATRIX

DESIGN MATRIX CRITERIA

To aid in narrowing down the options which are best suited to a particular project's needs, the Design Matrix includes the following criteria, with the associated symbols, to be considered when selecting the system components during design. Additional information on these criteria can be found on this page.

<p>CONSTRUCTION COST</p>	<p>\$ Low \$\$ Medium \$\$\$ High</p>	<p>Construction costs can vary greatly for each component and type, and a range from low to high is provided.</p>	<p>DURABILITY</p>	<p>● ● ● Low ● ● ● Medium ● ● ● High</p>	<p>For some projects, durability is desired for long-term use. For others, more temporary features may work well.</p>
<p>MAINTENANCE COST</p>	<p>\$ Low \$\$ Medium \$\$\$ High</p>	<p>Maintenance costs can vary greatly for each component and type.</p>	<p>INFILTRATION / PERMEABILITY</p>		<p>For the Capture components, Matrix options with this symbol allow infiltration into the surrounding soils. For the Move components, check dam or weir structures with this symbol are permeable and therefore offer additional filtration.</p>
<p>CLOGGING TENDENCY</p>	<p>● ● ● Low Frequency ● ● ● Medium Frequency ● ● ● High Frequency</p>	<p>Clogging can influence maintenance effort and cost, and is added here to summarize information in the Design and Maintenance notes.</p>	<p>ECOLOGICAL VALUE</p>		<p>Assigned to elements which provide additional ecological value through the introduction of plants which provide support for insects and other pollinators, as well as other biological inputs such as beneficial bacteria and fungi present in soils.</p>
<p>MAINTENANCE EFFORT</p>	<p>● ● ● Low Frequency ● ● ● Medium Frequency ● ● ● High Frequency</p>	<p>Maintenance effort is added here to summarize information in the Design and Maintenance notes.</p>			

1 COLLECT | INLETS

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	DURABILITY
		ROW	OPEN SPACE					
CURB CUT* (p.10)	1	●	●	\$	\$	● ○ ○	● ○ ○	● ● ○
TRENCH INLET* (p.10)	2	●	●	\$\$\$	\$\$	● ● ●	● ● ○	● ● ●

* Design Note: In addition to the chosen method above for collecting water from the street, water entering via sheet flow from the sidewalk should also be included in all features.

1 COLLECT | INLETS



Peabody Square

CURB CUT

Design Notes

- Simple design, easy to retrofit
- Prone to water bypassing
- May require gutter line regrading
- Can be damaged by plows. To minimize risk of damage, use slope to vertical granite transition curb.
- Best located at road sag / low points, requires low point set 1" lower than gutter line

Maintenance Notes

- Difficult to clog
- Easy to remove sediment and litter
- Can be taken off line in winter
- Monitor for rainwater bypasses
- Monitor for debris and clogging
- Shovel in winter, can become clogged by snow and ice



New England Ave

TRENCH INLET

Design Notes

- Accommodates pedestrians
- Use where inlets cross sidewalks
- Use solid plate across sidewalk surface instead of grate, for accessibility

Maintenance Notes

- Prone to clogging, monitor for debris
- Plate is heavy and needs to be removed for cleaning
- Can be taken off line and do not accept water into the system in winter

2 CAPTURE | SEDIMENT FOREBAYS

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	DURABILITY	INFILTRATION	ECO VALUE
		ROW	OPEN SPACE							
IMPERMEABLE PAVERS <i>(p.12)</i>	1	●	●	\$\$\$	\$	● ○ ○	● ○ ○	● ● ●		
MORTARED COBBLES / STONE <i>(p.12)</i>	1	●	●	\$\$\$	\$	● ○ ○	● ○ ○	● ● ●		
VEGETATED <i>(p.12)</i>	1	○	●	\$	\$\$	● ● ○	● ● ●	● ● ○	●	●
PERMEABLE PAVERS <i>(p.12)</i>	2	●	●	\$\$\$	\$\$	● ● ●	● ● ○	● ● ○	●	
WASHED RIVER STONE <i>(p.13)</i>	3	○	●	\$	\$\$\$	● ● ●	● ● ●	● ● ○	●	

2 CAPTURE | SEDIMENT FOREBAYS



IMPERMEABLE PAVERS

Design Notes

- Multiple design options
- Consider openings allow some water to pass
- If openings employed, install plants with firm stalks (e.g. rushes)
- Weir design must allow seepage if forebay is impermeable (e.g. orifices)
- Visually differentiate forebays from accessible surfaces

Maintenance Notes

- Easy to remove sediment buildup by shoveling
- No weeding or mowing required
- May hold water for extended periods
- Mortared joints may retain sediment over time
- Pavers may detach and shift



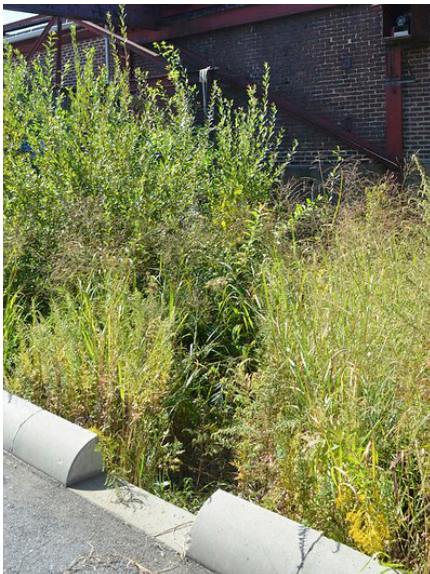
MORTARED COBBLES / STONE

Design Notes

- Multiple design options
- Consider openings to allow some water to pass
- If openings employed, install plants with firm stalks (e.g. rushes)
- Weir design must allow seepage if forebay is impermeable (e.g. orifices)
- Visually differentiate forebays from accessible surfaces

Maintenance Notes

- Easy to remove sediment buildup by shoveling
- No weeding or mowing required
- May hold water for extended periods
- Mortared joints may retain sediment over time



VEGETATED

Design Notes

- Best in areas with low anticipated sediment loading
- Vegetation provides additional treatment
- Natural appearance, can become unkempt / weedy

Maintenance Notes

- Manage vegetation, requires weeding or mowing
- Monitor soil for clogging or puddles
- If standing water is observed over extended period, remove and replace top 3" of soil and replant
- Infrequent cleaning
- Sediment removal requires removing and replanting vegetation



PERMEABLE PAVERS

Design Notes

- Multiple design options
- Visually differentiate forebays from accessible surfaces
- Voids can be planted

Maintenance Notes

- Shovel to remove litter and sediment buildup
- If standing water is observed over extended period, power wash pavers or pull up pavers, clean, and reinstall
- Pavers may shift over time, creating voids which become difficult to clean
- Requires frequent cleaning to prevent clogging
- Requires weeding, not mowing

2 CAPTURE | SEDIMENT FOREBAYS



WASHED RIVER STONE

Design Notes

- Simple construction
- Material is readily available
- Stone may migrate
- Can become weedy / unkempt

Maintenance Notes

- Difficult to remove sediment trapped between stones
- Monitor for clogging
- Once stone is full of sediment, remove stone, clean, and replace
- Requires weeding, not mowing

3 MOVE | WEIRS & CHECK DAMS

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	DURABILITY	PERMEABLE	ECO VALUE
		ROW	OPEN SPACE							
CURBING <i>(p.15)</i>	1	●	●	\$\$\$	\$	●○○	●○○	●●●		
METAL EDGING <i>(p.15)</i>	2	●	●	\$\$	\$	●○○	●○○	●●●		
GABION BASKET WITH STONE <i>(p.15)</i>	3	●	●	\$\$	\$\$\$	●●●	●●●	●●○	●	
EARTHEN / VEGETATED <i>(p.15)</i>	4	○	●	\$	\$\$	●○○	●●○	●○○	●	●
WOODEN LOG / COMPOST SOCK <i>(p.16)</i>	5	○	●	\$	\$\$	●○○	●○○	●○○	●	●

3 MOVE | WEIRS & CHECK DAMS



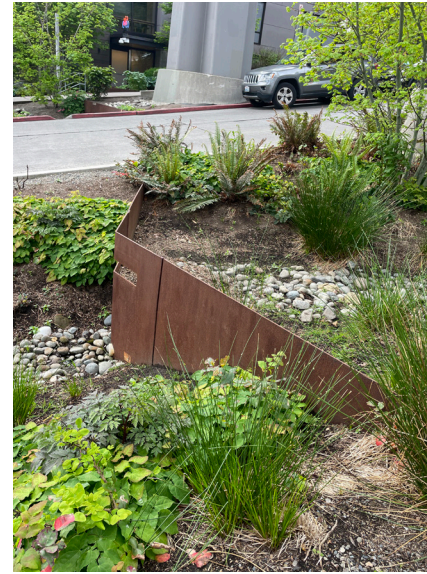
CURBING

Design Notes

- Multiple design options (material, size)
- Can use recycled curb pieces
- Space-efficient
- Impermeable
- Built appearance
- Forebay design must incorporate adequate drainage for drawdown

Maintenance Notes

- Minimal maintenance



METAL EDGING

Design Notes

- Can be dangerous/sharp edges
- Attractive appearance
- Space-efficient
- Impermeable

Maintenance Notes

- Minimal maintenance



GABION BASKET WITH STONE

Design Notes

- Can customize appearance (fill material)
- Sediment may migrate through the gaps
- May catch debris and garbage
- Built appearance

Maintenance Notes

- Monitor for clogging
- Once fill material is full of sediment, remove, clean and replace
- May require replacement every few years if sediment buildup is excessive



EARTHEN / VEGETATED

Design Notes

- Natural appearance
- Requires more space
- Seepage may undermine soil stability
- Prone to erosion and settlement
- Can become weedy / unkempt

Maintenance Notes

- Can be damaged during maintenance

Image Source:

Ekka, S., & Hunt, B. (2020, February 10). *Swale terminology for urban stormwater treatment*. NC State Extension Publications. <https://content.ces.ncsu.edu/swale-terminology-for-urban-stormwater-treatment>

3 MOVE | WEIRS & CHECK DAMS



WOODEN LOG / COMPOST SOCK


Design Notes

- Hardwoods preferred
- For limited, specific applications only
- Consider for naturalistic areas, educational sites, and nature play
- Can incorporate vegetation into sock
- Natural appearance
- Reclaimed / sustainable material

Maintenance Notes

- Degrades over time and will require replacement

4 FILTER | SURFACE MATERIALS

TYPE	RANK	APPLICATION ROW OPEN SPACE	CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	DURABILITY	ECO VALUE	
TREE (p.18)	N/A	● ●	REQUIRED FOR ALL APPLICATIONS						
NATIVE VEGETATION (p.18)	1	● ○	\$\$	\$\$	● ● ○	● ● ○	● ○ ○		
TURF (p.18)	1	○ ●	\$	\$\$	● ○ ○	● ○ ○	● ○ ○		
POROUS RESIN- BOUND STONE OR RUBBER PAVING (p.18)	2	● ●	\$\$	\$\$	● ○ ○	● ● ○	● ● ●		
ORGANIC MULCH (p.19)	3	● ●	\$	\$	● ● ●	● ○ ○	● ○ ○		
STONE MULCH (p.19)	3	● ●	\$	\$	● ○ ○	● ○ ○	● ● ○		
PERMEABLE PAVERS (p.19)	4	● ●	\$\$\$	\$\$	● ● ○	● ● ●	● ● ●		

4 FILTER | SURFACE MATERIALS



TREE

Design Notes

- Include in all applications
- Tree selection should consider site constraints (e.g., adjacent buildings, pedestrian routes, utilities) and exposure to urban conditions (salt, inundation, drought, heat)
- Vary tree species to prevent pest/disease risks to monocultures. If a consistent appearance is desired, consider choosing species with similar silhouettes
- Do not install tree staples or other underground anchoring devices

Maintenance Notes

- Monitor health & manage vegetation (water during first three years and during drought and hot weather, prune, replenish mulch as needed)



NATIVE VEGETATION

Design Notes

- High ecological value (biodiversity, pollinator habitat)
- Plant roots improve filtration / infiltration and perform transpiration
- Lowers heat island effect
- Natural appearance
- Can become weedy / unkempt
- Requires landscape maintenance and plant knowledge
- Can collect / hide trash

Maintenance Notes

- Manage vegetation (weeding, cutting back, replanting as needed)



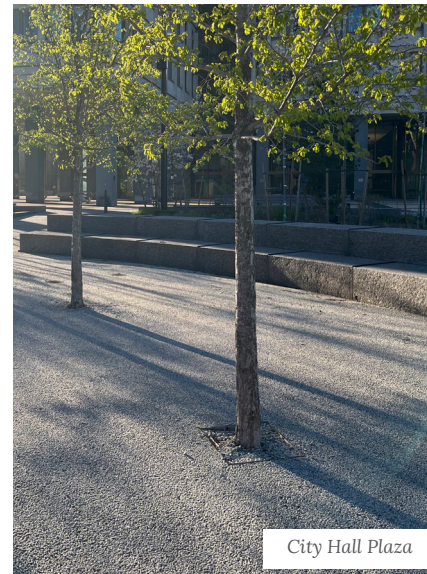
TURF

Design Notes

- Ease of maintenance
- May allow use of space
- Limited ecological value
- High water demand
- Requires mowing

Maintenance Notes

- Manage vegetation (mowing, weeding, reseeding as needed)



POROUS RESIN-BOUND STONE OR RUBBER PAVEMENT

Design Notes

- Use where accessible surfaces are required
- Easy to install, requiring limited tools / training
- Specialized construction
- Does not migrate
- Prevents weeds
- Makes litter pick-up easy
- Can be used as replacement for broken tree grates

Maintenance Notes

- Paving may wear over time
- Requires cleaning at least twice a year to prevent clogging

4 FILTER | SURFACE MATERIALS



Nubian Square

ORGANIC MULCH

Design Notes

- Provides nutrients to soil over time

Maintenance Notes

- Easily migrates with stormwater, will require replenishment
- Requires weeding



Codman Square

STONE MULCH

Design Notes

- Can lower heat island effect (light color peastone)
- May migrate or be thrown, can lead to tripping hazards
- Use a small aggregate size (e.g. peastone) to avoid tripping hazards

Maintenance Notes

- Will likely require replenishment
- Requires weeding



City Hall Plaza

PERMEABLE PAVERS


Design Notes

- Multiple design options
- Pavers may shift, not ideal for locations where accessible surfaces are required
- Voids can be planted
- Replacing trees requires a specialized contractor

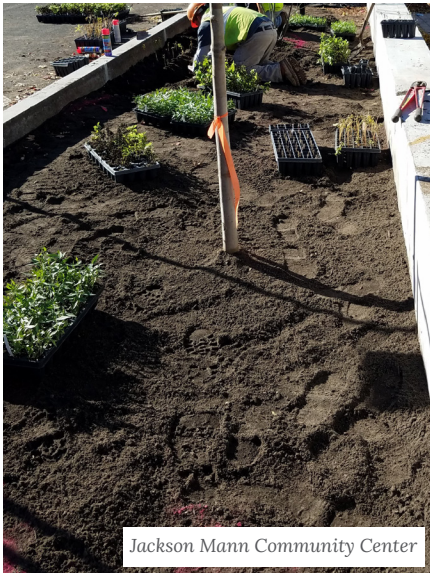
Maintenance Notes

- Weeding required
- Requires cleaning at least twice a year to prevent clogging
- Voids may become difficult to clean over time
- If standing water is observed over extended period, power wash pavers or pull up pavers, clean, and reinstall

4 FILTER | SUBSURFACE MATERIALS

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	ECO VALUE
		ROW	OPEN SPACE					
BIORETENTION SOIL MIX <i>(p.21)</i>	1	●	●	\$\$	\$	● ○ ○	● ● ○	
NATIVE SOIL WITH AMENDMENTS <i>(p.21)</i>	2	○	●	\$	\$	● ● ○	● ● ○	
STONE STORAGE LAYER <i>(p.21)</i>	N/A	●	●	\$\$	\$\$	● ● ○	● ○ ○	
LINER <i>(p.21)</i>	N/A	●	●	\$\$	\$	● ● ○	● ○ ○	

4 FILTER | SUBSURFACE MATERIALS



Jackson Mann Community Center

BIORETENTION SOIL MIX

Design Notes

- Can be fully designed for specific goals of the GI
- More transportation emissions
- Use well to moderately-draining soil mix in locations with existing soil types C/D and in areas receiving high salt load
- Use moderately to poorly-draining soil mix in locations with existing soil types A/B

Maintenance Notes

- Monitor soil for clogging
- If clogging occurs, aerate or remove top few inches and replace



Edward M. Kennedy Academy

NATIVE SOIL WITH AMENDMENTS

Design Notes

- Can be amended for specific GI goals
- Less transportation emissions
- Most “native soils” (largely urban fill) in Boston will not be suitable to be used for GI

Maintenance Notes

- Monitor soil for clogging
- If clogging occurs, aerate or remove top few inches and replace



Edward M. Kennedy Academy

STONE STORAGE LAYER

Design Notes

- Holds water for additional root uptake
- Additional stormwater storage
- Unmaintainable if clogged (below tree roots)
- May be difficult to accommodate in some Right-of-Ways

Maintenance Notes

- Monitor system to ensure stone isn't clogged



LINER

Design Notes

- Provides flexibility in areas where infiltration is not possible
- More complicated design and install
- Necessitates underdrain and connection to drainage system
- Limits plant selection
- Use only where required (contaminated soils, high water table, sensitive subsurface infrastructure, proximity to building foundations)

5 EXPAND & ABSORB | ROOT ZONE

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	MAINTENANCE EFFORT	PROPRIETARY PRODUCT AVAILABLE
		ROW	OPEN SPACE				
SUSPENDED PAVEMENTS <i>(p.23)</i>	1	●	●	\$\$\$	\$	● ● ○	○
SOIL CELLS <i>(p.23)</i>	2	●	●	\$\$	\$\$	● ● ○	●
SAND-BASED STRUCTURAL SOIL <i>(p.23)</i>	3	●	●	\$	\$	● ● ○	○

5 EXPAND & ABSORB | ROOT ZONE



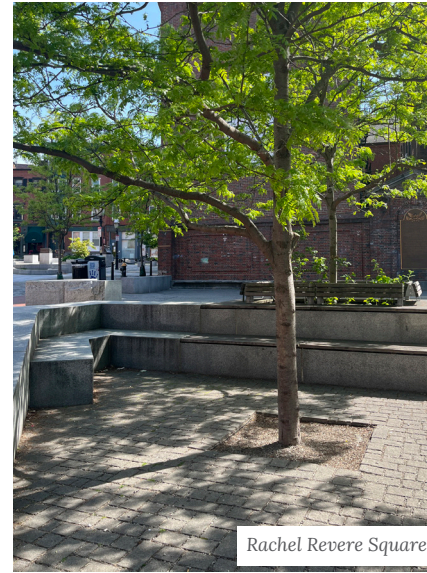
SUSPENDED PAVEMENTS

Design Notes

- Improves environment for trees
- Allows loose, root-friendly soils
- For improved air and water flow, consider porous paving atop root zone and/or aeration/water distribution system

Maintenance Notes

- Maintain aeration / water distribution system components
- Requires record-keeping for maintenance



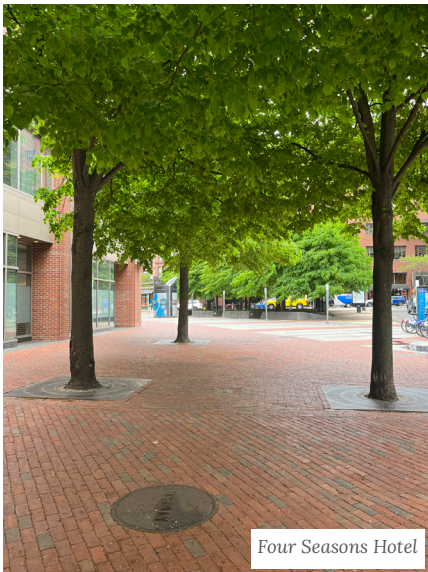
SOIL CELLS

Design Notes

- Improves environment for trees
- Allows loose, root-friendly soils
- Proprietary systems
- Can complicate utility installation / repair
- May be unfamiliar to installers
- For improved air and water flow, consider porous paving atop root zone and/or aeration/water distribution system
- Provide thorough installation instructions to contractor and construction oversight

Maintenance Notes

- Maintain aeration / water distribution system components
- Requires record-keeping for maintenance



SAND-BASED STRUCTURAL SOILS

Design Notes

- Improves environment for trees
- Readily infiltrates water
- Frequently used
- Trees may struggle to access sufficient water, not ideal as a growing medium
- For improved air and water flow, consider porous paving atop root zone and/or aeration/water distribution system
- Ensure planting soil surrounds root ball of tree, SBSS should not directly abut root ball

Maintenance Notes

- Maintain aeration / water distribution system components
- Requires record-keeping for maintenance if aeration / water distribution system included

6 OVERFLOW | OUTLETS

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	DURABILITY
		ROW	OPEN SPACE					
SECOND CURB CUT <i>(p.25)</i>	N/A	●	●	\$	\$	● ○ ○	● ○ ○	● ● ○
OVERFLOW STRUCTURE <i>(p.25)</i>	N/A	●	●	\$\$	\$\$	● ● ○	● ● ○	● ● ○
UNDERDRAIN <i>(p.25)</i>	N/A	●	●	\$\$	\$\$	● ● ○	● ● ○	● ● ●
EMERGENCY OVERFLOW / LEVEL SPREADER <i>(p.25)</i>	N/A	○	●	\$	\$	● ○ ○	● ○ ○	● ● ●

6 OVERFLOW | OUTLETS



Nubian Square

SECOND CURB CUT

Design Notes

- Simple design, easy to retrofit
- Less stormwater storage
- May require gutter line regrading
- Can be damaged by plows
- Can become clogged by snow / ice in winter

Maintenance Notes

- Easily maintained
- Monitor to ensure no clogging



Connect Historic Boston Bike Trail

OVERFLOW STRUCTURE

Design Notes

- Additional stormwater storage (overflow to subsurface stone storage layer)
- Allows direct discharge to storm drain system
- Provides outlet for underdrains
- Requires additional work within the Right-of-Way
- Use where greater recharge required
- Install larger risers for ease of maintenance

Maintenance Notes

- Monitor to ensure no clogging from debris
- Structure and pipes must be maintained, can be difficult to clean



UNDERDRAIN

Design Notes

- Distributes stormwater within subsurface gravel storage bed
- Ensures proper drainage for features with poor soils or liners
- Reduces standing water
- Requires an overflow structure and connection to storm drain system
- Use for lined trenches, where soils are poor, or where standing water is a concern

Maintenance Notes

- Check annually through cleanout to ensure no clogging
- Clean as needed



EMERGENCY OVERFLOW / LEVEL SPREADER

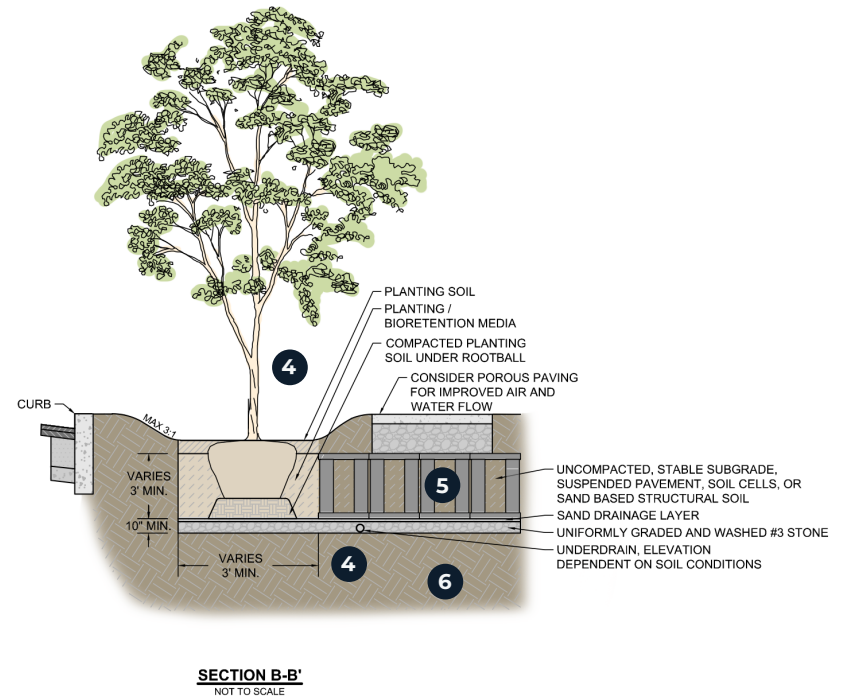
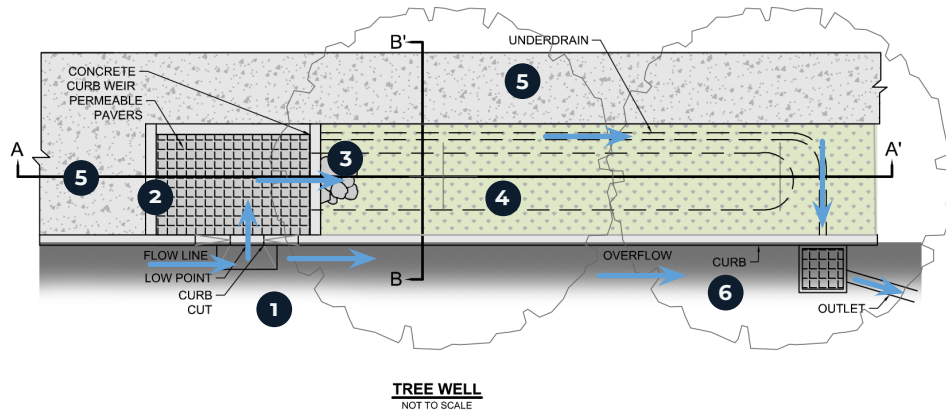
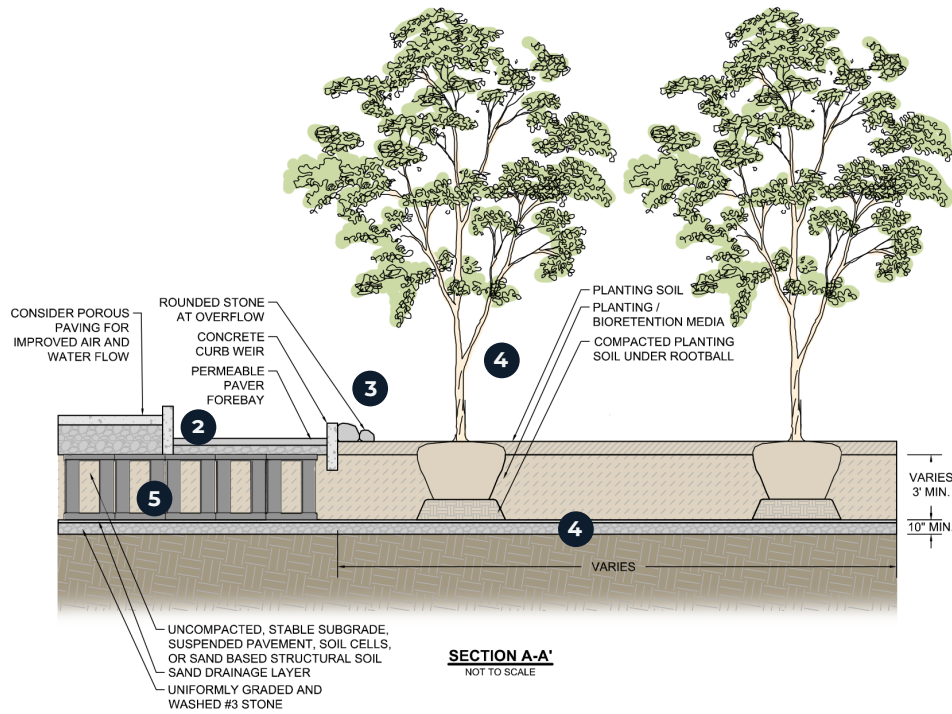
Design Notes

- Provides overflow for large storms if not discharging to gutter line or drainage systems
- Requires a safe off-site location to direct water
- Use in open spaces with off-site discharge locations (e.g. ponds, rivers)
- Use in features designed for large storms

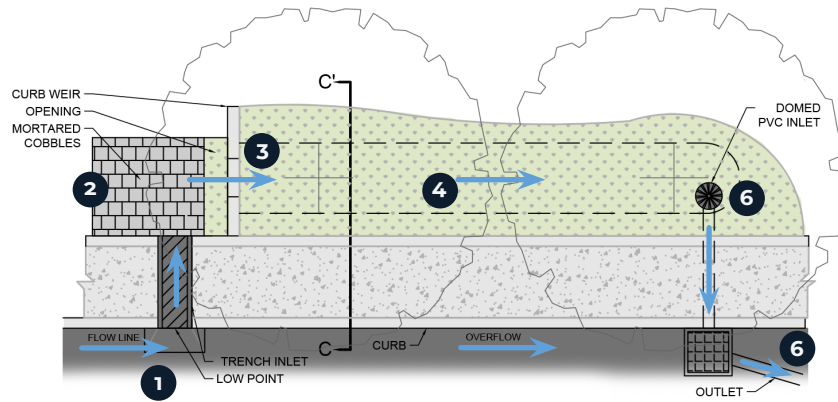
Maintenance Notes

- Monitor for erosion

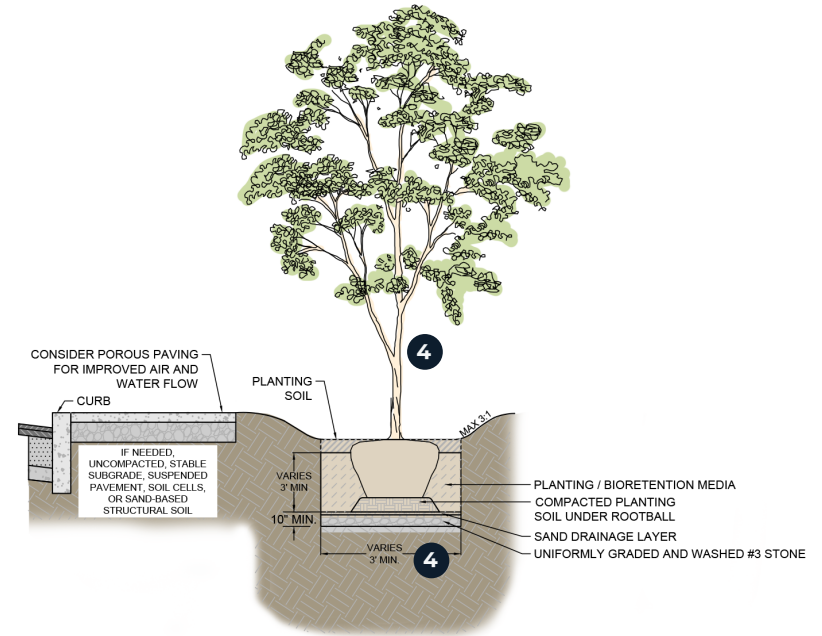
3.3 TYPICAL LAYOUTS



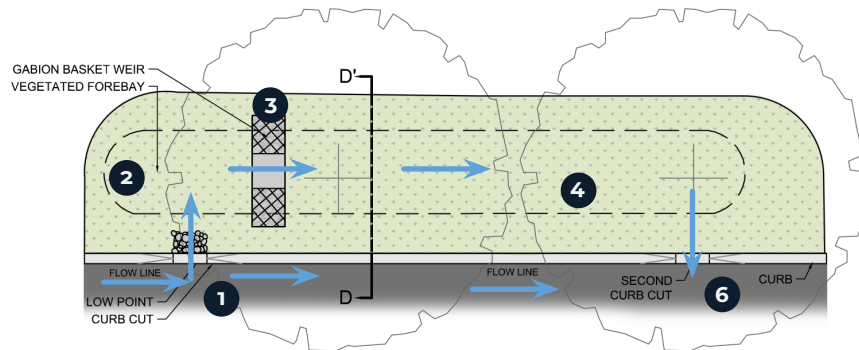
3.3 TYPICAL LAYOUTS CONTINUED



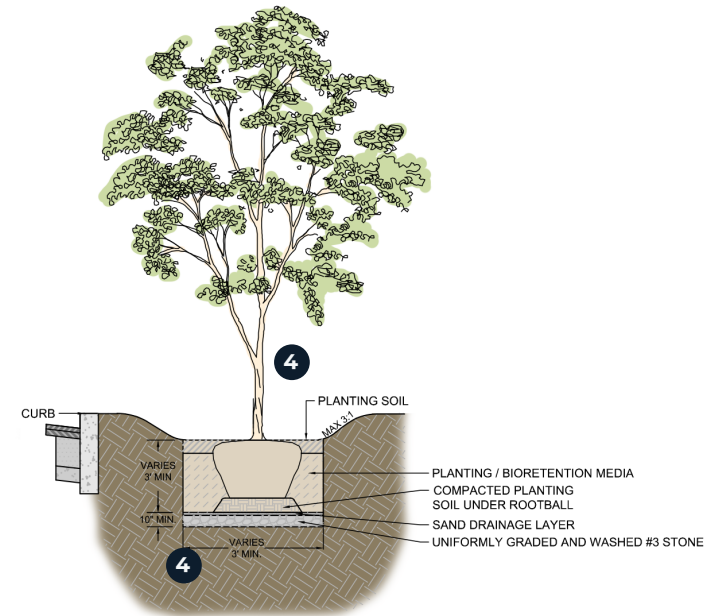
BACK OF SIDEWALK
NOT TO SCALE



SECTION C-C'
NOT TO SCALE



OPEN - NO SIDEWALK
NOT TO SCALE



SECTION D-D'
NOT TO SCALE

4 SUBSURFACE STORMWATER TREE SYSTEM

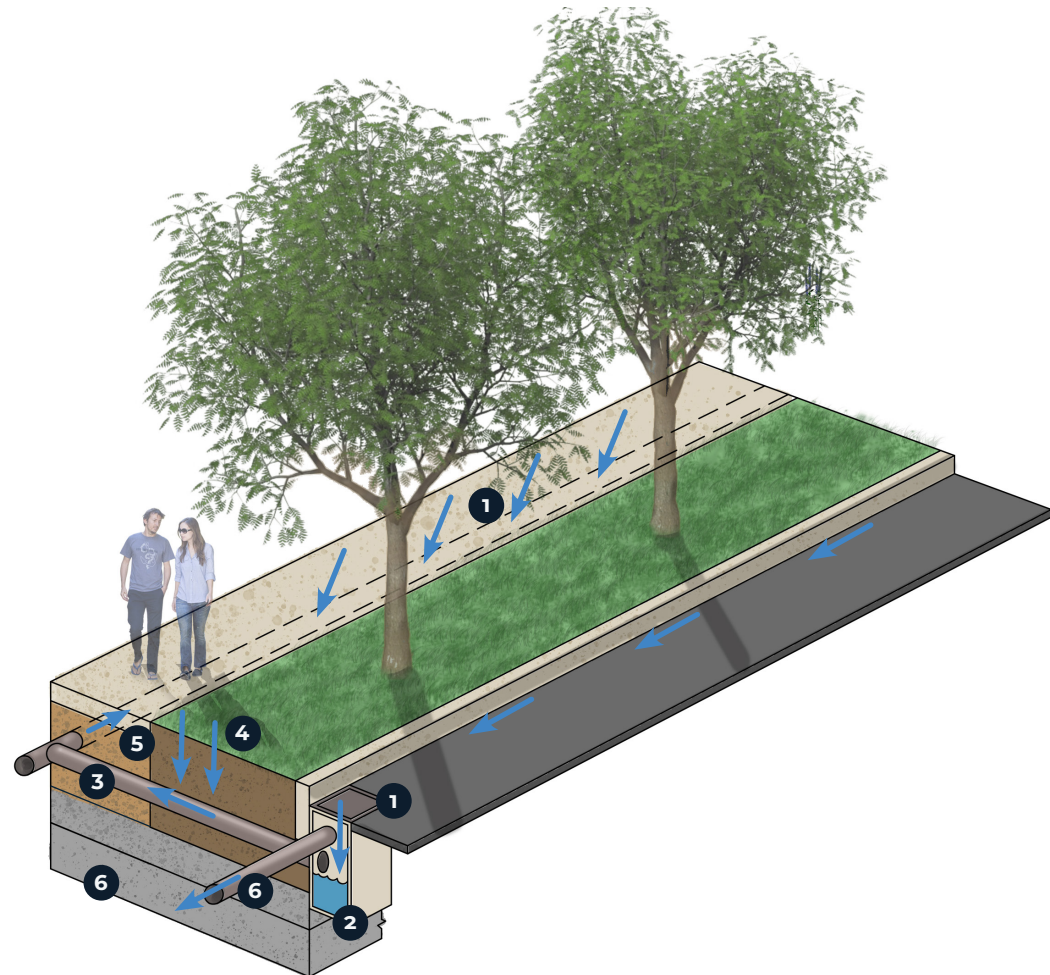
A Subsurface Stormwater Tree System provides stormwater storage in a gravel bed and infiltrates stormwater through the subsoils.

USE WHEN:

- Less surface space is available
- Retrofitting existing underground structures
- Larger volumes of water need to be stored underground

4.1 COMPONENTS

- 1 COLLECT**
Stormwater runoff enters the treatment system through an inlet at street level, or through sheet flow from adjacent paved surfaces such as a sidewalk.
- 2 CAPTURE**
The collected runoff is directed to a deep sump and pipe hood, which will allow debris and sediment to settle out.
- 3 MOVE**
The runoff then overflows into a distribution pipe that moves the runoff to the main filter area.
- 4 FILTER & STORE**
The runoff is filtered through a storage area of soil, roots, and optional gravel, which allows for tree root uptake and infiltration into the subsoils.
- 5 EXPAND & ABSORB**
The stormwater continues into an expanded root zone which allows more growing space for roots, greater infiltration and stormwater storage, and prevents clogging.
- 6 OVERFLOW**
The stormwater exits the system through subsurface infiltration providing groundwater recharge or via the outlet structure for larger storm events.



4.2 DESIGN MATRIX

1 COLLECT | INLETS

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	DURABILITY
		ROW	OPEN SPACE					
CATCH BASIN WITH GRATE* (p.30)	N/A	●	●	\$\$\$	\$\$	● ○ ○	● ○ ○	● ● ●
CURB INLET WITH STRUCTURE AND UNDERDRAIN* (p.30)	N/A	●	●	\$\$	\$	● ● ○	● ○ ○	● ● ○

* Design Note: In addition to the chosen method above for collecting water from the street, water entering via sheet flow from the sidewalk should also be included in all features.

1 COLLECT | INLETS



CATCH BASIN WITH GRATE

Design Notes

- Familiar design and maintenance
- Requires connection to storm drain system
- Maintenance may be neglected (sediment not visible)
- Must meet BWSC drainage structure specifications
- Use for larger roadway drainage projects where connection to the storm drain system is required
- Use for retrofits of existing catch basins

Maintenance Notes

- Typical catch basin maintenance, clean out sump with vacuum truck



CURB INLET WITH STRUCTURE AND UNDERDRAIN

Design Notes

- Minimizes work within the roadway
- May minimize required excavation depths
- Does not require connection to storm drain system
- Flexible design options (e.g. PVC drain basin in lieu of concrete structures)
- Use for smaller streetscape improvement projects when space is available in the Right-of-Way and connection to the storm drain system is not required
- Visually differentiate forebays from accessible surfaces

Maintenance Notes

- Additional maintenance is required for sediment forebay
- Monitor inlet to ensure no clogging
- Shovel and remove sediment buildup in forebay

2 CAPTURE | SEDIMENT FOREBAYS

TYPE	RANK	APPLICATION ROW OPEN SPACE	CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	DURABILITY	INFILTRATION
DEEP SUMP * (p.32)	N/A	● ●	\$	\$\$	● ○ ○	● ● ○ ***	● ● ●	
SEDIMENT FOREBAY WITH PERMEABLE PAVERS ** (p.32)	N/A	● ●	\$\$	\$\$	● ● ○	● ● ○	● ● ○	●

* Deep Sump: Use with "Catch Basin with Grate" inlet type

** Sediment Forebay with Permeable Pavers: Use with "Curb Inlet with Structure and Underdrain" inlet type

*** Specialized Equipment Needed

2 CAPTURE | SEDIMENT FOREBAYS



DEEP SUMP

Design Notes

- Familiar design and maintenance
- More tidy appearance (sediment not visible)
- Cleaning requires vacuum truck or clamshell
- Requires connection to storm drain system
- Maintenance may be neglected (sediment not visible)
- Use with “Catch Basin with Grate” inlet type
- Use inlet insert sack only during construction

Maintenance Notes

- Typical catch basin maintenance, clean out sump with vacuum truck



SEDIMENT FOREBAY WITH PERMEABLE PAVERS

Design Notes

- Multiple design options
- Captures sediment both at the surface and below grade
- Produces visual indicator that cleaning is required
- Use with “Curb Inlet with Structure and Underdrain” inlet type
- Use inlet insert sack only during construction

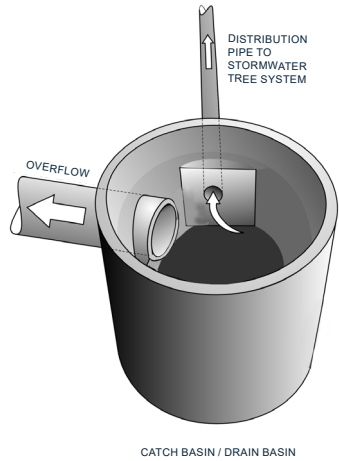
Maintenance Notes

- Monitor inlet to ensure no clogging
- Shovel and remove sediment buildup in forebay
- Clean out sump with vacuum truck

3 MOVE | WEIRS & CHECK DAMS

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT
		ROW	OPEN SPACE				
PIPE INVERTS (IN STRUCTURE) <i>(p.34)</i>	1	●	●	\$	\$	● ○ ○	● ○ ○
WEIR PLATE (IN STRUCTURE) <i>(p.34)</i>	2	●	●	\$\$	\$	● ● ●	● ● ○
PERFORATED DISTRIBUTION PIPE <i>(p.34)</i>	N/A	●	●	\$	\$\$	● ● ●	● ● ○

3 MOVE | WEIRS & CHECK DAMS



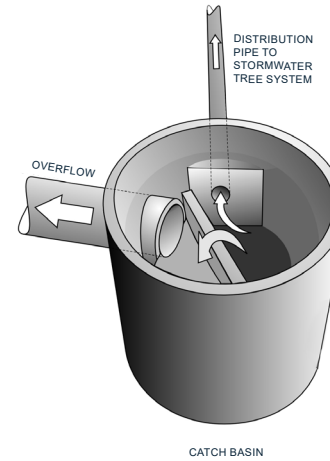
PIPE INVERTS (IN STRUCTURE)

Design Notes

- Simpler design, especially if connection to storm drain system is not required
- Easy retrofit of an existing structure if inverts allow
- Easy maintenance when combined with “Deep Sump”
- Limited to applications with compatible inverts (outlet to feature is lower than outlet to storm drain)

Maintenance Notes

- Typical catch basin / structure maintenance, clean out sump with vacuum truck



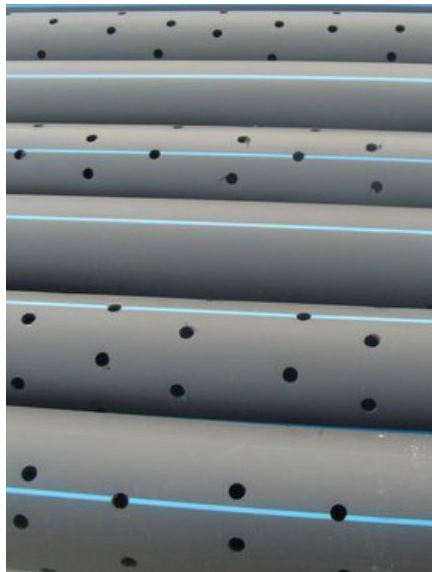
WEIR PLATE (IN STRUCTURE)

Design Notes

- Versatile
- Adaptable to all existing drainage inverts
- More complex design & construction
- Maintenance access is difficult
- May require a catch basin and manhole with a weir
- Use when outlet to feature is higher than outlet to storm drain

Maintenance Notes

- Typical catch basin / structure maintenance, clean out sump with vacuum truck
- Monitor to ensure no clogging



PERFORATED DISTRIBUTION PIPE


Design Notes

- Include in all applications

Maintenance Notes

- Monitor to ensure no clogging
- Check annually during cleanout to ensure no clogging has occurred and tree roots have not entered pipe
- Clean pipe as needed

4 FILTER & STORE | SURFACE MATERIALS

TYPE	RANK	APPLICATION ROW OPEN SPACE	CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	DURABILITY	ECO VALUE	
TREE (p.36)	N/A	● ●	REQUIRED FOR ALL APPLICATIONS						
NATIVE VEGETATION (p.36)	1	● ○	\$\$	\$\$	●●○	●●○	●○○		
TURF (p.36)	1	○ ●	\$	\$\$	●○○	●○○	●○○		
POROUS RESIN- BOUND STONE OR RUBBER PAVING (p.36)	2	● ●	\$\$	\$\$	●○○	●●○	●●●		
ORGANIC MULCH (p.37)	3	● ●	\$	\$	●●●	●○○	●○○		
STONE MULCH (p.37)	3	● ●	\$	\$	●○○	●○○	●●○		
PERMEABLE PAVERS (p.37)	4	● ●	\$\$	\$\$	●●○	●●●	●●●		

4 FILTER & STORE | SURFACE MATERIALS



Central Square

TREE

Design Notes

- Include in all applications
- Tree selection should consider site constraints (e.g., adjacent buildings, pedestrian routes, utilities) and exposure to urban conditions (salt, inundation, drought, heat)
- Vary tree species to prevent pest/disease risks to monocultures. If a consistent appearance is desired, consider choosing species with similar silhouettes
- Do not install tree staples or other underground anchoring devices

Maintenance Notes

- Monitor health & manage vegetation (water during first three years and during drought and hot weather, prune, replenish mulch as needed)



Nubian Square

NATIVE VEGETATION

Design Notes

- High ecological value (biodiversity, pollinator habitat)
- Plant roots improve filtration / infiltration and perform transpiration
- Lowers heat island effect
- Natural appearance
- Can become weedy / unkempt
- Requires landscape maintenance and plant knowledge
- Can collect / hide trash

Maintenance Notes

- Manage vegetation (weeding, cutting back, replanting as needed)



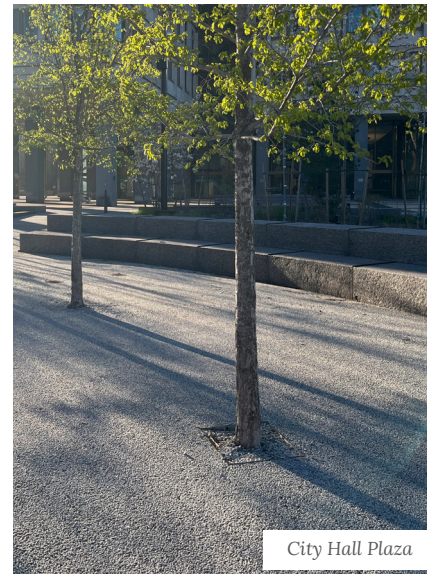
TURF

Design Notes

- Ease of maintenance
- May allow use of space
- Limited ecological value
- High water demand
- Requires mowing

Maintenance Notes

- Manage vegetation (mowing, weeding, reseeding as needed)



City Hall Plaza

POROUS RESIN-BOUND STONE OR RUBBER PAVEMENT

Design Notes

- Use where accessible surfaces are required
- Easy to install, requiring limited tools / training
- Specialized construction
- Does not migrate
- Prevents weeds
- Makes litter pick-up easy
- Can be used as replacement for broken tree grates

Maintenance Notes

- Paving may wear over time
- Requires cleaning at least twice a year to prevent clogging

4 FILTER & STORE | SURFACE MATERIALS



Nubian Square

ORGANIC MULCH

Design Notes

- Provides nutrients to soil over time

Maintenance Notes

- Easily migrates with stormwater, will require replenishment
- Requires weeding



Codman Square

STONE MULCH

Design Notes

- Can lower heat island effect (light color peastone)
- May migrate or be thrown, can lead to tripping hazards
- Use a small aggregate size (e.g. peastone) to avoid tripping hazards

Maintenance Notes

- Will likely require replenishment
- Requires weeding



City Hall Plaza

PERMEABLE PAVERS


Design Notes

- Multiple design options
- Pavers may shift, not ideal for locations where accessible surfaces are required
- Voids can be planted
- Replacing trees requires a specialized contractor

Maintenance Notes

- Weeding required
- Requires cleaning at least twice a year to prevent clogging
- Voids may become difficult to clean over time
- If standing water is observed over extended period, power wash pavers or pull up pavers, clean, and reinstall

4 FILTER & STORE | SUBSURFACE MATERIALS

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	ECO VALUE
		ROW	OPEN SPACE					
BIORETENTION SOIL MIX (p.39)	1	●	●	\$\$	\$	● ○ ○	● ● ○	
NATIVE SOIL WITH AMENDMENTS (p.39)	2	○	●	\$	\$	● ● ○	● ● ○	
STONE STORAGE LAYER (p.39)	N/A	●	●	\$\$	\$\$	● ● ○	● ○ ○	
LINER (p.39)	N/A	●	●	\$\$	\$	● ● ○	● ○ ○	

4 FILTER & STORE | SUBSURFACE MATERIALS



Jackson Mann Community Center

BIORETENTION SOIL MIX

Design Notes

- Can be fully designed for specific goals of the GI
- More transportation emissions
- Use well to moderately-draining soil mix in locations with existing soil types C/D and in areas receiving high salt load
- Use moderately to poorly-draining soil mix in locations with existing soil types A/B

Maintenance Notes

- Monitor soil for clogging
- If clogging occurs, aerate or remove top few inches and replace



Edward M. Kennedy Academy

NATIVE SOIL WITH AMENDMENTS

Design Notes

- Can be amended for specific GI goals
- Less transportation emissions
- Most “native soils” (largely urban fill) in Boston will not be suitable to be used for GI

Maintenance Notes

- Monitor soil for clogging
- If clogging occurs, aerate or remove top few inches and replace



Edward M. Kennedy Academy

STONE STORAGE LAYER

Design Notes

- Holds water for additional root uptake
- Additional stormwater storage
- Unmaintainable if clogged (below tree roots)
- May be difficult to accommodate in some Right-of-Ways

Maintenance Notes

- Monitor system to ensure stone isn't clogged



LINER

Design Notes

- Provides flexibility in areas where infiltration is not possible
- More complicated design and install
- Necessitates underdrain and connection to drainage system
- Limits plant selection
- Use only where required (contaminated soils, high water table, sensitive subsurface infrastructure, proximity to building foundations)

5 EXPAND & ABSORB | ROOT ZONE

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	MAINTENANCE EFFORT	PROPRIETARY PRODUCT AVAILABLE
		ROW	OPEN SPACE				
SUSPENDED PAVEMENTS <i>(p.41)</i>	1	●	●	\$\$\$	\$	● ● ●	●
SAND-BASED STRUCTURAL SOIL <i>(p.41)</i>	2	●	●	\$	\$	● ● ●	●
SOIL CELLS <i>(p.41)</i>	3	●	●	\$\$	\$\$	● ● ●	●

5 EXPAND & ABSORB | ROOT ZONE



SUSPENDED PAVEMENTS

Design Notes

- Improves environment for trees
- Allows loose, root-friendly soils
- For improved air and water flow, consider porous paving atop root zone and/or aeration/water distribution system

Maintenance Notes

- Maintain aeration / water distribution system components
- Requires record-keeping for maintenance



SAND-BASED STRUCTURAL SOILS

Design Notes

- Improves environment for trees
- Readily infiltrates water
- Frequently used
- Trees may struggle to access sufficient water, not ideal as a growing medium
- For improved air and water flow, consider porous paving atop root zone and/or aeration/water distribution system
- Ensure planting soil surrounds root ball of tree, SBSS should not directly abut root ball

Maintenance Notes

- Maintain aeration / water distribution system components
- Requires record-keeping for maintenance if aeration / water distribution system included



SOIL CELLS

Design Notes

- Improves environment for trees
- Allows loose, root-friendly soils
- Proprietary systems
- Can complicate utility installation / repair
- May be unfamiliar to installers
- For improved air and water flow, consider porous paving atop root zone and/or aeration/water distribution system
- Provide thorough installation instructions to contractor and construction oversight

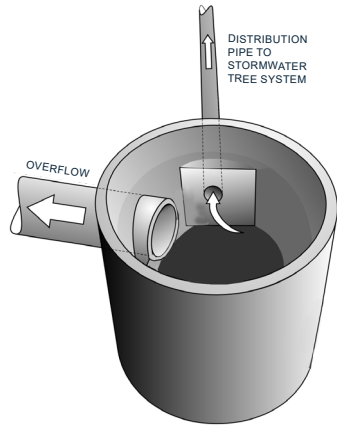
Maintenance Notes

- Maintain aeration / water distribution system components
- Requires record-keeping for maintenance

6 OVERFLOW | OUTLETS

TYPE	RANK	APPLICATION		CONSTRUCTION COST	MAINTENANCE COST	CLOGGING TENDENCY	MAINTENANCE EFFORT	DURABILITY
		ROW	OPEN SPACE					
CATCH BASIN WITH OVERFLOW TO DRAINAGE SYSTEM <i>(p.43)</i>	N/A	●	●	\$\$	\$	● ● ○	● ● ○	● ● ●
CURB INLET WITH STRUCTURE AND UNDERDRAIN <i>(p.43)</i>	N/A	●	●	\$\$	\$	● ● ○	● ● ○	● ● ○

6 OVERFLOW | OUTLETS



CATCH BASIN WITH PIPE OVERFLOW TO DRAINAGE SYSTEM

Design Notes

- Additional stormwater storage (overflow to subsurface gravel storage bed)
- Allows direct discharge to storm drain system
- Provides outlet for underdrains
- Requires additional work within the Right-of-Way
- Use where greater recharge required
- Install larger risers for ease of maintenance

Maintenance Notes

- Monitor to ensure no clogging from debris
- Structure and pipes must be maintained, can be difficult to clean



CURB INLET WITH STRUCTURE AND UNDERDRAIN

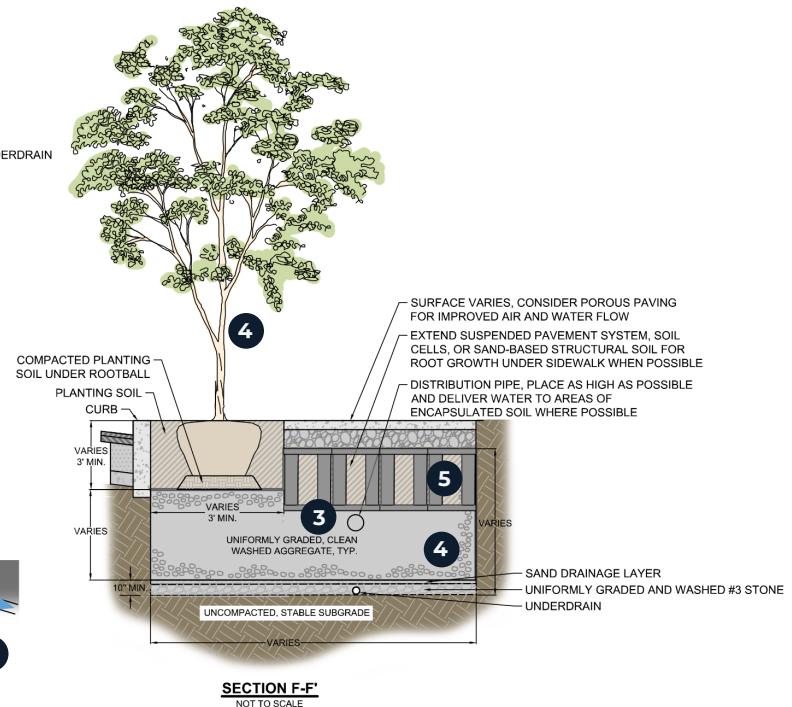
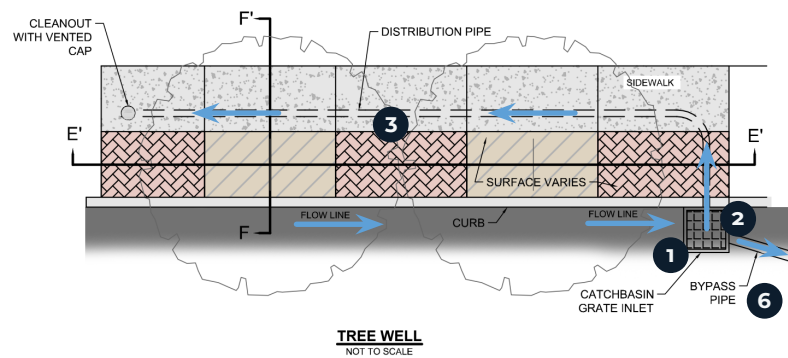
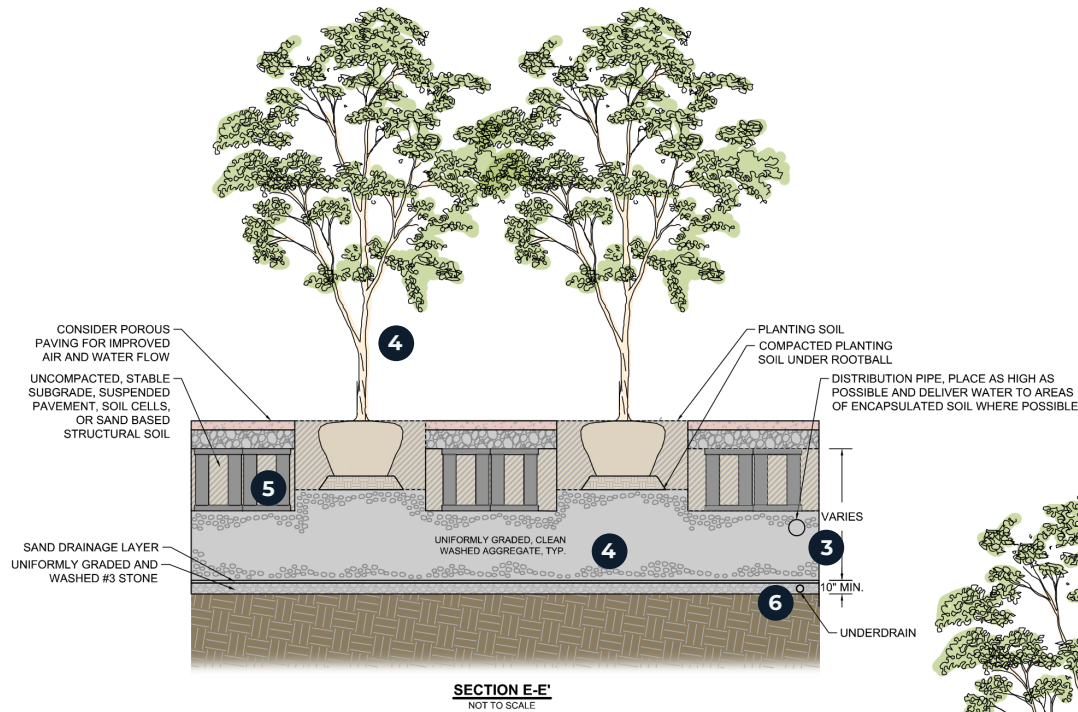
Design Notes

- Distributes stormwater within subsurface gravel storage bed
- Ensures proper drainage for features with poor soils or liners
- Reduces standing water
- Requires an overflow structure and connection to storm drain system
- Use for lined trenches, where soils are poor, or where standing water is a concern

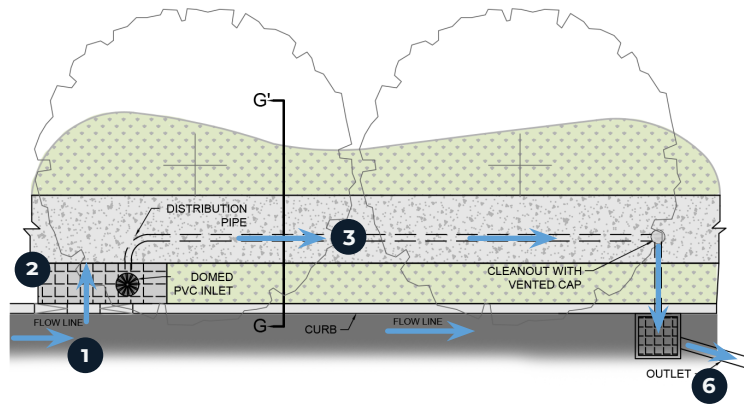
Maintenance Notes

- Check annually through cleanout to ensure no clogging
- Clean as needed

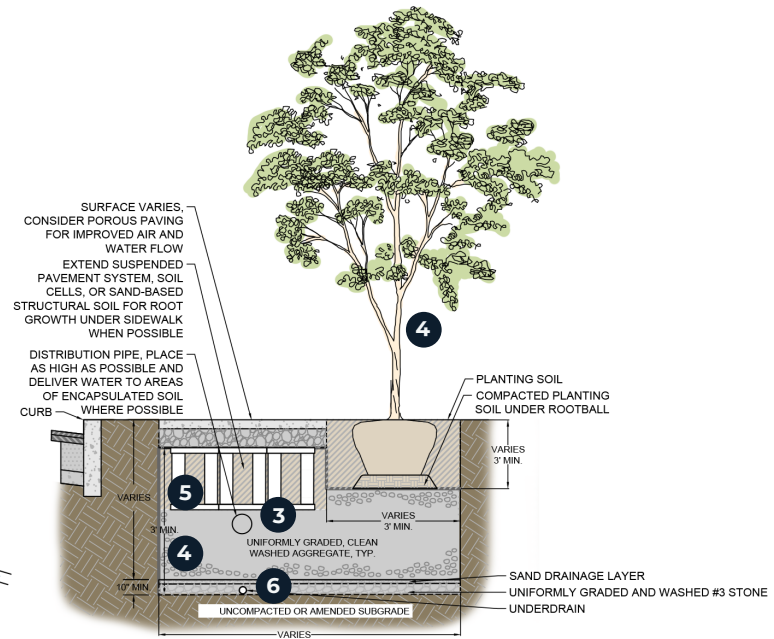
4.3 TYPICAL LAYOUTS



4.3 TYPICAL LAYOUTS CONTINUED



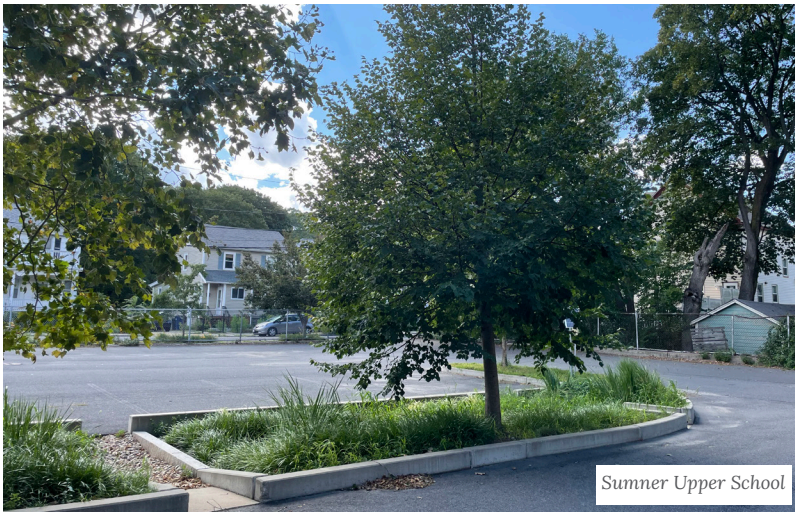
BEHIND SIDEWALK
NOT TO SCALE



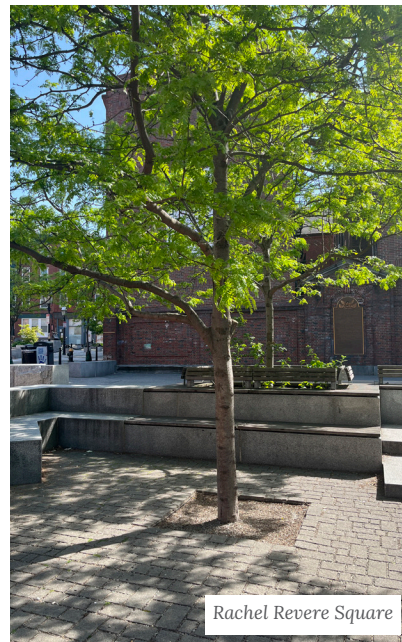
SECTION G-G
NOT TO SCALE



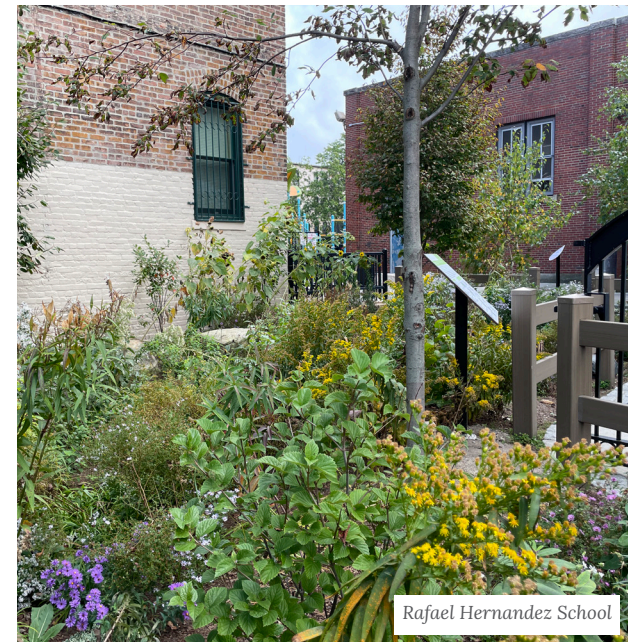
Jackson Mann Community Center



Summer Upper School



Rachel Revere Square



Rafael Hernandez School