

Sub-Surface Stormwater Storage Design

An aerial photograph showing a city area that has been severely flooded. In the foreground, several large industrial buildings with flat roofs are partially submerged in murky water. A baseball field is visible in the middle ground, also surrounded by floodwater. In the background, a residential area with houses and trees is visible, though some trees are isolated in the water. The sky is overcast. The right side of the image features a green geometric overlay consisting of several overlapping triangles and lines.

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- Background
- Soil Characteristics
- System Components
- Design

Past

- ▶ Large available tracts of land
- ▶ Larger margin on development
- ▶ Land available for building and infrastructure



Current

- ▶ Less buildable land available
- ▶ Higher cost of real estate
- ▶ Tighter site constraints to fit as much as possible
- ▶ Move toward Low Impact Development



1970's

- ▶ Stormwater is seen as inevitable part of land development
- ▶ Large detention basins at lowest point of site
- ▶ Limited to no treatment or retention



2000 to Present

- ▶ Increased regulation and government enforcement
- ▶ Rate and volume reductions
- ▶ Introduction of runoff treatment



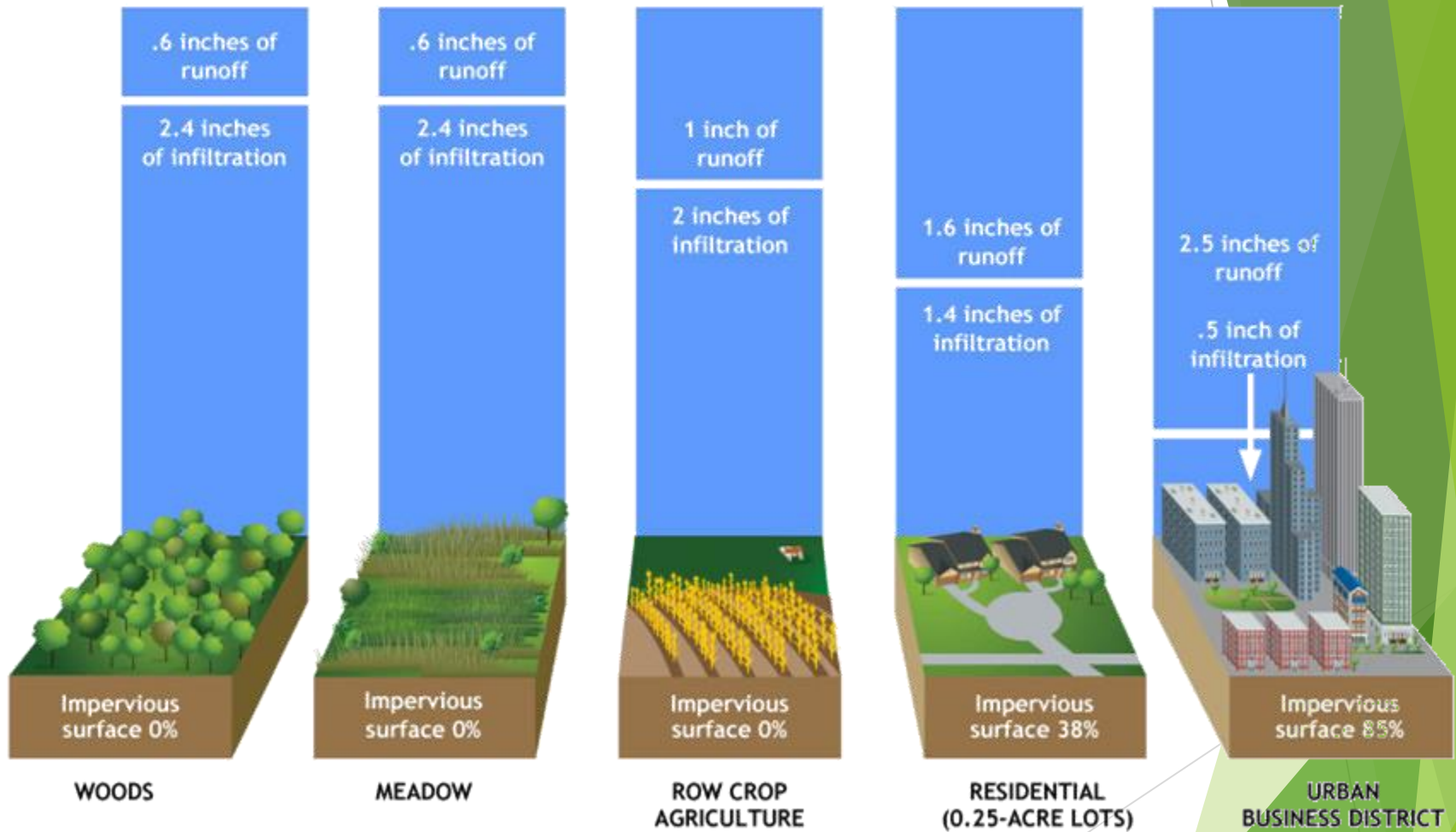


Image from
www.landscapeforlife.org

System Evolution

- ▶ Early systems
 - ▶ Stone and Stone with Pipe
 - ▶ Large footprint
 - ▶ Low to moderate void space
- ▶ Newer Systems
 - ▶ Arch chamber
 - ▶ Medium footprint
 - ▶ Moderate to large void space
 - ▶ Box structures
 - ▶ Best footprint
 - ▶ Largest available void space



Applications

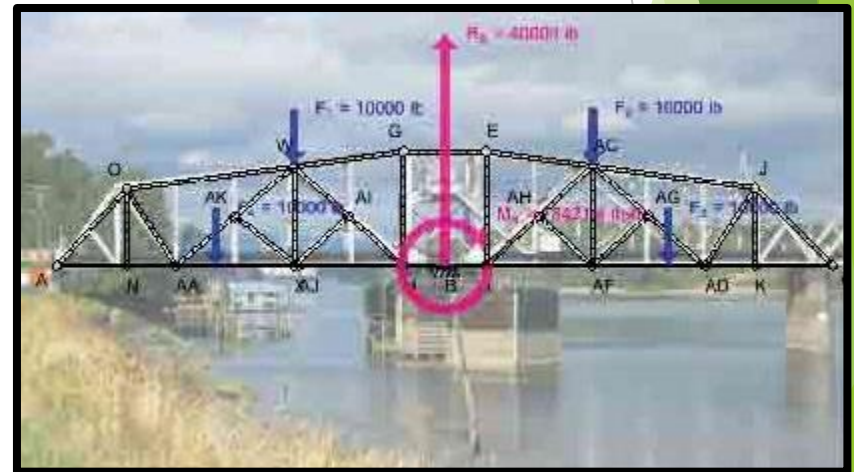
- ▶ Detention
 - ▶ Low to no infiltration rate
 - ▶ Lined system
- ▶ Infiltration
 - ▶ Available infiltration rate
 - ▶ No liner
- ▶ Rainwater Harvesting
 - ▶ Climate or site required
 - ▶ Lined system



Brooklyn Bridge Park

Engineering Knowledge

- ▶ Limited available training
 - ▶ System more than place to hide runoff
 - ▶ How often do you ask “how is it loaded” and “how is it supported”
- ▶ More than just a product
 - ▶ Structural element replacing soil
 - ▶ Just like foundation of building
 - ▶ Transfers load
 - ▶ Relies on sub-grade

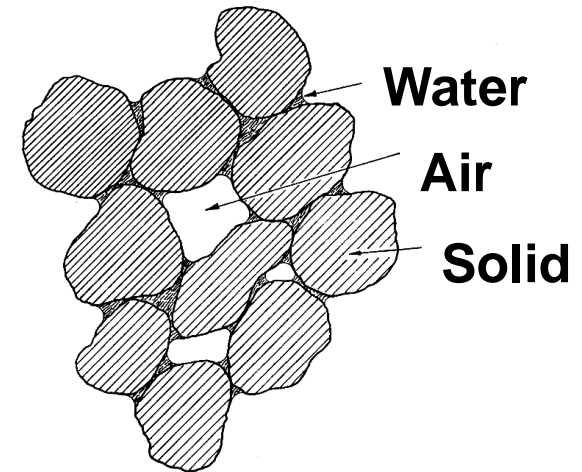


Soil Characteristics

- Description
- Loading
- Bearing Capacity
- Compaction

Earth

- ▶ Dynamic structure of air, soil and water
- ▶ Support structure
 - ▶ Distributes loading applied to surface
 - ▶ Varies based upon composition



Sub-Surface Storage System

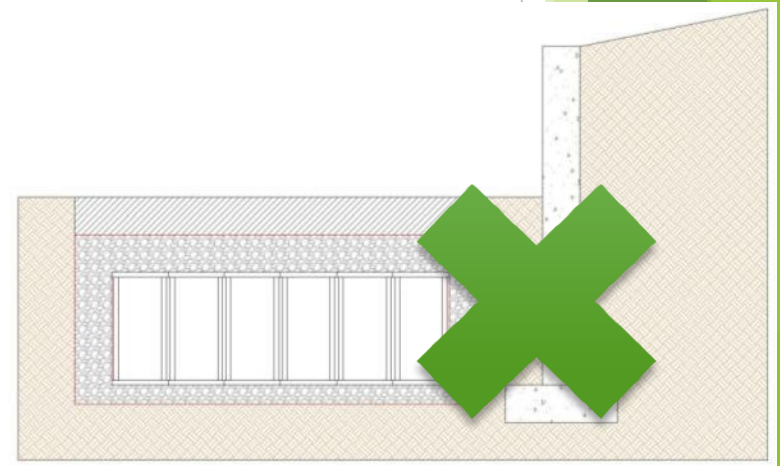
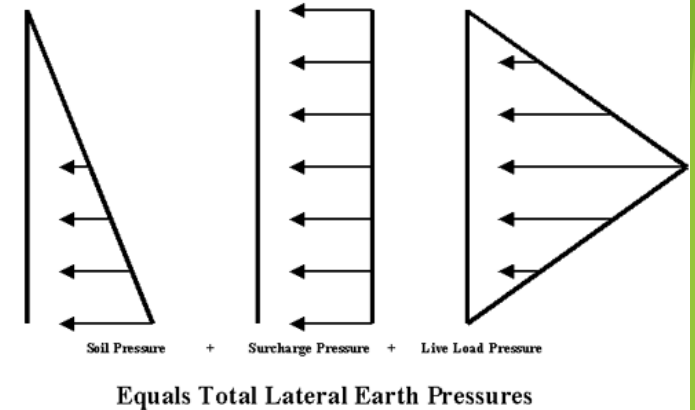
- ▶ Manufactured product
- ▶ Support structure
 - ▶ Transfers load
 - ▶ Relies on sub-grade for stability



Lateral Loading (Cont.)

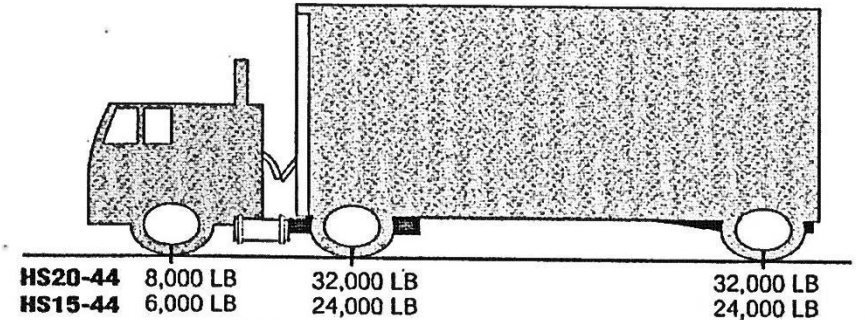
- ▶ Calculated Load
 - ▶ Soil Pressure
 - ▶ Surcharge Pressure
 - ▶ Live Load Pressure
- ▶ Results
 - ▶ Limiting factor for burial depth
 - ▶ Extend wall and building footings to system invert
 - ▶ Effects adjacent excavation

Earth Pressure Concepts and Theory

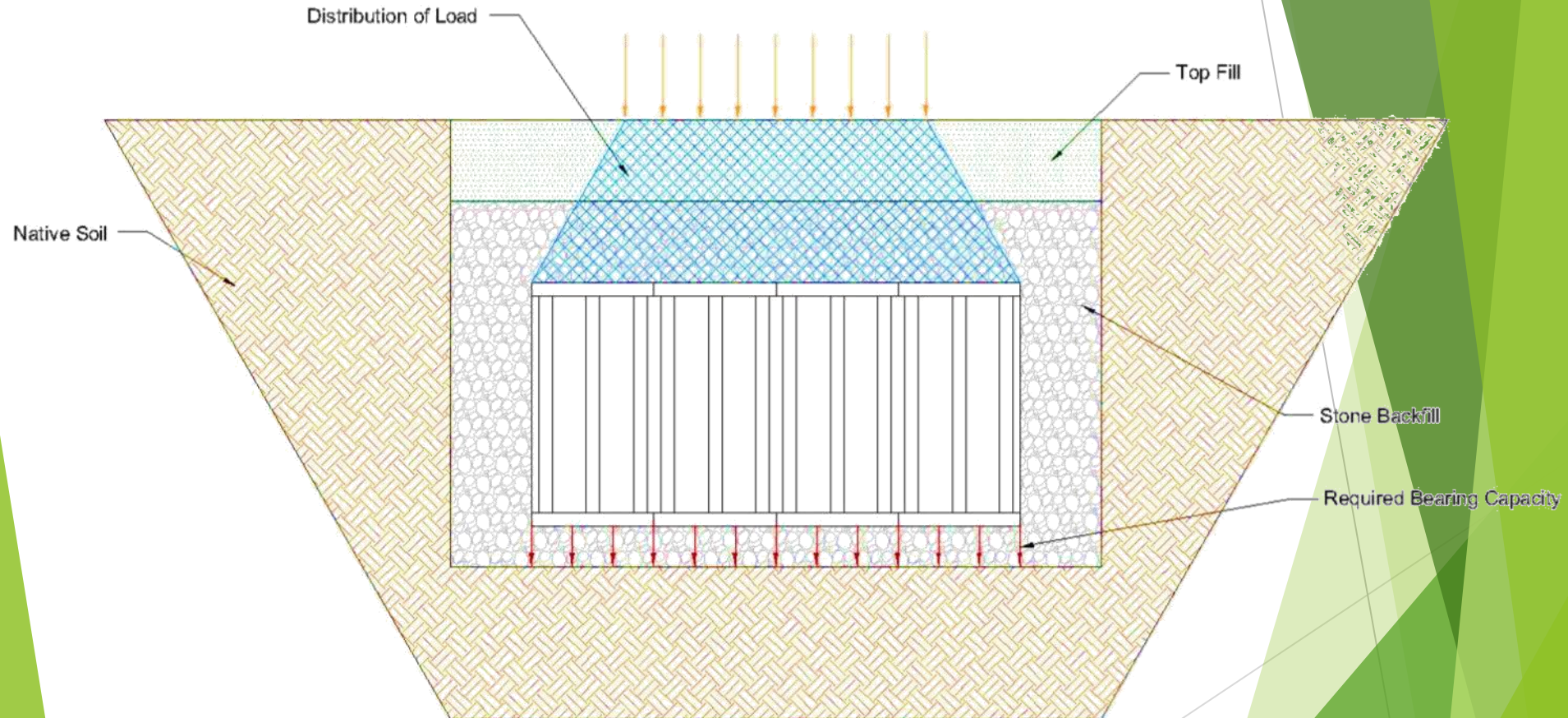


Vertical Loading

- ▶ Based on AASHTO LRFD for Bridge Design
 - ▶ American Association of State Highway and Transportation Officials (AASHTO)
 - ▶ Pedestrian loading
 - ▶ Vehicular loading
 - ▶ H-10 (16,000 lbs. per axle)
 - ▶ HS-15 (24,000 lbs. per axle)
 - ▶ HS-20 (32,000 lbs. per axle)
 - ▶ HS-25 (40,000 lbs. per axle)

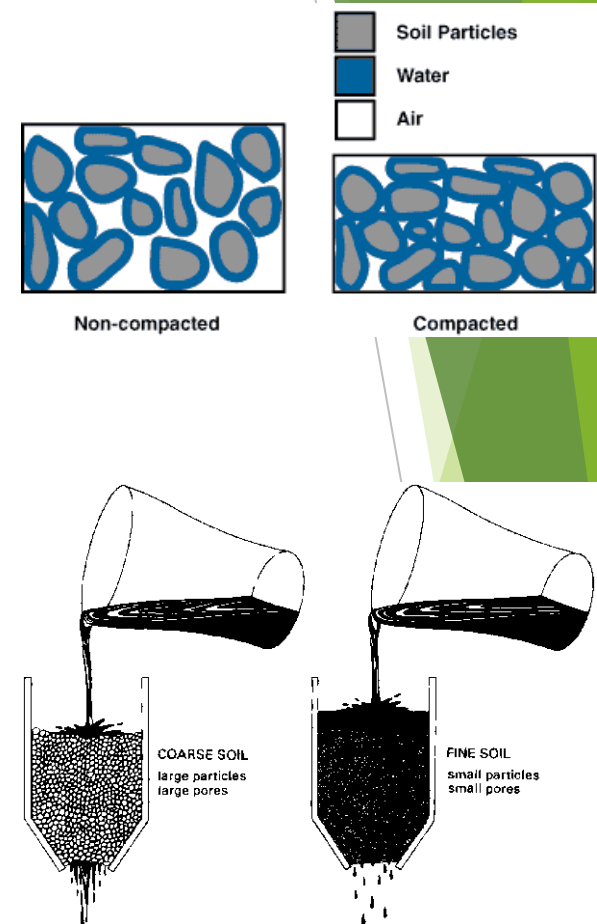


Bearing Capacity (Cont.)

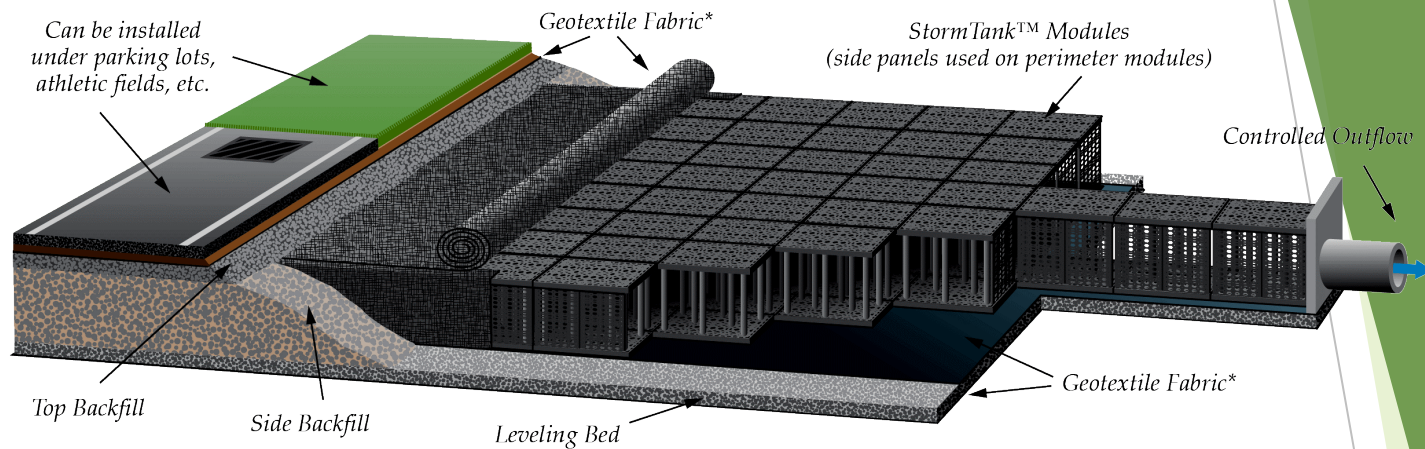


Compaction

- ▶ Soil compaction occurs when soil particles are pressed together, reducing pore space between them
- ▶ Increases soil strength
 - ▶ The ability of soil to resist being moved by an applied force
 - ▶ Limits differential settlement
- ▶ Reduces the infiltration rate
- ▶ Manufacturer's require between 90% & 95% modified proctor density.



System Components



* PVC or HDPE Liner can be incorporated as required by Engineer of Record

Sub-Surface Storage System Components

▶ Finished Surface

▶ Top Cover

▶ Geotextile Fabric

▶ Top Backfill

▶ Side Backfill

▶ Modules

▶ Leveling Bed

▶ Sub-Grade

Sub-Grade

- ▶ Material
 - ▶ Native soil
 - ▶ Compacted to 95% modified proctor density to limit differential settling
- ▶ Location where all load is applied
 - ▶ Potential for failure if available bearing capacity is exceeded.
 - ▶ Can be designed to distribute load to meet native soil properties



Leveling Bed

- ▶ Material
 - ▶ $\frac{3}{4}$ " Angular clean stone typical
 - ▶ Thickness per manufacturer/engineer requirements
- ▶ Non-structural element
 - ▶ Purpose is to provide level surface
 - ▶ Load is considered to transfer



Modules

▶ Material

- ▶ HDPE - flexible, susceptible to creep
- ▶ Polypropylene - more rigid than HDPE
- ▶ PVC - rigid, resistant to vertical loads
- ▶ Alternate materials

▶ Load

- ▶ Dead Load
- ▶ Applied Live Load is transferred from top to bottom
 - ▶ No distribution of load
 - ▶ Load applied to footprint of bottom



Side Backfill

- ▶ Material
 - ▶ ¾" Angular clean stone
 - ▶ Width per manufacturer/engineer requirements
- ▶ Load
 - ▶ Dead Load applied to base only
 - ▶ Distributes Lateral Load to side of system



Top Backfill

- ▶ Material
 - ▶ ¾" Angular clean stone
 - ▶ Thickness per manufacturer/engineer requirements.
- ▶ Load
 - ▶ Dead Load
 - ▶ Continues Live Load distribution
 - ▶ Varies based on material
 - ▶ Distributes load uniformly to modules



Geotextile Fabric

- ▶ Two layers
 - ▶ Soil/Stone Interface
 - ▶ Stone/Module Interface
- ▶ Prevents material migration
 - ▶ Movement of particles between interfaces
 - ▶ Differential settlement
- ▶ Non-structural
 - ▶ Applied only as a separator
 - ▶ Can be engineered to decrease loading



Top Cover

- ▶ Material
 - ▶ Compacted fill material (native soil)
 - ▶ Road base
- ▶ Loads
 - ▶ Dead Load
 - ▶ Applied Live Load is distributed
 - ▶ Varies based on material



Finished Surface

- ▶ Material
 - ▶ Pervious
 - ▶ Impervious
- ▶ Loads
 - ▶ Dead Loads
 - ▶ Live Loads is applied
 - ▶ Pedestrian Loading
 - ▶ Vehicular Loading

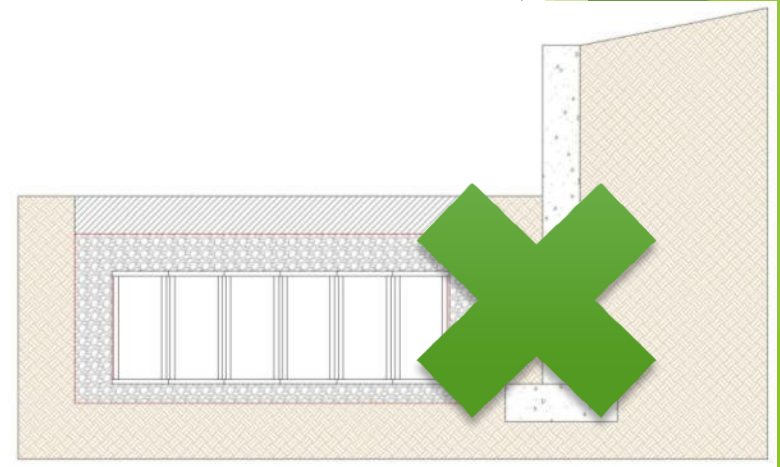
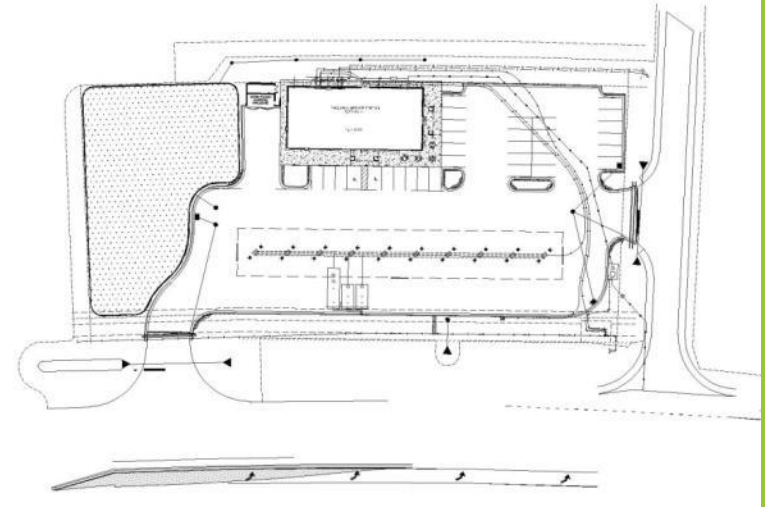


Design

- Layout
- Investigation
- Calculations
- Specification

Location

- ▶ Determine location and elevations of buildings and infrastructures
- ▶ Determine ground coverage
 - ▶ Impervious
 - ▶ Open Space
 - ▶ Rain Garden, Swale, etc.
- ▶ Locate system
 - ▶ Evaluate potential conflicts
 - ▶ Evaluate proximity to structures
 - ▶ Building
 - ▶ Retaining Walls



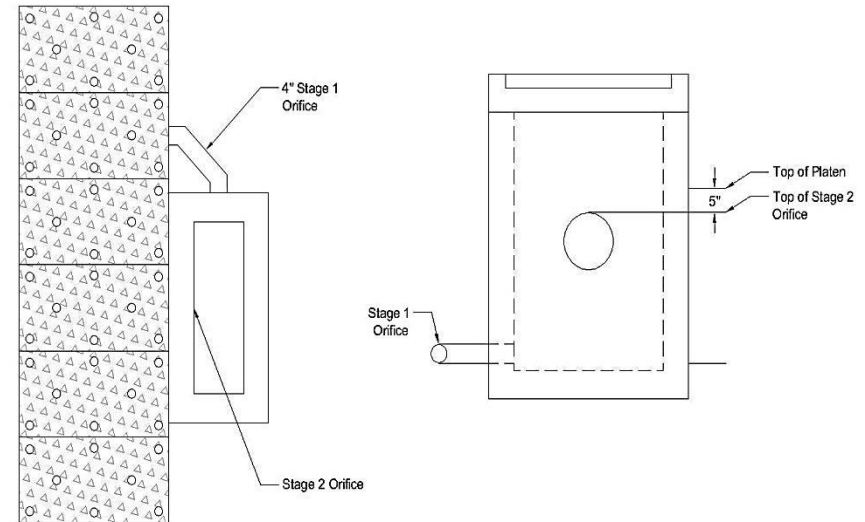
Geotechnical Investigation

- ▶ Soil Borings
 - ▶ Evaluate the system invert and investigate additional depth
 - ▶ Soil characteristics
 - ▶ Limiting zones
 - ▶ Bearing capacity
 - ▶ Determines the available capacity of the sub-grade to support the load
- ▶ Infiltration Rate
 - ▶ Evaluate at invert
 - ▶ Secondary testing to verify compacted conditions



System Sizing

- ▶ Module Height
 - ▶ System invert
 - ▶ Minimum required top cover
 - ▶ Bearing capacity
 - ▶ Void Space
- ▶ System Capacity/Footprint
 - ▶ Volume
 - ▶ Loading Ratio
- ▶ Routing
 - ▶ Same as above ground
 - ▶ Multi-stage orifice

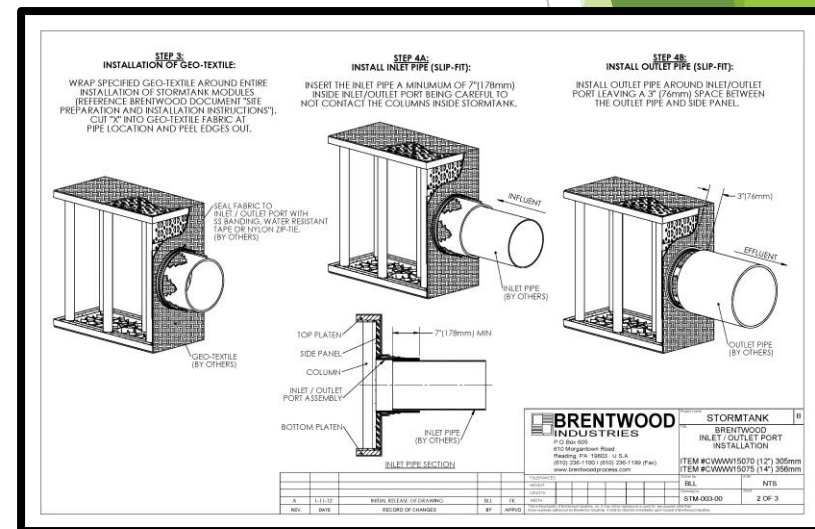
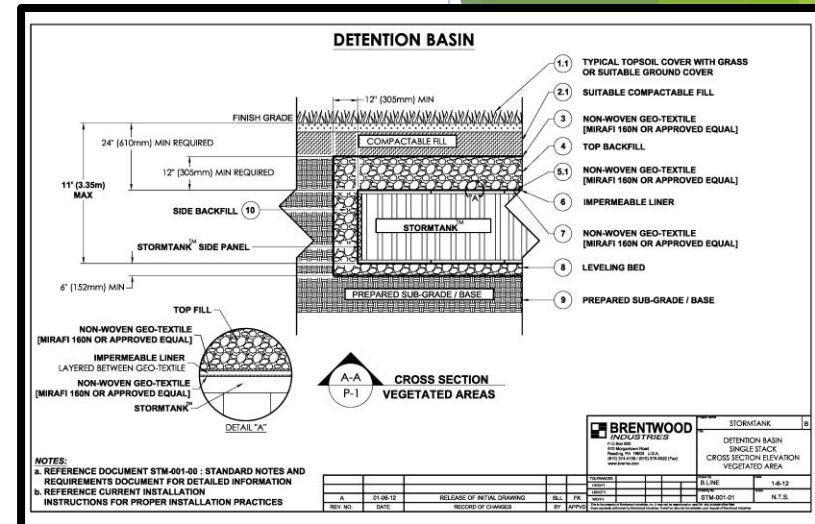


Plan Details

- ▶ Cross-section
- ▶ Connection and Cleanout Details
- ▶ Standard Notes
- ▶ Assembly & Installation Sequence
- ▶ Maintenance

Construction Documents

- ▶ CSI Specification
- ▶ Site Preparation/Installation Guide
- ▶ Maintenance Guidelines



Albany Airport

PVC lined
detention
540 - 3' tanks







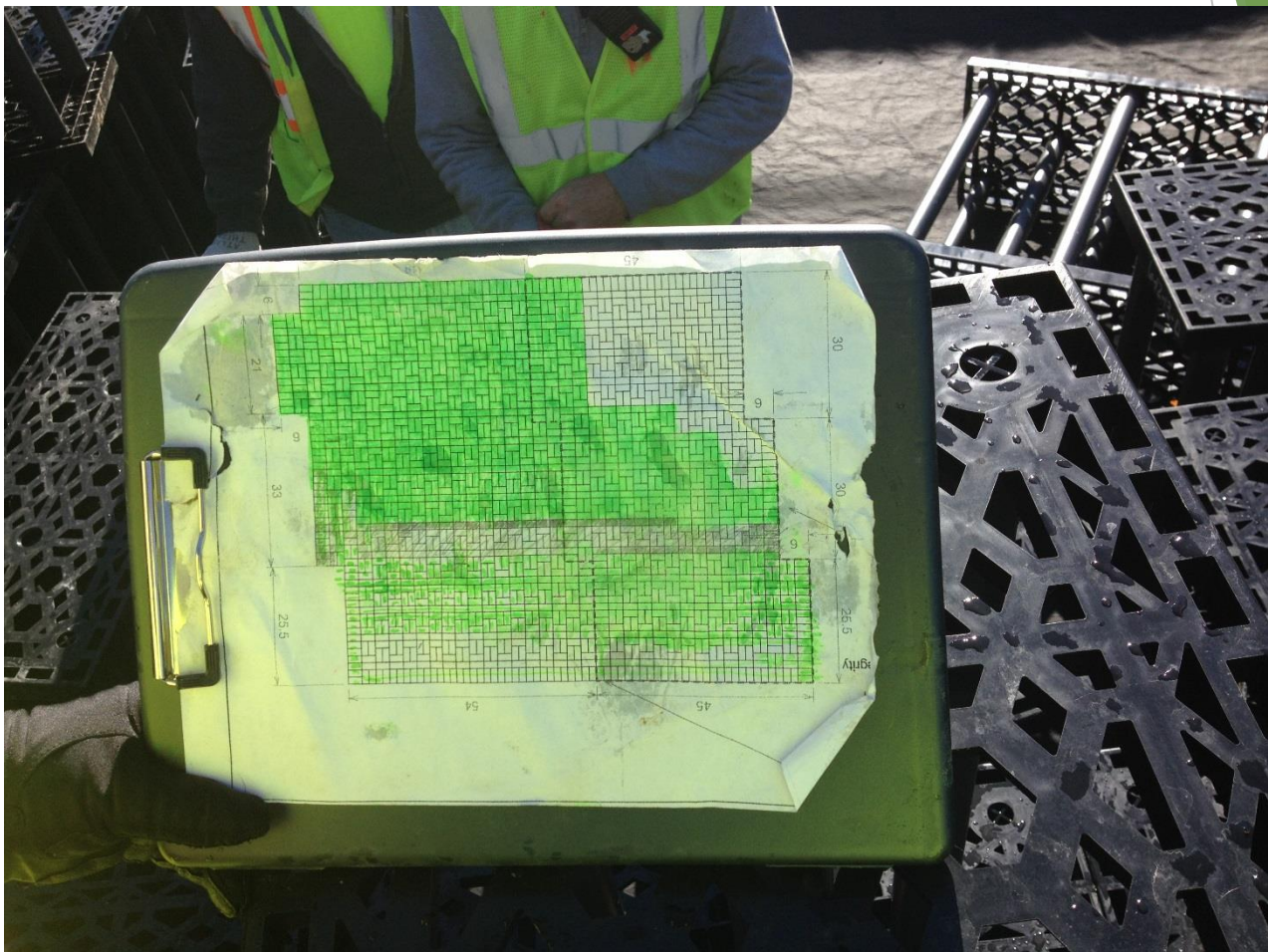
Watchtower Headquarters Tuxedo, NY

system 1- 2,880 tanks
system 2- 2,716 tanks
system 3- 1,200 tanks





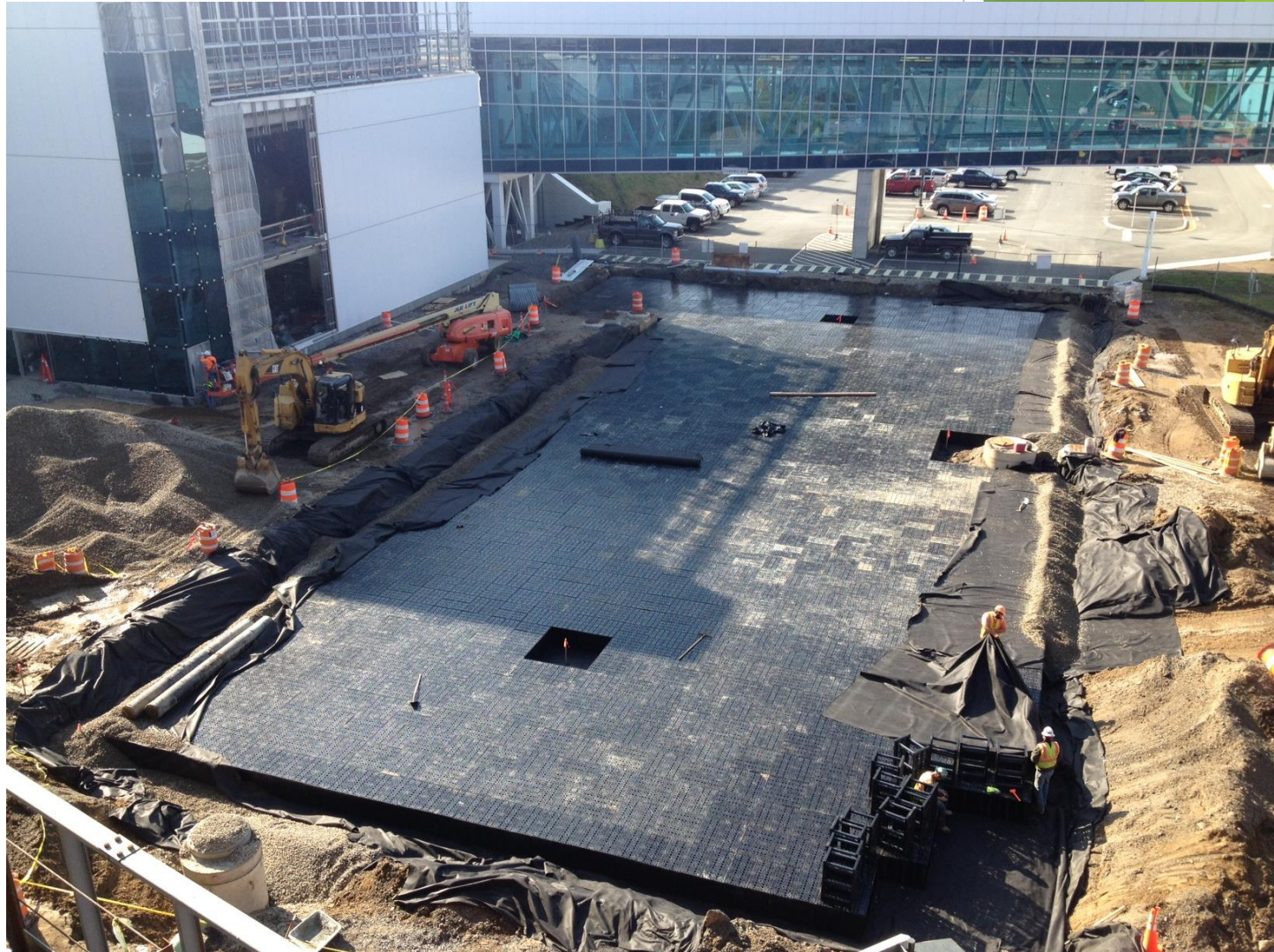




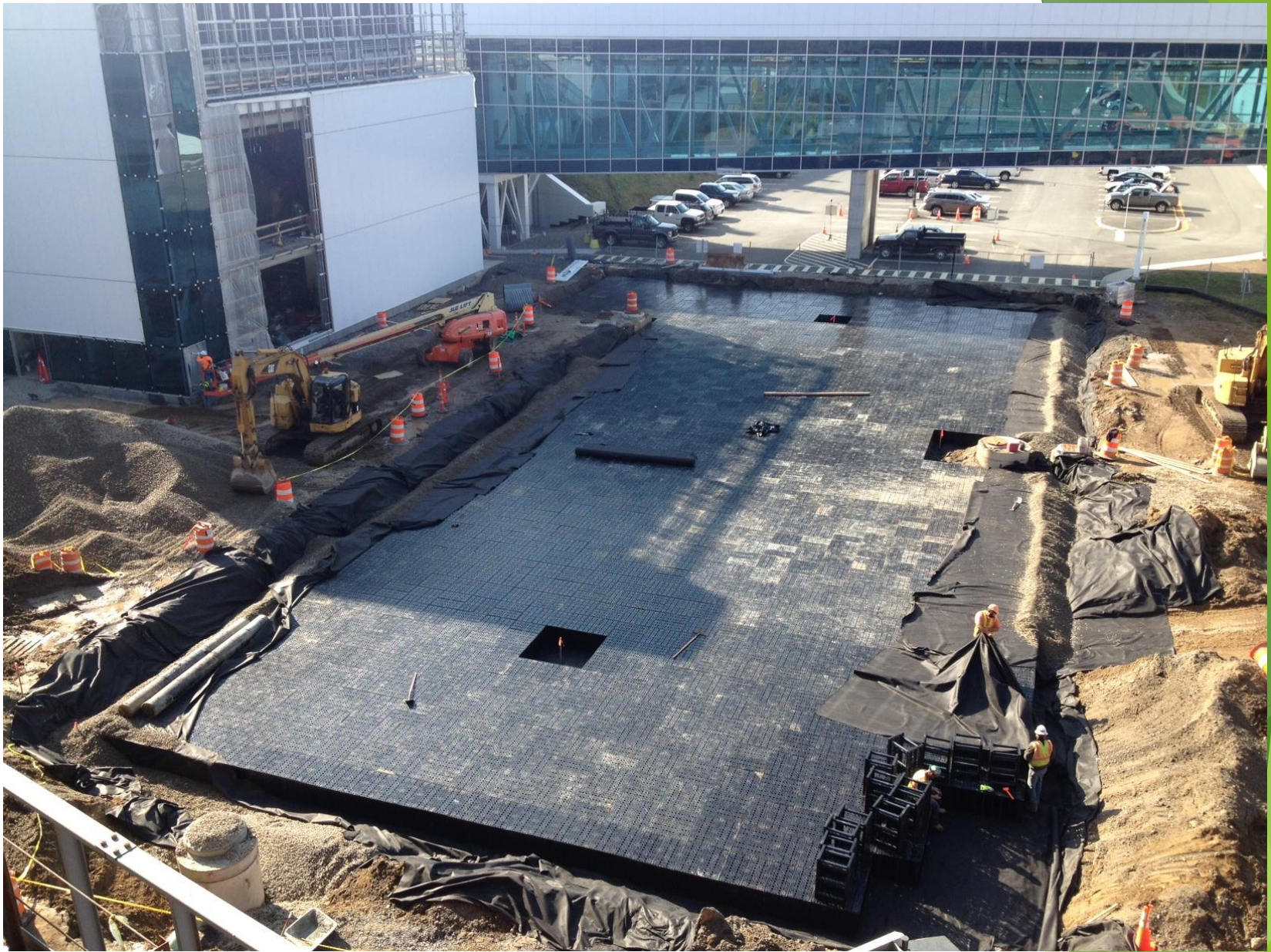


SUNY CNSE Albany, NY

2 Systems
24,672 ft³
2,630 - 2' tanks
304 - 3' tanks









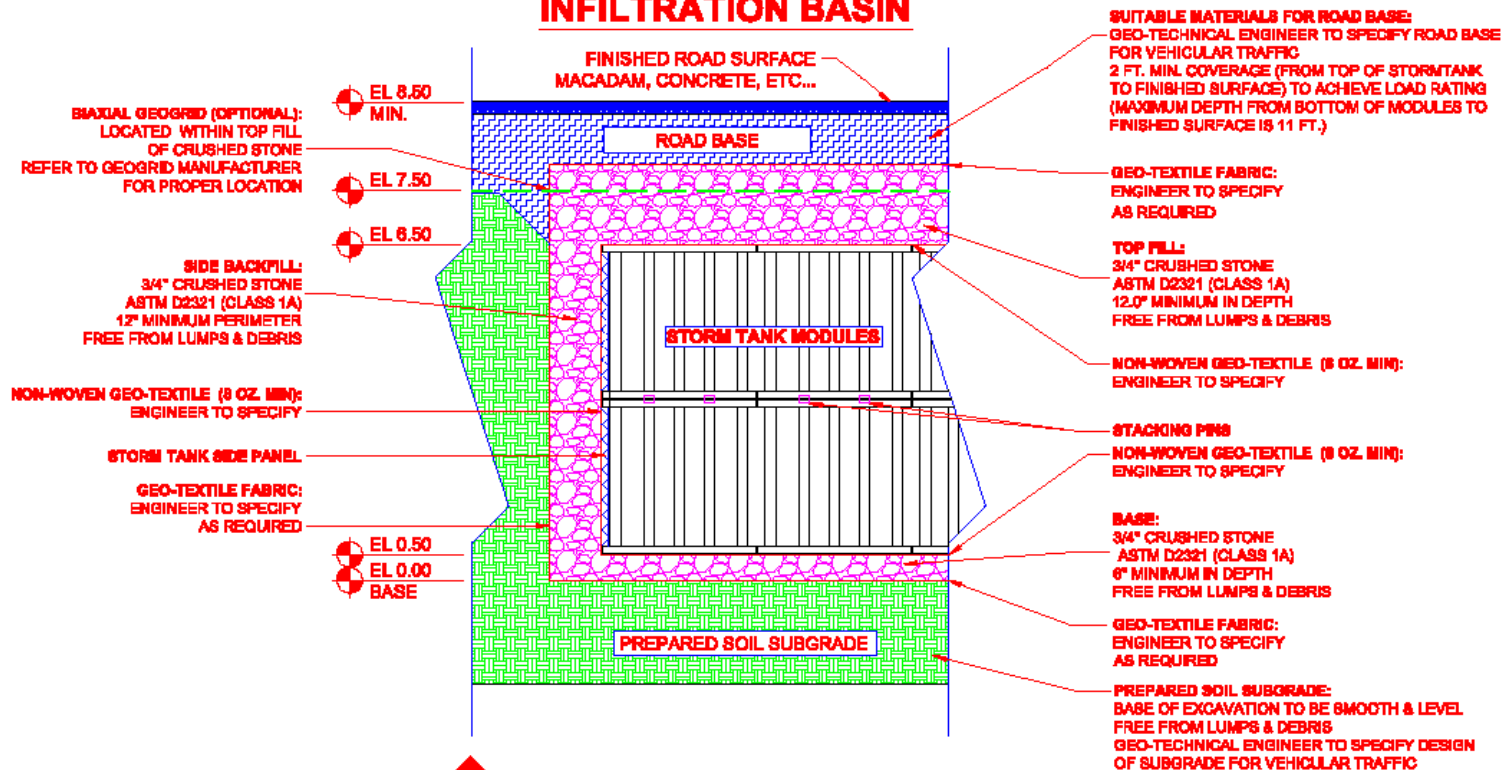
Brooklyn Bridge Park Brooklyn, NY

612 - 3' Tanks
Detention System





INFILTRATION BASIN



CROSS SECTION VEHICULAR TRAFFIC AREAS

WWEDCN-00036 2-24-09 DMB

Rev.	Date	Updated Notes	By
002	2-24-09	UPDATED NOTES	DMB
001	12-12-08	UPDATED NOTES	DMB
Rev. No.	Date	Record of Changes	By

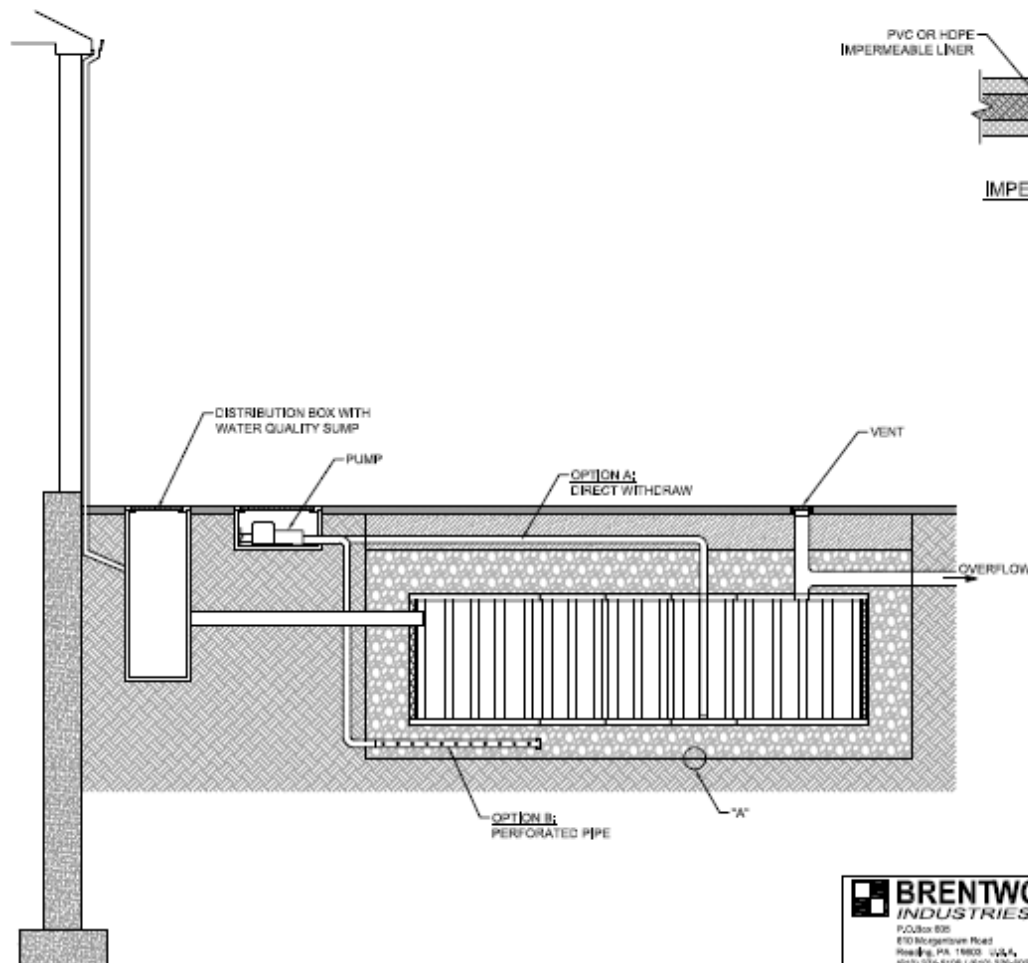
BRENTWOOD INDUSTRIES
P.O. Box 635
4745 Montgomery Road
Pleasant, PA 15068 U.S.A.
(724) 224-4745 / (724) 224-4746 (Fax)
www.brentwood.com

TOURNOISE **SUPPOSE** **DATE**
FABRIC 1/16" 1/16" 1/16"
LENGTH 1/16" 1/16" 1/16"
WIDTH 1/16" 1/16" 1/16"
NOTE: All dimensions are nominal. No tolerances are specified and all dimensions are nominal.
Data supplied by Brentwood Industries is not to be used for any other purpose.

STORM TANK	A
INFILTRATION DOUBLE STACK CROSS SECTION ELEVATION VEHICULAR TRAFFIC	
Drawn By	DMB
Date	2-24-09
Scale	N.T.S.
Rev.	002

CONCEPTUAL USE:

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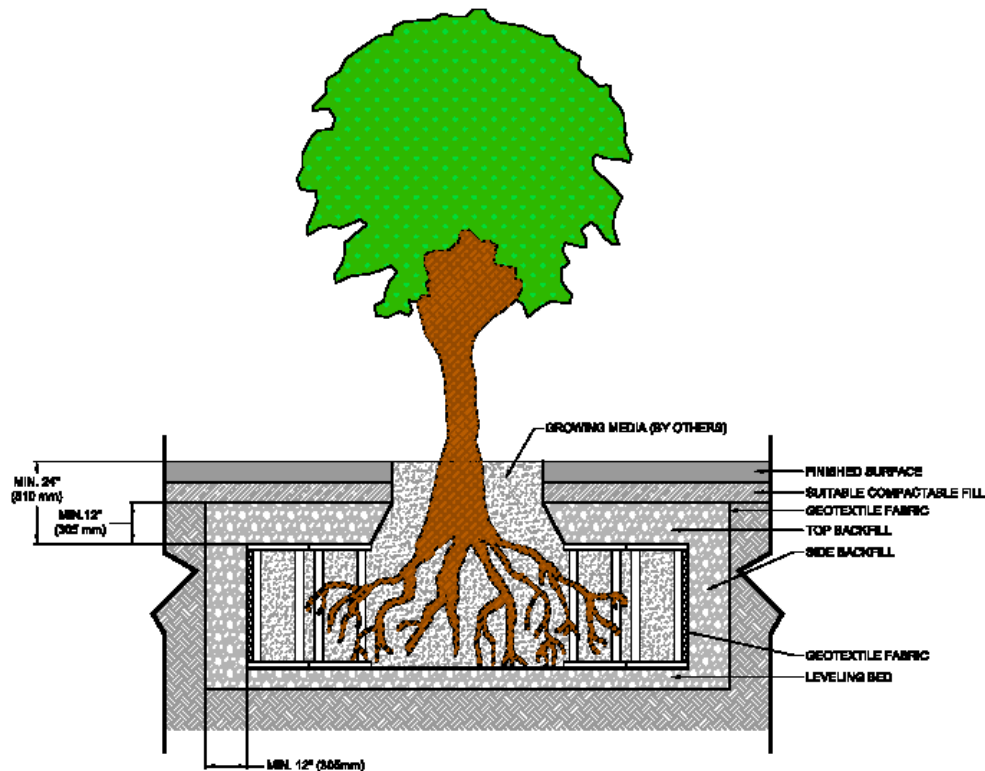
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P.O. Box 805
8700 Valley Forge Road
Reading, PA 19603 USA
(610) 374-9108 / (610) 374-0022 (Fax)
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Product Name
STORMTANK™

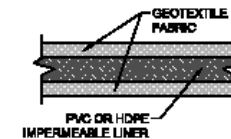
RAINWATER HARVESTING

A. 3/14/12		BUTAL, WILLIAM		30	PP	Drawn By	DATE
REV.		DATE		REASON FOR CHANGE		BY	DATE
						1/12/12	3/14/12
						1 of 1	1/12

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**DETAIL "A"
IMPERMEABLE LINER**

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Product Name		STORMTANK™	
Title		TREE BOX	
Drawn by		J. Bailey	
Check by		J. Bailey	
Date		07/14/09	
Scale		1 of 1	
Sheet		NTB	

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Questions:

1. Why would you include a geotextile fabric in an underground system?
A) prevent material migration B) avoid differential settlement C) both a & b
2. In a typical application, backfill and sidefill materials should be:
A) $\frac{3}{4}$ " angular clean stone B) sand C) pea stone
3. A majority of subsurface systems are constructed of:
A) thermoplastics B) concrete C) metal pipe D) A,B & C
4. While many systems are constructed from thermoplastic material, installation guidelines require a leveling bed, sidefill and topcover. True or False?

CONTACT INFORMATION:

VARI-TECH,LLC

WWW.VARITECH.COM

1-315-622-1800