KSA – 4 Blue Roofs and Stormwater Management

Speaker

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Acknowledgements/Credits

Alliance for the Great Lakes

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EPA 2004 Report to Congress

Kemper System America, Inc.

National Institute of Environmental Health Science

NYC DEP Rooftop Detention Brochure

NYC DEP Guidelines for Design & Construction of Storm Water Management Systems (July 2012)

San Francisco Public Utilities Commission Storm Water Management Tool Kit (June 2013)

Weill Cornell Medical College

Course Description

This course will describe the process in which storm water that enters the sewer system during significant precipitation events can lead to the dreaded occurrence of the combined sewer overflow. It will discuss some of the conditions that can be observed during the release of untreated sewage into our waterways as a result of a combined sewer overflow. It will discuss some of the strategies that are typically employed to reduce the peak runoff of storm water that contribute to the occurrence of combined sewer overflow with a focus on the use of roof retention systems or "Blue Roofs". Blue Roofs are a cost effective means to delay the storm water runoff thus reducing the peak storm water load to the system. These special roofs hold up to 3" of storm water from a rain event and by the use of restricted flow drains allow the water to slowly enter the system thus reducing the buildings contribution to the sewer system during peak loads. Blue Roofs require high quality waterproofing and can be designed in a variety of assemblies. Various assemblies will be discussed and specific project photos and waterproofing details will be introduced to the attendees.

LEARNING OBJECTIVES

- Understand the causes, look at the process, and identify some of the problems associated with the combined sewer over-flow phenomenon.

- Look at some of the measures being taken to address this concern including vegetated roofs, vegetated swales, pervious paving, water retention tanks, and blue roofing.

- Define Blue Roofing and discuss the current design issues in terms of limitations, requirements, best practices, and performance.

- Review case studies of projects in place discussing how design issues were addressed and providing a frame of reference to how these projects are typically being handled.

What is a Combined Sewer Over-flow?

- To understand a Combined Sewer Over-flow (CSO), one must first understand the concept of a Combined Sewer System (CSS).

So What is a Combined Sewer System?

Interaction/Activity

What is a Combined Sewer System?

A. A Combined Sewer System is one that is used to convey both sanitary and storm flows.

B. A Combined Sewer System is one that is used to convey sewage from multiple locations.

C. A Combined Sewer System is one that is able to be used to provide grey water for non-potable use.

What is a Combined Sewer System (CSS)?

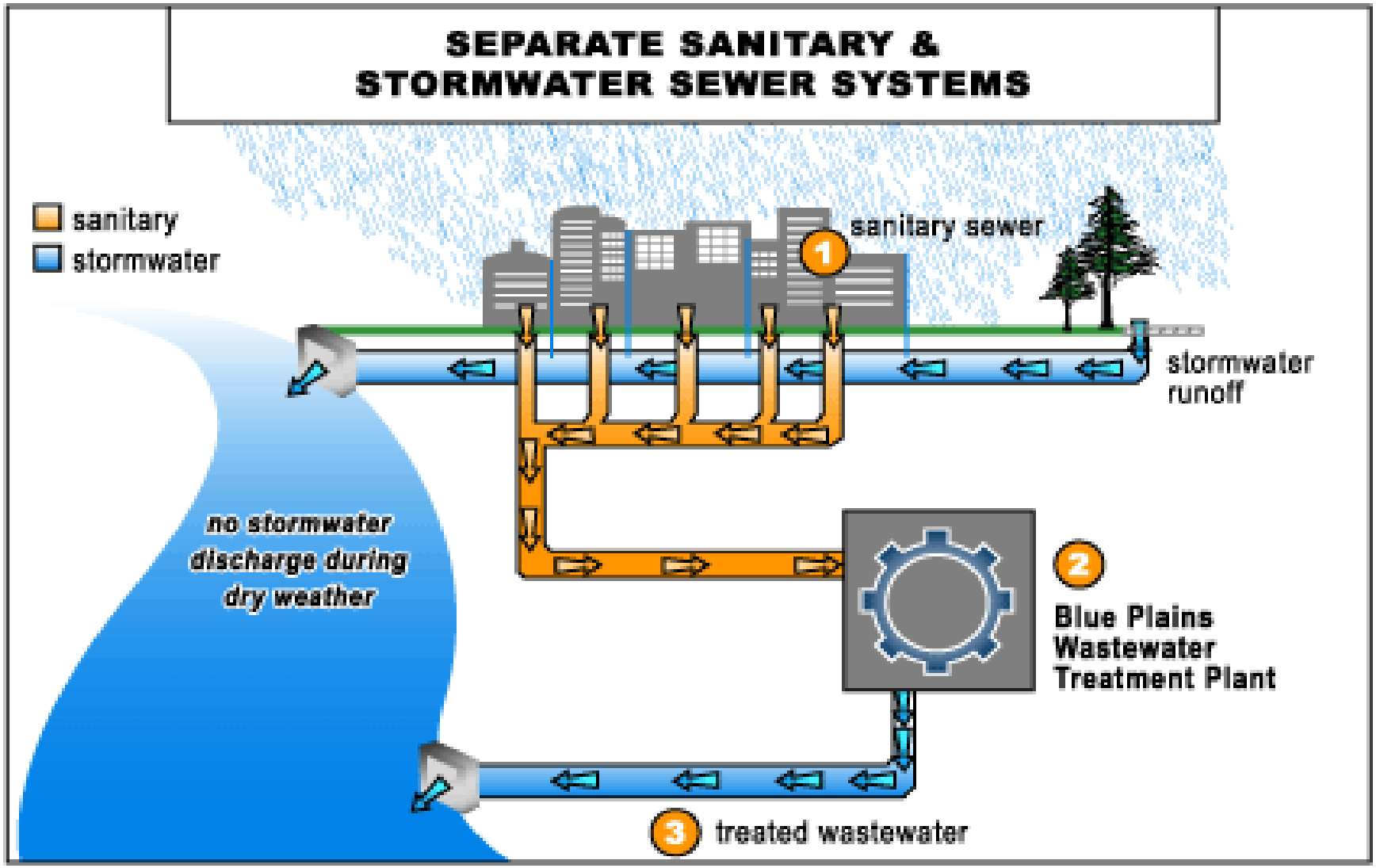
The answer is: **A**

- A Combined Sewer System is one that is used to convey both sanitary and storm flows.
- During times of heavy precipitation sewers are typically forced to accommodate higher flow rates.
- When these flow rates exceed their design capacity the excess storm water combines with untreated wastewater and it is directly discharged thru outfalls to prevent upstream flooding.

Source: NYC Environmental Protection CSO program documents

What is a Combined Sewer Over-flow?

District of Columbia Water and Sewer Authority



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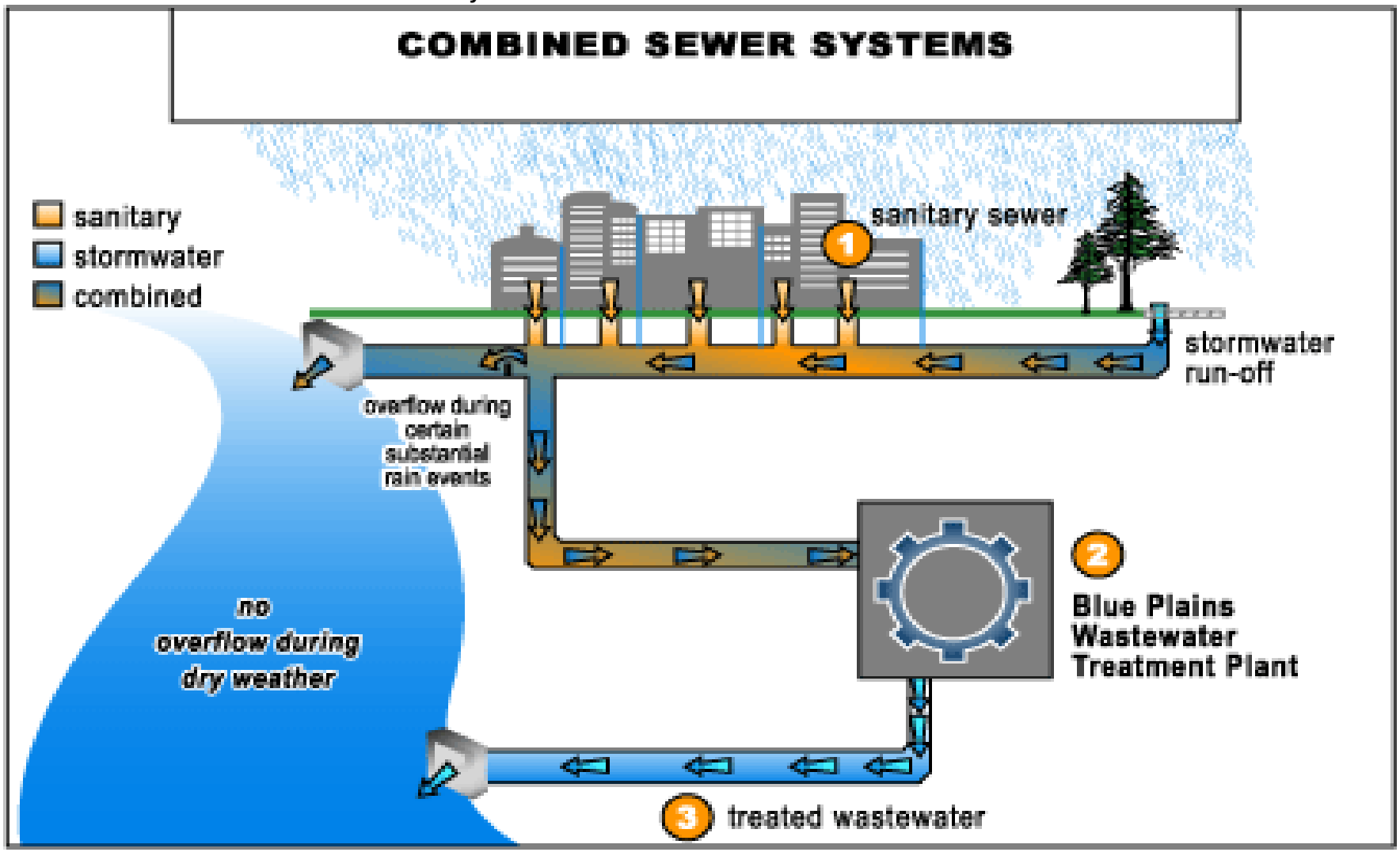

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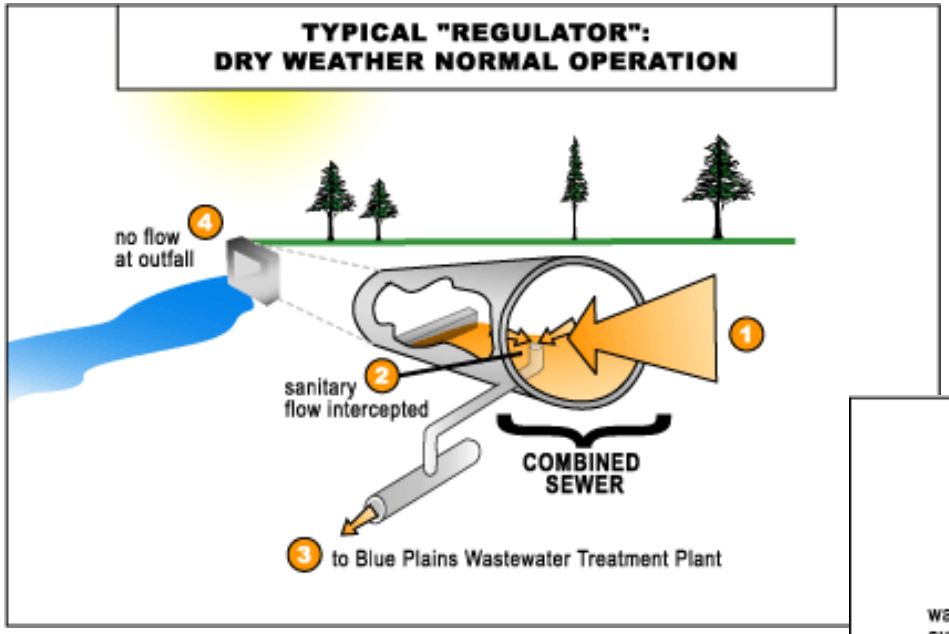
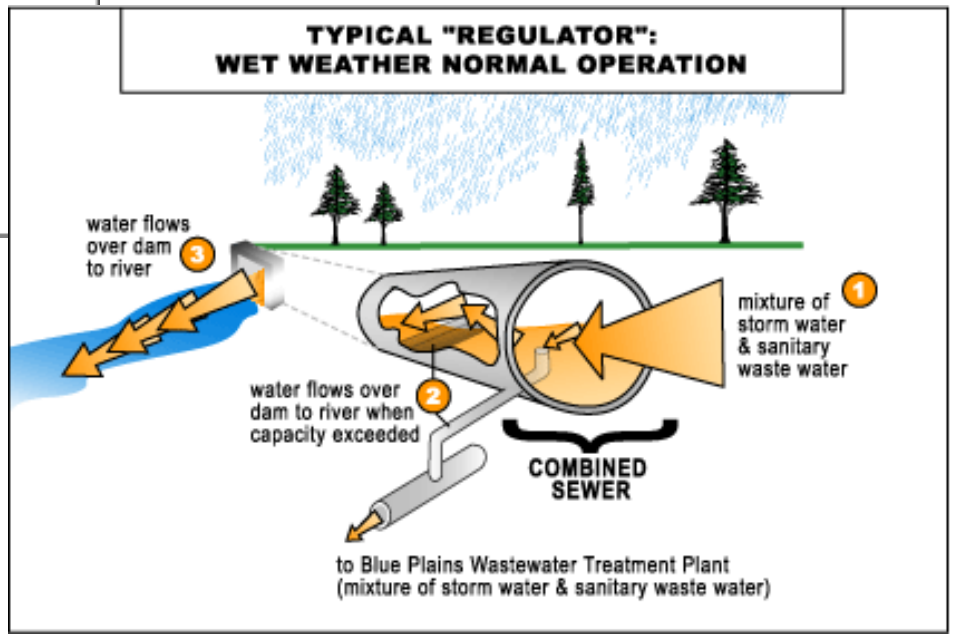
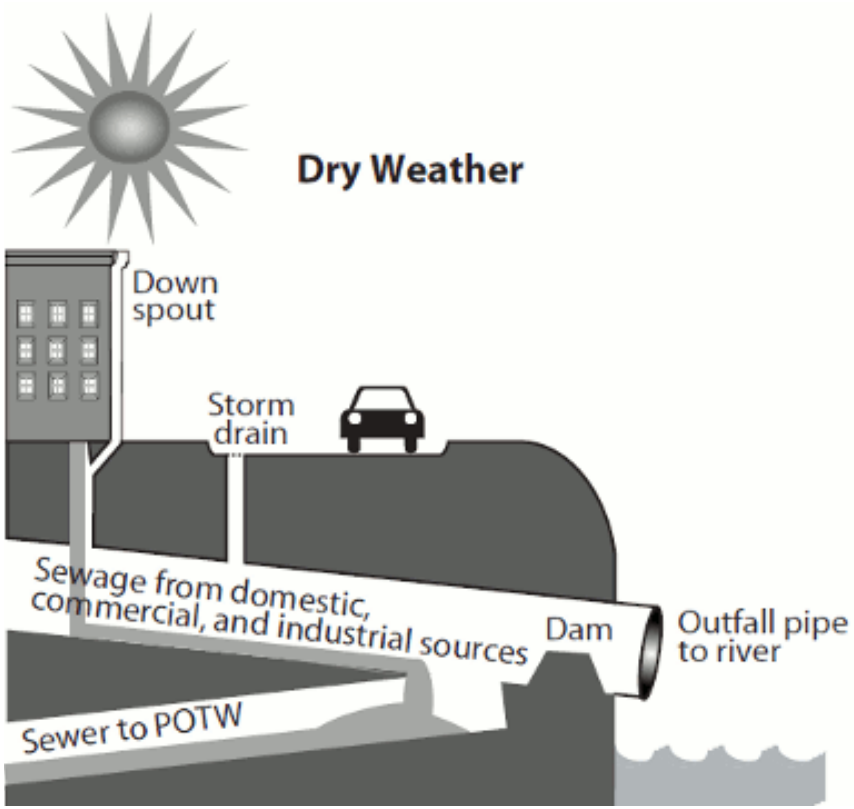


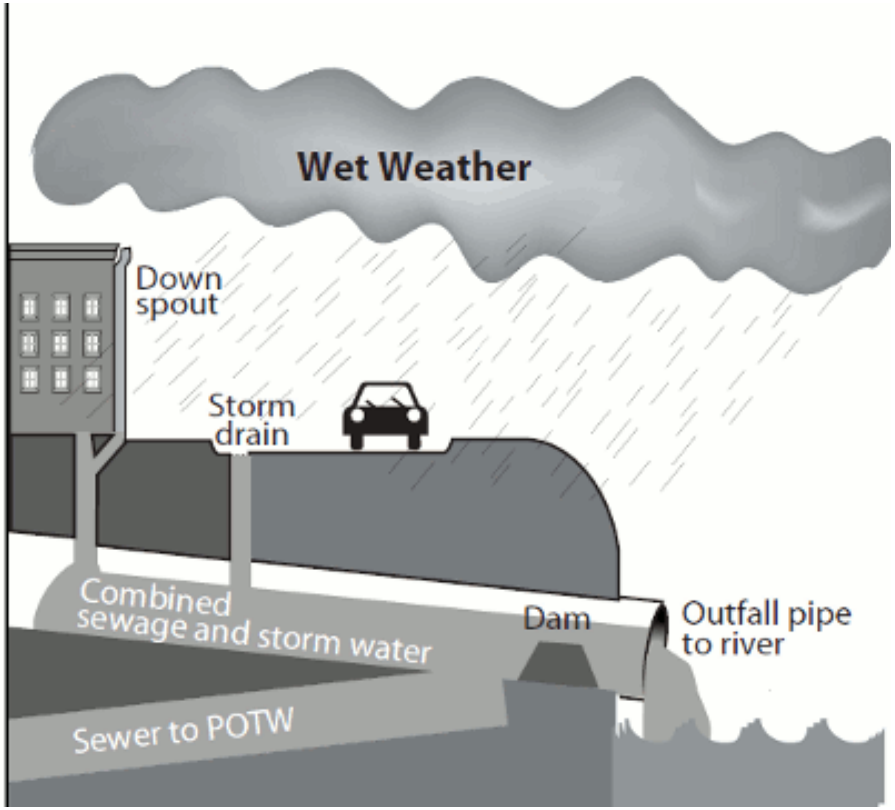


View from the top of Hunts Point Digester Tanks in Bronx, NY

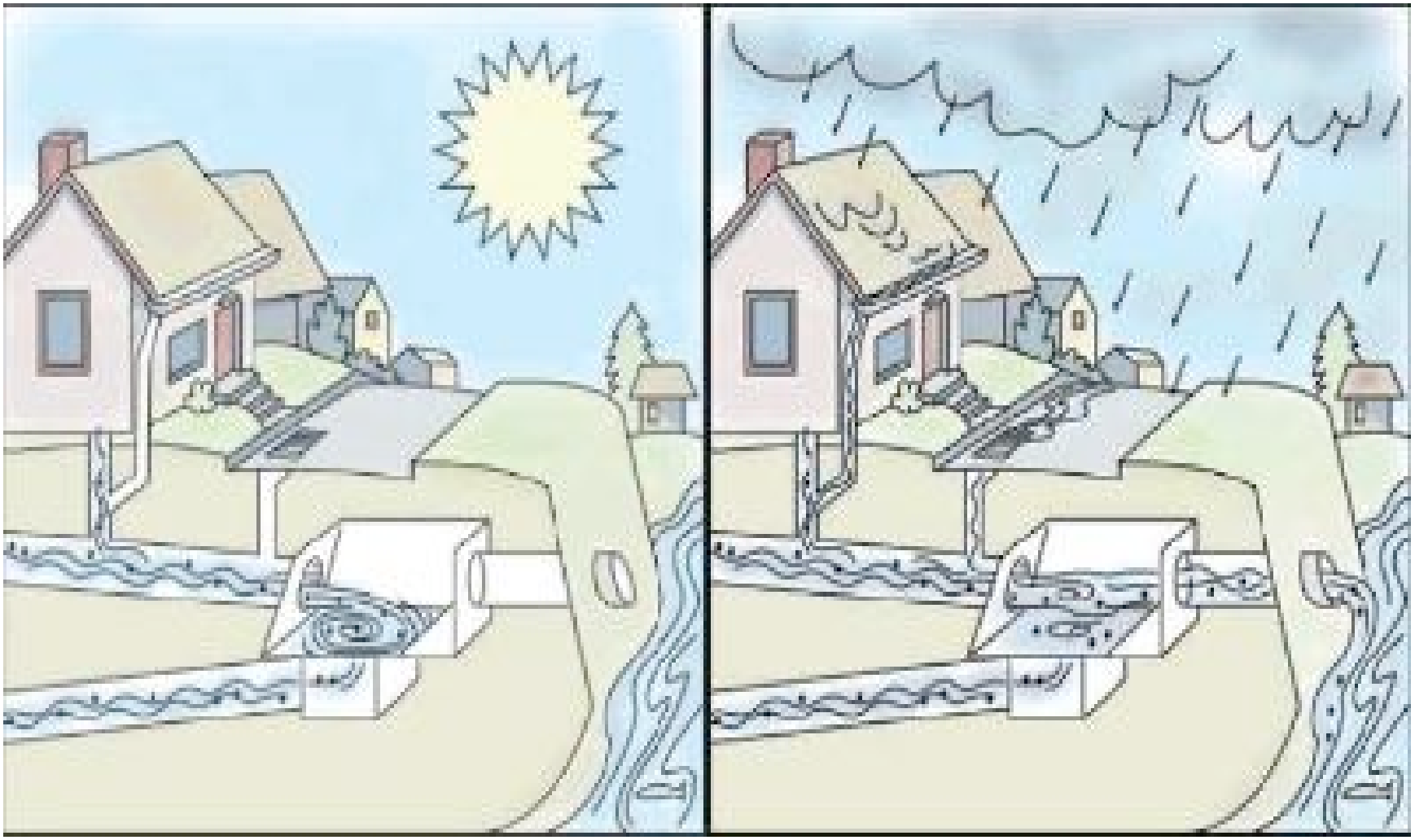
What is a Combined Sewer Over-flow?

Environmental Protection Agency, 2004 Report to Congress: Impacts and Control of CSOs and SSOs





Combined Sewer Over-flow Diagram



Estimated 722 communities with Combined Systems

Environmental Protection Agency, 2004 Report to Congress: Impacts and Control of CSOs and SSOs

San Francisco Public Utilities Commission

Problems Associated with Combined Sewer Overflows (CSO)

- According to the EPA, CSOs annually result in an estimated 850 billion gallons of untreated wastewater and storm water being discharged into U.S. waterways.

- CSOs flood waterways with contaminants including microbial pathogens, suspended solids, chemicals, trash, and nutrients that deplete dissolved oxygen.

Problems Associated with Combined Sewer Overflows (CSO)

- Microbial pathogens and toxins can be present in CSOs at levels that pose risks to human health. CSOs can therefore lead to contamination of drinking water supplies, beaches, and shellfish beds.
- The EPA estimates about 3,500–5,500 gastrointestinal illnesses each year are caused by CSO and SSO pollution of swimming waters from regularly monitored coastal and Great Lakes beaches.

CSO Pollution in the Great Lakes

Photo: Alliance For The Great Lakes

From: Reducing Combined Sewer Flows in the Great Lakes; 2012

www.greatlakes.org

What is being done to address the problem?

- There are two types of abatement categories: **water quality** and **technology** based. Water quality based abatement options may be more expensive.

- The following are options for abatement of CSO discharges as part of the long-term control plan. However, these options can be expensive and may be cost prohibitive for some communities:
  - System upgrades separating storm water and sewer lines
  - Adding storage tanks and retention basins to hold overflow during storm event
  - Expansion of treatment plant capacity
  - Screening and disinfection facilities for the overflow
  - Green infrastructure to reduce peak flow into the combined sewer system

REDUCING PEAK FLOW

Guidelines for the Design and Construction of Storm Water Management Systems - New York City Department of Environmental Protection & New York City Department of Buildings (JULY 2012)

- Sizing Storm Water Management Systems
- Subsurface Systems
- Rooftop Systems
  - Green Roofing
  - Blue Roofing
- Combination Systems
  - Rooftop Systems & Subsurface Systems

Interaction/Activity

REDUCING THE PEAK FLOW

Impervious conditions prevent rain from being absorbed into the ground and thus increase storm water flows into the system. In NYC it is estimated that ____% of the 305 square miles of land is covered with impervious surfaces…

A. 29%
B. 41%
C. 72%
D. 93%

REDUCING PEAK FLOW

The answer is C…

Impervious conditions prevent rain from being absorbed into the ground and thus increase storm water flows into the system. In NYC it is estimated that ***72%*** of the 305 square miles of land is covered with impervious surfaces…

REDUCING PEAK FLOW

San Francisco Plan: The game piece tools fall into four main categories…

- ***SINK IT (Retention):***

Holds storm water and infiltrates it…

- ***SLOW IT (Detention):***

Holds storm water flow and slowly releases to sewer system after the storm…

- ***REUSE IT (Storage and Reuse):***

Holds storm water and uses it to meet non-potable water demands (toilet flushing, irrigation, etc.)…

- ***MOVE IT (Conveyance):***

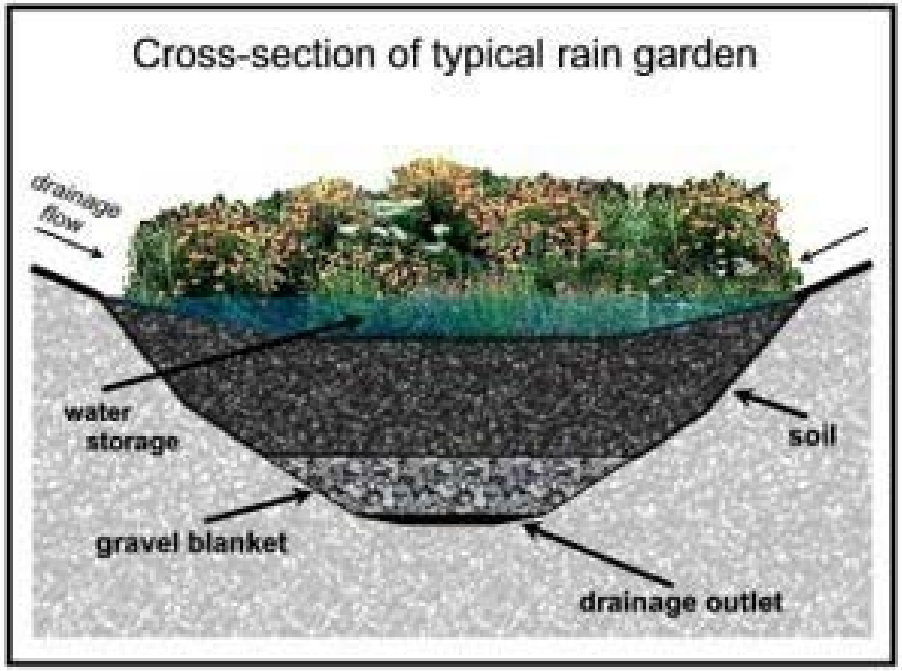
Directs flow to a downstream area for storage…

REDUCING PEAK FLOW

- San Francisco Water – Power – Sewer has published a guide for their Sewer System Improvement Program – Storm Water Management Tool Kit (June 2013)
  - Includes options to reduce peak flow including…
    - Rain Garden
    - Permeable Paving
    - Flow-Through Planter
    - Constructed Wetland
    - Storage Pipe
    - Detention Tank
    - Rainwater Harvesting
    - Creek Daylighting
    - Conveyance Pipe
    - Rooftop Systems
      - Green Roofs
      - Blue Roofs

RAIN GARDEN

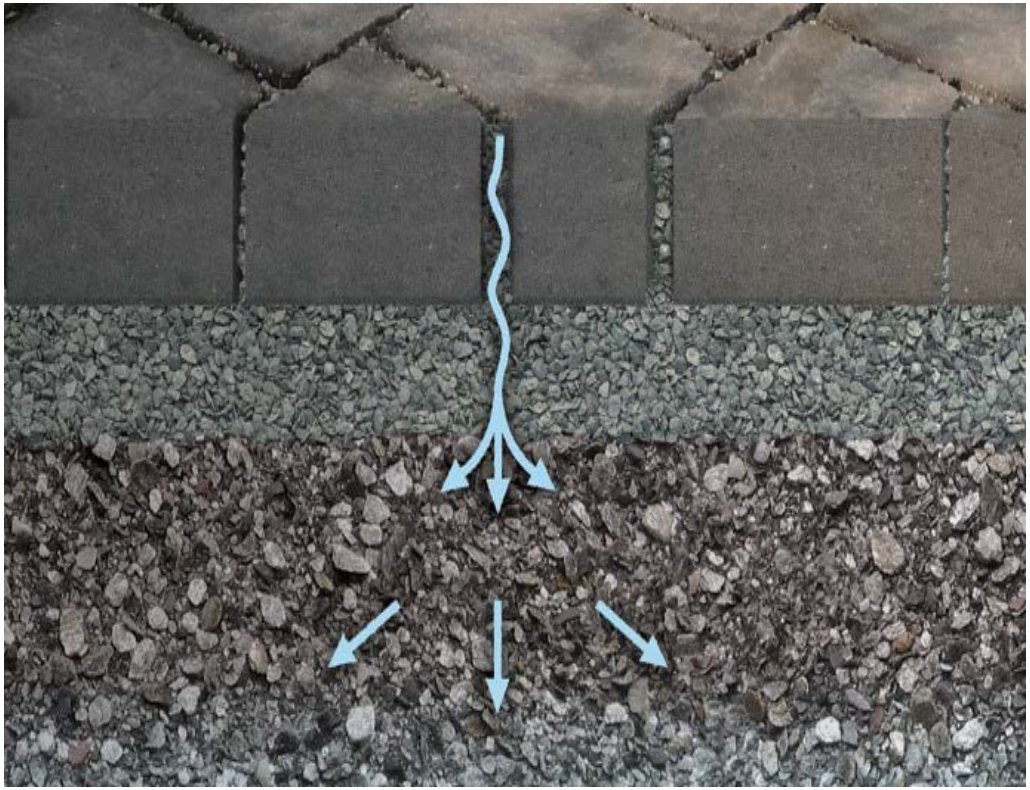
- A rain garden is a storm water facility that relies on vegetation and either native or engineered soils to capture, infiltrate and transpire water, and remove pollutants from runoff.



- Reduces storm water volume, attenuates peak flow, and improves storm water quality.
- Feature vegetation that can tolerate periodic inundation and contain soils with high organic content.
- Can be an aesthetic and habitat amenity as well as a storm water treatment facility.

PERMEABLE PAVING

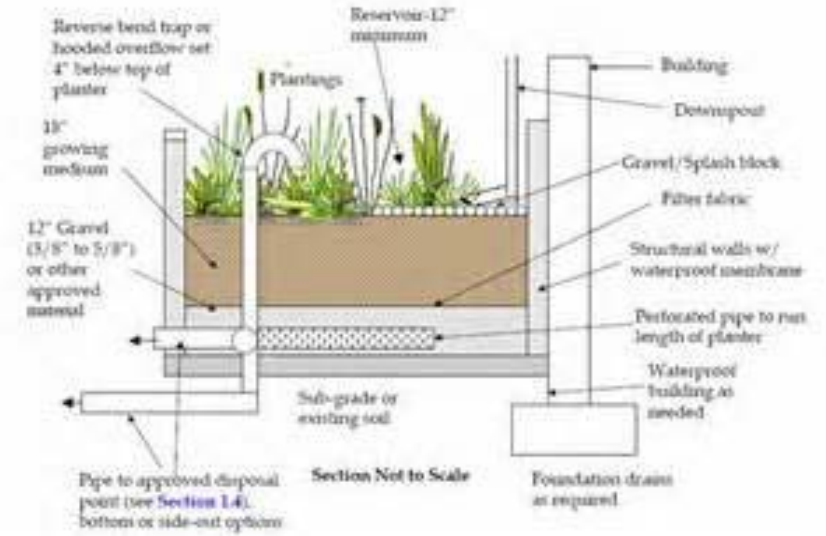
- Permeable paving is a porous load-bearing surface that temporarily stores rainwater in an underlying aggregate layer until it infiltrates into the soil below.

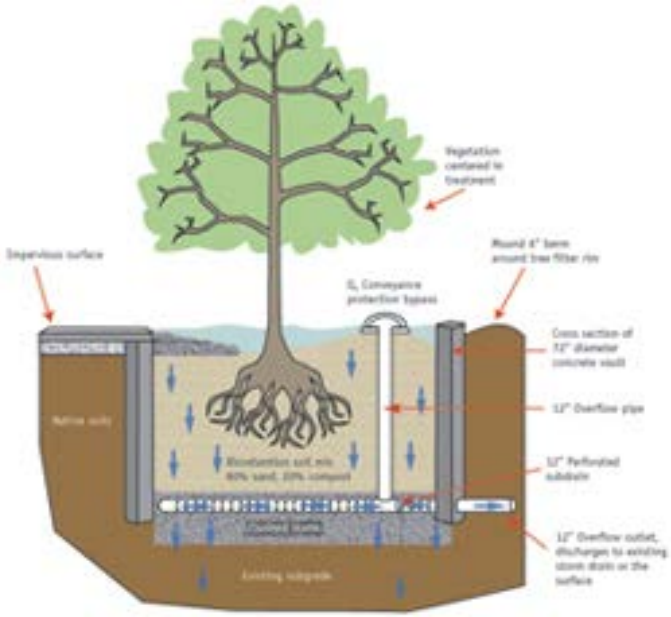


- Reduces annual runoff volumes, slows down peak flows, and improves water quality by removing oil and grease, metals, and suspended solids typically without removing nutrients.
- Infiltration rates of permeable surfaces may decline over time to varying degrees depending on design and installation, sediment loads, and consistency of maintenance.
- Common materials for the paving surface include porous asphalt, pervious concrete, interlocking block pavers, and plastic grid systems.

FLOW-THROUGH PLANTERS

- Flow-through planters are structural landscaped planters that collect storm water and filter out pollutants as the water percolates through the vegetation, growing medium, and gravel and then is slowly released to the sewer system.





- Tree box filters are flow-through planters with a concrete “box” that contains filtering growing media and a tree or large shrub.

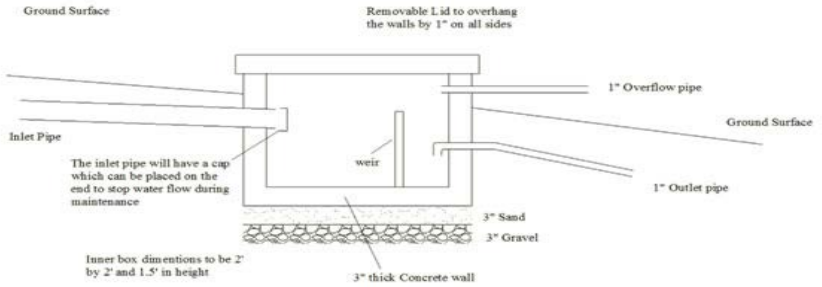
STORAGE PIPES

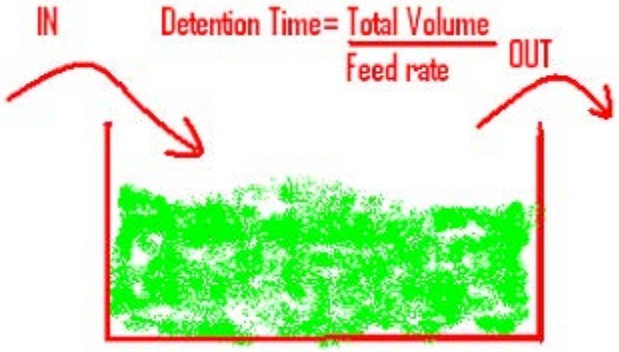
- Storage pipes are underground structures designed to temporarily hold a combination of wastewater (sewage) and storm water runoff during peak flows and then slowly release those flows to downstream treatment.

- Used to alleviate localized flooding, while also lessening the demand on treatment facilities during storm events and decreasing the likelihood of downstream flooding and/or combined sewer discharges.

DETENTION TANKS

- Detention tanks are underground structures designed to temporarily hold a combination of wastewater (sewage) and storm water during peak flows, and then slowly release those flows to downstream treatment.





- Used to alleviate localized flooding, while also lessening the demand on treatment facilities during storm events and decreasing the likelihood of downstream flooding and/or combined sewer discharges.
- Usually constructed out of concrete; the area above the tanks can be landscaped and used for other purposes, such as playgrounds or parking lots.

RAINWATER HARVESTING

- Collecting and using rainwater from impervious surfaces, such as roofs and patios, for non-potable use, such as irrigation and toilet flushing.

- It is now legal to divert storm water from San Francisco's combined sewer system. In 2005, city staff amended the plumbing code via Ordinance 137-05, making it possible to direct rainwater to alternative locations such as rain gardens, rain barrels, and cisterns.

- Proper design and sizing of the rainwater harvesting system are critical to ensure full runoff reduction benefits.

CREEK DAYLIGHTING

- Projects that uncover and restore creeks, streams, and rivers that were previously buried in underground pipes and culverts, covered by decks, or otherwise removed from view.

- The City of San Francisco has several historic creeks. Water from these creeks currently runs via the combined sewer system to treatment plants and then to the Bay and Ocean. Daylighting these historic creeks can decrease demand on the treatment facilities and enhance local neighborhoods.

CONVEYANCE PIPES

- Carry a combination of wastewater (sewage) and storm water runoff to downstream treatment.

- Can be used to alleviate localized flooding by directing storm water from constrained challenge areas to downstream areas that have adequate capacity to handle increased flows.

- Much of the sewer pipe network works with the natural topography and carries flows by gravity to downstream storage and treatment areas.

ROOFTOP SYSTEMS

- On certain sites, it may be possible to detain the entire required storage volume with a rooftop system.

- On sites where the non-roof area is significant, additional analysis of site conditions is required to determine whether a subsurface system or combination of rooftop and subsurface systems would be most effective.

- Rooftop systems may be used to compensate for non-roof areas and reduce the size of a subsurface system.

- Typical rooftop systems include vegetated (or green) roofs and retention (or blue) roofs.

VEGETATED ROOFS

- Vegetated roofs are roofs that are entirely or partially covered with vegetation and soils.

- These roofs improve water quality by filtering out contaminants including suspended solids, metals, and polycyclic aromatic hydrocarbons (PAHs) as the runoff flows through the growing medium or through direct plant uptake.

- The engineered soils absorb rainfall and release it slowly, thereby reducing the runoff volumes and delaying peak flows while plants use retained water and return the vapor to the air thru evapo-transpiration.

- Vegetated roofs may include components such as engineered soils as a growing medium, subsurface drainage and retention systems, root barriers and a high quality waterproofing membrane to protect the building from water infiltration.

BLUE ROOFS

- Commonly known as rooftop detention systems.

- Blue roofs are considered a low cost detention option.
  - Can be created with minor modifications to the roof design.
  - Require a waterproof membrane system.

- When Blue Roof design includes an exposed membrane, the detention system can be coupled with a waterproofing material that provides a reflective and emissive finish. In this case it can also be considered a cool roof which is designed to help to minimize the urban heat island effect and reduce building cooling costs.

DEFINING THE BLUE ROOF

WHAT IS ROOFTOP DETENTION?

According to the NYC DEP Rooftop Detention Brochure…

- Rooftop detention: ”Blue Roof” or controlled-flow system, is an easily installed, cost-effective alternative to temporarily store and gradually drain rainwater off a building’s rooftop.

- Detaining rainwater helps to slow its rate of release into the sewer system over a 24 hour period. It also reduces runoff during peak flow periods so that more mixed storm water & sewage can be treated at wastewater treatment plants protecting waterways from pollutants in urban runoff.

.

- Rooftop detention can also play a role in protecting our sewer systems from being overwhelmed during rainstorms while lowering the risk of street and driveway flooding and sewer back-ups in basements.

Storm Water Management

Temporal Delay of Storm Water Runoff:

A Blue Roof is designed to delay the time at which storm water runoff from the roof of the building enters the sewer system and thus can decrease the stress on the sewer system during the peak flow periods of a rain event.

Blue Roofing or Retention Roof Applications

- Typically designed on new construction projects in areas where storm water retention is an issue.

- Designed to hold a minimum of 3” of water from rain event and to allow it to slowly enter the sewer system thus minimizing the peak runoff.

- Need to use roofing materials that are not affected by standing water or ponding.

BLUE ROOF DESIGN CONSIDERATIONS

- Desired physical characteristics of the roof surface
- Roof slope
- Roofing materials
- Deflection & Loading capacity
- Structural Capacity
- Depth of retained water
- Drainage Configurations

BLUE ROOF DESIGN CONSIDERATIONS

- Durability of the waterproofing assembly is important for maximizing the operating life of a rooftop system.

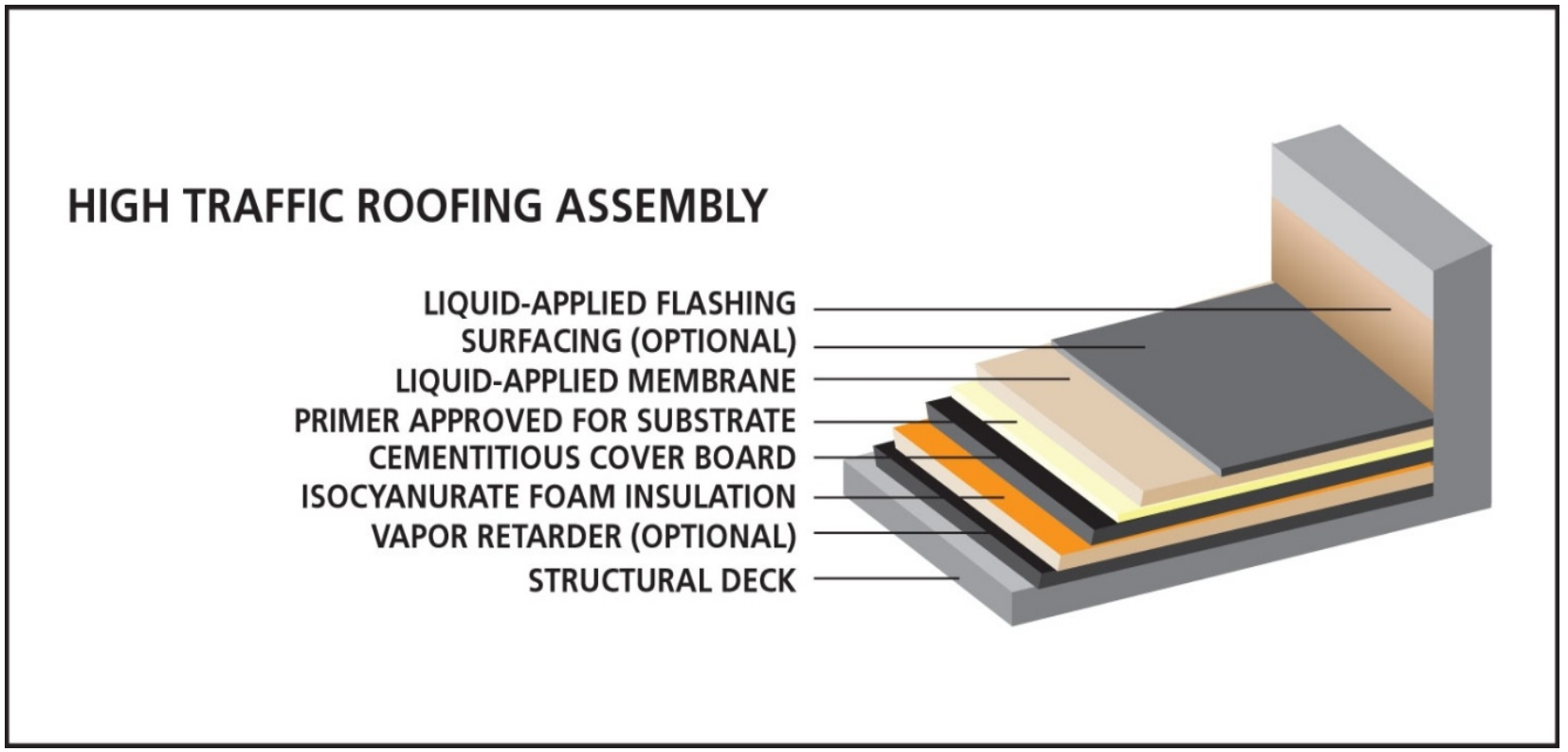
- Materials selected should be waterproofing and must have a long life expectancy and be accompanied by a manufacturer-provided quality control program.

- All roofing systems generally consist of waterproofing materials and insulation on top of the roof deck and structural support members.

- While a few types of insulation and waterproofing are available and can work as part of a rooftop system, the intended use of the roof for storage of water should be confirmed with the manufacturer to ensure the warranty covers such use.

BLUE ROOF SYSTEM COMPONENTS

Insulated Roof Assemblies



CRRC Cool Roof Colors / Compliance with Title 24

Smooth coatings are available for architectural appearance

or Energy Star reflectivity

COOL MINT

Reflectivity: 72.15%
Emittance: .91
SRI: 89

COOL ADOBE

Reflectivity: 75.83%
Emittance: .89
SRI: 94

COOL FROST

Reflectivity: 71.03%
Emittance: .88
SRI: 87

COOL STEEL

Reflectivity: 68.13%
Emittance: .89
SRI: 83

COOL WHITE

Reflectivity: 74.74%
Emittance: .84
SRI: 91

COOL EARTH

Reflectivity: 70.63%
Emittance: .90
SRI: 87

Fully Reinforced Liquid Resin System

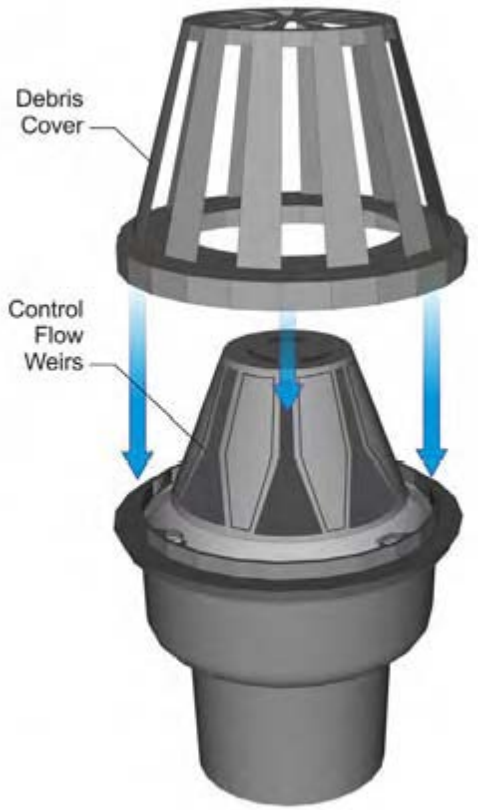
Membrane Field Application

Latest technology is low VOC and odor-free

Sustainable and Renewable

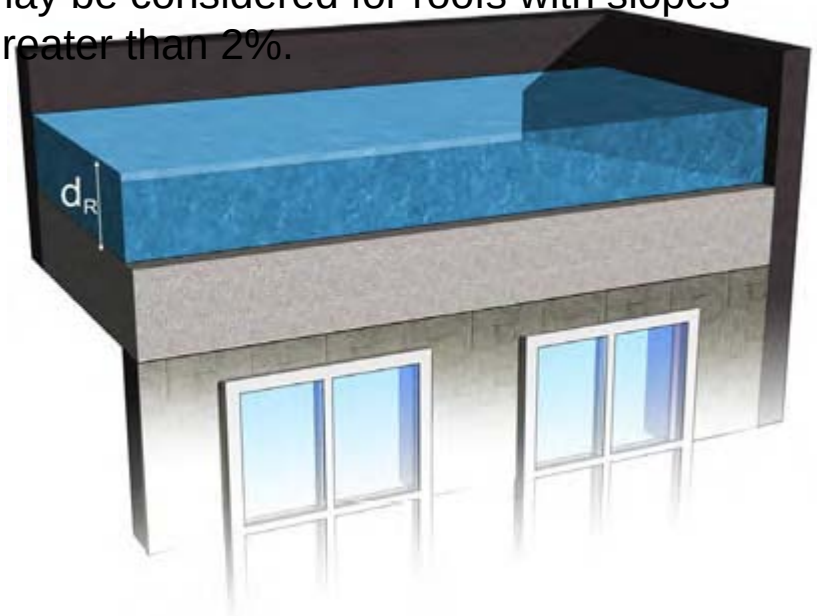
Solvent free liquid resin products made up of **80%** natural rapidly renewable resources are available.

Blue roofs utilizing controlled flow roof drains are typically designed as flat or nearly flat roofs (e.g., less than 2% slope).

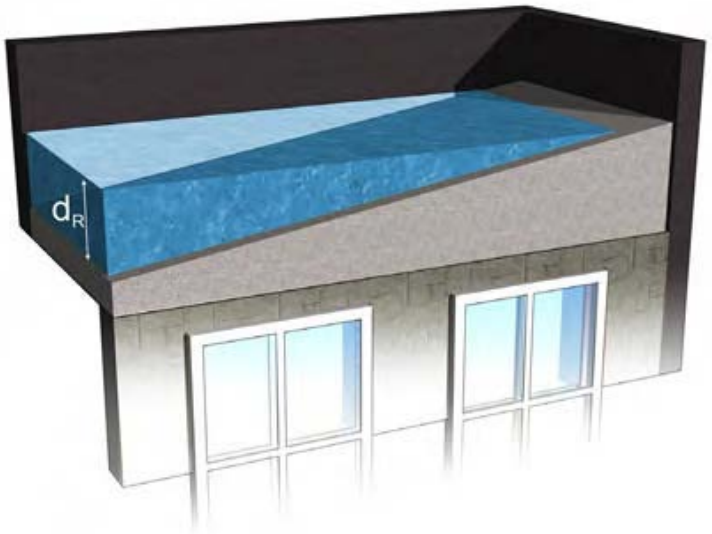


Slope should be a major consideration during building and rooftop design if a rooftop system is the selected method of detention.

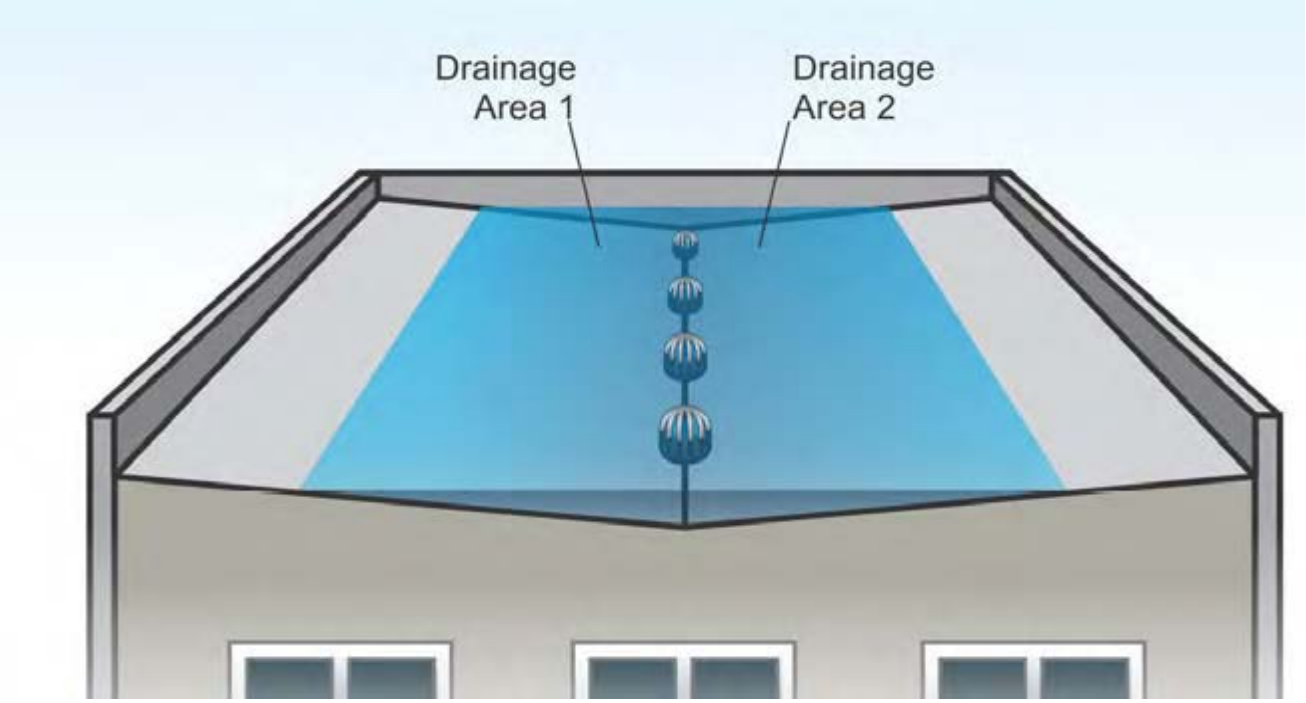
Blue roofs with modifications approved by DOB and DEP that mitigate slope and more evenly distribute the ponded water may be considered for roofs with slopes greater than 2%.

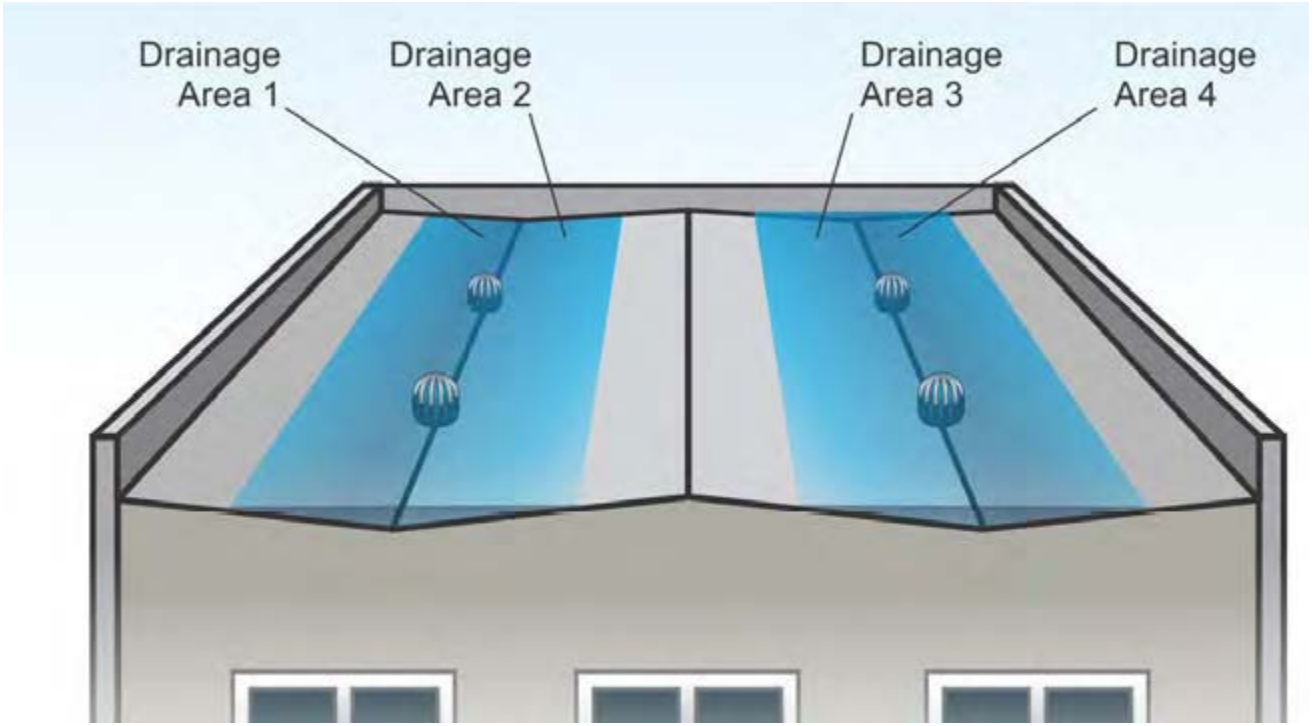


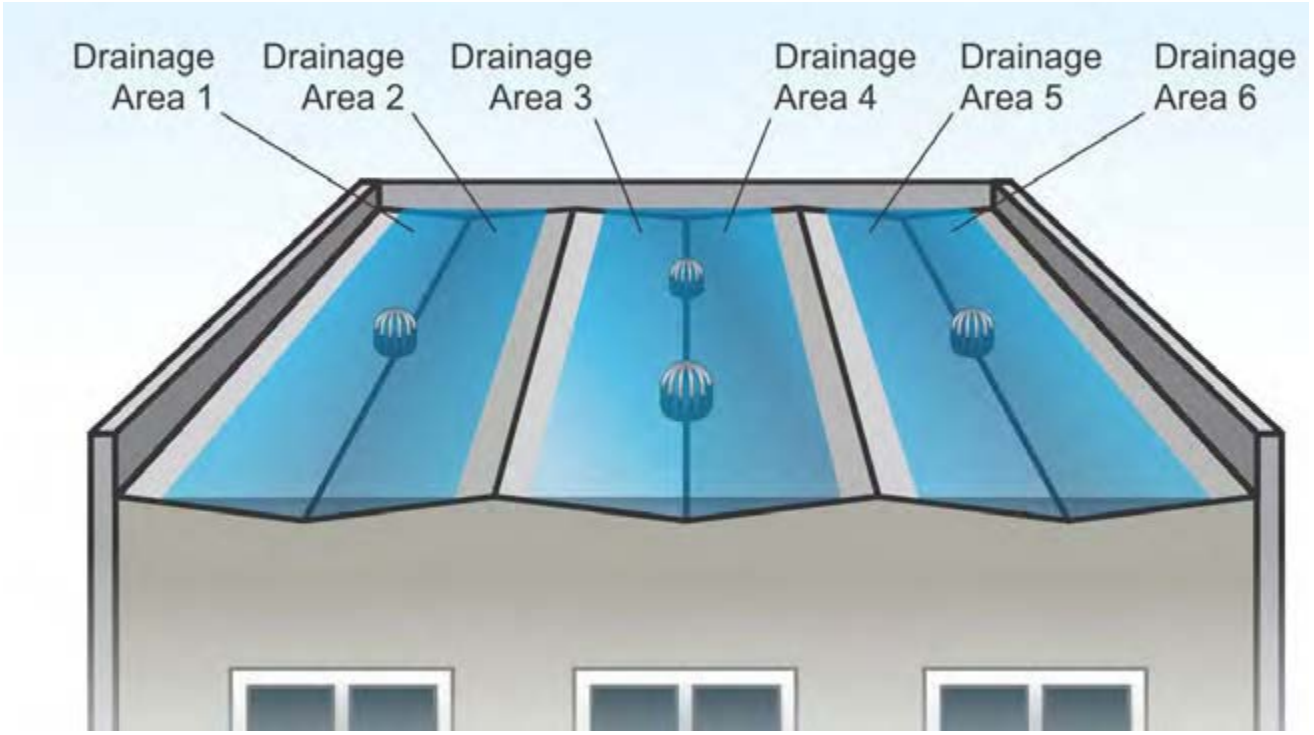
Large slopes may reduce storm water storage capacity on roofs below required storage volumes and cause greater depths of ponding and loading at the drains.



One inch of ponded storm water on a rooftop adds approximately five (5) pounds per square foot of loading.



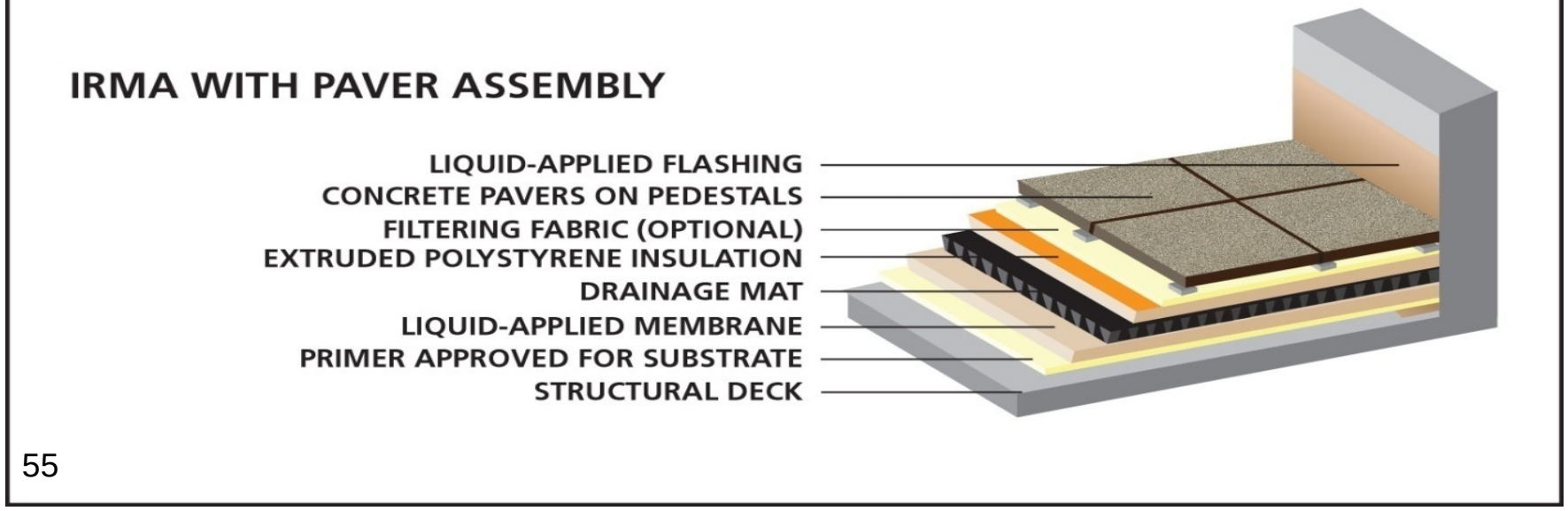

Drainage Area 1
Drainage Area 2
Drainage Area 3
Drainage Area 4


Drainage Area 1
Drainage Area 2
Drainage Area 3
Drainage Area 4
Drainage Area 5
Drainage Area 6

DESIGN CHALLENGES – Inverted Assembly

- If water ponding is determined to be incompatible with current or future uses, the rooftop system may be designed to occupy only a portion of the roof.

- For recreational use, decking or pavers in an inverted assembly over a blue roof could provide usable space above the ponded area.



DESIGN CHALLENGES – Inverted Assembly

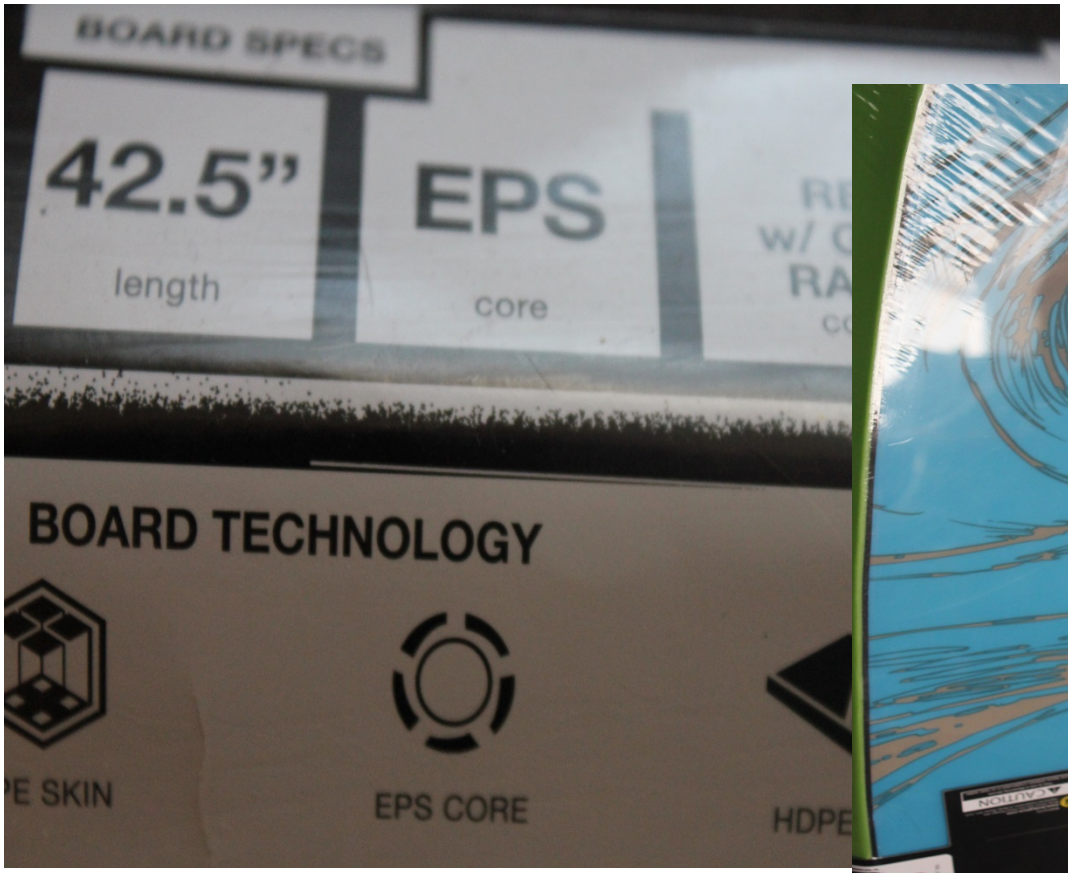
- Inverted or Protected Roof Membrane Assemblies typically use closed cell thermal insulations like EPS over the waterproofing membrane.

- EPS blocks have been used in the construction of floating docks, houses and swim platforms for many years.

- A 12” x 12” x 12” block of 1 lb. density EPS can float more than 55 lbs.

- This is an obvious challenge when planning to retain between 3” & 6” of storm water below the assembly.

DESIGN CHALLENGES – Inverted Assembly



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CASE STUDY – Weill Cornell Medical College

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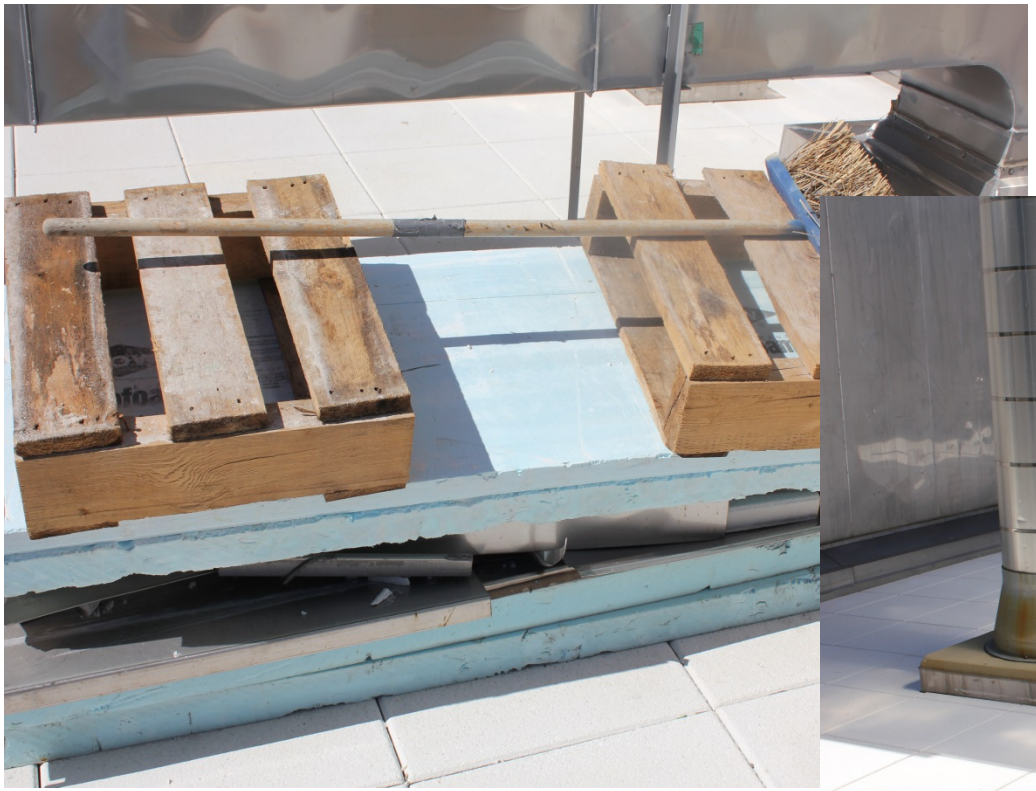
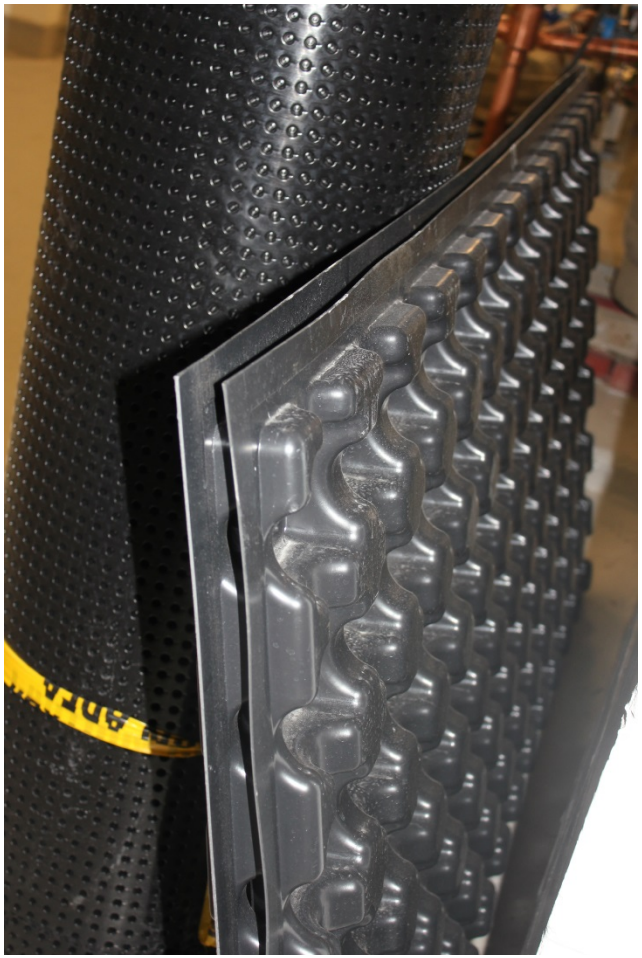


CASE STUDY – Weill Cornell Medical College



CASE STUDY – Weill Cornell Medical College

CASE STUDY – Weill Cornell Medical College

MAINTENANCE FOR BLUE ROOFS

- When appropriate maintenance free waterproofing membranes are employed on a Blue Roof, maintenance activities primarily focus on preventing clogging of drainage inlets.

- For Blue Roofs, maintenance activities can generally be performed by individual building owners or site maintenance staff as needed.

- Contact the contractor responsible for the installation of the rooftop system immediately if it is not performing as designed.

MAINTENANCE FOR BLUE ROOFS

- Semi-annually (under dry conditions)
  - Inspect roof drain inlets to ensure in good condition.
  - Inspect drain inlet screens/strainers to ensure in good condition.
  - Inspect roof membrane to check for signs of membrane or surfacing damage.

- Quarterly (and after rain events)
  - Inspect roof to verify achievement of water depth and drain time requirements.
  - Inspect secondary drainage inlets for blockage or debris.

- After snow & icing events
  - Check roof drain inlets for blockage caused by buildup of snow or ice.

Thank you for your attention!

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www.epa.gov/compliance/monitoring/programs/cwa/csos.html

www.neorsd.org/cso_edu.php

www.deq.state.mi.us/csosso

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