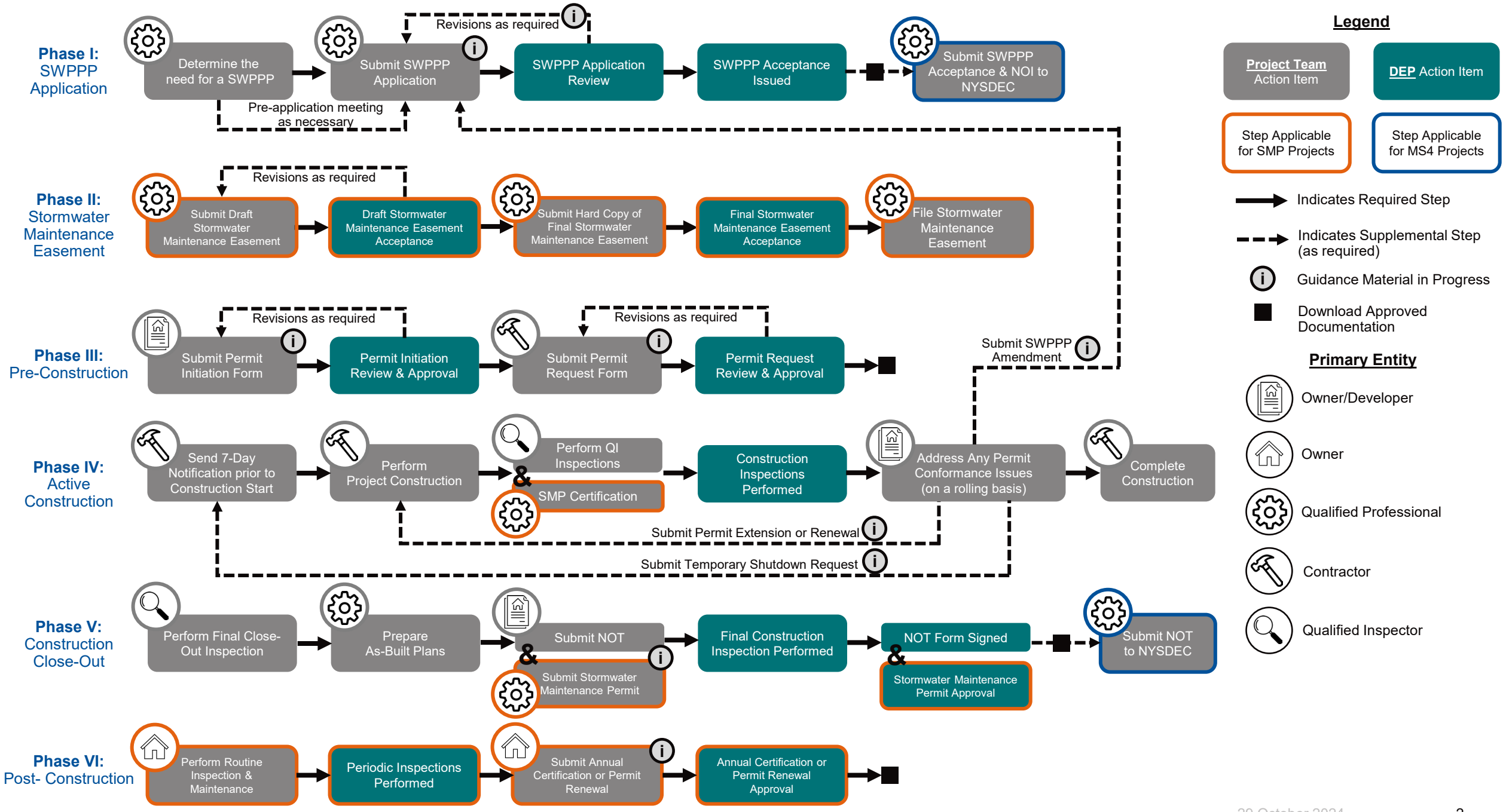
Green Roof Design for NYC Stormwater Permitting

October 28, 2024


Phase I: SWPPP Application
Determine the need for a SWPPP
Submit SWPPP Application
Revisions as required
Pre-application meeting as necessary
SWPPP Application Review
SWPPP Acceptance Issued
Submit SWPPP Acceptance & NOI to NYSDEC
Phase II: Stormwater Maintenance Easement
Revisions as required
Submit Draft Stormwater Maintenance Easement
Draft Stormwater Maintenance Easement Acceptance
Submit Hard Copy of Final Stormwater Maintenance Easement
Final Stormwater Maintenance Easement Acceptance
File Stormwater Maintenance Easement
Phase III: Pre-Construction
Revisions as required
Submit Permit Initiation Form
Permit Initiation Review & Approval
Revisions as required
Submit Permit Request Form
Permit Request Review & Approval
Submit SWPPP Amendment
Phase IV: Active Construction
Send 7-Day Notification prior to Construction Start
Perform Project Construction
Perform QI Inspections
&
SMP Certification
Construction Inspections Performed
Address Any Permit Conformance Issues (on a rolling basis)
Complete Construction
Submit Permit Extension or Renewal
Submit Temporary Shutdown Request
Phase V: Construction Close-Out
Perform Final Close-Out Inspection
Prepare As-Built Plans
Submit NOT
&
Submit Stormwater Maintenance Permit
Final Construction Inspection Performed
NOT Form Signed
&
Stormwater Maintenance Permit Approval
Submit NOT to NYSDEC
Phase VI: Post- Construction
Perform Routine Inspection & Maintenance
Periodic Inspections Performed
Submit Annual Certification or Permit Renewal
Annual Certification or Permit Renewal Approval
Legend
Project Team Action Item
DEP Action Item
Step Applicable for SMP Projects
Step Applicable for MS4 Projects
Indicates Required Step
Indicates Supplemental Step (as required)
Guidance Material in Progress
Download Approved Documentation
Primary Entity
Owner/Developer
Owner
Qualified Professional
Contractor
Qualified Inspector

Upcoming Guidance Materials

- Pre-Application Meeting Request Template
- SWPPP Submission Checklist
- Revised SWPPP Template

Published in May 2024

- Qualified Inspectors Workshop
- Geotechnical Investigations Workshop
- SMP Certification Checklists
- SWPPP Appendix Templates
- Updated Frequently Asked Questions
- Closeout Guidance

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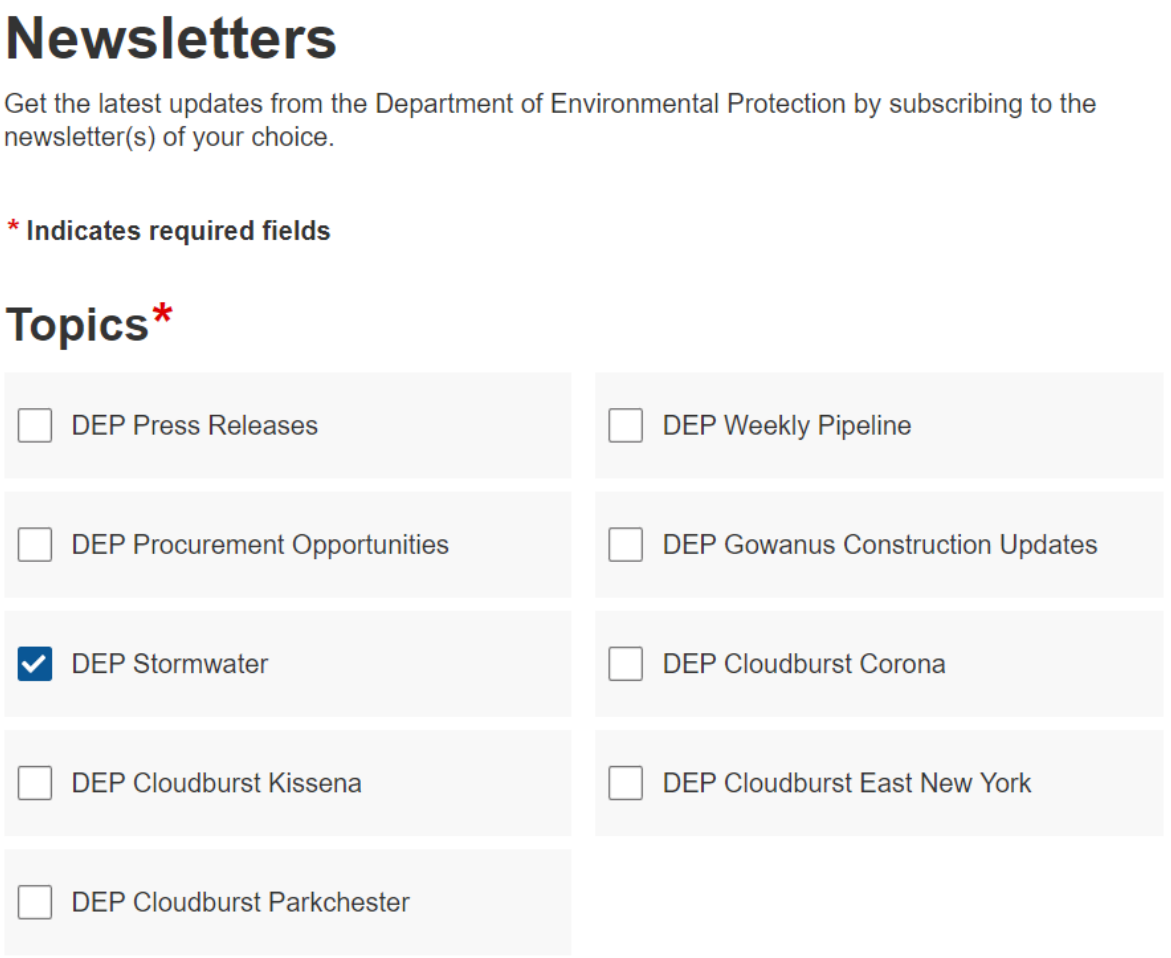
Newsletter sign-up:
nyc.gov/dep/newsletters

Stormwater Permits
stormwaterpermits@dep.nyc.gov

For active projects, always include your SWPPP ID



Objective

Green roofs are a rapidly evolving technology and an important tool for meeting the Stormwater Construction Permit requirements.

This workshop will provide guidance to designers who prepare Stormwater Pollution Prevention Plan (SWPPP) applications with green roofs.

Overview

Assumption:
Designer has already determined that a Stormwater Construction Permit is required and has established the required criteria.

NYC Environmental Protection

Introduction

Evolving Technology

Green Roof Design

- Part 1: Design Example
- Part 2: Frequently Asked Questions
- Part 3: Question & Answer

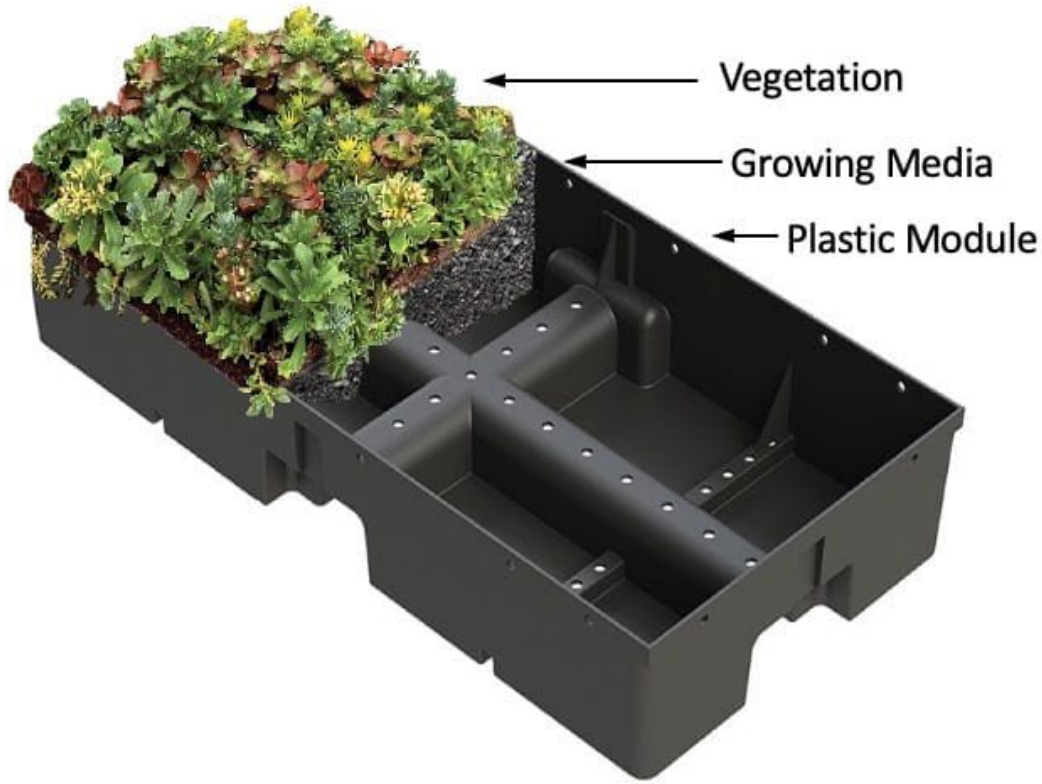
Introduction

NYC Environmental Protection

Introduction

System Types

LAYERED SYSTEM



MODULAR (TRAY) SYSTEM

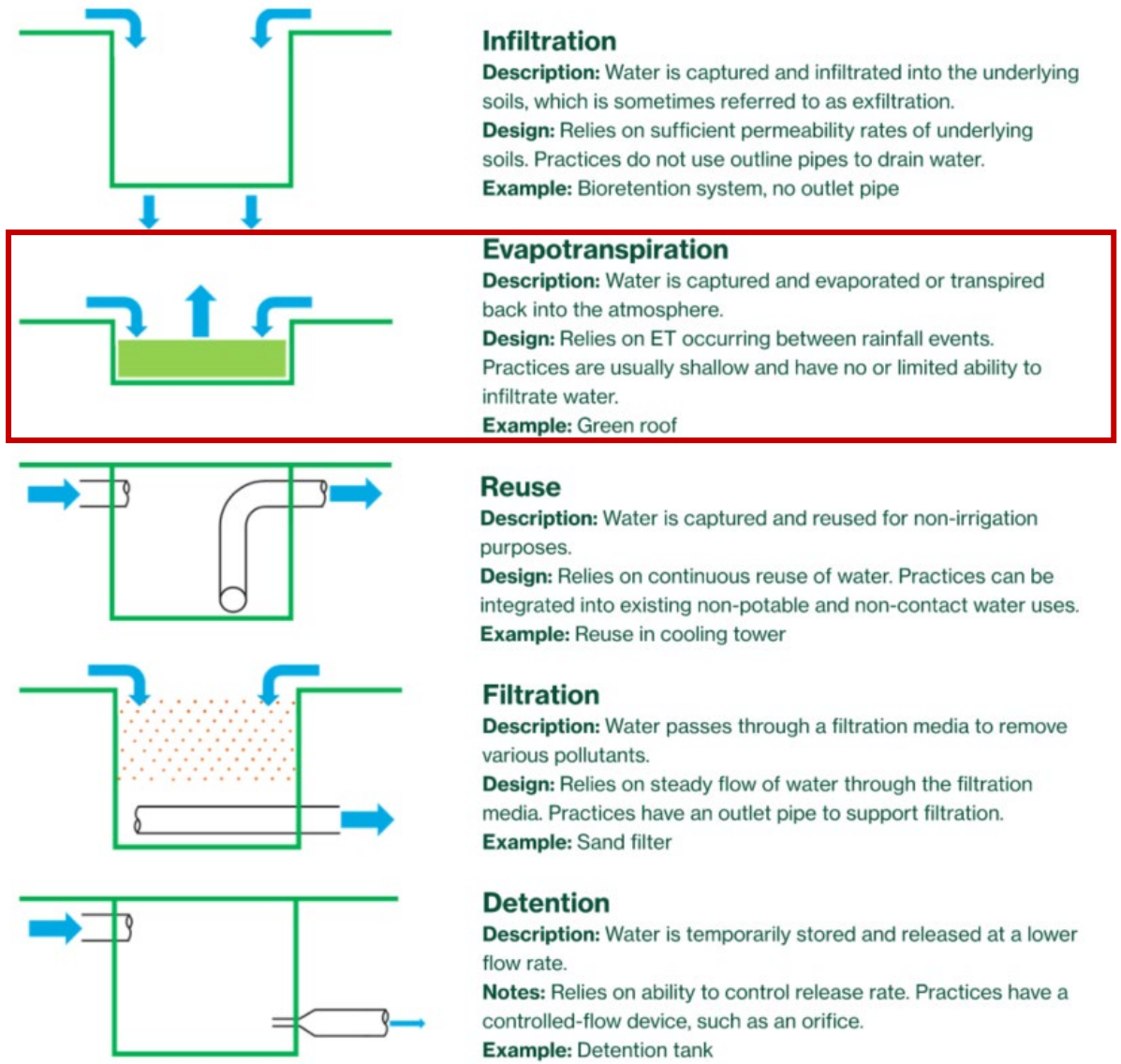
Reference: https://greenrisetech.com/environmental-products-supply/green-roof-products/green-roof-systems/

Introduction

Green Roof Function

- Green roofs primarily function as evapotranspiration (ET) systems
- The soil media of green roofs captures runoff, and that water is evaporated or transpired back into the atmosphere between storms
- ET systems provide runoff reduction since the total volume of runoff is decreased
- Some green roofs include components that can provide detention (more on this later)

Figure 4.1. SMP function diagrams.



Infiltration

Description: Water is captured and infiltrated into the underlying soils, which is sometimes referred to as exfiltration.
Design: Relies on sufficient permeability rates of underlying soils. Practices do not use outline pipes to drain water.
Example: Bioretention system, no outlet pipe

Evapotranspiration

Description: Water is captured and evaporated or transpired back into the atmosphere.
Design: Relies on ET occurring between rainfall events. Practices are usually shallow and have no or limited ability to infiltrate water.
Example: Green roof

Reuse

Description: Water is captured and reused for non-irrigation purposes.
Design: Relies on continuous reuse of water. Practices can be integrated into existing non-potable and non-contact water uses.
Example: Reuse in cooling tower

Filtration

Description: Water passes through a filtration media to remove various pollutants.
Design: Relies on steady flow of water through the filtration media. Practices have an outlet pipe to support filtration.
Example: Sand filter

Detention

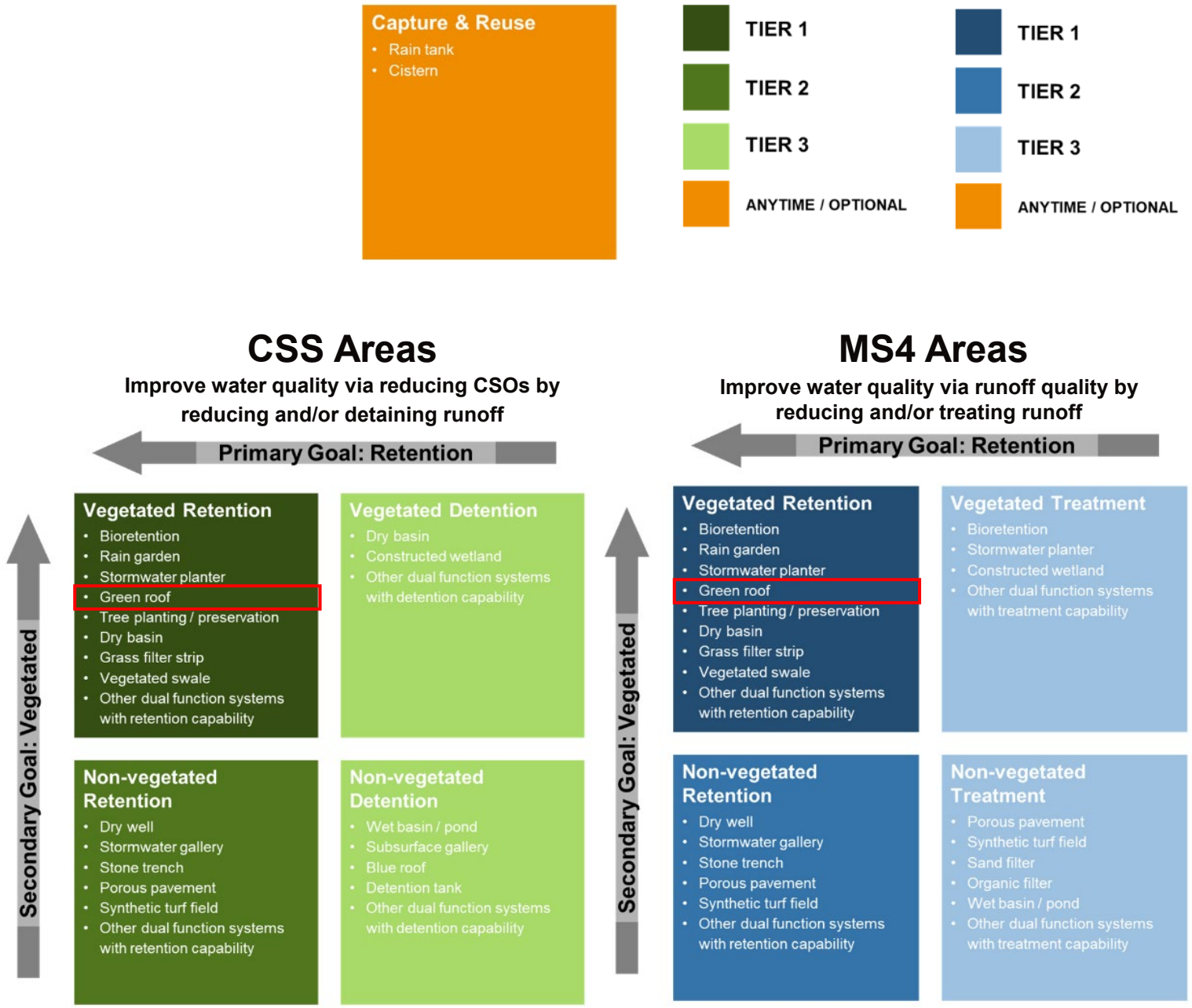
Description: Water is temporarily stored and released at a lower flow rate.
Notes: Relies on ability to control release rate. Practices have a controlled-flow device, such as an orifice.
Example: Detention tank

Reference: NYC DEP Stormwater Manual

Introduction

SMP Hierarchy

Green Roofs are a **Tier 1** stormwater management practice (SMP) for both CSS & MS4 projects



Reference: [NYC DEP Stormwater Manual]

Evolving Technology

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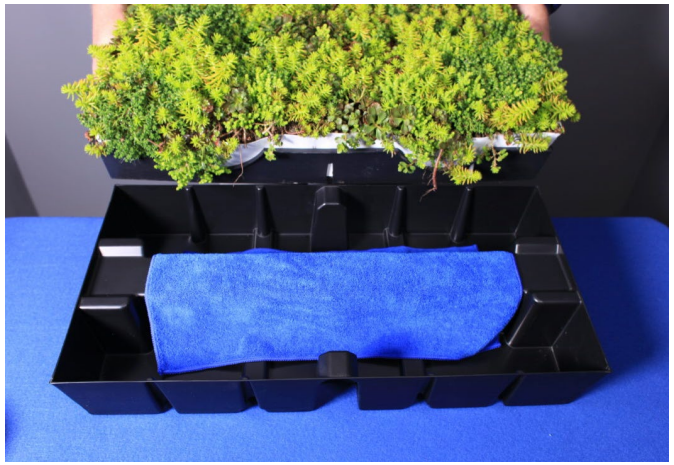
Evolving Technology

Emerging Components

Storage Cartridge with Wick

- Captured stormwater infiltrates through the soil profile and is stored within the tray
- Wicking technology allows stored water to transfer upward to plant roots to encourage root growth and transpiration
- Increases water available for ET and reduces irrigation needs



Reference: https://www.liveroof.com/products/roofblue/#

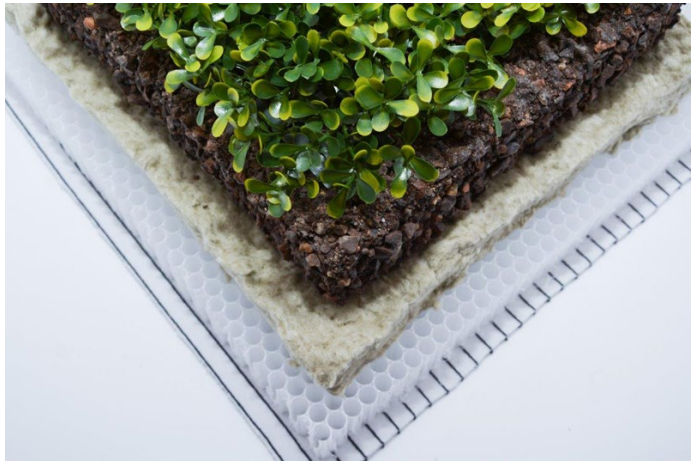
Retention Fleeces

- Retention fleece is placed beneath the vegetation and soil
- The material is highly absorbent and holds water which increases retention capabilities
- Typically, in contact with soils to promote uptake and ET

Reference: https://columbia-green.com/green-roof-systems/

Detention Layers

- Layer that temporarily stores runoff and releases it slowly
- Slow release often achieved by a secondary layer or openings below that restricts flow
- Storage capacity in detention layer recharges faster than soil media layer

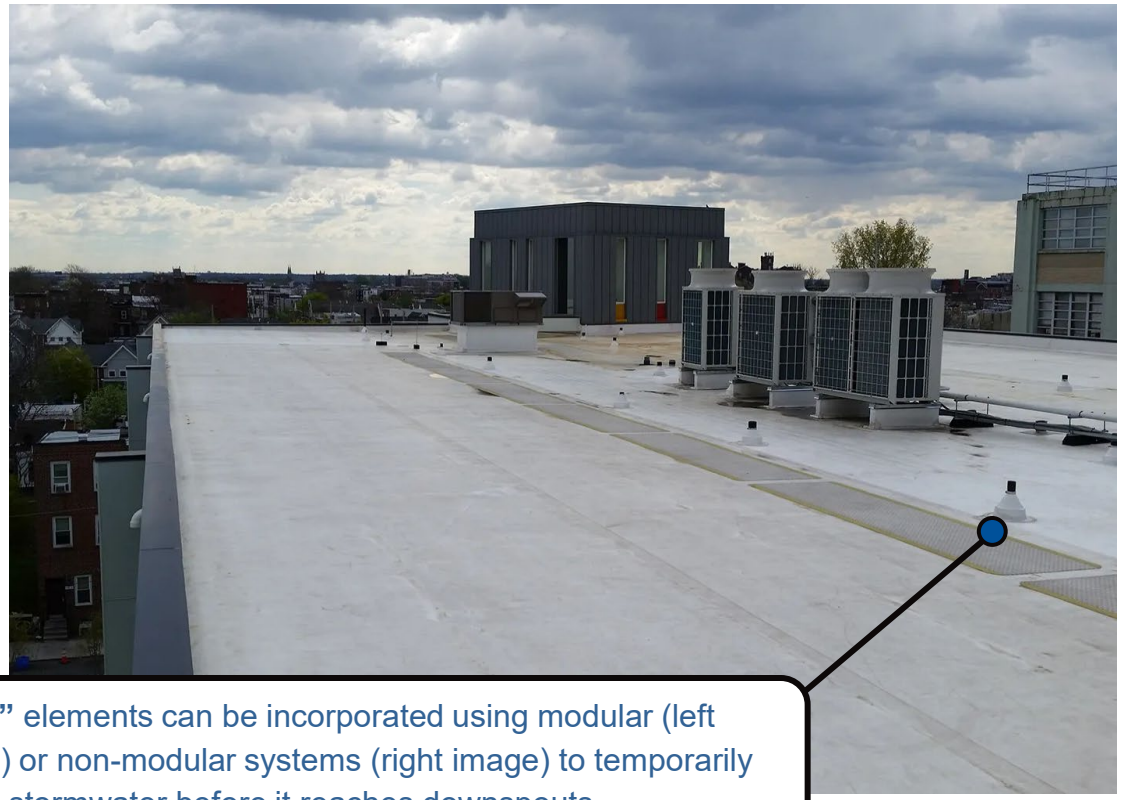


Reference: https://www.purple-roof.com/post/why-use-mineral-wool-on-green-roofs

Evolving Technology

Blue-Green Roofs

“Green” elements include trays holding soil and vegetation that allows for water retention and promotes biodiversity



“Blue” elements can be incorporated using modular (left image) or non-modular systems (right image) to temporarily detain stormwater before it reaches downspouts.

Evolving Technology

Bio-solar

- Bio-solar roofs integrate solar panels with green roofs to maximize energy efficiency and biodiversity of the available space
- Designs may utilize the weight of the green roofs to help support the solar panels (integrated ballasts)
- NYC Local Law 92 and 94 require that the roofs of certain buildings be partially covered with green roof or solar photovoltaic electricity generating systems [1]
- Local Law requires 100% of the ‘Sustainable Roofing Zone’ to be covered in either green roofs and/or solar energy systems

Bio-Solar Roof with Integrated Ballasts [2]

Bio-Solar Roof with Separate Ballast [3]

References:

1. NYC DOB Local Law 92/94
2. https://livingroofs.org/introduction-types-green-roof/biosolar-green-roofs-solar-green-roofs/
3. https://www.nyc.gov/site/ddc/resources/features/july-2016-green-roofs.page

Green Roof Design

Part 1: Design Example

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Design Example

Stormwater Management Criteria

When a Stormwater Construction Permit is applicable, a Stormwater Pollution Prevention Plan (SWPPP) **must** be prepared. The contents of the SWPPP will depend on which of the following criteria apply:

Erosion & Sediment Control (ESC)

Goal: Designed to minimize discharge of pollutants during construction activities

Water Quality Volume (WQv)

Goal: Aims to manage runoff from small, frequent storm events that can impact water quality

Runoff Reduction Volume (RRv)

Goal: Aims to preserve natural hydrologic functions

No-Net Increase (NNI)

Goal: Aims to reduce pollutants of concern in MS4 areas that discharge to an impaired waterbody

Sewer Operations (V_V & Q_{DRR})

Goal: Aims to manage runoff from larger storm events to maintain optimal flow rates in the City sewer system

This example will focus on meeting the WQv criteria

Design Example

Process

Step 1: Calculate Required Roof WQv

Step 2: Identify Rooftop Constraints

Step 3: Site the Practice Footprint

Step 4: Determine Practice Tributary Area

Step 5: Calculate Required Practice WQv

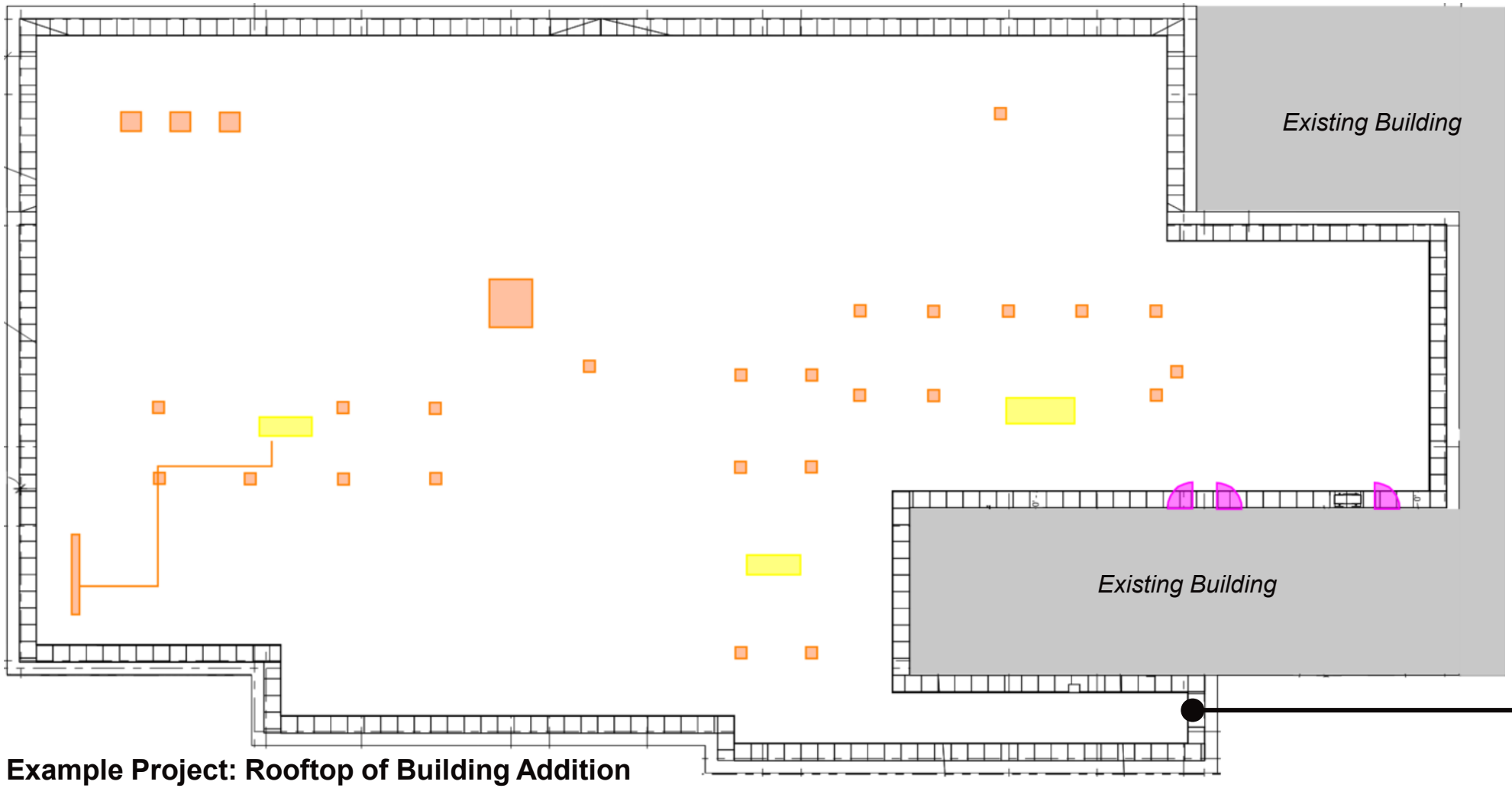
Step 6: Size Practice to meet Required WQv

Step 7: Determine the need for Secondary Practices to meet Roof WQv

Reference: https://www.brooklyngrangefarm.com/brooklyn-navy-yard

Design Example

Step 1: Calculate Required Roof WQv



Example Project: Rooftop of Building Addition

Design Example

Step 1: Calculate Required Roof WQv

EQ 2.1

$$WQ_V = \frac{1.5"}{12} * A * R_V$$

where:
WQ_V: water quality volume (cf)
A: contributing area (sf)
R_V: runoff coefficient relating total rainfall and runoff
R_V: 0.05 + 0.009(I),
I: percent impervious cover

Notes:

- 1.5" represents the rainfall associated with the 90th percentile event.
- WQv must be determined for each individual practice and across the entire site.

Reference: NYC DEP Stormwater Manual

Design Example

Step 1: Calculate Required Roof WQv

IMPORTANT TO NOTE:
When calculating WQv for the entire roof, the contributing area includes the total roof footprint whether it is covered with green roof or not.

EQ 2.1

$$WQ_V = \frac{1.5"}{12} * A * R_V$$

where:
WQ_V: water quality volume (cf)
A: contributing area (sf)
R_V: runoff coefficient relating total rainfall and runoff
R_V: 0.05 + 0.009(I),
I: percent impervious cover

$$= \frac{1.5"}{12} * 11{,}000\ SF * (0.05 + 0.009 * 100)$$

$$WQ_{V\ Roof\ DA} = 1{,}306\ CF$$

Notes:
- 1.5" represents the rainfall associated with the 90th percentile event.
- WQv must be determined for each individual practice and across the entire site.

Reference: NYC DEP Stormwater Manual

Design Example

Step 2: Identify Rooftop Constraints

FDNY Rooftop Access[1,2] (2022 NYC Fire Code: Section FC 504)

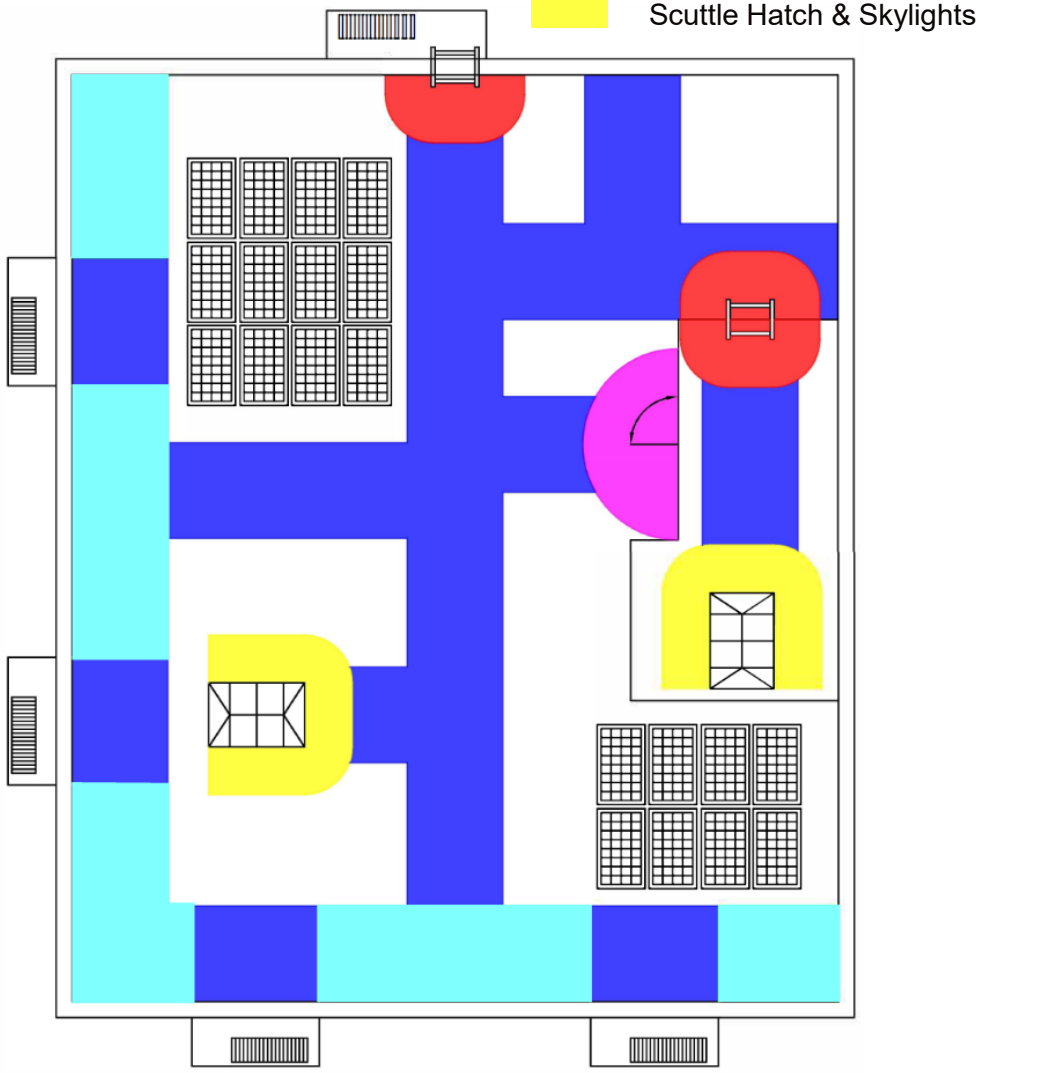
Applicable for rooftops ≤ 100 ft high with a slope of ≤ 20º

- ✓ **Perimeter Access Openings:** Every 12 feet of building frontage, requires a minimum 6 feet of opening (6ft L x 6ft W x 9 ft H)
- ✓ **Clear Paths:** 6 ft wide clear paths are required every 100 linear feet of rooftop, providing access front to back and side to side
- ✓ **Fire Escape & Rooftop Ladders:** 3 ft clear radius from each side
- ✓ **Roof Door:** 6 ft clear radius from hinges
- ✓ **Scuttle Hatch & Skylights:** 3ft clearances on each side

Mechanical Equipment Offsets

Coordinate with Building MEP to determine equipment offset required

(varies by system and configuration)



FDNY Clearance Requirements Map[1]

Reference:

1. https://nysolarmap.com/media/2216/2024-fdny-rooftop-presentation-ingenito-march_20_2024.pdf
2. https://www.nyc.gov/assets/fdny/downloads/pdf/about/Chapter-05.pdf

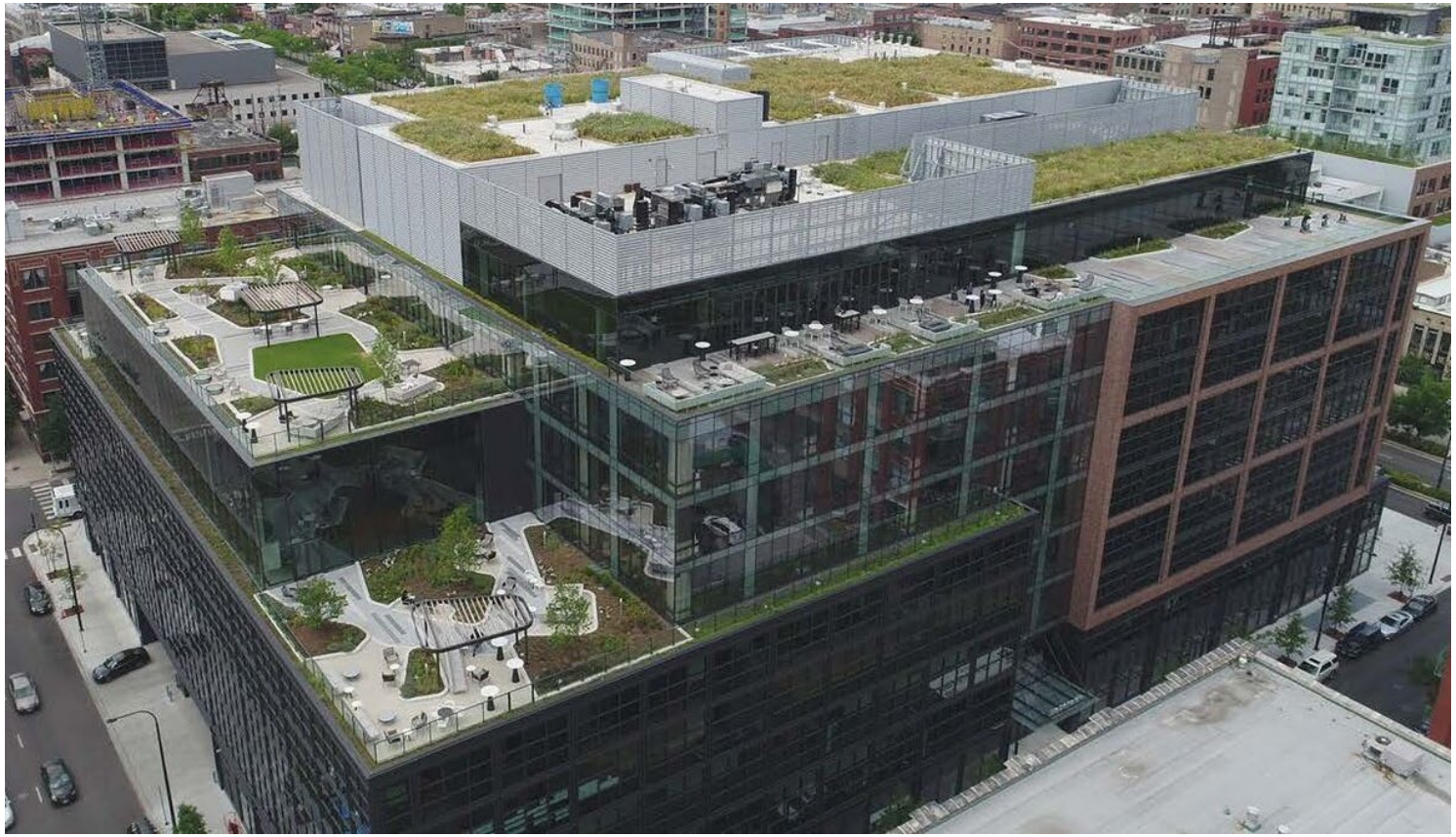
Design Example

Step 2: Identify Rooftop Constraints

Other Constraints

In cases where the designer believes there are other constraints that would limit the use of green roofs, the **designer must provide a detailed justification** for DEP review.

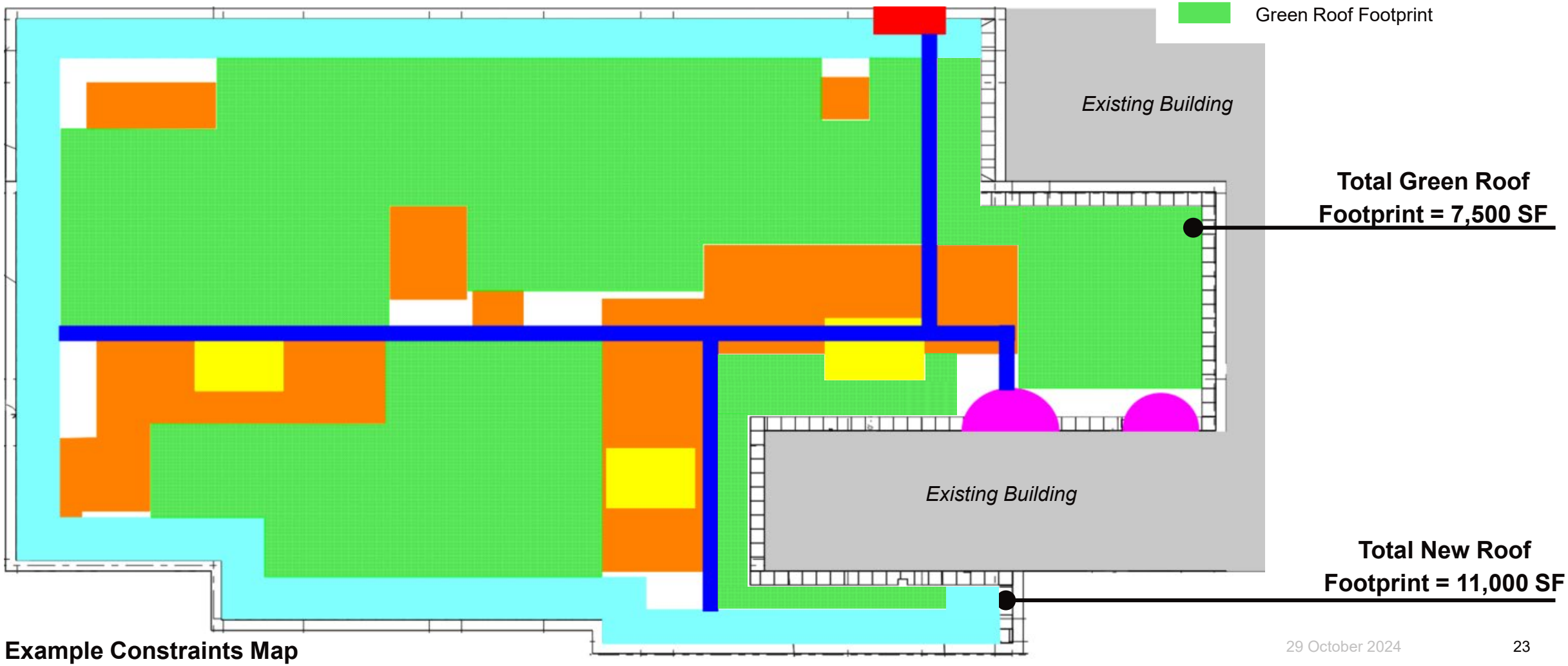
Note: The use of rooftop stormwater planters should also be evaluated in cases where green roofs are constrained.



Reference: https://greenroofs.org/aoe/2020/mcdonalds-headquarters

Design Example

Step 3: Site the Practice Footprint



Example Constraints Map

Design

Step 4: Determine Practice Tributary Area

NYC DEP Stormwater Manual establishes a maximum loading ratio for green roofs of **1:1**

Since non-vegetated areas do not typically convey water onto the green roof surface (more on this later)

Therefore:

Total Tributary Drainage Area	=	**Total Green Roof Practice Footprint**
7,500 SF		**7,500 SF**

Table 4.3. General design requirements for ET SMPs.

Design Parameter[a]	Green roof
MAX. loading ratio, practice-to-contributing area	1:1
MAX. contributing area	-
MIN. infiltration rate of underlying soils	-
Vertical separation from groundwater/ bedrock[b]	-
Surface ponding depth	-
Media layers	Green roof media Stone base[c]
Surfacing media depth	-
Leveling media depth	-
Planting/filter media depth	4" MIN[d]
Stone base depth	Varies
Slope of surface media	Varies[e]
Slope of bottom of practice	Varies[e]
MAX. Drawdown time	-

Reference: NYC DEP Stormwater Manual

Design

Step 5: Calculate Practice WQv

IMPORTANT TO NOTE:
When calculating WQv for the individual practice, the contributing area includes only the area tributary to the practice.

EQ 2.1

$$WQ_V = \frac{1.5"}{12} * A * R_V$$

where:
WQ_V: water quality volume (cf)
A: contributing area (sf)
R_V: runoff coefficient relating total rainfall and runoff
R_V: 0.05 + 0.009(I),
I: percent impervious cover

$$= \frac{1.5"}{12} * 7{,}500\ SF * (0.05 + 0.009 * 100)$$

$$WQ_{V\ Practice} = 890\ CF$$

Notes:
- 1.5" represents the rainfall associated with the 90th percentile event.
- WQv must be met for each individual practice and the entire site.

Reference: *NYC DEP Stormwater Manual*

Design Example

Step 6: Size Practice to meet WQv

Table 4.3. General design requirements for ET SMPs.

Design Parameter[a]	Green roof
MAX. loading ratio, practice-to-contributing area	1:1
MAX. contributing area	-
MIN. infiltration rate of underlying soils	-
Vertical separation from groundwater/ bedrock[b]	-
Surface ponding depth	-
Media layers	Green roof media Stone base[c]
Surfacing media depth	-
Leveling media depth	-
Planting/filter media depth	4" MIN[d] (A)
Stone base depth	Varies
Slope of surface media	Varies[e]
Slope of bottom of practice	Varies[e]
MAX. Drawdown time	-

[a] SMPs in MS4 areas shall follow any additional criteria set forth in the NYS SWMDM for all parameters or components that are not already defined in the NYC SWM.

[b] Minimum vertical separation from the top of groundwater table in sole source aquifers is increased to 4 feet. Vertical separation requirements are waived for practices enclosed in concrete with adequate anchoring to withstand uplift pressures.

(B) [c] Evapotranspiration practices must allow drainage of excess water via outlet pipe, weep hole, or other equivalent measure. Geosynthetics can be used as a drainage course instead of stone base, where appropriate, in accordance with manufacturer's specifications.

(A) [d] Green roof media depth of 6-inches is preferred.

[e] Configuration of green roof systems varies widely, see manufacturer's specifications.

Design Requirements:

A. Minimum media depth is 4” with 6” depth preferred

B. Systems must have a means of draining excess water

Reference: NYC DEP Stormwater Manual

Design Example

Step 6: Size Practice to meet Required WQv

EQ 4.1

$$V_{SMP} = V_P + V_S + V_I + V_D$$

where:
V_{SMP} = storage volume of SMP (cf)
V_P = volume of surface ponding (cf)
V_S = volume of voids in the soil media layer (cf)
V_I = volume of voids created by internal structures such as chambers or pipes (cf)
V_D = volume of voids in the drainage media (cf)

EQ 4.8

$$V_A = V_{SMP} * F_A$$

where:
V_A = storage volume that may be applied to relevant stormwater management requirement (cf)
V_{SMP} = storage volume of SMP (cf)
F_A = percentage of storage volume that may be applied to the stormwater management requirement (%)

Table 4.1. Percent of SMP volume that may be applied to SW management criteria by SMP function.

SMP Function	Percent of SMP Volume Applied to Requirement (F_A) WQv	RRv	Vv
Infiltration	100	100	50
Evapotranspiration	100	100	0
Reuse[A]	100	100	50
Filtration	100[B]	40[C]	0
Detention	100[D]	0	100

[A] Designers must demonstrate continuous and reliable capacity throughout the year (see Section 4.11)
[B] Applies to MS4 areas only
[C] Applies to practices with engineered soils only
[D] Applies to CSS areas and select detention practices with treatment abilities in MS4 areas

Reference: NYC DEP Stormwater Manual

Design Example

Step 6: Size Practice to meet WQv

IMPORTANT TO NOTE:
Default value of 0.20 reflects the percent of soil volume that is available to store water at the start of an event on average throughout the year

EQ 4.1

N/A N/A N/A

$$V_{SMP} = V_P + V_S + V_I + V_D$$

where:
V_{SMP} = storage volume of SMP (cf)
V_P = volume of surface ponding (cf)
V_S = volume of voids in the soil media layer (cf)
V_I = volume of voids created by internal structures such as chambers or pipes (cf)
V_D = volume of voids in the drainage media (cf)

EQ 4.4

$$V_S = A_{SMP} * D_S * n_S$$

where:
V_S = volume of voids in the soil media layer (cf)
A_{SMP} = area of the SMP (sf)
D_S = depth of soil media layer (ft)
n_S = available porosity of soil media (cf/cf)

$$= 7{,}500\ SF * \frac{7.2"}{12} * 0.20$$

$$V_{SMP} = V_S = 900\ CF$$

Reference: [NYC DEP Stormwater Manual]

Design Example

Step 6: Size Practice to meet WQv

IMPORTANT TO NOTE:
For simple systems that use only soil media, 7.2" is the minimum green roof depth to meet $WQ_{V\ Practice\ Req}$. However, green roof modular systems are typically manufacturer as incremental depths (i.e. 4", 6", 8").

Therefore, using the minimum depth required, the designer should determine the depth of the proposed system and the calculate the V_{SMP} based on that depth.

Table 4.1. Percent of SMP volume that may be applied to SW management criteria by SMP function.

	Percent of SMP Volume Applied to Requirement (F_A)		
SMP Function	**WQv**	**RRv**	**Vv**
Infiltration	100	100	50
Evapotranspiration	100	100	0
Reuse[A]	100	100	50
Filtration	100[B]	40[C]	0
Detention	100[D]	0	100

[A] Designers must demonstrate continuous and reliable capacity throughout the year (see Section 4.11)
[B] Applies to MS4 areas only
[C] Applies to practices with engineered soils only
[D] Applies to CSS areas and select detention practices with treatment abilities in MS4 areas

EQ 4.8

$$V_A = V_{SMP} * F_A$$

where:
V_A = storage volume that may be applied to relevant stormwater management requirement (cf)
V_{SMP} = storage volume of SMP (cf)
F_A = percentage of storage volume that may be applied to the stormwater management requirement (%)

Use **EQ 4.8** & **Table 4.1** to determine Total SMP Storage Volume applicable to WQv, RRv, & Vv requirements:

$$WQ_{V\ Available} = (7{,}500\ SF * \frac{7.2"}{12} * 0.20) * 1.0$$

$$WQ_{V\ Available} = 900\ CF$$

✓ $WQ_{V\ Available}(900\ CF) > WQ_{V\ Practice}(890\ CF)$

Reference: *NYC DEP Stormwater Manual*

Design Example

Step 7: Determine the need for Secondary Practices to meet Roof WQv

$$WQ_{V\ Practice}(890\ CF) < WQ_{V\ Roof\ DA}\ (1{,}306\ CF)$$

$WQ_{V\ Practice}$ is less than the $WQ_{V\ Roof\ DA}$, therefore, a

Secondary Practice is required to meet WQv

Design Example

Step 7: Determine the need for Secondary Practices to meet Roof WQv

CSS Areas

Improve water quality via reducing occurrence of combined sewer overflows by removing and/or detaining runoff

Lot-Line Buildings

Ex.: Rooftop connects to detention system within footprint of the building

Not Lot-Line Buildings

Ex.: Rooftop connects to retention system (when feasible) or detention system

MS4 Areas

Improve water quality via runoff quality by removing and/or treating runoff

Lot-Line Buildings

Ex.: Rooftop connects to detention system within footprint of the building that includes water quality units (filtration)

Not Lot-Line Buildings

Ex.: Rooftop connects to retention system (when feasible) or detention system that includes water quality units (filtration)

Note:

The NYC DEP MS4 Interactive Map provides approximate boundaries for areas discharging to MS4 system and impaired waterbodies. Point of discharge to MS4 system should be confirmed via site records.

Green Roof Design

Part 2: FAQs

NYC Environmental Protection

FAQs

Q1

My green roof soil has a Maximum Media Water Retention (MMWR) greater than 20% by volume, can I use percent MMWR instead of the 0.2 available porosity?

No. Available porosity represents the average percent of soil volume that is **available** to store rainfall at the start of an event. It considers both the typical physical properties of the green roof soil and NYC climate. MMWR represents the **maximum** percent of soil volume if the soil were to be oven dried before a storm and is therefore higher than the available porosity.

FAQs

Q2

Can green roofs manage runoff from non-vegetated areas?

Non-vegetated areas typically do not drain onto the green roof surface where it can be stored. Instead, water from non-vegetated areas typically drain to the downspout either directly or through a non-storage layer of the green roof.

Managing non-vegetated areas would require the applicant to demonstrate that runoff from non-vegetated areas drain onto the green roof surface and are dispersed across a large area to allow storage in the soil.

Reference: https://www.waterproofmag.com/2010/04/green-roof-as-a-retrofit-option/

FAQs

Q3

When calculating SMP storage volumes, can I take credit for retention fleece storage?

Studies suggest that retention fleeces promote additional ET and increase the volume of available storage in the practice.

Retention fleeces will be reviewed and approved on a case-by-case basis until their performance and design criteria can be established. **(See Q8 for documentation).**

Retention fleeces can be used when the depth of soil media is at least 4 inches. The depth of retention fleeces cannot exceed the depth of soil media.

Reference: https://www.purple-roof.com/post/why-use-mineral-wool-on-green-roofs

FAQs

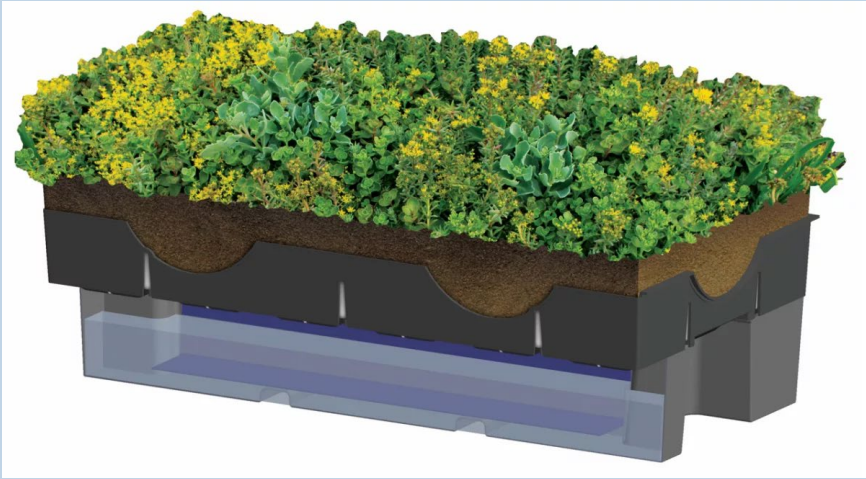
Q4

When calculating SMP storage volumes, can I take credit for cartridge storage?

Studies suggest that storage cartridges with wicks promote additional ET and increase the volume of available storage in the practice.

cartridges with wicks will be reviewed and approved on a case-by-case basis until their performance and design criteria can be established. **(See Q8 for documentation).**

Storage cartridges without a wick will not be accepted by NYC DEP at this time due to insufficient evidence that demonstrates meaningful evaporation occurs below the soil media.



Reference: https://liveroof.com/roofblue-retain-saves-water-and-enhances-plant-growth/

FAQs

Q5

Can green roofs count towards detention requirements?

There are specific components intended for detention that, if they meet the release rate required, can be counted as detention.

However, the soil media itself is not a detention layer as it relies on ET to recharge available storage.

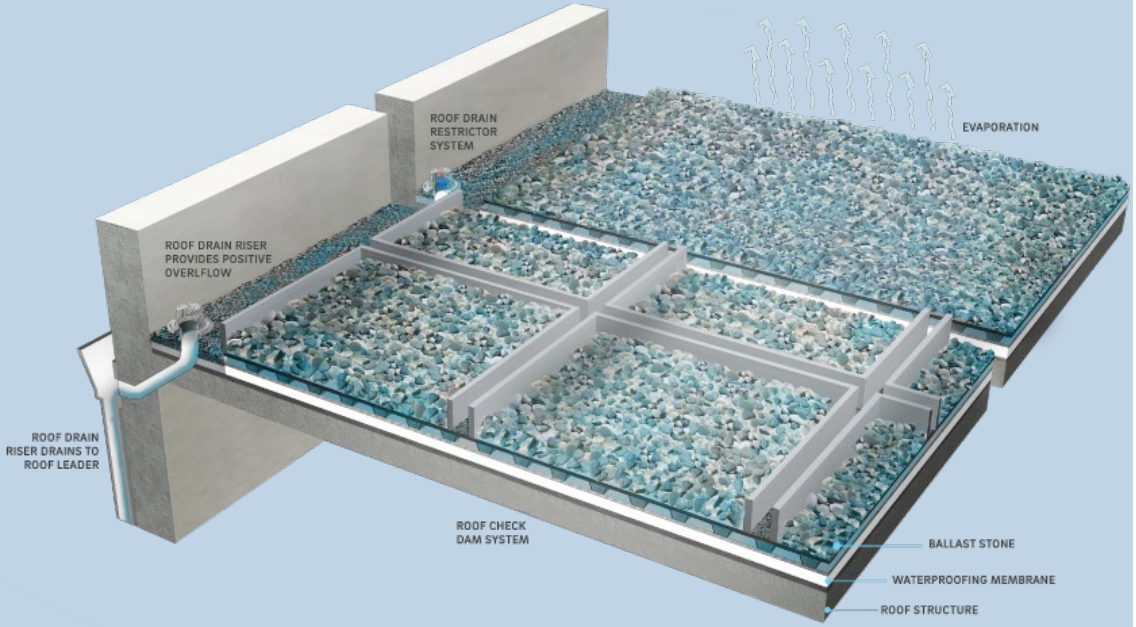
Reference: https://www.icbprojects.co.uk/solutions/green-roof-systems/blue-roof-systems

FAQs

Q6

Can blue roofs or detention layers count towards retention requirements?

Detention elements are designed to temporarily store water for release at a slower rate. While some evaporation may occur during this detention time, it is not significant. Therefore, blue roofs and detention layers within green roofs are not counted towards retention.



Reference: https://water.phila.gov/gsi/tools/blue-roof/

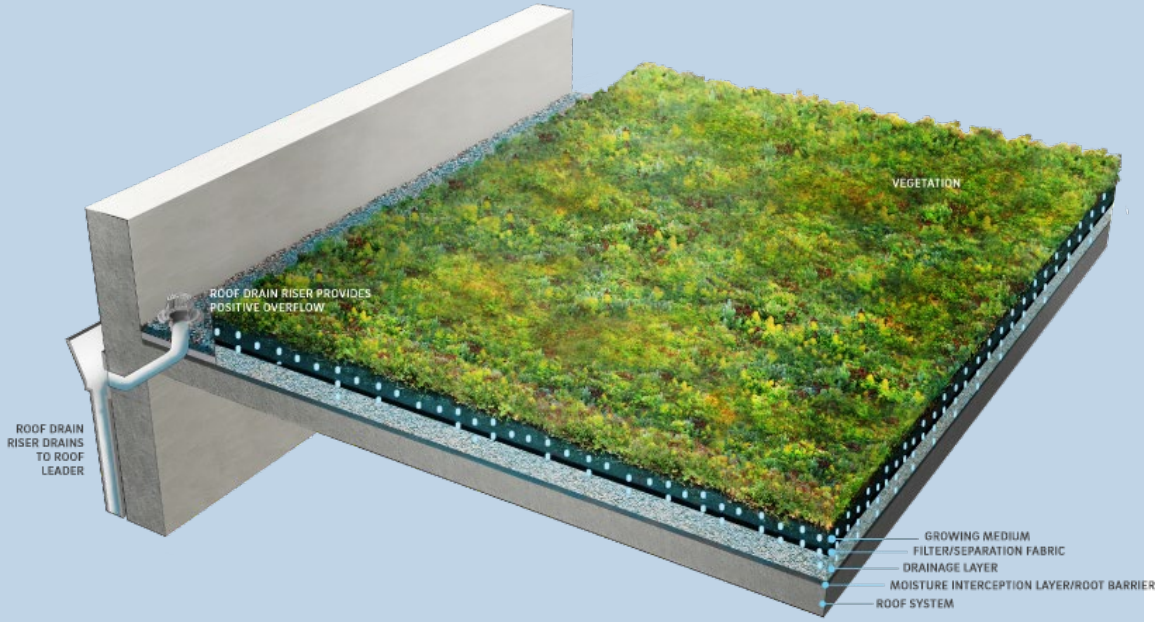
FAQs

Q7

Can drainage media in green roofs count as retention or detention storage?

The drainage media layer in green roofs does not count towards retention, since runoff in that layer drains to the downspout.

However, if the roof has a hybrid blue roof and green roof system (i.e. downspout has a control device) and the blue roof water is temporarily stored in the drainage media layer, that volume can count towards detention.



Reference: https://water.phila.gov/development/stormwater-plan-review/manual/chapter-4/4-3-green-roofs/

FAQs

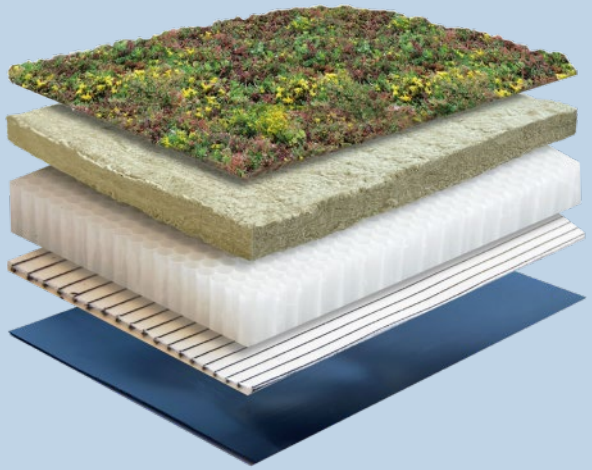
Q8

If I am proposing a non-standard system, what do I need to provide for design review & approval?

For pollutant removal in MS4 areas, non-standard and innovative systems must be evaluated and approved via one of the processes outlined in the NYS SWMDM.

For runoff reduction systems, the applicant must include in the SWPPP the reasons for alternative design and provide information that demonstrates the system achieves the required criteria.

For example, the use of retention fleeces would require the applicant to demonstrate what percent of the retention fleece volume is **available** for storage at the start of rainfall events, on average throughout the year.



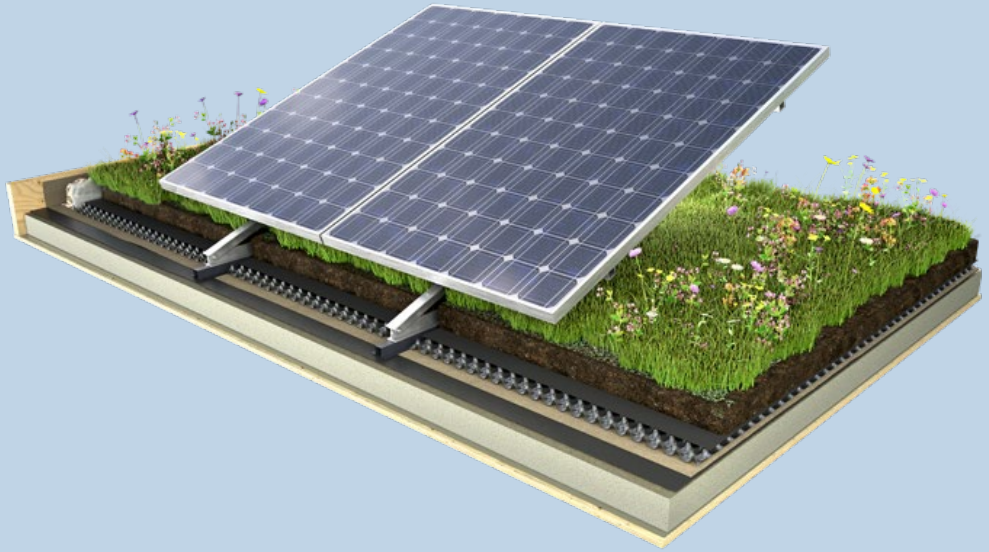
Reference:
https://www.sempergreen.com/en/solutions/green-roofs/types/detention-and-retention-roof

FAQs

Q9

Are solar panels considered a green roof design constraint?

Solar Panels are **NOT** a green roof constraint. Green roofs can be co-located with solar panels as a bio-solar roof. The green roof can act to help ballast (and cool) the solar panels, while runoff from the panels drains onto and across the green roof surface.



Reference: https://www.icbprojects.co.uk/solutions/green-roof-systems/bio-solar

Green Roof Design

Part 3: Q & A

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