GREEN INFRASTRUCTURE DESIGNS

SCALABLE SOLUTIONS TO LOCAL CHALLENGES

JULY 2015

delta institute

GUIDON DESIGN
SUSTAINABLE ARCHITECTURE + ENGINEERING

ABOUT DELTA INSTITUTE

Founded in 1998, Delta Institute is a Chicago-based nonprofit organization working to build a more resilient environment and economy through sustainable solutions. Visit online at **www.delta-institute.org**.

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1 | INTRODUCTION

Introduction

Many municipalities struggle to effectively address stormwater and flooding issues that impact their communities, and they are increasingly interested in green infrastructure as tool for stormwater management. However, these municipalities often face 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, Delta Institute (Delta), created this practical toolkit which features scalable tools and design templates.

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, which green infrastructure treatments 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 broadly applicable to a variety of sites and decision-makers, but they maintain a focus on addressing the issues and constraints that are specific to resource-constrained municipal managers and decision-makers.

All of the green infrastructure treatments included in this toolkit can be scaled to sites across a wide geography, but they are particularly well-suited to the Midwestern climate.

Why Green Infrastructure?

To avoid flooding, precipitation must be redirected from impermeable surfaces, which is often achieved using a "gray infrastructure" approach which uses gutters and underground pipe networks that discharge to local sewers or water bodies. *Green infrastructure* is a valuable supplemental tool to alleviate stormwater overflow, and it uses natural conditions to slow the movement of water, helping to manage the flow of stormwater and mitigate flooding issues.

Green infrastructure can also deliver a variety of co-benefits to the surrounding community. For example, rocks and soil can help stormwater infiltrate the soil, and plants can purify the water by storing contaminants in their root systems. Additionally, green infrastructure can mitigate flooding while also helping to alleviate stress on aging gray infrastructure systems.

Green infrastructure can also support community planning objectives and provide 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.

2 | STORMWATER MANAGEMENT

Overview

Stormwater management is paramount to the design and function of any human development. The natural water cycle allows for the infiltration of stormwater into the ground and for the absorption of water by plant roots and leaves (evapotranspiration). Impervious surfaces from pavement and buildings fulfill our need for shelter and commerce, but they also eliminate 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 as it flows over impervious surfaces, causing increased water quality issues.

Gray vs. Green Infrastructure

When rain falls on an impervious surface, it must be redirected to avoid flooding of streets and buildings. The traditional approach to redirecting runoff has been to remove it from the area as quickly as possible. 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 it down, collecting and treating rainwater 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, or it slowly redirects runoff elsewhere. The green infrastructure approach mitigates flooding of receiving waters and aging infrastructure which gets 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. Stormwater quality regulations are also becoming increasingly more and more stringent. 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 above ground storage volume. 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 by the warming of hard surfaces.

3 | GREEN INFRASTRUCTURE

Techniques

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 for a full list of resources. 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:

- Bioswale/Hybrid ditch
- Stormwater Planter (with tree option)
- Rain garden
- Underground storage
- Pervious Pavement

Please note the techniques rely heavily on the capture and infiltration of rainwater where it falls on the ground. Potentially contaminated parcels or brownfield will need to be evaluated on a case-by-case basis to determine the appropriate use of these techniques.

Engineered Soil

Several of the green infrastructure techniques include the use of engineered soil, also known as amended soil. Engineered soil creates a layer that filters stormwater runoff at a consistent rate to a layer of aggregate beneath. The aggregate layer provides stormwater volume storage that holds runoff until it infiltrates into the native soil beneath. Engineered soil is critical to the functionality of the green infrastructure techniques, because it provides a growing medium for native plants and filters out pollutants as the runoff flows through the layer. The mix for the engineered soil listed in the design templates was based upon the requirements outlined in the City of Chicago's Stormwater Management Manual, which states that engineered soil is a consistent mixture of 40% sand, 30% topsoil, and 30% compost. The Manual also stipulates that the engineered soil mix contain less than 5% fine particle soils in order to prevent clogging. Specifications for engineered soil are included in Appendix C.

Geotextile Fabric

All 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 clogging of the system. The selection of the particular geotextile by the design engineer is a critical factor for the success of the installation.

Non-woven fabrics are most appropriate for filtration, and there are two types to consider. Heat-bonded non-woven fabrics are not recommended, because they will clog very quickly by fine soil particles within the system. Needle-punched fabrics are recommended, because they are much more effective at maintaining filtration over the long term. However, needle-punched fabrics will clog as well if too many fine soil particulates are introduced into the system. The design engineer should work closely with manufacturers to determine the best geotextile fabric for the specific application.

Depth to Groundwater Table

An important consideration for any of these techniques is the depth to the groundwater table. Green infrastructure should be located in an area where the groundwater table is further than 2 feet from the bottom of the installation. This is a safety precaution, as it ensures proper drainage and prevents the groundwater table from interfacing with the bottom of the technique which would inhibit infiltration. The depth to groundwater 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 techniques is critically important. 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. Ideally, green infrastructure techniques should be installed in areas where the soil composition allows for adequate infiltration into the groundwater, defined as greater than 0.5 inches per hour (in/hr).

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.

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 design the green infrastructure. The best testing method is the Pilot Infiltration Test (PIT) developed by the State of Washington Department of Ecology and published in the *2012 Stormwater Management Manual for Western Washington*[1]. While developed in the Pacific Northwest, the PIT is applicable to Great Lakes Region.

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 must be used to drain the system between storm events. One technique to provide resiliency for green infrastructure is to include the underdrain even if the soil infiltration is adequate because of the relatively low marginal cost. In that case, the underdrain is capped inside of the overflow structure as a backup in case something goes wrong with the expected infiltration. Holes can be drilled in the cap to control the runoff out of the system.

1 http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

Native Plants

Several of the green infrastructure techniques include the use of native plants. Not only have native plants adapted to be drought tolerant for their region, but they also have roots systems that are much deeper and more expansive than non-native plants. The larger root system allows native plants to absorb more water and promotes higher pollutant removal efficiencies. This is known as biofiltration.

Native plants can be installed using various sizes, and two common ones are 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 in order to improve survivability.

Design Templates

The design templates developed for this toolkit 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 technique (Sections 5-9), and each 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. The plans and specifications combine to 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 green infrastructure technique have been listed by specification number and title in

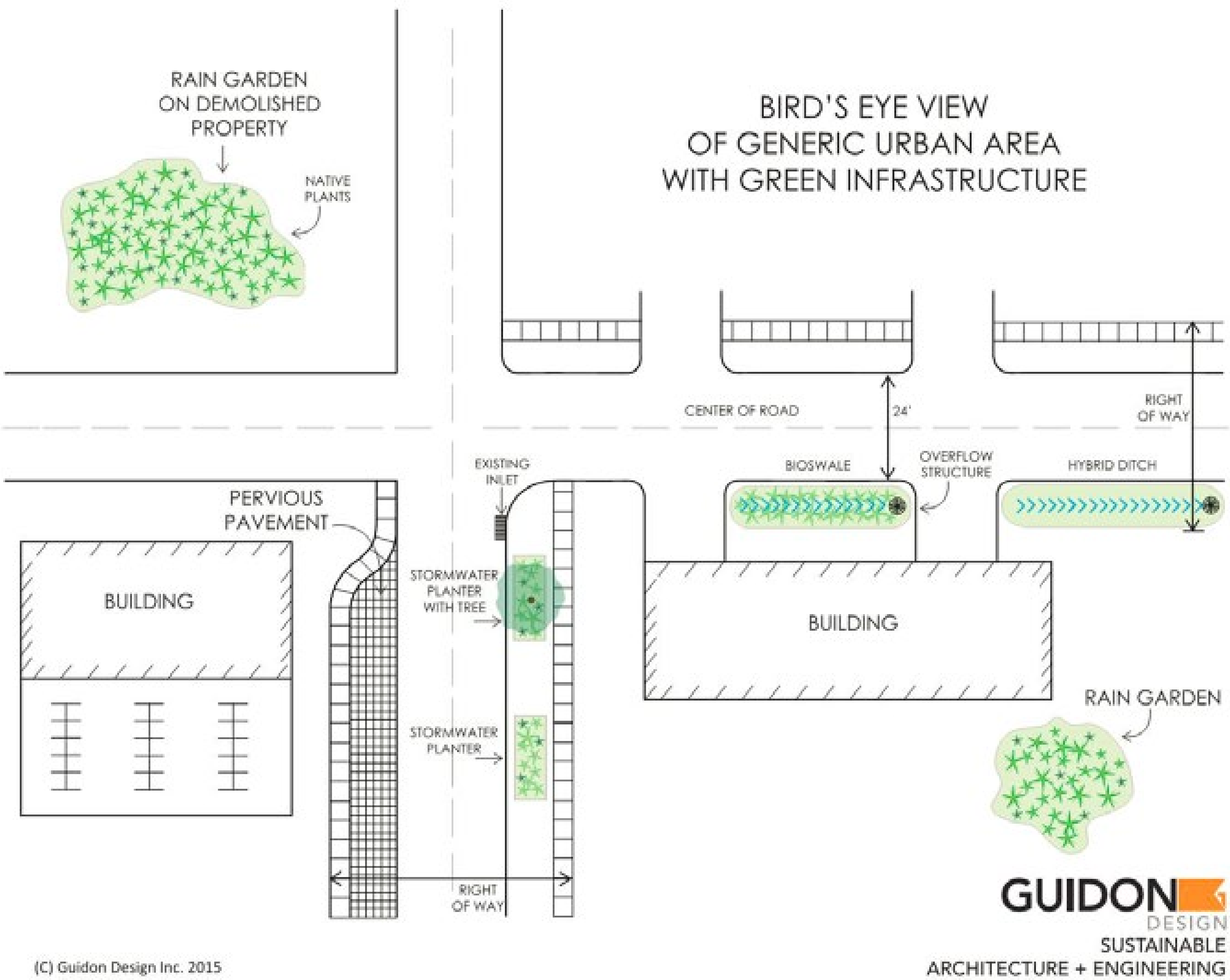
Sections 5-9 of the report and excerpts . The design engineer can use the Illinois Urban Manual standard specifications as a starting point for any of the green infrastructure techniques in this toolkit. However, the sections should be tailored to be site specific according to the project requirements. Excerpts from the Manual are included in Appendix B, and the latest revisions and publications are available online[2].

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 techniques (see Appendix C). Other items that are not covered by the Manual are manufacturer specific, including pervious pavers, underground storage, 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.

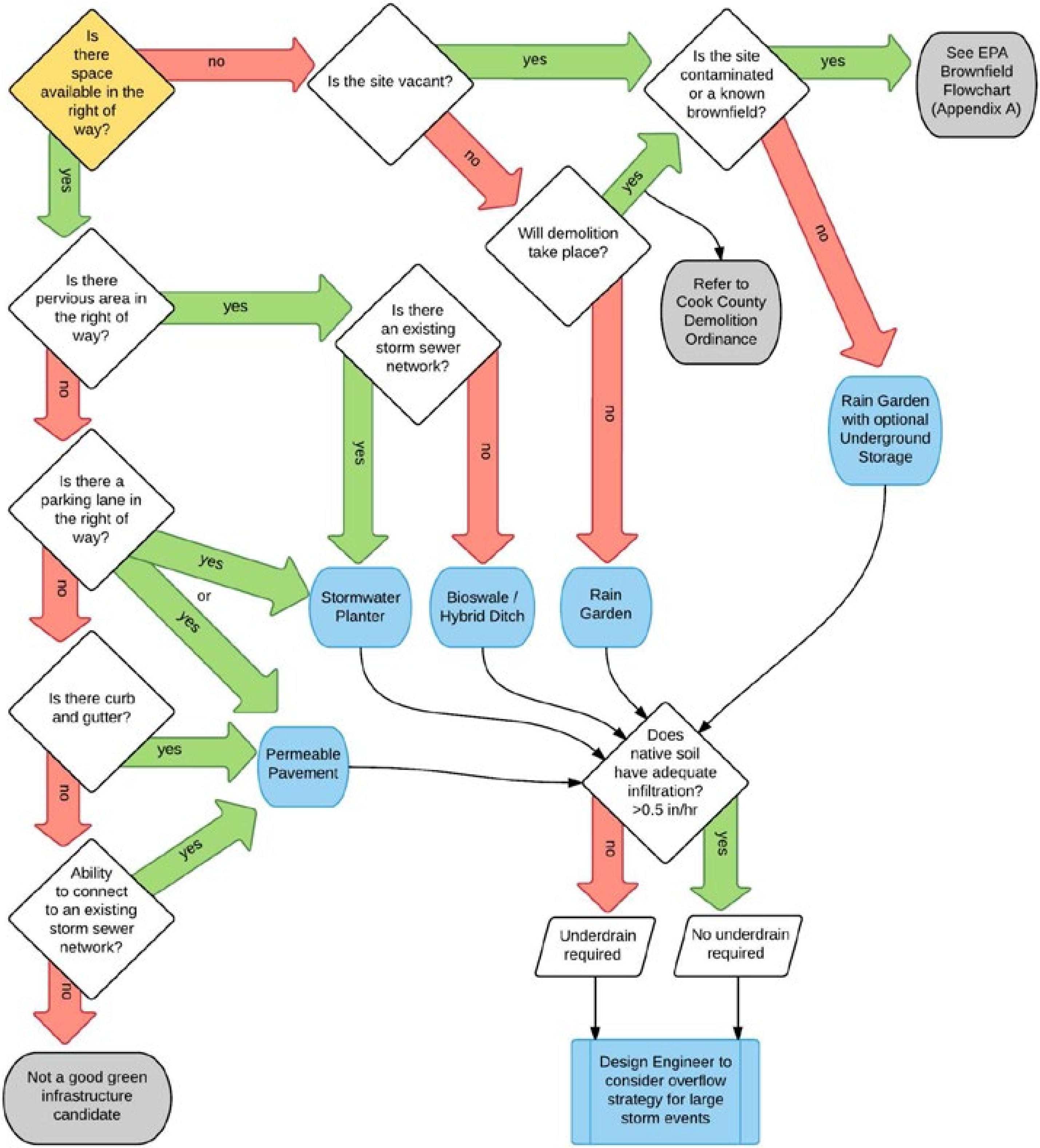
2 http://www.aiswcd.org/illinois-urban-manual/

4 | DECISION SUPPORT TOOL

When a municipal manager determines that green infrastructure is something they want to pursue for a particular parcel, they can use the following Decision Support Tool to select the technique that will be most appropriate for their particular situation. Choosing the most appropriate technique can be a challenging process that must be filtered through a project's location, density, topography, soils, groundwater, budget, and feasibility. The decision support tool is a combination of a bird's eye view drawing showing all of the green infrastructure techniques and a flow chart which has been developed specifically for this project to assist in deciding which green infrastructure technique is the most appropriate.



Green Infrastructure Flow Chart



5 | BIOSWALE/HYBRID DITCH

Download Bioswale/Hybrid Ditch CAD files
at ftp://deltaweb@www.delta-institute.org/CAD/GI_BHD/GI_BHD.zip

5 | 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 native plantings and a hybrid ditch will have grass. 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 ditch is beneath the surface. A bioswale/ hybrid ditch has an engineered soil sub-base, which is a mixture of topsoil, sand, and compost. The importance of the engineered soil cannot be over-emphasized. It provides an effective filter for removing pollutants and sediment from runoff, and an excellent growing media for the native 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 native 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 native soil. The overflow structure and perforated underdrain connect the stormwater planter to the larger storm network, carrying excess runoff downstream. If there are driveway crossings along the bioswale, then an overflow structure is set 6 to 9 inches above the engineered soil layer to convey stormwater from large rainfall events.

The benefit of this technique is the scalable design length. The major drawback is the width required to achieve the appropriate storage depth, which can preclude its use or trigger the need for right-of-way acquisition depending on the site constraints. It does require maintenance and upkeep, the level of which depends on the type of vegetation that is planted on the surface.

- Location: Right-of-way
- Width: At least 5'
- Length: Scalable
- Drainage Area: <5 acres

source: http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm

CUSTOMIZATION OPTIONS

This technique can be customized in a number of different ways. The aesthetics can be tailored through native plant selection. It is recommended that native plant plugs are used to establish the bioswale. For a more mature plant aesthetic plants in gallons can be used, but this is more expensive. Hybrid ditches are typically planted with seed, but sod could be chosen for a higher quality finish at a premium price.

Other customization options are a function of the site conditions. An overflow structure or culvert must be included at driveway crossings. An underdrain is required if the site is flat or is found to have poor infiltration for the native soils. 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 native plants in bioswales have an establishment period and need to be watered 3 times a week for the first 4 weeks after installation. The native 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. The bioswales would also require a spring clean-up to remove built up debris from the winter, provide pre-emergent plant care and install / replace 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 techniques with native 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. 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 technique in Sections 5-9 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.

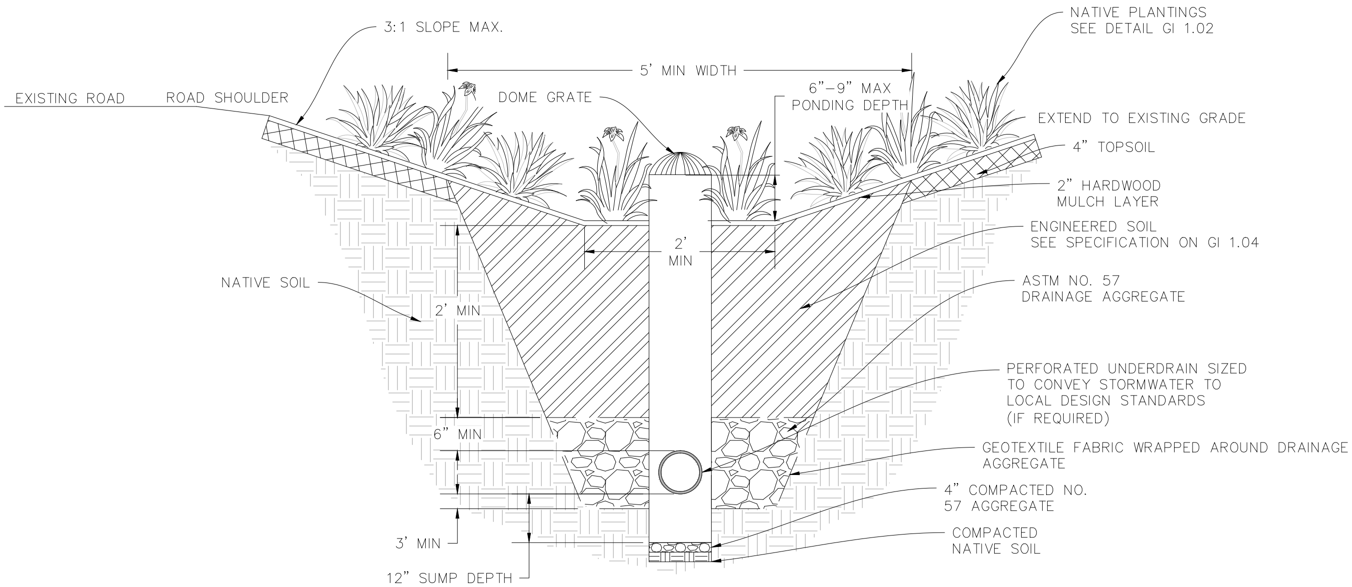
	Item	Description	Installed Cost[1]	Unit
GI Technique	*Bioswale*	*Per detail GI 1.01: Includes 2" mulch, 24" eng. soil, 18" compacted stone, geotextile, AND excavation[3]*	*$ 12.00*	*SF[2]*
GI Technique	*Hybrid Ditch*	*Per detail GI 1.03: Includes 24" eng. soil, 18" compacted stone, geotextile, AND excavation[3]*	*$ 11.50*	*SF[2]*
Required Selection	*Grass*	*Seed: hand push spreader*	*$ 0.03*	*SF*
		Sod: 1" deep, bluegrass	*$ 0.60*	*SF*
Required Selection	*Native Plantings*	*Plugs*	*$ 1.50*	*SF*
		Gallons	*$ 3.00*	*SF*
Custom Options	*Overflow structure*	*15" drainage basin with dome grate*	*$ 1,000*	*EA*
	Underdrain	*12" HDPE perforated underdrain*	*$ 32.00*	*LF*
	Overflow pipe	*12" HDPE with stone backfill*	*$ 60.00*	*LF*
	Connection to existing storm network	*4' diameter manhole placed atop existing pipe, less than 8' deep, with backfill*	*$ 4,600*	*EA*
	Connect to existing storm structure	*Core drill existing structure, connect overflow pipe*	*$ 1,500*	*EA*

SPECIFICATIONS

As discussed in Section 3, 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 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 IS NOT SUITABLE.
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

GI 1.01
1 OF 4
SCALE: NTS

BIOSWALE WITH NATIVE PLANTINGS

A COLLABORATION OF:

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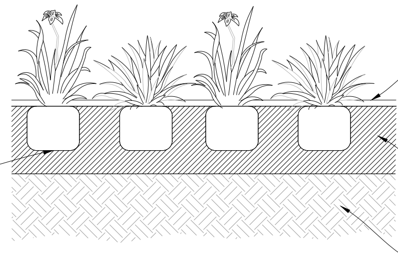
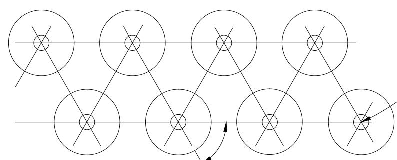
GUIDON DESIGN

ILLINOIS DEPARTMENT OF NATURAL RESOURCES



SECTION



PLAN VIEW

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]

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

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

GI 1.02
2 OF 4
SCALE: NTS

BIOSWALE WITH NATIVE PLANTINGS

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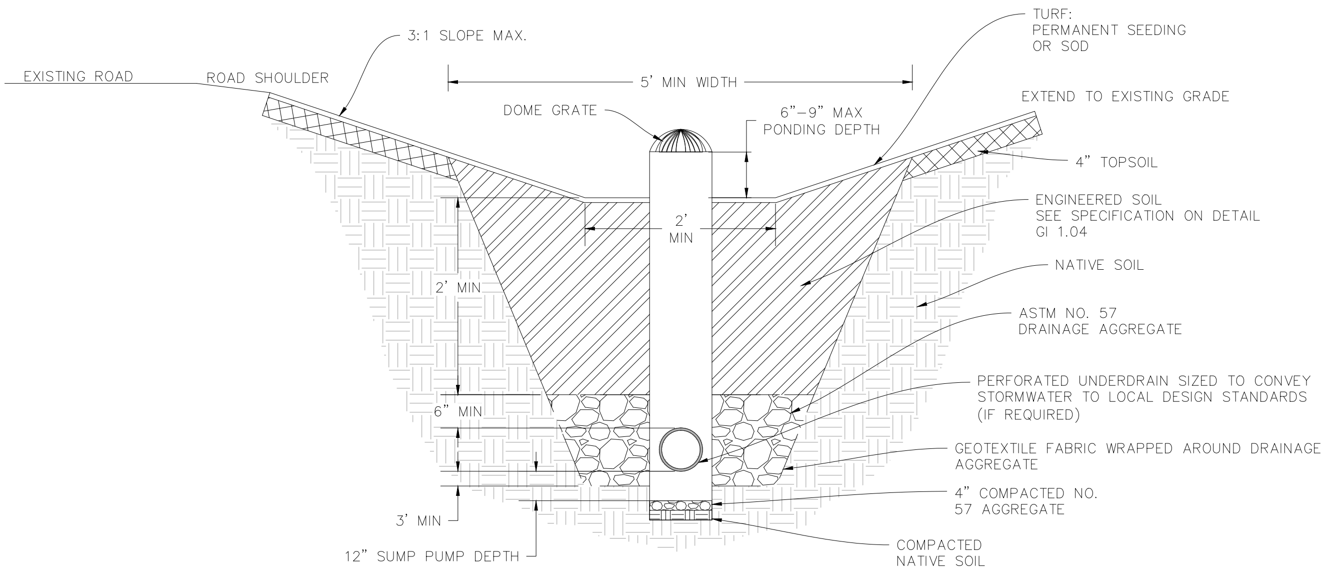

HYBRID DITCH TYPICAL SECTION

HYBRID DITCH IN RESIDENTIAL INSTALLATION[7]

DESIGN GUIDANCE

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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 IS NOT SUITABLE.
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/

HYBRID DITCH

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delta institute
GUIDON DESIGN
ILLINOIS DEPARTMENT OF NATURAL RESOURCES

NOTES

1. BIOSWALE PLANTINGS:
   a. THE BIOSWALE SHOULD BE POPULATED WITH PLANTS NATIVE TO THE INSTALLATION LOCATION. NATIVE PLANTS, GRASSES AND FLOWERS ESTABLISH DEEPER ROOTS AND REMOVE MORE POLLUTANTS FROM RUNOFF.
   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.
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. 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 NATIVE SOIL AFTER EXCAVATION WHERE INFILTRATION WILL TAKE PLACE TO COUNTERACT THE EFFECTS OF COMPACTION AND CLOGGING.
7. MINIMIZE NATIVE SOIL DISTURBANCE WHILE INSTALLING OVERFLOW STRUCTURE.
8. LONGITUDINAL SLOPE OF SWALE SHOULD BE BETWEEN 0.5% AND 2.5%. IF AN UNDERDRAIN IS INCLUDED IN THE PROJECT, THE SURFACE OF THE ENGINEERED SOIL CAN BE FLAT.

ENGINEERED SOIL SPECIFICATION

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 8 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. REPLACE UNSUCCESSFULLY ESTABLISHED PLANTS.
6. INSPECT AND CORRECT EROSION PROBLEMS, DAMAGE TO VEGETATION, SEDIMENT AND DEBRIS ACCUMULATION AND POOLS OF STANDING WATER.
7. INSPECT FOR UNIFORMITY IN CROSS-SECTION AND LONGITUDINAL SLOPE, CORRECT AS NEEDED.
8. REMOVE ALL LABELS, WIRES, ETC. FROM PLANTS.

SCALE: NTS

BIOSWALE AND HYBRID DITCH NOTES

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GUIDON DESIGN

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

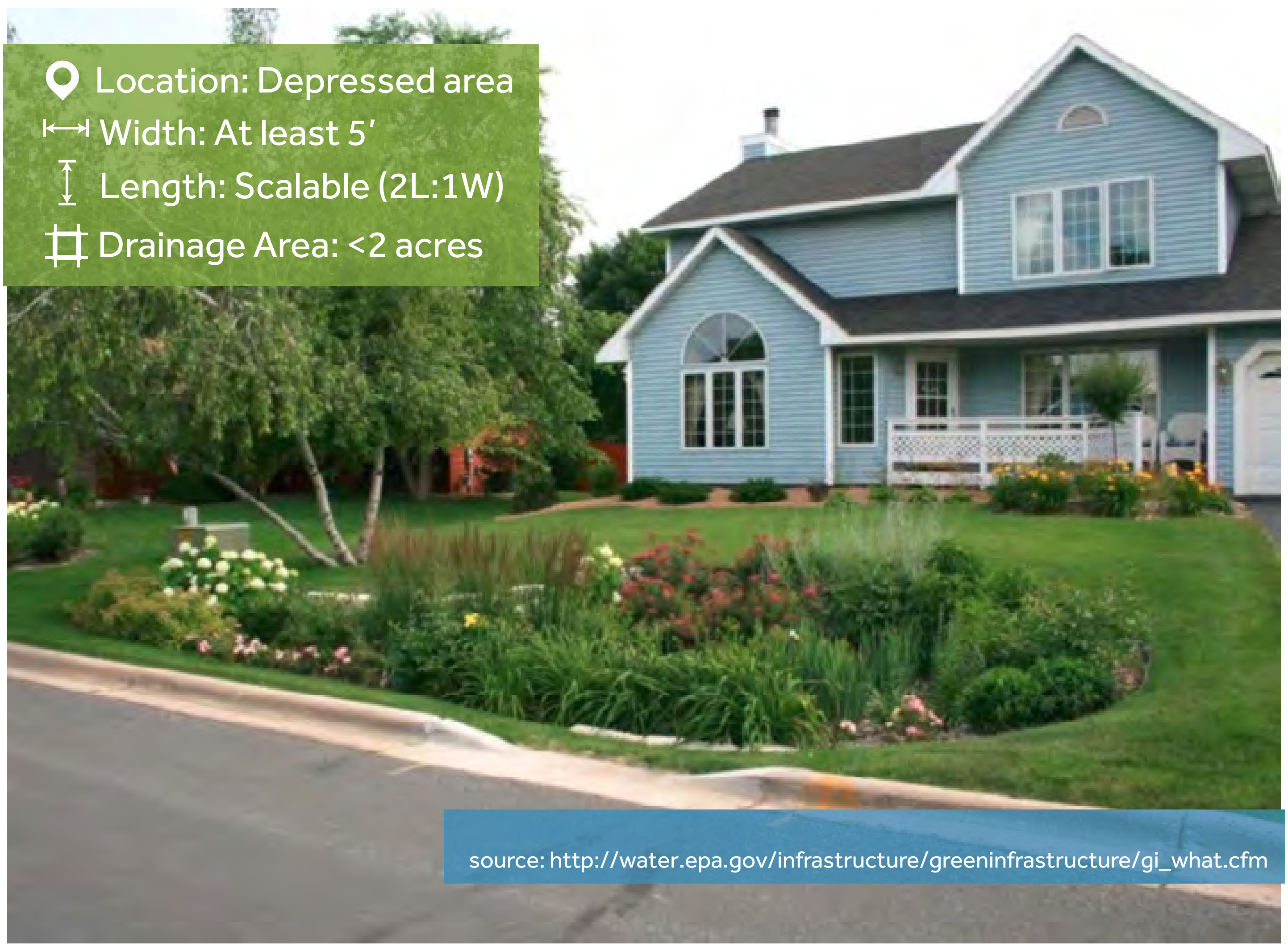
6 | RAIN GARDEN

Download Rain Garden CAD files
at ftp://deltaweb@www.delta-institute.org/CAD/GI_RG/GI_RG.zip

6 | 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 flows through the engineered soil layer to a layer of stone beneath. A rain garden is planted with native 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.



source: http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm

CUSTOMIZATION OPTIONS

A geotechnical engineer should test the infiltration rate of the underlying soil in the location of the rain garden. If the infiltration rate is greater than 0.5 in/hr, then runoff flows through to groundwater at an adequate rate. If the infiltration rate is less than that, then a perforated underdrain is required to convey filtered water that does not infiltrate into the soil. The overflow structure connects the stormwater planter to the larger pipe network, carrying excess runoff downstream. The design engineer should select whether plugs or gallons will be used, along with the species mix for the native plants.

MAINTENANCE

The native plants need to be watered 3 times per week during an establishment period, 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. Debris removal must occur monthly for the life of the rain garden. Trimming, removal, and replacement of dead plants must occur on an as-needed basis.

COST INFORMATION

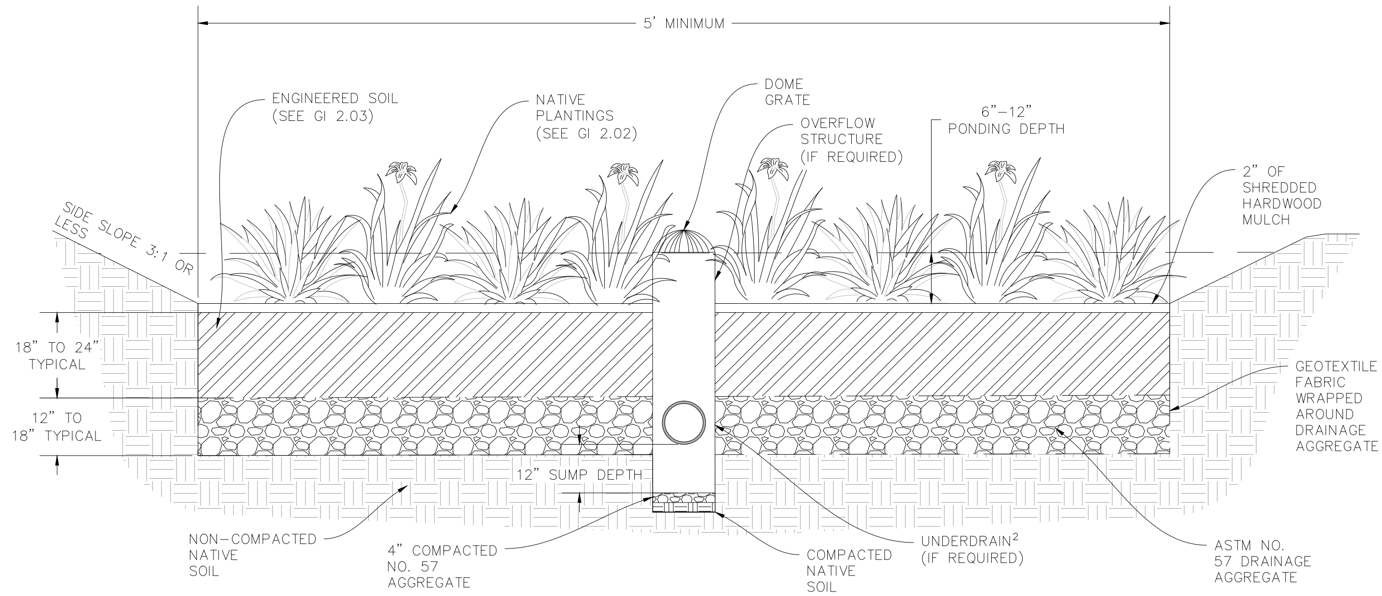
	Item	Description	Installed Cost[1]	Unit
GI Technique	Rain Garden	Per detail GI 2.01: includes 2" mulch, 24" eng. soil, 18" compacted stone, geotextile AND excavation[3]	$ 12.00	SF[2]
Required Selection	Native Plantings	Plugs	$ 1.50	SF
		Gallons	$ 3.00	SF
Custom Options	Overflow structure	12" drainage basin with dome grate	$ 750	EA
	Underdrain	12" HDPE perforated storm pipe	$ 32.00	LF
	Overflow pipe	12" HDPE with stone backfill	$ 60.00	LF
	Connect to existing storm network	4' diameter manhole placed atop existing pipe, less than 8' deep, with backfill	$ 4,600	EA
	Connect to existing storm structure	Core drill existing structure, connect overflow pipe	$ 1,500	EA

[1] Installed cost include material and labor based on bid tabs from related projects and RS Means.
[2] Unit price based on a 2,000 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.
[3] Baseline costs for rain gardens include items shown in detail GI 2.01. Breakout includes: shredded hardwood mulch ($30/cy), engineered soil ($45/cubic yd.), ASTM No 57 stone ($50/ton), geotextile fabric ($5/sq. yd.)

SPECIFICATIONS

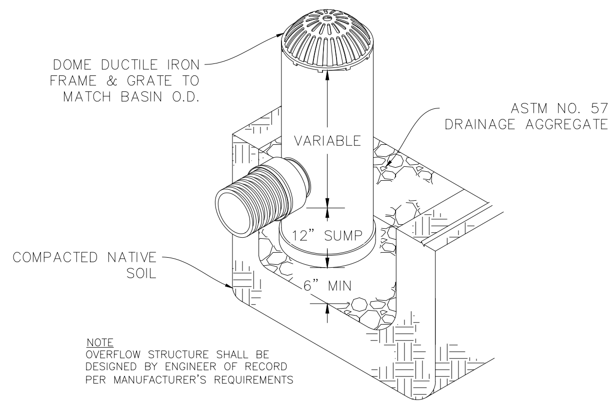
The construction techniques and materials involved in a rain garden installation are identical to that of a bioswale. As such, the minimum specification sections required are also the same. For more information on use of the standard specifications from the Illinois Urban Manual, refer to Appendix B.

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 UNDRERGROUND STORAGE.
4. CAPACITY OF DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
5. IF NO, TECHNIQUE IS NOT SUITABLE.

GI 2.01
1 OF 3
SCALE: NTS

RAIN GARDEN

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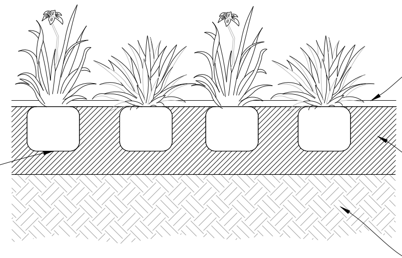
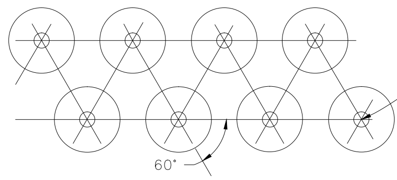


SECTION



PLAN VIEW

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 PALUDA	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

NATIVE PLANTINGS & MAINTENANCE GUIDELINES

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ILLINOIS DEPARTMENT OF NATURAL RESOURCES

NOTES

1. RAIN GARDEN PLANTINGS:
   a. THE RAIN GARDEN SHOULD BE POPULATED WITH PLANTS NATIVE TO THE INSTALLATION LOCATION. NATIVE GRASSES AND FLOWERS ESTABLISH DEEPER ROOTS AND REMOVE MORE POLLUTANTS FROM RUNOFF THAN TURF OR NON-NATIVES.
   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.
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. 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 NATIVE SOIL AFTER EXCAVATION WHERE INFILTRATION WILL TAKE PLACE TO COUNTERACT THE EFFECTS OF COMPACTION AND CLOGGING.
6. MINIMIZE NATIVE SOIL DISTURBANCE WHILE INSTALLING OVERFLOW STRUCTURE.

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. REPLACE UNSUCCESSFULLY ESTABLISHED PLANTS.
6. INSPECT AND CORRECT EROSION PROBLEMS, DAMAGE TO VEGETATION, SEDIMENT AND DEBRIS ACCUMULATION AND POOLS OF STANDING WATER.
7. REMOVE ALL LABELS, WIRES, ETC. FROM PLANTS.

RAIN GARDEN NOTES

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delta institute

GUIDON DESIGN

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

7 | STORMWATER PLANTERS

Download Stormwater Planter CAD files
at ftp://deltaweb@www.delta-institute.org/CAD/GI_SWP/GI_SWP.zip

7 | 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 flows to the gutter in the street and drains into the stormwater planter through openings in the curbing.

A concrete splash pad helps to collect the bulk of sediment and to prevent erosion of the mulch and engineered soil. Rainfall can also flow to the stormwater planter from the adjacent sidewalk through 4-inch openings cut into the curb. Runoff is filtered through a layer of engineered soil, a mixture of topsoil, sand and compost. A variety of native plants in the engineered soil take some of the runoff up through their dense root system. Beneath the engineered soil sits a layer of stone, which rests atop the native soil. 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. Additionally, if the native soil infiltration is inadequate, then 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.

Location: Right-of-way
Width: Scalable
Length: Scalable
Drainage Area: <2 acres

Source: http://water.epa.gov/infrastructure/greeninfrastructure/upload/Pittsburgh-United-Fact-Sheets-508.pdf

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 convenience option is to include an 18-inch wide curb on the street side of the planter to assist individuals when they exit their vehicles.
As discussed in Section 3, the underlying native soil should be tested during detailed design. If the infiltration rate is less than 0.5 in/hr, then a perforated underdrain should be included. Another option is to include the underdrain even if the native soils have adequate infiltration rates because of the marginal incremental cost. The underdrain can be capped in the overflow structure and the discharge rate controlled should the infiltration into the ground become compromised.

The stormwater planter detail GI 3.04 includes a wide selection of native plants that can be selected. The design engineer could choose any combination and layout for the native plants 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 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. 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.

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. One option to give roots the opportunity to expand beyond the planter is to include PVC sleeves in the curb. Another option is to install a proprietary product like a Silva Cell (www.deeproot.com).

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 (see Section 5). This includes water for native 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 Sections 5-9 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.

SPECIFICATIONS

Because 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

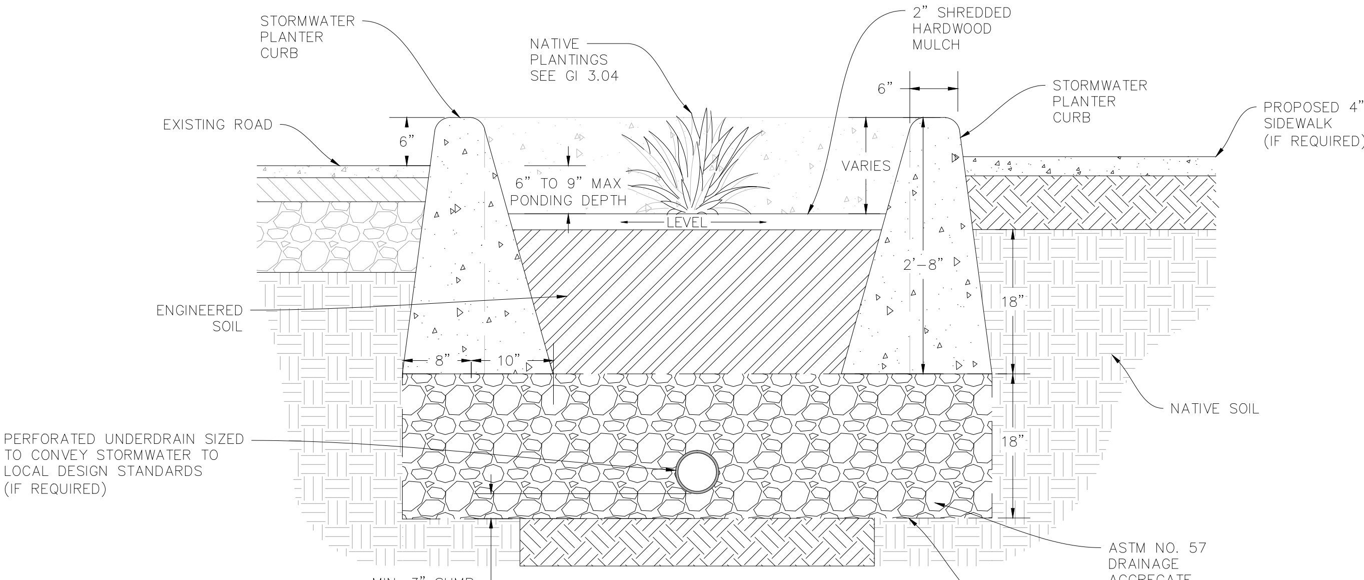
23 – Earthfill
24 - Drainfill
25 - Rockfill
26 – Topsoiling
32 – Structure Concrete
34 – Steel Reinforcement
35 – Concrete Repair
44 - Corrugated Polyethylene Tubing
46 - Tile Drains
94 – Contractor Quality Control
95 - Geotextile
707 - Digging, Transporting, Planting, and Establishment of Trees, Shrubs 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

	Item	Description	Installed Cost[1]	Unit
GI Technique	***Stormwater Planter***	***Includes 2" mulch, 18" eng. soil, 18" compacted stone, geotextile, and excavation[3]***	**$ 10.50**	***SF[2]***
Required Component	*Stormwater planter curb*	*Curb, stormwater planter, (includes jointing and dowel bars)[4]*	*$ 45.00*	*LF*
	Splash Pad	*4" concrete planter drainage pad, 2.5' wide*	*$ 16.50*	*LF[5]*
Required Selection	*Native Plantings*	*Plugs*	*$ 1.50*	*SF*
		Gallons	*$ 3.00*	*SF*
Custom Options	*Tree*	*Varies by species*	*$150 - 1,000*	*EA*
	Structural soil	*CU Structural Soil*	*$ 120.00*	*CY*
	Underdrain	*12" HDPE Storm Pipe*	*$ 32.00*	*LF*
	Connect to existing storm network	*4' diameter manhole placed atop existing pipe, less than 8' deep, with backfill*	*$ 4,600*	*EA*
	Connect to existing storm structure	*Core drill existing structure, connect overflow pipe*	*$ 1,500*	*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.
[3] Unit price for Stormwater Planter refers to footprint occupied by engineered soil (not inclusive of curbs).
[4] Multiply stormwater planter perimeter length by the unit price
[5] Multiply width of engineering soil by the unit price



STORMWATER PLANTER SECTION

STORMWATER PLANTER INSTALLATION[5]

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)

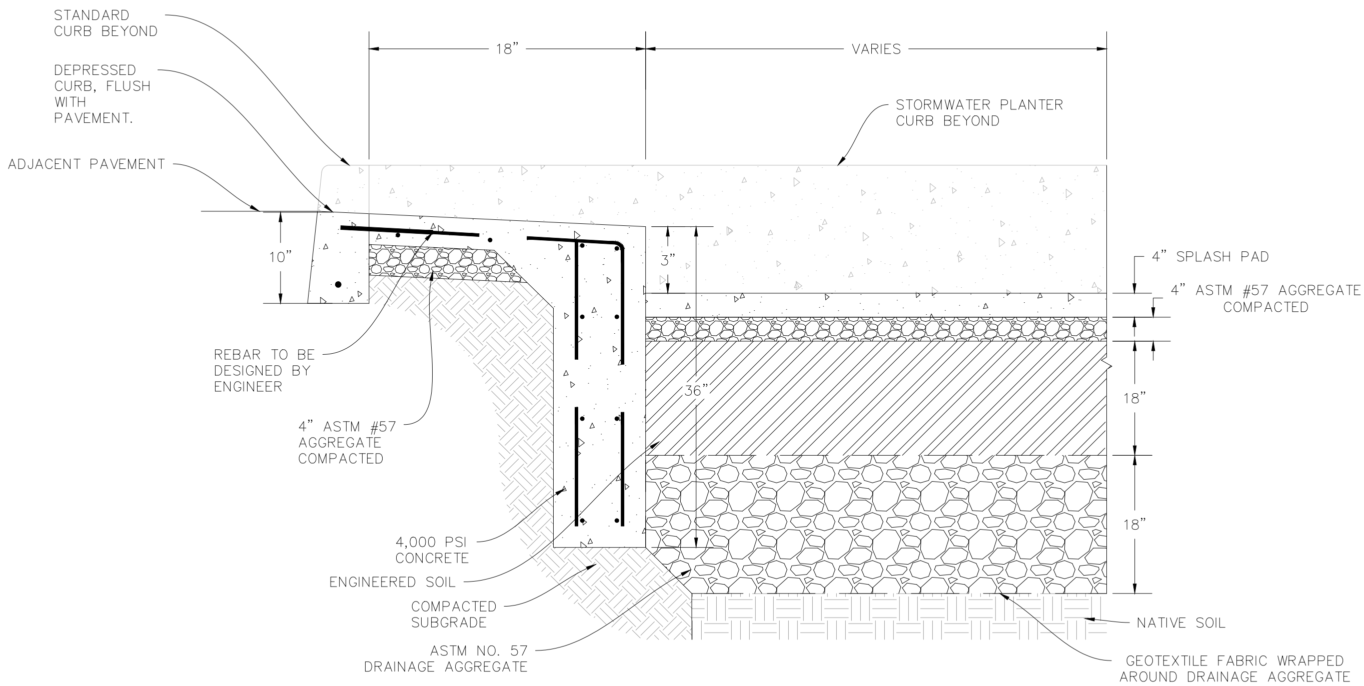
DETAILED DESIGN PRELIMINARY WORKSHEET

- ☐ 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]

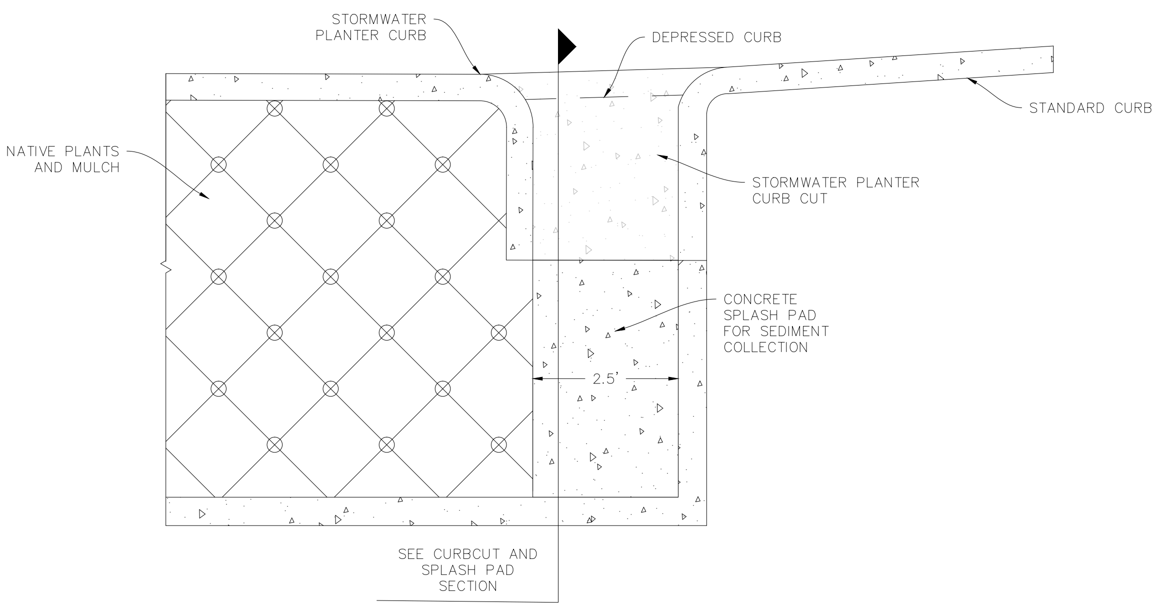
1. NATIVE SOIL INFILTRATION NEEDS TO BE GREATER THAN 0.5 INCHES/HOUR. IF IT IS NOT AN UNDERDRAIN MUST BE INCLUDED.
2. IF STORAGE CAPACITY REQUIRED EXCEEDS AVAILABLE FOOTPRINT, INCREASE THICKNESS OF DRAINAGE AGGREGATE OR CONSIDER UNDERGROUND STORAGE.
3. CAPACITY OF DOWNSTREAM SYSTEM TO BE ANALYZED BY DESIGNER.
4. IF NO, TECHNIQUE IS NOT SUITABLE.
5. STORMWATER PLANTER ON INDIANAPOLIS CULTURAL TRAIL, PHOTO BY GUIDON DESIGN

STORMWATER PLANTER

A COLLABORATION OF: delta institute, GUIDON DESIGN, ILLINOIS DEPARTMENT OF NATURAL RESOURCES



STORMWATER PLANTER CURB CUT AND SPLASH PAD DETAIL

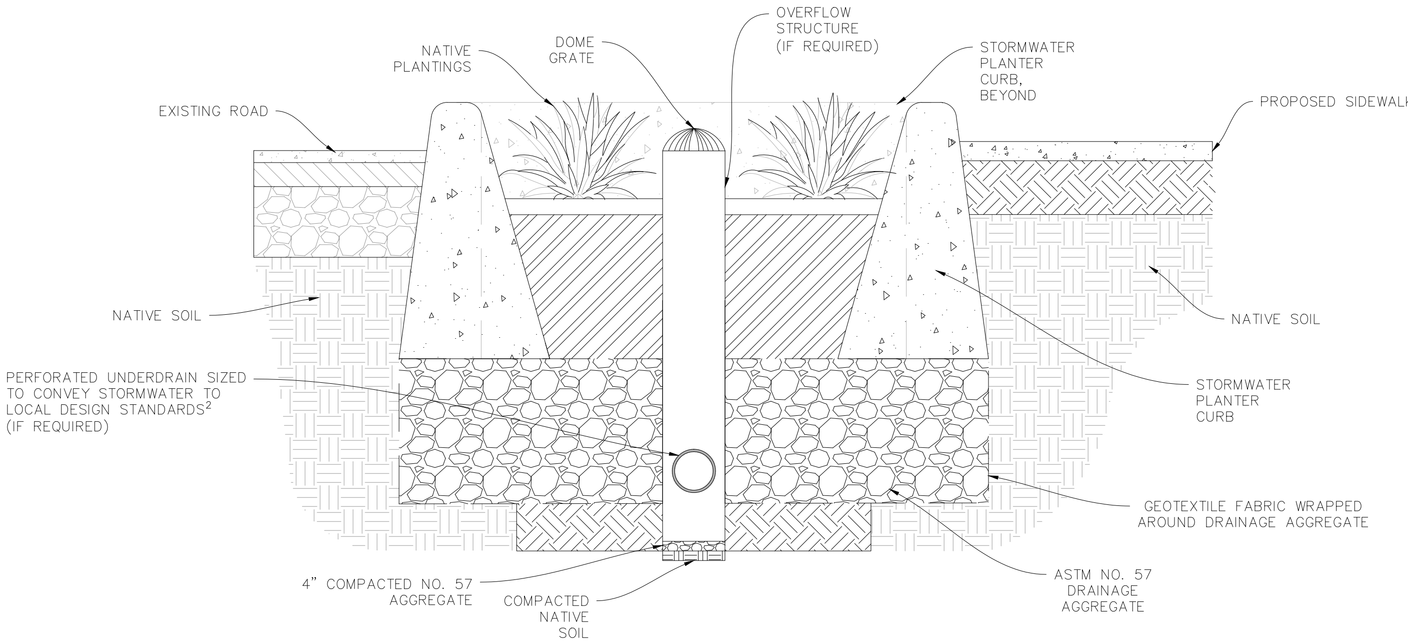


CURB CUT AND SPLASH PAD PLAN VIEW

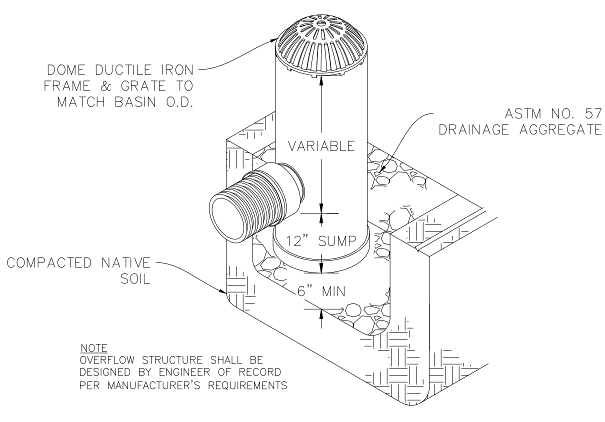
GI 3.02
2 OF 8
SCALE: NTS

STORMWATER PLANTER CURB DETAIL AND CUT

A COLLABORATION OF:



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

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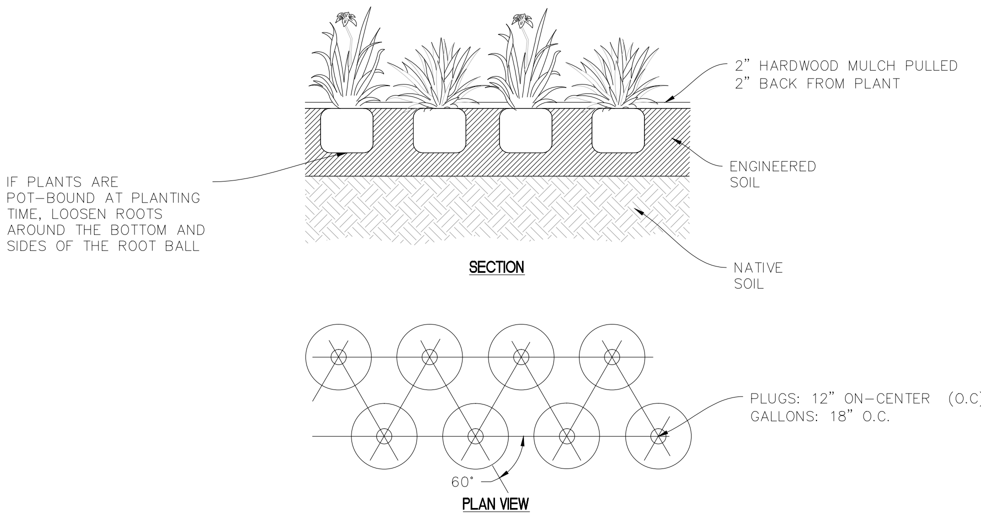

NATIVE PLANTINGS PLUG DETAIL

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

NATIVE PLANTINGS

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RECOMMENDED TREE SPECIES FOR STORMWATER PLANTERS

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

TREE SPECIES FOR STORMWATER PLANTERS

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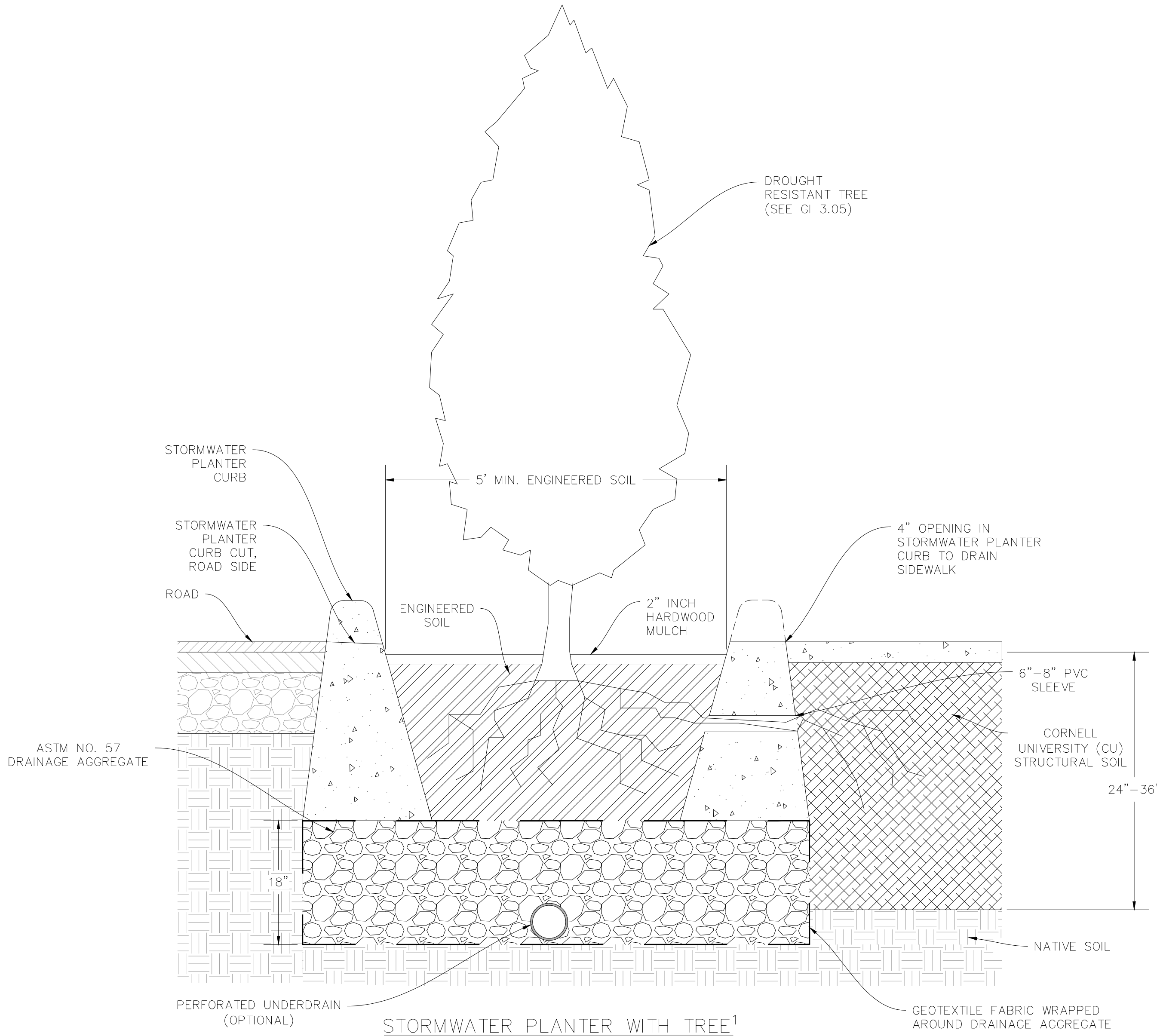

STORMWATER PLANTER WITH TREE[1]

NOTE

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

GI 3.06
6 OF 8
SCALE: NTS

STORMWATER PLANTER WITH TREE

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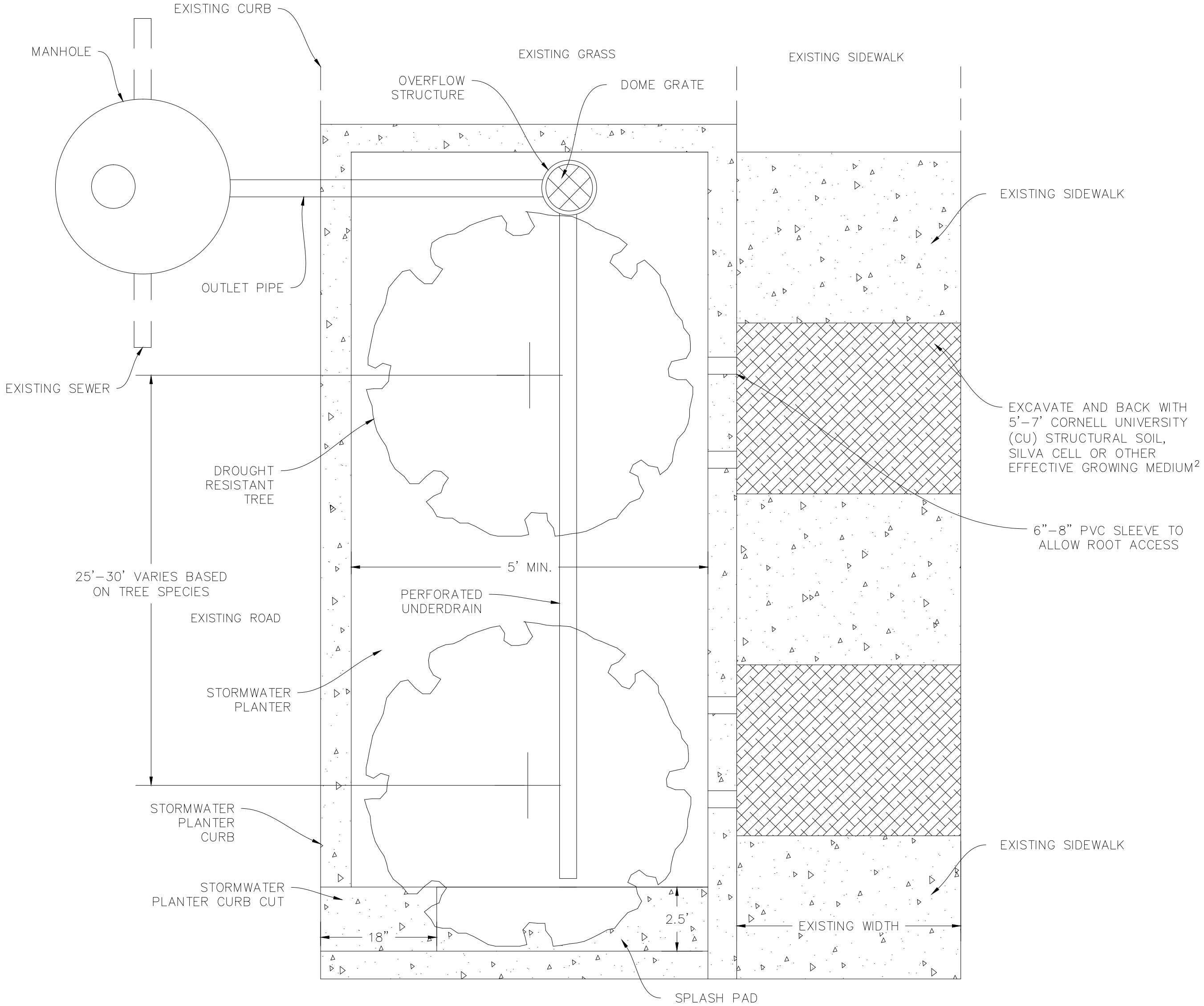
ILLINOIS DEPARTMENT OF NATURAL RESOURCES



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 REQUIRED, PROVIDE 4" OPENINGS IN STORMWATER PLANTER CURB TO ALLOW FOR DRAINAGE OF ADJACENT SIDEWALK

GI 3.07

SCALE: NTS

STORMWATER PLANTER W/ TREE PLAN VIEW

A COLLABORATION OF: delta institute, GUIDON DESIGN, ILLINOIS DEPARTMENT OF NATURAL RESOURCES

NOTES

1. STORMWATER PLANTER PLANTINGS:
   a. THE PLANTER SHOULD BE POPULATED WITH PLANTS NATIVE TO THE INSTALLATION LOCATION. NATIVE PLANTS, GRASSES AND FLOWERS ESTABLISH DEEPER ROOTS AND REMOVE MORE POLLUTANTS FROM RUNOFF.
   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.
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. 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 NATIVE SOIL AFTER EXCAVATION WHERE IT INTERFACES WITH ENGINEERED SOIL TO COUNTERACT 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 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 8 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.

STORMWATER PLANTER NOTES

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ILLINOIS DEPARTMENT OF NATURAL RESOURCES

8 | PERMEABLE PAVEMENT

Download Permeable Pavement CAD files
at ftp://deltaweb@www.delta-institute.org/CAD/GI_PP/GI_PP.zip

8 | 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 or in parking areas for the redevelopment for vacant lots.

Runoff then flows down through open graded stone layers that have a void ratio of approximately 40 percent. Void ratio is an expression for the amount of open area between the material where water flows. Larger aggregate will have a higher void ratio than smaller aggregate like pea gravel. After rainwater is stored in the stone layer, it can then infiltrate into the native soil. If the native soil infiltrates at less than 0.5 in/hr, then runoff must discharge through an underdrain to an existing storm network or other outlet. 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.

MAINTENANCE

Care should be taken to avoid the runoff of sediment from adjacent areas onto the permeable pavers as much as possible. Avoid the application of sand onto the pavers during the winter time. 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.

Location: Parking lot
Width: At least 2'
Length: Scalable
Drainage Area: Varies

source: http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm

Frequency of replacement will depend on site conditions and pollutant loading. Maintenance costs from manufacturers is estimated to be approximately $0.20 / square foot / year.

COST INFORMATION

Cost information is provided for each green infrastructure technique in Sections 5-9 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.

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 - Manufacture specific

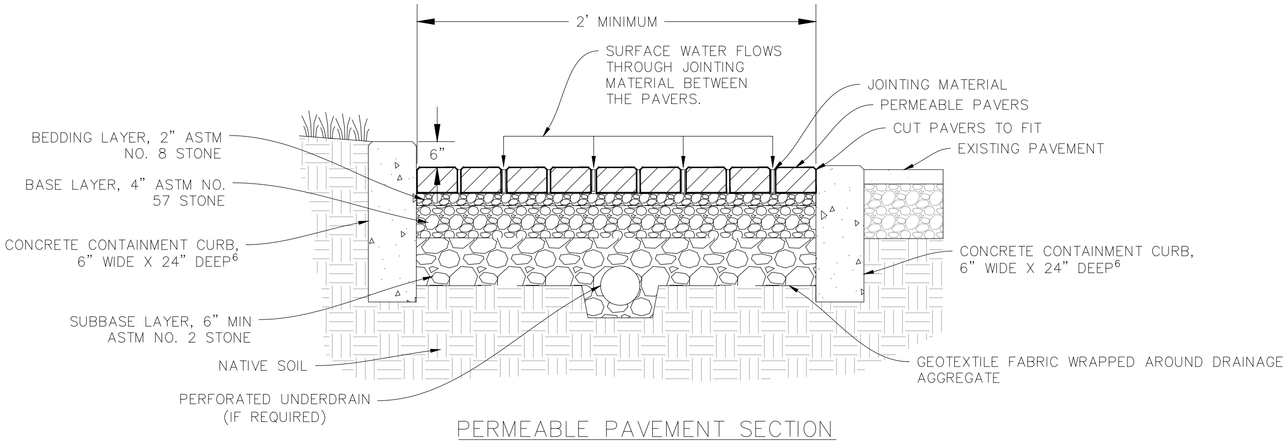
	Item	Description	Installed Cost[1]	Unit
GI Technique	*Permeable pavement*	*Pavers, stone layers (bedding, base, and subbase), geotextile and excavation*	*$ 15.00*	*SF[2]*
Required component	*Bedding layer*	*2" ASTM No. 8 Stone*	*$ 45.00*	*TON*
	Base layer	*4" ASTM No. 57 Stone*	*$ 30.00*	*TON*
	Subbase layer[3]	*6" ASTM No. 2 Stone*	*$ 35.00*	*TON*
	Geotextile	*Non-woven geotextile fabric*	*$ 5.00*	*SY*
	Curb	*Containment curb*	*$ 35.00*	*LF[4]*
Custom options	*Underdrain*	*12" HDPE perforated storm pipe*	*$ 32.00*	*LF*
	Connect to existing storm structure	*Core drill existing structure, connect overflow pipe*	*$ 1,500*	*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



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 5.01)

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 IS NOT SUITABLE.
6. CONCRETE CONTAINMENT CURB MUST BE INSTALLED ON ALL SIDES OF THE PERMEABLE PAVERS.

GI 4.01
1 OF 2
SCALE: NTS

PERMEABLE PAVEMENT

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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. AGGREGATE BASE COURSE DEPTH DEPENDENT ON TRAFFIC LOADING AND NATIVE SOILS IN A WET, UNCOMPACTED STATE.
3. PERVIOUS PAVEMENT SURFACES NEED TO BE PROTECTED FROM SEDIMENT DURING THE ENTIRE CONSTRUCTION PROCESS.
4. FULL EXTENT OF POROUS PAVEMENT SHALL BE FENCED OFF DURING CONSTRUCTION TO PREVENT COMPACTION OF SUBGRADE AND STOCKPILING OF CONSTRUCTION MATERIALS OVER SURFACE.
5. 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 RESTORE INFILTRATION CAPACITY.
6. 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. AVOID APPLICATION OF SAND DURING WINTER TIME.
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 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 BASE COURSE SHALL BE UNIFORMLY GRADED WITH 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

1.2. UNLESS OTHERWISE APPROVED BY THE ENGINEER, COARSE AGGREGATE FOR THE AGGREGATE BASE COURSE SHALL BE UNIFORMLY GRADED WITH 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

1.3. UNLESS OTHERWISE APPROVED BY THE ENGINEER, COARSE AGGREGATE FOR THE AGGREGATE BASE COURSE SHALL BE UNIFORMLY GRADED WITH THE FOLLOWING GRADATION (ASTM NO. 2)

US STANDARD SIEVE SIZE	PERCENT PASSING
3"	100
2.5"	90-100
2"	35-70
1.5"	0-15
$\frac{3}{4}$"	0-5

1.4. NON WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC, NEED PUNCHED) SHALL CONFORM TO THE FOLLOWING:

A. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
B. GRAB TENSILE STRENGTH MIN 115 LB ASTM D-4632-86
C. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
D. PUNCTURE RESISTANCE MIN 45 LB ASTM D-4833-88
E. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

PERMEABLE PAVEMENT NOTES

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9 | UNDERGROUND STORAGE

Download Underground Storage CAD files
at ftp://deltaweb@www.delta-institute.org/CAD/GI_US/GI_US.zip

9 | UNDERGROUND STORAGE

Underground storage can be an effective green infrastructure technique in situations when large storage volumes are required, such as localized flooding and combined sewer overflow 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.

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 within the outlet structure can be designed to control the storage depth within the system, allowing for high infiltration volumes. The discharge of stored stormwater (above or below ground) to the existing storm network is a traditional approach to stormwater management. In order for the underground storage system to be truly a green system, it must infiltrate stormwater into the ground. Underground storage is also considered green infrastructure when paired with another green infrastructure technique, such as a surface treatment.

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

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

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.

	Item	Description	Installed Cost[1]	Unit
GI Technique	*Underground Storage*	*Storage material, geotextile, stone envelope, excavation and hauling*	*$ 6.00*	*CF*[2]
Custom Options	*Additional stone*	*Enlarged stone envelope*[3]	*$ 32.00*	*TON*
	Underdrain	*12" HDPE perforated storm pipe*	*$ 32.00*	*LF*
	Outlet structure	*4' concrete manhole, less than 8' deep*	*$ 3,000*	*EA*
	Overflow weir	*6" wide weir with backfill in outlet structure*	*$ 500.00*	*EA*
	Connect to existing storm network	*Manhole, standard doghouse, sanitary, 4' diameter, less than 8' deep, with B-borrow backfill and connection to existing pipe*	*$ 4,600*	*EA*
	Connect to existing storm structure	*Core drill existing structure, connect overflow pipe*	*$ 1,500*	*EA*
	Surface treatment	*Varies*[4]	-	-

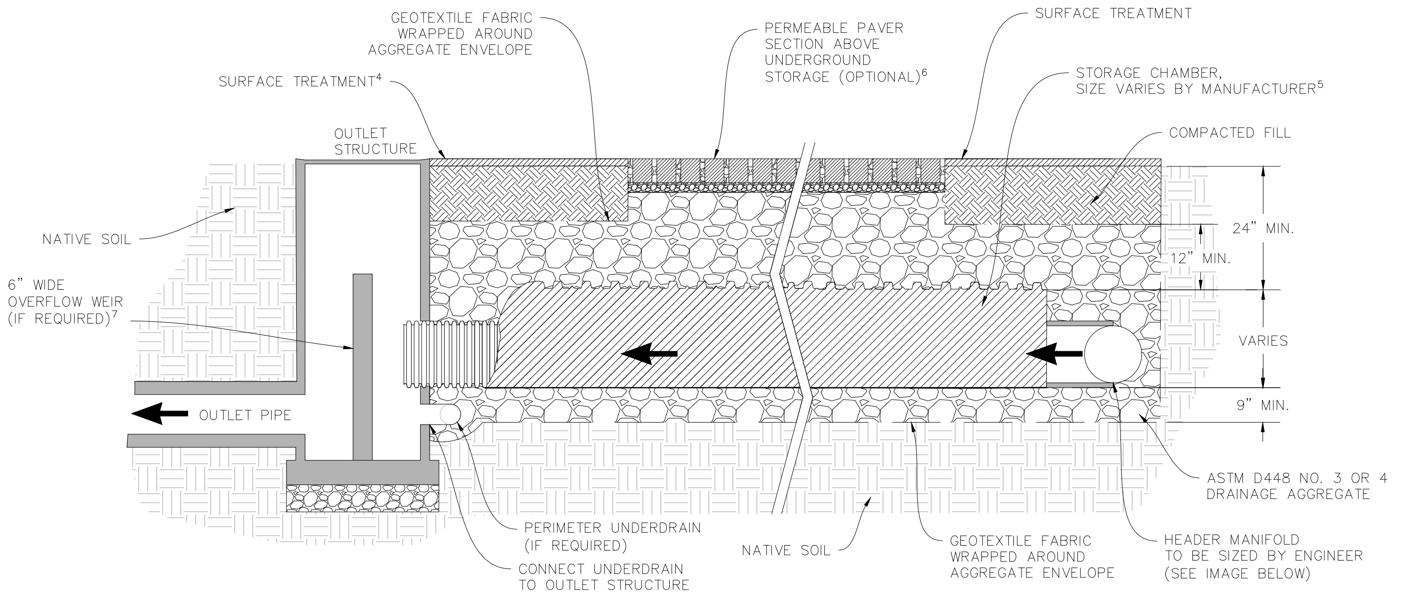
[1] Installed cost include material and labor based on bid tabs from related projects and RS Means.
[2] Unit price based on a 8,500 cubic foot installation beneath a commerical parking area (see GI 5.01). Pricing from various manufacturer's range from $5-7. Unit prices for specific projects will vary 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 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. PERMEABLE PAVERS CAN BE PAIRED WITH UNDERGROUND STORAGE. RUNOFF FILTERS DOWN THROUGH STONE SUBBASE AND INTO THE CHAMBERS.
7. OVERFLOW WEIR CAN BE PLACED IN OUTLET MANHOLE IF NATIVE SOIL INFILTRATION RATE IS GOOD (>0.5IN/HR). THE WEIR HEIGHT IS VARIABLE AND CAN BE SET AT AN ELEVATION THAT ALLOWS A LARGE VOLUME OF RUNOFF TO INFILTRATE. LARGE STORM EVENTS OVERTOP THE WEIR AND DISCHARGE THROUGH THE OUTLET PIPE.

UNDERGROUND STORAGE

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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), THEN A PERFORATED UNDERDRAIN SHOULD BE INCLUDED TO EMPTY THE SYSTEM.
4. STORAGE MATERIAL SHOULD BE UNOBSTRUCTRED FROM INTERNAL SUPPORT PANELS THAT WOULD IMPEDE THE FLOW THROUGH THE MATERIAL.
5. STRUCTURAL DESIGN OF THE STORAGE MATERIAL IS SUBJECT TO AASHTO DESIGN REQUIREMENTS.
6. IF MATERIAL IS CORRUGATED PLASTIC IT MUST MEET THE REQUIREMENTS OF THE ASTM F2418 AND ASTM F2787.
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 NOT BE BACKFILLED WITH A DOZER OR AN EXCAVATOR SITUATED OVER THE CHAMBERS.
13. JOINTS BETWEEN MATERIAL SHOULD BE PROPERLY SEALED.
14. MAINTAIN MINIMUM SPACING BETWEEN MATERIAL PER MANUFACTURER'S RECOMMENDATIONS.
15. STONE SURROUNDING MATERIAL MUST BE CLEAN, CRUSHED, ANGULAR STONE MEETING THE ASTM D448 DESIGNATION OF #3 OR #4.
16. STONE MUST BE PLACED ON THE TOP OF THE CENTER OF THE MATERIAL TO ANCHOR IT IN PLACE.
17. TAKE PROACTIVE STEPS TO PROTECT THE SUBSURFACE STORMWATER MANAGEMENT SYSTEM FROM CONSTRUCTION SITE RUNOFF.
18. CARE MUST BE TAKEN WITH THE TYPE AND PLACEMENT OF CONSTRUCTION EQUIPMENT. REFER TO MANUFACTURER'S RECOMMENDATION.
19. SITE ENGINEER IS RESPONSIBLE FOR DETERMINING BEARING RESISTANCE OF SUBGRADE SOILS AND THE DEPTH OF FOUNDATION STONE.
20. PERIMETER STONE MUST EXTEND HORIZONTALLY TO EXCAVATION WALL IN ALL SITUATIONS.

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 5.02
2 OF 2
SCALE: NTS

UNDERGROUND STORAGE NOTES

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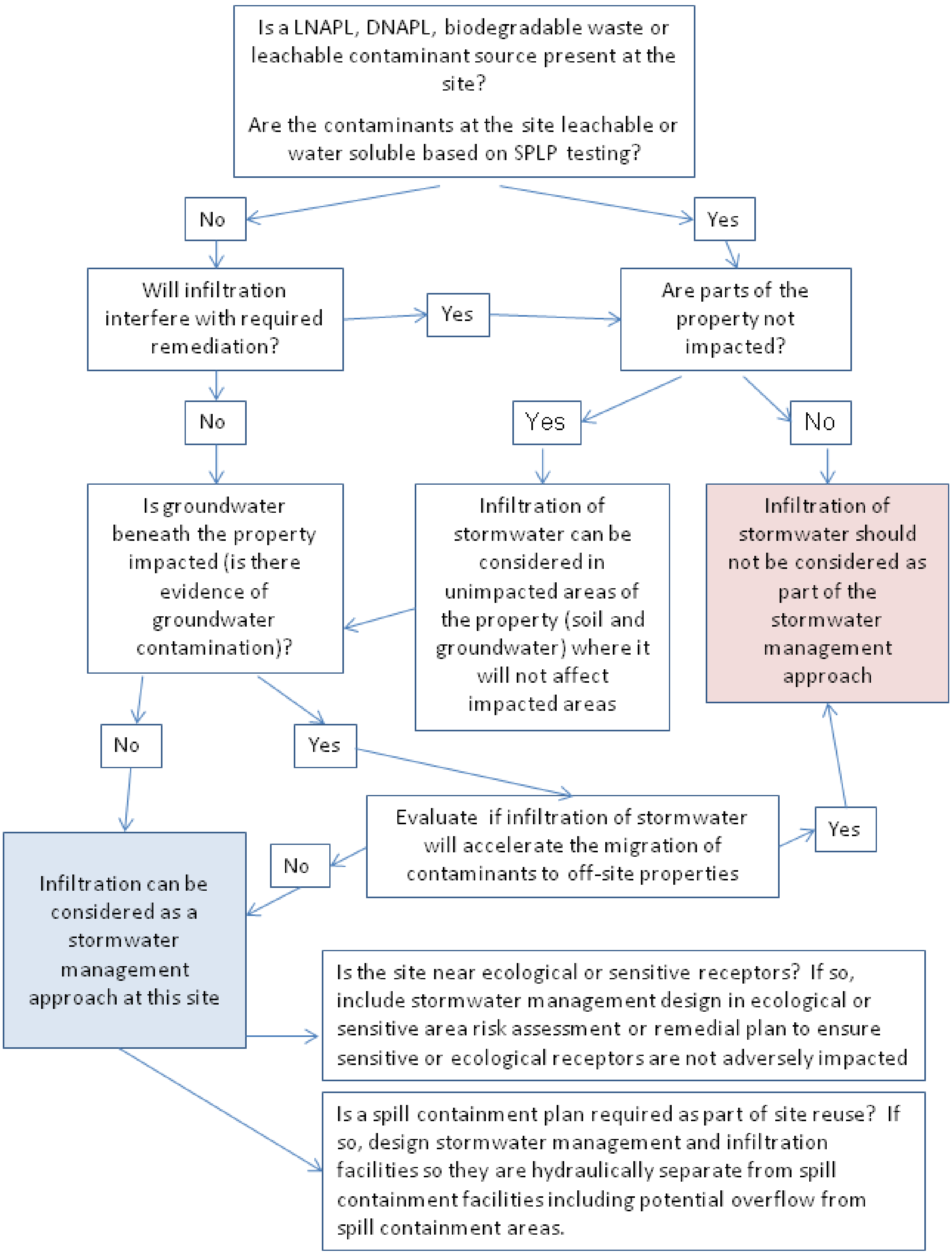
APPENDIX A: EPA BROWNFIELDS DECISION FLOW CHART

Decision Flowchart for the Use of Stormwater Infiltration at Brownfield Sites



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-urban-manual/).

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

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	**Specification**
Metal Pipe Conduits			
51.	Corrugated Metal Pipe	5/01	5/01
52.	Steel Pipe	5/01	5/01
53.	Ductile-Iron Pipe	5/01	5/01
Riprap and Slope Protection			
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
Water Control Gates and Valves			
71.	Water Control Gates	5/01	5/01
Miscellaneous Structural Work			
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
Miscellaneous Construction			
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
Vegetation			
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)

No.	Specification	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)

		Date
Miscellaneous Structural Materials		
581.	Metal	10/98
582.	Galvanizing	10/98
583.	Coal Tar-Epoxy Paint	10/98
584.	Structural Timber and Lumber	10/98
585.	Wood Preservatives and Treatment	11/97
Miscellaneous Construction Materials		
591.	Field Fencing Materials	11/97
592.	Geotextile	4/12
593.	Lime	11/97
Miscellaneous Materials		
800.	Paper and Plastic Netting	4/08
801.	Jute Netting	4/08
802.	Erosion Control Blankets	4/08
803.	Straw Blankets	4/08
804.	Material for Topsoiling	4/08
805	Erosion Control Blanket – Turf Reinforcement Mat (TRM)	2/11

IUM April 2012

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APPENDIX C: ENGINEERED SOIL SPECIFICATION

As discussed in Section 3, 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 C).

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.