USWR Case Study

SCA: K206

Original: April 7, 2023
Revision #2: July 11, 2023

This guidance is a DEP-prepared document to assist designers with a USWR compliance submission.

For further assistance with terminology and calculations referenced throughout this document, please refer to the NYC Stormwater Manual:
https://www.nyc.gov/assets/dep/downloads/pdf/water/stormwater/unified-stormwater-rule/uswr_nyc_stormwater_manual.pdf

Overview
Steps

Meeting WQv & RRv

- Determine WQv/RRv for the site
- Identify site constraints and select practices
- Determine WQv/RRv for each practice
- Design practices and calculate storage volume
- Confirm storage volume meets practice WQv/RRv
- Confirm total effective volume meets site WQv/RRv
- If unmet, modify design as needed
- If still unmet, manage remaining WQv with Tier 3 practices and confirm RRv meets RRv min

Meeting Vv

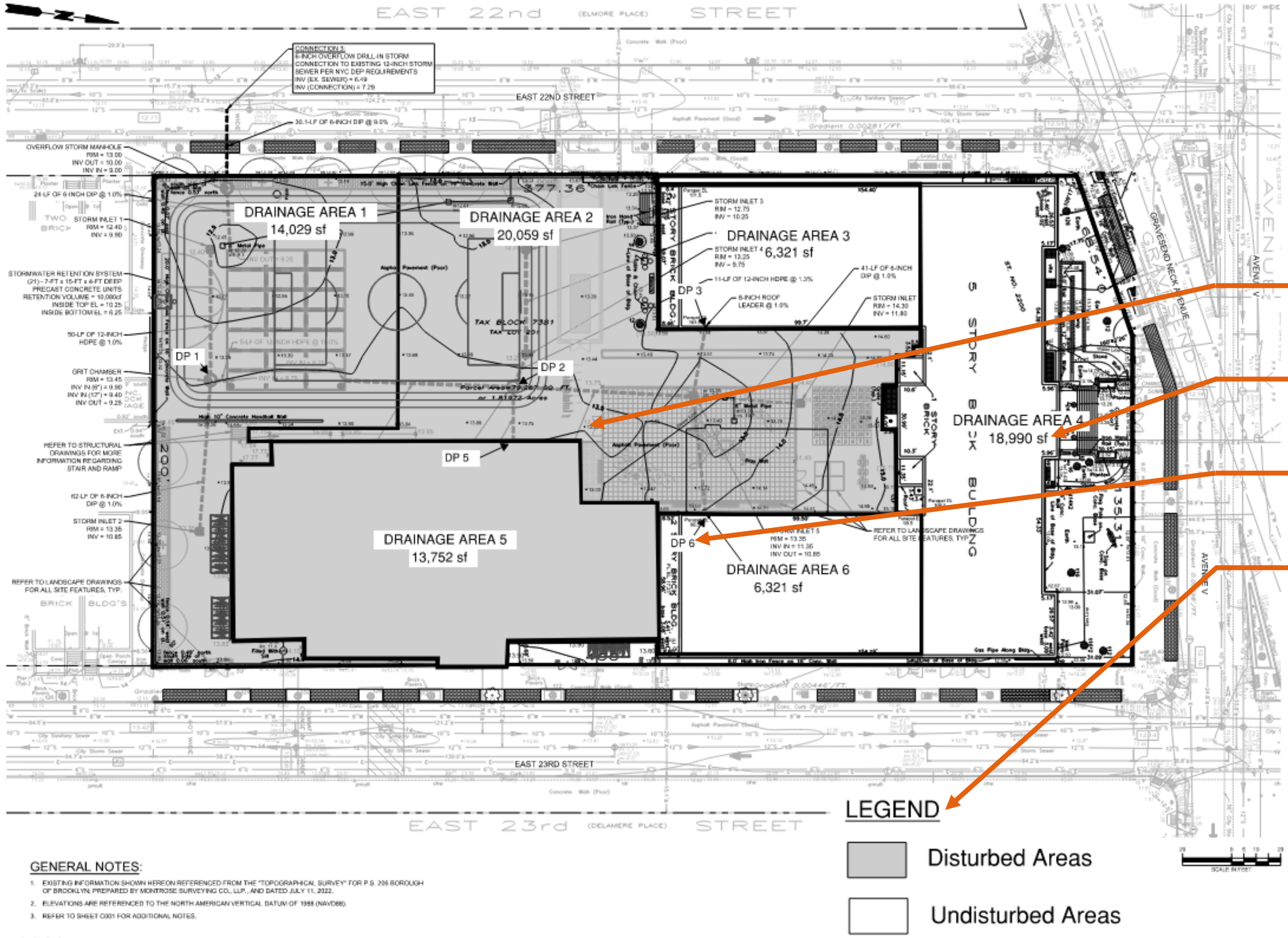
- Determine Vv and Q_{DRR} for each site connection
- Calculate portion of WQv that may be applied to Vv
- Design practices and calculate volume of storage
- Confirm volume of storage meets remaining Vv
- Confirm peak flow rate meets Q_{DRR}, if applicable
- If unmet, modify design to meet criteria

Meeting WQv & RRv

Determine WQv for the Site

Determine WQv for the Site

Delineate drainage areas for proposed conditions



Delineation Map:

- Show proposed contours that incorporate grade changes from existing conditions
- Provide measurement of each drainage area
- Show the Design Point (DP) used to delineate each drainage area
- Differentiate between disturbed vs. undisturbed areas

Determine WQv for the Site

Calculate WQv from disturbed drainage areas

Prepare table to summarize each drainage area

- Determine percent impervious cover (I) based on surface types
- Pervious SMPs can either be applied to Rv reduction or as storage volume, not both
- Calculate WQv for each disturbed area using EQ2.1 from the USWR

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

Proposed Drainage Area	Disturbance Type	Area (sf)	Pervious Area from SMPs (sf)	Pervious Area from SMPs applied as Rv reduction (sf)	Other Pervious Areas (sf)	Impervious Area (sf)	I (%)	Rv (-)	WQv (cf)
Drainage Area 1	Disturbed	14029	1093	1093	0	12936	92	0.8799	1542.98
Drainage Area 2	Disturbed	20059	361	361	0	19698	98.20	0.9338	2341.39
Drainage Area 3	Undisturbed	-	-	-	-	-	-	-	-
Drainage Area 4	Undisturbed	-	-	-	-	-	-	-	-
Drainage Area 5	Disturbed	13752	7552	0	0	13752	100	0.9500	1633.05
Drainage Area 6	Undisturbed	-	-	-	-	-	-	-	-
								Total:	**5517.60**

Determine WQv for the Site

Calculate WQv for any undisturbed drainage areas that are managed by an existing SMP being removed

Prepare table to summarize each drainage area

- Determine percent impervious cover (I) based on surface types
- Calculate WQv for each undisturbed area using EQ2.1 from the USWR

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

Proposed Drainage Area	Disturbance Type	Area (sf)	Pervious Area from SMPs (sf)	Pervious Area from SMPs applied as Rv reduction (sf)	Other Pervious Areas (sf)	Impervious Area (sf)	I (%)	Rv (-)	WQv (cf)
Drainage Area 1	Disturbed	-	-	-	-	-	-	-	-
Drainage Area 2	Disturbed	-	-	-	-	-	-	-	-
Drainage Area 3	Undisturbed	6321	0	0	0	6321	100	0.9500	750.62
Drainage Area 4	Undisturbed	-	-	-	-	-	-	-	-
Drainage Area 5	Disturbed	-	-	-	-	-	-	-	-
Drainage Area 6	Undisturbed	6321	0	0	0	6321	100	0.9500	750.62
								Total:	**1501.20**

Determine WQv for the Site

Calculate total WQv and RRv for the Site

The total WQv for the site is the sum of:

- WQv for disturbed drainage areas: 5,517 cf; and
- WQv for undisturbed drainage areas with SMPs being removed: 1,501 cf

The entire WQv must be reduced to the maximum extent practicable (MEP):

- Meaning that site WQv = site RRv

$$WQ_{V,Site} = RR_{V,Site} = 7018.8\ cf$$

Meeting WQv & RRv

Identify site constraints and select practices

Identify site constraints and select practices

Identify site constraints and select practices

Refer to the SMP hierarchy for the appropriate sewer/stormwater system

Primary Goal: Retention

Secondary Goal: Vegetated

Vegetated Retention
- Bioretention
- Rain garden
- Stormwater planter
- Green roof
- Tree planting / preservation
- Dry basin
- Grass filter strip
- Vegetated swale
- Other dual function systems with retention capability

Vegetated Detention
- Dry basin
- Constructed wetland
- Other dual function systems with detention capability

Capture & Reuse
- Rain tank
- Cistern

Non-vegetated Retention
- Dry well
- Stormwater gallery
- Stone trench
- Porous pavement
- Synthetic turf field
- Other dual function systems with retention capability

Non-vegetated Detention
- Wet basin / pond
- Subsurface gallery
- Blue roof
- Detention tank
- Other dual function systems with detention capability

TIER 1
TIER 2
TIER 3
ANYTIME / OPTIONAL

SMP hierarchy for CSS areas

Primary Goal: Retention

Secondary Goal: Vegetated

Vegetated Retention
- Bioretention
- Rain garden
- Stormwater planter
- Green roof
- Tree planting / preservation
- Dry basin
- Grass filter strip
- Vegetated swale
- Other dual function systems with retention capability

Vegetated Treatment
- Bioretention
- Stormwater planter
- Constructed wetland
- Other dual function systems with treatment capability

Capture & Reuse
- Rain tank
- Cistern

Non-vegetated Retention
- Dry well
- Stormwater gallery
- Stone trench
- Porous pavement
- Synthetic turf field
- Other dual function systems with retention capability

Non-vegetated Treatment
- Porous pavement
- Synthetic turf field
- Sand filter
- Organic filter
- Wet basin / pond
- Other dual function systems with treatment capability

TIER 1
TIER 2
TIER 3
ANYTIME / OPTIONAL

SMP hierarchy for MS4 areas
(Applies to Case Study)

Identify site constraints and select practices

Refer to the SMP hierarchy checklist to identify the impact of site constraints

For each drainage area in this MS4 site, evaluate the feasibility of applicable SMPs from the highest to lowest tier, based on the following site constraints:

- **Soil constraints** are present when permeability tests indicate that infiltration rated are less than 0.5 in/hr
- **Subsurface constraints** are present when the bottom of a proposed practice would be less then 3-ft from the groundwater table or bedrock
- **Hotspot constraints** are present when land use or soil conditions increase the risk of runoff contamination
- **Surface constraints** are present when regulations require the use of paved surfaces.
- **Space constraints** are present when there are required setbacks from existing site features

SMP HIERARCHY CHECKLIST - MS4 AREAS

			Percent of SMP volume applied[a]			Site constraints that limit SMP feasibility[b]				
Tier[c]	Function Type[d]	Practice Type[e]	WQv	RRv	Vv	Soil	Subsurface	Hotspot	Surfaces	Space
Tier 1	Infiltration (Vegetated)	Bioretention	100	100	50	X	X	X	X	X
		Rain garden	100	100	50	X	X	X	X	X
		Stormwater planter	100	100	50	X	X	X	X	X
		Tree planting / preservation	SC	SC	0					
		Dry basin	100	100	50	X	X	X	X	X
		Grass filter strip	SC	SC	0	X	X	X	X	X
		Vegetated swale	SC	SC	0	X	X	X	X	X
	Evapotranspiration[f]	Rain garden	100	100	0		X		X	X
		Stormwater planter	100	100	0				X	
		Tree planting / preservation	SC	SC	0					
		Green roof	100	100	0					
Tier 2	Infiltration (Non-vegetated)	Dry well	100	100	50	X	X	X		X
		Stormwater gallery	100	100	50	X	X	X		X
		Stone trench	100	100	50	X	X	X	X	X
		Porous pavement	100	100	50	X	X	X		X
		Synthetic turf field	100	100	50	X	X	X	X	X
Anytime / Optional	Reuse	Rain tank	100	100	SC					
		Cistern	100	100	SC					
Tier 3	Filtration[g]	Bioretention	100	40	0		X		X	X
		Stormwater planter	100	40	0		X		X	X
		Porous pavement	100	0	0		X			X
		Synthetic turf field	100	0	0		X		X	X
		Sand filter	100	0	0		X		X	
		Organic filter	100	0	0		X		X	
	Detention[g,h]	Constructed wetland	100	0	100		X		X	X
		Wet basin / pond	100	0	100		X		X	X
Other	Detention[g,i,j]	Dry basin	0	0	100		X		X	X
		Stormwater gallery	0	0	100		X			X
		Blue roof	0	0	100					
		Detention tank	0	0	100					

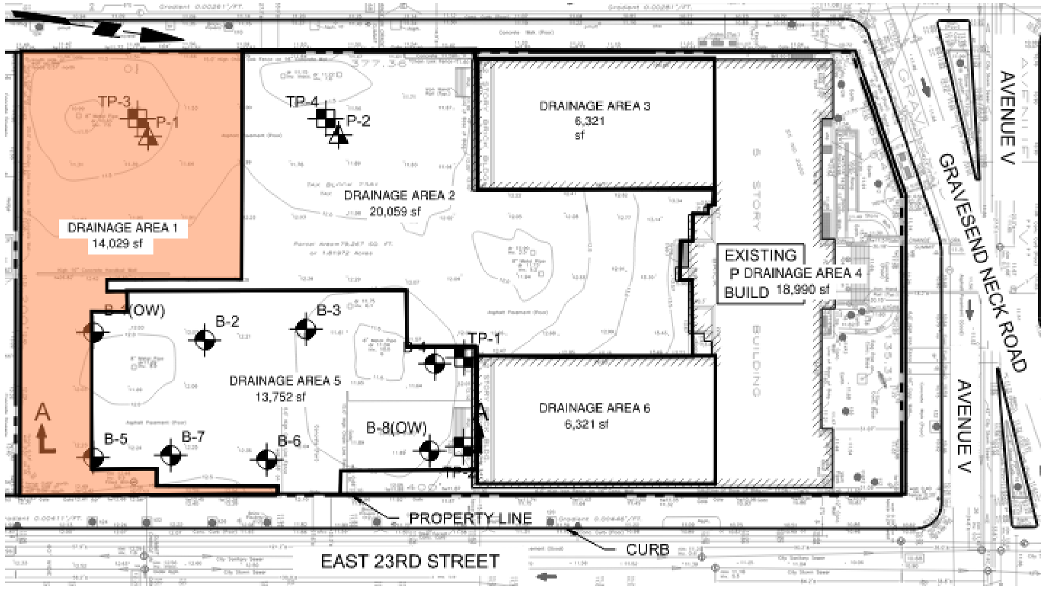
The SMP Hierarchy Checklist can be found in Appendix A of the USWR. Note that in this table, an "X" marker indicates that the presence of the associated site constraint would prevent the use of the practice listed in that row. Conversely, a blank cell indicates that the presence of the constraint *does not* render the SMP unfeasible. Therefore, if a constraint is identified in a drainage area, the designer would need to select practices where the associated cell is *blank.*

Identify site constraints and select practices

Identify site constraints for each disturbed drainage area: Drainage Area 1

Evaluate the impact of each site constraint on SMP feasibility in Drainage Area 1:

- Soil constraints:
  - Infiltration rate at P-1 (5-ft): 0.73 in/hr > 0.5 in/hr
  - No constraints up to 5-ft below grade
- Subsurface constraints:
  - Groundwater depth: 10.5-ft below grade
  - No bed rock found in subsurface exploration
  - No constraints up to 7.5-ft
- Hotspot constraints
  - No land uses or soil conditions causing constraints identified
- Surface constraints
  - Paved play area may not be reduced
  - Surface constraints prevent the installation of vegetated practices
- Space constraints
  - Practice must be 5-ft from property line
  - No other
  - Refer to Appendix C of USWR for details on identifying space constraints



Drainage Area	Soil	Subsurface	Hotspot	Surface	Space
Drainage Area 1	None up to 5-ft below grade	None up to 7.5-ft below grade		Y	

Identify site constraints and select practices

Select highest tier feasible practice for each drainage area: Drainage Area 1

Disturbed Drainage Area	Soil	Subsurface	Hotspot	Surface	Space
Drainage Area 1	None up to 5-ft below grade	None up to 7.5-ft below grade		Y	

Refer to the SMP hierarchy checklist to identify feasible practices:

- Tree planting (Tier 1) – can be used to increase pervious area
- Green roof (Tier 1) – not applicable, no buildings in this drainage area
- Dry well (Tier 2) – soil and subsurface conflicts at greater depths prevent this practice from being used
- Stormwater gallery (Tier 2) – can accommodate larger capacity be constructed at shallower depths

SMP HIERARCHY CHECKLIST - MS4 AREAS

Tier[c]	Function Type[d]	Practice Type[e]	Percent of SMP volume applied[a]: WQv	RRv	Vv	Site constraints that limit SMP feasibility[b]: Soil	Subsurface	Hotspot	Surfaces	Space
Tier 1	Infiltration (Vegetated)	Bioretention	100	100	50	X	X	X	X	X
		Rain garden	100	100	50	X	X	X	X	X
		Stormwater planter	100	100	50	X	X	X	X	X
		Tree planting / preservation	SC	SC	0					
		Dry basin	100	100	50	X	X	X	X	X
		Grass filter strip	SC	SC	0	X	X	X	X	X
		Vegetated swale	SC	SC	0	X	X	X	X	X
	Evapotranspiration[f]	Rain garden	100	100	0		X		X	X
		Stormwater planter	100	100	0				X	
		Tree planting / preservation	SC	SC	0					
		Green roof	100	100	0					
Tier 2	Infiltration (Non-vegetated)	Dry well	100	100	50	X	X	X		X
		Stormwater gallery	100	100	50	X	X	X		X
		Stone trench	100	100	50	X	X	X	X	X
		Porous pavement	100	100	50	X	X	X		X
		Synthetic turf field	100	100	50	X	X	X	X	X
Anytime / Optional	Reuse	Rain tank	100	100	SC					
		Cistern	100	100	SC					
Tier 3	Filtration[g]	Bioretention	100	40	0		X		X	X
		Stormwater planter	100	40	0		X		X	X
		Porous pavement	100	0	0		X			X
		Synthetic turf field	100	0	0		X		X	X
		Sand filter	100	0	0		X		X	
		Organic filter	100	0	0		X		X	
	Detention[g,h]	Constructed wetland	100	0	100		X		X	X
		Wet basin / pond	100	0	100		X		X	X
Other	Detention[g,i,j]	Dry basin	0	0	100		X		X	X
		Stormwater gallery	0	0	100		X			X
		Blue roof	0	0	100					
		Detention tank	0	0	100					

In this case, feasible practices are those for which the Surface cell is *blank.*

In this case, the Tier 1 **tree planting / preservation** SMPs were used in areas that did not have surface constraints. The remaining WQv was managed via the Tier 2 **stormwater gallery** SMP. This complies with the SMP hierarchy checklist.

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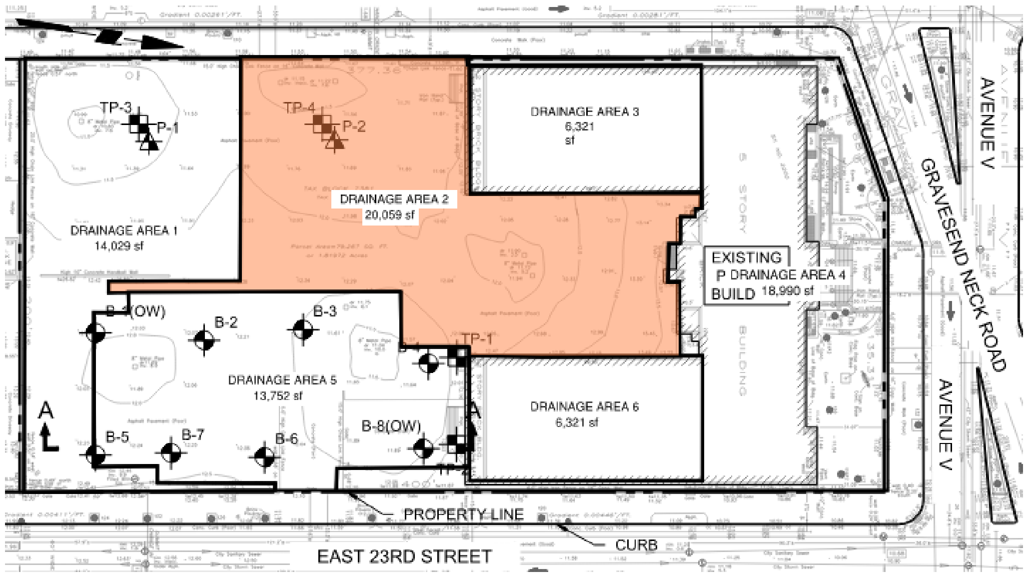
Identify site constraints and select practices

Identify site constraints for each disturbed drainage area: Drainage Area 2

Evaluate the impact of each site constraint on SMP feasibility in Drainage Area 2:

- Soil constraints:
  - Infiltration rate at P-2 (5-ft): 0.35 in/hr < 0.5 in/hr
  - Soil constraints present
- Subsurface constraints:
  - Groundwater depth: 10.5-ft below grade
  - No bed rock found in subsurface exploration
  - No constraints up to 7.5-ft
- Hotspot constraints
  - No land uses or soil conditions causing constraints identified
- Surface constraints
  - Paved play area may not be reduced
  - Surface constraints prevent the installation of vegetated practices
- Space constraints
  - Practice must be 5-ft from property line
  - No other
  - Refer to Appendix C of USWR for details on identifying space constraints



Drainage Area	Soil	Subsurface	Hotspot	Surface	Space
Drainage Area 2	Y	None up to 7.5-ft below grade		Y	

Identify site constraints and select practices

Select highest tier feasible practice for each drainage area: Drainage Area 2

Disturbed Drainage Area	Soil	Subsurface	Hotspot	Surface	Space
Drainage Area 2	Y	None up to 7.5-ft below grade		Y	

Refer to the SMP hierarchy checklist to identify feasible practices:

- Tree planting (Tier 1) – can be used to increase pervious area
- Green roof (Tier 1) – not applicable, no buildings in this drainage area
- Porous pavement (Tier 3) – requires disruption of play area

SMP HIERARCHY CHECKLIST - MS4 AREAS

Tier[c]	Function Type[d]	Practice Type[e]	Percent of SMP volume applied[a]: WQv	RRv	Vv	Site constraints that limit SMP feasibility[b]: Soil	Subsurface	Hotspot	Surfaces	Space
Tier 1	Infiltration (Vegetated)	Bioretention	100	100	50	✕	✕	✕	✕	✕
		Rain garden	100	100	50	✕	✕	✕	✕	✕
		Stormwater planter	100	100	50	✕	✕	✕	✕	✕
		Tree planting / preservation	SC	SC	0					
		Dry basin	100	100	50	✕	✕	✕	✕	✕
		Grass filter strip	SC	SC	0	✕	✕	✕	✕	✕
		Vegetated swale	SC	SC	0	✕	✕	✕	✕	✕
	Evapotranspiration[f]	Rain garden	100	100	0		✕		✕	✕
		Stormwater planter	100	100	0				✕	
		Tree planting / preservation	SC	SC	0					
		Green roof	100	100	0					
Tier 2	Infiltration (Non-vegetated)	Dry well	100	100	50	✕	✕	✕		✕
		Stormwater gallery	100	100	50	✕	✕	✕		✕
		Stone trench	100	100	50	✕	✕	✕	✕	✕
		Porous pavement	100	100	50	✕	✕	✕		✕
		Synthetic turf field	100	100	50	✕	✕	✕	✕	✕
Anytime / Optional	Reuse	Rain tank	100	100	SC					
		Cistern	100	100	SC					
Tier 3	Filtration[g]	Bioretention	100	40	0		✕		✕	✕
		Stormwater planter	100	40	0		✕		✕	✕
		Porous pavement	100	0	0		✕			✕
		Synthetic turf field	100	0	0		✕		✕	✕
		Sand filter	100	0	0		✕		✕	
		Organic filter	100	0	0		✕		✕	
	Detention[g,h]	Constructed wetland	100	0	100		✕		✕	✕
		Wet basin / pond	100	0	100		✕		✕	✕
Other	Detention[g,i,j]	Dry basin	0	0	100		✕		✕	✕
		Stormwater gallery	0	0	100		✕			✕
		Blue roof	0	0	100					
		Detention tank	0	0	100					

In this case, feasible practices are those for which the Soil and Surface cells are *blank*.

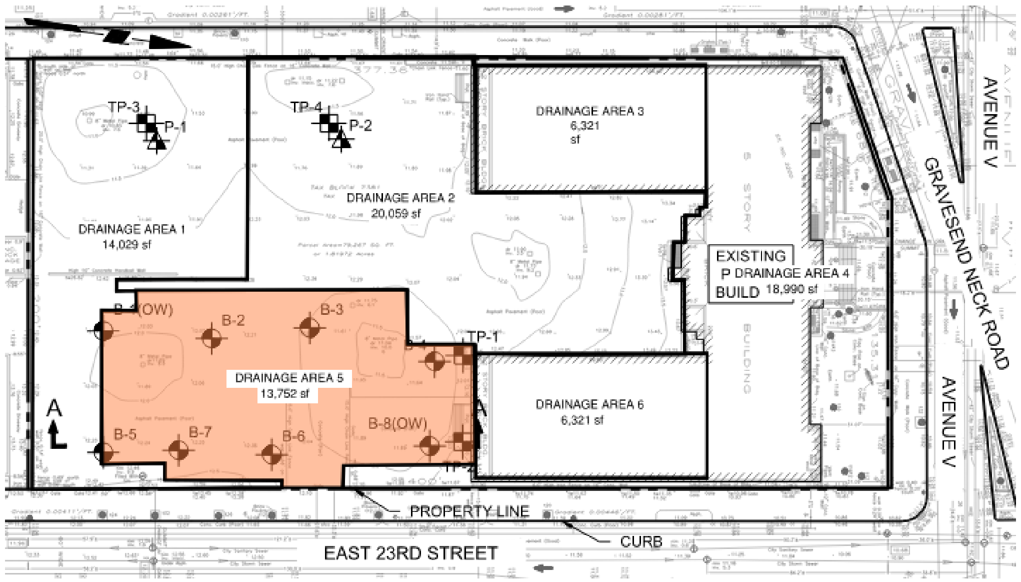
In this case, the Tier 1 **tree planting / preservation** SMPs were used in areas that did not have surface constraints. The remaining WQv is managed in by the Tier 2 stormwater gallery selected for Drainage Area 1. This complies with the SMP hierarchy checklist.

Identify site constraints and select practices

Identify site constraints for each disturbed drainage area: Drainage Area 5

Evaluate the impact of each site constraint on SMP feasibility in Drainage Area 5, where the construction of a new building is planned:

- Soil constraints:
  - Infiltration rate on building roof: 0 in/hr < 0.5 in/hr
  - Soil constraints present
- Subsurface constraints:
  - Groundwater and bed rock depth limitations not applicable to building roofs, but no subsurface available for use on roofs
  - Subsurface constraints present
- Hotspot constraints
  - No land uses or soil conditions causing constraints identified
- Surface constraints
  - Roof may be used to install vegetated practices
  - No surface constraints identified
- Space constraints
  - Practice will be limited to available area on the roof



Drainage Area	Soil	Subsurface	Hotspot	Surface	Space
Drainage Area 2	Y	Y			Y

Identify site constraints and select practices

Select highest tier feasible practice for each drainage area: Drainage Area 5

Disturbed Drainage Area	Soil	Subsurface	Hotspot	Surface	Space
Drainage Area 5	Y	Y			Y

Refer to the SMP hierarchy checklist to identify feasible practices:

- Tree planting (Tier 1) – not applicable; building will cover entire drainage area
- Stormwater planter (Tier 1) – may be used as a smaller vegetated practice on the roof area
- Green roof (Tier 1) – may be used as a larger vegetated practice on the roof area

SMP HIERARCHY CHECKLIST - MS4 AREAS

			Percent of SMP volume applied[a]			Site constraints that limit SMP feasibility[b]				
Tier[c]	Function Type[d]	Practice Type[e]	WQv	RRv	Vv	Soil	Subsurface	Hotspot	Surfaces	Space
Tier 1	Infiltration (Vegetated)	Bioretention	100	100	50	X	X	X	X	X
		Rain garden	100	100	50	X	X	X	X	X
		Stormwater planter	100	100	50	X	X	X	X	X
		Tree planting / preservation	SC	SC	0					
		Dry basin	100	100	50	X	X	X	X	X
		Grass filter strip	SC	SC	0	X	X	X	X	X
		Vegetated swale	SC	SC	0	X	X	X	X	X
	Evapotranspiration[f]	Rain garden	100	100	0		X		X	X
		Stormwater planter	100	100	0				X	
		Tree planting / preservation	SC	SC	0					
		Green roof	100	100	0					
Tier 2	Infiltration (Non-vegetated)	Dry well	100	100	50	X	X	X		X
		Stormwater gallery	100	100	50	X	X	X		X
		Stone trench	100	100	50	X	X	X	X	X
		Porous pavement	100	100	50	X	X	X		X
		Synthetic turf field	100	100	50	X	X	X	X	X
Anytime / Optional	Reuse	Rain tank	100	100	SC					
		Cistern	100	100	SC					
Tier 3	Filtration[g]	Bioretention	100	40	0		X		X	X
		Stormwater planter	100	40	0		X		X	X
		Porous pavement	100	0	0		X			X
		Synthetic turf field	100	0	0		X		X	X
		Sand filter	100	0	0		X		X	
		Organic filter	100	0	0		X		X	
	Detention[g,h]	Constructed wetland	100	0	100		X		X	X
		Wet basin / pond	100	0	100		X		X	X
Other	Detention[g,i,j]	Dry basin	0	0	100		X		X	X
		Stormwater gallery	0	0	100		X			X
		Blue roof	0	0	100					
		Detention tank	0	0	100					

In this case, feasible practices are those for which the Soil, Subsurface and Surface cells are *blank.*

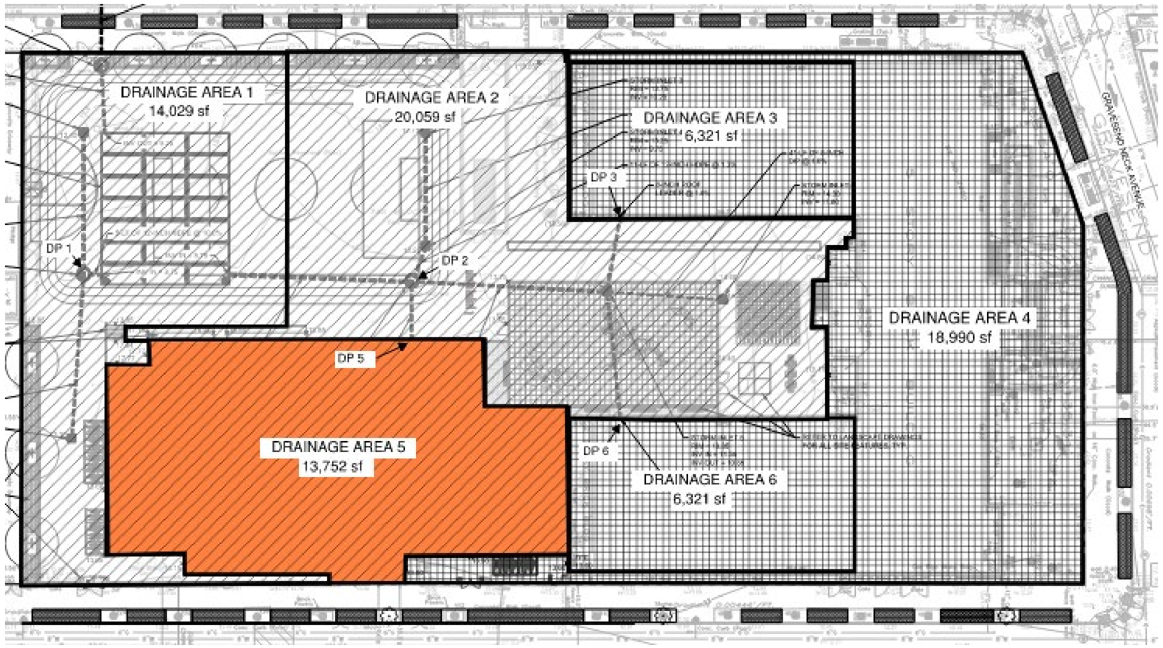
In this case, the Tier 1 **green roof** SMP was used on the roof. The remaining WQv is managed in by the Tier 2 stormwater gallery selected for Drainage Area 1. This complies with the SMP hierarchy checklist.

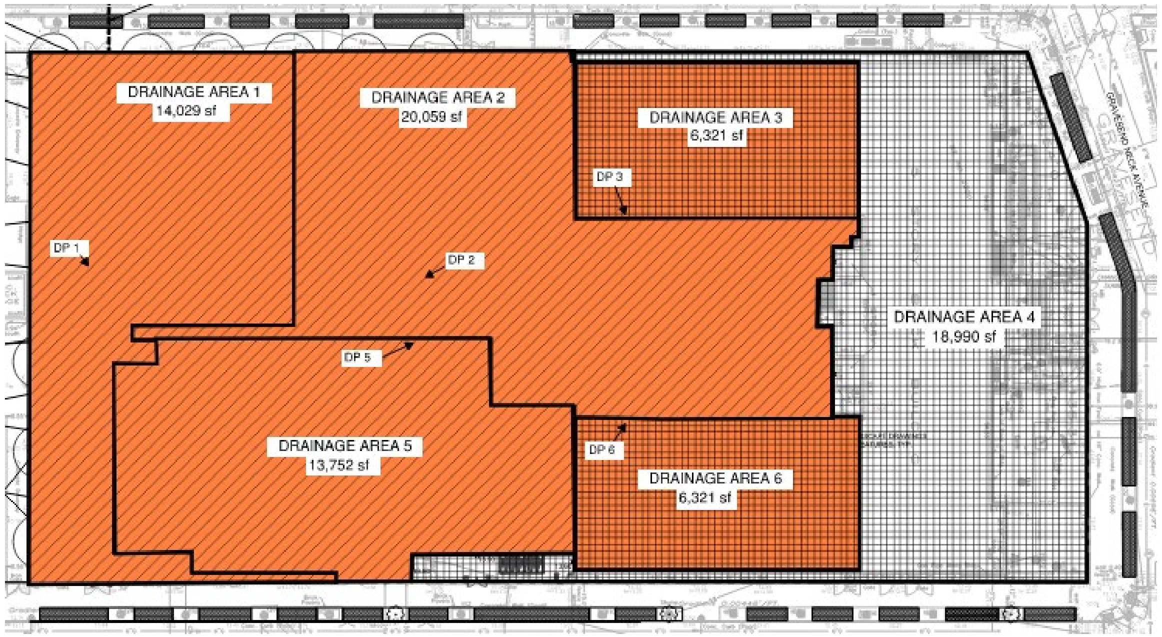
Meeting WQv & RRv

Determine WQv for each practice

Determine WQv for each practice

Delineate contributing areas for each practice





Contributing area for green roof is DA #5

- Area = 13,752 sf
- Note that areas not covered by green roof will drain directly to Design Point 5

Contributing area for stormwater gallery is DA #1-3 & #5-6

- Area = 60,482 sf
- Note that DA #5 is also managed by upstream green roof

Determine WQv for each practice

Calculate the allowable contributing area for each practice

Prepare table to summarize each practice

- Max allowable contributing area based on max loading ratio or max contributing area
- For green roofs, max loading ratio is 1:1 (USWR Table 4.3)
- For stormwater gallery, max contributing area is 5 acre (USWR Table 4.5)

Stormwater Management Practice	Practice Area (sf)	Contributing Area (sf)	Max Allowable Contributing Area (sf)	Allowable Contributing Area (sf)
Green Roof	7,552	13,752	7,552	7,552
Stormwater Gallery	2,788.75	60,482	217,800	60,482

Determine WQv for each practice

Calculate preliminary WQv for each practice

Prepare table to summarize each practice

- Practices used to meet WQv cannot also be applied to reduce impervious area
- Permeable pavers do not have WQv calculation, since applied as Rv reduction
- Calculate WQv for each practice using EQ2.1 from the USWR

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

Stormwater Management Practice	Allowable Contributing Area (sf)	Pervious Area from SMPs (sf)	Pervious Area from SMPs applied as Rv reduction (sf)	Other Pervious Areas (sf)	Impervious Area (sf)	I (%)	Rv (-)	Preliminary WQv (cf)
Green Roof	7,552	7,552	0	0	7,552	100	0.95	896.8
Stormwater Gallery	60,482	9,006	1,454	0	59,028	97.6	0.9283	7018.2

Determine WQv for the Site

Calculate adjusted WQv and RRv for each practice

In cases where an upstream practice conveys water to a downstream practice:

- Subtract the upstream practice WQv from the downstream practice WQv
- The resulting value is the adjusted WQv

The entire WQv must be reduced to the maximum extent practicable (MEP):

- Meaning that practice WQv = practice RRv

Stormwater Management Practice	Preliminary WQv (cf)	Upstream WQv (cf)	Adjusted Practice WQv (cf)
Green Roof	896.8	0	896.8
Stormwater Gallery	7018.2	-896.8	6121.4

$$WQ_{V,GR} = 896.8\ cf$$

$$WQ_{V,SG} = 6121.4\ cf$$

Meeting WQv & RRv

Design practices and calculate storage volume

ARCADIS

Design practices and calculate storage volume

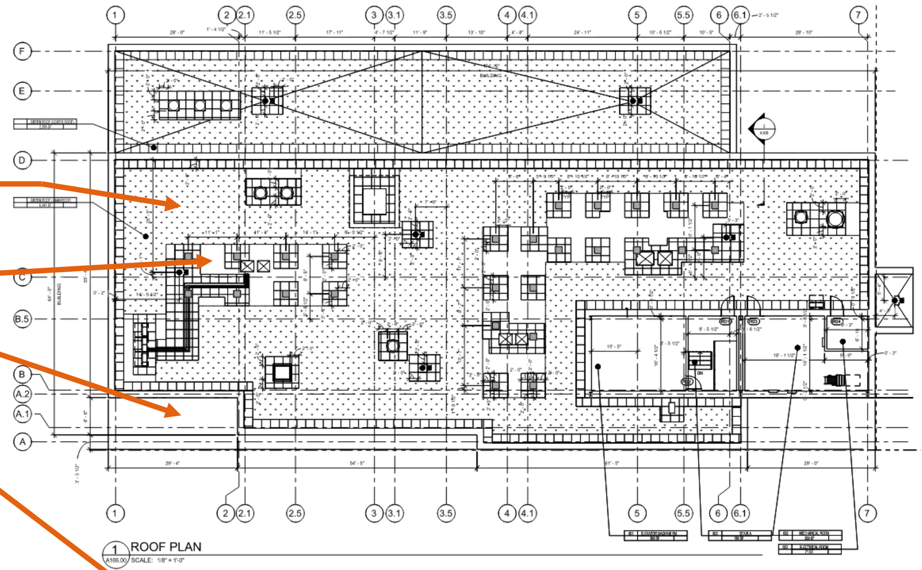
Identify design criteria of each practice (green roof)

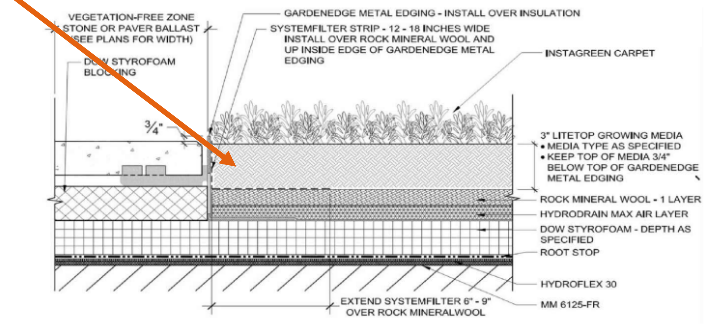
Refer to USWR Table 4.3 for ET SMP design requirements.

The following requirements apply to the green roof:

- The ratio of the Practice to the Contributing Area is 1:1.
  - Exact area of the green roof must be used as the practice area
  - Voids in structure and drainage area surrounding the green roof may not be used as part of the practice area
- A minimum of 4-inches of green roof media depth is required
  - In this case, the 3-inch growing media is insufficient

Design Parameter[a]	Rain garden	Stormwater Planter	Tree planting/ preservation	Green roof
MAX. loading ratio, practice-to-contributing area	1:5	1:5	1:4	1:1
MAX. contributing area	1000 sf	15000 sf	400 sf	-
MIN. infiltration rate of underlying soils	-	-	-	-
Vertical separation from groundwater/ bedrock[b]	3' MIN	3' MIN	-	-
Surface ponding depth	3" MAX	3" MAX	-	-
Media layers	Mulch Eng. Soil Stone base[c]	Mulch Eng. Soil Stone base[c]	Mulch Topsoil	Green roof media Stone base[c]
Surfacing media depth	2-3" TYP	2-3" TYP	Varies	-
Leveling media depth	-	-	-	-
Planting/filter media depth	1' MIN 2' MAX	1.5' MIN	Varies	4" MIN[d]
Stone base depth	Varies	Varies	-	Varies
Slope of surface media	1:3 MAX	No Slope	-	Varies[e]
Slope of bottom of practice	No Slope	No Slope	-	Varies[e]
MAX. Drawdown time	-	-	-	-



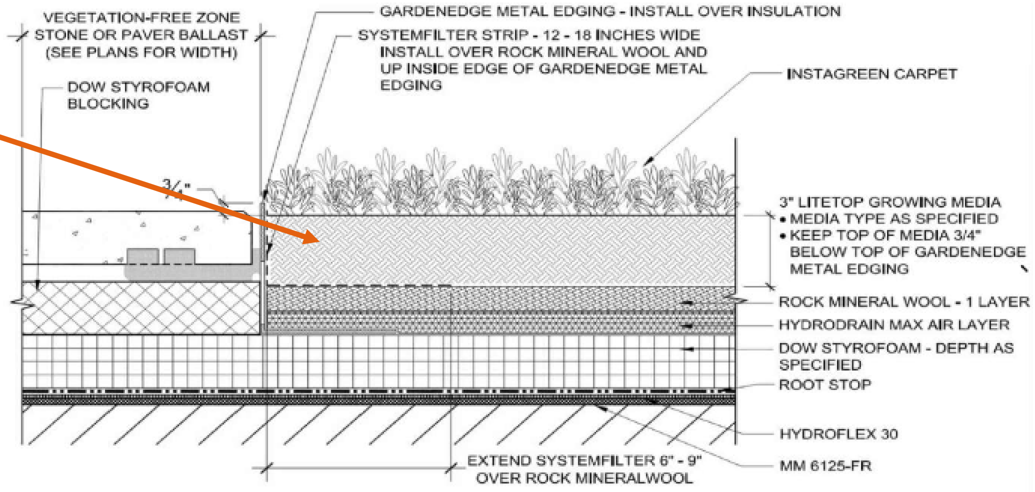


3 GREEN ROOF - DETAIL
A106.00 SCALE: N.T.S

Design practices and calculate storage volume

Identify storage components of each practice (green roof)

- Green roof
  - V_P does not apply; no ponding on green roof
  - V_S applies to engineered green roof soil
  - V_I does not apply; no internal storage structures
  - V_D does not apply; green roof drainage media not configured to store water
  - $\boldsymbol{V_{SMP,GR} = V_{S,GR}}$



3 GREEN ROOF - DETAIL

A106.00 SCALE: N.T.S

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)

Design practices and calculate storage volume

Calculate storage volume of components for each practice (green roof)

- Green roof
  - $A_{SMP,GR}(sf) = 7552$
  - $D_S(ft) = \frac{3"}{12} = 0.25$
  - $n_S(cf/cf) = 0.2$
  - $V_{S,GR}(cf) = A_{SMP} \times D_S \times n_S = 7552 \times 0.25 \times 0.2 = 377.6\ cf$
  - $V_{SMP,GR} = V_{S,GR} = 377.6\ cf$
- Notes
  - Green roof requires a 4" minimum media depth (USWR Table 4.3)
  - Available porosity of soil set to default value

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)

$$V_{SMP,GR} = 377.6\ cf$$

Design practices and calculate storage volume

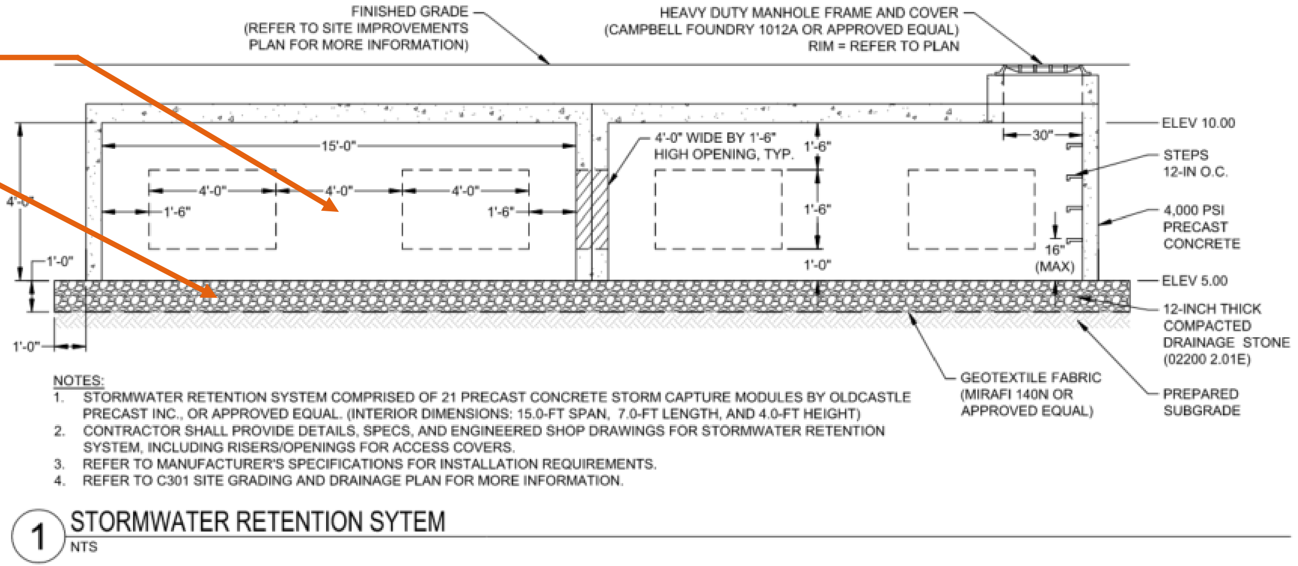
Identify storage components of each practice (stormwater gallery)

- Stormwater gallery
  - V_P does not apply; no surface ponding
  - V_S does not apply; no soil media
  - V_I applies to each of the precast concrete storage modules
  - V_D applies to the layer of drainage media below the storage modules
  - $\boldsymbol{V_{SMP,SG} = V_{I,SG} + V_{D,SG}}$

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)



Note: Details show that discharge elevation is higher than top of storage elevation, therefore entire practice functions as infiltration system

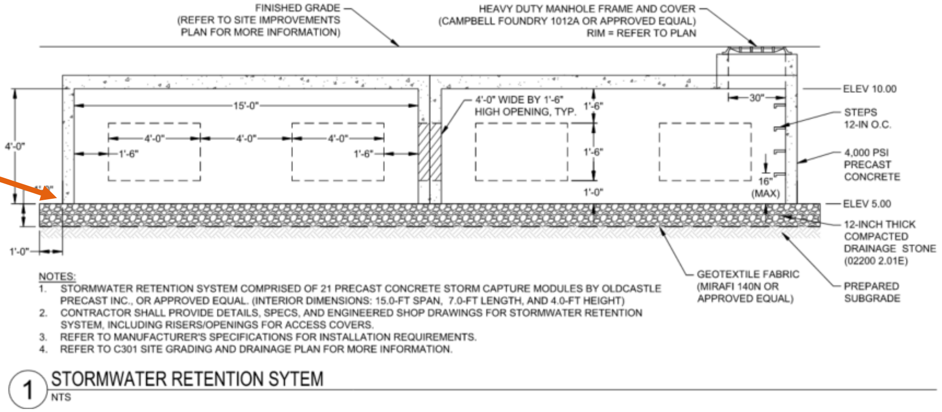
Design practices and calculate storage volume

Identify design criteria of each practice (stormwater gallery)

Design Parameter[d]	Grass filter strip	Vegetated swale	Dry well	Stormwater gallery	Stone trench	Porous pavement	Synthetic turf field
MAX. loading ratio, practice-to-contributing area	1:3 (Prv.) 1:1.25 (Imp.)	-	-	-	-	-	-
MAX. contributing area	10,000 sf	5 acre	1 acre	5 acre	5 acre	5 acre	5 acre
MIN. infiltration rate of underlying soils	0.5 in/hr	0.5 in/hr	0.5 in.hr	0.5 in/hr	0.5 in/hr	0.5 in/hr	0.5 in/hr
Vertical separation from groundwater / bedrock[e]	3' MIN	3' MIN	3' MIN	3' MIN	3' MIN	3' MIN	3' MIN
Surface ponding depth	-	4" MAX[f]	-	-	-	-	-
Media layers	Native soils or Topsoil	Native soils or Topsoil	Stone base	Stone base	Pea gravel Stone base Sand filter	Leveling media Subbase[g] Stone base	Leveling media Subbase[g] Stone base
Surfacing media depth	-	-	-	-	6" TYP	-	-
Leveling media depth	-	-	-	-	-	2-4" TYP	2-4" TYP
Planting/filter media depth	-	-	-	-	6" MIN	-	-
Stone base depth	-	-	12" MIN	12" MIN	12" MIN	12" MIN	12" MIN
Slope of practice surface	15% MAX 8% MAX (AVG.)	1:3 MAX[h]	-	-	-	5% MAX	-
Slope practice bottom	-	0.5% MIN 4% MAX	No Slope	No Slope	No Slope	-	No Slope
MAX. Drawdown time	-	-	Total = 48hr	Total = 48hr	Total = 48hr	Total = 48hr	Total = 48hr

Refer to USWR Table 4.2 for Infiltration SMP design requirements.
The following requirements apply to the stormwater gallery:

- The maximum contributing area must be < 5 acres
  - Contributing area is 1.38 acres; design criteria is met
- The minimum infiltration rate of underlying soils must be > 0.5 in/hr
  - Infiltration rate is 0.73 in/hr; design criteria is met
- Minimum distance from bottom of practice to groundwater or bedrock > 3-ft
  - Distance to groundwater is 6.5 feet; design criteria is met
- Media layer must be stone base
- Minimum stone base depth is 12-in
- Bottom of practice must not be sloped
- Maximum drawdown time must be 48-hours. The drawdown time for infiltration practices can be calculated using USWR Eq. 4.11.



EQ 4.11

$$dt_{SMP} = \frac{V_{SMP}}{\left(\frac{i}{12}\right) * A_{INF}}$$

Design practices and calculate storage volume

Calculate storage volume of components for each practice (stormwater gallery)

- Stormwater gallery
  - $V_M(cf) = L \times W \times D = 15 \times 7 \times 4 = 420$
  - $V_N = 21$
  - $V_{I,SG}(cf) = V_M \times V_N = 420 \times 21 = 8820\ cf$

  - $A_{SMP}(sf) = L \times W = 57.5 \times 48.5 = 2788.75$
  - $D_D(ft) = 1$
  - $V_{I,d}(ft) = 0$
  - $n_D(cf/cf) = 0.4$
  - $V_{D,SG}(cf) = (A_{SMP} \times D_D - V_{I,d}) \times n_D = (2788.5 \times 1 - 0) \times 0.4 = 1115.5\ cf$

  - $V_{SMP,SG} = V_{I,SG} + V_{D,SG} = 8820 + 1115.5 = 9935.5\ cf$
- Notes
  - Details show that discharge elevation is higher than top of storage elevation, therefore entire practice functions as infiltration system

EQ 4.5

$$V_I = V_M * N_M$$

where:
V_I = volume of voids created by internal structure (cf)
V_M = interior volume of one modular structure (cf)
N_M = number of modular structures (unit less)

EQ 4.7

$$V_D = (A_{SMP} * D_D - V_{I,d}) * n_D$$

where:
V_D = volume of voids in the drainage media (cf)
A_{SMP} = area of the SMP (sf)
D_D = depth of the drainage media (ft)
$V_{I,d}$ = volume of voids created by internal structures within the drainage media (cf)
n_D = porosity of drainage media (cf/cf)

$$V_{SMP,SG} = 9935.5\ cf$$

Design practices and calculate storage volume

Where applicable, calculate drawdown time of practice (stormwater gallery)

- Stormwater gallery
  - $V_{SMP,SG} = 9935.5\ cf$
  - $A_{INF}(sf) = L \times W \times \#\ Modules = 15 \times 7 \times 21 = 2205\ sf$
  - $i = 0.74 \frac{in}{hr}$
  - $dt_{SMP} = \frac{V_{SMP}}{\frac{i}{12} \times A_{INF}} = \frac{9935.5}{\frac{0.74}{12} \times 2205} = 73.69\ hr$ > 48 hours
  - The maximum drawdown requirement is not met.

EQ 4.11

$$dt_{SMP} = \frac{V_{SMP}}{\left(\frac{i}{12}\right) * A_{INF}}$$

Meeting WQv & RRv

Confirm storage volume meets practice WQv/RRv

Confirm storage volume meets practice WQv/RRv

Compare applicable storage volume to WQv/RRv requirement for each practice

Prepare table to summarize each practice

- Applicable SMP volume calculated based on USWR EQ4.8
- Percent of volume applicable based on practice type (USWR Table 4.1)
- Green roof volume does not meet WQv for practice
- Stormwater gallery volume exceeds WQv for practice
- The effective SMP volume used for WQv/RRv is the lesser of the applicable SMP volume or WQv/RRv for the practice
- Note: unmet WQv of green roof will drain to stormwater gallery (see next slide)

Stormwater Management Practice	Practice Type	SMP Volume (cf)	Applicable SMP Volume for WQv/RRv (cf)	Adjusted Practice WQv/RRv (cf)	Meets Criteria?	Effective SMP Volume for WQv/RRv (cf)
Green Roof	ET	377.6	377.6	896.8	No	377.6
Stormwater Gallery	Infiltration	9935.5	9935.5	6121.4	Yes	6121.4

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.

	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

Confirm storage volume meets selected practice WQv/RRv

Compare applicable storage volume to WQv/RRv requirement for each practice

- In this case, unmet WQv/RRv of the green roof can be applied to the stormwater gallery, since the green roof drains to the stormwater gallery
- Therefore, some of the unused volume of the stormwater gallery can be applied to meet the practice WQv/RRv criteria, see calculations below
- This would not be the case if the green roof and stormwater gallery had independent contributing 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 (%)

Stormwater Management Practice	Practice Type	SMP Volume (cf)	Applicable SMP Volume for WQv/RRv (cf)	Adjusted Practice WQv/RRv (cf)	Reallocated WQv/RRv (cf)	Meets Criteria?	Effective SMP Volume for WQv/RRv (cf)
Green Roof	ET	377.6	377.6	896.8	896.8 - 519.2	N/A	377.6
Stormwater Gallery	Infiltration	9935.5	9935.5	6121.4	6121.4 + 519.2	Yes	6640.6

Meeting WQv & RRv

Confirm total effective volume meets site WQv/RRv

Confirm total effective volume meets site WQv/RRv

Compare total effective storage volume to WQv/RRv requirement for site

- Total effective SMP volume is the sum of the effective volume of each practice
- That value is then compared to the site WQv/RRv calculated in the first step

Notes:

- The total storage volume of practices does not get compared to site WQv/RRv
- Designers must first consider what storage volume is effective for WQv/RRv management based on the contributing area and other factors

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 (%)

Stormwater Management Practice	Practice Type	SMP Volume (cf)	Applicable SMP Volume for WQv/RRv (cf)	Adjusted Practive WQv/RRv (cf)	Reallocated WQv/RRv (cf)	Meets Criteria?	Effective SMP Volume for WQv/RRv (cf)	Site WQv/RRv	Meets Criteria?
Green Roof	ET	377.6	377.6	896.8	896.8 - 519.2	N/A	377.6	-	
Stormwater Gallery	Infiltration	9935.5	9935.5	6121.4	6121.4 + 519.2	Yes	6640.6	-	
						Total:	**7018.2**	**7018.8**	**Yes**

Meeting WQv & RRv

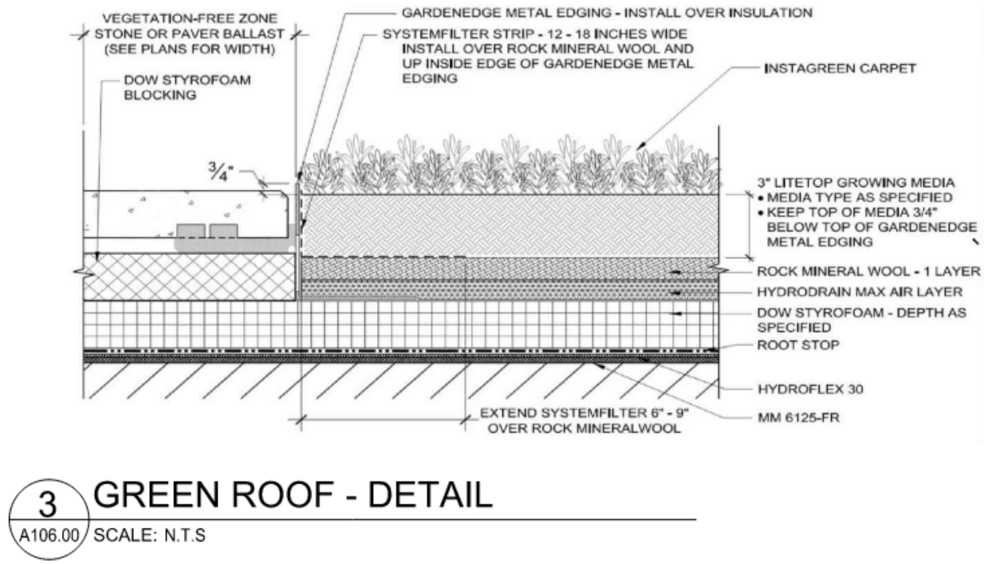
If unmet, modify design as needed

If unmet, modify design as needed

Green roof design

- As noted earlier, green roof requires a 4” minimum media depth (USWR Table 4.3)
- Designers must increase the depth to apply as WQv/RRv practice

- Separately, designers may consider increasing further to meet practice WQv/RRv for green roof, without needed to convey unmet WQv/RRv to stormwater gallery



If unmet, modify design as needed

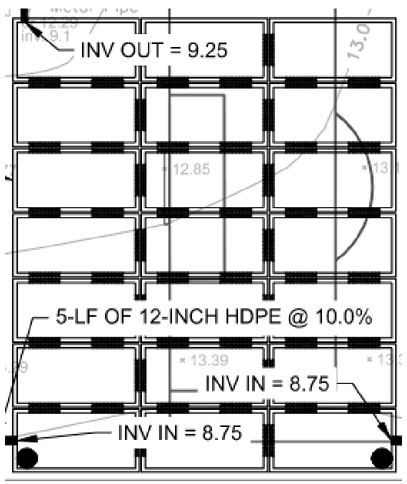
Stormwater gallery design

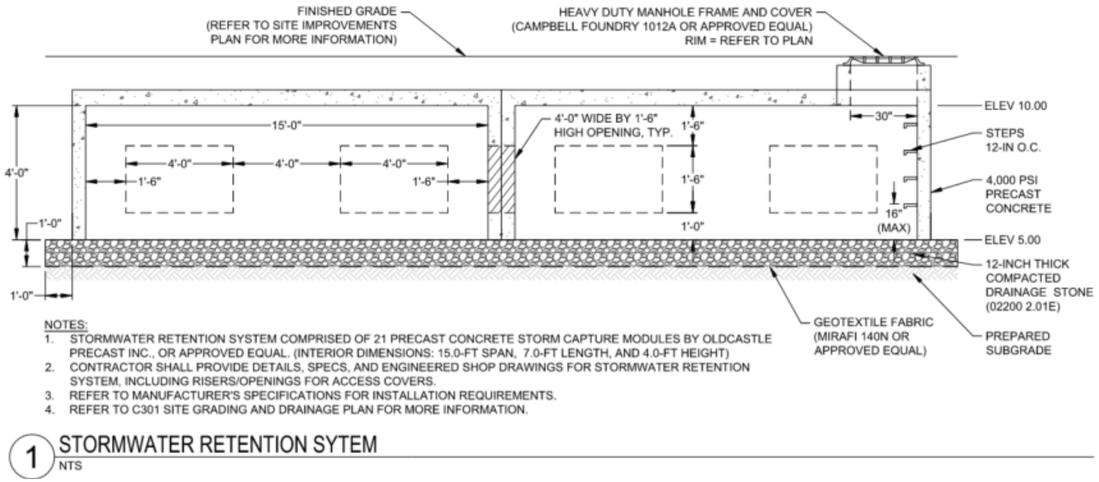
- As noted earlier, stormwater galleries require a maximum drawdown time of 48 hours (USWR Table 4.2)
- Designers must increase the area of the stormwater gallery to meet the drawdown time requirement

- Note that in this case, the stormwater gallery effective storage volume of the gallery ($V_{SMP,Eff}$) is smaller than the available storage volume (V_{SMP}). The drawdown time associated with the effective storage volume meets the drawdown time requirement.

$$dt_{SMP} = \frac{V_{SMP}}{\frac{i}{12} \times A_{INF}} = \frac{9935.5}{\frac{0.74}{12} \times 2205} = \mathbf{73.69\ hr}$$

$$dt_{SMP,Eff} = \frac{V_{SMP,Eff}}{\frac{i}{12} \times A_{INF}} = \frac{6640.6}{\frac{0.74}{12} \times 2205} = \mathbf{48.8\ hr}$$





Meeting WQv & RRv

If still unmet, manage remaining WQv with Tier 3 practices and confirm RRv meets RRv min

If still unmet, manage remaining WQv with Tier 3 practices and confirm RRv meets RRv min

Meeting Minimum Requirements

The primary goal of RRv is to reduce runoff equivalent to the entire WQv using retention-based practices, such as infiltration, ET, and reuse

- In cases where the entire WQv cannot be reduced, designers must show, with no exceptions, that runoff reduction is achieved equivalent to RRv min
- RRv min is calculated using USWR EQ2.2
- Note that even when RRv min is successfully reduced, the entire WQv must still be managed via treatment in MS4 areas or detention in CSS areas.

Notes

- In this case study, the entire WQv was reduced
- Further, RRv min would be zero since no new impervious cover was created

EQ 2.2

$$RR_V = \frac{1.5''}{12} * 0.95 * Aic * S$$

where:
Aic: total area of new impervious cover (sf)
S: specific reduction factor, see Table 2.5

Meeting Vv

Meeting Vv

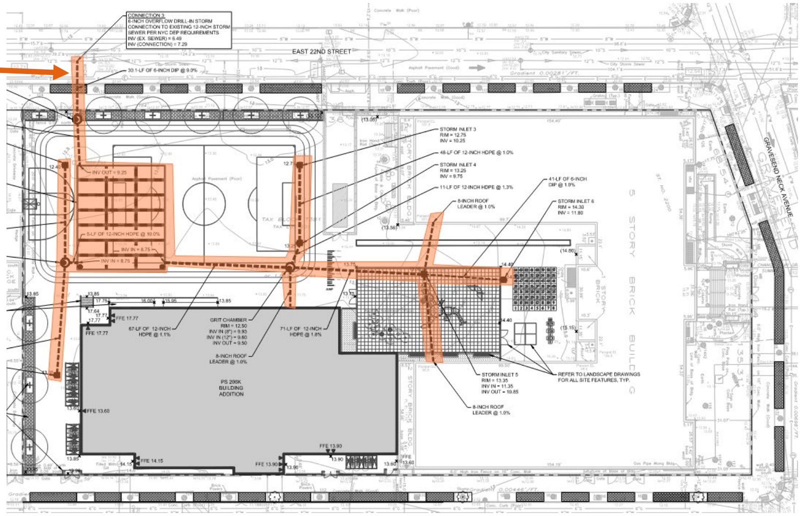
Determine Vv for each site connection

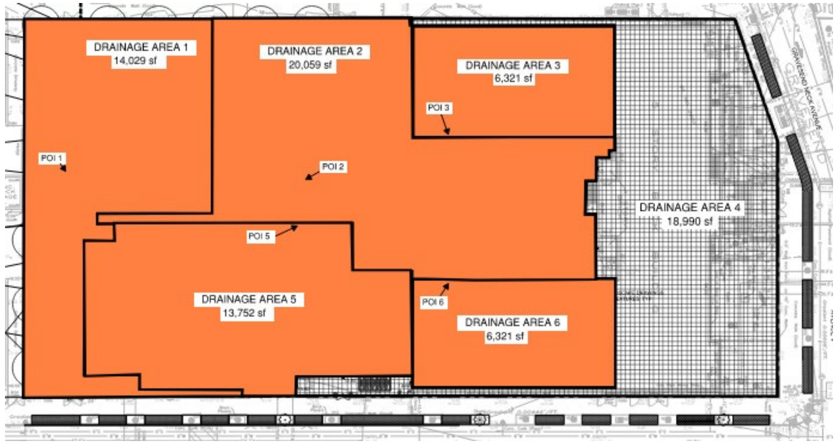
Determine Vv for each site connection

Determine Vv for each site connection

Identify site connections and contributing areas

- Indicate where a new site connection is proposed
  - Indicate whether it is a House or Site Connection Proposal
    - This project includes one site connection proposal
  - Indicate whether it drains to a Combined Sewer System (CSS) or Municipal Separate Storm and Sewer System (MS4)
    - This project drains to an MS4
- Identify drainage areas that contribute to the new connection
  - Drainage Area 1: 14029 sf
  - Drainage Area 2: 20,069 sf
  - Drainage Area 3: 6,321 sf
  - Drainage Area 5: 13,752 sf
  - Drainage Area 6: 6,321 sg



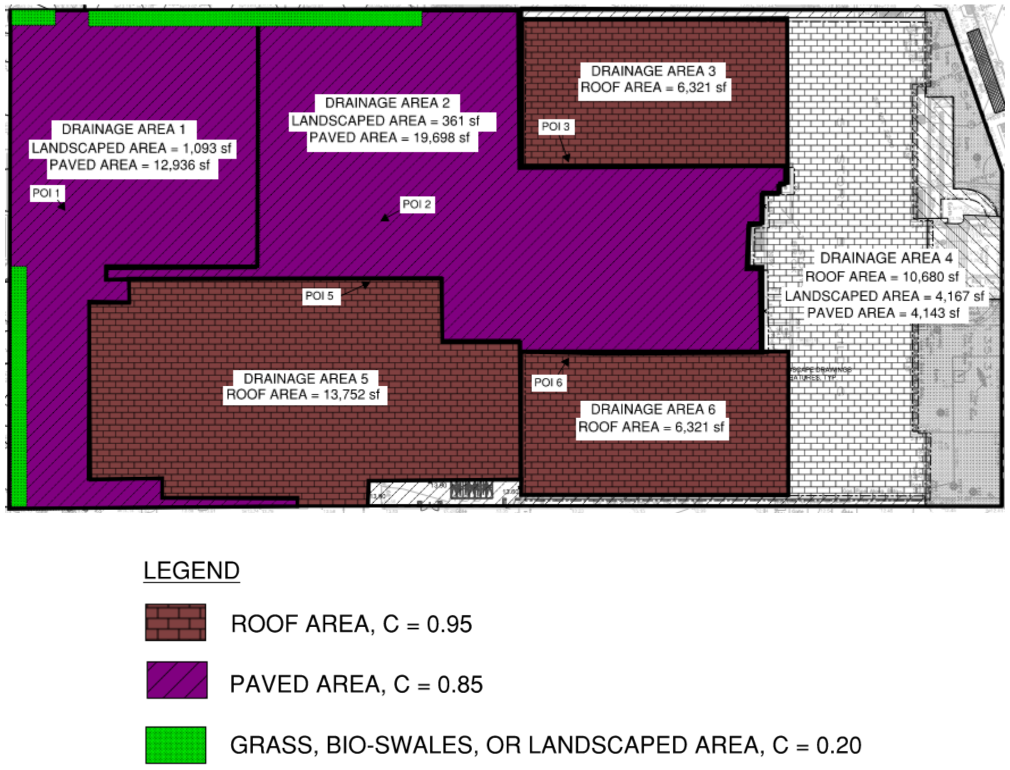


Determine Vv for each site connection

Identify contributing areas and associated runoff coefficients

- Measure the area of each surface type
- Identify the runoff coefficient for each type using USWR Table 2.8
  - In this case, the green roof area is assigned a coefficient of 0.95 (regular rooftop) since the depth of media is 3 inches
  - In cases where a green roof has a depth equal to or greater than 4 inches, a C value of 0.7 is assigned.

Contributing Drainage Area	Total Area (sf)	Landscaped Area (sf)	Paved Area (sf)	Roof Area (sf)
Drainage Area 1	14029	1093	12936	0
Drainage Area 2	20059	361	19698	0
Drainage Area 3	6321	0	0	6321
Drainage Area 4	-	-	-	-
Drainage Area 5	13752	0	13752	0
Drainage Area 6	6321	0	0	6321
Total Areas Contributing to Site Connection 3	**60482**	**1454**	**46386**	**12642**



Determine Vv for each site connection

Calculate Vv

- $R_D(in) = 1.50$
  - Rainfall depth for MS4 areas with SCP (USWR Table 2.7)
- $A = 14029 + 20059 + 6321 + 13752 + 6321 = 60482$
  - Sum of contributing drainage areas shown in Step 1.2
- $C_W = \frac{1454 \times 0.20 + 46386 \times 0.85 + 12642 \times 0.95}{1454 + 46386 + 12642} = 0.8553$
  - Weighted average of the runoff coefficients for landscaped, paved, and roofed areas identified in Step 1.2
- $V_V = \frac{1.5''}{12} \times 60482 \times 0.8553 = 6466.3\ cf$

EQ 2.3

$$V_V = \frac{R_D}{12} * A * C_W$$

where:

V_V: sewer operations volume (cf)

R_D: rainfall depth (in)

A: contributing area (sf)

C_W: weighted runoff coefficient relating peak rate of rainfall and runoff

$$V_V = 6466.3\ cf$$

Meeting Vv

Calculate portion of Vsmp that may be applied to Vv

Calculate portion of WQv that may be applied to Vv

Calculate the applicable storage volume for each practice and determine if Vv is met

- Identify the percent of each SMP volume that may be applied to Vv (USWR Table 4.1)
  - Green roof volume cannot be applied to Vv because it is an evapotranspiration practice
  - However, if rooftop drains were outfit with flow control device, then some volume from blue/green roof system may be applied
  - 50% of the stormwater gallery volume can be applied to Vv
- $V_A = V_{SMP,SG} \times 50\% = 9935.5 \times 50\% = 4967.8\ cf$
  - Note that the entire stormwater gallery volume is considered infiltration because the invert of the gallery is above the site connection manhole
- $V_V = 6466.3\ cf > V_A$
  - Vv is not met by existing practices

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.

	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

Meeting Vv

If unmet, modify design to meet criteria

If unmet, modify design to meet criteria

Determine whether modifications to existing practices can achieve Vv and make necessary modifications

- A portion of the required Vv for the new site connection is not met by existing practices
    - $V_{V,remaining} = V_V - V_A = 6466.3 - 4967.8 = 1498.5\ cf$

Stormwater Management Practice	Vv (cf)	SMP Volume (cf)	Volume of Practice Credited to Vv	Vv met?	Remaining Vv
Stormwater Gallery	6466.3	9935.5	4967.8	NO	1498.5

The stormwater gallery does not contain sufficient volume to meet Vv. The design must be modified to increase volume. For infiltration practices, 2996.7 cf of additional volume would be required. For detention practices, 1498.5 cf of additional volume would be required.

For example, using the current infiltration stormwater gallery, an additional 840 sf of area would be needed to meet the requirement.