A Design Guide for Green Stormwater Infrastructure Best Management Practices

Scalable Solutions to Local Challenges

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CONTENTS

1 | INTRODUCTION

Many municipalities struggle to effectively address stormwater and flooding issues that impact their communities, and they are increasingly interested in green infrastructure as a tool for stormwater management and for meeting regulatory requirements around water quality. However, there are often barriers to green infrastructure installation, such as the lack of capacity and technical expertise for implementation. These barriers can be particularly significant for municipalities with constrained human and financial resources. To help municipal managers and decision-makers begin the process of exploring and implementing green infrastructure, RISC has updated Delta Institute's original toolkit to feature scalable tools and design templates for green infrastructure on different landscapes. The target audience for this toolkit includes public sector managers, planners, and decision makers, particularly those at the municipal level. This toolkit aims to:

- Provide users with a clearer understanding of how to identify opportunities for green infrastructure implementation.
- Illustrate which practices are most suitable for a specific site or purpose, and;
- How to make informed decisions based on reasonable cost estimates.

These tools are designed to be applicable to a variety of sites and decision-makers, but focus on addressing issues and constraints that are specific to resource constrained municipal managers and decision-makers. All of the green infrastructure treatments in this guide are particularly well-suited to the Midwestern climate but can be scaled to sites across a wide geography. Importantly, the practices identified in this guide are best suited for stormwater management issues in urban and suburban locations on properties, parks, and rights of way, etc. While these techniques share similar goals, they differ from the practices suitable for agricultural locations. More information on those practices can be found at the following site https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/.

Why Green Infrastructure?

To avoid both riverine and surface flooding, water must be drained from impermeable surfaces, often using "gray infrastructure" like gutters and underground pipe networks that discharge to local sewers or water bodies. Green infrastructure is a valuable supplemental tool to manage stormwater using natural processes to slow the movement of water, treat runoff, manage the flow, and mitigate flooding issues. In many instances, green infrastructure is also necessary to help municipalities and sewer districts comply with state and federal requirements, regulations, and consent decrees, that are centered around issues like pollutant loading and sewer discharges. Due to the spatial and financial constraints around expanding and enlarging gray infrastructure like sewer lines, green infrastructure can often serve as a compact, distributed, and economical solution for meeting water quality improvement requirements.

Green infrastructure can also deliver a variety of co-benefits to the surrounding community. For example, rocks and soil can assist with stormwater infiltration and groundwater recharge. Simultaneously, the plant life and microorganisms that exist in green infrastructure sites can purify the water by consuming contaminants, and assisting with decomposition. Additionally, green infrastructure can mitigate flooding, and help to alleviate stress on aging gray infrastructure systems. See Table 1 on the following page for more co-benefits of the included designs. Green infrastructure supports community planning objectives and provides additional benefits. These benefits include more aesthetically pleasing uses of blighted parcels or brownfields, which can create economic development opportunities while providing habitat or recreational improvements. Overall green infrastructure installations can enhance neighborhood vitality and increase property values.

Co-Benefits of Green Infrastructure Practices

	Rain Garden	Stormwater Planter	Bioswale/ Hybrid Ditch	Box Tree Filter	Green Roof	Permeable Pavement	Underground Storage	Naturalized Detention	Filter Strip/ Level Spreader	Vegetated Swale	Urban Tree Planting
Reduce Pests	■	■	■	■	■	■	■	■			
Reduce Urban Heat Island Effect	■	■	■	■	■	■	■				■
Improve Water Quality	■	■	■	■	■	■		■	■	■	■
Improve Air Quality	■	■	■	■	■			■	■	■	■
Increase and Improve Green Spaces	■	■	■	■	■			■			■
Reduce Energy Costs					■						■

■ Benefit Applies to GI Practice

□ Benefit Does Not Apply to GI Practice

2 | STORMWATER MANAGEMENT

Overview

Stormwater management is paramount to the design and function of any human development. The natural water cycle includes infiltration of stormwater into the ground and absorption and evapotranspiration of water by vegetation. Impervious surfaces from pavement and buildings fulfill our need for shelter and commerce, but they also impede opportunities for infiltration and natural plant processes. This causes more rainfall to flow from impervious surfaces, and the increased rainfall runoff causes flooding and accelerates erosion. Rainfall runoff also collects pollutants and sediment as it flows over impervious surfaces, causing increased water quality issues. To limit the impacts that pollutant runoff has on watersheds, state and federal agencies maintain requirements on many communities around phenomena like Total Maximum Daily Loads (TMDLs) and combined sewer discharges. To ensure that these state and federal standards are met, and that runoff volume and pollution is reduced, municipalities oftentimes require land development projects to include stormwater management best practices (BMPs) in their designs, as a part of the permitting process. Importantly, and increasingly, green infrastructure serves as an example of an effective stormwater BMP that can be integrated with gray infrastructure on site.

Integrating Green and Gray Infrastructure

When rain falls on an impervious surface, it must be drained to avoid flooding of streets and buildings. The traditional approach to draining runoff has been to remove it from the area as quickly as possible. This is known as conveyance. Embedded below the street system is an underground network of pipes and structures that are designed to move stormwater quickly from the streets, parking lots, and buildings. This method conveys runoff and discharges it into nearby water bodies, and is referred to as "gray" infrastructure because the curb, gutter and concrete pipe are often gray. Green infrastructure aims to mimic natural, pre-development conditions by slowing runoff from precipitation down, collecting and treating it as close as possible to the point where it falls. This allows for the natural processes of infiltration and evapotranspiration to occur and minimizes stormwater runoff. There are multiple ways that this can be integrated into the design of the urban fabric. For example, a strategically-placed planting bed can function as a pocket storage area for rainwater. This allows rainwater to infiltrate directly into the ground water table and allows for uptake into plants.

The green infrastructure approach mitigates flooding of receiving waters and aging infrastructure, which can get overwhelmed with urban runoff during even moderate storms. Municipalities face a growing need for effective stormwater management because of localized flooding, due to inadequate gray infrastructure and more extreme weather events caused by climate change. Specifically, the National Climate Assessment projects that within the Midwest, climate change will produce “increased flooding and extreme rainfall, causing erosion, a decline in water quality, and producing negative impacts on transportation, agriculture, human health, and infrastructure.” As the acreage of impervious surfaces grows with the population within the Midwest, the simultaneous pattern of wetter and more extreme climate in the region creates a pressing need to improve its stormwater management capacity. In response to this problem, local and regional stormwater quality regulations are becoming increasingly more stringent. As previously mentioned however, expanding and enhancing gray infrastructure as the sole solution to address this problem is cost-prohibitive. In turn, green infrastructure is a method of handling stormwater that can be cost-effective and aesthetically-pleasing and can improve the capacity of the existing gray infrastructure by adding storage volume, both above and below ground. Green infrastructure also improves water quality by creating opportunities to filter and settle sediment out of the stormwater. It has the additional benefit of reducing the temperature of surface runoff, which is increased due to the warming of dark, impervious surfaces.

While green infrastructure can serve in a standalone manner, it is most effective and impactful when it is integrated with gray infrastructure improvements. Integrating green and gray infrastructure achieves efficiencies in design, project cost, and even assists with satisfying regulatory requirements around upgrading infrastructure. Examples of how green infrastructure techniques can be integrated into conventional gray infrastructure are provided in Figure 1.

Figure 1: Methods for retrofitting gray infrastructure with green infrastructure

GREEN UPDATES TO GRAY INFRASTRUCTURE

When incorporated into existing gray stormwater systems, green infrastructure can help manage water volume and velocity entering into the sewer; improve water quality in runoff, pre and post sewer conveyance; and reduce the impact on existing infrastructure, communities, and ecosystems.

Where

Sewer and drainage areas located on roads, parking lots, office buildings, and lawns.

When

For new construction or retrofitting existing systems.

or

How: Green Infrastructure Techniques

Infiltration

Improve infiltration by using bioretention to reduce runoff velocity and volume, and recharge groundwater.

Benefits: Reduce CSO events, flooding, and coastal erosion.

Upstream BMPs: Bioswale, Rain Garden, Stormwater Planter, Permeable Pavement Box, Tree Filter, Filter Strip/Level Spreader, Stormwater Trees

Downstream BMPs: Semi-wet Pond

Water Treatment

Reduce non-point source pollution in runoff before it enters sewers and other water bodies.

Benefits: Remove pollutants, contaminants and nutrients in runoff.

Upstream BMPs: Bioswale, Rain Garden, Stormwater Planter, Box Tree Filter, Filter Strip/Level Spreader, Stormwater Trees, Green Roof

Downstream BMPs: Wet Pond, Semi-wet Pond

Detention

Store excess stormwater to control runoff volume and velocity before it moves downstream.

Benefits: Reduce erosion, water levels, wear on infrastructure and pollution in runoff.

Upstream BMPs: Underground Storage, Green Roof

Downstream BMPs: Wet Pond, Semi-wet Pond

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3 | GREEN INFRASTRUCTURE

Green Infrastructure Practices

There are numerous green infrastructure techniques that can be incorporated into a site and many resources available on the design criteria of those techniques. See Appendix D (Resources) for a full list of resources. In 2015, Guidon Design conducted a charrette to holistically evaluate green infrastructure techniques that are available on the market. This evaluation process led to the identification of three purposes that green infrastructure addresses: conveyance, detention, and infiltration. From this charrette, Guidon selected the most appropriate techniques that could be chosen for use on a parcel-by-parcel basis. In this initial phase, very urban practices (like stormwater planters and permeable pavement) were the primary techniques that were explored and illustrated. As part of the 2021 update, ECT added additional practices, such as naturalized detention, that are applicable to more suburban and rural areas. This section of the Guide will serve to introduce the specific practices, components, and design considerations for green infrastructure, as well as summarize the resources for green infrastructure that are provided in the Guide.

Green infrastructure practices are readily adaptable to a range of conditions, including contaminated sites, and the clean-up requirements for contaminated sites often present green infrastructure opportunities. As the practices rely heavily on the capture and infiltration of rainwater where it lands, which could be on the ground, within a planter or on a roof. Potentially contaminated parcels or brownfields need to be evaluated on a case-by-case basis to determine the appropriate use of these techniques.

- Bioswale/Hybrid Ditch
- Rain Garden
- Stormwater Planters
- Naturalized Detention Basin
- Vegetated Filter Strip/Level Spreaders
- Vegetated Swales
- Urban Tree Planting
- Box Tree Filter
- Stormwater Trees
- Green Roof
- Permeable Pavement
- Underground Storage

Table 1: Green infrastructure practices featured in this guide

Practice	Location	Primary Stormwater Purpose	Primary Challenges	Relative Cost
Bioswale/Hybrid Ditch	Upstream Building Parking Lots, Setbacks, Backyards	Bio-retention Infiltration Water treatment	Appropriate growing area, Intensive maintenance	$
Rain Garden	Campuses and Parks			
Stormwater Planters	Upstream Streets, Sidewalks		Right of way space Salt-tolerant plant selection	$$

Practice	Location	Primary Stormwater Purpose	Primary Challenges	Relative Cost
Naturalized Detention Basin[A]	Downstream Subdivisions Campuses and Parks	Water treatment Detention	Expensive, Large	$$$
Vegetated Filter Strip/Level Spreaders[B]	Upstream/ Downstream Roadway corridors Campuses and Parks	Water treatment Velocity control	Appropriate growing area, Intensive maintenance	$
Vegetated Swales[C]			Expensive Large	$$
Urban Tree Planting	Upstream/ Downstream All locations	Infiltration Water treatment Velocity control	Available space, Time to maturity	$
Box Tree Filter[D]	Streets, Sidewalks	Infiltration Water treatment	Available space, Uncommon technique	$$
Green Roof[E]	Large building roofs	Infiltration	Heavy, Expensive	$$$
Permeable Pavement	Parking lots, driveways, alleys	Infiltration	Expensive, Maintenance intensive	$$
Underground Storage	Parking lots, driveways, alleys	Infiltration Detention	Expensive	$$$

[A,B,C] These techniques were added as part of ECT's work in the 2021 update, to reflect commonly used practices in rural and suburban locations.

[D,E] These techniques were added after Guidon's process and were selected by Northwestern for inclusion because of their relevance to the Chicago metropolitan region's built environment.

Standard Green Infrastructure Components

Particularly below the surface, there are numerous components to a green infrastructure installation, that dictate its performance. Major components include engineered soil and geotextile fabric.

Engineered Soil

Several of the green infrastructure practices include the use of engineered soil, also known as amended soil for bioretention soil. Engineered soil creates a layer that filters stormwater runoff at a consistent rate to a subgrade or a layer of aggregate beneath. Where used, the aggregate layer provides stormwater volume storage that holds runoff until it infiltrates into the native soil beneath and (or) slowly drains to downstream stormwater systems. Engineered soil is critical to the functionality of the green infrastructure practices, because it provides a growing medium for plant material and filters out pollutants as the runoff flows through the layer. There are a range of mixes specified in various stormwater manuals and ordinances around the region and country, but most specify varying amounts of coarse sand, topsoil, and compost. Due to the highly variable nature of topsoil (particularly in regards to clay content), this guide recommends limiting the engineered soil mix to coarse sand and well-aged compost. Although compost can also be variable, a mix of sand and compost has reliably low clay content and high organic matter content, providing a good growing medium with relatively high permeability. Example specifications for engineered soil are included in Appendix C (Engineered Soil Specification).

Geotextile Fabric

Most of the techniques include the use of geotextile fabric to be wrapped around the drainage aggregate. The fabric acts as a barrier between layers of soil and aggregate while allowing runoff to filter through. It is important, because it prevents the migration of particulates from one layer to the next which prevents the loss of runoff storage volume. The mixing of fine and coarse grained soils can also lead to the subsidence (or the caving in) of the system, as the mixed material begins to be displaced by the separated materials. The selection of the particular geotextile by the design engineer is a critical factor for the success of the installation. Woven monofilament fabrics provide good soil separation, and are less subject to blinding and clogging than non-woven, needle punch fabrics. For this reason, woven monofilament fabrics should be used in most cases. However, non-woven needle punch fabrics provide superior filtration, and a four foot wide strip is recommended between the engineered soil and gravel layers that can be installed specifically over the length of perforated pipes, where present (a requirement in Wisconsin). Due to their high potential for clogging, filter socks should never be placed on perforated pipes and instead the fabric should wrap around the entire gravel layer that the perforated pipe is contained within. For bioretention systems (like bioswales and rain gardens), some jurisdictions (notably Iowa and Wisconsin) require a choker layer of ASTM #8 stone between the bioretention soil and gravel storage layers, instead of fabric.

Green Infrastructure Design Considerations

Beyond these standard subsurface design elements however, there numerous design considerations in a green infrastructure installation, namely **planting approach and plant selection, depth to the groundwater table, and the soil infiltration rate.**

Planting Approach and Plant Selection

Several green infrastructure practices rely on plants as a critical component to their design. Regardless of the planting approach, designers should rely primarily on perennial herbaceous plants for their green infrastructure practices. Perennial means that the plant lives for multiple years, and herbaceous means that the plants have soft above-ground tissues that die-back each winter. A preference should also be given to the use of grasses and grass-like plants in the design. Herbaceous perennials, especially grasses, are more effective at stabilizing the soil from erosion, and maintaining soil organic carbon and soil permeability than woody plants like trees and shrubs.

The type of plants used and the arrangement in which they are planted is an important design decision as it affects the type of maintenance that the facility will require. An ornamental planting approach may be more appropriate for small spaces within the urban environment, whereas a naturalized approach may be best for larger and more rural spaces.

An ornamental landscape is one that most people are familiar with. It is what most people use for their home landscapes. Ornamental landscapes rely on the use of plants whose traits are carefully selected by growers to be durable, long-lived, and produce bold leaves or flower displays. These plants are typically not native to one specific region, having been originally imported from all over the world. Since each selection of plant tends to possess identical genes, these landscapes can be relatively sterile, and produce few, if any, viable offspring. The arrangement of ornamental plantings usually displays plants in blocks or groupings. The simple collection of these large masses of individual plants is what many people think of when they imagine a garden.

The naturalized landscape approach utilizes locally-native plants in arrangements that attempt to mimic a common regional plant communities, like a prairie. The placement of these plants is more dense and diverse than in an ornamental landscape. Unlike its ornamental cousin, the naturalized landscape is designed to self-replicate through natural reproduction. Native plants are also adapted to be drought tolerant for their region, and have root systems that are deeper and more extensive than most non-native plants.

One of the greatest benefit of a naturalized landscape is the habitat it provides for native plants and animals. This can be especially important in urban areas, where the remaining natural areas are few and far between. For these reasons, a naturalized planting is the approach represented throughout this document and the one included in the templates.

Native plants can be installed using various sizes, most commonly seen as "plugs" and "gallons." A plug is a small plant that has grown in an approximately 2-inch wide by 5-inch deep container. A gallon is a more mature plant that is larger and fits into a gallon-sized container. Gallons are more expensive than plugs, because they take more time and effort for the nursery to grow prior to installation. They should be selected in instances where it is important for the installation to look fully grown from the beginning. Otherwise, plugs are recommended because they are more cost-effective and end up producing the same size plant at maturity. Both sizes of native plants require consistent watering during an establishment period to improve survivability.

Long-term maintenance for the plantings is something that should be considered when selecting the right planting approach. Naturalized plantings have unique maintenance needs that require specialized services, such as plant identification and prescribed burning. The ornamental approach can be maintained with conventional landscape management.

Plants should be selected to match the conditions they will experience at the site. Some of this will be determined by the green infrastructure practice, but the surrounding environment will also play a role. Information to consider when selecting plants includes:

- **Sun Exposure:** Most nurseries will provide information on how much direct exposure to sunlight each plant prefers each day. This is usually described as full sun (more than 6 hours), part sun (4 to 6 hours), and full shade (less than 4 hours).
- **Soil Moisture:** Moisture levels in the soil will be the result of soil makeup and local drainage patterns. As a general rule, clay-based soils will hold a lot more water

than sandy soils, while loamy soils will be somewhere in between the two.

- **Salt Exposure:** Salt is very damaging to the health of plants. Choose salt-tolerant plants if green infrastructure measures will receive runoff from roadways and parking lots that are subject to winter de-icing.
- **Flood Duration:** This is the length of time that the site will be flooded after a major rain event. Most engineered bio-retention facilities will be designed to fully drain within 48 hours. If a basin is not outfitted with an underdrain, then it may depend solely on infiltration to evacuate water, so flood duration can be more variable.
- **Soil pH:** Plant health is dependent on soil pH which is a measurement of how acidic or alkaline the soil is. Soil pH is measured on a scale of 1 to 14 with a measurement of 7.0 considered absolute neutral. Measurements below 7 are increasingly acidic; measurements above 7 are increasingly alkaline. Most plants prefer neutral to mildly acidic soil, with a pH between 6.1 and 7.5. Soil test kits and pH meters are available at most home improvement stores.
- **Planting Soil Depth:** The root structures of larger woody plants like trees require deeper soils than many herbaceous plants. A typical bio-retention facility will be constructed of 18 inches of planting soil over a gravel drainage layer, which will limit the plantings to small shrubs and perennial materials. The soil depth of a semi-intensive green roof can be 6 to 17 inches which will limit the plantings to perennial grasses and forbs. An extensive green roof has the shallowest soil depth of all at 3 to 5 inches which will limit the plantings to hardy succulents like sedums.

In addition to the parameters described above, plants should meet the following requirements:

- Non-invasive, or overly aggressive species
- Locally available
- Relatively long-lived
- Not be locally endangered or threatened
- Not suitable for large landscape applications

With all of the variables, it can be challenging to identify a group of plants suited to a specific site. If these factors are identified, however, local nurseries should be able to provide guidance. Tools that can aid the user with plant selection are available online, such as the Milwaukee Metropolitan Sewerage District's plant selection tool for green infrastructure available here: https://www.freshcoastguardians.com/resources/services/plant-selection

Depth to Groundwater Table

An important consideration for any green infrastructure practices is the depth to the groundwater table. In no case should green infrastructure be located less than 2 feet above the groundwater table. This is a safety precaution, as it ensures proper drainage and prevents the groundwater table from interfacing with the bottom of the practice, which would inhibit infiltration. In areas served by combined sewer systems, maintaining this separated distance also prevents the green infrastructure practice from becoming a source of clear water discharge to the sewer system and wastewater treatment facility. Many jurisdictions possess existing ordinances that specify the required distance between the bottom of a green infrastructure site and the groundwater table (or seasonal high groundwater elevation), and these local ordinances should be consulted during a project's planning stage. The depth to groundwater (and seasonal high groundwater elevation) should be determined by a geotechnical engineer, early in the design process.

Infiltration Rate

The infiltration rate of native soil beneath all of the green infrastructure practices is an important parameter that affects the performance and design of the feature. Soils have different infiltration rates based on their composition. Sandy and rocky soils have higher infiltration rates, and silty soils have lower infiltration rates. Clay soils have the lowest rates of all the soil types. Where feasible, green infrastructure practices should be installed in areas where the soil composition allows for significant infiltration into the groundwater, defined as greater than 0.5 inches per hour (in/hr). Below this rate, infiltration will still occur, but the volume of infiltration during an event will be so small that the infiltration outflow should not be considered as a determining factor, when sizing a green infrastructure practice.

The design engineer should work with a geotechnical engineer to determine the actual infiltration rates for the soil at the particular location where the infiltration will occur. An in-place test should be conducted at the proposed installation at the lowest elevation of the green infrastructure. If there are a series of techniques being installed in an area, then multiple tests throughout the site should be done to create a profile of infiltration rates throughout the project site.

There are several tests available to help determine in-place infiltration rates, but most were designed for other applications and are not appropriate for use with green infrastructure. The type of test is an important discussion point between the design engineer and the geotechnical engineer so that the best data is available for the design of green infrastructure. There are several methods for testing infiltration rates. For large undeveloped sites, the best testing method is the Pilot Infiltration Test (PIT) developed by the State of Washington Department of Ecology. This test involves flooding a 100 square foot test pit, and measuring the rate at which the water falls. For smaller sites, in areas experiencing redevelopment or infill development, the single ring infiltrometer test specified within the City of Chicago stormwater ordinance provides usable results with the indicated adjustments and limitations.

If the in-place test determines that the infiltration rate of the native soil is greater than 0.5 in/hr, then the soil is able to adequately drain runoff through the system and into the groundwater. If the tested infiltration rate is less than 0.5 in/hr, then an underdrain should be used to drain the system between storm events. Even with higher infiltration rates, an underdrain may be warranted, particularly if there is an intention to use the practice to meet both stormwater rate control and runoff volume reduction goals. For practices intended to be drained only by infiltration, a capped underdrain can provide resiliency and adaptability for green infrastructure in the event that stormwater infiltration at the site does occur as forecasted. Holes can be drilled in the cap to control the runoff out of the system.

Resources for Green Infrastructure Design

To assist municipalities and landowners in implementing green infrastructure projects, that effectively key components and considerations, this guide has included design templates, specifications, and cost information for each green infrastructure practice. Descriptions of the information provided are as follows:

Design Templates

The design templates that are included in Section 5 are intended to bridge the gap between the technical and non-technical user, to promote green infrastructure design and implementation. A design template has been developed for each green infrastructure practice, which includes technical drawings (details and cross-sections), construction notes, and cost and maintenance information. The templates also include photos of the green infrastructure technique to help all users better understand how they fit into the urban environment.

Specifications

During the design process for a project, the design engineer will create construction plans that show what will be constructed and where it will be located on the site, along with construction details for various elements. The design engineer will also prepare specifications for the project, a set of sections covering the entire scope of construction. Together, the plans and specifications create a visual and written representation of the designer's instructions and expectations for the finished product. When a contractor wins a project, the plans and specifications become a contract that guides the construction process. To a degree, the language included in specifications reads like a legal contract and can sometimes be difficult to understand by the non-technical person. In general, each specification section has a title describing the contents of the section, and will typically include the scope, materials, required submittals and shop drawings, execution, warranty, and basis of payment. Each part is very specific in order to give clear instructions to the contractor.

The Illinois Urban Manual contains a set of standard specifications covering a wide range of typical construction activities. Many components of green infrastructure construction are identical to conventional construction, which makes the standard specifications very useful. For example, the excavation of a stormwater planter and the forming and pouring a concrete containment curb for a permeable pavement would have the same specifications as common excavation and concrete work. The specification sections from the Illinois Urban Manual that are relevant to each of the surface-based techniques have been listed by specification number and title in Section 5 of the report and excerpts. The design engineer can use the Illinois Urban Manual standard specifications as a starting point for any of the green infrastructure techniques in this toolkit. However, the sections should be tailored to be site specific according to the project requirements. Excerpts from the Manual are included in Appendix B (Illinois Urban Manual), and the latest revisions and publications are available online.[1]

In addition to the specifications presented in the Illinois Urban Manual, this toolkit provides a section for engineered soil, which is a critical component to several of the green infrastructure practices (Appendix C). Other items that are not covered by the Manual are manufacturer specific, including pervious pavers, underground storage, geotextiles, and overflow structures and castings. Specifications for these items need to be addressed on a case-by-case basis using the technical background of the design engineer and the guidance and requirements of the manufacturer.

1 http://www.aiswcd.org/illinois-urban-manual/

Cost Information

This section provides detailed information regarding the costs described for green infrastructure practices, as well as the inclusion of cost estimates for design engineering and project mobilization, two line items that are essential prerequisites for initiating construction work, and in turn, should be considered as part of the overall price for a project. Various line items in the Guide have also now been associated with the units of measurement through which they are commonly planned and purchased. The Guide's cost units are as follows:

Table 2: Common units of measurement

Unit (Abbreviation)	Unit (Abbreviation)	Unit (Abbreviation)
Lump Sum (LS)	Square Foot (SF)	Cubic Yards (CY)
Each (EA)	Linear Foot (LF)	Square Yards (SY)
Acre (ACRE)	Cubic Foot (CF)	Ton (TON)

Among the various materials that are used within a green infrastructure practice, some units of measurement for estimating quantities can be three-dimensional in nature (CY and CF), some are two dimensional(SF and SY), weight (tons, pounds), per piece (EA), or total (LS). Detailed in the table below are unit conversions for a 5-foot by 20- foot green infrastructure site (with a 6-inch depth), along with the typical applications for which these units of measurement are used, for planning and purchasing.

Table 3: Unit conversion tables and applications

**For a 5-foot by 20-foot site with a 6-inch depth*

Units	Total	Equation	Formula	Typical Applications
Square Feet	100.00	20 x 5	Length x Width	Overall site size, seeding, sod, liner, green roof units, porous unit pavers
Cubic Feet	600.00	20 x 5 x 6	Length x Width x Height	Underground stormwater chamber, concrete curb encasement
Square Yards	11.11	(20 x 5) ÷ 9	(Length x Width) ÷ 9	Geotextile Fabric, Erosion Blanket, Grading
Cubic Yards	22.22	(20 x 5 x 6) ÷ 27	(Length x Width x Height) ÷ 27	Excavation, Hauling, Mulch, Soil, Stone, Topsoil
Linear Feet	N/A	N/A	N/A	Storm sewer, perforated piping, backfill, curb, level spreader
Each	N/A	N/A	N/A	Plants (plugs, gallons), trees, shrubs, drainage basin, splash pad, rip rap, storm sewer connection, underdrain cleanout, outlet control structure, berm check dam, grate, encasement access, driveway culvert

Units	Total	Equation	Formula	Typical Applications
Lump Sum	N/A	N/A	N/A	Mobilization, Design engineering
Ton	N/A	N/A	N/A	Gravel
Acre	N/A	N/A	N/A	Invasive species removal

Cost Values Across Regions

There is no clear "discount" or "premium" for delivering green infrastructure projects across different states and regions. Factors like the month when bids are solicited, or a project's varying simplicity or complexity, tend to be the determinant in increasing or decreasing project cost. Projects that are bid during the height of construction season and entail complex efforts around permitting, site access, material storage, as well as extensive off-site hauling will prove to be comparatively expensive, versus projects that secure bids before construction season, are easy to permit, with simple site access and no issues around where material can be stored, and where offsite hauling is not extensive or necessary.

4 | DECISION SUPPORT TOOLS

When a municipal manager determines that green infrastructure is something they want to pursue, they can use the Decision Support Tools in this document to select the technique that will be most appropriate for their subject parcel. Choosing the most appropriate technique can be a challenging process, which will ultimately be dictated by a project's location, built environment, topography, soils, groundwater, budget, and overall feasibility. Figures 2 and 3 provide bird's eye view drawings that illustrate green infrastructure practices applied throughout urban and rural settings. The Green Infrastructure Flow Chart (Figure 4) will assist users in deciding which green infrastructure practice is the most appropriate.

Figure 2: Bird's eye view of generic urban area with green infrastructure

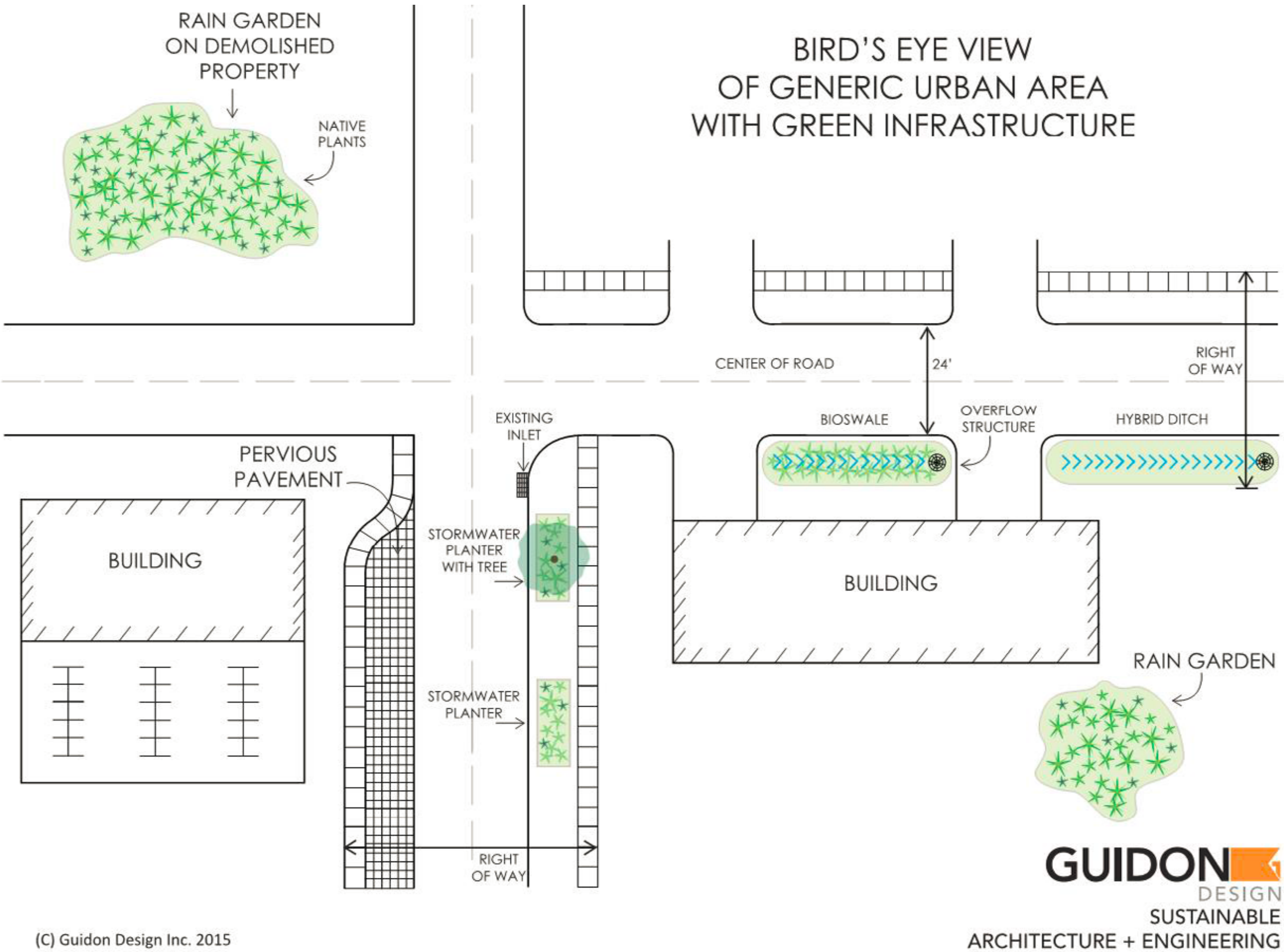


Figure 3: Bird's eye view of generic rural area with green infrastructure

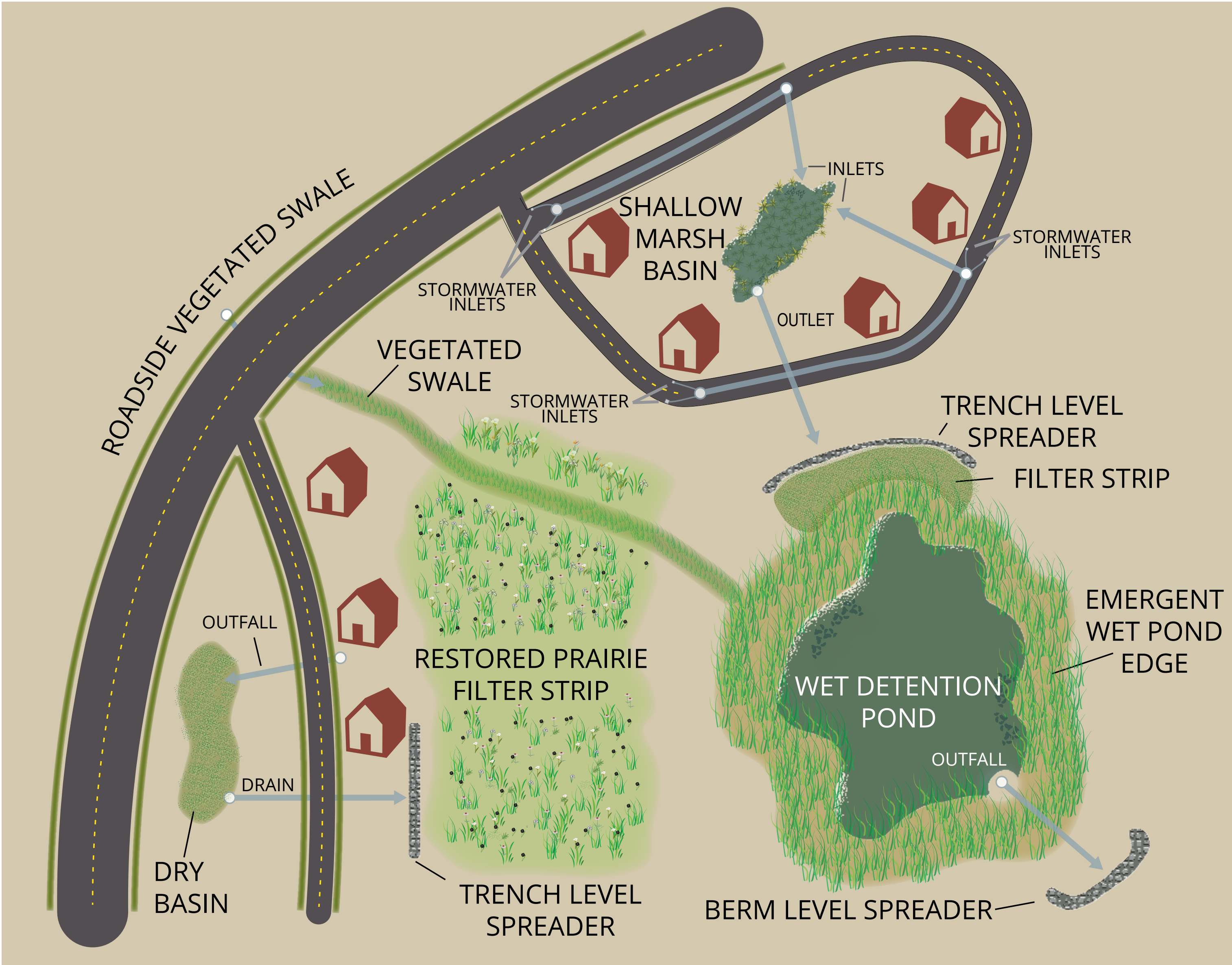
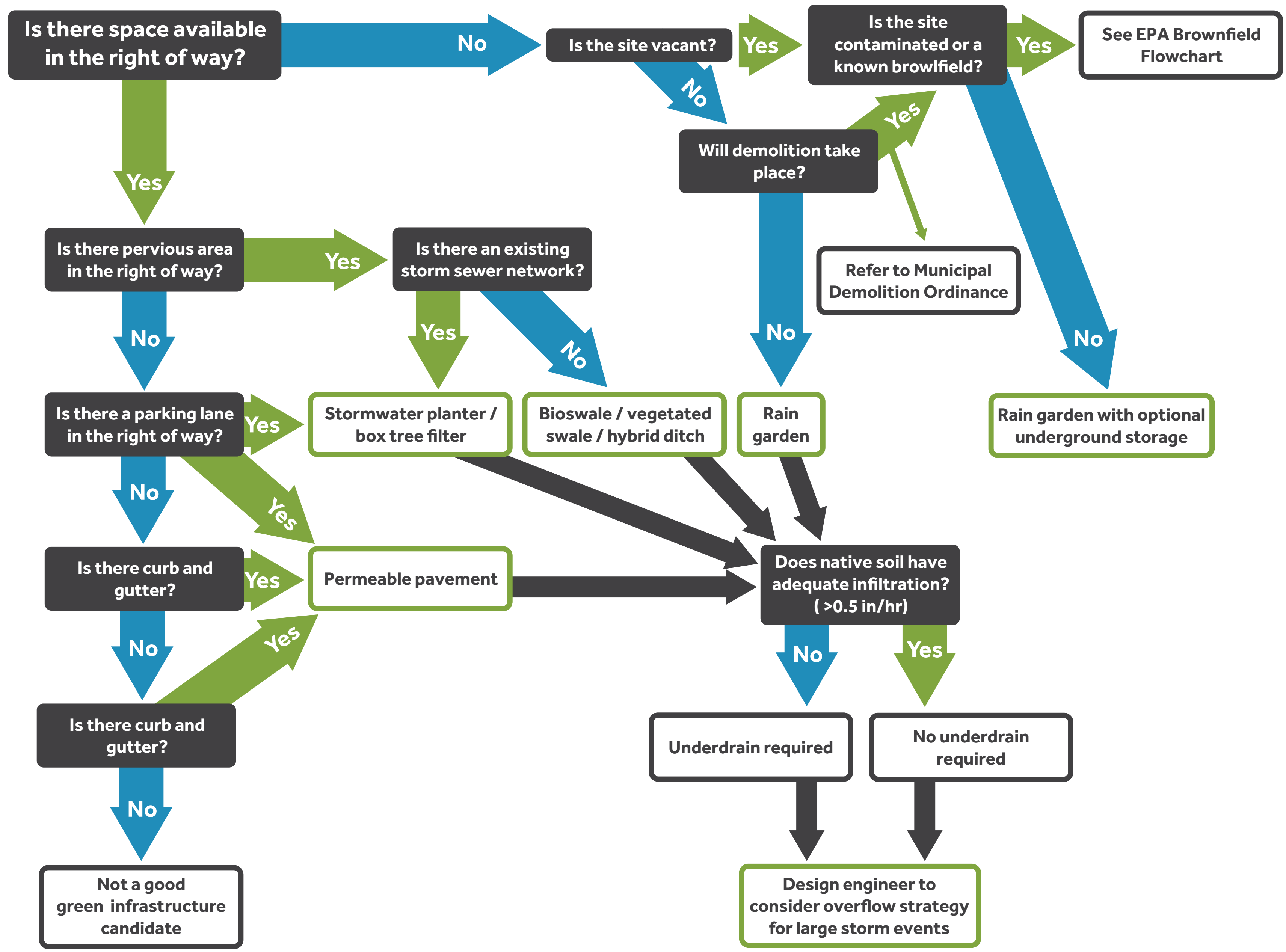


Figure 4: Green infrastructure practice selection decision tree



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5 | GREEN INFRASTRUCTURE BEST PRACTICES

Bio-Retention Practices

Many of the common green infrastructure techniques serve as examples of bioretention. Whether installed on rights-of-way or in a residential backyard, bioretention practices focus on capturing stormwater runoff, filtering pollutants, and promoting infiltration that recharges the groundwater on-site. All bio-retention practices consist of a basin-like shape that encourages the in-flow of runoff from an adjacent roadway, parking lot, or property. Once runoff has entered the basin, it is distributed evenly across a filtering medium of woody and herbaceous plants, mulch, and engineered soil. The intention of this design is to reduce the velocity of the runoff, and subsequently, to remove pollutants as the runoff slowly infiltrates the soil. As infiltration occurs, the removal of runoff pollutants will be conducted through the work of the site's plants and microorganisms through processes like adsorption, decomposition and the uptake of particulate pollutants by the plant's root structure.

A bio-retention site's ability to reduce or halt the velocity of runoff will greatly increase its capacity to filter pollutants, as all of the previous processes mentioned can only transpire effectively once this has occurred. As infiltration begins, the absorbed stormwater passes slowly through layers of engineered soil and stone aggregate, before it continues through to the subgrade that lies beneath the bioretention site, or alternatively, exiting through a perforated underdrain that has been included in the installation.

Bio-retention practices tend to be most effective when located upstream, and when they have been designed specifically to manage and filter runoff before it enters the sewer system. In turn, these practices should be applied in close proximity to sewer inlets, in places where runoff (and runoff pollution) from impervious surfaces typically collects, and where it can be managed and treated before it enters the sewer.

Bio-retention practices tend to be smaller in size than other forms of green stormwater infrastructure, which is largely a product of the urban, developed locations where they are most commonly found. In turn, while bio-retention practices often are not the only solution needed to address flooding in an area, they can assist with managing a portion of an area's stormwater volumes, as well as treating it before it enters the sewer, and they can reduce occurrences of combined sewer overflows (CSOs), a priority water pollution concern for municipalities with combined sewer systems (CSS).[1] Combined sewer overflows occur when the volume of stormwater or wastewater exceed the capacity of the CSS or treatment plant and results in untreated water discharging directly into nearby water bodies.[2]

Bio-Retention Practices

- Bioswale - Hybrid Ditch
- Rain Garden
- Stormwater Planter

Typical Locations

- Upstream
- Rights of Way (roads, sidewalks)
- Parking Lots
- Building Sets and Backyards

1, 2 https://www.epa.gov/npdes/combined-sewer-overflows-csos

Bioswale/Hybrid Ditch

A bioswale / hybrid ditch functions in some ways like a conventional grass ditch that sits within the right-of-way along the road edge. Rainwater runoff flows across the crown of a road and enters at any point along its length. The main difference between the two is that a bioswale will have herbaceous perennial plantings and a hybrid ditch will have turf grass. In addition to providing biofiltration as discussed in the introductory section, a bioswale / hybrid ditch slopes with the road to act as a conveyance channel which connects to an existing conventional ditch, surface water, or storm sewer.

The significant difference between a bioswale / hybrid ditch and a conventional vegetated swale (GI 6) is beneath the surface. A bioswale/hybrid ditch has an engineered soil sub-base, which is a mixture of sand, and compost (and sometimes topsoil). The importance of the engineered soil cannot be overstated. It provides a sponge to absorb and hold runoff for later use by plant material, a physical filter for removing pollutants and sediment from runoff, and an excellent growing media for herbaceous perennial plants. A specification section for engineered soil that can be incorporated into the construction documents is located in Appendix C.

In the case of the bioswale, a variety of large herbaceous plants in the engineered soil take some of the runoff up through their dense root system. Additionally, an optional perforated underdrain within the stone layer can convey filtered water that does not infiltrate into the subgrade soil.

Customization Options

This practice can be customized in a number of ways. The aesthetics can be tailored through plant selection. It is recommended that large herbaceous plugs be used to establish a bioswale. Gallon-sized plants may be used to more quickly establish plants. Hybrid ditches are typically planted with seed, but sod could be chosen for a more immediate finish.

Figure 5: Bioswale in a suburban setting

An erosion control blanket should be used over the surface of the bioswale, to prevent erosion during vegetation establishment. Seeding should be placed under the blanket. Live plant material will require cutting through the blanket, for each plant. When live planting, leaf mulch could be used as an alternative to erosion control blanket. When a hybrid ditch is vegetated using sod, no erosion blanket is needed.

Other customization options are a function of the site conditions. An overflow structure and perforated underdrain can connect the bioswale to the larger storm network, carrying excess runoff downstream. An overflow structure or culvert must be included at a site with driveway crossings.

There are several ways to manage driveway crossings. Overflow structures with rim elevations above the bottom, but below the street, can be provided at each crossing. Depending on the infiltration capacity of the ditch, rarer overflow events can conversely be allowed to overtop the edge of the ditch, and flow to the street's curb and gutter section to convey runoff past the driveway.

An underdrain will also be required if the site is flat or is found to have poor infiltration in its subgrade soils. Underdrains do not necessarily need to extend the full length of the bioswale and a stub at the downstream end of the bioswale may simply be used. With this design, the aggregate layer serves as the below grade conveyance, but at a lower rate than through an underdrain. This provides additional time for runoff infiltration and utilization by the plant material. Lastly, optional overflow pipes must be connected to the larger storm network, either by connecting to an existing structure, or by installing a new manhole atop an existing pipe.

Maintenance

The herbaceous plants in bioswales have an establishment period and need to be watered 3 times a week for the first 4 weeks after installation. The herbaceous plants also need to be watered twice a week through October of the first year. After that point, the drought tolerant plants should withstand normal weather cycles. Other maintenance includes monthly debris removal, weeding, and pruning. Bioswales would also require a spring clean-up to remove built up debris from the winter, provide pre-emergent plant care, and installation and replacement of mulch. The perennials also need to be cut back in mid-March or November.

A hybrid ditch is maintained like any other roadside ditch, requiring only regular mowing and debris removal. The maintenance costs for green infrastructure practices with large, herbaceous plants and engineered soil is significant. If the installation is not maintained properly and on a regular basis, then the functionality of the system will become compromised. The specific cost will depend on the scale and complexity of the installation and the bidding environment for the labor contract. It is possible to self-perform the maintenance work or to save money by working with a not-for-profit that provides volunteer labor. The design engineer should work to calculate a site-specific life cycle cost that accounts for maintenance when considering the feasibility of the project.

Cost Information

Cost information is provided for each green infrastructure practice. The installed costs are based on project experience, bid tabs, and information from the RS Means Building Construction Costs Data (2020 edition), which is an industry standard compilation of unit costs for various construction activities. The costs in the table below can be used to scope a project, but a project-specific cost estimate should be prepared by the design engineer that takes into account the project scale and complexity, material cost trends, and the labor and bidding environment.

Table 4: Bioswale/hybrid ditch unit costs[1], [2]

	Item	Description	Unit Price	Unit
GI Technique	Bioswale/Hybrid Ditch	Design/Engineering	15% of Construction Cost	LS
		Mobilization	$10,000.00	LS
		Excavation & Haul	$45.00	CY
		Leaf Mulch	$70.00	CY
		Engineered Soil	$80.00	CY
		Open-Grade Crushed Stone	$65.00	CY
		Geotextile Fabric	$5.00	SY
		Erosion Blanket	$3.00	SY
Required Component	Native Plantings	Plugs (12" on center)	$5.00	EA
		Gallons (36" on center)	$15.00	EA
Custom options	Outlet Control/ Overflow structure	Outlet Control Drainage Basin (varies by size)	$2,800.00	EA
	Underdrain	4" HDPE Perforated Pipe	$20.00	LF
	Storm Sewer	12" HDPE storm sewer	$65.00	LF
	Underdrain Cleanout		$600.00	EA
	Connection to existing storm structure		$600.00	EA

1 Installed cost include material and labor based on bid tabs from related projects and RS Means.

2 Unit price based on a 1,000 linear foot installation within the right of way in a residential area with 1/8 acre lots. Unit prices for specific projects will vary based on scale, complexity, labor environment, and material cost trends. A detailed cost estimate should be prepared by the design engineer.

Specifications

Specifications are an important component in the design of green infrastructure. Along with the construction documents, the design engineer should make site-specific customizations to the following sections of the standard specifications from the Illinois Urban Manual in order to have a full set of specifications for a bioswale or hybrid ditch. Other sections can be included on an as-needed basis. Further instructions on the use of specifications are included in Appendix B, and an engineered soil specification is included in Appendix C.

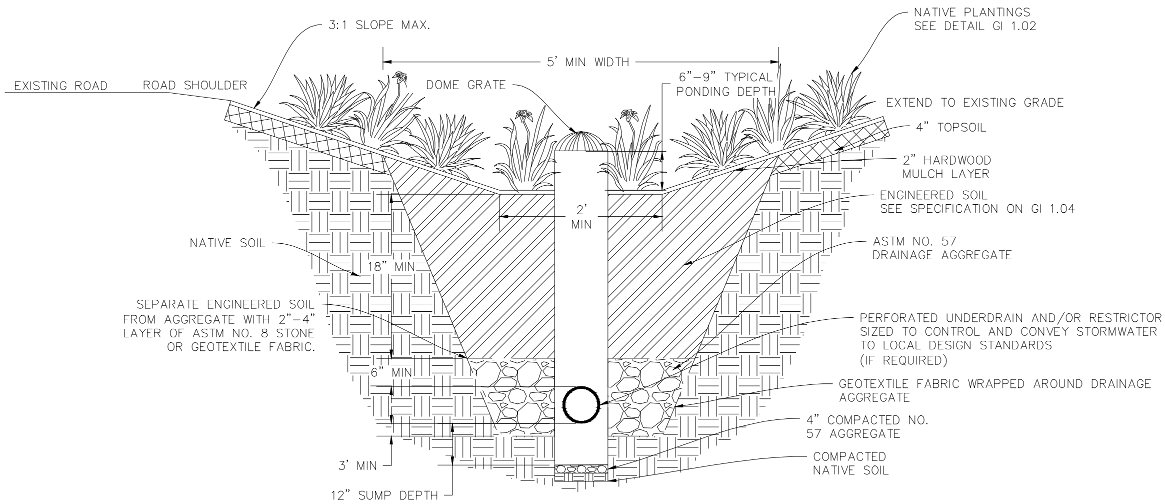
Construction Specifications

2 - Clearing and Grubbing
5 - Pollution Control
6 - Seeding, Sprigging and Mulching
7 - Construction Surveys
8 - Mobilization and Demobilization
21 - Excavation
23 - Earthfill
24 - Drainfill
25 - Rockfill
26 - Topsoiling
44 - Corrugated Polyethylene Tubing
46 - Tile Drains
94 - Contractor Quality Control
95 - Geotextile
707 - Digging, Transporting, Planting, and Establishment of Trees, Shrubs and Vines
752 - Stripping, Stockpiling, Site Preparation and Spreading Topsoil

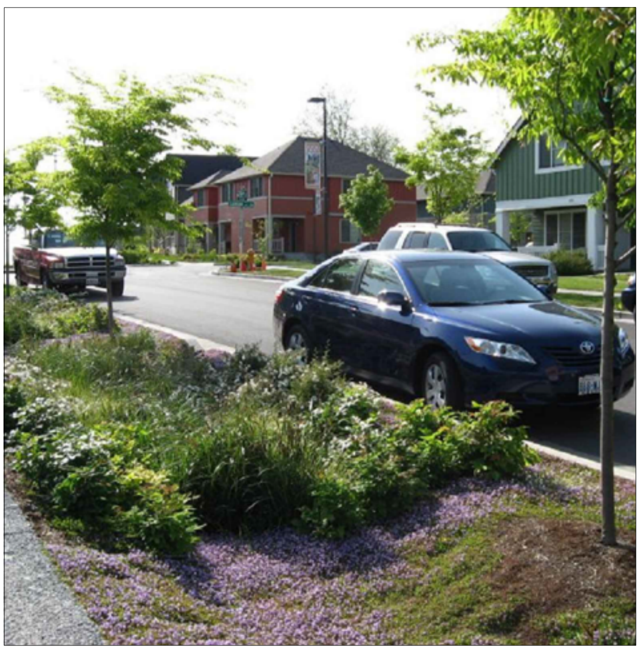
Material Specifications

521 - Aggregates for Drainfill and Filters
548 - Corrugated Polyethylene Tubing
592 - Geotextile
804 - Material for Topsoiling
Appendix C - Engineered Soil

Bioswale with Native Plantings (pt. 1)



BIOSWALE TYPICAL SECTION



BIOSWALE IN RESIDENTIAL INSTALLATION WITH NATIVE PLANTS[7]

DESIGN GUIDANCE

TYPICAL LOCATION: LONG NARROW SPACE WITHIN RIGHT OF WAY, IN PARKING LOT, OR ADJACENT TO BUILDING[1]

WIDTH: 2' MIN BOTTOM / 5' MIN FOR ENGINEERED SOIL
MAX WIDTH DEPENDENT ON SPACE AVAILABLE

LENGTH: SCALABLE

CONTRIBUTING DRAINAGE AREA: < 2 ACRES

AVAILABLE OPTIONS: OVERFLOW STRUCTURE
UNDERDRAIN VS. INFILTRATION
NATIVE PLANT: PLUGS VS. GALLONS

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ NATIVE SOIL INFILTRATION[2]:____________ IN/HR
- ☐ REQUIRED STORAGE CAPACITY[3]:________ CUBIC FT
- ☐ CONNECT TO EXISTING STORM NETWORK: YES/NO[4]
- ☐ DEPTH TO GROUNDWATER TABLE >2 FT: YES/NO[5]
- ☐ ADJACENT TO DRIVEWAY CROSSING: YES/NO[6]
- ☐ OUTLET: STORM SEWER OR DAYLIGHT TO GRADE

1. COULD BE USED IN VARIOUS RESIDENTIAL, COMMERCIAL OR INDUSTRIAL APPLICATIONS.
2. NATIVE SOIL INFILTRATION NEEDS TO BE GREATER THAN 0.5 INCHES/HOUR. IF IT IS NOT, AN UNDERDRAIN MUST BE INCLUDED.
3. IF STORAGE CAPACITY REQUIRED EXCEEDS AVAILABLE FOOTPRINT, INCREASE THICKNESS OF DRAINAGE AGGREGATE OR CONSIDER UNDERGROUND STORAGE.
4. CAPACITY OF DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
5. IF NO, TECHNIQUE MAY NOT MEET CODE WITHOUT A LINER.
6. IF YES, AN OVERFLOW AND UNDERDRAIN MUST BE INCLUDED, OVERFLOW STRUCTURE MUST BE A MINIMUM OF 6" BELOW DRIVEWAY.
7. HTTP://WATER.EPA.GOV/INFRASTRUCTURE/GREENINFRASTRUCTURE/GI_WHAT.CFM

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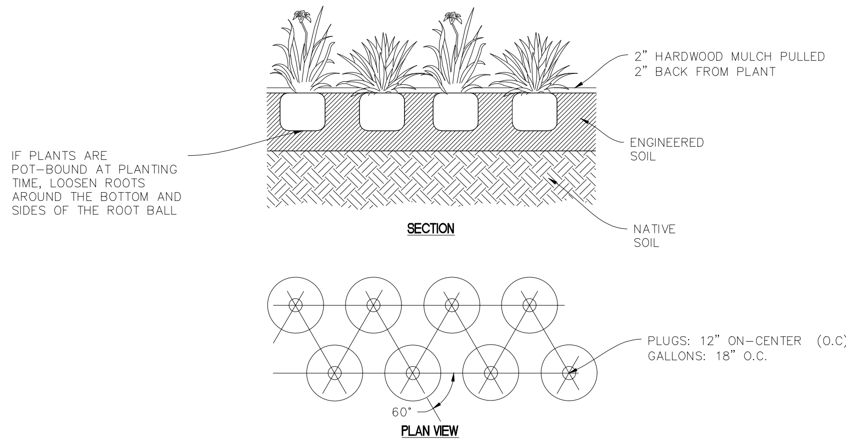
1 OF 4
SCALE: NTS

BIOSWALE WITH NATIVE PLANTINGS

A COLLABORATION OF:

Bioswale with Native Plantings (pt. 2)



NATIVE PLANTINGS PLUG DETAIL

MIX	BOTANICAL NAME	COMMON NAME	RECOMMENDED PLANTING METHOD	NATIVE TO ILLINOIS	MOISTURE
1/3	*GRASSES*				
	PANICUM VIRGATUM	SWITCH GRASS	PLUG	YES	MESIC-WET
	SORGHASTRUM NUTANS	INDIAN GRASS	PLUG	YES	MESIC
	CAREX VULPINOIDEA	FOX SEDGE	PLUG	YES	WET
1/3	*FLOWERS*				
	ASCLEPIAS INCARNATA	SWAMP MILKWEED	PLUG	YES	WET
	ASTER NOVAE-ANGILAE	NEW ENGLAND ASTER	PLUG	YES	MESIC-WET
	ECHINACEA PALLIDA	PALE PURPLE CONE FLOWER	PLUG	YES	MESIC
	IRIS VIRGINICA	BLUE FLAG IRIS	PLUG	YES	WET
	JUNCUS TORREYI	TORREY'S RUSH	PLUG	YES	WET
	LOBELIA CARDINALS	CARDINAL FLOWER	PLUG	YES	WET
	RUDBECKIA HIRTA	BLACK-EYED SUSAN	PLUG	YES	MESIC
	SOLIDAGO GIGANTEA	LATE GOLDENROD	PLUG	YES	MESIC-WET
	VERBENA HASTATA	BLUE VERVAIN	PLUG	YES	WET
1/3	*SEDGES*				
	CAREX LANUGINOSA	WOOLY SEDGE	PLUG	YES	WET
	CAREX SCOPARIA	LANCE-FRUITED OVAL SEDGE	PLUG	YES	WET
	CAREX VULPINOIDEA	FOX SEDGE	PLUG	YES	WET

SUGGESTED NATIVE PLANTING SPECIES AND MIX SCHEDULE[1,2]

DESIGN GUIDANCE

PLUGS

- RECOMMENDED INSTALLATION METHOD FOR NATIVE PLANTS
- STANDARD SIZE IS 2" DIA. (11.3 CUBIC INCH BY VOLUME)
- AVG PRICE = $1.50/SF ($1.10/PLUG)
- OPTIMUM PLANTING WINDOW:
  APRIL 15–JUNE 15 AND SEPT 15–OCT 15..
- NUMBER OF PLUGS AT 12" O.C. = L X W X 1.10

GALLONS

- USE FOR MORE MATURE LOOKING PLANTS OR WHERE AESTHETICS AT INSTALLATION IS VERY IMPORTANT
- AVG PRICE = $3.00/SF ($5.00/GALLON)
- PLANTING WINDOW IS MORE FLEXIBLE BECAUSE OF GREATER ROOT MASS
- NUMBER OF GALLONS AT 18" O.C. = L X W X 0.50

1 TABLE IS AMENDED FROM THE ILLINOIS NATIVE PLANT GUIDE "SPECIES INFORMATION SUMMARY TABLE": HTTP://WWW.NRCS.USDA.GOV/WPS/PORTAL/NRCS/DETAIL/IL/TECHNICAL/?CID=NRCS141P2_030715#TABLE
2 REFER TO PLANT SELECTION SECTION OF THIS GUIDE FOR FURTHER ADVICE ON SELECTING AN APPROPRIATE PLANT MIX.

BIOSWALE MAINTENANCE GUIDELINES

TASK	FREQUENCY	TIMEFRAME
ESTABLISHMENT WATERING	3XWEEK	FIRST 4 WEEKS AFTER INSTALLATION
1ST YEAR WATERING	2XWEEK	THROUGH OCTOBER OF FIRST YEAR; SUBSEQUENT YEARS ONLY IN DROUGHT
WEEDING	2X MONTH	THROUGH 1ST YEAR
MULCHING	ANNUALLY	THROUGH 3 YEARS
MOWING/COMPLETE CUTBACK	ANNUALLY	THROUGH 3 YEARS
TRASH REMOVAL	1XMONTH	ONGOING
TRIM VEGETATION	AS NEEDED	ONGOING
REPLACE DEAD PLANTS	AS NEEDED	ONGOING

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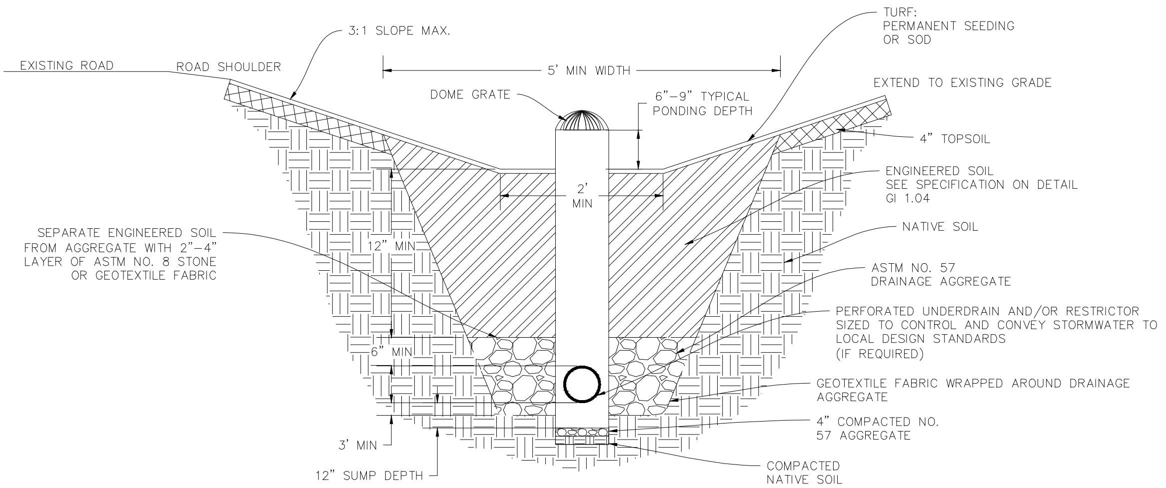
2 OF 4
SCALE: NTS

BIOSWALE WITH NATIVE PLANTINGS

A COLLABORATION OF:

Hybrid Ditch



HYBRID DITCH TYPICAL SECTION

HYBRID DITCH IN RESIDENTIAL INSTALLATION[7]

DESIGN GUIDANCE

TYPICAL LOCATION: LONG NARROW SPACE WITHIN RIGHT OF WAY, IN PARKING LOT, OR ADJACENT TO BUILDING[1]

WIDTH: 2' MIN BOTTOM / 5' MIN FOR ENGINEERED SOIL
MAX WIDTH DEPENDENT ON SPACE AVAILABLE

LENGTH: SCALABLE

CONTRIBUTING DRAINAGE AREA: < 2 ACRES

AVAILABLE OPTIONS: OVERFLOW STRUCTURE
UNDERDRAIN VS. INFILTRATION
TURF: SEEDING VS. SOD

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ NATIVE SOIL INFILTRATION[2]:____________ IN/HR
- ☐ REQUIRED STORAGE CAPACITY[3]:_________ CUBIC FT
- ☐ CONNECT TO EXISTING STORM NETWORK: YES/NO[4]
- ☐ DEPTH TO GROUNDWATER TABLE >2 FT: YES/NO[5]
- ☐ ADJACENT TO DRIVEWAY CROSSING: YES/NO[6]
- ☐ OUTLET: STORM SEWER OR DAYLIGHT TO GRADE

1. COULD BE USED IN VARIOUS RESIDENTIAL, COMMERCIAL OR INDUSTRIAL APPLICATIONS.
2. NATIVE SOIL INFILTRATION NEEDS TO BE GREATER THAN 0.5 INCHES/HOUR. IF IT IS NOT, AN UNDERDRAIN MUST BE INCLUDED.
3. IF STORAGE CAPACITY REQUIRED EXCEEDS AVAILABLE FOOTPRINT, INCREASE THICKNESS OF DRAINAGE AGGREGATE OR CONSIDER UNDERGROUND STORAGE.
4. CAPACITY OF DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
5. IF NO, TECHNIQUE MAY NOT MEET CODE WITHOUT A LINER.
6. IF YES, AN OVERFLOW AND UNDERDRAIN MUST BE INCLUDED. OVERFLOW STRUCTURE MUST BE A MINIMUM OF 6" BELOW DRIVEWAY.
7. HTTP://WWW.NRCS.USDA.GOV/WPS/PORTAL/NRCS/SITE/NATIONAL/HOME/

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3 OF 4
SCALE: NTS

HYBRID DITCH

A COLLABORATION OF:

delta institute

GUIDON DESIGN

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Bioswale and Hybrid Ditch Notes

NOTES

1. BIOSWALE PLANTINGS:
   a. THE BIOSWALE SHOULD BE POPULATED WITH PLANTS NATIVE AND/OR ADAPTED TO THE INSTALLATION LOCATION. NATIVE PLANTS, GRASSES AND FLOWERS ESTABLISH DEEPER ROOTS AND IMPROVE SOIL HEALTH TO MAINTAIN PERMEABILITY.
   b. SELECT A MIXTURE OF NATIVE PLANTS BASED ON SITE CONDITIONS TO IMPROVE BIODIVERSITY AND AESTHETICS. SELECTED PLANTS SHOULD BE DROUGHT AND FLOOD TOLERANT. ONE SUCCESSFUL APPROACH USES THE FOLLOWING NATIVE PLANT MIX:
   $\frac{1}{3}$ SEDGES, $\frac{1}{3}$ FLOWERS, AND $\frac{1}{3}$ GRASSES.
2. HYBRID DITCH PLANTINGS:
   a. A DENSE COVER OF WATER TOLERANT, EROSION-RESISTANT GRASS MUST BE ESTABLISHED.
   b. SELECT GRASS SPECIES THAT WILL FORM A DENSE TURF WITH VIGOROUS, UPRIGHT GROWTH.
   c. GRASS SPECIES MUST BE RESISTANT TO PERIODIC INUNDATION AND PERIODIC DROUGHT AND MUST BE SALT TOLERANT.
   d. GRASS MUST BE APPROPRIATE TO THE SOIL TYPE AND AMOUNT OF LIGHT AVAILABLE.
3. SCHEDULE PRE-INSTALLATION MEETING WITH THE DESIGN ENGINEER 72 HOURS IN ADVANCE OF GREEN INFRASTRUCTURE CONSTRUCTION.PLANTING THAT REQUIRES FOOT OR MACHINE TRAFFIC SHALL ONLY BE CONDUCTED ON DRY SOILS.
4. CONSTRUCT GREEN INFRASTRUCTURE AND INSTALL PLANTS AS EARLY AS POSSIBLE TO ALLOW FOR PLANT ESTABLISHMENT PRIOR TO DIRECTING STORMWATER TO IT. CONSIDER THE SELECTED PLANT SPECIES WHEN DETERMINING ESTABLISHMENT PERIOD.
5. AREAS IN AND AROUND GREEN INFRASTRUCTURE SHOULD BE PROTECTED DURING EARTH MOVING AND CONSTRUCTION TO PREVENT COMPACTION THAT WOULD REDUCE INFILTRATION RATES OF SUBGRADE AND ENGINEERED SOILS. ALSO PROTECT AREA THROUGHOUT CONSTRUCTION FROM SEDIMENT TRANSPORT THAT WOULD CLOG THE INFILTRATION CAPACITY OF NATIVE AND ENGINEERED SOILS.
6. CONTRACTOR SHOULD RAKE OR ROTOTILL THE TOP SIX INCHES OF SUBGRADE SOILS AFTER EXCAVATION TO REMEDIATE THE EFFECTS OF COMPACTION AND CLOGGING.
7. LONGITUDINAL SLOPE OF SWALE SHOULD BE BETWEEN 0.5% AND 2.5%. IF SUBGRADE SOILS ARE CONDUCIVE TO INFILTRATION OR AN UNDERDRAIN IS INCLUDED, THE SURFACE OF THE ENGINEERED SOIL CAN BE FLAT.

GEOTEXTILE FABRIC SPECIFICATION

1. A WOVEN, MONOFILAMENT GEOTEXTILE SHALL BE USED CONFORMING TO THE FOLLOWING:
   a. MINIMUM FLOW RATE OF 145 GAL/MIN/FT ASTM D-4491
   b. GRAB TENSILE STRENGTH MIN 365 X 200 LB ASTM D-4632
   c. GRAB ELONGATION MAX 24 X 10%ASTM D-4632
   d. TRAPEZOIDAL TEAR MIN 115 X 75 LBS ASTM D-4533
   e. CBR PUNCTURE RESISTANCE MIN 675 LB ASTM D-6241
   f. APPARENT OPENING SIZE 4060-90 U.S STANDARD SIEVE

ENGINEERED SOIL SPECIFICATION

1. ENGINEERED SOIL MIX SHALL BE A BLEND OF 70% TO 90% COARSE SAND AND 10% TO 25% COMPOST BY VOLUME AND MEET THE FOLLOWING REQUIRMENTS:
   a. COMPOSE SHALL BE WELL AGED AND MEET WISCONSIN DNR TECHNICAL SPECIFICATION S100
   b. ORGANIC MATTER CONTENT OF MIX FROM 3-5% BY WEIGHT
   c. PROPORTION OF CLAY (HYDROMETER ANALYSIS) SHALL BE 2% TO 5%
   d. pH OF MIX SHALL BE 5.5 TO 8.0
   e. THE ENGINEERED SOIL THICKNESS SHALL BE ADEQUATE TO SUPPORT THE ROOTING DEPTH OF THE SELECTED VEGETATION WITH A MINIMUM THICKNESS OF 18 INCHES EXCEPT FOR THE HYBRID DITCH WHERE THE ENGINEERED SOIL MAY BE REDUCED TO 12"
2. ENGINEERED SOIL MAY BE OBTAINED OFF SITE OR CREATED BY TESTING NATIVE SOILS AND MIXING WITH IMPORTED MATERIALS AS NEEDED PROVIDED THE MIX MEETS THE SPECIFICATIONS ABOVE.
3. ENGINEERED SOIL SHALL BE DRY AND FRIABLE AND UNIFORMLY MIXED. ITS CHARACTERISTICS SHALL BE VERIFIED BY MATERIALS TESTING PRIOR TO PLACEMENT.
4. PLACE DRY AND FRIABLE SOIL IN 8-12 INCH LIFTS.
5. AFTER PLACEMENT, LIGHTLY COMPACT DRY SOIL WITH A HAND ROLLER WEIGHING NO MORE THAN 100 LBS PER FOOT OF WIDTH. DO NOT USE A VIBRATORY COMPACTOR.
6. TO PRESERVE INFILTRATION CAPACITY OF NATIVE SOIL, KEEP MACHINERY AND CONSTRUCTION SITE RUNOFFF OUTSIDE OF GREEN INFRASTRUCTURE AREA.

MAINTENANCE GUIDELINES

1. WATER PLANTS THOROUGHLY FOLLOWING PLANTING TO SETTLE THE SOIL AROUND THE ROOTS UNTIL ESTABLISHMENT HAS TAKEN PLACE.
2. REMOVE DEBRIS AND RUBBISH ON A MONTHLY BASIS.
3. PERFORM SPRING MAINTENANCE TO REMOVE BUILT UP DEBRIS FROM WINTER, PROVIDE PRE-EMERGENT PLANT CARE AND INSTALL/REPLACE MULCH AS NECESSARY.
4. TRIM VEGETATION TO ENSURE SAFETY, AESTHETICS, PROPER OPERATION, OR TO SUPPRESS WEEDS AND INVASIVE VEGETATION.
4. CUT BACK PERENNIALS AND REMOVE LEAF DEBRIS AT END OF GROWING SEASON.
5. REPLACE UNSUCCESSFULLY ESTABLISHED PLANTS.
6. INSPECT AND CORRECT EROSION PROBLEMS, DAMAGE TO VEGETATION, AND SEDIMENT AND DEBRIS ACCUMULATION.
7. INSPECT FOR CLOGGED SOILS AS EVIDENCED BY EXTENDED PERIODS OF PONDING. IN SOME CASES CLOGGED SOILS MAY BE REMEDIATED BY SIMPLY RAKING THE SURFACE TO REMOVE CRUSTED SEDIMENT. IN OTHER CASES, THE TOP SEVERAL INCHES OF ENGINEERED SOIL MAY NEED TO BE REMOVED AND REPLACED.
8. INSPECT FOR UNIFORMITY IN CROSS-SECTION AND LONGITUDINAL SLOPE, CORRECT AS NEEDED.
9. REMOVE ALL LABELS, WIRES, ETC. FROM PLANTS.

	BIOSWALE AND HYBRID DITCH NOTES	A COLLABORATION OF:
GI 1.04 4 OF 4 SCALE: NTS		

Rain Garden

Rain gardens present an opportunity for infiltration in a low spot of a property. The rain garden acts like a bowl that fills up with water and then drains slowly to the native soil or an engineered underdrain system.

During rain events, runoff collects inside the rain garden until it reaches the height of an overflow structure, typically set 6 inches to 1 foot above the engineered soil layer. Runoff that doesn't enter the overflow structure filters through the engineered soil layer to subgrade or a layer of stone beneath. A rain garden is planted with native or large herbaceous plants to encourage infiltration and to promote biofiltration. Native plants have a deeper root network than grass, which draws surface water deeper into the ground. Native plants are naturally drought and flood tolerant, which allows them to thrive in the rain garden.

Customization Options

A geotechnical engineer should test the infiltration rate of the underlying soil in the location of the rain garden. The design should consider the infiltration capacity of the subgrade soils when designing the system and determine the need for an underdrain. If the infiltration rate is greater than 0.5 in/ hr, then the volume of runoff infiltrated during the event may be sufficient, so as to not require an underdrain as part of the rain garden's design for managing runoff volumes. Depending on the specifics of the site, an overflow structure may be warranted to prevent flooding of surrounding areas. In certain cases, surface overflow to the adjacent landscape and the street may prove to be minimal, and therefore acceptable. The design engineer should also select whether plugs or gallons will be used, along with the species mix for the herbaceous plants. Establishment through seeding is also an option, however, it will take longer for vegetation to establish and more intensive maintenance will be required during the establishment period to control weeds.

Figure 6: Rain garden in a suburban setting

Maintenance

Native plants need to be watered 3 times per week during an establishment period, typically the first 4 weeks after installation. During the first year of establishment, the plants will need to be watered and weeded twice per week through October of the first year, and during any subsequent years in which there is a drought. Mulching and mowing will occur annually through the first three years of establishment. Establishment can take up to five years if plants are established by seeding. Debris removal and weeding will be necessary as needed throughout the life of the rain garden. Trimming, removal, and replacement of dead plants must occur on an as-needed basis.

Cost Information

Cost information is provided for each green infrastructure practice. The installed costs are based on project experience, bid tabs, and information from the RS Means Building Construction Costs Data (2020 edition), which is an industry standard compilation of unit costs for various construction activities. The costs in the table below can be used to scope a project, but a project-specific cost estimate should be prepared by the design engineer that takes into account the project scale and complexity, material cost trends, and the labor and bidding environment.

Table 5: Rain garden unit costs[1,2]

	Item	Description	Unit Price	Unit
GI Technique	Rain Garden	Design/Engineering	15% of Construction Cost	LS
		Mobilization	$10,000.00	LS
		Excavation & Haul	$45.00	CY
		Leaf Mulch	$70.00	CY
		Engineered Soil	$80.00	CY
		Open-Grade Crushed Stone	$65.00	CY
		Geotextile Fabric	$5.00	SY
		Erosion Blanket	$3.00	SY
Required Component	Splash Pad	Cobble Splash Pad	$250.00	EA
	Native Plantings	Plugs (12" on center)	$5.00	EA
		Gallons (36" on center)	$15.00	EA
Custom options	Trees	Varies by species and size	$400.00	EA
	Shrub	Varies by species and size	$60.00	EA
	Outlet Control/ Overflow structure	Outlet Control Drainage Basin (varies by size)	$2,800.00	EA
	Underdrain	4" HDPE Perforated Pipe	$20.00	LF
	Storm Sewer	12" HDPE storm sewer	$65.00	LF
	Underdrain Cleanout		$600.00	EA
	Connection to existing storm structure		$600.00	EA

1 Installed cost includes material and labor based on bid tabs from related projects and RS Means.

2 Unit price based on a 2,000 sf rain garden with a 1.0 acre drainage area located within a publicly controlled park. Unit prices will vary. Unit prices for specific projects will vary based on scale, complexity, labor environment, and material cost trends. A detailed cost estimate should be prepared by the design engineer.

Specifications

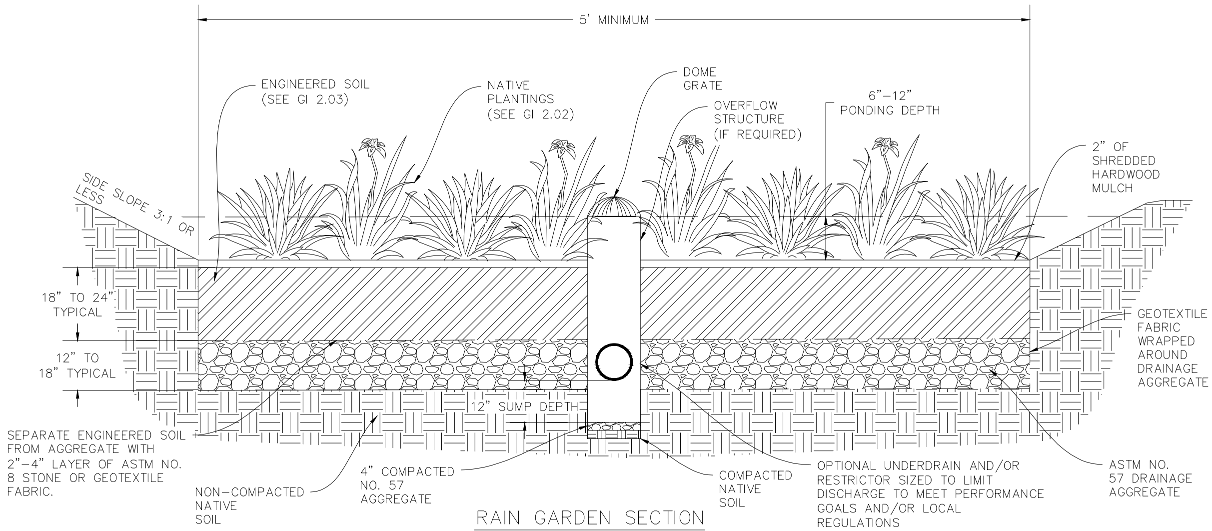
The construction techniques and materials involved in a rain garden installation are identical to that of a bioswale. As such, the minimum specification sections required are also the same. For more information on use of the standard specifications from the Illinois Urban Manual, refer to Appendix B.

Construction Specifications

2 - Clearing and Grubbing
5 - Pollution Control
6 - Seeding, Sprigging and Mulching
7 - Construction Surveys
8 - Mobilization and Demobilization
21 - Excavation
23 - Earthfill
24 - Drainfill
25 - Rockfill
26 - Topsoiling
44 - Corrugated Polyethylene Tubing
46 - Tile Drains
94 - Contractor Quality Control
95 - Geotextile
707 - Digging, Transporting, Planting, and Establishment of Trees, Shrubs and Vines
752 - Stripping, Stockpiling, Site Preparation and Spreading Topsoil

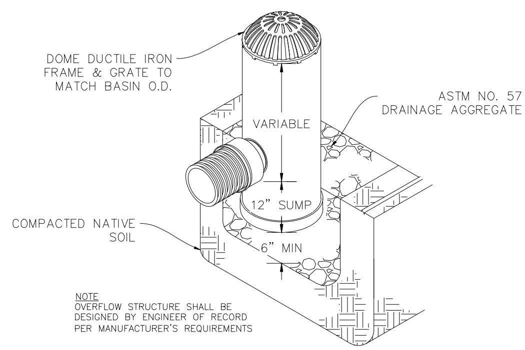
Material Specifications

521 - Aggregates for Drainfill and Filters
548 - Corrugated Polyethylene Tubing
592 - Geotextile
804 - Material for Topsoiling Appendix C – Engineered Soil



RAIN GARDEN SECTION

RAIN GARDEN IN RESIDENTIAL INSTALLATION[1]



OVERFLOW STRUCTURE

DESIGN GUIDANCE

TYPICAL LOCATION: DEPRESSED AREA LOCATED IN RIGHT OF WAY OR IN DEMOLITION LOCATION

WIDTH: 5' MIN., NO MAX.

LENGTH: SCALABLE, 2L:1W DESIRABLE

CONTRIBUTING DRAINAGE AREA: < 2 ACRES

AVAILABLE OPTIONS: OVERFLOW STRUCTURE
UNDERDRAIN
NATIVE PLANT SELECTION

DETAILED DESIGN PRELIMINARY WORKSHEET

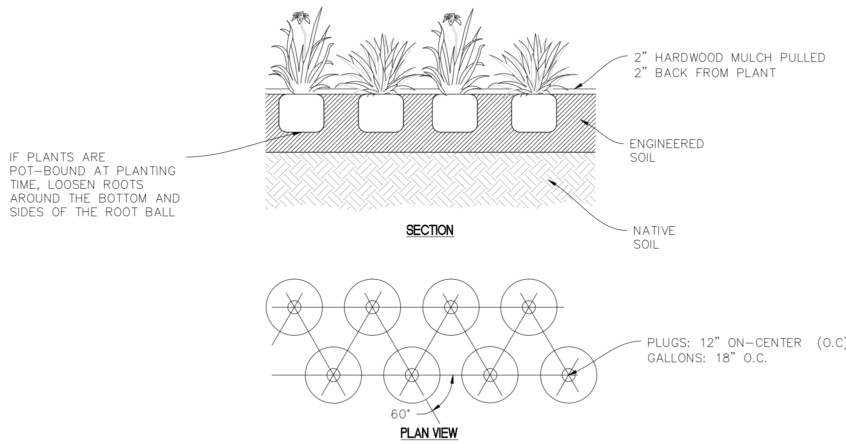
- ☐ NATIVE SOIL INFILTRATION[2]: ____________ IN/HR
- ☐ REQUIRED STORAGE CAPACITY[3]: __________ CUBIC FT
- ☐ CONNECT TO EXISTING STORM NETWORK: YES/NO[4]
- ☐ DEPTH TO GROUNDWATER TABLE > 2 FT: YES/NO[5]

1. HTTP://WATER.EPA.GOV/INFRASTRUCTURE/GREENINFRASTRUCTURE/GI_WHAT.CFM
2. NATIVE SOIL INFILTRATION NEEDS TO BE GREATER THAN 0.5 INCHES/HOUR. IF IT IS NOT, AN UNDERDRAIN MUST BE INCLUDED.
3. IF STORAGE CAPACITY EXCEEDS AVAILABLE FOOTPRINT SPACE, INCREASE THICKNESS OF DRAINAGE AGGREGATE OR CONSIDER UNDERGROUND STORAGE.
4. CAPACITY OF DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
5. IF NO, TECHNIQUE MAY NOT MEET CODE WITHOUT A LINER.

GI 2.01
1 OF 3
SCALE: NTS

RAIN GARDEN

A COLLABORATION OF:



NATIVE PLANTINGS PLUG DETAIL

MIX	BOTANICAL NAME	COMMON NAME	RECOMMENDED PLANTING METHOD	NATIVE TO ILLINOIS	MOISTURE
1/3	*GRASSES*				
	PANICUM VIRGATUM	SWITCH GRASS	PLUG	YES	MESIC-WET
	SORGHASTRUM NUTANS	INDIAN GRASS	PLUG	YES	MESIC
	CAREX VULPINOIDEA	FOX SEDGE	PLUG	YES	WET
1/3	*FLOWERS*				
	ASCLEPIAS INCARNATA	SWAMP MILKWEED	PLUG	YES	WET
	ASTER NOVAE-ANGILAE	NEW ENGLAND ASTER	PLUG	YES	MESIC-WET
	ECHINACEA PALLIDA	PALE PURPLE CONE FLOWER	PLUG	YES	MESIC
	IRIS VIRGINICA	BLUE FLAG IRIS	PLUG	YES	WET
	JUNCUS TORREYI	TORREY'S RUSH	PLUG	YES	WET
	LOBELIA CARDINALS	CARDINAL FLOWER	PLUG	YES	WET
	RUDBECKIA HIRTA	BLACK-EYED SUSAN	PLUG	YES	MESIC
	SOLIDAGO GIGANTEA	LATE GOLDENROD	PLUG	YES	MESIC-WET
	VERBENA HASTATA	BLUE VERVAIN	PLUG	YES	WET
1/3	*SEDGES*				
	CAREX LANUGINOSA	WOOLY SEDGE	PLUG	YES	WET
	CAREX SCOPARIA	LANCE-FRUITED OVAL SEDGE	PLUG	YES	WET
	CAREX VULPINOIDEA	FOX SEDGE	PLUG	YES	WET

SUGGESTED NATIVE PLANTING SPECIES AND MIX[1]

DESIGN GUIDANCE

PLUGS

- RECOMMENDED INSTALLATION METHOD FOR NATIVE PLANTS
- STANDARD SIZE IS 2" DIA. (11.3 CUBIC INCH BY VOLUME)
- AVG PRICE = $1.50/SF ($1.10/PLUG)
- OPTIMUM PLANTING WINDOW:
  APRIL 15–MAY 15 AND OCT 1–31.
- NUMBER OF PLUGS AT 12" O.C. = L X W X 1.10

GALLONS

- USE FOR MORE MATURE LOOKING PLANTS OR WHERE AESTHETICS AT INSTALLATION IS VERY IMPORTANT
- AVG PRICE = $3.00/SF ($5.00/GALLON)
- PLANTING WINDOW IS MORE FLEXIBLE BECAUSE OF GREATER ROOT MASS
- NUMBER OF GALLONS AT 18" O.C. = L X W X 0.50

1 TABLE IS AMENDED FROM THE ILLINOIS NATIVE PLANT GUIDE "SPECIES INFORMATION SUMMARY TABLE": HTTP://WWW.NRCS.USDA.GOV/WPS/PORTAL/NRCS/DETAIL/IL/TECHNICAL/?CID=NRCS141P2_030715#TABLE

NATIVE PLANTING MAINTENANCE GUIDELINES

TASK	FREQUENCY	TIMEFRAME
ESTABLISHMENT WATERING	3XWEEK	FIRST 4 WEEKS AFTER INSTALLATION
1ST YEAR WATERING	2XWEEK	THROUGH OCTOBER OF FIRST YEAR; SUBSEQUENT YEARS ONLY IN DROUGHT
WEEDING	2X MONTH	THROUGH 1ST YEAR
MULCHING	ANNUALLY	THROUGH 3 YEARS
MOWING/COMPLETE CUTBACK	ANNUALLY	THROUGH 3 YEARS
TRASH REMOVAL	1XMONTH	ONGOING
TRIM VEGETATION	AS NEEDED	ONGOING
REPLACE DEAD PLANTS	AS NEEDED	ONGOING

GI 2.02
2 OF 3
SCALE: NTS

NATIVE PLANTINGS & MAINTENANCE GUIDELINES

A COLLABORATION OF:

NOTES

1. RAIN GARDEN PLANTINGS:
   a. THE RAIN GARDEN SHOULD BE POPULATED WITH PLANTS NATIVE AND/OR ADAPTED TO THE INSTALLATION LOCATION. NATIVE GRASSES AND FLOWERS ESTABLISH DEEPER ROOTS AND IMPROVE SOIL HEALTH TO MAINTAIN PERMEABILITY.
   b. SELECT A MIXTURE OF NATIVE PLANTS BASED ON SITE CONDITIONS TO IMPROVE BIODIVERSITY AND AESTHETICS. SELECTED PLANTS SHOULD BE DROUGHT, FLOOD AND SALT TOLERANT. ONE SUCCESSFUL APPROACH USES THE FOLLOWING NATIVE PLANT MIX:
   $\frac{1}{3}$ SEDGES, $\frac{1}{3}$ FLOWERS, AND $\frac{1}{3}$ GRASSES (SEE GI 2.02).
2. SCHEDULE PRE-INSTALLATION MEETING WITH THE DESIGN ENGINEER 72 HOURS IN ADVANCE OF GREEN INFRASTRUCTURE CONSTRUCTION. PLANTING THAT REQUIRES FOOT OR MACHINE TRAFFIC SHALL ONLY BE CONDUCTED ON DRY SOILS.
3. CONSTRUCT GREEN INFRASTRUCTURE AND INSTALL PLANTS AS EARLY AS POSSIBLE TO ALLOW FOR PLANT ESTABLISHMENT PRIOR TO DIRECTING STORMWATER TO IT. CONSIDER THE SELECTED PLANT SPECIES WHEN DETERMINING ESTABLISHMENT PERIOD.
4. AREAS IN AND AROUND GREEN INFRASTRUCTURE SHOULD BE PROTECTED DURING EARTH MOVING AND CONSTRUCTION TO PREVENT COMPACTION THAT WOULD REDUCE INFILTRATION RATES OF SUBGRADE AND ENGINEERED SOILS. ALSO PROTECT AREA THROUGHOUT CONSTRUCTION FROM SEDIMENT TRANSPORT THAT WOULD CLOG THE INFILTRATION CAPACITY OF NATIVE AND ENGINEERED SOILS.
5. CONTRACTOR SHOULD RAKE OR ROTOTILL THE TOP SIX INCHES OF SUBGRADE SOILS AFTER EXCAVATION TO REMEDIATE THE EFFECTS OF COMPACTION AND CLOGGING.

GEOTEXTILE FABRIC SPECIFICATION

1. A WOVEN, MONOFILAMENT GEOTEXTILE SHALL BE USED CONFORMING TO THE FOLLOWING:
   a. MINIMUM FLOW RATE OF 145 GAL/MIN/FT ASTM D-4491
   b. GRAB TENSILE STRENGTH MIN 365 X 200 LB ASTM D-4632
   c. GRAB ELONGATION MAX 24 X 10%ASTM D-4632
   d. TRAPEZOIDAL TEAR MIN 115 X 75 LBS ASTM D-4533
   e. CBR PUNCTURE RESISTANCE MIN 675 LB ASTM D-6241
   f. APPARENT OPENING SIZE 4060-90 U.S STANDARD SIEVE

ENGINEERED SOIL SPECIFICATIONS

1. ENGINEERED SOIL MIX WILL ADHERE TO THE FOLLOWING:
   a. 40% SAND, 30% TOPSOIL, AND 30% COMPOST
   b. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   c. LESS THAN 5% MINERAL FINES CONTENT (CLAY)
   d. 2 FOOT MINIMUM THICKNESS
   e. COMPACT TO 85% MAXIMUM DENSITY PER ASTM D 1557
   f. MINIMUM LONG-TERM HYDRAULIC CONDUCTIVITY OF 1 INCH/HOUR PER ASTM D2434.
   g. MAXIMUM IMMEDIATE HYDRAULIC CONDUCTIVITY OF 12 INCHES/HOUR.
2. ENGINEERED SOIL MAY BE OBTAINED OFF SITE OR CREATED BY TESTING NATIVE SOILS AND MIXING WITH IMPORTED MATERIALS AS NEEDED TO ACHIEVE SPECIFICATIONS.
3. ENGINEERED SOIL SHOULD BE MIXED UNIFORMLY AND ITS CHARACTERISTICS SHOULD BE VERIFIED BY MATERIALS TESTING PRIOR TO PLACEMENT.
4. PLACE UNSATURATED SOIL IN 6 INCH LIFTS. DO NOT PLACE IF SATURATED.
5. TO PRESERVE INFILTRATION CAPACITY OF NATIVE SOIL, KEEP MACHINERY OUTSIDE OF GREEN INFRASTRUCTURE AREA.
6. AFTER PLACEMENT, COMPACT EACH LIFT TO 85% MAXIMUM DENSITY USING WATER UNTIL JUST SATURATED OR BY WALKING ON THE SURFACE. DO NOT USE A VIBRATORY COMPACTOR.

MAINTENANCE GUIDELINES

1. WATER PLANTS THOROUGHLY FOLLOWING PLANTING TO SETTLE THE SOIL AROUND THE ROOTS UNTIL ESTABLISHMENT HAS TAKEN PLACE.
2. REMOVE DEBRIS AND RUBBISH ON A MONTHLY BASIS.
3. PERFORM SPRING MAINTENANCE TO REMOVE BUILT UP DEBRIS FROM WINTER, PROVIDE PRE-EMERGENT PLANT CARE AND INSTALL/REPLACE MULCH AS NECESSARY.
4. TRIM VEGETATION TO ENSURE SAFETY, AESTHETICS, PROPER OPERATION, OR TO SUPPRESS WEEDS AND INVASIVE VEGETATION.
4. CUT BACK PERENNIALS AND REMOVE LEAF DEBRIS AT END OF GROWING SEASON.
5. CUT BACK PERENNIALS AND REMOVE LEAF DEBRIS AT END OF GROWING SEASON.
6. REPLACE UNSUCCESSFULLY ESTABLISHED PLANTS.
7. INSPECT AND CORRECT EROSION PROBLEMS, DAMAGE TO VEGETATION, AND SEDIMENT AND DEBRIS ACCUMULATION.
8. INSPECT FOR CLOGGED SOILS AS EVIDENCED BY EXTENDED PERIODS OF PONDING. IN SOME CASES CLOGGED SOILS MAY BE REMEDIATED BY SIMPLY RAKING THE SURFACE TO REMOVE CRUSTED SEDIMENT. IN OTHER CASES, THE TOP SEVERAL INCHES OF ENGINEERED SOIL MAY NEED TO BE REMOVED AND REPLACED.
9. REMOVE ALL LABELS, WIRES, ETC. FROM PLANTS.

	RAIN GARDEN NOTES	A COLLABORATION OF:
GI 2.03 3 OF 3 SCALE: NTS		

Stormwater Planters

A stormwater planter is a linear infiltration basin that typically sits between a street and a sidewalk in the right-of-way and is surrounded by vertical curbing. Rainwater runoff from the sidewalk and/or the street drains into the stormwater planter through openings in the curbing. If the planter is designed to manage street runoff the planter surface must be below the street gutter elevation.

A cobble or concrete splash pad helps to collect the bulk of sediment and to prevent erosion of the mulch and engineered soil. Runoff is filtered through a layer of engineered soil, a mixture of sand and compost (and sometimes topsoil). A variety of herbaceous plants in the engineered soil take some of the runoff up through their dense root system. Beneath the engineered soil, a layer of stone may be provided between the engineered soil and subgrade. Clean runoff that has been filtered by the engineered soil and the plantings can infiltrate into the ground, eventually recharging the groundwater.

During rain events, runoff collects inside the stormwater planter until it reaches the height of an overflow structure, typically set 6 to 9 inches above the engineered soil layer. In other cases, the planter can be allowed to overflow through a curb cut and continue down the curb and gutter system. Additionally, if the native soil infiltration is inadequate, a perforated underdrain is required within the stone layer to convey filtered water that does not infiltrate into the soil. The overflow structure and perforated underdrain connect the stormwater planter to the larger pipe network, carrying excess runoff downstream.

Figure 7: Stormwater planter in a suburban setting

Customization Options

Stormwater planters are scalable by both length and width depending on the space available and the target storage volume. During the design phase, the design engineer should strive to integrate the stormwater planters into the surrounding community by considering access to adjacent homes or businesses. Another option is to include an 18-inch wide courtesy walk between the pavement curb and the on the street side of the planter to assist individuals when they exit their vehicles. The curb height surrounding the planter may be increased to 18-inches to provide an ad-hoc seat wall. A planting palette with taller vegetation should be used with taller curb heights.

As previously discussed, a geotechnical engineer should test the infiltration rate of the underlying soil in the location of the rain garden. The design should consider the infiltration capacity of the subgrade soils when designing the system and determine the need for an underdrain. If the infiltration rate is greater than 0.5 in/ hr, then the volume of runoff infiltrated during the event may be sufficient, so as to not require an underdrain as part of the rain garden's design for managing runoff volumes. Depending on the specifics of the site, an overflow structure may be warranted to prevent flooding of surrounding areas. In certain cases, surface overflow to the adjacent landscape and the street may prove to be minimal, and therefore acceptable.

The design engineer should also select whether plugs or gallons will be used, along with the species mix for the native plants. The stormwater planter detail GI 3.04 provides a wide selection of herbaceous plants that can be selected, including many native species. The design engineer could choose any combination and layout to create a custom style. One could even create multiple plant palettes for the same project based on color or ability to attract bees, birds, and butterflies. These palettes could be presented to property owners to choose the type of plants that will be installed in the right-of-way in front of their home or business, as a means of community engagement. Also, the typical concrete splash pad could be substituted with decorative cobbles or glacial boulders for a different look, but at a higher cost.

Another option for the stormwater planter is to include trees. Urban tree infrastructure is an important stormwater management technique, because the leaf area and roots can absorb a tremendous amount of water when mature. Research has shown that street trees survive longer and grow to be larger and more mature when an adequate volume of planting soil is provided7. When trees are planted in compacted soil or put in a tree box, the root structure is abbreviated. Either the tree will die or the surrounding infrastructure will be compromised by the roots. Since trees also cast significant shade when mature, the herbaceous species around the tree may need to be modified to account for the increasing levels of shade as the tree grows.

One potential solution for this is to install Cornell University (CU) Structural Soil around and adjacent to the tree location. CU Structural Soil is a proprietary product developed at Cornell University that combines compacted drainage aggregate (ASTM No. 57 stone) for structural stability with a proven growing medium, loamy soil. In addition to CU soils, there are numerous blends of non-proprietary and sand-based and aggregate-based mixes that can be used. Another option for providing soil volume for trees along with structural support for pavements above is to install a proprietary product like a Silva Cell (www.deeproot.com). Where structural soil or support cells are provided to expand the soil volume beyond the planter, openings in the planter walls will be needed to provide root access to the soil.

Lastly, the shape of a stormwater planter can be modified and expanded into a parallel parking lane or stalls in a parking lot. This is called a stormwater bump out, and it can provide larger storage volumes as well as give flexibility to the aesthetic of an installation.

Maintenance

The maintenance required for a stormwater planter is similar to that of a bioswale. This includes water for plant establishment, watering, trash and debris removal, mulch replacement, weeding and annual trimming of the native plants. Within a couple of years, the native plants will be mature and fill the stormwater planter, choking out invasive species.

Cost Information

Cost information is provided for each green infrastructure technique in the Green Infrastructure Best Practices section of this report. The installed costs are based on project experience, bid tabs, and information from the RS Means trends, and the labor and bidding environment.

Table 6: Stormwater planter unit costs[1], [2]

	Item	Description	Unit Price	Unit
GI Technique	Stormwater planter	Design/Engineering	15% of Construction Cost	LS
		Mobilization	$10,000.00	LS
		Excavation & Haul	$45.00	CY
		Leaf Mulch	$70.00	CY
		Engineered Soil	$80.00	CY
		Open-Grade Crushed Stone	$65.00	CY
		Geotextile Fabric	$5.00	SY
		Erosion Control Blanket	$3.00	SY
Required Component	Stormwater Planter Curb	Curb, stormwater planter (6" barrier curb with 24" total height)	$50.00	LF
	Splash Pad	Cobble Splash Pad	$250.00	EA
Required Selection	Native Plantings	Plugs (12" on center)	$5.00	EA
		Gallons (36" on center)	$15.00	EA
Custom options	Trees	Varies by species and size	$400.00	EA
	Shrub	Varies by species and size	$60.00	EA
	Structured Soil	CU Structural Soil	$120.00	CY
	Outlet Control/ Overflow Structure	Outlet Control Drainage Basin (varies by size)	$2,800.00	EA
	Underdrain	4" HDPE Perforated Pipe	$20.00	LF
	Storm Sewer	12" HDPE storm sewer	$65.00	LF
	Underdrain Cleanout		$600.00	EA
	Connection to existing storm structure		$600.00	EA

1 Installed cost include material and labor based on bid tabs from related projects and RS Means.

2 Unit price based on a 2,400 linear foot installation within the right of way in a residential area with 1/8 acre lots. Unit prices for specific projects will vary based on scale, complexity, labor environment, and material cost trends. A detailed cost estimate should be prepared by the design engineer.

Specifications

Since a stormwater planter is like an enclosed bioswale, the specification sections required closely align to that of bioswales. The main difference is that stormwater planters also include concrete construction for the surrounding curbs and splash pad. Oftentimes existing concrete sidewalks or curbs will need to be repaired as a result of incidental damage during construction. The specification sections listed below are the standard sections from the Illinois Urban Manual (see Appendix B) that the design engineer should customize when creating construction documents for a stormwater planter, along with the engineered soil section (see Appendix C).

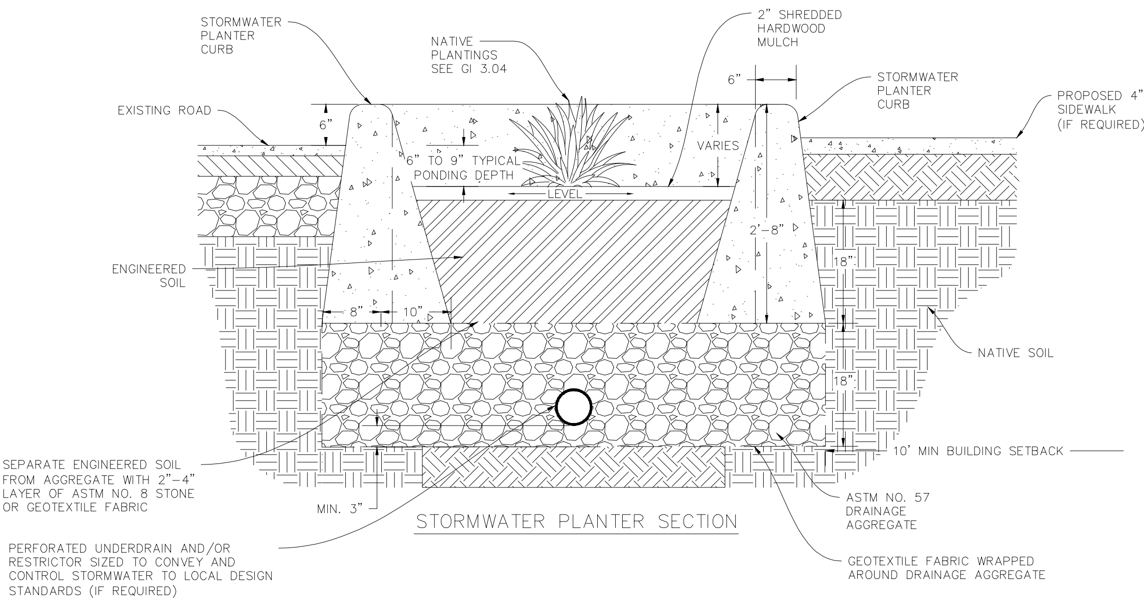
Construction Specifications

2 - Clearing and Grubbing
5 - Pollution Control
6 - Seeding, Sprigging and Mulching
7 - Construction Surveys
8 - Mobilization and Demobilization
10 - Water for Construction
21 - Excavation
23 - Earthfill
24 - Drainfill
25 - Rockfill
26 - Topsoiling
32 - Structure Concrete
34 - Steel Reinforcement
35 - Concrete Repair
44 - Corrugated Polyethylene Tubing
46 - Tile Drains
94 - Contractor Quality Control
95 - Geotextile
707 - Digging, Transporting, Planting, and Establishment of Trees, Shrubs and Vines
752 - Stripping, Stockpiling, Site Preparation and Spreading Topsoil

Material Specifications

521 - Aggregates for Drainfill and Filters
522 - Aggregates for Portland Cement Concrete
531 - Portland Cement
534 - Concrete Curing Compound
535 - Preformed Expansion Joint Filler
536 - Sealing Compound for Joints in Concrete and Concrete Pipe
539 - Steel Reinforcement (for Concrete)
548 - Corrugated Polyethylene Tubing
592 - Geotextile
804 - Material for Topsoiling Appendix C – Engineered Soil

Stormwater Planter



STORMWATER PLANTER SECTION

STORMWATER PLANTER INSTALLATION[5,6]

DESIGN GUIDANCE

TYPICAL LOCATION: WITHIN RIGHT OF WAY, BETWEEN ROAD CURB AND SIDEWALK

WIDTH: SCALABLE

CONTRIBUTING DRAINAGE AREA: < 2 ACRES

AVAILABLE OPTIONS: OVERFLOW STRUCTURE (GI 3.03)
UNDERDRAIN VS. INFILTRATION
NATIVE PLANT: PLUGS VS. GALLONS
TREE INFRASTRUCTURE (GI 3.06)

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ NATIVE SOIL INFILTRATION[1]:______________IN/HR
- ☐ REQUIRED STORAGE CAPACITY[2]:__________CUBIC FT
- ☐ CONNECT TO EXISTING STORM NETWORK: YES/NO[3]
- ☐ DEPTH TO GROUNDWATER TABLE > 2 FT: YES/NO[4]

1. NATIVE SOIL INFILTRATION NEEDS TO BE GREATER THAN 0.5 INCHES/HOUR. IF IT IS NOT AN UNDERDRAIN MUST BE INCLUDED.
2. IF STORAGE CAPACITY REQUIRED EXCEEDS AVAILABLE FOOTPRINT, INCREASE THICKNESS OF DRAINAGE AGGREGATE OR CONSIDER UNDERGROUND STORAGE.
3. CAPACITY OF DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
4. IF NO, TECHNIQUE MAY NOT MEET CODE WITHOUT A LINER.
5. STORMWATER PLANTER ON INDIANAPOLIS CULTURAL TRAIL, PHOTO BY GUIDON DESIGN.
6. USE DETAIL GI 3.02 CURB CUR AND SPLASH PAD DETAIL WHEN CURB CUT DRAINAGE AREA IS RELATIVELY LARGE ANND POTENTIAL FOR EROSION IS HIGH.
7. PROVIDE MINIMUM 10 FOOT SEPARATION BETWEEN PLANTER AND BUILDING FOUNDATIONS OR A LINER TO PREVENT SEEPAGE AND/OR DRAINAGE TO FOOTING DRAINS.

GI 3.01
1 OF 8
SCALE: NTS

STORMWATER PLANTER

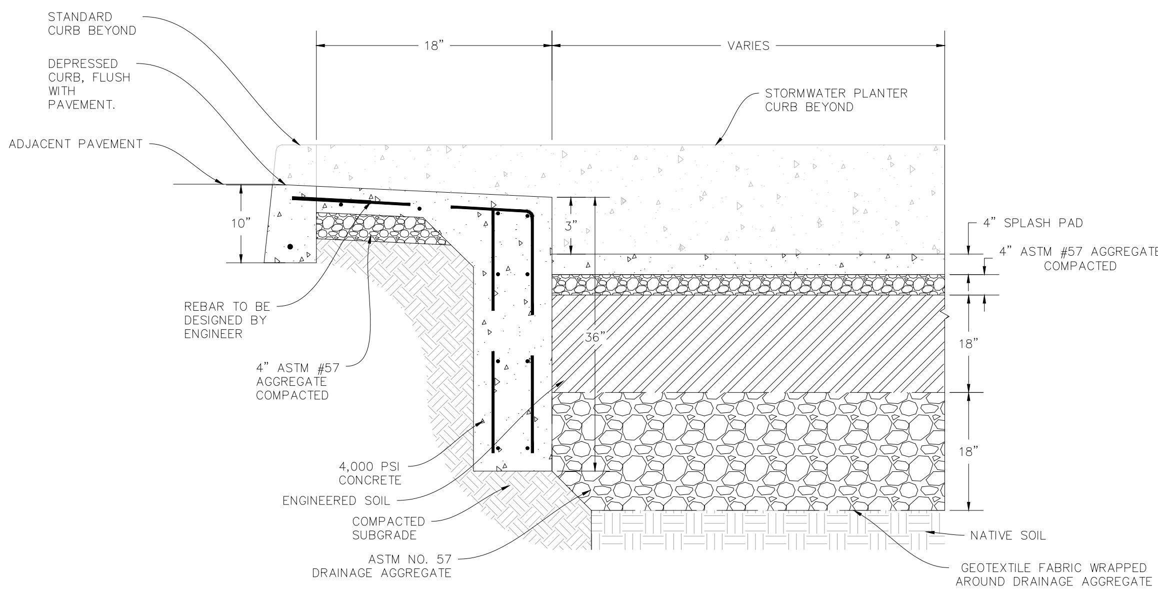
A COLLABORATION OF:

delta institute

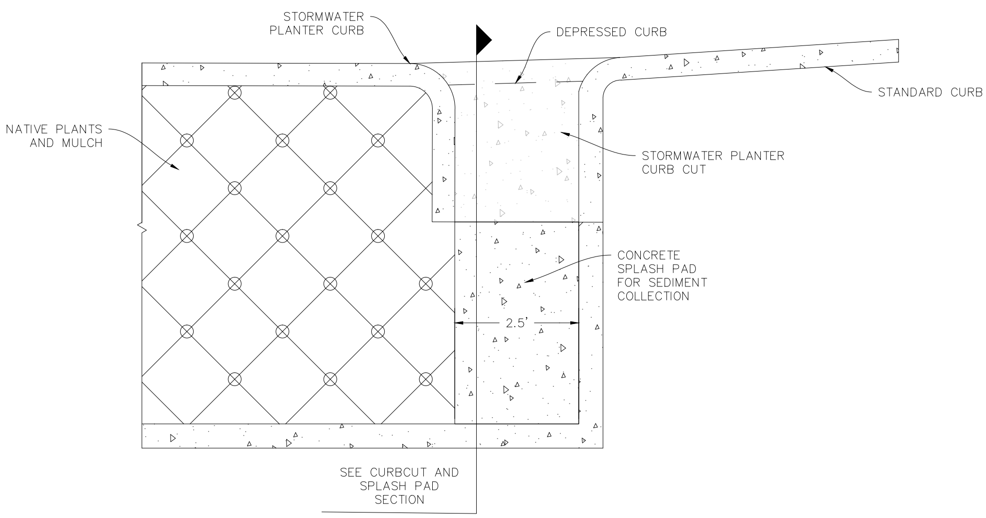
GUIDON DESIGN

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Stormwater Planter Curb Detail and Cut



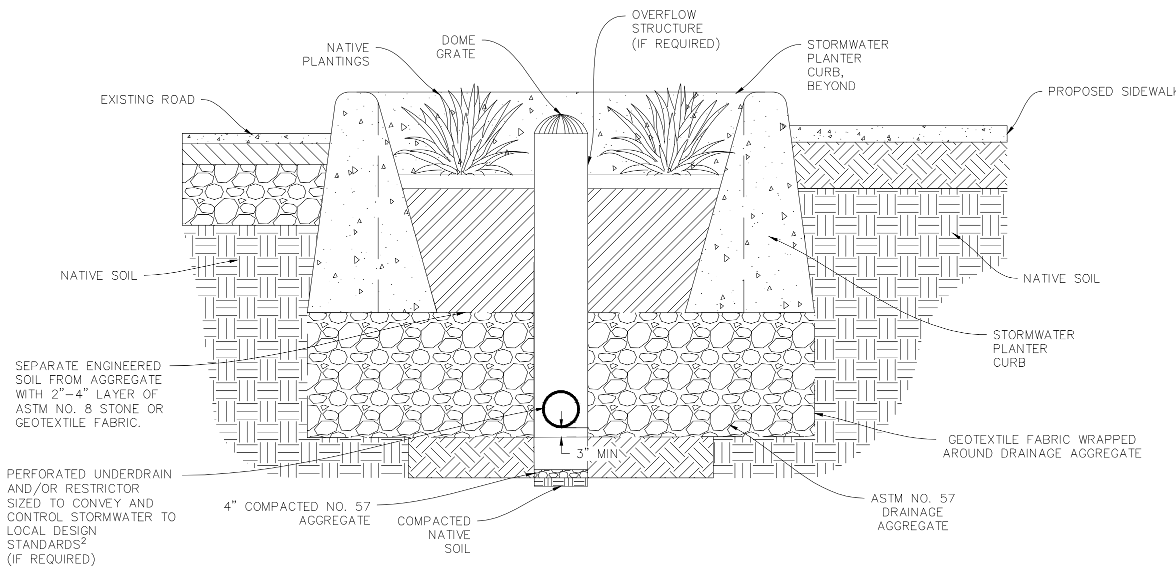
STORMWATER PLANTER CURB CUT AND SPLASH PAD DETAIL



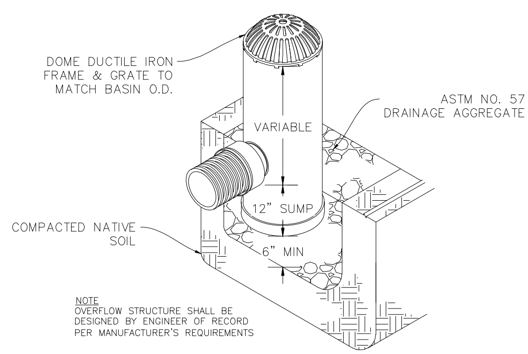
CURB CUT AND SPLASH PAD PLAN VIEW

	STORMWATER PLANTER CURB DETAIL AND CUT	A COLLABORATION OF: delta institute, GUIDON DESIGN, ILLINOIS DEPARTMENT OF NATURAL RESOURCES
GI 3.02 2 OF 8 SCALE: NTS		

Stormwater Planter with Overflow Structure



STORMWATER PLANTER WITH OVERFLOW SECTION[1]



OVERFLOW STRUCTURE

NOTE

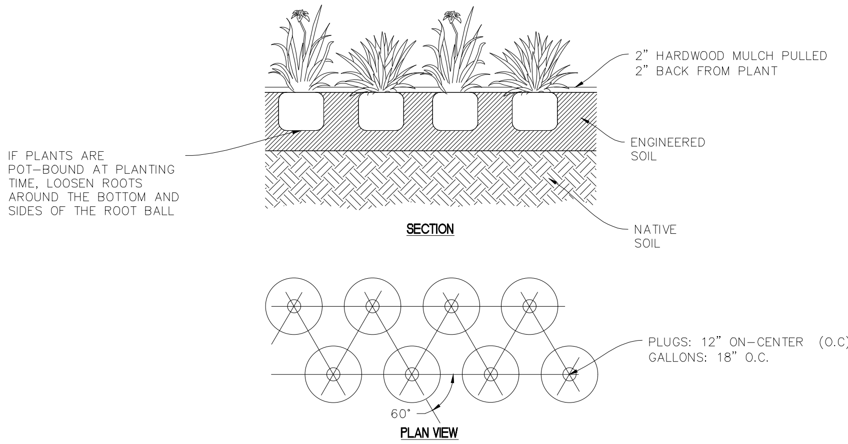
1. STORMWATER PLANTER WITH OVERFLOW STRUCTURE HAS THE SAME DIMENSIONS AS THE STORMWATER PLANTER SECTION SHOWN ON GI 3.01.

GI 3.03
3 OF 8
SCALE: NTS

STORMWATER PLANTER WITH OVERFLOW STRUCTURE

A COLLABORATION OF:

Native Plantings



NATIVE PLANTINGS PLUG DETAIL

MIX	BOTANICAL NAME	COMMON NAME	RECOMMENDED PLANTING METHOD	NATIVE TO ILLINOIS	MOISTURE
1/3	*GRASSES*				
	PANICUM VIRGATUM	SWITCH GRASS	PLUG	YES	MESIC-WET
	SORGHASTRUM NUTANS	INDIAN GRASS	PLUG	YES	MESIC
	CAREX VULPINOIDEA	FOX SEDGE	PLUG	YES	WET
1/3	*FLOWERS*				
	ASCLEPIAS INCARNATA	SWAMP MILKWEED	PLUG	YES	WET
	ASTER NOVAE-ANGILAE	NEW ENGLAND ASTER	PLUG	YES	MESIC-WET
	ECHINACEA PALLIDA	PALE PURPLE CONE FLOWER	PLUG	YES	MESIC
	IRIS VIRGINICA	BLUE FLAG IRIS	PLUG	YES	WET
	JUNCUS TORREYI	TORREY'S RUSH	PLUG	YES	WET
	LOBELIA CARDINALS	CARDINAL FLOWER	PLUG	YES	WET
	RUDBECKIA HIRTA	BLACK-EYED SUSAN	PLUG	YES	MESIC
	SOLIDAGO GIGANTEA	LATE GOLDENROD	PLUG	YES	MESIC-WET
	VERBENA HASTATA	BLUE VERVAIN	PLUG	YES	WET
1/3	*SEDGES*				
	CAREX LANUGINOSA	WOOLY SEDGE	PLUG	YES	WET
	CAREX SCOPARIA	LANCE-FRUITED OVAL SEDGE	PLUG	YES	WET
	CAREX VULPINOIDEA	FOX SEDGE	PLUG	YES	WET

SUGGESTED NATIVE PLANTING SPECIES AND MIX[1,2]

DESIGN GUIDANCE

PLUGS

- RECOMMENDED INSTALLATION METHOD FOR NATIVE PLANTS
- STANDARD SIZE IS 2" DIA. (11.3 CUBIC INCH BY VOLUME)
- AVG PRICE = $1.50/SF ($1.10/PLUG)
- OPTIMUM PLANTING WINDOW:
  APRIL 15–MAY 15 AND OCT 1–31.
- NUMBER OF PLUGS AT 12" O.C. = L X W X 1.10

GALLONS

- USE FOR MORE MATURE LOOKING PLANTS OR WHERE AESTHETICS AT INSTALLATION IS VERY IMPORTANT
- AVG PRICE = $3.00/SF ($5.00/GALLON)
- PLANTING WINDOW IS MORE FLEXIBLE BECAUSE OF GREATER ROOT MASS
- NUMBER OF GALLONS AT 18" O.C. = L X W X 0.50

1 TABLE IS AMENDED FROM THE ILLINOIS NATIVE PLANT GUIDE "SPECIES INFORMATION SUMMARY TABLE": HTTP://WWW.NRCS.USDA.GOV/WPS/PORTAL/NRCS/DETAIL/IL/TECHNICAL/?CID=NRCS141P2_030715#TABLE
2 REFER TO PLANT SELECTION SECTION OF THIS GUIDE FOR FURTHER ADVICE ON SELECTING AN APPROPRIATE PLANT MIX.

NATIVE PLANTING MAINTENANCE GUIDELINES

TASK	FREQUENCY	TIMEFRAME
ESTABLISHMENT WATERING	3XWEEK	FIRST 4 WEEKS AFTER INSTALLATION
1ST YEAR WATERING	2XWEEK	THROUGH OCTOBER OF FIRST YEAR; SUBSEQUENT YEARS ONLY IN DROUGHT
WEEDING	2X MONTH	THROUGH 1ST YEAR
MULCHING	ANNUALLY	THROUGH 3 YEARS
MOWING/COMPLETE CUTBACK	ANNUALLY	THROUGH 3 YEARS
TRASH REMOVAL	1XMONTH	ONGOING
TRIM VEGETATION	AS NEEDED	ONGOING
REPLACE DEAD PLANTS	AS NEEDED	ONGOING

GI 3.04
4 OF 8
SCALE: NTS

NATIVE PLANTINGS

A COLLABORATION OF:

delta institute

GUIDON DESIGN

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

RECOMMENDED TREE SPECIES FOR STORMWATER PLANTERS[2]			
COMMON NAME	GENUS	SPECIES	FAMILY
BOXELDER	ACER	NEGUNDO	ACERACEAE
FREEMAN MAPLE	ACER	X FREEMANII (RUBRUMXSACCA RINUM)	ACERACEAE
KENTUCKY COFFEETREE	GYMNOCLADUS	DIOICUS	FABACEAE
SWEETGUM HAPPIDAZE	LIQUIDAMBAR	STYRACIFLUA	HAMAMELIDACEAE
OSAGE ORANGE	MACLURA	POMIFERA	MORACEAE
BLACKGUM	NYSSA	SYLVATICA	CORNACEAE
AMERICAN SYCAMORE	PLATANUS	OCCIDENTALIS	PLATANACEAE
LONDON PLANETREE	PLATANUS X	ACERIFOLIA	PLATANACEAE
AMERICAN BASSWOOD	TILIA	AMERICANA	TILIACEAE
AMERICAN ELM	ULMUS	AMERICANA	ULMACEAE
AMERICAN ELM, PRINCETON	ULMUS	AMERICANA	ULMACEAE
AMERICAN ELM	ULMUS	AMERICANA	ULMACEAE

DIVERSITY OF TREE SPECIES IS AN IMPORTANT FACTOR TO CONSIDER. A COMMON RULE OF THUMB IS KNOWN AS THE 10–20–30 RULE[1]. IT STATES THAT IN AN URBAN FOREST POPULATION, NO SINGLE FAMILY, GENUS AND SPECIES OF TREE SHOULD MAKEUP MORE THAN 30%, 20% AND 10% RESPECTIVELY; OF THE TOTAL POPULATION. THIS IS RECOMMENDED IN ORDER TO MITIGATE RISK OF PEST AND DISEASE FATALITIES IN THE FUTURE.

1. SANTAMOUR, F.S., JR 1990. TREES FOR URBAN PLANTING: DIVERSITY UNIFORMITY, AND COMMON SENSE. TREES FOR THE NINETIES: LANDSCAPE TREE SELECTION, TESTING, EVALUATION, AND INTRODUCTION; PROCEEDINGS OF THE SEVENTH CONFERENCE OF THE METROPOLITAN TREE IMPROVEMENT ALLIANCE. PP 57–65

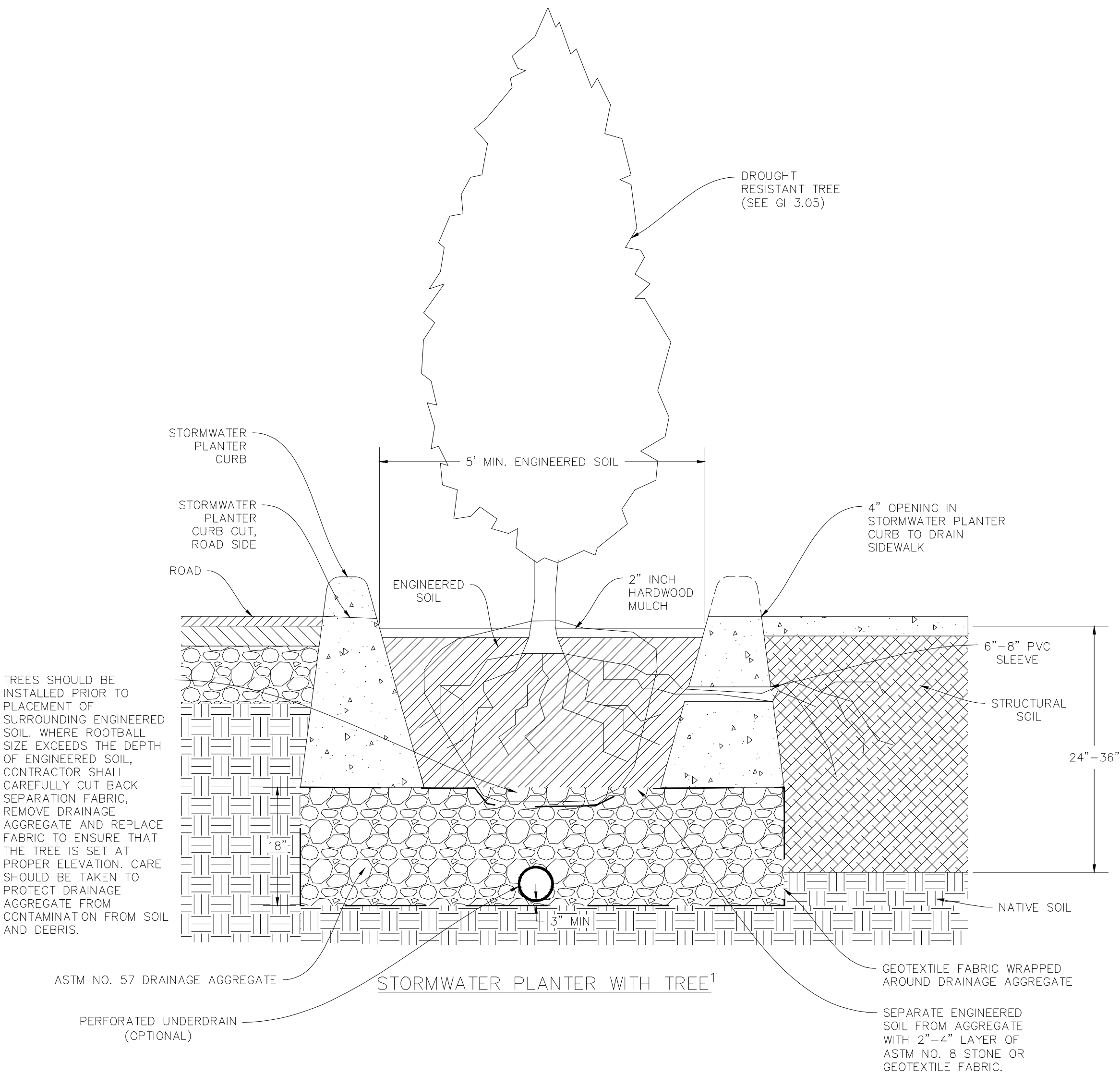
2 REFER TO PLANT SELECTION SECTION OF THIS GUIDE FOR FURTHER ADVICE ON SELECTING AN APPROPRIATE PLANT MIX.

GI 3.05
5 OF 8
SCALE: NTS

TREE SPECIES FOR STORMWATER PLANTERS

A COLLABORATION OF:

Stormwater Planter with Tree



STORMWATER PLANTER WITH TREE[1]

NOTE

1. STORMWATER PLANTER WITH TREE HAS THE SAME DIMENSIONS AS THE STORMWATER PLANTER SECTION SHOWN ON GI 3.01.

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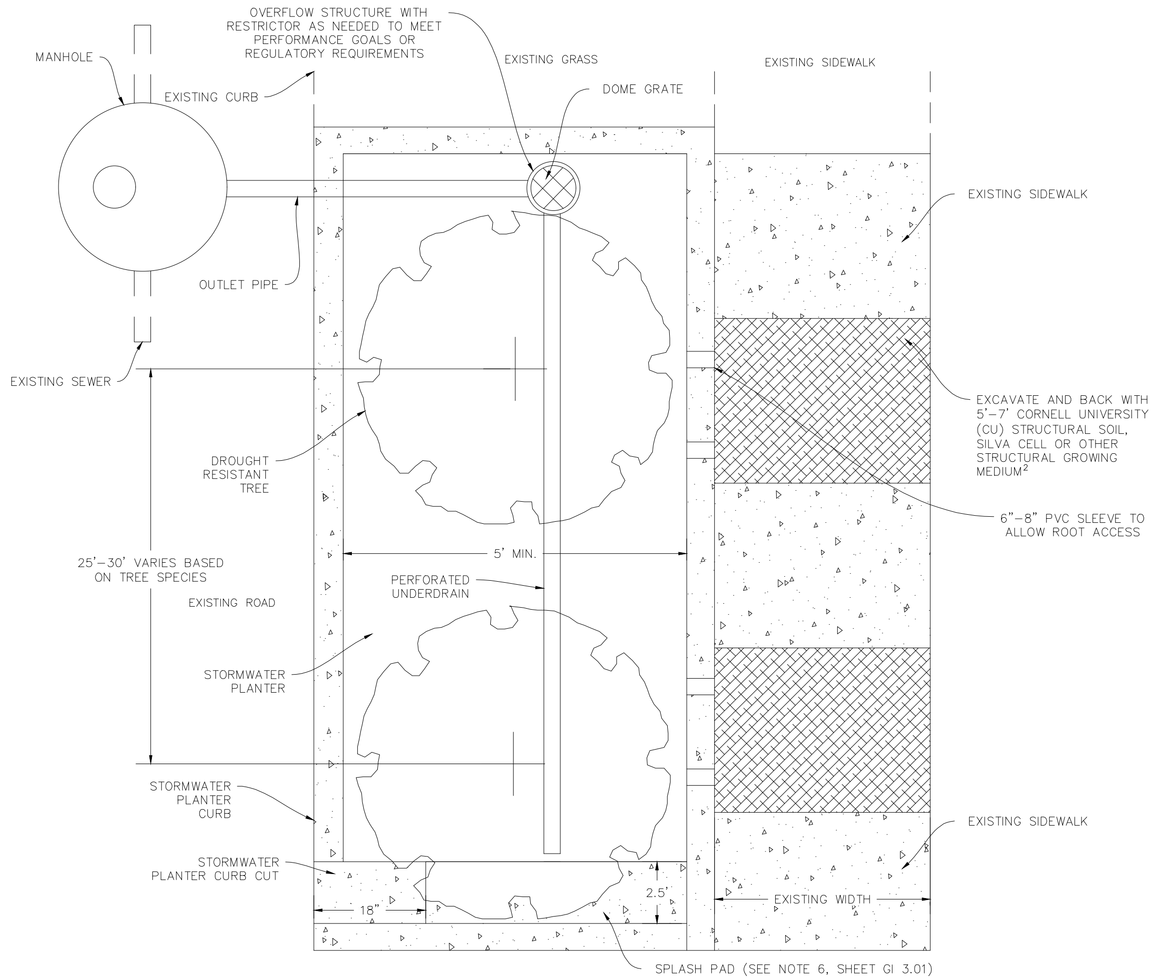
GI 3.06 6 OF 8 SCALE: NTS		

Stormwater Planter with Tree Plan View



STORMWATER PLANTER WITH TREE PLAN VIEW

DESIGN CONSIDERATIONS

☐ TREE SPACING[1]: ________ FT

☐ TREE PLANTING SOIL VOLUME[2]: ________ CUBIC FT

☐ PROVIDE DRAINAGE INTO PLANTER FROM ADJACENT SIDEWALK: YES/NO[3]

1. 40 FT – SPACING FOR BIG SHADE TREE, WILL TAKE MANY YEARS TO ACHIEVE SIGNIFICANT CANOPY.
   25–30 FT – SPACING FOR QUICK ESTABLISHMENT OF CANOPY, SOME CROWDING WHEN TREES REACH MATURITY.
   15–20 FT – SPACING FOR DENSE SPACING, WILL RESULT IN DIE OFF OR NECESSARY REMOVAL OF TREES IN 7–10 YEARS.
2. ULTIMATE TREE SIZE IS DIRECTLY CORRELATED TO GROWING MEDIUM VOLUME. SEE WWW.JAMESURBAN.NET/FLASHCARDS/
3. IF DESIRED, PROVIDE 4" OPENINGS IN STORMWATER PLANTER CURB TO ALLOW FOR DRAINAGE OF ADJACENT SIDEWALK

GI 3.07
7 OF 8
SCALE: NTS

STORMWATER PLANTER W/ TREE PLAN VIEW

A COLLABORATION OF:

delta institute · GUIDON DESIGN · ILLINOIS DEPARTMENT OF NATURAL RESOURCES

delta institute · ECT Environmental Consulting & Technology, Inc.

Stormwater Planter Notes

NOTES

1. STORMWATER PLANTER PLANTINGS:
   a. THE BIOSWALE SHOULD BE POPULATED WITH PLANTS NATIVE AND/OR ADAPTED TO THE INSTALLATION LOCATION. NATIVE PLANTS, GRASSES AND FLOWERS ESTABLISH DEEPER ROOTS AND IMPROVE SOIL HEALTH TO MAINTAIN PERMEABILITY.
   b. SELECT A MIXTURE OF NATIVE PLANTS BASED ON SITE CONDITIONS TO IMPROVE BIODIVERSITY AND AESTHETICS. SELECTED PLANTS SHOULD BE DROUGHT AND FLOOD TOLERANT. ONE SUCCESSFUL APPROACH USES THE FOLLOWING NATIVE PLANT MIX:
   $\frac{1}{3}$ SEDGES, $\frac{1}{3}$ FLOWERS, AND $\frac{1}{3}$ GRASSES.
2. SCHEDULE PRE-INSTALLATION MEETING WITH THE DESIGN ENGINEER 72 HOURS IN ADVANCE OF GREEN INFRASTRUCTURE CONSTRUCTION. PLANTING THAT REQUIRES FOOT OR MACHINE TRAFFIC SHALL ONLY BE CONDUCTED ON DRY SOILS
3. CONSTRUCT GREEN INFRASTRUCTURE AND INSTALL PLANTS AS EARLY AS POSSIBLE TO ALLOW FOR PLANT ESTABLISHMENT PRIOR TO DIRECTING STORMWATER TO IT. CONSIDER THE SELECTED PLANT SPECIES WHEN DETERMINING ESTABLISHMENT PERIOD.
4. AREAS IN AND AROUND GREEN INFRASTRUCTURE SHOULD BE PROTECTED DURING EARTH MOVING AND CONSTRUCTION TO PREVENT COMPACTION THAT WOULD REDUCE INFILTRATION RATES OF SUBGRADE AND ENGINEERED SOILS. ALSO PROTECT AREA THROUGHOUT CONSTRUCTION FROM SEDIMENT TRANSPORT THAT WOULD CLOG THE INFILTRATION CAPACITY OF NATIVE AND ENGINEERED SOILS.
5. CONTRACTOR SHOULD RAKE OR ROTOTILL THE TOP SIX INCHES OF SUBGRADE SOILS AFTER EXCAVATION TO REMEDIATE THE EFFECTS OF COMPACTION AND CLOGGING.
6. MINIMIZE NATIVE SOIL DISTURBANCE WHILE INSTALLING OVERFLOW STRUCTURE.

TREE NOTES

1. GROWING MEDIUM SHALL BE PLACED ADJACENT TO STORMWATER PLANTER.
2. GROWING MEDIUM TO BE EITHER CU STRUCTURAL SOIL OR SILVA CELL MATERIAL OR APPROVED EQUAL
3. VOLUME OF GROWING MEDIUM TO BE DETERMINED ACCORDING TO THE ABOVE MANUFACTURER'S RECOMMENDATIONS.
4. SELECTION OF THE TREE WILL BE BASED ON REGIONAL AVAILABILITY AND PRICE.

ENGINEERED SOIL SPECIFICATIONS

1. ENGINEERED SOIL MIX SHALL BE A BLEND OF 70% TO 90% COARSE SAND AND 10% TO 25% COMPOST BY VOLUME AND MEET THE FOLLOWING REQUIRMENTS:
   a. COMPOSE SHALL BE WELL AGED AND MEET WISCONSIN DNR TECHNICAL SPECIFICATION S100
   b. ORGANIC MATTER CONTENT OF MIX FROM 3-5% BY WEIGHT
   c. PROPORTION OF CLAY (HYDROMETER ANALYSIS) SHALL BE 2% TO 5%
   d. pH OF MIX SHALL BE 5.5 TO 8.0
   e. THE ENGINEERED SOIL THICKNESS SHALL BE ADEQUATE TO SUPPORT THE ROOTING DEPTH OF THE SELECTED VEGETATION WITH A MINIMUM THICKNESS OF 18 INCHES EXCEPT FOR THE HYBRID DITCH WHERE THE ENGINEERED SOIL MAY BE REDUCED TO 12"
2. ENGINEERED SOIL MAY BE OBTAINED OFF SITE OR CREATED BY TESTING NATIVE SOILS AND MIXING WITH IMPORTED MATERIALS AS NEEDED PROVIDED THE MIX MEETS THE SPECIFICATIONS ABOVE.
3. ENGINEERED SOIL SHALL BE DRY AND FRIABLE AND UNIFORMLY MIXED. ITS CHARACTERISTICS SHALL BE VERIFIED BY MATERIALS TESTING PRIOR TO PLACEMENT.
4. PLACE DRY AND FRIABLE SOIL IN 8-12 INCH LIFTS.
5. AFTER PLACEMENT, LIGHTLY COMPACT DRY SOIL WITH A HAND ROLLER WEIGHING NO MORE THAN 100 LBS PER FOOT OF WIDTH. DO NOT USE A VIBRATORY COMPACTOR.
6. TO PRESERVE INFILTRATION CAPACITY OF NATIVE SOIL, KEEP MACHINERY AND CONSTRUCTION SITE RUNOFFF OUTSIDE OF GREEN INFRASTRUCTURE AREA.

GEOTEXTILE FABRIC SPECIFICATION

1. A WOVEN, MONOFILAMENT GEOTEXTILE SHALL BE USED CONFORMING TO THE FOLLOWING:
   a. MINIMUM FLOW RATE OF 145 GAL/MIN/FT ASTM D-4491
   b. GRAB TENSILE STRENGTH MIN 365 X 200 LB ASTM D-4632
   c. GRAB ELONGATION MAX 24 X 10%ASTM D-4632
   d. TRAPEZOIDAL TEAR MIN 115 X 75 LBS ASTM D-4533
   e. CBR PUNCTURE RESISTANCE MIN 675 LB ASTM D-6241
   f. APPARENT OPENING SIZE 4060-90 U.S STANDARD SIEVE

GI 3.08
8 OF 8
SCALE: NTS

STORMWATER PLANTER NOTES

A COLLABORATION OF:

Naturalized Detention Practices

Detention basins are constructed depressions, with discharge sufficiently restricted to store stormwater, and gradually release it to the downstream drainage system. Control of stormwater discharge rates from new development has been required since the early 1980s in many parts of the Great Lakes region and detention basins have been used in the vast majority of cases to meet this requirement.

The earliest detention basins were dry bottom basins that completely drained between events. The basins were typically vegetated with turf grass and designed to control only the largest events to prevent flooding. Beginning in the middle 1990's detention basins began to be designed as wet ponds or shallow wetlands to improve pollutant removal performance and that practice continues today, as required by Federal, State, and local requirements. Simultaneously, the allowable stormwater release rate from urban developments has been reduced over the years in an attempt to mitigate both runoff volume and rate increases. As a result, detention times have increased and it has become increasingly difficult to prevent dry, turf bottom detention basins from becoming very muddy and unusable, as active recreational space. Due to the wet conditions and the need to provide water quality benefits, modern detention basins are typically designed as wet ponds or as shallow wetland basins, with vegetation that is suited to the wet conditions. The vegetation is maintained in a naturalized fashion and is usually comprised of native herbaceous plants from habitats that have growing conditions similar to those of the detention basin. Herbaceous plants consist of flowering perennials, grasses, and grass-like plants that have soft vascular structures which die back each winter, as opposed to woody plants that have persistent above-ground trunks and branches.

Detention basins rely primarily on settling to remove pollutants. However, additional removal can occur via biologic uptake and transformation by aquatic organisms and wetland vegetation. Settling efficiency and biologic uptake and transformation are dependent on the amount of time that runoff resides in the basin (also known as residence time). Wet ponds and shallow marsh basins increase the runoff residence time from the short period of the event to the extended period between events, and are therefore much more effective at pollutant removal than dry turf bottom basins.

Many jurisdictions in the Great Lakes region require control of large events to protect against flooding, as well as for more moderate sized events to protect against accelerated stream bank erosion and "flashy" hydrology that can impair stream, lake, and wetland ecology.

Bio-Retention Practices

- Wet-Bottom Detention Ponds
- Shallow Marsh Basins
- Dry Bottom Detention
- Typical Locations
- Downstream
- Subdivisions
- Campuses and Parks

Customization Options

Detention basins are relatively large facilities that occupy significant land area and therefore are best suited for larger developments located in suburban and rural areas where there is adequate space. In some cases, detention basins can be integrated into parks and other open space to provide passive and active recreational opportunities, in addition to stormwater management. In many larger developments, detention basins are designed as landscape features that act as both visual and recreational amenities, particularly when combined with trails, outlooks, boardwalks, and other features.

Where dry bottom detention basins may be desired to provide active recreational space, surface detention can be combined with upstream green infrastructure practices to meet water quality and runoff volume control requirements. The upstream green infrastructure will typically reduce the volume and frequency of runoff reaching the surface detention basin and therefore better support active use turf areas. Upstream green infrastructure will also improve the quality of runoff discharging to detention ponds, reducing the potential for algae blooms or other conditions in detention ponds that can sometimes be considered objectionable by residents.

Detention basins can often be located and designed as regional facilities, serving multiple developments (or multiple phases of a planned development) to improve space efficiency, and allow for larger ponds or basins that can serve as regional amenities. When the tributary developments are new, they should typically include on-site green infrastructure to improve the quality of runoff entering the regional basin, and to potentially reduce the size of stormwater conveyance infrastructure between the development and the detention basin.

For categorization purposes, there are three detention basin configurations as described below. However, there are infinite variations of basins that can be designed to include aspects and components of these three basic types.

Wet Bottom Detention Ponds

Detention ponds have a permanent pool of open water that is typically four to six feet deep or greater below the outlet structure. Historically, many detention ponds were vegetated with turf side slopes down to the water's edge or to a rip rap edge. Naturalized basins should include flat slopes around the perimeter of the pond to support emergent wetland vegetation that will provide aquatic and terrestrial habitat and improve water quality. Large ponds may also include islands and other features to increase visual and habitat diversity.

Shallow Marsh Basins

Shallow marsh detention basins feature a shallow depression below the outlet structure such that the bottom area is fully vegetated with emergent vegetation. The residence time is less with shallow marsh basins than with ponds, and therefore fewer pollutants are removed through settling. Greater interaction between runoff and native plants and their root systems increases the potential for biological uptake of nutrients.

Dry Bottom Detention

Dry bottom basins either have a flat bottom or positive slope along their floor leading to the outlet structure which results in much drier soils between rain events. They can be naturalized with native plants, like wet bottom and marsh basins are, though these plants will come from drier, mesic soil environments. Turf grass can also be used in dry bottom basins. Basins with turf grass will need minimum bottom slopes of 2% toward the outlet structure to ensure adequate drainage between events. Dry bottom basins with turf alone cannot meet the water quality and/or retention requirements of most stormwater ordinances, and therefore must be paired with upstream or downstream green infrastructure. Dry bottom basins with only turf provide little water quality benefit and are therefore not the focus of this document.

Maintenance

Inspection and maintenance activities for naturalized detention basins should focus on vegetative management, erosion repair, and sediment and debris removal. Inspection and maintenance activities will be most intensive during the first one to three years and can typically be reduced once initial design and construction issues are addressed and vegetation is established.

The outlet structure of detention basins should be inspected for debris that may be obstructing the outlet control orifice or weir. Detention basins should also be inspected to identify significant erosion at inlet structures, along the shoreline of wet ponds, and between the inlet and outlet of dry basins. Erosion potential is greatest prior to full vegetation establishment, but will continue through the life of the basin.

Detention basins should also be inspected for sedimentation that is most likely to occur near inlets to the basin. The rate of sediment accumulation may be significant if the tributary area is not stabilized and proper sediment control is not provided. Once the tributary area is stabilized the rate of sediment accumulation should slow. During the first year, the detention basin should be inspected monthly and after significant rainfall events that could cause erosion. After the first year and after issues have been resolved, annual inspection should be adequate.

Intensive landscape maintenance should occur during the first three years to ensure proper establishment of the landscape. Seeded landscapes may take up to five years to establish. At the end of the establishment period and in perpetuity after that, annual vegetative maintenance should occur. Annual prescribed burning is the preferred long term vegetative maintenance strategy for native grass-dominated landscapes. Mowing may be an alternative for areas where prescribed burn is not feasible. During the first year before the soil is fully stabilized, repair of gully erosion and scour holes may be necessary at points of concentrated inflow.

Cost Information

Cost information is provided for each green infrastructure technique in Section 5 of this report. The installed costs are based on project experience, bid tabs, and information from the RS Means trends, and the labor and bidding environment.

Table 7: Naturalized detention practices unit costs[1]

	Item	Description	Unit Price	Unit
GI Technique	Naturalized detention basin	Design/Engineering	15% of Construction Cost	LS
		Mobilization	$10,000.00	LS
		Excavation & Haul	$45.00	CY
		Grading	$12.00	SY
		Topsoil (6")	$25.00	CY
		Erosion Control Blanket	$3.00	SY
Required Component	Native Plantings	Seeding	$0.50	SF
		Plugs (12" on center)	$5.00	EA
		Gallons (36" on center)	$15.00	EA
	Inlet Protection	Rip Rap	$500.00	EA
	Outlet Control Structure	48" Manhole with Outlet Control	$2,800.00	EA
	Storm Sewer	12" HDPE storm sewer	$65.00	LF
	Connection to existing manhole		$600.00	EA
Custom Options	Impermeable Liner		$0.00	SF

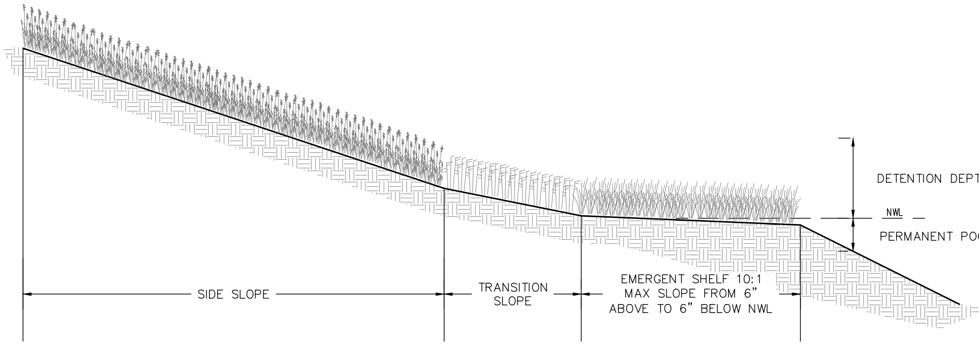
1 Installed cost include material and labor based on bid tabs from related projects and RS Means.

Specifications

Specifications are an important component in the design of green infrastructure. Along with the construction documents, the design engineer should modify the following Illinois Urban Manual specifications for the specific conditions present at the site. Other sections can be included on an as-needed basis.

Construction Specifications
2 - Clearing and Grubbing
5 - Pollution Control
6 - Seeding, Sprigging and Mulching
7 - Construction Surveys
8 - Mobilization and Demobilization
21 - Excavation
23 - Earthfill
25 - Rockfill
26 - Topsoiling
44 - Corrugated Polyethylene Tubing

Wet Bottom Detention Pond



WET BOTTOM DETENTION POND SECTION

DESIGN GUIDANCE – WET DETENTION PONDS

TYPICAL LOCATION: WITHIN OPEN SPACE AREAS OF RESIDENTIAL, COMMERCIAL, AND INSTITUTIONAL DEVELOPMENTS. REGIONAL DETENTION CAN BE LOCATED WITHIN PARKS AND OTHER OPEN SPACE

PERMANENT POOL: THE PERMANENT POOL DEPTH SHOULD BE A MINIMUM OF 4 – 6 FEET DEEP TO MINIMIZE RESUSPENSION OF BOTTOM SEDIMENTS AND MAINTAIN OPEN WATER CONDITIONS. THE POOL DEPTH SHOULD BE INCREASED TO TEN FEET TO SUPPORT FISH.

SIDE SLOPES: AT THE SHORELINE, SLOPES SHOULD BE 5:1 TO 10:1 OR FLATTER TO DISSIPATE WAVE ENERGY AND TO SUPPORT EMERGENT VEGETATION. APPROXIMATELY ONE FOOT ABOVE THE SHORELINE, THE SLOPE MAY BE INCREASED BUT TYPICALLY SHOULD NOT EXCEED 4:1 TO FACILITATE VEGETATIVE MANAGEMENT AND MAINTAIN BANK STABILITY.

SAFETY SHELF: MANY JURISDICTIONS REQUIRE A SAFETY SHELF BE PROVIDED WITHIN THE POND. A SHALLOW EMERGENT SHELF AT THE SHORELINE CAN SERVE AS A SAFETY SHELF.

SHORELINE EROSION PROTECTION: SHORELINES SHOULD BE PROTECTED FROM EROSION CAUSED BY WAVE ACTION AND WATER LEVEL FLUCTUATIONS. WHERE SHALLOW SHORELINE SLOPES ARE NOT PROVIDED, RIP RAP OR OTHER ARMORING SHOULD BE PROVIDED.

INLET PROTECTION: ARMORING SHOULD BE PROVIDED AT STORM SEWER INLETS TO PREVENT SCOUR BY HIGH VELOCITY FLOW ENTERING THE BASIN.

DETENTION DEPTH: THE DEPTH OF THE BASIN WILL BE DETERMINED BY THE REQUIRED DETENTION STORAGE VOLUME AND THE AREA OF THE BASIN. IT IS RECOMMENDED THAT THE DEPTH AT HIGH WATER LEVEL NOT EXCEED THREE FEET TO MINIMIZE NEGATIVE VEGETATION IMPACTS.

VEGETATION: NATIVE EMERGENT VEGETATION TOLERANT OF WATER LEVEL FLUCTUATIONS SHOULD BE PROVIDED ON THE EMERGENT SHELF. NATIVE HERBACEOUS VEGETATION SUITED TO WET–MESIC SOIL CONDITIONS SHOULD BE PLANTED BETWEEN THE SHORELINE AND THE HIGH WATER ELEVATION.

DETAILED DESIGN PRELIMINARY WORKSHEET

☐ 2–YEAR RELEASE RATE	________	CFS
100–YEAR RELEASE RATE	________	CFS
☐ PROVIDED DETENTION STORAGE	________	CF
☐ NORMAL WATER LEVEL	________	FT
☐ HIGH WATER LEVEL	________	FT
☐ PERMANENT POOL DEPTH	________	IN
☐ SIDE SLOPES	________	H: V
☐ AQUATIC SHELF?	________	Y/N

1. COMMENTS

GI 4.01
SCALE: NTS

WET BOTTOM DETENTION POND

A COLLABORATION OF:

delta institute
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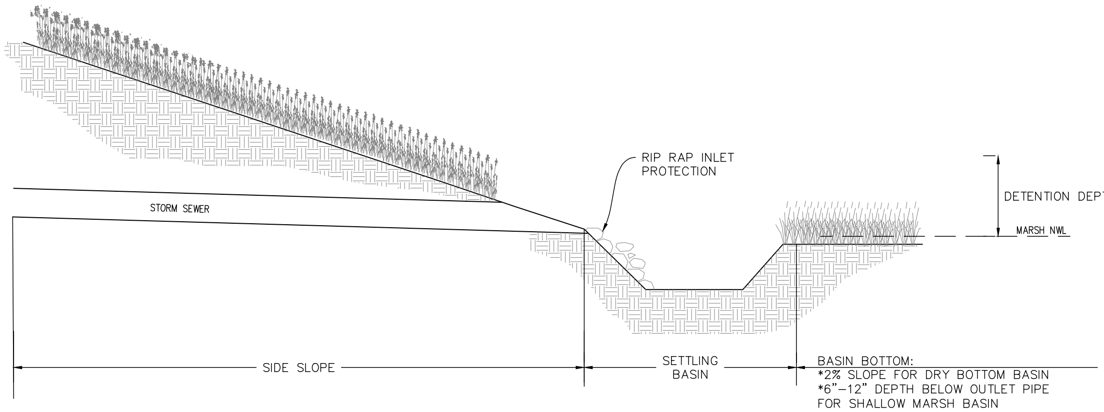
Shallow Marsh and Dry Bottom Detention Basin



SHALLOW MARSH AND DRY BOTTOM DETENTION SECTION

DESIGN GUIDANCE – SHALLOW MARSH AND DRY BOTTOM DETENTION

TYPICAL LOCATION: WITHIN OPEN SPACE AREAS OF RESIDENTIAL, COMMERCIAL, AND INSTITUTIONAL DEVELOPMENTS. REGIONAL DETENTION CAN BE LOCATED WITHIN PARKS AND OTHER OPEN SPACE

PERMANENT POOL: TO SUPPORT EMERGENT VEGETATION, THE PERMANENT POOL SHOULD NOT BE MORE THAN 6 – 12 INCHES DEEP. FOR DRY BOTTOM BASINS, THERE SHOULD BE NO PERMANENT POOL

SIDE SLOPES: SIDE SLOPES TYPICALLY SHOULD NOT EXCEED 4:1 TO FACILITATE VEGETATIVE MANAGEMENT AND MAINTAIN BANK STABILITY. NEAR THE BOTTOM OF THE BASIN, THE SLOPE SHOULD FLATTEN TO 5:1 OR 10: TO PROVIDE A SMOOTH TRANSITION FROM DRIER TO WETTER PLANT SPECIES.

INLET PROTECTION: SETTLING BASINS ARE RECOMMENDED AT EACH INLET TO PROVIDE ENERGY DISSIPATION AND SEDIMENT TRAPPING IN AN EASILY MAINTAINABLE LOCATION. THIS WILL ALSO REDUCE POTENTIAL SEDIMENT–INDUCED VEGETATION SMOTHERING IN THE BASIN. ARMORING SHOULD ALSO BE PROVIDED AT STORM SEWER INLETS TO PREVENT SCOUR BY HIGH VELOCITY FLOW ENTERING THE BASIN.

DEPTH: THE DEPTH OF THE BASIN WILL BE DETERMINED BY THE REQUIRED DETENTION STORAGE VOLUME AND THE DETENTION AREA OF THE BASIN. IT IS RECOMMENDED THAT THE DEPTH AT HIGH WATER LEVEL NOT EXCEED THREE FEET TO MINIMIZE NEGATIVE VEGETATION IMPACTS.

VEGETATION: NATIVE EMERGENT VEGETATION TOLERANT OF WATER LEVEL FLUCTUATIONS SHOULD BE PROVIDED ON THE BASIN FLOOR. NATIVE HERBACEOUS VEGETATION SUITED TO WET–MESIC SOIL CONDITIONS SHOULD BE PLANTED BETWEEN THE SHORELINE AND THE HIGH WATER ELEVATION.

GROUNDWATER INTERACTION: THE NORMAL WATER LEVEL (THE INVERT OF THE OUTLET CONTROL ORIFICE OR WEIR) SHOULD BE LOCATED ABOVE THE ORDINARY HIGH GROUNDWATER LEVEL TO AVOID CONTINUOUS FLOW THROUGH THE BASIN THAT WILL REDUCE RESIDENCE TIME AND WATER QUALITY PERFORMANCE.

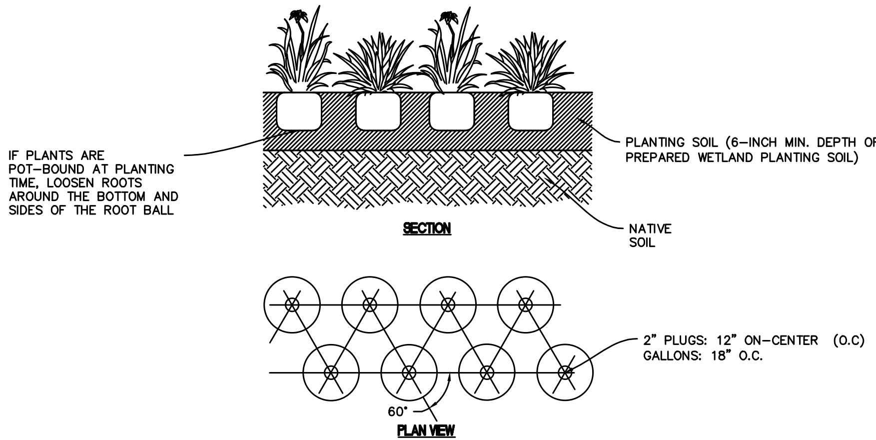
DETAILED DESIGN PRELIMINARY WORKSHEET

☐	2–YEAR RELEASE RATE	______	CFS
	100–YEAR RELEASE RATE	______	CFS
☐	PROVIDED DETENTION STORAGE	______	CF
☐	NORMAL WATER LEVEL	______	FT
☐	HIGH WATER LEVEL	______	FT
☐	PERMANENT POOL DEPTH	______	IN
☐	SIDE SLOPES	______	H: V

GI 4.02
SCALE: NTS

SHALLOW MARSH AND DRY BOTTOM DETENTION BASIN

A COLLABORATION OF:



NATIVE PLANTINGS PLUG DETAIL

MIX	BOTANICAL NAME	COMMON NAME	RECOMMENDED PLANTING METHOD	NATIVE TO MIDWEST	MOISTURE
2/3	**GRASSES, SEDGES, RUSHES**				
	Carex annectens (Carex brachyglossa)	Yellowfruit Sedge, Small Yellow Fox Sedge	PLUG	YES	MESIC - 6" EMERGENT
	Carex comosa	Bristly Sedge, Bottlebrush Sedge	PLUG	YES	WET - 6" EMERGENT
	Carex cristatella	Crested Oval Sedge	PLUG	YES	MESIC - 6" EMERGENT
	Carex hystericina	Bottlebrush Sedge, Porcupine Sedge	PLUG	YES	MESIC - 6" EMERGENT
	Carex vulpinoidea	Brown Fox Sedge	PLUG	YES	MESIC - 6" EMERGENT
	Glyceria grandis	American Manna Grass, Reed Manna Grass	PLUG	YES	WET - 6" EMERGENT
	Juncus effusus	Sof Rush	PLUG	YES	WET - 6" EMERGENT
	Juncus torreyi	Torrey's Rush	PLUG	YES	MESIC - 6" EMERGENT
	Leersia oryzoides	Rice Cut Grass	PLUG	YES	WET - 6" EMERGENT
	Schoenoplectus tabernaemontani	Soft-stem Bulrush	PLUG	YES	WET - 12" EMERGENT
	Scirpus atrovirens	Dark Green Bulrush	PLUG	YES	WET - 12" EMERGENT
	Scirpus cyperinus	Wool Grass	PLUG	YES	WET - 6" EMERGENT
1/3	**FORBS**	Common Water Plantain	BARE ROOT	YES	
	Alisma subcordatum	Common Water Plantain	BARE ROOT	YES	0" - 12" EMERGENT
	Iris virginica var. shrevii	Blue Flag Iris	BARE ROOT	YES	WET - 6" EMERGENT
	Pontedaria cordata	Pickerel Weed	BARE ROOT	YES	0" - 6" EMERGENT

SUGGESTED NATIVE PLANTING SPECIES AND MIX[1,2]

NATIVE PLANT INSTALLATION: EMERGENT PLANT SIZE SHOULD BE CHOSEN SO THAT TWO–THIRDS OF THE VEGETATION REMAINS ABOVE WATER AFTER PLANTING. EMERGENT PLANTS ARE OFTEN INSTALLED IN SUMMER AFTER SEASONALLY HIGH WATER LEVELS HAVE PASSED. FENCING AND GOOSE FOILS SHOULD BE INSTALLED TO PROTECT PLANTS FROM BROWSING.

1. REFER TO PLANT SELECTION SECTION OF THIS GUIDE FOR FURTHER ADVICE ON SELECTING AN APPROPRIATE PLANT MIX.
2. THIS PLANT MIX ASSUMES A NATURALIZED PLANTING FOR A SITE WITH FULL SUN, 0" TO 6" EMERGENT CONDITIONS, NEUTRAL PH, AND MEDIUM FLOOD DURATION.

GI 4.03
SCALE: NTS

NATURALIZED DETENTION PLANTING

A COLLABORATION OF:

delta institute

Environmental Consulting & Technology, Inc.

Naturalized Detention Notes

NATURALIZED DETENTION NOTES

SITE PREPARATION AND PROTECTION

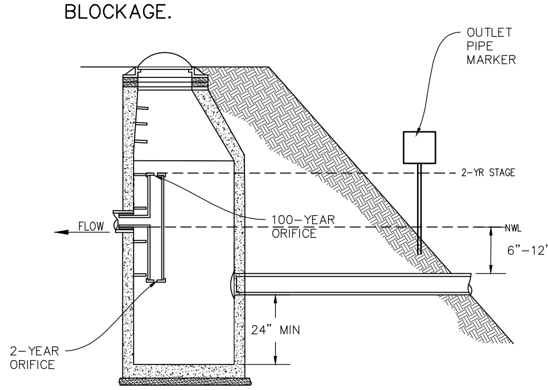
1. WHEN THE VEGETATED AREAS ARE LOCATED ON COMPACTED SOILS OR AREAS OF FILL, THE SURFACE SHOULD BE RIPPED TO A MINIMUM DEPTH OF 6 INCHES, RAKED TO A SMOOTH AND EVEN SURFACE, AND LIGHTLY COMPACTED TO SUPPORT FOOT TRAFFIC.
2. THE PREPARED DETENTION BASIN SHOULD BE PROTECTED FROM CONSTRUCTION SITE TRAFFIC TO AVOID SOIL COMPACTION
3. DURING CONSTRUCTION, THE DETENTION BASIN SHOULD BE PROTECTED FROM UNFILTERED CONSTRUCTION SITE RUNOFF THAT COULD CLOG THE SOIL SURFACE AND PREVENT VEGETATION ESTABLISHMENT.
4. IF THE DETENTION BASIN IS TO BE USED AS A SEDIMENT BASIN DURING CONSTRUCTION, SOFT, FINE SEDIMENT THAT IS READILY RESUSPENDED WHEN SATURATED SHOULD BE REMOVED PRIOR TO FINAL GRADING.

VEGETATION ESTABLISHMENT AND MANAGEMENT

1. THE ENTIRE BASIN SHOULD BE STABILIZED WITH EROSION CONTROL BLANKET. SEED SHOULD BE APPLIED PRIOR TO PLACEMENT OF THE BLANKET. PLUGS SHOULD BE PLANTED THROUGH THE BLANKET.
2. AREAS OF THE BASIN BELOW NORMAL WATER LEVEL AND THAT WILL BE MOST FREQUENTLY INUNDATED DURING EVENTS SHOULD BE ESTABLISHED USING PLANT PLUGS.
3. SIDE SLOPES THAT WILL NOT BE FREQUENTLY INUNDATED OR SUBJECT TO SHEET RUNOFF MAY BE ESTABLISHED FROM SEED.
4. SEEDING OF UPLAND AREAS SHOULD OCCUR IN SPRING OR AS A DORMANT FALL PLANTING. SEEDING SHOULD NOT OCCUR MID-SUMMER WHEN TEMPERATURE AND EVAPORATION RATES ARE HIGH UNLESS IRRIGATION WILL BE PROVIDED. PLUGGING OF UPLAND AREAS SHOULD OCCUR BETWEEN APRIL 15-JUNE 15, OR SEPT 1-OCT 15. LIVE WETLAND PLANTS ARE GENERALLY BEST PLANTED IN SUMMER AFTER SEASONALLY HIGH WATER LEVELS HAVE PASSED.
5. INTENSIVE VEGETATION MAINTENANCE SHOULD BE PROVIDED FOR A MINIMUM THREE-YEAR PERIOD UNTIL THE VEGETATION IS WELL ESTABLISHED AND CAN OUTCOMPETE WEEDS. DURING THE ESTABLISHMENT PERIOD, WEEDS SHOULD BE CONTROLLED THROUGH HAND PULLING OR SPOT HERBICIDE APPLICATION. SEEDED PLANTINGS MAY TAKE UP TO FIVE YEARS TO ESTABLISH.
6. ONCE ESTABLISHED, VEGETATION WILL REQUIRE A MINIMUM OF ANNUAL MONITORING AND MAINTENANCE TO CONTROL WEEDS. ANNUAL PRESCRIBED BURNING IS THE PREFERRED METHOD OF MAINTENANCE, BUT ANNUAL MOWING AND WEEDING MAY ALSO BE USED. WEEDING MUST OCCUR PRIOR TO WEED PLANTS SETTING SEED.

OUTLET CONTROL STRUCTURE NOTES

1. OUTLET CONTROL STRUCTURES SHOULD BE DESIGNED TO PREVENT CLOGGING FROM FLOATABLES AND SEDIMENT BURIAL. THIS IS PARTICULARLY IMPORTANT FOR SMALLER DEVELOPMENTS THAT REQUIRE VERY SMALL ORIFICES (<4 INCHES) TO MEET RELEASE RATE REQUIREMENTS.
2. TO PREVENT ORIFICE CLOGGING, IT IS RECOMMENDED THAT THE DISCHARGE PIPE FROM THE BASIN TO THE OUTLET CONTROL STRUCTURE BE LOCATED 6 TO 12 INCHES BELOW THE NORMAL WATER LEVEL TO REDUCE THE AMOUNT OF DEBRIS REACHING THE STRUCTURE. THE STRUCTURE SHOULD ALSO INCLUDE A SUBMERGED LOW FLOW (2-YEAR) ORIFICE TO FURTHER PREVENT DEBRIS BLOCKAGE.



NATURALIZED DETENTION OUTLET CONTROL DETAIL

MAINTENANCE NOTES

1. DETENTION BASIN OUTLET STRUCTURES SHOULD BE INSPECTED FOR CLOGGING AFTER EACH EVENT OVER 0.5 TO 1.0 INCHES DURING THE FIRST YEAR. BASED ON THE EXPERIENCE DURING THE FIRST YEAR, THE FREQUENCY CAN BE REDUCED IN FUTURE YEARS.
2. COMMUNITIES AND/OR PROPERTY OWNER ASSOCIATIONS SHOULD CONDUCT EDUCATION CAMPAIGNS FOR RESIDENTS AND LANDSCAPE CONTRACTORS TO ENSURE THAT DETENTION BASINS AREN'T USED AS DISPOSAL SITES FOR LANDSCAPE WASTE.
3. AN ACCESS ROUTE SHOULD BE PROVIDED FOR EQUIPMENT NECESSARY FOR SEDIMENT REMOVAL.
4. MAINTAINING HEALTHY AND WEED FREE PLANT COMMUNITIES IN THE LOWER PORTIONS OF WET PONDS AND WETLAND BASINS WILL REQUIRE STAFF AND/OR CONTRACTORS DEDICATED TO MANAGING THE BASINS. ADEQUATE FUNDING SOURCES SHOULD BE IDENTIFIED.

GI 4.04
SCALE: NTS

NATURALIZED DETENTION NOTES

A COLLABORATION OF:

Bio-Filtration Practices

Biofiltration practices are primarily focused on utilizing a site's blend of plant species, soils, and microorganisms to remove particulates from stormwater runoff, thereby improving water quality. While biofiltration is among the benefits provided by a bioretention practice (like a rain garden), bioretention practices are also designed to absorb stormwater on-site, in addition to treating it. Conversely, instead of absorbing the stormwater that it captures, biofiltration practices focus primarily on treating runoff as it moves through the site, in addition to reducing its velocity (which reduces erosion and sedimentation downstream). Improved stormwater infiltration may be the result of a biofiltration project, but it serves as a secondary benefit to its primary purpose, which is to clean and slow the flow of stormwater as it moves downstream.

Unlike bioretention and naturalized detention practices, which require a flat site grade, biofiltration sites are often applied on a slope, or at the crest of a sloping site, to help treat and slow stormwater runoff as it drains into a riparian body, basin, or storm sewer outfall. "Vegetated filter strips" are of the most common examples of a bio-filtration practice, which utilize a mixture of herbaceous plants to treat, slow, and evenly distribute stormwater runoff as it moves downstream. To enhance their ability to address flow velocity and distribution, vegetated filter strips are commonly implemented in tandem with level spreaders. An excavated depression installed at flat grade directly above or upstream from vegetated filter strips, the purpose of level spreaders is to convert faster, concentrated stormwater flow into a slower, more evenly distributed sheet flow. Vegetated swales are also an example of a biofiltration practice. Similar to bioswales, vegetated swale treat stormwater runoff as it moves through a site, assisted by the site's herbaceous plants and microorganisms, as it ultimately travels downstream.

While biofiltration is a valuable ecological service across all land uses, techniques that more exclusively focus on bio-filtration are common in rural, low density areas. Since rural areas tend to have less development, a greater abundance of pervious surfaces, and more flexibility around where to locate improvements on site, practices that are specifically focused on improving infiltration on site are not needed as greatly as they are in dense, urban areas with lots of impervious surfaces, where routine flooding is more directly related to poor drainage. Rural areas however can produce a great number of stressors on regional water quality, which oftentimes derive from agricultural land uses. Fertilizers, pesticides, equipment chemicals, and exposed soils (related to agriculture) can result in the significant loading of nutrients, pollutants, and sediment into rural water bodies, which serve to harm water quality and habitat throughout an entire watershed. In turn, biofiltration techniques serve as critical methods for treating runoff in rural locations before it enters into water bodies.

Filter Strip/Level Spreader

Vegetated filter strips are broad vegetated areas used to filter and absorb sheet runoff from adjacent land areas. Filter strips have long been used in agricultural areas to capture sediment runoff from agricultural fields, before it discharges into drainage-ways, streams, and other water bodies. They can also be used in urban applications to filter sheet runoff from parking lots and other broad impervious areas. Particularly in instances, where the rate of runoff may be large and long, a level spreader is often installed upstream from a filter strip, to reduce the velocity of runoff and distribute it over the width of the filter strip (ultimately, converting concentrated flow into sheet flow).

Filter strips may be used as a standalone BMP or as an upstream pre-treatment to downstream BMPs. For instance, a well-vegetated lawn can function as a filter strip, to "disconnect" roof runoff from the storm sewer system. In many cases, newly-graded landscapes may be used as locations for filter strips, particularly new lawns and freshly-graded areas that are adjacent to parking lots. In these cases, care must be taken during grading to provide proper conditions for sheet flow across the landscape. Proper soil and vegetative conditions should also be provided to allow new landscapes to thrive, protecting against erosion and providing high levels of filtration. This includes proper site preparation, use of a topsoil with low clay content, an erosion blanket, and intensive vegetation establishment measures. After installation, care must be taken to ensure that the filter strip is adequately stabilized prior to receiving runoff.

Combined level spreader-filter strip systems can also be used as a final step in a "treatment train," to avoid concentrated discharges to local water bodies and aquatic areas, while providing final "polishing" and absorption of runoff. In this case, existing undisturbed landscapes can also serve as locations for filter strips, where the vegetation and soil structure is well established, soil health is high, and the topography is free of rills or gullies.

When planned in tandem with filter strips, level spreaders must be installed in a manner that is level with the land contour, so that the runoff is uniformly distributed over the width of the receiving filter strip. Level spreaders must be designed to accommodate a wide range of flows from the smallest events to the 100-year storm event, without erosion or damage.

Customization Options

While filter strips mostly vary based on plant selection, level spreaders come in two basic forms: Berm Level Spreaders and Trench Level Spreaders. Although the appearance of these two forms differs greatly, both must be laid level along the contour to be successful. Berm level spreaders are berms constructed of open graded stone, typically placed downstream from a flared end section storm sewer discharge. The runoff from the storm sewer ponds behind the berm and uniformly seeps through the berm for most events. For large events, runoff can weir flow (or spill) over the top of the level berm. To prevent short circuiting and erosion at the ends of the level spreader, the level spreader must be tied into higher ground at the ends such that the ground elevation at the ends of the berm is higher than the level top of the berm.

Trench level spreaders are similar to infiltration trenches, but operate in reverse, with the runoff seeping out of the top of the level spreader and distributing as gentler sheet flow over the width of the filter strip, after the trench's total volume has been filled by runoff. Trench level spreaders can be used to intercept surface runoff that is coming from an upstream location, or can be introduced via a perforated pipe receiving runoff from a detention basin. (See the detail 6.02 in this section.) As with a berm level spreader, the trench level spreader must be able to accommodate a broad range of flows.

The choice of selecting a berm or trench level spreader will depend on site-specific conditions such as topography, storm sewer depth, visual access, and flow rates. Berm level spreaders will typically be able to manage a larger range of flow rates than trench types, since large events can flow over the top of the berm. Trench level spreaders will be more appropriate downstream of detention storage where discharge rates are moderated. Trench level spreaders are also much less visible in the landscape, being mostly below grade. In many cases, vegetation will tend to migrate into trench level spreaders, making them less visible over time. Soil should not be introduced into the level spreader to avoid loss of hydraulic capacity, however, a modest amount of plant growth within the trench will not significantly affect performance.

Maintenance

Inspection and maintenance activities will be most intensive during the site's first three years, and typically may be reduced once initial design and construction issues are addressed, and landscapes are established. Inspections should identify whether significant erosion and sedimentation has transpired, along with assessing vegetative health. The ends of the level spreaders, particularly trench level spreaders, should be marked with permanent stand-posts (or other markers), since they can be difficult to locate as vegetation grows within and around the level spreader. Inspections on level spreaders, particularly in Year 1 should identify areas where the stone has shifted or obvious low points where most of the runoff is discharging. Filter strip inspections should identify whether rill or gully erosion has transpired. The vegetation should also be inspected to identify bare areas that could be subject to erosion or areas of weed growth. In Year 1, the level spreader and filter strip should be inspected monthly and after significant rainfall events, which can cause erosion. After Year 1 (and any corrective measures), annual inspection is adequate.

Maintenance will be most intensive during the site's first three years during the filter strip's vegetation's establishment period. For filter strips located on newly graded and/or vegetated areas, intensive landscape maintenance should occur in the first three years to ensure proper establishment of the landscape. After the first three years, annual vegetative maintenance should occur. Annual prescribed burning is the preferred long term vegetative maintenance strategy for native prairie-type landscapes. However, mowing may be an alternative for areas where a prescribed burn is not feasible. Level spreaders should be kept free of woody vegetation that could displace stone or affect hydraulic performance. However, fine rooted herbaceous vegetation should not affect performance and need not be removed.

Cost Information

Cost information is provided for each green infrastructure practice in Section 5 of this report. The installed costs are based on project experience, bid tabs, and information from the RS Means trends, and the labor and bidding environment.

Table 8: Bio-filtration practices unit costs[1]

	Item	Description	Unit Price	Unit
GI Technique	Vegetated filter strip	Design/Engineering	15% of Construction Cost	LS
		Mobilization	$10,000.00	LS
		Excavation & Haul	$45.00	CY
		Grading	$12.00	SY
		Erosion Control Blanket	$3.00	SY
Required Component	Vegetation Establishment	Seeding & Sod	$0.50	SF
		Plugs (12" on center)	$5.00	EA
		Gallons (36" on center)	$15.00	EA
Custom Options	Berm Level Spreader		$200.00	LF
	Trench Level Spreader		$100.00	LF
	Invasive Species Removal	Herbacide Application	$1,000.00	ACRE

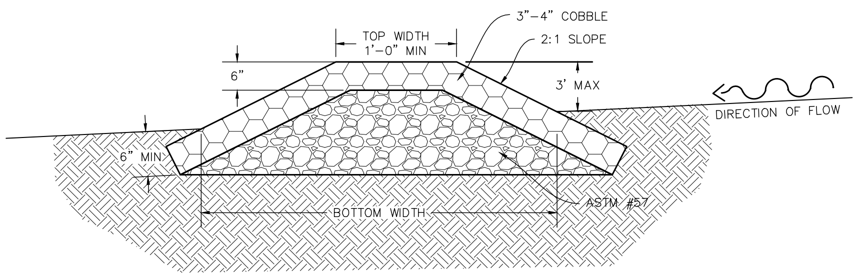
1 Installed cost include material and labor based on bid tabs from related projects and RS Means.

Specifications

Specifications are an important component in the design of green infrastructure. Along with the construction documents, the design engineer should modify the following Illinois Urban Manual specifications for the specific conditions present at the site. Other sections can be included on an as-needed basis.

Construction Specifications

2 - Clearing and Grubbing
5 - Pollution Control
6 - Seeding, Sprigging and Mulching
7 - Construction Surveys
8 - Mobilization and Demobilization
21 - Excavation
23 - Earthfill
25 - Rockfill
26 - Topsoiling
44 - Corrugated Polyethylene Tubing



BERM LEVEL SPREADER SECTION

DESIGN GUIDANCE – BERM LEVEL SPREADER

TYPICAL LOCATION: DETENTION OUTLET PIPE AND OTHER LOCATIONS OF CONCENTRATED RUNOFF.

LEVEL SPREADER LENGTH: THE LENGTH OF THE LEVEL SPREADER (LENGTH OF BERM) SHOULD MATCH THE WIDTH OF THE DOWNSTREM FILTER STRIP AND/OR BE LONG ENOUGH TO LIMIT THE DISCHARGE RATE TO 0.20 CFS/FT OF LEVEL SPREADER LENGTH AS DESCRIBED ON SHEET GI 5.03.

DESIGN FLOW RATES: THE LEVEL SPREADER SHOULD BE DESIGNED TO PASS THE 90 % EVENT THROUGH THE GRAVEL BERM WITHOUT OVERTOPPING. THE 100–YEAR EVENT SHOULD BE USED TO SIZE THE SURFACE ROCK TO PREVENT DAMAGE DURING LARGE EVENTS.

LEVEL SPREADER HEIGHT: THE HEIGHT OF THE LEVEL SPREADER SHOULD BE SUFFICIENT TO PASS THE DESIGN FLOW RATE. THE FLOW CAPACITY CAN BE CALCULATED FROM DARCY'S LAW. THE UNIT WIDTH FLOW RATE IS GIVEN BY Q=KIH WHERE:

Q=UNIT WIDTH FLOW (CFS/FT)

K=HYDRAULIC CONDUCTIVITY = 0.13 FT/S FOR ¾" OPEN GRADED STONE

I=HYDRAULIC GRADIENT (UNITLESS)=BERM HEIGHT/BERM BOTTOM WIDTH

H=DEPTH OF FLOW THROUGH BERM = HEIGHT OF BERM.

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ UNIT WIDTH FLOW RATE ________ CFS/FT
- ☐ LEVEL SPREADER WIDTH ________ FT
- ☐ LEVEL SPREADER BOTTOM WIDTH ________ FT
- ☐ LEVEL SPREADER HEIGHT ________ FT

1. COMMENTS

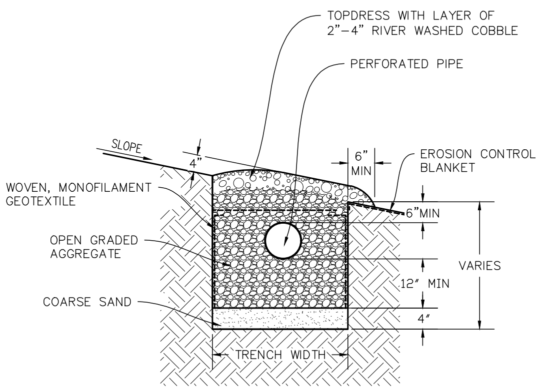
GI 5.01
SCALE: NTS

BERM LEVEL SPREADER

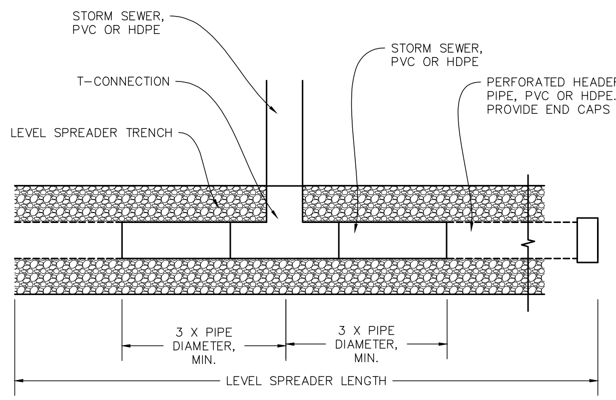
A COLLABORATION OF:

delta institute
ECT Environmental Consulting & Technology, Inc.
RISC SOLUTIONS

Trench Level Spreader



TRENCH LEVEL SPREADER SECTION



TRENCH LEVEL SPREADER DETAIL

DESIGN GUIDANCE – TRENCH LEVEL SPREADER

TYPICAL LOCATION: DETENTION OUTLET PIPE AND OTHER LOCATIONS OF CONCENTRATED RUNOFF.

LEVEL SPREADER LENGTH: THE LENGTH OF THE LEVEL SPREADER (LENGTH OF BERM) SHOULD MATCH THE WIDTH OF THE DOWNSTREAM FILTER STRIP AND/OR LONG ENOUGH TO LIMIT THE DISCHARGE RATE TO 0.20 CFS/FT OF LEVEL SPREADER LENGTH AS DESCRIBED ON SHEET GI 5.03

PERFORATED PIPE SIZE: THE PERFORATED PIPE SERVES AS A MANIFOLD TO DISTRIBUTE THE RUNOFF OVER THE LENGTH OF THE LEVEL SPREADER AND THEREFORE THE PIPE SHOULD BE SIZED TO MINIMIZE HEADLOSS OVER ITS LENGTH UNDER THE DESIGN FLOW RATE.

TRENCH WIDTH: THE TRENCH WIDTH SHOULD BE SUFFICIENT TO ACCOMMODATE THE EXPECTED FLOW RATES WITH ACCEPTABLE HEADLOSS AND WITHOUT DISPLACEMENT OF THE STONE WITHIN THE TRENCH DUE TO UPLIFT. TYPICALLY A TRENCH WIDTH THAT IS THREE TIMES THE PERFORATED PIPE DIAMETER WILL BE ADEQUATE WITH A MINIMUM TRENCH WIDTH OF TWO FEET.

TRENCH DEPTH: THE TRENCH SHOULD BE SUFFICIENTLY DEEP TO ACCOMMODATE THE SECTION SHOWN HERE.

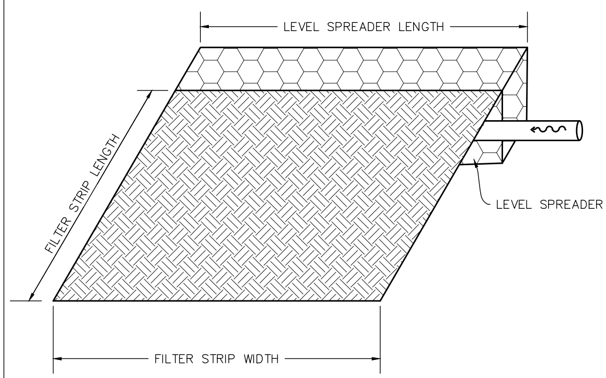
DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ UNIT WIDTH FLOW RATE ____________ CFS/FT
- ☐ LEVEL SPREADER WIDTH ____________ FT
- ☐ LEVEL SPREADER TRENCH WIDTH ____________ FT
- ☐ LEVEL SPREADER TRENCH DEPTH ____________ FT

1. COMMENTS

	TRENCH LEVEL SPREADER	A COLLABORATION OF:
GI 5.02 SCALE: NTS		

Vegetated Filter Strip



VEGETATED FILTER STRIP

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ UNIT WIDTH FLOW RATE: ________ CFS/FT
- ☐ FILTER STRIP WIDTH: ________ FT
- ☐ FILTER STRIP LENGTH: ________ FT
- ☐ FILTER STRIP SLOPE: ________ FT

1. COMMENTS

DESIGN GUIDANCE – FILTER STRIP

TYPICAL LOCATION: DOWNSPOUT DISCHARGES, EDGES OF PARKING LOTS OR OTHER PAVED AREAS, DETENTION OR OTHER GSI OUTLET PIPES, AND OTHER LOCATIONS OF CONCENTRATED RUNOFF.

WIDTH: THE WIDTH OF THE FILTER STRIP WILL VARY BASED ON SITE SPECIFIC CONDITION AND FLOW RATES BUT SHOULD BE AS WIDE AS FEASIBLE TO MINIMIZE THE FLOW RATE THAT MUST BE MANAGED PER FOOT OF WIDTH OF THE FILTER STRIP. GENERALLY, THE MINIMUM WIDTH SHOULD BE 20 FEET AND THE FLOW AND THE DISCHARGE RATE SHOULD NOT EXCEED APPROXIMATELY 0.20 CFS/FT OF WIDTH.

FILTER STRIP SLOPE: THE FILTER STRIP SLOPE SHOULD NOT EXCEED 2% TO 5% TO PREVENT RE-CONCENTRATION OF RUNOFF AND RILL EROSION.

FILTER STRIP LENGTH: THE POLLUTANT REMOVAL AND RUNOFF REDUCTION PERFORMANCE OF THE FILTER STRIP IMPROVES WITH INCREASING FILTER STRIP LENGTH. HOWEVER, MAINTAINING SHEET FLOW FOR LENGTHS GREATER THAN 100 TO 300 FEET CAN BE DIFFICULT. WORK BY THE CHICAGO METROPOLITAN AGENCY FOR PLANNING (CMAP) SHOWED THAT PERFORMANCE IS OPTIMIZED WHEN THE LENGTH OF THE FILTER STRIP IS HALF THE EFFECTIVE IMPERVIOUS LENGTH.CMAP DEFINED THE EFFECTIVE IMPERVIOUS LENGTH AS TRIBUTARY IMPERVIOUS AREA DIVIDED BY THE WIDTH OF THE FILTER STRIP WIDTH.

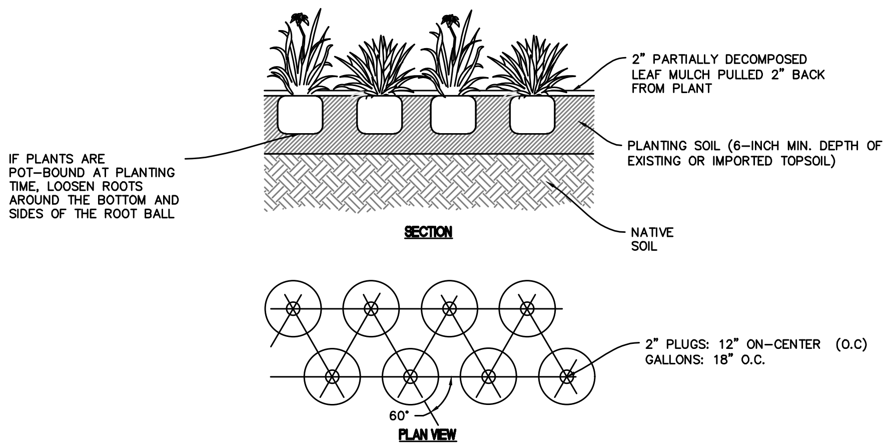
FILTER STRIP VEGETATION: A DENSE STAND OF HERBACEOUS (NON-WOODY) VEGETATION SHOULD BE ESTABLISHED TO PREVENT SURFACE EROSION. TALLER VEGETATION WILL INCREASE THE ROUGHNESS OF THE FILTER STRIP AND REDUCE VELOCITIES AND POTENTIAL FOR EROSION. THE PLANT MIXTURE CAN BE COMPOSED OF TURFGRASSES IN AREAS THAT WILL RECEIVE RELATIVELY SMALL AMOUNTS OF RUNOFF, SUCH AS AT RESIDENTIAL DOWNSPOUT LOCATIONS. FOR AREAS WITH LARGER RUNOFF VOLUMES, NATIVE GRASS-DOMINATED PLANT COMMUNITIES (LIKE PRAIRIES) SHOULD BE USED. A PLANT COMMUNITY NATIVE TO THE REGION SHOULD BE CHOSEN BASED UPON SITE SPECIFIC CONDITIONS SUCH AS SUN EXPOSURE AND SOIL MOISTURE. SALT TOLERANT SPECIES SHOULD BE SPECIFIED FOR FILTER STRIPS THAT WILL RECEIVE SALTY WINTER RUNOFF FROM PARKING LOTS AND ROADWAYS.

GI 5.03
SCALE: NTS

VEGETATED FILTER STRIP

A COLLABORATION OF:

Filter Strip Planting



NATIVE PLANTINGS PLUG DETAIL

MIX	BOTANICAL NAME	COMMON NAME	RECOMMENDED PLANTING METHOD	NATIVE TO MIDWEST	MOISTURE
2/3	**GRASSES & SEDGES**				
	Bouteloua curtipendula	Side Oats Grama Grass	PLUG	YES	DRY-MESIC
	Carex hystericina	Bottlebrush Sedge, Porcupine Sedge	PLUG	YES	MESIC-WET
	Carex stipata	Fox Sedge, Awl Fruit Sedge, Prickly Sedge	PLUG	YES	MESIC-WET
	Elymus canadensis	Canada Wild Rye	PLUG	YES	DRY-MESIC
	Schizachyrium scoparium	Little Bluestem	PLUG	YES	DRY-MESIC
	Sorghastrum nutans	Indian Grass	PLUG	YES	DRY-MESIC
	Sporobolus heterolepis	Prairie Dropseed	PLUG	YES	DRY-MESIC
1/3	**FORBS**				
	Asclepias verticillata	Whorled Milkweed	PLUG	YES	DRY-MESIC
	Coreopsis palmata	Prairie Coreopsis	PLUG	YES	DRY-MESIC
Legume	*Dalea purpurea (Petalostemum purpureum)*	Prairie Clover	PLUG	YES	MESIC
	Monarda fistulosa	Wild Bergamot	PLUG	YES	DRY-MESIC
	Penstemon digitalis	Foxglove Beard Tongue	PLUG	YES	DRY-MESIC
	Ratibida pinnata	Grey-head Coneflower	PLUG	YES	MESIC
	Zizia aurea	Golden Alexanders	PLUG	YES	MESIC

SUGGESTED NATIVE PLANTING SPECIES AND MIX[1,2]

INSTALLATION GUIDANCE

TURFGRASS INSTALLATION: TO ESTABLISH VEGETATION QUICKLY, IT IS RECOMMENDED THAT TURFGRASS SOD BE USED. IF SEEDING IS USED, RUNOFF SHOULD BE DIVERTED UNTIL AT LEAST 12 WEEKS AFTER INITIAL GERMINATION. THE OPTIMAL PLANTING WINDOWS FOR SOD ARE APRIL 15 – JUNE 15 AND SEPT 1 – OCT 31.

NATIVE PLANT INSTALLATION: TO ESTABLISH VEGETATION QUICKLY, IT IS RECOMMENDED THAT NATIVE PLANTS BE INSTALLED AS 2" DIAMETER PLUGS. THE 2" PLUGS SHOULD BE PLANTED 12 TO 18 INCHES APART. IT'S USUALLY MORE EFFECTIVE TO USE SMALLER PLANTS LIKE THE 2" PLUGS ON TIGHTER SPACINGS THAN PLANTS IN LARGER CONTAINERS ON LARGER SPACINGS. THE OPTIMAL PLANTING WINDOWS FOR CONTAINERIZED NATIVE HERBACEOUS PLANTS ARE MAY 15 – JUNE 30 AND SEPT 1 – OCT 15.

1. REFER TO PLANT SELECTION SECTION OF THIS GUIDE FOR FURTHER ADVICE ON SELECTING AN APPROPRIATE PLANT MIX.
2. THIS PLANT MIX ASSUMES A NATURALIZED PLANTING FOR A SITE WITH FULL SUN, DRY TO MESIC SOILS, NEUTRAL PH, MEDIUM SALT EXPOSURE, AND SHORT FLOOD DURATION.

GI 5.04
SCALE: NTS

FILTER STRIP PLANTING

A COLLABORATION OF:

Filter Strip/Level Spreader Notes

FILTER STRIP NOTES

1. SITE PREPARATION AND PROTECTION
   - 1.1. WHEN THE FILTER STRIP IS LOCATED ON COMPACTED SOILS OR AREAS OF FILL, THE SURFACE SHOULD BE RIPPED TO A MINIMUM DEPTH OF 6 INCHES, RAKED TO A SMOOTH AND EVEN SURFACE, AND LIGHTLY COMPACTED TO SUPPORT FOOT TRAFFIC.
   - 1.2. THE PREPARED FILTER STRIP AREA SHOULD BE PROTECTED FROM CONSTRUCTION SITE TRAFFIC TO AVOID SOIL COMPACTION
   - 1.3. DURING CONSTRUCTION, THE FILTER STRIP AREA SHOULD BE PROTECTED FROM UNFILTERED CONSTRUCTION SITE RUNOFF THAT COULD CLOG THE SOIL SURFACE AND PREVENT VEGETATION ESTABLISHMENT.
   - 1.4. THE FILTER STRIP SHOULD BE STABILIZED WITH EROSION CONTROL BLANKET. SEED SHOULD BE APPLIED PRIOR TO PLACEMENT OF THE BLANKET. PLUGS SHOULD BE PLANTED THROUGH THE BLANKET.
2. VEGETATION ESTABLISHMENT
   - 2.1. FILTER STRIPS MAY BE ESTABLISHED FROM SEED AND/OR PLANT PLUGS/SOD, BUT LIVE PLANT PLUGS/SOD ARE PREFERRED.THE FILTER STRIP SHOULD BE COVERED WITH EROSION BLANKET.
   - 2.2. IF SEEDING IS USED, THE FILTER STRIP AREA SHOULD BE SEEDED, COVERED WITH EROSION BLANKET, AND PLANTED AS SPECIFIED BY THE ENGINEER.
   - 2.3. IF SEEDING IS USED, IT SHOULD OCCUR IN SPRING OR AS A DORMANT FALL PLANTING. SEEDING SHOULD NOT OCCUR MID-SUMMER WHEN TEMPERATURE AND EVAPORATION RATES ARE HIGH UNLESS IRRIGATION WILL BE PROVIDED.
   - 2.4. FOR NATIVE HERBACEOUS PLANTINGS, INTENSIVE VEGETATION MAINTENANCE SHOULD BE PROVIDED FOR A MINIMUM THREE-YEAR PERIOD UNTIL THE VEGETATION IS WELL ESTABLISHED AND CAN OUTCOMPETE WEEDS. DURING THE ESTABLISHMENT PERIOD, WEEDS SHOULD BE CONTROLLED THROUGH HAND PULLING OR SPOT HERBICIDE APPLICATION.
   - 2.5. ONCE NATIVE HERBACEOUS PLANTINGS ARE ESTABLISHED, VEGETATION WILL REQUIRE A MINIMUM OF ANNUAL MONITORING AND MAINTENANCE TO CONTROL WEEDS. ANNUAL PRESCRIBED BURNING IS THE PREFERRED METHOD OF MAINTENANCE BUT ANNUAL MOWING AND WEEDING MAY ALSO BE USED. WEEDING MUST OCCUR PRIOR TO WEED PLANTS SETTING SEED.

BERM LEVEL SPREADER NOTES

1. THE LEVEL SPREADER LAYOUT MUST BE SURVEYED TO ENSURE THE THAT THE BASE OF THE SPREADER IS LOCATED ON THE CONTOUR.
2. THE BASE OF THE LEVEL SPREADER SHOULD BE EMBEDDED A MINIMUM OF 6 INCHES INTO THE SOIL SURFACE TO AVOID UNDERMINING OF THE LEVEL SPREADER.
3. THE TOP OF THE SPREADER SHOULD BE SURVEYED LEVEL EXCEPT AT THE RAISED ENDS.
4. THE LEVEL SPREADER ENDS SHOULD CONTINUE UPSLOPE TO A GROUND ELEVATION THAT IS A MINIMUM OF 6 TO 12 INCHES ABOVE THE CREST OF THE CENTRAL LEVEL SPREADER TO ENSURE THAT RUNOFF DOES NOT FLOW AROUND THE LEVEL SPREADER.
5. THE CORE OF THE LEVEL SPREADER SHOULD BE COMPOSED OF APPROXIMATELY 1"OPEN GRADED STONE TO PROVIDE FILTRATION OF RUNOFF.
6. THE SURFACE OF THE LEVEL SPREADER SHOULD 3"- 6"OPEN GRADED STONE AS NEEDED TO PROVIDE STABILITY DURING OVER-TOPPING.

TRENCH LEVEL SPREADER NOTES

1. THE LEVEL SPREADER LAYOUT MUST BE SURVEYED TO ENSURE THE THAT THE SPREADER IS LOCATED ON THE CONTOUR.
2. THE TRENCH LEVEL SPREADER SHOULD BE COMPOSED OF A MINIMUM 24"DEEP BY 24"WIDE TRENCH FILLED WITH 1"OPEN GRADED STONE. (ALSO SEE DETAIL NOTES)
3. THE TOP OF THE TRENCH SHOULD BE CAPPED WITH 2"TO 4"OPEN GRADED STONE TO PROVIDE STABILITY.
4. THE TRENCH SHOULD BE OVERFILLED A MINIMUM OF 4 INCHES AND THE STONE SHOULD EXTEND A MINIMUM OF 6 INCHES DOWNSLOPE FROM THE TRENCH TO PROTECT THE TRENCH EDGE FROM EROSION AND PROMOTE RUNOFF SEEPAGE FROM THE FACE OF THE LEVEL SPREADER.

GI 5.05
SCALE: NTS

FILTER STRIP / LEVEL SPREADER NOTES

A COLLABORATION OF:

Vegetated Swale

Swales are constructed open channel drainageways. Swales are used as an alternative to, or an element of, conventional storm sewer drainage systems. Swales vegetated with grass or other suitable vegetation provide natural conveyance and at the same time filter pollutants and allow for modest infiltration. Naturalized vegetation is comprised of native herbaceous plants from habitats that have growing conditions similar to those of the swale, and can provide greater benefits than standard turf grass. Herbaceous plants consist of flowering perennials, grasses, and grass-like plants that have soft vascular structures which die back each winter, as opposed to woody plants that have persistent above-ground trunks and branches. Where possible, natural drainageways on the development site should be maintained and used as part of the swale drainage system. This requires that locations of structures and lots be based on site topography and natural features. Where man-made swales are installed, the guidelines in this section should be used to aid in their design, maximize their pollutant removal, and minimize the potential for erosion problems.

Vegetated swales are typically used as an alternative to storm sewers and can be used for drainage along roadways, between homes, and other local runoff management applications. Vegetated swales can also be used for more regional applications to manage runoff from whole neighborhoods and larger geographies.

Properly designed vegetated swales provide water quality and runoff volume reduction benefits, as well as conveyance, but do not significantly reduce discharge rates. Thus, vegetated swales are often part of a system of green infrastructure that also includes detention (at a minimum) to provide rate control.

Customization Options

There are many customization options for vegetated swales, including selection of vegetation, use of check dams, and integration with bioretention. Vegetated swales can be planted with traditional turf grass or can be naturalized to enhance infiltration and filtration. Naturalized vegetation may also be better suited to swales that receive significant runoff and/or are located on low gradient slopes.

The water quality and runoff volume reduction performance of vegetated swales can be further enhanced by inclusion of shallow check dams to retain and filter runoff. Check dams can take many forms, including low soil berms, permeable rock berms, and porous soil berms. Low soil berms retain runoff behind them, infiltrating the runoff ponded upstream. Permeable rock berms generally pass low flows, but slow runoff from larger events, reducing the potential for scour and modestly reducing flow rates. Porous soil berms allow slow drainage through them, providing time for infiltration and also providing physical filtration as runoff slowly passes through the berm. Vegetated porous soil berms put filtered runoff into contact with the root systems, enhancing uptake of nutrients. Through spacing and armoring, soil check dams must be protected from scour, as runoff cascades over the crest of the dam.

Vegetated swales can also be designed as bioretention, featuring bioretention soil and gravel storage to further improve infiltration and filtration. Many local jurisdictions will not provide credit toward runoff reduction requirements for swales unless they include check dams or are designed as hybrid swale/bioretention systems.

Maintenance

Inspection and maintenance activities for vegetated swales should focus on vegetative management, erosion repair, and sediment and debris removal. Inspection and maintenance activities will be most intensive during the first one to three years and typically may be reduced once initial design and construction issues are addressed and vegetation is established.

Vegetated swales should be inspected to identify significant erosion and sedimentation as well as to assess vegetative health. The swale and soil check dams should be inspected to identify scour in need of repair, with particular focus on culvert crossings and stormwater inlets. Extended periods of low flow can lead to formation of pilot channels that may need repair or stabilization. The vegetation should be inspected to identify bare areas that could be subject to erosion or significant weeds. During the first year, the swale should be inspected monthly and after significant rainfall events that could cause erosion. After the first year and after issues have been resolved, annual inspection should be adequate.

Maintenance will be most intensive during the first year when scour protection at culverts and storm inflows may need adjustment. For swales vegetated with native vegetation, intensive vegetative maintenance should occur during the first three to five years to ensure proper establishment of the landscape and control of weeds. At the end of the establishment period and in perpetuity after that, annual vegetative maintenance should occur. Annual prescribed burning is the preferred long term vegetative maintenance strategy for native landscapes. However, mowing may be an alternative for areas where prescribed burning is not feasible.

Cost Information

Cost information is provided for each green infrastructure technique in Section 5 of this report. The installed costs are based on project experience, bid tabs, and information from the RS Means trends, and the labor and bidding environment.

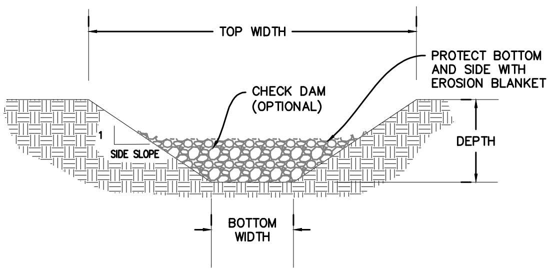
Table 9: Vegetated swale practices unit costs

	Item	Description	Unit Price	Unit
GI Technique	Vegetated swale	Design/Engineering	15% of Construction Cost	LS
		Mobilization	$10,000.00	LS
		Excavation & Haul	$45.00	CY
		Grading	$12.00	SY
		Erosion Control Blanket	$3.00	SY
Required Component	Vegetation Establishment	Seeding & Sod	$0.50	SF
		Plugs (12" on center)	$5.00	EA
		Gallons (36" on center)	$15.00	EA
Custom Options	Berm Check Dam		$600.00	EA
	Driveway Culvert	12" RCP w/ end sections	$2,500.00	EA

Specifications

Specifications are an important component in the design of green infrastructure. Along with the construction documents, the design engineer should modify the following Illinois Urban Manual specifications for the specific conditions present at the site. Other sections can be included on an as-needed basis.

Construction Specifications
2 - Clearing and Grubbing
5 - Pollution Control
6 - Seeding, Sprigging and Mulching
7 - Construction Surveys
8 - Mobilization and Demobilization
21 - Excavation
23 - Earthfill
25 - Rock Riprap
26 - Topsoiling
27 - Diversions and Waterways



VEGETATED SWALE SECTION

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ 6–MONTH DESIGN FLOW RATE: ________ CFS
- 10–YEAR DESIGN FLOW RATE: ________ CFS
- ☐ BOTTOM WIDTH: ________ FT
- ☐ SIDE SLOPES: ________ H: V
- ☐ TOP WIDTH: ________ FT
- ☐ SWALE VEGETATION: ________

DESIGN GUIDANCE – VEGETATED SWALE

TYPICAL LOCATION: WITHIN RIGHT OF WAY ALONG STREETS AND HIGHWAYS AND DRAINAGEWAYS WITHIN RESIDENTIAL, COMMERCIAL AND INSTITUTIONAL CAMPUS DEVELOPMENTS.

SIDE SLOPE AND BOTTOM WIDTH: SIDE SLOPES SHOULD BE 4:1 OR FLATTER TO MINIMIZE VELOCITIES BUT MAY BE REDUCED TO 3:1 WHERE SPACE IS CONSTRAINED. A 2–FOOT MINIMUM BOTTOM WIDTH SHOULD BE USED TO FACILITATE MAINTENANCE.

DEPTH: DEPTH IS DETERMINED BY REQUIRED CAPACITY, LONGITUDINAL SLOPE, BOTTOM WIDTH, SIDE SLOPES, AND VEGETATION

DESIGN FLOW RATE: REQUIRED CAPACITY IS TYPICALLY SPECIFIED BY LOCAL CODE WITH MOST REQUIRING 10–YEAR DESIGN FOR LOCAL SWALES AND 50–YEAR TO 100–YEAR CAPACITY FOR REGIONAL SWALES.

DESIGN VELOCITY: TO PROMOTE FILTERING AND SETTING, SWALES SHOULD BE DESIGNED FOR 1.5 FT/S OR LOWER VELOCITIES FOR 6–MONTH AND SMALLER EVENTS. FOR LARGE EVENTS, THE VELOCITY SHOULD NOT EXCEED THE PERMISSIBLE VELOCITY FOR THE GIVEN VEGETATION AND LONGITUDINAL SLOPE.

SWALE VEGETATION: TALLER GROWING NATIVE VEGETATION WILL REDUCE VELOCITIES AND IMPROVE WATER QUALITY PERFORMANCE. SHORTER VEGETATION WILL IMPROVE CAPACITY. A PLANT COMMUNITY NATIVE TO THE REGION SHOULD BE CHOSEN BASED UPON SITE SPECIFIC CONDITIONS SUCH AS SUN EXPOSURE AND SOIL MOISTURE. SALT TOLERANT SPECIES SHOULD BE SPECIFIED FOR SWALES THAT WILL RECEIVE SALTY WINTER RUNOFF FROM PARKING LOTS AND ROADWAYS.

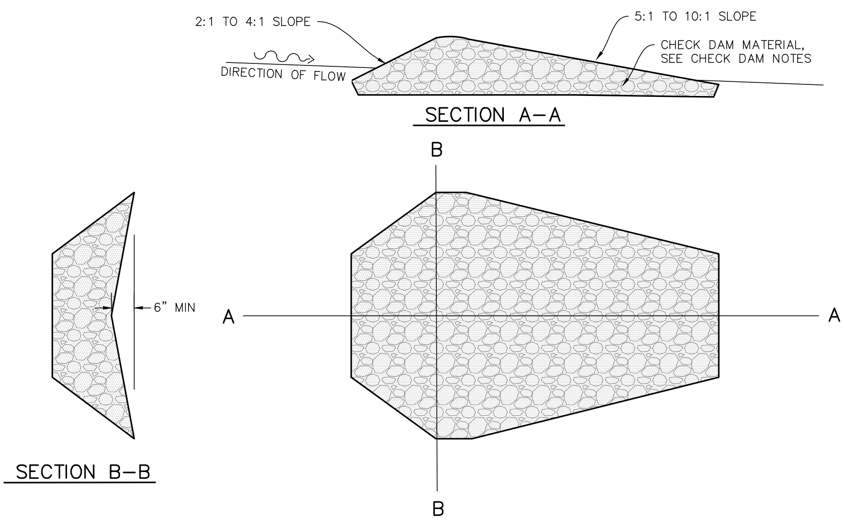
ROUGHNESS AND RETARDANCE: WHEN SIZING A SWALE, ITS DIMENSIONS SHOULD BE DETERMINED USING RETARDANCE AND DESIGN TABLES OR MANNING'S EQUATION USING APPROPRIATE N–VALUES. SWALE CAPACITY SHOULD BE BASED ON RETARDANCE FACTORS A OR B FOR TALLER NATIVE VEGETATION OR FACTORS D OR E FOR LOW GROWING TURF VEGETATION. SEE NRCS FOR USE OF RETARDANCE FACTORS FOR SWALE SIZING. ALSO SEE THE CHECK DAM DESIGN GUIDANCE FOR SIZING SWALES FEATURING CHECK DAMS.

GI 7.01
SCALE: NTS

VEGETATED SWALE

A COLLABORATION OF:

Swale Check Dam



SWALE CHECK DAM DETAIL

DESIGN GUIDANCE – CHECK DAMS

TYPICAL LOCATION: ROCK CHECK DAMS ARE USED FOR STEEPER SWALES TO PREVENT SCOUR. SOIL CHECK DAMS ARE USED OR TO ENHANCE INFILTRATION AND FILTRATION OF RUNOFF.

CHECK DAM MATERIAL: SEE THE NOTES SECTION OF THIS DETAIL FOR RECOMMENDED MATERIALS FOR SOIL, ROCK, AND POROUS SOIL CHECK DAMS.

CHECK DAM VEGETATION: SOIL CHECK DAMS CAN BE VEGETATED WITH THE SAME PLANT MATERIAL AS THE REMAINDER OF THE SWALE.

CHECK DAM HEIGHT: THE HEIGHT AND MATERIAL OF THE CHECK DAM SHOULD BE DESIGNED TO ALLOW DRAINAGE OF UPSTREAM WATER WITHIN 12 TO 48 HOURS, DEPENDING ON UPSTREAM VEGETATION.

CHECK DAM SPACING: TO MINIMIZE THE POTENTIAL FOR SCOUR AT THE BASE OF CHECK DAMS, THEY SHOULD BE SPACED SUCH THAT THE CREST OF THE DOWNSTREAM CHECK IS ABOVE THE BASE OF THE UPSTREAM CHECK DAM.

CHECK DAM & SWALE SIZING: WHEN SIZING A SWALE TO PROVIDE ITS DESIGN CAPACITY, THE INFLUENCE OF CHECK DAMS MUST BE CONSIDERED. FOR SHALLOW FLOW OVER A CHECK DAM, THE BROAD–CRESTED WEIR EQUATION MAY BE USED. FOR DEEPER FLOWS, CHANNEL ROUGHNESS WILL CONTROL AND THE CHANNEL CROSS SECTION BELOW THE CREST OF THE DAMS SHOULD BE IGNORED WHEN CALCULATING CHANNEL CONVEYANCE CAPACITY.

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ CHECK DAM MATERIAL ____________
- ☐ CHECK DAM VEGETATION ____________
- ☐ CHECK DAM HEIGHT ____________ FT
- ☐ CHECK DAM SPACING ____________ FT

1. COMMENTS

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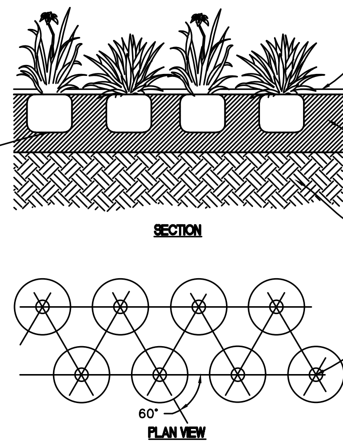
Vegetated Swale Planting



MIX	BOTANICAL NAME	COMMON NAME	RECOMMENDED PLANTING METHOD	NATIVE TO MIDWEST	MOISTURE
2/3	GRASSES & SEDGES				
	Bromus kalmii	Prairie Brome, Kalm's Brome	PLUG	YES	MESIC-WET
	Carex brevior	Plains Oval Sedge	PLUG	YES	DRY-WET
	Carex bromoides	Brome-Like Sedge	PLUG	YES	MESIC-WET
	Carex granularis	Limestone Meadow Sedge	PLUG	YES	MESIC-WET
	Carex pellita	Wolly Sedge	PLUG	YES	WET
	Carex vulpinoidea	Brown Fox Sedge	PLUG	YES	MESIC-WET
	Glyceria striata	Fowl Manna Grass	PLUG	YES	MESIC-WET
	Leersia oryzoides	Rice Cut Grass	PLUG	YES	WET
	Panicum virgatum	Switch Grass	PLUG	YES	MESIC-WET
	Spartina pectinata	Prairie Cord Grass	PLUG	YES	MESIC-WET
1/3	FORBS				
	Asclepias incarnata	Swamp Milkweed	PLUG	YES	MESIC-WET
	Lobelia siphilitica	Great Blue Lobelia	PLUG	YES	MESIC-WET
	Lythrum alatum	Winged Loosestrife	PLUG	YES	MESIC-WET
	Packera obovata (Senecio obovatus)	Squaw Weed	PLUG	YES	MESIC-WET
	Rudbeckia subtomentosa	Sweet Coneflower	PLUG	YES	MESIC-WET
Legume	Senna hebecarpa (Cassia hebecarpa)	Wild Senna, American Senna, Wild Cassia	PLUG	YES	MESIC-WET
	Veronicastrum virginicum	Culver's Root	PLUG	YES	MESIC-WET

SUGGESTED NATIVE PLANTING SPECIES AND MIX[1,2]

NATIVE PLANT INSTALLATION: TO ESTABLISH VEGETATION QUICKLY, IT IS RECOMMENDED THAT NATIVE PLANTS BE INSTALLED AS 2" DIAMETER PLUGS. THE 2" PLUGS SHOULD BE PLANTED 12 TO 18 INCHES APART. IT'S USUALLY MORE EFFECTIVE TO USE SMALLER PLANTS LIKE THE 2" PLUGS ON TIGHTER SPACINGS THAN PLANTS IN LARGER CONTAINERS ON LARGER SPACINGS. THE OPTIMAL PLANTING WINDOWS FOR CONTAINERIZED NATIVE HERBACEOUS PLANTS ARE MAY 15 – JUNE 30 AND SEPT 1 – OCT 15.

1. REFER TO PLANT SELECTION SECTION OF THIS GUIDE FOR FURTHER ADVICE ON SELECTING AN APPROPRIATE PLANT MIX.
2. THIS PLANT MIX ASSUMES A NATURALIZED PLANTING FOR A SITE WITH FULL SUN, MESIC TO WET SOILS, NEUTRAL PH, LOW SALT EXPOSURE, AND SHORT FLOOD DURATION.

	VEGETATED SWALE PLANTING	A COLLABORATION OF:
GI 7.03 SCALE: NTS		delta institute ECT Environmental Consulting & Technology, Inc.

Vegetated Swale and Check Dam Notes

VEGETATED SWALE NOTES

1. SITE PREPARATION AND PROTECTION
 1.1. WHEN THE SWALE IS LOCATED ON COMPACTED SOILS OR AREAS OF FILL, THE SURFACE SHOULD BE RIPPED TO A MINIMUM DEPTH OF 6 INCHES, RAKED TO A SMOOTH AND EVEN SURFACE, AND LIGHTLY COMPACTED TO SUPPORT FOOT TRAFFIC.
 1.2. THE PREPARED SWALE SHOULD BE PROTECTED FROM CONSTRUCTION SITE TRAFFIC TO AVOID SOIL COMPACTION
 1.3. DURING CONSTRUCTION, THE SWALE SHOULD BE PROTECTED FROM UNFILTERED CONSTRUCTION SITE RUNOFF THAT COULD CLOG THE SOIL SURFACE AND PREVENT VEGETATION ESTABLISHMENT. POROUS SOIL CHECK DAMS WILL BE PARTICULARLY VULNERABLE TO CLOGGING BY CONSTRUCTION SITE RUNOFF AND A TEMPORARY NON-WOVEN FABRIC SHOULD BE PLACED OVER THE PREPARED CHECK DAM UNTIL THE UPSTREAM SITE IS STABILIZED. ONCE THE SITE IS STABILIZED, THE CLOGGED FABRIC MAY BE REMOVED AND THE CHECK DAM PLANTED.
 1.4. THE SWALE SHOULD BE STABILIZED WITH EROSION CONTROL BLANKET. SEED SHOULD BE APPLIED PRIOR TO PLACEMENT OF THE BLANKET. PLUGS SHOULD BE PLANTED THROUGH THE BLANKET.
2. VEGETATION ESTABLISHMENT
 2.1. SWALES MAY BE ESTABLISHED FROM SEED AND/OR PLANT PLUGS
 2.2. SEEDING SHOULD OCCUR IN SPRING OR AS A DORMANT FALL PLANTING. LIVE PLUGS CAN BE PLANTED IN THE SPRING (APRIL 15–JUNE15) OR EARLY FALL (SEPT 1–OCT 15). SEEDING AND PLUGGING SHOULD NOT OCCUR MID-SUMMER WHEN TEMPERATURE AND EVAPORATION RATES ARE HIGH UNLESS IRRIGATION WILL BE PROVIDED.
 2.3. INTENSIVE VEGETATION MAINTENANCE SHOULD BE PROVIDED FOR A MINIMUM THREE-YEAR PERIOD UNTIL THE VEGETATION IS WELL ESTABLISHED AND CAN OUTCOMPETE WEEDS. DURING THE ESTABLISHMENT PERIOD, WEEDS SHOULD BE CONTROLLED THROUGH HAND PULLING OR SPOT HERBICIDE APPLICATION.
 2.4. ONCE ESTABLISHED, VEGETATION WILL REQUIRE A MINIMUM OF ANNUAL MONITORING AND MAINTENANCE TO CONTROL WEEDS. ANNUAL PRESCRIBED BURNING IS THE PREFERRED METHOD OF MAINTENANCE, BUT ANNUAL MOWING AND WEEDING MAY ALSO BE USED. WEEDING MUST OCCUR PRIOR TO WEED PLANTS SETTING SEED.

GENERAL CHECK DAM NOTES

1. SEE VEGETATED SWALE AND CHECK DAM DESIGN GUIDANCE FOR SIZING SWALES WITH CHECK DAMS.
2. SELECTION OF CHECK DAM MATERIAL WILL DEPEND ON CHECK DAM PURPOSE. CHECK DAMS DESIGNED TO REDUCE EROSION AND SCOUR POTENTIAL FOR HIGH GRADIENT SWALES SHOULD BE CONSTRUCTED OR ARMORED WITH APPROPRIATE SIZE ROCK. CHECK DAMS DESIGNED TO ENHANCE INFILTRATION SHOULD CONSTRUCTED WITH SOIL OR POROUS SOIL. CHECK DAMS DESIGNED TO FILTER RUNOFF SHOULD BE CONSTRUCTED OF POROUS SOIL.
3. ROCK AND POROUS SOIL CHECK DAMS SHOULD BE KEYED INTO THE CHANNEL BOTTOM AND SIDE SLOPES A MINIMUM OF 6 INCHES.
4. SOIL AND POROUS SOIL CHECK DAMS SHOULD BE ARMORED TO PROTECT AGAINST EROSION USING APPROPRIATE SIZED ROCK OR PERMANENT EROSION BLANKET.

ROCK CHECK DAM NOTES

1. ROCK CHECK DAMS SHOULD BE CONSTRUCTED OF APPROPRIATELY SIZED ANGULAR STONE. THE ILLINOIS URBAN MANUAL RECOMMENDS USE OF ILLINOIS DOT GRADATIONS OF CA-1, CA-2, CA-3, OR CA-4 FOR DRAINAGE AREAS LESS THAN TWO ACRES AND ILLINOIS DOT RR-3 OR RR-4 FOR DRAINAGE AREAS LESS THAN 10 ACRES.
2. THE CENTER OF THE CHECK DAM SHOULD BE A MINIMUM 6 INCHES LOWER THAN THE SIDES SUCH THAT FLOW OVER THE CHECK DAM IS CONFINED TO AN AREA THAT IS ARMORED. HAND PLACEMENT WILL BE REQUIRED TO ENSURE THAT THE CENTER IS LOWER THAN THE SIDES AND THAT RUNOFF WILL NOT FLOW AROUND THE ROCK.

POROUS SOIL CHECK DAM NOTES

1. POROUS SOIL CHECK DAMS MUST BE CONSTRUCTED OF MATERIAL THAT IS STABLE, POROUS, AND A GOOD GROWING MEDIUM.
2. THE POROUS CHECK DAM SOIL SHOULD BE A MIX OF APPROXIMATELY 60% RR3 RIP RAP, AND 40% BIORETENTION SOIL MIX BY VOLUME (SEE BIORETENTION SECTION FOR BIORETENTION SOIL MIX). THE RIP RAP/SOIL MIX SHOULD BE ADJUSTED AS NEEDED TO MAINTAIN INTERLOCK BETWEEN RIP RAP STONES WHILE FULLY FILLING THE VOIDS BETWEEN ROCKS WITH BIORETENTION SOIL.

	VEGETATED SWALE AND CHECK DAM NOTES	A COLLABORATION OF:
GI 7.04 SCALE: NTS		

Urban Tree Planting Practices

Urban forestry provides communities with improved aesthetics, habitat, shade, carbon sequestration, and a reduced urban heat island effect. In addition to these benefits, planting urban trees can also assist a community with stormwater management.

Urban trees can reduce runoff velocity and volumes, by intercepting rainfall, spurring evapotranspiration, and encouraging infiltration and groundwater recharge, while simultaneously consuming infiltrated water through its root system. However, as with all green infrastructure practices, planting locations serve as critical both for maximizing a tree's targeted stormwater benefits, as well as for ensuring its ongoing health and survival. Species selection is particularly critical when planting in urban rights-of-way, where flooding can occur routinely, where tolerance to road salt is a necessity for survival, and where a parkway's size and dimension can serve to constrain the growth of a tree's root structure.

While trees can provide benefits for stormwater management on their own, combining tree planting with bioretention practices will serve to increase the volume of stormwater captured and treated, particularly in urban areas where impervious surfaces and compacted soils can often outweigh the positive impact that trees can make on reducing runoff volume and velocity. Box tree filters serve as an example of combining tree planting with bioretention practices. Much like a stormwater planter, box tree filters provide various layers of filtering media, including mulch, engineered soil and gravel, which serves to assist with the capture and treatment of runoff, in addition to supporting the tree's root structure.

The decision around whether to pursue basic urban tree planting or a combined tree planting-bioretention approach will largely be a product of a project's scope, location, surrounding land uses, and budget. As trees are larger than any other plant used in green infrastructure practices, they bring a wide range of benefits, considerations, and complications beyond those related to stormwater management.

Urban Stormwater Tree Planting

Location & Spacing Methods

Planting trees for stormwater management requires making deliberate choices around site location and spacing in addition to species. Generally speaking, species planted for stormwater management should be planted where runoff collects, near the bottom of slopes, and close to the right of way. Planting locations that are close to the right of way mean that species which are tolerant to road salt, sediment, and runoff inundation should also be selected, which often means species that grow naturally in lowland, floodplain locations. Different species also require different soil types (ranging from sandy to clay-based) and different soil pH levels (ranging from acidic to alkaline). Planting locations must also avoid disruptions to above and below ground utilities, in addition to providing shade (based on the site's existing sun exposure) and protection from wind. Generally speaking, the spacing for an urban tree should be equivalent to its expected width at full maturity with the understanding that urban trees planted in small parkways seldom reach the full size of a naturally growing specimen. In other words, a tree that is expected to reach a full crown width of 30 feet should be planted approximately 30 feet from a tree of the same species.

Planting Methods

Irrespective of the species or delivery method, it is critical to keep the roots moist before the planting process begins. When digging a hole for tree planting, it should be sized twice as wide as the root ball. Once the tree is placed in the hole, the top-most root should be within 1" of soil's surface. If planting a bare root tree, roots should be distributed evenly, making sure roots are straight, and not bent, crossed, or "J" rooted. Once the backfilling of soil begins, the tree must be kept standing straight, and the backfilled soil must cover the top of the highest-most woody root. The backfilled soil should then be heel over with a boot or pressed with a shovel to remove air pockets. The entire backfilled area must then be watered, and layered with 2–4" of mulch. The mulch should be kept away from the trunk, and the mulching should not take on a volcano-like shape around the tree.

Customization Options

Recommended Species

Varying species will serve to be appropriate green stormwater infrastructure installations, based on soil moisture, planting location, salt tolerance, and their ability to be included in a bioretention practice, amongst other considerations. Table 10 provides a summary of preferable tree species for green stormwater infrastructure throughout the Great Lakes region.

Table 10: Recommended tree species for green stormwater infrastructure

Scientific Name	Common Name	Soils	Compatible BMPs	Street Tree	Floodplain Tree	Salt Tolerant
Acer saccharum	Sugar maple	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	No	Low
Acer freemanii	Freeman Maple	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	No	Low
Acer rubrum	Red Maple	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	Yes	Low

Scientific Name	Common Name	Soils	Compatible BMPs	Street Tree	Floodplain Tree	Salt Tolerant
Betula nigra	River Birch	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	Yes	Low
Celtis occidentalis	Hackberry	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	Yes	Medium
Ostrya virginiana	American Hophornbeam	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	Yes	Low
Tilia americana	American Basswood (Linden)	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	No	Low
Populus tremuloides	Quaking Aspen	Dry/Mesic	Bioswale	No	No	High
Prunus serotina	Black Cherry	Mesic/Wet	Rain Garden	No	No	High
Quercus alba	White Oak	Dry/Mesic	Rain Garden	No	No	High
Quercus Bicolor	Swamp White Oak	Dry/Mesic	Bioswale, Rain Garden, Box Tree Filter	Yes	Yes	High
Quercus macrocarpa	Bur Oak	Mesic/Wet	Bioswale, Rain Garden, Box Tree Filter	Yes	No	Medium
Quercus Rubra	Red Oak	Mesic/Wet	Bioswale, Rain Garden, Box Tree Filter	Yes	No	High
Quercus palustris	Pin Oak	Mesic/Wet		Yes	Yes	Low
Ulmus americana	Hybrid American Elm	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	Yes	High
Metasequoia glyptostroboides	Dawn Redwood	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	Yes	Low
Taxodium distichum	Common Bald Cyprus	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	Yes	Medium
Thuja occidentalis	Northern White Cedar	Mesic/Wet	Rain Garden	No	No	Medium

Scientific Name	Common Name	Soils	Compatible BMPs	Street Tree	Floodplain Tree	Salt Tolerant
Amelanchier laevis	Allegheny Serviceberry	Dry/Mesic	Rain Garden	No	Yes	Low
Juniperus virginiana	Eastern Red Cedar	Dry/Mesic	Bioswale	No	No	Low
Gymnocladus	Kentucky Coffeetree	Mesic/Wet	Rain Garden, Storm. Planter Box Tree Filter	Yes	Yes	High
Liquidanbar Stiraciflua	Sweetgum Happidaze	Mesic/Wet	Rain Garden, Box Tree Filter	Yes	Yes	Medium
Platanus occidentalis	American Sycamore	Mesic/Wet		Yes	Yes	Medium
Platanus x acerifolia	London Planetree	Mesic/We		Yes	Yes	Medium
Populus deltoides	Eastern Cottonwood	Mesic/Wet		Yes	Yes	Medium
Gleditsia triacanthos	Honeylocust	Mesic/Wet		Yes	Yes	High
Acer saccarinium	Silver Maple	Mesic/Wet		Yes	Yes	Medium
Catalpa speciosa	Northern Catalpa	Mesic/Wet		Yes	Yes	Medium

Planting Formats

Irrespective of the species or the location, a defining choice in undertaking urban tree planting will be selecting a bare root tree, a container tree, or a balled-and-burlap tree, all of which present varying strengths and weaknesses.

Bare Root Trees

"Bare root" tree stock is oftentimes the most inexpensive choice for planting, as they are the smallest and lightest option, making them the easiest format to transport. In turn, bare root trees are an economical choice for planting projects that include a large number of trees. Instead of being cultivated in a soil mixture, bare root trees are typically cultivated by wrapping the root system in a moisture-retaining material, such as sphagnum moss peat, sawdust or wet paper. Bare root tree stock must be planted when they are completely dormant, and this can only occur in the Spring or Fall, before the tree's leaves appear, or after its leaves fall (but before the ground freezes). The tree's roots must be kept moist at all times, because if the roots dry out, the tree dies. In turn, preserving moisture in the root system and a shorter planting season window are the primary constraints of bare root stock.

Container Trees

"Container tree" stock (trees grown in plastic containers) tend to be slightly more expensive to plant than bare root stock (on account of their size and weight), but are widely available, can be sourced year round, and can be planted while dormant or leafing. While in the containers, trees require intensive watering (1-2 times a day) to prevent the root system from drying out. Root girdling (when the roots grow in a circular form) can also be a problem with container trees, if the tree is kept for too long in its container, which can ultimately lead to the tree's death.

Balled and Burlap Trees

Balled and Burlap stock (B&B) is grown with a firm ball of soil surrounding its roots, and wrapped with burlap with twine, nails or wiring. B&B stock is very heavy, making it more expensive to transport than bare root or container stock. They are structurally very sound however, making them an ideal planting choice for large caliper trees. They can also be planted during any time in the growing season, though supplemental watering after planting is critical during hot and dry weather.

Maintenance

Watering

Watering bags (i.e., tree gators, either donut-shaped or other types) should be installed at the time of planting. Watering bags should be checked weekly, and filled with water as needed during the first growing season. Bags should be removed during the dormant season to protect the tree from fungus and molds. After the first year, the bags should be checked every two weeks, and should be filled as needed. Watering bags can be completely removed after two growing seasons.

Mulching Trees

Trees must be mulched, at a depth of 2-4 inches, at the time of planting. Mulch must be maintained in a level circular area around the base of each tree. Mulch must not be piled or mounded near the tree trunk. One year after planting, mulch should be evaluated, and if needed, additional mulch must be added to maintain 2-4 inches of depth.

Staking and Tying Trees

Trees that are planted near large open areas and are subject to high winds must be staked to improve firmness against the wind. This is particularly important for larger, "balled and burlapped" trees. One year after planting, trees must be evaluated for firmness, and if trees are stable, stakes can be removed. Upon completion of the second growing season, all stakes must be removed.

Pruning

Newly-planted trees should need little pruning if they were properly cared for in the nursery. In the first year after planting, the contractor must remove only dead or broken branches. After then, weakly-attached limbs and co-dominant leaders (a tree that has more than one main trunk that is similar in diameter) should be removed to promote healthy trees with good form.

Tree Protection

Tree mulch should help protect the base of newly-planted trees from lawn mower damage, by keeping mowers away from the tree base. However, to protect the newly-planted trees in areas where wildlife browsing may be an issue, trees must be protected using plastic mesh fencing or other tree guard products (such as tubes). After tree establishment, these structures can be removed.

Cost Information

Cost information is provided for each green infrastructure technique in Section 5 of this report. The Installed costs are based on project experience, bid tabs, and information from the RS Means trends, and the labor and bidding environment.

Table 11: Urban stormwater tree planting practice unit costs

	Item	Description	Unit Price	Unit
GI Technique	Urban Tree Planting	Tree (varies by tree species)	$400.00	EA
		Planting (varies by method)	$250.00	LS
Custom Options	Warranty	Planting Warranty	$60.00	EA

Specifications

Along with the construction documents, the design engineer should make site-specific customizations to the following sections of the standard specifications from the Illinois Urban Manual in order to have a full set of specifications for a green roof. Other sections can be included on an as-needed basis. Further instructions on the use of specifications are included in Appendix B. Specifications for engineered soil differ from those outlined in Appendix C.

Construction Specifications

707 - Digging, Transporting, Planting, and Establishment of Trees, Shrubs and Vines

Box Tree Filter

Box tree filters take in curbside runoff and treat it through physical and biological methods that are similar to other bioretention systems, before discharging it into existing storm sewer infrastructure. As a result, water that enters the storm sewers is cleaner, while trees and microbial communities uptake nutrients that would otherwise be washed into local streams, lakes, or wetlands.

Stormwater enters the unit through a curbside inlet into a concrete-encased area. Mulch, soil, engineered soil, and gravel filter out particulates and associated nutrients along with heavy metals and other inorganic compounds prevalent in urban runoff. Microbial communities in the root system of the tree remove organic carbon, nitrogen, and phosphorus to use them as part of their life cycle processes, while trees incorporate these nutrients into their biomass. From there, water flows through a surface inlet or external system connection to the existing stormwater infrastructure.

Customization Options

Box tree filter encasements have a range of standardized sizes, and an appropriate size can be determined by assessing the runoff reduction needs and physical constraints of the area. A variety of trees can be used in these units, with tree selection dependent on the climate, species native to the area, and the size of the installation. Slow growing, medium-sized trees will prevent degradation of the concrete encasement by the tree's root system. A manhole cover can be installed directly adjacent to the planted tree to allow easier access for future maintenance.

Maintenance

Typically, box tree filters need to be watered three times per week for the first four weeks after installation. Box tree filters require annual mulching through the first three years of establishment. Pruning and trimming of the tree as needed improves its health, growth, and appearance. Debris and litter caught in the tree grate should be removed monthly for the life of the installation.

Figure 8: Box tree filter in suburban setting

Cost Information

Cost information is provided for each green infrastructure technique in Section 5 of this report. The Installed costs are based on project experience, bid tabs, and information from the RS Means trends, and the labor and bidding environment.

Table 12: Box tree filter practice unit costs

	Item	Description	Unit Price	Unit
GI Technique	Box Tree Filter	Design/Engineering	15% of Construction Cost	LS
		Mobilization	$10,000.00	LS
		Excavation & Haul	$45.00	CY
		Hardwood Mulch	$45.00	CY
		Engineered Soil	$60.00	CY
		Gravel Subgrade	$45.00	CY
Required Component	Concrete Encasement	Curb installation, box tree filter	$45.00	CF
	Grate	Varies by size	$600.00	EA
	Underdrain	3" perforated PVC pipe, irrigation port or external system connection	$0.00	LF
	Perforated Pipe Cleanout		$1,000.00	LF
	Connection to existing storm infrastructure		$600.00	EA
Required Selection	Tree	Varies by species	$400.00	EA
Custom Options	Access to Concrete Encasement	Varies by species	$300.00	EA

Specifications

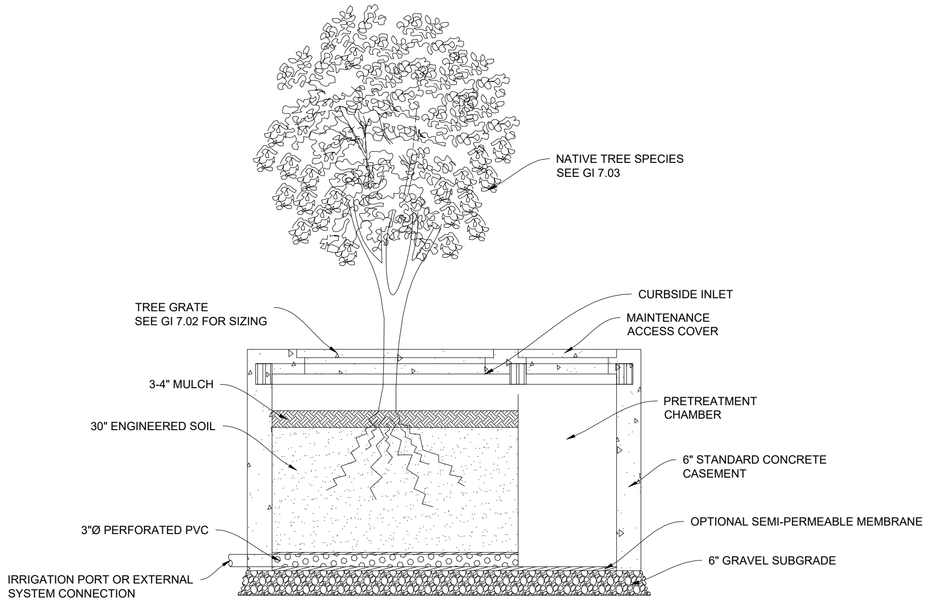
Along with the construction documents, the design engineer should make site-specific customizations to the following sections of the standard specifications from the Illinois Urban Manual in order to have a full set of specifications for a green roof. Other sections can be included on an as-needed basis. Further instructions on the use of specifications are included in Appendix B. Specifications for engineered soil differ from those outlined in Appendix C.

Construction Specifications

2 - Clearing and Grubbing
5 - Pollution Control
7 - Construction Surveys
8 - Mobilization and Demobilization
9 - Traffic Control
10 - Water for construction
21 - Excavation
23 - Earthfill
24 - Drainfill
25 - Rockfill
26 - Topsoiling
27 - Diversion and Waterways
32 - Structure Concrete
34 - Steel Reinforcement
35 - Concrete Repair
45 - Plastic Pipe
94 - Contractor Quality Control
592 - Geotextile
707 - Digging, Transporting, Planting, and Establishment of Trees, Shrubs and Vines
752 - Stripping, Stockpiling, Site Preparation and Spreading Topsoil

Material Specifications

521 - Aggregates for Drainfill and Filters
522 - Aggregates for Portland Cement Concrete
531 - Portland Cement
534 - Concrete Curing Compound
535 - Preformed Expansion Joint Filler
536 - Sealing Compound for Joints in Concrete and Concrete Pipe
539 - Steel Reinforcement (for Concrete)
547 - Plastic Pipe
592 - Geotextile
804 - Material for Topsoiling



BOX TREE FILTER TYPICAL SECTION

BOX TREE FILTER IN RESIDENTIAL INSTALLATION[5]

DESIGN GUIDANCE

TYPICAL LOCATION: CURBSIDE, AREA BETWEEN SIDEWALK AND STREET[1]

WIDTH: 4' MIN TO ALLOW FOR GRATE CLEARANCE, MAX WIDTH DEPENDENT ON SPACE AVAILABLE

LENGTH: MINIMUM 3'

CONTRIBUTING DRAINAGE AREA: ~1/4 ACRE PER UNIT

AVAILABLE OPTIONS: UNDERGROUND STORAGE, SEWER CONNECTION, GROUNDWATER INFILTRATION SYSTEM

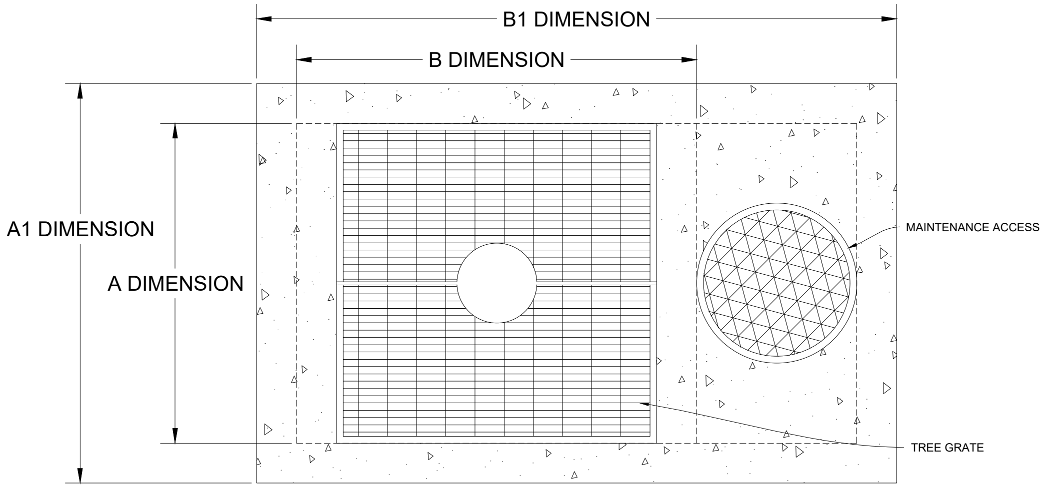
DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ NATIVE SOIL INFILTRATION[2]:______________ IN/HR
- ☐ REQUIRED STORAGE CAPACITY[3]:__________ CUBIC FT
- ☐ CONNECT TO EXISTING STORM NETWORK: YES/NO[4]
- ☐ DISTANCE TO CURB >3 FT: YES/NO
- ☐ ADJACENT TO CURBSIDE: YES/NO

1. COULD BE USED IN VARIOUS RESIDENTIAL, COMMERCIAL OR INDUSTRIAL APPLICATIONS.
2. NATIVE SOIL INFILTRATION CAN BE NO GREATER THAN 4 INCHES/HOUR.
3. STORAGE CAPACITY VARIES WITH UNIT SIZE. IF IS CAPACITY EXCEEDED, MORE UNITS MUST BE INSTALLED
4. CAPACITY OF DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
5. HTTP://ACTREES.ORG/NEWS/TREES-IN-THE-NEWS/NEWSROOM/RHODE-ISLAND-CASE-STUDY-FILTERING-STORMWATER-WITH-TREES/

NORTHWESTERN UNIVERSITY 2016	BOX TREE FILTER	A COLLABORATION OF: delta institute, NORTHWESTERN UNIVERSITY
GI 8.01 1 OF 3 SCALE: NTS		

Box Tree Filter Size Selection



TOP VIEW AND SIZE SELECTION DETAIL

TABULATION									
POD SIZE		FOOT PRINT (OD)		TREE / GRATE QUANTITY SEE NOTE X	RATED FLOW CAPACITY (GPM / CFS)	MAX. DRAINAGE AREA TREATED [1] (ACRE)	MAX. DRAINAGE AREA TREATED [2] (ACRE)	MAX. DRAINAGE AREA TREATED [3] (ACRE)	MAX. DRAINAGE AREA TREATED [4] (ACRE)
A DIM	B DIM	A1 DIM	B1 DIM						
4'	4'	5'	7'	1 EA	16 / 0.036	0.18	0.22	0.30	0.44
4'	5'	5'	8'	1 EA	20 / 0.045	0.23	0.28	0.38	0.56
4'	6'	5'	9'	1 EA	24 / 0.054	0.27	0.33	0.44	0.67
4'	7'	5'	10'	1 EA	28 / 0.062	0.31	0.39	0.52	0.78
4'	8'	5'	11'	1 EA	32 / 0.071	0.36	0.44	0.59	0.89
4'	9'	5'	12'	1 EA	36 / 0.080	0.40	0.50	0.67	1.00
4'	10'	5'	13'	1 EA	40 / 0.089	0.45	0.56	0.74	1.11
4'	11'	5'	14'	2 (MAX)	44 / 0.098	0.49	0.61	0.82	1.23
4'	12'	5'	15'	2 (MAX)	48 / 0.11	0.55	0.69	0.92	1.38
5'	4'	6'	7'	1 EA	20 / 0.045	0.23	0.28	0.38	0.56
5'	5'	6'	8'	1 EA	25 / 0.056	0.28	0.35	0.47	0.70
5'	6'	6'	9'	1 EA	30 / 0.067	0.34	0.42	0.56	0.84
5'	7'	6'	10'	1 EA	35 / 0.078	0.39	0.49	0.65	0.98
5'	8'	6'	11'	1 EA	40 / 0.089	0.49	0.61	0.82	1.23
5'	9'	6'	12'	1 EA	45 / 0.10	0.50	0.63	0.83	1.25
5'	10'	6'	13'	1 EA	50 / 0.111	0.55	0.70	0.93	1.39
5'	11'	6'	14'	2 (MAX)	55 / 0.123	0.62	0.77	1.03	1.54
5'	12'	6'	15'	2 (MAX)	60 / 0.133	0.67	0.83	1.11	1.66
6'	4'	7'	7'	1 EA	24 / 0.054	0.27	0.33	0.44	0.67
6'	5'	7'	8'	1 EA	30 / 0.067	0.34	0.42	0.56	0.84
6'	6'	7'	9'	1 EA	36 / 0.080	0.40	0.50	0.67	1.00
6'	7'	7'	10'	1 EA	42 / 0.094	0.47	0.59	0.78	1.18
6'	8'	7'	11'	1 EA	48 / 0.11	0.55	0.69	0.92	1.38
6'	9'	7'	12'	1 EA	54 / 0.12	0.60	0.75	1.00	1.50
6'	10'	7'	13'	1 EA	60 / 0.134	0.67	0.83	1.11	1.67
6'	11'	7'	14'	2 (MAX)	66 / 0.147	0.74	0.92	1.23	1.84
6'	12'	7'	15'	2 (MAX)	72 / 0.160	0.80	1.00	1.33	2.00

[1] C = 1.00, I = 0.20 inch / hour
[2] Commercial Development where; C = 0.80, I = 0.20 inch / hour
[3] Detached Multi-Unit Residential where; C = 0.60, I = 0.20 inch / hour
[4] Suburban Residential where; C = 0.40, I = 0.20 inch / hour

C - values from San Diego County Hydrology Manual (2002)
I - values reflect Uniform Intensity Approach targeting 85%-ile storm (CASQA).

SIZING SELECTION FOR BOX TREE FILTER[1]

DESIGN GUIDANCE

SIZE SELECTION

- CONCRETE ENCASING PURCHASED AS WHOLE UNIT
- SIZING DEPENDENT OF DRAINAGE AREA
- STANDARD MANUFACTURER DIMENSIONS
- TREE SELECTION RESTRICTED BY SIZE OF UNIT

BOX TREE FILTER MAINTENANCE GUIDELINES		
TASK	FREQUENCY	TIMEFRAME
ESTABLISHMENT WATERING	3XWEEK	FIRST 4 WEEKS AFTER INSTALLATION
MULCHING	ANNUALLY	THROUGH 3 YEARS
TRASH REMOVAL	1XMONTH	ONGOING
TRIM TREE	AS NEEDED	ONGOING

1 TABLE FROM: http://www.kristar.com/index.php/low-impact-development-lid/treepod-biofilter

NORTHWESTERN CIVIL AND ENVIRONMENTAL ENGINEERING 2016 GI 8.02 2 OF 3 SCALE: NTS	BOX TREE FILTER SIZE SELECTION	A COLLABORATION OF: delta institute NORTHWESTERN UNIVERSITY

Box Tree Filter Notes

RECOMMENDED TREE SPECIES FOR BOX TREE FILTERS			
COMMON NAME	GENUS	SPECIES	FAMILY
RED MAPLE	ACER	RUBRUM	ACERACEAE
RED OAK	QUERCUS	RUBRA	FAGACEAE
SWEETGUM HAPPIDAZE	LIQUIDAMBAR	STYRACIFLUA	HAMAMELIDACEAE
SWAMP WHITE OAK	QUERCUS	BICOLOR	FAGACEAE
HACKBERRY	CELTIS	OCCIDENTALIS	CANNABACEAE

1."A COMPARATIVE ANALYSIS OF CONVENTIONAL STREET TREE PITS AND STORMWATER TREE PITS FOR STORMWATER MANAGEMENT IN ULTRA URBAN ENVIRONMENTS." CHARLES RIVER WATERSHED ASSOCIATION, MAR. 2009. WEB.<HTTP://WWW.CRWA.ORG/HS-FS/HUB/311892/FILE-642201447-PDF/OUR_WORK_/BLUE_CITIES_INITIATIVE/RESOURCES/CRWA_STORMWATER_TREES_URBAN_ENVIRONMENT.PDF>.

NOTES

1. SCHEDULE PRE–INSTALLATION MEETING WITH THE DESIGN ENGINEER 72 HOURS IN ADVANCE OF GREEN INFRASTRUCTURE CONSTRUCTION.
2. AREAS IN AND AROUND GREEN INFRASTRUCTURE SHOULD BE PROTECTED DURING EARTH MOVING AND CONSTRUCTION TO PREVENT COMPACTION THAT WOULD REDUCE INFILTRATION RATES. ALSO PROTECT AREA THROUGHOUT CONSTRUCTION FROM SEDIMENT TRANSPORT THAT WOULD CLOG THE INFILTRATION CAPACITY OF NATIVE AND ENGINEERED SOILS.
3. MULCH SHOULD BE REPLACED ANNUALLY OR AS NEEDED, DEPENDING ON RAIN FREQUENCY FOR BEST RESULTS.

TREE NOTES

1. BOX TREE FILTER TREE DETAILS:
   a. THE BOX FILTER SHOULD BE POPULATED WITH A SINGLE TREE FOR EACH GRATE OPENING.
   b. NATIVE SPECIES WITH DROUGHT RESISTANT CHARACTERISTICS SHOULD BE PRIORITIZED.
   c. SELECT A SLOW GROWING TREE OF MEDIUM SIZE TO PREVENT DEGRADATION OF CONCRETE ENCASEMENT BY ROOT SYSTEM.
2. GROWING MEDIUM SHALL BE PLACED ADJACENT TO STORMWATER PLANTER.
3. GROWING MEDIUM TO BE EITHER CU STRUCTURAL SOIL, SILVA CELL MATERIAL OR APPROVED EQUAL
4. VOLUME OF GROWING MEDIUM TO BE DETERMINED ACCORDING TO THE ABOVE MANUFACTURER'S RECOMMENDATIONS.
5. SELECTION OF THE TREE WILL BE BASED ON REGIONAL AVAILABILITY AND PRICE.

ENGINEERED SOIL SPECIFICATIONS

1. WHEN A PROPRIETARY TREE BOX FILTER IS USED, THE MANUFACTURERS ENGINEERED SOIL SHOULD BE USED AS MAY BE REQUIRED TO MAINTAIN THE MANUFACTURERS WARRANTY.
2. WHEN DESIGNING A NON–PROPRITARY TREE BOX FILTER, THE ENGINEERED SOIL MIX SHALL BE A BLEND OF 70% TO 90% COARSE SAND AND 10% TO 25% COMPOST BY VOLUME AND MEET THE FOLLOWING REQUIREMENTS:
   a. COMPOST SHALL BE WELL AGED AND MEET WISCONSIN DNR TECHNICAL SPECIFICATION S100
   b. ORGANIC MATTER CONTENT OF MIX FROM 3–5% BY WEIGHT
   c. PROPORTION OF CLAY (HYDROMETER ANALYSIS) SHALL BE 2% TO 5%
   d. pH OF MIX SHALL BE 5.5 TO 8.0
   e. THE ENGINEERED SOIL THICKNESS SHALL BE ADEQUATE TO SUPPORT THE ROOTING DEPTH OF THE SELECTED TREE OR SHRUB SPECIES.
2. ENGINEERED SOIL MAY BE OBTAINED OFF SITE OR CREATED BY TESTING NATIVE SOILS AND MIXING WITH IMPORTED MATERIALS AS NEEDED PROVIDED THE MIX MEETS THE SPECIFICATIONS ABOVE
3. ENGINEERED SOIL SHALL BE DRY AND FRIABLE AND UNIFORMLY MIXED. ITS CHARACTERISTICS SHALL BE VERIFIED BY MATERIALS TESTING PRIOR TO PLACEMENT.
4. PLACE DRY AND FRIABLE SOIL IN 8–12 INCH LIFTS.
5. AFTER PLACEMENT, LIGHTLY COMPACT DRY SOIL BY HAND TAMPING. DO NOT USE A VIBRATORY COMPACTOR. AFTER PLANTING OF THE TREE, WATER THE SOIL SURFACE UNTIL WATER APPEARS IN THE UNDERDRAIN. PROVIDE ADDITIONAL SOIL AS NEEDED TO PROVIDE PROPER COVER OF THE ROOT BALL.
6. TO PRESERVE INFILTRATION CAPACITY OF NATIVE SOIL, KEEP MACHINERY AND CONSTRUCTION SITE RUNOFF OUTSIDE OF GREEN INFRASTRUCTURE AREA.

NORTHWESTERN UNIVERSITY 2016
WITH EDITS BY ECT, 2021

GI 8.03
3 OF 3
SCALE: NTS

BOX TREE FILTER NOTES

A COLLABORATION OF:

Green Roof

A green roof transforms an otherwise impervious surface into one capable of retaining and filtering stormwater. A substrate of growing media is planted with vegetation and absorbs stormwater that would otherwise flow through a traditional system of gutters and sewers. By retaining the stormwater, green roofs allow for natural processes like evaporation and transpiration to occur, slowly releasing water to the atmosphere. The system also reduces the rate of runoff for water that cannot be absorbed, especially for smaller and more frequent rain events.

The primary stormwater benefit of a green roof is the reduction in runoff rates it provides for an otherwise impervious roof. Most green roofs are not designed to store the volume of rainwater that a typical detention basin can accommodate. Even still, a modest amount of retention can be anticipated. The capacity of the green roof will be determined by the thickness of the substrate layer, the slope of the roof, the amount and time of rainfall, and antecedent rainfall.

A green roof can be installed on a new or existing structure with the load bearing capacity to support it. A green roof adds a considerable amount of weight to a building compared to a gray roof. It is necessary to consider factors of human traffic, weather and climatic conditions, and temporary installations in addition to the saturated weight of the green roof itself when calculating the maximum load capacity.

Customization Options

There are two primary types of green roofs. The first and most common is a layered system which is built in place on the roof. The second type of green roof uses a modular system containing pre-vegetated plastic trays. The modular trays tend to be more expensive than a layered green roof, but can be cost competitive on smaller roofs or on roofs where building the layers in place is problematic, such as on top of very tall buildings. The modular trays also offer the instant appeal of mature vegetation on the day of installation.

Figure 9: Green roof in urban setting

The deck is the structural portion of the roof that supports everything above it. It can be constructed from concrete, wood, metal, plastic, gypsum, or composite, though concrete is recommended when a green roof is involved. Corrugated metal decks require an additional support and insulation layer. There is usually a division in trades and in the responsibility for designing the roof and the green roof components. The building's roof deck and waterproofing layer (roof membrane) are almost always designed by an architect and constructed by trained roofers. The design of the green roof components on the other hand can come from a variety of sources, such as a landscape architect or a manufacturer. They are also frequently installed by companies specializing in green roofs. The waterproofing layer of the roof should be protected at all times during the construction of a green roof. This can be especially important when multiple trades and designers are involved. Because the construction can require large buckets of material to be deposited onto the roof, a thick spongy protection fabric is often the first thing to be put down.

A layered green roof is built as its name implies - by stacking its components in layers. The protection fabric protects the membrane from the minor impacts of placing and moving green roof components around. It is often a non-woven, synthetic poly-propylene fiber mat similar in appearance to the felt blankets movers use to protect furniture. Additional protection, however, is required when a bitumen-based membrane is used or when the roots could be in contact with polystyrene insulation. In these applications a root barrier made of polyethylene sheets is placed over the protection fabric. The drainage layer is one of the most critical components of a green roof system.

The type of drainage layer further divides a layered green roof into two sub-types. Layered systems can use aggregate drainage layers made of light-weight expanded clay, or pumice. Alternatively, they can use manufactured drainage boards which can be molded plastic sheets or composite geotextiles. Proprietary green roof systems, such as those available from Hydrotech and Carlisle, use manufactured drainage boards. No matter the type of drainage layer used, a separation fabric is placed over it to contain the growing media above it. The separation fabric is usually a thin, non-woven, needle-punched, poly-propylene sheet. It is designed specifically to allow water to pass through it, but not soil particles. The growing media above it is also specially designed. Green roof soils are generally light-weight and composed of a mixture of drainage aggregate and organic material. They are manufactured to limit the amount of fines that might otherwise clog the separation fabric below. A layered green roof also needs edges to contain the material in the system. This can be as simple as a parapet wall extension, or may involve the use of aluminum or stainless steel angled edge restraints.

The thickness of the growing media can vary and does not need to be uniform across the entire area. Intensive green roofs have a thicker layer of substrate (greater than 6 inches), which allows for greater variety in plant selection, but require more maintenance, are more costly, and weigh more. Semi Intensive green roofs with 4 to 6 inches of soil and extensive green roofs with 2 to 3 inches of soil have thinner substrate layers that can only support drought-tolerant and self-seeding plants but require fewer labor and financial investments and weigh less. Along with the thickness of the substrate layer, plant selection depends on climate, locality, plant growth rate, and size at maturity. Modules, plugs, vegetated mats, seeds, nursery containers, and cuttings are all viable planting options, each with their own benefits and disadvantages. The maximum width and length are scalable, limited by the area and design constraints of the roof.

Maintenance

A green roof needs to be watered usually 3 times per week during the first 4 weeks after installation. During the first year of establishment, the plants will need to be watered and weeded regularly through October and during any subsequent years in which there is a drought. If mulch is used it may need to be supplemented annually through the first three years of establishment. Debris removal must occur monthly for the life of the roof garden. Trimming, removal, and replacement of dead plants must occur on an as-needed basis.

Cost Information

Green roofs are unique compared to the other green infrastructure techniques found in this toolkit due to the diverse range of customization options and the role their building's design plays in their development. Due to this, the cost for installing a green roof is highly variable. A reasonable budget for an extensive layered green roof would be $25-40 per square foot; a semi intensive layered green roof would be $35-50 per square foot; and an intensive layered green roof would be $45-100 per square foot.

Specifications

Specifications are an important component in the design of green infrastructure. Along with the construction documents, the design engineer should make site-specific customizations to the following sections of the standard specifications from the Illinois Urban Manual in order to have a full set of specifications for a green roof. Other sections can be included on an as-needed basis. National standards for the design of green roofs have been developed and should be considered. ANSI/SPRI RP-14 establishes wind design standards and ANSI/SPRI VF-1 established fire design standards. Further instructions on the use of specifications are included in Appendix B. Specifications for engineered soil used in green roofs differ from those outlined in Appendix C.

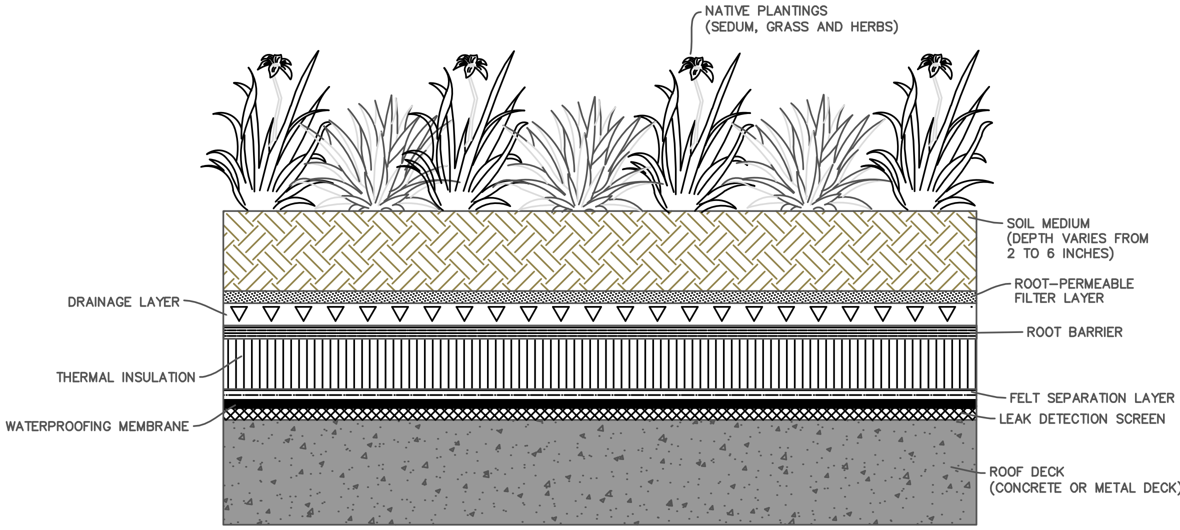
Construction Specifications

5 - Pollution Control
7 - Construction Surveys
8 - Mobilization and Demobilization
9 - Water for Construction
26 - Topsoiling
32 - Structure Concrete
34 - Steel Reinforcement
35 - Concrete Repair
97 - Flexible Membrane Liner

Material Specifications

531 - Portland Cement
804 - Material for Topsoiling

Extensive Green Roof



GREEN ROOF TYPICAL SECTION

EXTENSIVE GREEN ROOF INSTALLATION[1]

DESIGN GUIDANCE

TYPICAL LOCATION: ROOFTOP OF A BUILDING OR HOUSE[2]

THICKNESS OF GROWING MEDIUM: 2 TO 6 INCHES

AVAILABLE OPTIONS: NATIVE PLANT SELECTION (GRASSES, SUCCULENTS AND HERBS)[3]

GROWING MEDIUM: EXPANDED SHALE, VOLCANIC PUMICE, SCORIA, SAND, PEAT AND CRUSHED BRICK MATERIAL[4]

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ NEW BUILDING: YES/NO
- ☐ DEAD LOAD REQUIREMENTS: ________ LB/FT^2
- ☐ LIVE LOAD REQUIREMENTS: ________ LB/FT^2
- ☐ REQUIRED STORAGE CAPACITY: ________ CUBIC FT
- ☐ MEDIUM DEPTH: ________ IN
- ☐ NATIVE SOIL INFILTRATION: ________ IN/HR
- ☐ CONNECT TO EXISTING STORM NETWORK: YES/NO
- ☐ SLOPE OF ROOF: ________ %
- ☐ COMPLIANCE WITH LOCAL FIRE CODES: YES/NO
- ☐ NATURAL OR ARTIFICIAL DRAINAGE SYSTEM: ________
- ☐ ROOFTOP SPACE: ________ FT^2

1. IMAGE CREDIT: © 2021 ENVIRONMENTAL CONSULTING & TECHNOLOGY, INC.
2. COULD BE USED IN VARIOUS RESIDENTIAL, COMMERCIAL OR INDUSTRIAL APPLICATIONS
3. SEE GI 9.02 FOR NATIVE PLANTS
4. SEE GI 9.03 FOR GROWING MEDIUM SPECIFICATIONS

Northwestern University 2016	EXTENSIVE GREEN ROOF	A COLLABORATION OF:
GI 9.01 1 OF 3 SCALE: NTS		delta institute NORTHWESTERN UNIVERSITY

Native Plantings

BOTANICAL NAME	COMMON NAME	FAMILY	PLANTING MEDIUM (IN.)	HEIGHT UP TO (IN.)	NATIVE TO ILLINOIS?
		GRASSES			
BOUTELOUA CURTIPENDULA	SIDE OATS GRAMA	POACEAE	6	30	YES
SPOROBOLUS HETEROLEPIS	PRAIRIE DROPSEED	POACEAE	6	30	YES
ANDROPOGON GERARDII	BIG BLUE STEM	POACEAE	4 - 6	36 +	YES
		HERBACEOUS PERENNIALS			
CAMPANULA ROTUNDIFOLIA	HAREBELL	CAMPANULACEAE	6	12	YES
PHLOX SUBULATA	MOSS PHLOX	POLEMONIACEAE	6	5	NO
ANTENNARIA DIOICA	PUSSYTOES	ASTERACEAE	4	10	NO
AGASTACHE FOENICULUM	ANISE HYSSOP	LAMIACEAE	6	25	YES
ARTEMISA CAUDATA	BEACH WORMWOOD	ASTERACEAE	4 - 6	36	YES
		HERBS			
THYMUS PRAECOX	MOTHER OF THYME	LAMIACEAE	4	2	NO
ALLIUM CERNUUM	NODDING ONION	AMARYLLIDACEAE	6	36	YES
		HARDY SUCCULENTS			
SEDUM SEXANGULARE	TASTELESS STONECROP	CRASSULACEAE	4	4	NO
SEDUM KAMTSCHATICUM	ORANGE STONECROP	CRASSULACEAE	4	5	NO
SEDUM ACRE	GOLDMOSS STONECROP	CRASSULACEAE	4 - 6	7	NO
SEMPERVIVUM	HEN AND CHICKS	CRASSULACEAE	4	8	NO

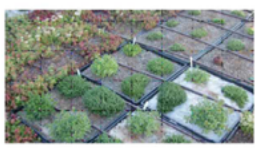
SUGGESTED PLANTING SPECIES[1]

PLANT MODULE[3]

PLANT PLUGS[4]

VEGETATED MATS[5]

NURSERY CONTAINERS[6]



CUTTINGS[7]

SEEDS[8]

PLANT INSTALLATION METHODS

DESIGN GUIDANCE[1]

MODULES
- MOST EXPENSIVE METHOD
- SOLD BY COMPANIES LIKE GREEN GRID AND GREEN ROOF BLOCK

PLUGS
- MOST PRECISE INSTALLATION METHOD
- OPTIMUM PLANTING: APRIL 15–MAY 15 AND SEPT 01–OCT 15.

VEGETATED MATS
- WORK WELL FOR SLOPING ROOFS
- DIFFICULT TO TRANSPORT AND MAY REQUIRE EXPERTISE

SEEDS
- LONGER ESTABLISHMENT PERIOD AND LEAST EXPENSIVE

NURSERY CONTAINERS
- USE TO PLANT DISCRETE AREAS OF A ROOF

CUTTINGS
- VIABLE AND POPULAR METHOD, ESPECIALLY FOR SEDUM

NATIVE PLANTING MAINTENANCE GUIDELINES[1]

TASK	FREQUENCY	TIMEFRAME
ESTABLISHMENT PERIOD	–	FIRST 12 TO 18 MONTHS
HAND WEEDING	–	IS NEEDED MORE DURING ESTABLISHMENT PERIOD
PLANT IRRIGATION	DAILY TO PERIODIC	FIRST THREE WEEKS OF ESTABLISHMENT PERIOD
FERTILIZATION	ANNUALLY	FIRST SIX YEARS

1 SNODGRASS, E.C., & SNODGRASS, L.L. (2006). *GREEN ROOF PLANTS: A RESOURCE AND PLANTING GUIDE*
2 HAWKE, RICHARD. 2015. "AN EVALUATION STUDY OF PLANTS FOR USE ON GREEN ROOFS." (38).
3 HTTP://GREENROOFOUTFITTERS.COM/
4 HTTP://PIZZONURSERY.COM/PRODUCTS/
5 HTTP://GREENROOFSOLUTIONS.COM/VEGETATED-MATS.HTML
6 HTTP://WWW.AMERINURSERY.COM/GROWING/EVALUATING-ZEOLITE-IN-AN-EXTENSIVE-GREEN-ROOF-SUBSTRATE/
7 HTTP://WWW.VEGETALID.COM/SOLUTIONS/GREEN-ROOFS/WITH-PLANT-CUTTINGS.HTML
8 HTTP://WWW.ZMESCIENCE.COM/ECOLOGY/SEED-SIZE-NUMBER-INCREASED-0543543/

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GI 9.02 2 OF 3 SCALE: NTS		delta institute NORTHWESTERN UNIVERSITY

delta institute
ECT Environmental Consulting & Technology, Inc.

Extensive Green Roof Notes

NOTES

1. THE DECKING OF A GREEN ROOF CAN BE CONSTRUCTED FROM CONCRETE, WOOD, METAL, PLASTIC, GYPSUM, OR COMPOSITE. HOWEVER, CONCRETE IS THE RECOMMENDED STRUCTURAL MATERIAL FOR GREEN ROOFS DUE TO THEIR STRENGTH AND DURABILITY.
2. GREEN ROOF CAN BE SUPPLIED AS PRE-ASSEMBLED MODULAR SYSTEMS OR AS A LAYERED SYSTEM.
   a. MODULAR SYSTEMS TYPICALLY COME AS COMPLETE TRAYS THAT ARE TRANSPORTED TO THE ROOF AND LAID ACCORDING TO MANUFACTURER'S REQUIREMENTS. THE TRAYS CAN BE PROVIDED READY FOR PLANTING OR PRE-PLANTED.
   b. LAYERED SYSTEMS ARE CUSTOM DESIGNED FOR THE SPECIFIC APPLICATION AND GENERALLY COMPOSED OF THE COMPONENTS SHOWN IN DETAILS GI 9.01. THE REMAINDER OF THE NOTES ON THIS SHEET ARE PROVIDED TO GUIDE DESIGN OF LAYERED SYSTEMS.
3. AS WITH ANY ROOF, A 100% WATERPROOF MEMBRANE IS REQUIRED TO PREVENT ANY LEAKS AND DAMAGE TO THE ROOF DECK. THE REPARE OF LEAKS IN THE MEMBRANE WILL REQUIRE REMOVAL OF ALL OR A PORTION OF THE GREEN ROOF SYSTEM. LEAK DETECTION SYSTEMS ARE COMMERCIALLY AVAILABLE TO IDENTIFY THE LOCATION OF LEAKS TO AVOID REMOVAL OF THE ENTIRE ROOF SYSTEM TO FIND THE LEAK. LEAK DETECTION SYSTEMS ARE INSTALLED PRIOR TO THE GREEN ROOF SYSTEM. COMMON METHODS FOR WATERPROOFING ARE MODIFIED BITUMEN MEMBRANES, SINGLE-PLY MEMBRANES AND LIQUID APPLIED METHODS.
4. AN INSULATION LAYER IS NEEDED TO PROVIDE COOLING ENERGY SAVINGS TO THE BUILDING. THE LAYER CAN BE INSTALLED EITHER BELOW OR ABOVE THE WATERPROOF MEMBRANE. IF THE INSULATION LAYER IS INSTALLED ABOVE THE WATERPROOF MEMBRANE, IT IS KNOWN AS AN INVERTED ROOF MEMBRANE ASSEMBLY (IRMA) SYSTEM.
5. FOR MOST MEMBRANE TYPES, A ROOT BARRIER IS REQUIRED TO PREVENT ROOT INTRUSION THAT COULD DAMAGE THE WATERPROOFING OR INSULATING LAYERS. IT NEEDS TO BE INSTALLED ABOVE THE WATERPROOFING MEMBRANE. THE ROOT BARRIER LAYER IS OFTEN MADE FROM PVC OR HDPE (HIGH DENSITY POLYETHYLENE) SHEETS.
6. DRAINAGE SYSTEMS MAY EITHER BE AGGREGATE SUCH AS EXPANDED CLAY OR SHALE OR MAY BE PROPRIETARY DRAINAGE BOARDS OF VARIOUS TYPES. DRAINAGE BOARDS ARE OFTEN LIGHTER WEIGHT THAN AGGREGATE BUT MAY HAVE LOWER WATER HOLDING CAPACITY THAN AGGREGATE.
7. A PERMEABLE POLYPROPYLENE FABRIC MUST BE INCLUDED BETWEEN THE GROWING MEDIUM AND THE DRAINAGE LAYER TO AVOID CLOGGING.
8. PLANT SELECTION WILL DEPEND ON DIFFERENT FACTORS SUCH AS PLANT EXPOSURE TO SUNLIGHT, WIND, SHADE, HUMIDITY, AND TEMPERATURE FLUCTUATIONS.
9. APPLICABLE ASTM STANDARDS FOR GREEN ROOF SYSTEMS ARE:
   - ASTM E 2396 – STANDARD TEST METHOD FOR SATURATED WATER PERMEABILITY OF GRANULAR DRAINAGE MEDIA [FALLING-HEAD METHOD] FOR GREEN ROOF SYSTEMS
   - ASTM E 2397 – STANDARD PRACTICE FOR DETERMINATION OF DEAD LOADS AND LIVE LOADS ASSOCIATED WITH GREEN ROOF SYSTEMS
   - ASTM E 2398 – STANDARD TEST METHOD FOR WATER CAPTURE AND MEDIA RETENTION OF GEOCOMPOSITE DRAIN LAYERS FOR GREEN ROOF SYSTEMS
   - ASTM E 2399 – STANDARD TEST METHOD FOR MAXIMUM MEDIA DENSITY FOR DEAD LOAD ANALYSIS OF GREEN ROOF SYSTEMS
   - ASTM E 2400 – STANDARD GUIDE FOR SELECTION, INSTALLATION, AND MAINTENANCE OF PLANTS FOR GREEN ROOF SYSTEMS
   - ASTM WK 575 – PRACTICE FOR ASSESSMENT OF GREEN ROOFS
   - ASTM WK 4239 – STANDARD TEST METHOD FOR SATURATED WATER PERMEABILITY OF GRANULAR DRAINAGE MEDIA [FALLING-HEAD METHOD] FOR GREEN ROOFS

GROWING MEDIUM SPECIFICATIONS

1. THE MEDIUM CONSISTS OF A LIGHTWEIGHT, POROUS LAYER.
2. IT IS USUALLY OF 2 TO 6 INCHES OF DEPTH.
3. MEDIUM DEPTH WILL AFFECT PLANT SELECTION AND RATE OF VEGETATION GROWTH.
4. THE SUBSTRATE SHOULD HAVE 75 TO 90% OF INORGANIC MATERIAL.
5. INORGANIC MATERIAL PROVIDES VERTICAL STABILITY AND PREVENTS SHRINKAGE.
6. THE MEDIUM WILL DEPEND ON THE TYPES OF PLANTS TO BE PLANTED ON THE ROOF, CLIMATIC CONDITIONS, DEAD AND LIVE LOADS REQUIREMENTS AND DRAINAGE NEEDS.
7. MATERIALS THAT ARE RECOMMENDED AS A GROWING MEDIUM ARE EXPANDED SHALE, EXPANDED SLATE, VOLCANIC PUMICE, SAND, CRUSHED BRICK MATERIALS AND BAKED CLAY.
8. THE REST SHOULD BE ORGANIC COMPOST AND NOT SOIL SINCE SOIL CONTAINS SILT THAT CAN CLOG AND DISRUPT THE DRAINAGE SYSTEM.

MAINTENANCE GUIDELINES

1. THE ANNUAL MAINTENANCE OF AN EXTENSIVE GREEN ROOF COSTS APPROXIMATELY $2.90/M^2 ($0.27/FT^2). MEANWHILE, THE ANNUAL MAINTENANCE OF A CONVENTIONAL BLACK ROOF COSTS $0.2/M^2 ($0.02/FT^2).
2. THE GREATEST MAINTENANCE OCCURS DURING THE FIRST TWO YEARS (ESTABLISHMENT PERIOD) AND IT IS CRITICAL FOR LONG-TERM SUCCESS OF THE ROOF. SPECIFICALLY, PLANT IRRIGATION IS CRUCIAL DURING THE FIRST THREE WEEKS OF THE ESTABLISHMENT PERIOD.

Northwestern University 2016 WITH EDITS BY ECT, 2021	EXTENSIVE GREEN ROOF NOTES	A COLLABORATION OF: delta institute NORTHWESTERN UNIVERSITY
GI 9.03 3 OF 3 SCALE: NTS		

Permeable Pavement

Permeable pavement allows the infiltration of rainwater through the jointing material placed in the spaces between the pavers. Permeable pavers are ideal for right-of-way applications, such as parallel parking lanes or gutter retrofits. This technique can also be used for green alley applications, parking areas, and pedestrian pavements. Permeable pavements are ideal retrofitting existing pavements and for redevelopment sites where it can often be difficult to provide adequate space for other green infrastructure practices.

When runoff flows over a surface of permeable pavement, it infiltrates through open graded stone layers that have a porosity of approximately 40%. Porosity is an expression indicating the ratio of open void space that is available to hold the total the total volume of the soil and gravel material. Larger, open-graded aggregate will have a higher rate of porosity than sand or dense-graded aggregate (which can possess a broader range of aggregate size within its mix). Many jurisdictions require porosity values of 30-36% during design, to provide a factor of safety. After rainwater is stored in the stone layer, it can then infiltrate into the subgrade soil. The design should consider the infiltration capacity of the subgrade soils when designing the system and determine whether there is a need for an underdrain that is connected to the storm sewer network or other outlet. If the infiltration rate is greater than 0.5 in/ hr, then the volume of runoff infiltrated during the event may be sufficient, so as to not require an underdrain as part of the permeable pavement's design for managing runoff volumes. Concrete containment curbs are placed around the installation to prevent lateral movement.

Customization Options

Permeable pavement can be located anywhere there is existing impervious surface area, including residential, commercial and industrial locations. The minimum width of a permeable pavement design is 2 feet, and the maximum length and width are scalable. Oftentimes the pavers will be used on the edge of a road or in the parallel parking lane adjacent to the drive lane. Large storm events can discharge to an existing or proposed storm sewer inlet. There are many manufacturers for permeable pavers, allowing for many size, color and layout pattern configurations.

"Permeable pavement" systems can be topped with other permeable surfaces such as artificial turf and rubber-surfaces (both commonly used in playgrounds) to accommodate a range of site uses. Permeable pavement systems can be sized to provide both storage for infiltration, water quality, and detention purposes. Depending on the run-on area that drains to the permeable paving, an 18-inch section of open graded base aggregate will be sufficient to provide detention storage.

The engineer should resist the temptation to "overdrain" the pavement system, which can lead to reduced time for infiltration and less efficient detention for larger storms. In many cases underdrains will only be necessary at the downstream end of the pavement slope. Underdrains can utilize the resistance to flow from the aggregate to slow drainage within the aggregate base, to improve detention performance. The engineer should design the underdrain system, including underdrain spacing and sizing, to meet the desired performance goals. In most cases, the system should be designed to avoid upflow runoff out of the surface of the permeable pavers at the downstream end, to avoid the flowing water from washing out the aggregate in the paver joints.

Maintenance

Care should be taken to avoid the runoff of sediment from adjacent areas onto the permeable pavers as much as possible. Sand should not be used for winter traction on permeable paving systems, since the sand will clog the openings. When infiltration through the pavers becomes unacceptable, a vacuum truck is required to remove joint material and sediment accumulated between the pavers. The joint material will then need to be replaced. Frequency of replacement will depend on site conditions and sediment loading. Maintenance costs from manufacturers is estimated to be approximately $0.60 per square foot a year.

Cost Information

Cost information is provided for each green infrastructure technique in Section 5 of this report. The installed costs are based on project experience, bid tabs, and information from the RS Means trends, and the labor and bidding environment.

Table 13: Permeable pavement practices unit costs [1,2,3]

	Item	Description	Unit Price	Unit
GI Technique	Permeable Pavement	Design/Engineering	15% of Construction Cost	LS
		Mobilization	$10,000.00	LS
		Excavation & Haul	$45.00	CY
		Porous unit Pavers (Machine Installed)	$10.00	SF
		Geotextile Fabric	$5.00	SY
		ASTM No. 8 Stone bedding	$95.00	CY
		ASTM No. 57 Stone base	$65.00	CY
Required Component	Curb	Flush Curb	$25.00	LF
	Curb	Curb & Gutter section	$25.00	LF
Custom Options	Subbase Layer	ASTM No.2 Stone	$65.00	CY
	Underdrain	4" HDPE perforated storm pipe	$20.00	LF
	Perforated Pipe Cleanout		$600.00	EA
	Storm Sewer	12" HDPE storm sewer	$65.00	LF
	Connection to existing storm sewer		$600.00	EA

1 Installed cost include material and labor based on bid tabs from related projects and RS Means.

2 Unit price based on a small (500 sf) urban alley retrofit project with hand placement of the permeable pavers. For larger installations, pavers can be machine installed, which increases efficiency and reduces the unit price. Unit prices for specific projects will vary based on scale, complexity, labor environment, and material cost trends. A detailed estimate should be prepared by the design engineer.

3 The system storage capacity can be increased by enlarging the stone envelope. Stone void space ratio is 40% and the unit weight is 100 lb/cf. 4 Multiply permeable pavement perimeter length by the unit price.

Specifications

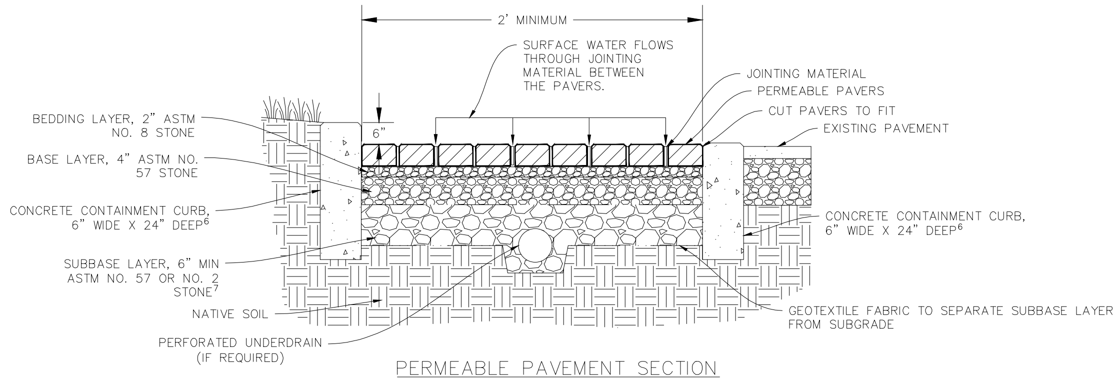
Although permeable pavers function differently than stormwater planters, the construction required to build them is very similar to a stormwater planter, because they are both surrounded by concrete curbing. The main difference is that permeable pavers do not use engineered soil or plants. Refer to Appendix C for more information on how to customize the standard specifications from the Illinois Urban Manual.

Construction Specifications

2 - Clearing and Grubbing
5 - Pollution Control
7 - Construction Surveys
8 - Mobilization and Demobilization
10 - Water for Construction
21 - Excavation
23 - Earthfill
24 - Drainfill
25 - Rockfill
32 - Structure Concrete
34 - Steel Reinforcement
35 - Concrete Repair
44 - Corrugated Polyethylene Tubing
46 - Tile Drains
94 - Contractor Quality Control
95 - Geotextile
752 - Stripping, Stockpiling, Site Preparation and Spreading Topsoil

Material Specifications

521 - Aggregates for Drainfill and Filters
522 - Aggregates for Portland Cement Concrete
531 - Portland Cement
534 - Concrete Curing Compound
535 - Preformed Expansion Joint Filler
536 - Sealing Compound for Joints in Concrete and Concrete Pipe
539 - Steel Reinforcement (for Concrete)
548 - Corrugated Polyethylene Tubing
592 - Geotextile Permeable Pavers - Manufacturer specific



PERMEABLE PAVEMENT SECTION

PERMEABLE PAVERS[1]

DESIGN GUIDANCE

TYPICAL LOCATION: PARALLEL PARKING LANE WITHIN RIGHT OF WAY OR IN PARKING AREA OF REDEVELOPMENT

WIDTH: 2' MIN, SCALEABLE

LENGTH: SCALABLE

CONTRIBUTING DRAINAGE AREA: VARIES ON SCALE

AVAILABLE OPTIONS: UNDERDRAIN
UNDERGROUND STORAGE (GI 11.01)

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ NATIVE SOIL INFILTRATION[2]: ____________ IN/HR
- ☐ REQUIRED STORAGE CAPACITY[3]: __________ CUBIC FT
- ☐ CONNECT TO EXISTING STORM NETWORK: YES/NO[4]
- ☐ DEPTH TO GROUNDWATER TABLE > 2 FT: YES/NO[5]

1. AQUA ROC PAVERS BY BELGARD SHOWN IN ALLEY RETROFIT (PHOTO BY GUIDON DESIGN)
2. NATIVE SOIL INFILTRATION NEEDS TO BE GREATER THAN 0.5 INCHES/HOUR. IF IT IS NOT, AN UNDERDRAIN MUST BE INCLUDED.
3. IF STORAGE CAPACITY EXCEEDS AVAILABLE FOOTPRINT SPACE, INCREASE THICKNESS OF DRAINAGE AGGREGATE OR CONSIDER UNDRERGROUND STORAGE.
4. IMPACT ON DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
5. IF NO, TECHNIQUE MAY NOT MEET CODE WITHOUT A LINER.
6. CONCRETE CONTAINMENT CURB MUST BE INSTALLED ON ALL SIDES OF THE PERMEABLE PAVERS.
7. THE THICKNESS OF THE BASE AND SUBBASE SHOULD BE SIZED TO MEET THE STRUCTURAL REQUIREMENTS OF THE APPLICATION AS WELL AS THE STORMWATER GOALS.

GI 10.01
1 OF 2
SCALE: NTS

PERMEABLE PAVEMENT

A COLLABORATION OF:

delta institute

GUIDON DESIGN

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

PERMEABLE PAVEMENT NOTES

1. NATIVE SOIL INFILTRATION RATE TO BE 0.5 INCHES/HOUR OR GREATER. IF NOT, THEN AN UNDERDRAIN IS REQUIRED.
2. RUN–ON TRIBUTARY RUN–ON AREA SHALL NOT EXCEED 3:1 RELATIVE TO THE PERMEABLE PAVEMENT AREA. RUN–ON SHALL BE DISTRIBUTED OVER THE AREA OF THE PERMEABLE PAVING TO AVOID HYDRAULICALLY OVERLOADING THE SURFACE AND BYPASSING RUNOFF.
3. AGGREGATE BASE AND SUBBASE COURSE THICKNESS DEPENDENT ON TRAFFIC LOADING AND SUBGRADE SOIL PROPERTIES AS WELL AS REQUIRED STORAGE TO MEET STORMWATER GOALS AND/OR REGULATORY REQUIREMENTS.
4. THE SUBBASE COURSE SHALL BE CRUSHED STONE OR CRUSHED GRAVEL MEETING ASTM GRADATION #57 OR #2. #2 STONE MAY BE USED WHEN THE SUBGRADE SURFACE IS FLAT. #57 STONE IS PREFERRED WHEN THE SUBGRADE IS SLOPED DUE TO ITS SLOWER DRAINGE RATE PROVIDING MORE TIME FOR INFILTRATION AND DETENTION.
5. FULL EXTENT OF POROUS PAVEMENT SHALL BE FENCED OFF DURING CONSTRUCTION TO PREVENT COMPACTION OF SUBGRADE AND STOCKPILING OF CONSTRUCTION MATERIALS OVER SURFACE.
6. PERVIOUS PAVEMENT SURFACES SHALL BE PROTECTED FROM SEDIMENT DURING THE ENTIRE CONSTRUCTION PROCESS.
7. IF DURING EXCAVATION OF NATIVE SOILS, THE BOTTOM OF THE TECHNIQUE IS EXPOSED TO RAIN, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO REMOVE CRUSTED SURFACES AND RESTORE INFILTRATION CAPACITY.
8. AGGREGATE BASE COURSE SHALL BE WASHED ON–SITE TO REDUCE WASH LOSS TO 0.5%. ROCK SHOULD BE HOSED OFF WHILE ON TRUCK OR AFTER STOCKPILING. HOSE OFF AS PILE IS UTILIZED AS FINES WILL MIGRATE TO LOWER LEVELS OF PILE.

MAINTENANCE GUIDELINES

1. PREVENT RUN–ON OF SEDIMENT IN RUNOFF FROM ADJACENT AREAS.
2. SWEEP/VACUUM ONE OR TWO TIMES PER YEAR.
3. TO PREVENT CLOGGING OF THE SURFACE, SAND SHALL NOT BE USED DURING WINTER TO IMPROVE TRACTION.IF ABRASIVES ARE REQUIRED, CLEAN ASTM #8 OR #9 STONE SHALL BE USED.
4. WHEN INFILTRATION RATES THROUGH THE JOINTS BECOMES UNACCEPTABLE, USE A VAC TRUCK TO REMOVE JOINT MATERIAL ALONG WITH ACCUMULATED SEDIMENT. REPLACE JOINT MATERIAL. FREQUENCY OF THIS MAINTENANCE WILL VARY BASED ON SEDIMENT LOADING.

MATERIALS SPECIFICATIONS

1. BASE COURSE

1.1. ALL AGGREGATES BENEATH THE PAVEMENT SHALL BE CRUSHED STONE OR CRUSHED GRAVEL AND MEET THE FOLLOWING:

1.1.1. MAXIMUM WASH LOSS OF 0.5%

1.1.2. MINIMUM DURABILITY INDEX OF 35

1.1.3. MAXIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS

1.1. UNLESS OTHERWISE APPROVED BY THE ENGINEER, COARSE AGGREGATE FOR THE AGGREGATE BEDDING LAYER SHALL MEET THE FOLLOWING GRADATION (ASTM NO. 8)

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{1}{2}$"	100
$\frac{3}{8}$"	85–100
4	10–30
8	0–10
16	0–5

1.2. UNLESS OTHERWISE APPROVED BY THE ENGINEER, COARSE AGGREGATE FOR THE AGGREGATE BASE COURSE SHALL MEET THE FOLLOWING GRADATION (ASTM NO. 57)

US STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95–100
$\frac{1}{2}$"	25–60
4	0–10
8	0–5

1.3. UNLESS OTHERWISE APPROVED BY THE ENGINEER, COARSE AGGREGATE FOR THE AGGREGATE SUBBASE COURSE SHALL MEET ASTM NO. 57 OR NO. 2 GRADATION.

1.4. GEOTEXTILE FABRIC SHALL SHALL BE WOVEN, MONOFILAMENT GEOTEXTILE CONFORMING TO THE FOLLOWING:

A. MINIMUM FLOW RATE OF 145 GAL/MIN/FT2 ASTM D–4491
B. GRAB TENSILE STRENGTH 365 X 200LB ASTM D–4632
C. GRAB ELONGATION MAX 24 X 10% ASTM D–4632
D. TRAPEZOID TEAR MIN 115 X 75 LBS ASTM D–4533
E. CBR PUNCTURE RESISTANCE MIN 675 LB ASTM D–6241
F. APPARENT OPENING SIZE 4060–90 U.S. STANDARD SIEVE.

GI 10.02
2 OF 2
SCALE: NTS

PERMEABLE PAVEMENT NOTES

A COLLABORATION OF:

delta institute

GUIDON DESIGN

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Underground Storage

Underground storage can be an effective green infrastructure technique in situations when large storage volumes are required, in areas with routine localized flooding and combined sewer overflows, to reduce the volume and rate of stormwater entering the sewer system. Underground storage can provide an effective detention solution in areas where surface level detention basins are spatially infeasible, particularly in urban areas. Generally, runoff enters the system and fills up a stone base beneath the chambers. Once the voids in the stone base are filled, then the open area of the chamber acts as efficient open storage, holding a high volume of water per unit of footprint area.

Depending on the infiltration rate of the underlying native soil, the underground storage system will either discharge directly into the groundwater or slowly through a perforated underdrain connected to an outlet. A weir or orifice within the outlet structure can be designed to control the storage depth within the system, allowing for higher infiltration volumes. The discharge of stored stormwater (above or below ground) to the existing storm network is a traditional approach to stormwater management, with the rate controlled using orifices or other devices. For the underground storage system to be truly a green system, it must infiltrate stormwater into the ground, or be paired with other green infrastructure practices such as permeable pavement and/or bioretention systems.

Customization Options

The layout options for underground storage are both flexible and scalable. A design engineer can arrange the system to fit a desired shape and can select the height of the storage chambers and length of the system to meet the required storage volume. There are several manufacturers of underground chamber systems, as well as other underground storage solutions available. The technical designer should consider the particular requirements of the chosen system.

The system can be paired with other green infrastructure techniques. When placed under bioretention, runoff is filtered through the engineered soil layer and flows directly into the underground storage through the stone layer. Large storm events enter through the overflow structure that can be connected to the chambers. Permeable pavers filter runoff as well and direct flow through the underlying stone layer that is hydraulically connected to the stone envelope around the underground storage.

Figure 10: Underground storage chambers for stormwater

Source: https://commons.wikimedia.org/wiki/File%3AParking_lot_stormwater_detention_system.jpg

Maintenance

The underground storage system should include inspection ports that are used to observe the amount of accumulated sediment within the system. Once the accumulation has reached a level indicated by the manufacturer, the system needs to be cleaned via JetVac, which sprays water on the inside of the chambers, loosens the sediment, and vacuums it out of the system. Maintenance of the system is accessed using a manhole structure and distribution pipe manifold. The inspection port should be inspected semi-annually or per manufacturer guidelines. Maintenance costs will vary based on the size of the installation and ease of access. A standard JetVac maintenance should cost $1,500 -$ 2,500.

Cost Information

Cost information is provided for each green infrastructure practice in Section 5 of this report. The installed costs are based on project experience, bid tabs and information from the RS Means Building Construction Costs Data (2012 edition), which is an industry standard compilation of unit costs for various construction activities. The costs in the table below can be used to scope a project, but a project specific cost estimate should be prepared by the design engineer that takes into account the project scale and complexity, material cost trends, and the labor and bidding environment.

Table 14: Underground storage practices unit costs[1],[2],[3],[4]

	Item	Description	Unit Price	Unit
GI Technique	Underground Storage	Design/Engineering	15% of Construction Cost	LS
		Mobilization	$10,000.00	LS
		Excavation & Haul	$45.00	CY
		Chamber System	$7.50	CF
		Geotextile Fabric	$5.00	SY
Custom Options	Underdrain	4" HDPE Perforated underdrain	$20.00	LF
	Surface restoration		$3.00	SF
	Outlet Control/Overflow Structure		$3,500.00	EA
	Storm Sewer	12" HDPE storm sewer	$65.00	LF
	Connecting to existing storm structure		$600.00	EA

1 Installed cost include material and labor based on bid tabs from related projects and RS Means.

2 Unit price based on an 8,500 cubic foot installation beneath a commercial parking area (see GI 11.01). Pricing from various manufacturer's range from $5-7. Unit prices for specific projects will vary based on scale, complexity, labor environment, and material cost trends. A detailed cost estimate should be prepared by the design engineer.

3 The system storage capacity can be increased by enlarging the stone envelope. Stone void space ratio is 40% and the unit weight is 100 lb/cf.

4 Surface treatment costs will vary based on chosen surface application

Specifications

The underground storage technique utilizes many of the same construction techniques and materials as the other green infrastructure techniques, but it does not inherently include concrete or plantings. Please note that the underground storage technique can be paired with various surface treatments, including any of the other green infrastructure techniques. The design engineer should customize the specifications included in the construction documents to reflect all the items included in the design. Refer to the instructions on using the Illinois Urban Manual standard specifications included in Appendix B.

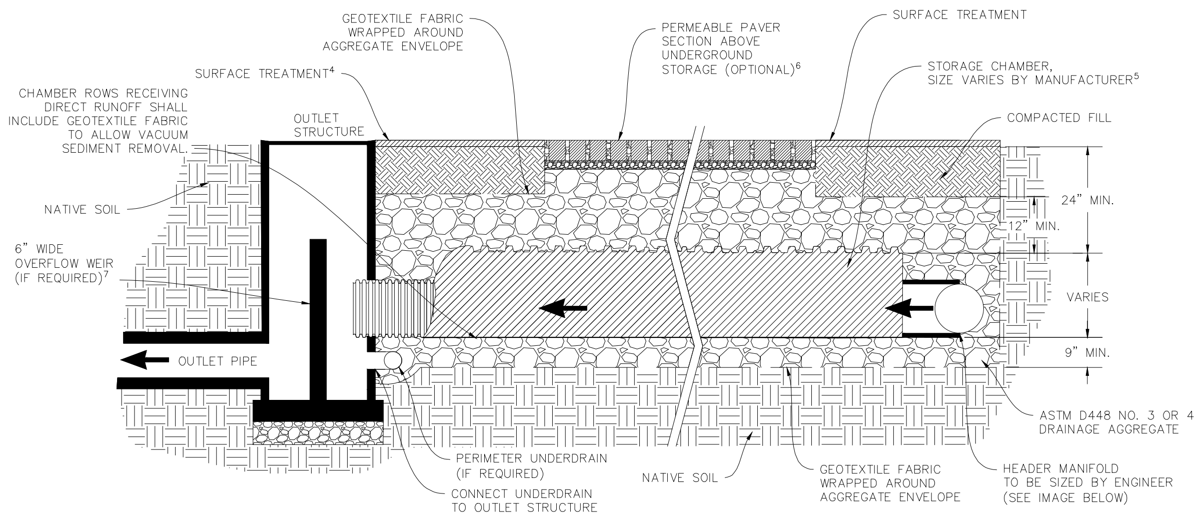
Construction Specifications

2 - Clearing and Grubbing
5 - Pollution Control
7 - Construction Surveys
8 - Mobilization and Demobilization
21 - Excavation
23 - Earthfill
24 - Drainfill
25 - Rockfill
44 - Corrugated Polyethylene Tubing
46 - Tile Drains
94 - Contractor Quality Control
95 - Geotextile
752 - Stripping, Stockpiling, Site Preparation and Spreading Topsoil

Material Specifications

521 - Aggregates for Drainfill and Filters
536 - Sealing Compound for Joints in Concrete and Concrete Pipe
548 - Corrugated Polyethylene Tubing
592 - Geotextile Underground Storage – Manufacturer specific

Underground Storage



UNDERGROUND STORAGE SECTION

STORMTECH SUBSURFACE CHAMBERS ARE AN EXAMPLE OF UNDERGROUND STORAGE[3]

DESIGN GUIDANCE

TYPICAL LOCATION: VACANT LOTS, DEMOLITION OR REDEVELOPMENT SITES, BENEATH OR ADJACENT TO OTHER GI TECHNIQUES

LENGTH AND WIDTH: SCALABLE

CONTRIBUTING DRAINAGE AREA: VARIABLE

AVAILABLE OPTIONS: OVERFLOW STRUCTURE
UNDERDRAIN
UNDERDRAIN WITH WEIR

SURFACE TREATMENT: PERMEABLE PAVEMENT
BIORETENTION
NATIVE PLANTINGS
TURF
PAVEMENT

DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ NATIVE SOIL INFILTRATION[1]: ____________ IN/HR
- ☐ REQUIRED STORAGE CAPACITY ____________ CUBIC FT
- ☐ CONNECT TO EXISTING STORM NETWORK[2]: YES/NO
- ☐ DEPTH TO GROUNDWATER TABLE > 2 FT[4]: YES/NO

1. NATIVE SOIL INFILTRATION NEEDS TO BE GREATER THAN 0.5 INCHES/HOUR. IF IT IS NOT AN UNDERDRAIN MUST BE INCLUDED.
2. CAPACITY OF DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
3. HTTP://WWW.STORMTECH.COM/
4. IF NO, TECHNIQUE IS NOT SUITABLE.
5. SIZE OF CHAMBER VARIES BY MANUFACTURER AND STORAGE VOLUME DESIRED. DESIGN ENGINEER MUST ACCOUNT FOR MANUFACTURER'S REQUIREMENTS AND TOLERANCE.
6. UNDERGROUND STORAGE CAN BE PAIRED WITH PERMEABLE PAVEMENT AND BIORETENTION SYSTEMS. DIRECT STORM SEWER DISCHARGE TO UNDERGROUND STORAGE IS DISCOURAGED WITHOUT MAINTENANCE ACCESS TO REMOVE ACCUMULATED SEDIMENT AND DEBRIS. INSPECTION PORTS MUST BE PROVIDED TO MONITOR SEDIMENT ACCUMULATION AND DRAINAGE RATE.
7. OUTLET CONTROLS CAN BE INCLUDED TO PROVIDE BOTH RETENTION AND DETENTION STORAGE AND MEET PROJECT GOALS AND/OR REGULATORY REQUIREMENTS.

GI 11.01
1 OF 2
SCALE: NTS

UNDERGROUND STORAGE

A COLLABORATION OF:

Underground Storage Notes

NOTES

1. SURFACE TREATMENT IS FLEXIBLE AND DEPENDENT ON THE SITE AND USE. OPTIONS INCLUDE TURF, NATIVE PLANTINGS, PAVEMENT, PERMEABLE PAVEMENT AND BIORETENTION.
2. HEADER MANIFOLD DISTRIBUTES RUNOFF TO THE CHAMBERS. RUNOFF CAN FLOW FROM INLETS OR THE OVERFLOW STRUCTURE OF OTHER GI TECHNIQUES(RAIN GARDEN, STORMWATER PLANTER, HYBRID DITCH, AND PERMEABLE PAVERS). MANIFOLD MUST BE SIZED BY DESIGN ENGINEER
3. IF NATIVE SOILS HAVE POOR INFILTRATION (<0.5 IN/HR), AN OUTLET FROM THE SYSTEM SHALL BE PROVIDED.
4. INSPECTION PORTS SHALL BE PROVIDED TO MONITOR SEDIMENT ACCUMULATION AND DRAINAGE RATE.
5. MAINTENANCE ACCESS SHALL BE PROVIDED TO ALLOW REMOVAL OF ACCUMULATED SEDIMENT.
6. CHAMBER ROWS RECEIVING DIRECT RUNOFF SHALL INCLUDE A WOVEN FABRIC LAYER AT THE BASE OF THE CHAMBER TO FACILITATE VACUUM REMOVAL OF ACCUMULATED SEDIMENT.
7. MATERIAL MUST BE APPROVED BY SITE ENGINEER PRIOR TO INSTALLATION. MANUFACTURER SHOULD SUBMIT INFORMATION REGARDING THE STRUCTURAL INTEGRITY, SAFETY FACTOR FOR DEAD AND LIVE LOADS, AND THE 50 YEAR CREEP MODULUS DATA.
8. A CROSS SECTION SHOULD BE PROVIDED THAT THE STRUCTURAL EVALUATION IS BASED ON.
9. MATERIAL AND END CAPS ARE TO BE PRODUCED IN AN ISO 9001 CERTIFIED MANUFACTURING FACILITY.
10. MATERIAL SHOULD NOT BE INSTALLED UNTIL A REPRESENTATIVE FROM THE MANUFACTURER HAS A PRE-CONSTRUCTION MEETING WITH INSTALLER.
11. MATERIAL TO BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S GUIDANCE.
12. MATERIAL SHOULD BACKFILLED OVER THE CHAMBERS ACCORDING TO MANUFACTURER'S WRITTEN INSTRUCTIONS.
13. JOINTS BETWEEN CHAMBERS SHOULD BE PROPERLY SEALED TO PREVENT INTRUSION OF BACKFILL MATERIAL.
14. MAINTAIN MINIMUM SPACING BETWEEN MATERIAL PER MANUFACTURER'S RECOMMENDATIONS.
15. STONE SURROUNDING MATERIAL MUST BE CLEAN, CRUSHED, ANGULAR OPEN GRADED STONE MEETING THE MEETING THE MANUFACTURERS REQUIREMENTS
16. TAKE PROACTIVE STEPS TO PROTECT THE SUBSURFACE STORMWATER MANAGEMENT SYSTEM FROM CONSTRUCTION SITE RUNOFF.
17. CARE MUST BE TAKEN WITH THE TYPE AND PLACEMENT OF CONSTRUCTION EQUIPMENT. REFER TO MANUFACTURER'S RECOMMENDATION.
18. SITE ENGINEER IS RESPONSIBLE FOR DETERMINING BEARING RESISTANCE OF SUBGRADE SOILS AND THE DEPTH OF FOUNDATION STONE.
19. PERIMETER STONE MUST EXTEND HORIZONTALLY TO EXCAVATION WALL IN ALL SITUATIONS.
20. GEOTEXTILE FABRIC SHALL BE WOVEN, MONOFILAMENT GEOTEXTILE CONFORMING TO THE FOLLOWING:
    a. MINIMUM FLOW RATE OF 145 GAL/MIN/FT2 ASTM D-4491
    b. GRAB TENSILE STRENGTH MIN 365X200 LB ASTM D-4632
    c. GRAB ELONGATION MAX 24X10% ASTM D-4632
    d. TRAPIZOID TEAR MIN 115X75 LBS ASTM D-4533
    e. CBR PUNCTURE RESISTANCE MIN 675 LB ASTM D-6241
    f. APPARENT OPENING SIZE 4060-90 U.S. STANDARD SIEVE

MAINTENANCE GUIDELINES		
TASK	FREQUENCY	TIMEFRAME
INSPECT UNDERGROUND STORAGE	SEMI-ANNUALLY/ AS NEEDED	FIRST YEAR/ ONGOING
JETTING AND VACTORING	ANNUALLY/ AS NEEDED	FIRST YEAR/ ONGOING

GI 11.02
2 OF 2
SCALE: NTS

UNDERGROUND STORAGE NOTES

A COLLABORATION OF:

GLOSSARY OF TERMS

Aggregate: a clustered mass of individual soil particles varied in shape, ranging in size from a microscopic granule to a small crumb, and considered the basic structural unit of soil

Caliper: The diameter of a tree's trunk at breast height itself. The measurement is generally made at 4.5 feet above the soil.

Conveyance: The action of transferring water from one location to another, commonly through sewer systems.

Concentrated Flow: The movement of surface water which, resulting from its length and velocity, takes the form of a channel. Concentrated flow tend to exhibit higher velocity, and can be responsible for inducing soil erosion.

Evapotranspiration: The loss of water from the soil both, by evaporation and by transpiration from the plants growing thereon.

Forbs: An herbaceous flowering plant, separate from grasses and sedges.

Gully: A trench or ravine that has formed in the earth, as a result of running water, and where running water often runs after rainfall.

Herbaceous Plants: Species that have little to no woody tissue in their stem structure.

Infiltration: The process by which surface water enters the soil.

Perennial Plants: Species that live beyond two growing seasons.

Porosity: The ratio, expressed as a percentage, of the volume of the pores in a rock or rock stratum, to the total volume of the mass.

Residence Time: The duration or period that water remains in a particular medium or place.

Rill: A small brook or stream.

Sheet Runoff: A form of flow that is produced when runoff travels over a surface in such a manner that its resulting distribution becomes more even, less concentrated, and with a lower level of velocity.

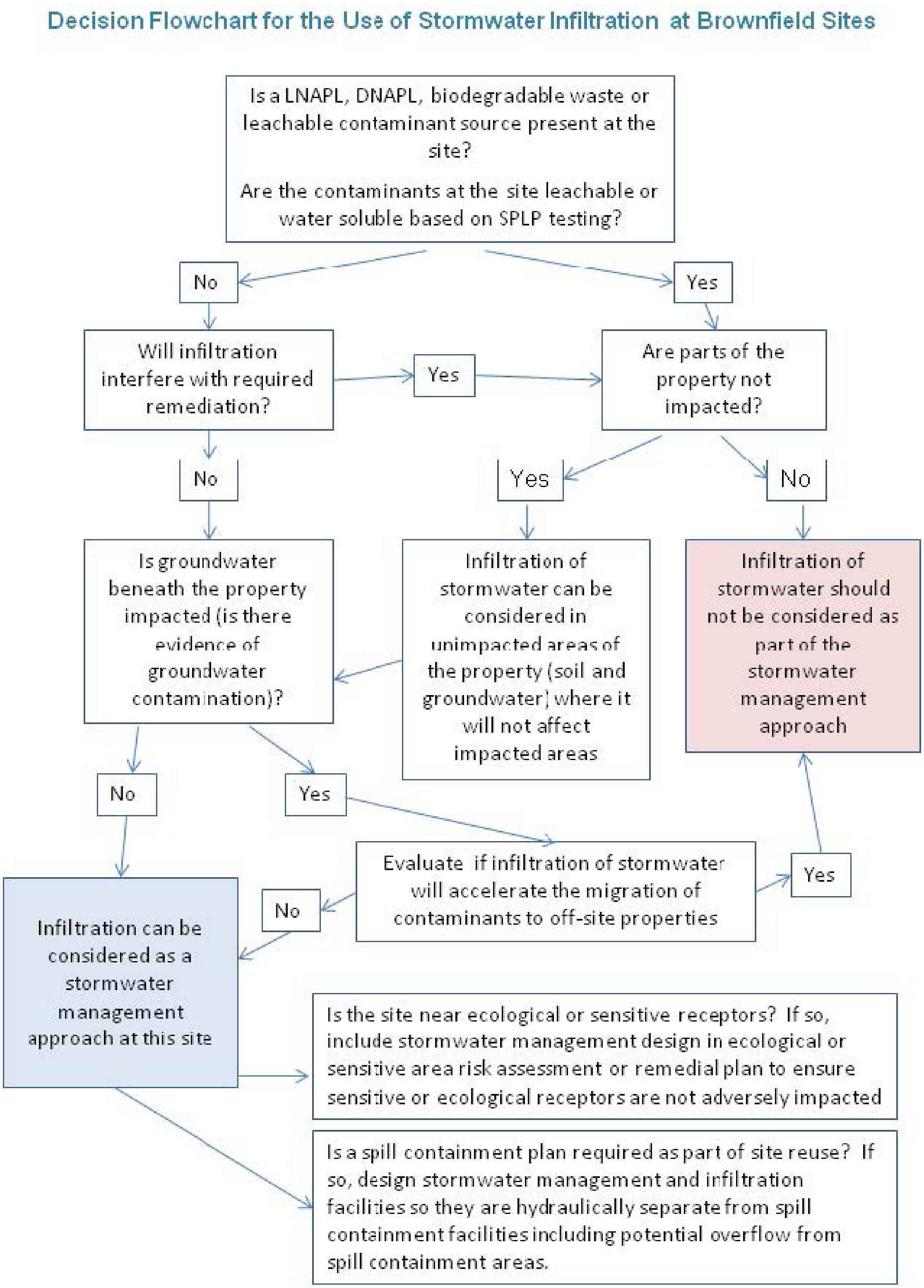
Subgrade: Native soil material existing beneath surface materials, such as pavement, etc.

Substrate: A layer of soil beneath the surface, upon which an organism grows.

Underdrain: A concealed drain with openings through which the water enters when the water table reaches the level of the drain.

APPENDIX A

EPA Brownfields Decision Flow Chart



APPENDIX B

Illinois Urban Manual

The Illinois Urban Manual was created to provide guidance for the design and construction of best management practices (BMPs) in both urban and rural communities. The compilation continues to evolve,and the latest revisions and publications are available online: http://www.aiswcd.org/illinois-urbanmanual.

Two major components of the Illinois Urban Manual are comprehensive construction and material specification sections. The intent of these standard specifications is to provide common specification language that is streamlined for use by design engineers in contract documents. Most of the sections included in the Manual were taken from the NRCS's National Engineering Handbook Part 642.

Portions of the Illinois Urban Manual are included in this Appendix for reference, including an explanation of how to use the specifications and a table of contents showing all of the sections available.

Illinois Urban Manual

An Erosion and Sediment Control Best Management Practice Manual

ILLINOIS URBAN MANUAL

Association of Illinois Soil and Water Conservation Districts

Section 1

Introduction to Illinois Urban Manual

Preface

This manual is intended for use as a technical reference by developers, planners, engineers, government officials and others involved in land use planning, building site development, and natural resource conservation in rural and urban communities and developing areas.

The standards and associated materials describe best management practices (BMPs) for controlling non-point source pollution impacts that affect ecosystems in existing communities and developing areas. The manual includes an array of BMPs in the following broad categories:

- soil erosion and sediment control;
- stormwater management; and
- special area protection.

Beyond conventional BMP considerations, the manual addresses fish and wildlife habitat improvement, visual and environmental quality and other relevant ecosystem enhancement applications. Where previous BMP manuals have tended to focus on limited aspects of construction site erosion or stormwater runoff control, this manual is designed for more comprehensive, multi-objective ecosystem protection and enhancement.

This manual supersedes the Illinois EPA's 1987 *"Standards and Specifications for Soil Erosion and Sediment Control"* (commonly known as the "Yellowbook") and the original *"1995 Illinois Urban Manual."* It also replaces Chapter 6, entitled "Procedures and Specifications", of the Association of Illinois Soil and Water Conservation District's 1988 *"Procedures and Standards for Urban Soil Erosion and Sedimentation Control in Illinois"* (commonly known as the "Greenbook"). This manual was prepared for the Illinois Environmental Protection Agency (EPA) by the United States Department of Agriculture's (USDA) - Natural Resources Conservation Service (NRCS) in Illinois. The NRCS was formerly known and recognized as the Soil Conservation Service (SCS). Initially released in 1995, the manual is being revised by a committee made up of federal and state resource agencies, regional planning commissions, local units of government, and the private sector.

Funding in part for the development and maintenance of this manual was provided by Section 319 of the Clean Water Act through Illinois EPA.

Section revised June 2009

Introduction

This manual is intended to be a dynamic document. Several sections may stay static for long periods of time. Others, such as sections 4, 5, 6, and 7, will likely be expanded on a regular basis to include additional conservation practice standards, construction specifications, material specifications and standard drawings not yet developed.

This manual sets no policy, rules, regulations or restrictions. However, it is anticipated that various units of government and local, state, or federal agencies would use these technical materials to guide development of policy, ordinances, restrictions, or regulations. If adopted by reference in a regulatory program, such as in a Soil Erosion and Sediment Control Ordinance adopted by a local jurisdiction, the contents of the manual have the force of law.

No individual section of this manual will contain all the guidance or material necessary to fully assist users to develop or implement site specific plans. Other references or sections of other manuals or handbooks that supplement this publication should be utilized as appropriate. Other primary reference materials to support this manual are listed in the References section of the practice standards or in Section 9 - References. All references to IDOT in the practice standards and on the standard drawings refer to the *Illinois Department of Transportation Standard Specifications for Road and Bridge Construction,* adopted 2007 or the latest version. The standard drawings use an 'RR' designation in place of a gradation number. Assume the 'RR' to be synonymous with 'Gradation'.

Users of the manual are encouraged to contact the following if you have any questions or additional information or assistance is needed:

1. NRCS/SWCD County Office (in the phone book under U.S. Government, Department of Agriculture, the Illinois NRCS website www.il.nrcs.usda.gov under "Directories", or the AISWCD website http://aiswcd.org, or

2. Illinois EPA, Bureau of Water - Watershed Management Section, 1021 North Grand Avenue East, PO Box 19276, Springfield, IL 62794-9276 (phone 217-782-3362), website: www.epa.state.il.us/water/index.html, or

3. Kelly Thompson, AISWCD Program Coordinator, at 4285 North Walnut Street Road Springfield, IL 62707 (phone 217-744-3414), Email at kelly.thompson@aiswcd.org

Revised June 2009
AISWCD

Section 5

Construction Specifications

Introduction

This section contains construction specifications and instructions for their use. The construction specifications along with material specifications (see Section 6) make up the contract specifications and can be used as the requirements in construction contracts. To make the construction specifications complete the last section must be written to identify the specific methods that apply, identify and describe bid items, and list any specific instructions that pertain to the job under construction. This last section is normally shown with the heading ITEMS OF WORK AND CONSTRUCTION DETAILS.

The construction specifications and instructions for use are from NRCS's National Engineering Handbook Series (NEH) Part 642 (formerly referred to as NEH Section 20) as well as several state interim specifications. The interim specifications are numbered starting at 200 and do not usually have a corresponding instruction for use.

A general discussion is included that describes how a bid schedule is set up, how construction specifications are compiled, and how construction details and bid items are set up in the specifications. Some examples are included in the discussion. The discussion is an abridged version from NEH Part 642.

Current updates of construction specifications from NRCS's National Engineering Handbook Series Part 642 can be found at http://www.ftw.nrcs.usda.gov/nehcs.html. The notice for the May 2001 release of the construction specifications in Part 642 identified revisions to Construction Specification 51 - Corrugated Metal Pipe and Construction Specification 94 - Contractor Quality Control. These changes are reflected in this release of Chapter 5 of the Illinois Urban Manual. The dates on the other construction specifications have not been updated; however, the technical content of all other construction specifications has not likely changed.

General Discussion

The body of a construction contract consists of general provisions, a bid schedule, specifications, drawings, inspection requirements, performance time, contract administration data and, when applicable, special provisions and wage rate decisions. Typically the general provisions are administrative and technical requirements that apply to all items of construction and to all contracts. The bid schedule tabulates the items of work for which direct payment will be made, shows the estimated quantities of work and the units of measurement, and provides space for the entry of contract prices. The specifications and drawings include the technical details and requirements of the contract. The office responsible for the design of the work develops the drawings and specifications and, in cooperation with the responsible administrative office, the bid schedule. The special provisions are administrative instructions and requirements that apply to the specific contract and are prepared by the responsible administrative office.

Terms and Definitions

The following terms and definitions are used relative to specifications for construction contracts:

National Standard Construction Specifications state the technical and workmanship requirements for the various operations required in the construction of the works, the methods of measurement, and the basis of payment.

National Standard Material Specifications state the quality of materials to be incorporated in the permanent works. The material specifications make up Section 6 of this manual.

Interim Specifications are specifications prepared for use in contracts that include construction items or materials not covered by National Standard Specifications.

Standard Specifications are National Standard and Interim specifications.

Construction Details are prepared by the design office and state the special requirements peculiar to a specific work of construction. They may take the form of written addenda to the standard construction specifications or notes on the drawings.

Contract Specifications are the complete specifications prepared for a specific contract and consist of construction and material specifications supplemented by lists and descriptions of items of work and construction details.

National Standard Construction Specifications

National standard construction specifications are to be used verbatim. Some national standard specifications have sections that contain alternative methods of achieving work. The specification writer may delete the methods not used in the contract; however, the method selected must be used verbatim. Only methods identified in the specification may be deleted from the national standard construction specification. Each of the national standard construction specifications is supplemented by instructions for its use. These instructions state the applicability of the specification and discuss the items of information that must be included in the contract specifications and drawings in order to completely define the specified item. They also discuss the conditions under which it may be appropriate to use any of the various methods listed. These instructions are included for use by design personnel and are not to be included in contract specifications.

National Standard Material Specifications

National standard material specifications have been prepared for those materials whose quality must be uniform in all areas of applicability. National standard material specifications are to be used verbatim. They are not supplemented by instructions for use. Items of information that must be included in the contract specifications in order to completely describe the materials required for a specific contract are listed in the instructions for use of the construction specifications to which the material specifications are complementary.

Reference to material specifications may be in national standard construction specifications or may be placed in the construction details (either written in the specifications or noted on the contract drawings).

Interim Specifications

Interim specifications are for items that are not covered by national standard construction and material specifications. Interim specifications follow the same format as the national standard specifications. They are typically unique to a specific locality and therefore are not national in scope.

Selecting Appropriate Standard Specifications

The type of work to be done or the type of structural detail required will often dictate the construction method or sequence. The specification requirements must be compatible with the methods that must be used. The specification writer must also make sure that the methods selected in one specification are compatible with those selected in another. For example, the method of designating pay limits for excavation and earthfill.

Bid Schedule

The bid schedule forms the basis for payments to the Contractor and must list all items of work for which direct payment will be made. Since the efficiency of contract administration is directly affected by the manner in which the schedule is organized, the preparation of the bid schedule requires the close cooperation of the responsible design engineer and the contracting officer. Operating procedures must include provision for administrative review of the bid schedule in the early stages of its development as well as upon completion.

Designating the Items of Work

Considerable judgment based on design, construction, and contracting experience is required to divide the work into items for inclusion in the bid schedule. The schedule must be sufficiently comprehensive to allow the Contractor to make reasonably accurate estimates of the cost of doing the work and to enable the Contracting Officer to keep orderly records of work progress and to accurately compute progress and final payments due; on the other hand, the number of scheduled items should be held to the minimum needed to accomplish these purposes. The practicable extent to which the work should be divided into scheduled items must be judged in light of the quantities of work involved and local construction practices and procedures. The bid schedule should include those items necessary to result in fair and equitable treatment of the owner(s) and the Contractor.

Division of the Work into Items For maximum efficiency of contract administration, the work should be divided into items on the basis of the following principles:

1. **The work should be divided into items in a manner that will insure reasonable refinement of unit prices.** The cost of any given type of work will vary according to its complexity and the complicating effects of the conditions under which it must be done. Generally, the scope of a bid item should be limited to a given type of work of a particular order of complexity and cost. Exceptions to this rule may be justified on small jobs involving relatively small quantities of work.

2. **The work should be divided into items in a manner that will prevent confusion of supplemental job requirements.** Similar types of work may involve different sizes of components or different qualities of materials. To prevent confusion, each variation of a given type of work should be established as a separate item of work. Also, the grouping of non-related items or similar components of separate works of improvement should be avoided.

3. **The work should be divided into items in a manner consistent with the cost sharing arrangements established in the work plan and the project agreement.** For many projects, certain works of improvement may be paid for entirely or partially by different sponsoring organizations. To facilitate accounting of project costs, the work for such improvements should be established as separate items of work in the bid schedule.

Numbering and Titling

Bid items must be numbered consecutively beginning with the number one (1). Sub-item numbers shall not be used. Each bid item shall be given a descriptive title that distinctly identifies the work to be done. **All items that involve significant quantities of work (or significant procurement cost in the case of prefabricated units) should be designated as separate bid items.**

Pay Items

Measurable items whose quantities may be subject to variation should be designated for payment on a unit price basis, and the estimated quantity of work and units of measurement must be shown in the schedule. Items that involve significant quantities of work, but are not conveniently measurable or whose quantities are not subject to variation, may be designated for payment on a lump-sum basis. An item involving a **relatively insignificant** quantity of work that is subject to only **very minor variation** may be designated as a subsidiary item, compensation for which is included in the payment for another item which has a logical relationship to the subsidiary item. Subsidiary items will not be numbered nor listed in the bid schedule, but must be designated and described in the "Items of Work and Construction Details" of the item and also referenced in the "Items of Work and Construction Details" Section of the specification for the pay item to which it is subsidiary.

Units of measurement must be compatible with the measurement and payment clauses of the specifications.

Example 1
A typical bid schedule format is demonstrated by the following:

Bid Schedule

1	Clearing, Class A	1	12.5	ac.	________	________
2	Mobilization & Demobilization	8	1	Job	xxxx_	________
3	Excavation, Common	21	300	cu. yd.	________	________
4	Loose Rock Riprap	61	500	ton	________	________

Contract Specifications

Contract specifications shall consist of an assembly of the appropriate standard construction and material specifications. Each construction specification will be supplemented by a Section entitled: "Items of Work and Construction Details". The supplemental Section of each construction specification shall: (1) be prepared especially for each invitation; (2) designate by number and title all of the bid items (exactly as numbered and titled in the bid schedule) to be performed in conformance with the requirements of the specification; (3) designate all subsidiary items to be performed in conformance with the requirements of the specification; (4) for each designated item of work, state such supplemental requirements and items of information as are needed to relate the construction specification to the job at hand; (5) bear the number that is next in sequence after the number of the last Section of the standard specification; and (6) be inserted into the contract specification as the last page(s) of the construction specification.

Compilation

A contract specification must conform verbatim to the standard construction or material specification except, in a Section for which the standard specification offers methods, not all of the methods need to be included in that Section of the contract specification or be a one-time-use specification. The methods selected must be compatible with one another and with the conditions, materials and methods prevalent in the area of applicability and the requirements of the specified structural element.

More than one method may be included in any Section of a construction specification, in which case, the methods shall be numbered sequentially (i.e., Method 1, Method 2, etc.). The method applicable to each respective item of work, material, measurement and payment shall be identified in the construction detail Section. The instruction for each construction specification identifies the optional methods and provides guidance on their use.

Identifying

The title of each contract specification shall be the same as that of the standard construction or material specification.

When a construction specification is modified for a specific job by deleting specific methods from the standard specification, the state abbreviation and project name shall be added below “NRCS-IL-URB” in the lower left corner to indicate to the user and reviewers that the standard specification has been modified. The date at the bottom of the pages of the national standard specification shall not be changed. The pages should be renumbered consecutively.

When a construction specification is not modified by deleting specific methods from the standard specification, the numbering and footer information on the standard specification shall not be changed.

The Items of Work and Construction Details pages shall have the state abbreviation and the project name below “NRCS-IL-URB” in the lower left corner, the same page numbering format as the standard specification centered at the bottom of the page, and the date of compilation in the lower right corner.

Measurement and Payment

Each construction specification contains a Section that describes the method measurement to be used for the work performed or the material furnished and the manner of payment to be made in full compensation of the work described. The basis for designating separate work items was described earlier under the “Bid Schedule” Section. Within the conditions described therein, each of the construction specifications may be modified to include a lump sum payment method. The format and working of the method will generally be as follows:

For items of work for which specific lump sum prices are established in the contract, the quantity of work will not be measured for payment. Payment for this item will be made at the contract lump sum price for the item and will constitute full compensation for completion of the work.

Preparing Construction Details

The construction details for each item of work should be concise and will normally contain (see individual instruction for use of each construction specification):

1. Such definitions and descriptions as are needed to define the scope of work;
2. The information required to define the types and qualities of materials to be used in the work;
3. Special requirements such as foundation preparation, grading tolerances, provisions for coordinating with other work, obtaining "As Built" geology data, etc.; and
4. Other items of instruction necessary to define the construction requirements peculiar to the item of work.

The construction details should contain only such information and instructions as are needed to relate the construction specification to the job at hand. It is neither necessary nor desirable to emphasize or attempt to interpret provisions of the specification by repetition of the provisions in the construction details in the same or similar words.

In preparing construction details, it must be recognized that notes on the drawings have the effect of specifications in defining the type and quality of materials to be furnished and in defining the scope of the work. Supplemental information or requirements that are directly related to details shown on the drawings may be stated in notes on the drawings rather that in the specifications if that arrangement will more conveniently and effectively convey the information to the appropriate individuals that will benefit from this data. The engineer responsible for the design must use good judgment in deciding where various supplemental data should be located for maximum effectiveness. Usually, information shown by notes on the drawings need not be repeated in the specifications; however, if there is a compelling reason for doing so, great care must be taken to prevent conflicts between the notes and the specifications.

Construction details should not conflict with or interpret the general terms and conditions of the contract. They may modify a clause in the standard specifications if the standard specification contains the phrase "unless otherwise specified

Example 2

The following example demonstrates a typical construction detail for excavation that would be prepared for a specific contract and inserted at the end of Construction Specification 21, Excavation:

LIST OF CONSTRUCTION SPECIFICATIONS and INSTRUCTIONS FOR USE

(Numerical and Topical)

		Date	
		Instruction	Specification
Site Preparation			
1.	Clearing	5/01	5/01
2.	Clearing and Grubbing	5/01	5/01
3.	Structure Removal	5/01	5/01
4.	Channel Clearing and Snagging	5/01	5/01
5.	Pollution Control	5/01	5/01
6.	Seeding, Sprigging and Mulching	5/01	5/01
7.	Construction Surveys	5/01	5/01
8.	Mobilization and Demobilization	5/01	5/01
9.	Traffic Control	5/01	5/01
10.	Water for Construction	5/01	5/01
Foundation Work			
11.	Removal of Water	5/01	5/01
12.	Relief Wells	5/01	5/01
13.	Piling	5/01	5/01
14.	Pressure Grouting	5/01	5/01
Earthwork			
21.	Excavation	5/01	5/01
23.	Earthfill	5/01	5/01
24.	Drainfill	5/01	5/01
25.	Rockfill	5/01	5/01
26.	Topsoiling	5/01	5/01
27.	Diversions and Waterways	5/01	5/01
28.	Lime-Treated Earthfill	5/01	5/01
29.	Soil-Cement	5/01	5/01
Concrete and Reinforcement			
31.	Concrete for Major Structures	5/01	11/05
32.	Structure Concrete	5/01	5/01
33.	Shotcrete	5/01	5/01
34.	Steel Reinforcement	5/01	11/05
35.	Concrete Repair	5/01	5/01
Non-Metal Pipe Conduits and Drains			
41.	Reinforced Concrete Pressure Pipe Conduits	5/01	5/01
42.	Concrete Pipe Conduits and Drains	5/01	5/01
43.	Clay Pipe	5/01	5/01
44.	Corrugated Polyethylene Tubing	5/01	5/01
45.	Plastic Pipe	5/01	5/01
46.	Tile Drains	5/01	11/05

LIST OF CONSTRUCTION SPECIFICATIONS and INSTRUCTIONS FOR USE cont.
(Numerical and Topical)

	Date Instruction	Date Specification
<u>Metal Pipe Conduits</u>		
51. Corrugated Metal Pipe	5/01	5/01
52. Steel Pipe	5/01	5/01
53. Ductile-Iron Pipe	5/01	5/01
<u>Riprap and Slope Protection</u>		
61. Rock Riprap	5/01	11/05
62. Grouted Rock Riprap	5/01	5/01
63. Treatment of Rock Surfaces	5/01	5/01
64. Wire Mesh Gabions and Mattresses Twisted (Woven) or Welded Mesh	5/01	11/05
<u>Water Control Gates and Valves</u>		
71. Water Control Gates	5/01	5/01
<u>Miscellaneous Structural Work</u>		
81. Metal Fabrication and Installation	5/01	5/01
82. Painting Metalwork	5/01	11/05
83. Timber Fabrication and Installation	5/01	5/01
84. Painting Wood	11/05	11/05
<u>Miscellaneous Construction</u>		
91. Chain Link Fence	5/01	5/01
92. Field Fence	5/01	5/01
93. Identification Markers or Plaques	5/01	5/01
94. Contractor Quality Control	5/01	5/01
95. Geotextile	5/01	5/01
96. Field Office	5/01	5/01
97. Flexible Membrane Liner	11/05	11/05
98. Geosynthetic Clay Liner	11/05	11/05
760. Temporary Stream Diversion	N/A	9/2011
<u>Vegetation</u>		
204. Sodding		4/00
707. Digging, Transporting, Planting, and Establishment of Trees, Shrubs and Vines		8/94
750. Use of Woody Plantings for Streambank Stabilization		4/00
751. Use of Grasses for Streambank Stabilization		4/00
752. Stripping, Stockpiling, Site Preparation and Spreading Topsoil		8/94

LIST OF MATERIAL SPECIFICATIONS
(Numerical and Topical)

		Date
Foundation Materials		
511.	Steel Piles	10/98
512.	Wood Piles	10/98
513.	Precast Concrete Piles	10/98
514.	Cast-in-Place Concrete Piles	10/98
Aggregates and Rock		
521.	Aggregates for Drainfill and Filters	10/98
522.	Aggregates for Portland Cement Concrete	10/98
523.	Rock for Riprap	1/97
Concrete Materials		
531.	Portland Cement	10/98
532.	Mineral Admixtures for Concrete	10/98
533.	Chemical Admixtures for Concrete	10/98
534.	Concrete Curing Compound	10/98
535.	Preformed Expansion Joint Filler	11/97
536.	Sealing Compound for Joints in Concrete and Concrete Pipe	11/97
537.	Non-Metallic Waterstops	10/98
538.	Metal Waterstops	10/98
539.	Steel Reinforcement (for Concrete)	1/97
Non-metal Pipe and Fittings		
541.	Reinforced Concrete Pressure Pipe	11/97
542.	Concrete Culvert Pipe	11/97
543.	Non-Reinforced Concrete Pipe	10/98
544.	Clay Pipe and Drain Tile	10/98
545.	(Reserved)	
546.	(Reserved)	
547.	Plastic Pipe	10/98
548.	Corrugated Polyethylene Tubing	10/98
Metal Pipe and Fittings		
551.	Metallic-Coated Corrugated Steel Pipe	10/98
552.	Aluminum Corrugated Pipe	10/98
553.	Ductile-Iron Pipe	10/98
554.	Steel Pipe	10/98
Water Control Gates and Valves		
571.	Slide Gates	10/98
572.	Flap Gates, Metal	10/98
573.	Radial Gates	10/98

LIST OF MATERIAL SPECIFICATIONS cont.

(Numerical and Topical)

IUM April 2012

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A contract specification must conform verbatim to the standard construction or material specification except, in a Section for which the standard specification offers methods, not all of the methods need to be included in that Section of the contract specification or be a one-time-use specification. The methods selected must be compatible with one another and with the conditions, materials and methods prevalent in the area of applicability and the requirements of the specified structural element.

More than one method may be included in any Section of a construction specification, in which case, the methods shall be numbered sequentially (i.e., Method 1, Method 2, etc.). The method applicable to each respective item of work, material, measurement and payment shall be identified in the construction detail Section. The instruction for each construction specification identifies the optional methods and provides guidance on their use.

Identifying

The title of each contract specification shall be the same as that of the standard construction or material specification.

When a construction specification is modified for a specific job by deleting specific methods from the standard specification, the state abbreviation and project name shall be added below “NRCS-IL-URB” in the lower left corner to indicate to the user and reviewers that the standard specification has been modified. The date at the bottom of the pages of the national standard specification shall not be changed. The pages should be renumbered consecutively.

When a construction specification is not modified by deleting specific methods from the standard specification, the numbering and footer information on the standard specification shall not be changed.

The Items of Work and Construction Details pages shall have the state abbreviation and the project name below “NRCS-IL-URB” in the lower left corner, the same page numbering format as the standard specification centered at the bottom of the page, and the date of compilation in the lower right corner.

Measurement and Payment

Each construction specification contains a Section that describes the method measurement to be used for the work performed or the material furnished and the manner of payment to be made in full compensation of the work described. The basis for designating separate work items was described earlier under the “Bid Schedule” Section. Within the conditions described therein, each of the construction specifications may be modified to include a lump sum payment method. The format and working of the method will generally be as follows:

APPENDIX C

Engineered Soil Specification

Engineered soil is a critically important green infrastructure component. The functionality and effectiveness of the technique is in jeopardy if the engineered soil is specified, manufactured, or installed incorrectly. The following engineered soil specification section was created based on the standard engineered soil composition prescribed in the City of Chicago's Stormwater Management Manual. The specification goes beyond the mix of the soil to dictate submittal and construction requirements and the basis of payment. The format was designed to match the standard specifications in the Illinois Urban Manual (Appendix B).

MATERIAL SPECIFICATION

ENGINEERED SOIL

1. SCOPE

This work shall consist of providing and placing Engineered Soil for the green infrastructure indicated on the plans. This work shall include the preservation from injury or defacement of all vegetation and objects designated to remain.

GENERAL REQUIREMENTS

Engineered soil shall be protected from all sources of additional moisture at the Supplier, in covered conveyance, and at the Project Site until incorporated into the Work. Soil placement and compaction will not be allowed when the ground is frozen or excessively wet, or when the weather is too wet.

ENGINEERED SOIL

Engineered Soil shall consist of the following components, mixed in equal parts by volume by the Supplier prior to delivery to the project site:

1) 40% Sand
2) 30% Topsoil
3) 30% Compost

The mixture shall be well-blended to produce a homogeneous mix. Efforts should be made to incorporate organic matter content to 8 to 10 percent by weight, with the final mix to be determined by the engineer based on samples and material testing results submitted.

Engineered soil shall contain 0%-5% mineral fines content.

Engineered Soil Gradation Requirements:

US Standard Sieve Size	Percent Passing
3/8”	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	0-5

Compost products shall be the result of the biological degradation and transformation of Type I or III Feedstocks under controlled conditions designed to promote aerobic decomposition. Compost shall be stable with regard to oxygen consumption and carbon dioxide generation. Compost shall be mature with regard to its suitability for serving as a soil amendment or an erosion control BMP. The compost shall have a moisture content that has no visible free water or dust produced when handling the material.

MATERIAL SPECIFICATION

SUBMITTALS

1) Standard Test Particle Size Analysis for Engineered Soil;
2) ASTM D 1557 Results
3) Material source certification
4) Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards

CONSTRUCTION REQUIREMENTS

Contractor shall not start hybrid ditch construction until the site draining to hybrid ditch area has been stabilized and authorization is given by Engineer.

At the locations shown on the drawings, excavate, grade, and shape to the contours indicated to accommodate placing of Engineered Soil to the thicknesses required. Dispose of excavated soil or reuse elsewhere as the Contract or Engineer will allow. Scarify the subgrade soil a minimum of 3 inches deep where slopes allow, as determined by the Engineer prior to placing Engineered Soil.

Mixing or placing Engineered Soil will not be allowed if the area receiving Engineered Soil is wet or saturated or has been subjected to more than ½-inch of precipitation within 48-hours prior to mixing or placement. Engineer shall have final authority to determine if wet or saturated conditions exist.

Place Engineered Soil loosely. Final grade shall be measured only after the soil has been water or boot compacted, which requires filling the cell with water, without creating any scour or erosion, to at least 1 inches of ponding. If water compaction is not an option, final grade shall be measured at X inches above the grade specified on the plans to allow for settling after the first storm. X is calculated by depth of soil x 0.85 and rounded up to the nearest whole number.

Place Engineered Soil in loose lifts not exceeding 8 inches. Compact to a relative compaction of 85 percent of Modified maximum dry density (ASTM D 1557), where slopes allow, as determined by the Engineer.

METHOD OF MEASUREMENT

Measurement for Engineered Soil will be by the cubic yard.

BASIS OF PAYMENT

Compensation for the cost necessary to complete the work described in this Section will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1) "Engineered Soil" per cubic yard.

The Bid item price for "Engineered Soil" shall include all costs for the work necessary to furnish, place, compact, excavate, grade, shape, mix, dispose of, and as necessary.

APPENDIX D

Resources

Iowa Stormwater Management Manual. Iowa Department of Natural Resources. April 2010.

Illinois Urban Manual: A Technical Manual Designed for Urban Ecosystem Protection and Enhancement. Natural Resources Conservation Service. Revised December 2002.

Implementing Stormwater Infiltration Practices at Vacant Parcels and Brownfield Sites. Washington, D.C.: U.S. Environmental Protection Agency, Office of Water, Office of Solid Waste and Emergency Response, 2013.

Flashcards: Urban Trees as a Stormwater Utility. James Urban, FASLA. http://www.jamesurban.net/flashcards/

Oregon State University, Water and Watershed Education, and Stormwater Solutions. http://extension.oregonstate.edu/stormwater/standard-details

Santamour, F.S., JR. *Trees for Urban Planting: Diversity Uniformity, and Common Sense.* Trees for the Nineties: Landscape Tree Selection, Testing, Evaluation, and Introduction; Proceedings of the Seventh Conference of the Metropolitan Tree Improvement Alliance. PP 57-65.

Stormwater Management Ordinance Manual. City of Chicago. Department of Water Management. March 2014.

GSA Green Roof Benefits and Challenges, Cost Benefit Analysis. https://app_gsagov_prod_rdcgwaajp7wr.s3.amazonaws.com/Cost_Benefit_Analysis.pdf

RISC SOLUTIONS

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HIP INVESTOR Human Impact + Profit

CDP DISCLOSURE INSIGHT ACTION

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