VERMONT

Design Examples Using RCN Approach – Take Two

Vermont Stormwater Management Manual Update, Meeting #6

Shelburne Town Offices

June 13, 2014

STONE ENVIRONMENTAL INC

Horsley Witten Group
Sustainable Environmental Solutions

Adamant Accord
Meeting Facilitation and Mediation Services

RCN Tables: HSG D – Area Weighted CN Woods in "Good Condition"

HydroGroup D

Predevelopment CN 77

woods "in good condition"

		Storm Depth Treated by Runoff Reduction Practices (inches)								
%I	CN	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6
0%	80									
5%	81									
10%	82									
15%	83									
20%	84									
25%	85	79								
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40%	87	79	77							
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50%	89	80	77							
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75%	94	82	79							
80%	94	83	79							
85%	95	84	80							
90%	96	84	81	77						
95%	97	85	82	77						
100%	98	86	82	78						

RCN Tables: HSG D – Volume Weighted CN Woods in "Good Condition"

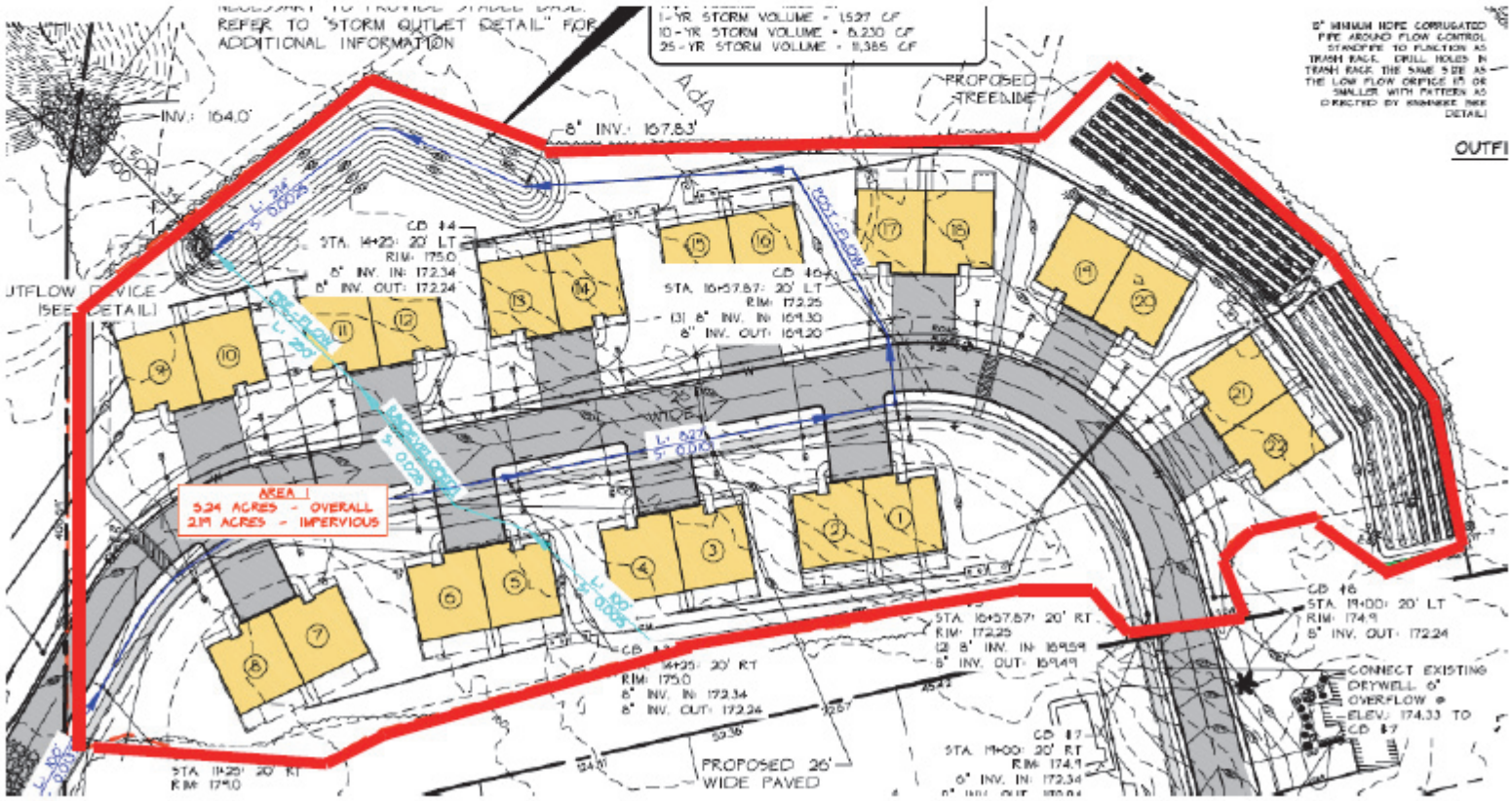
	Depth Runoff Treated with GSI (inches)								
%I	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6
0%	74	74	74	74	74	74	74	74	74
5%	75	75	75	75	75	75	75	75	74
10%	77	77	77	76	76	75	75	74	74
15%	78	78	77	76	76	75	75	74	73
20%	79	78	77	77	76	75	74	74	73
25%	80	79	78	77	76	75	74	73	72
30%	80	79	78	77	76	75	74	73	72
35%	81	80	79	77	76	75	74	72	71
40%	82	80	79	78	76	75	74	72	70
45%	82	81	79	78	77	75	73	72	70
50%	83	81	80	78	77	75	73	71	69
55%	83	82	80	79	77	75	73	71	69
60%	84	82	81	79	77	75	73	70	68
65%	84	83	81	79	77	75	72	70	67
70%	85	83	81	79	77	75	72	70	67
75%	86	84	82	79	77	75	72	69	66
80%	86	84	82	80	77	75	72	69	65
85%	87	85	82	80	77	75	72	68	65
90%	87	85	83	80	78	75	71	68	64
95%	88	85	83	80	78	75	71	67	63
100%	88	86	83	81	78	75	71	67	62

Area vs. Volume Weighted CN

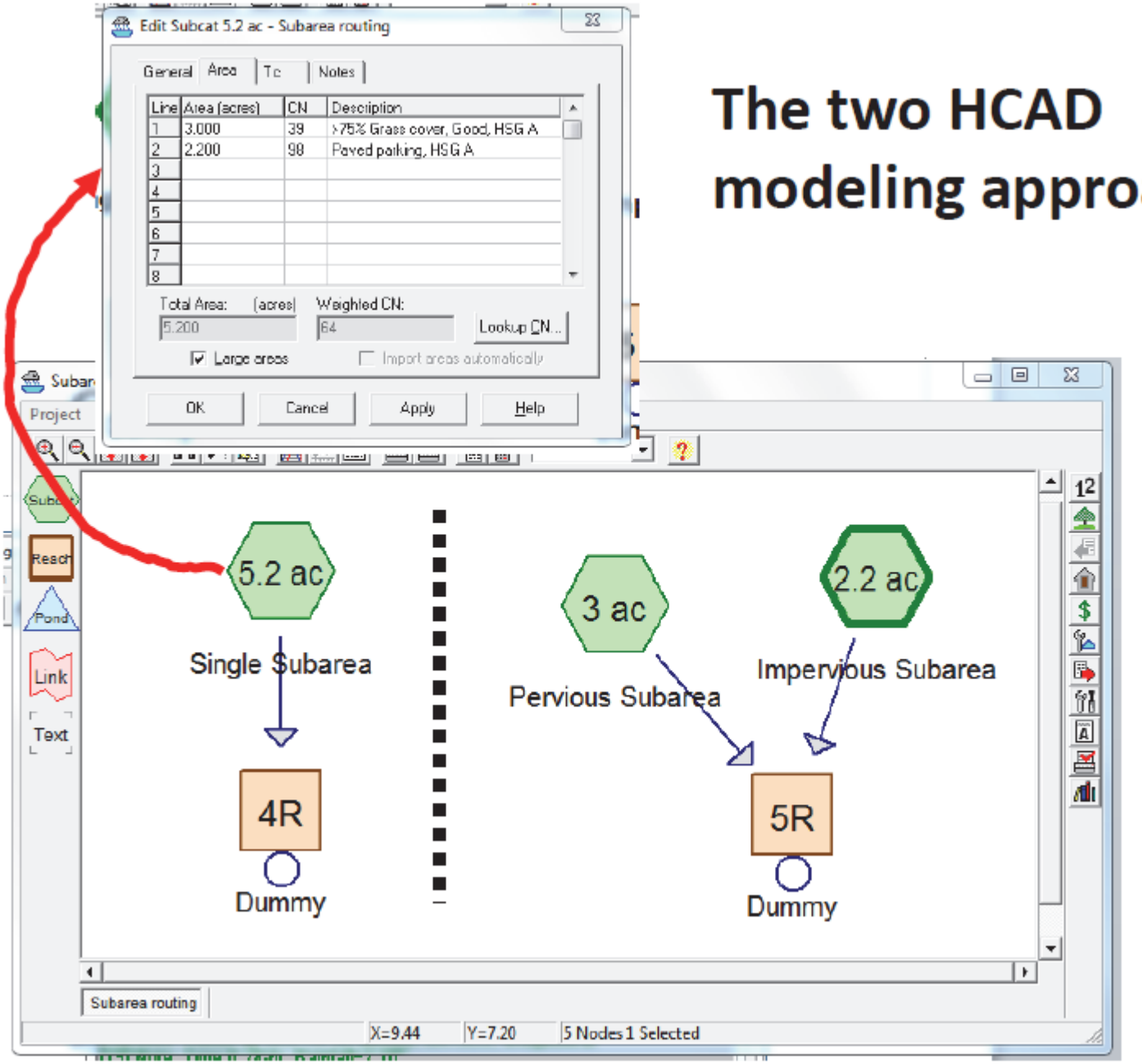
5.2 site acres

42% impervious

HSG A Soils

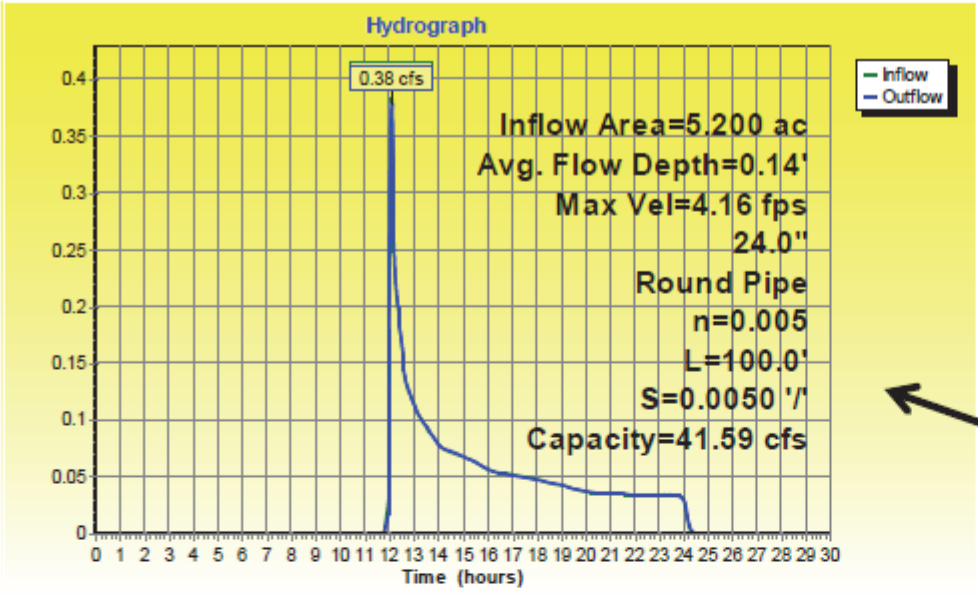


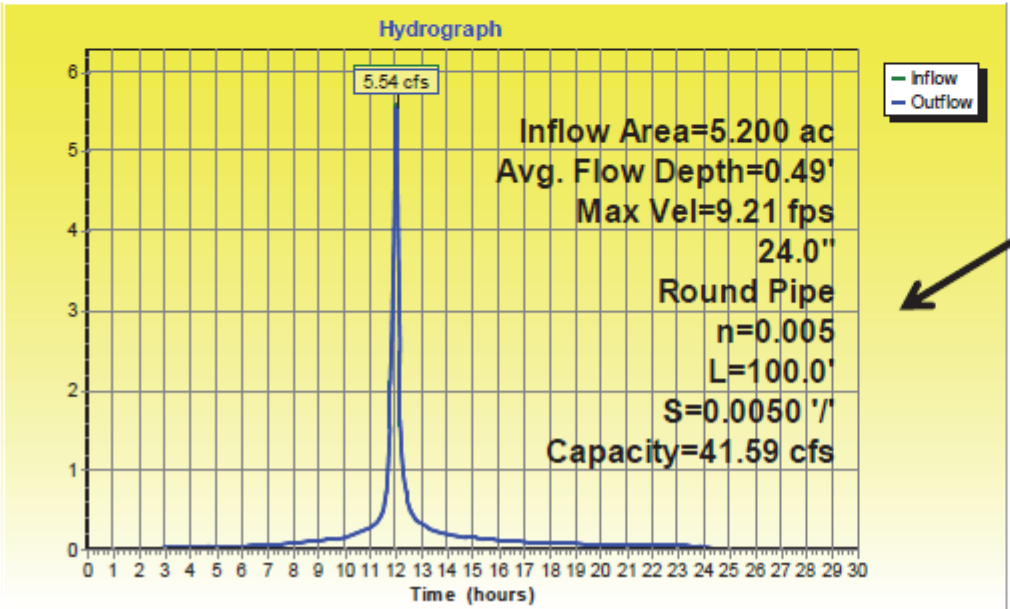
Area vs. Volume Weighted CN

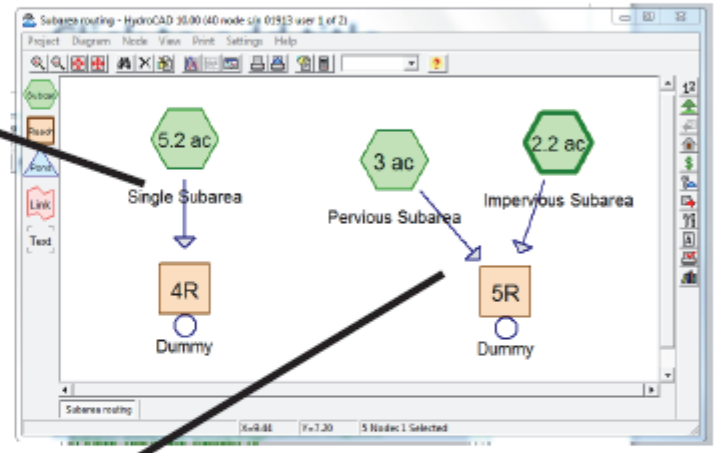


The two HCAD modeling approaches

Area vs. Volume Weighted CN







Big difference in resulting flows

RCN Tables: HSG D – Volume Weighted CN Open Space in "Good Condition"

	Depth Runoff Treated with GSI (inches)								
%I	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6
0%	77	77	77	77	77	77	77	77	77
5%	78	78	78	78	78	78	78	78	77
10%	79	79	79	79	79	78	78	77	77
15%	81	80	80	79	78	78	77	77	76
20%	81	81	80	79	78	78	77	76	75
25%	82	81	80	79	78	78	77	76	75
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75%	86	84	82	80	78	76	73	70	67
80%	87	85	83	80	78	75	73	70	66
85%	87	85	83	80	78	75	72	69	65
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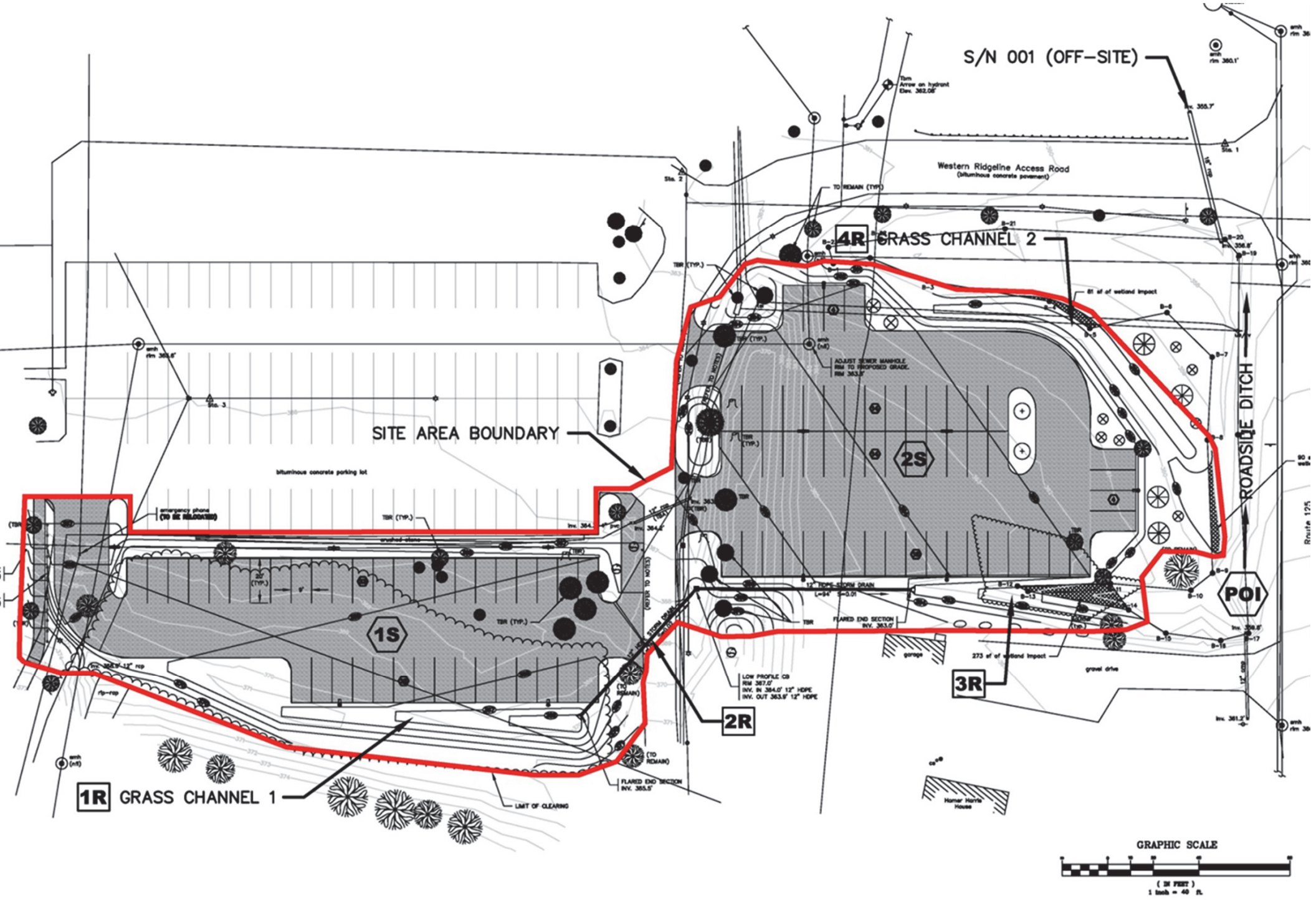
Our Site – Overflow Parking Lot



Our Site – Overflow Parking Lot

Site Data:

- Location: Addison County, VT
- Parcel Area: 1.37 acres
- Site Area: 0.99 acres
  - DA #1: 0.42 acres
  - DA #1 Imperv: 0.28 acres
  - DA #2: 0.57 acres
  - DA #2 Imperv: 0.45 acres
- Soils: 100% HSG D

Step 1: Site Planning

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Section 1 – Stormwater Treatment Practice Sizing Criteria

Section 2 – Required Site Planning Practices

Section 3 – Non-Structural Stormwater Treatment Practices

Section 4 –Structural Stormwater Treatment Practices

Section 5 – Limited Applicability Structural STPs

Step 1: Site Planning

VSMM 2014?, VOL. 1

- Section 1 – Stormwater Treatment Practice Sizing Criteria
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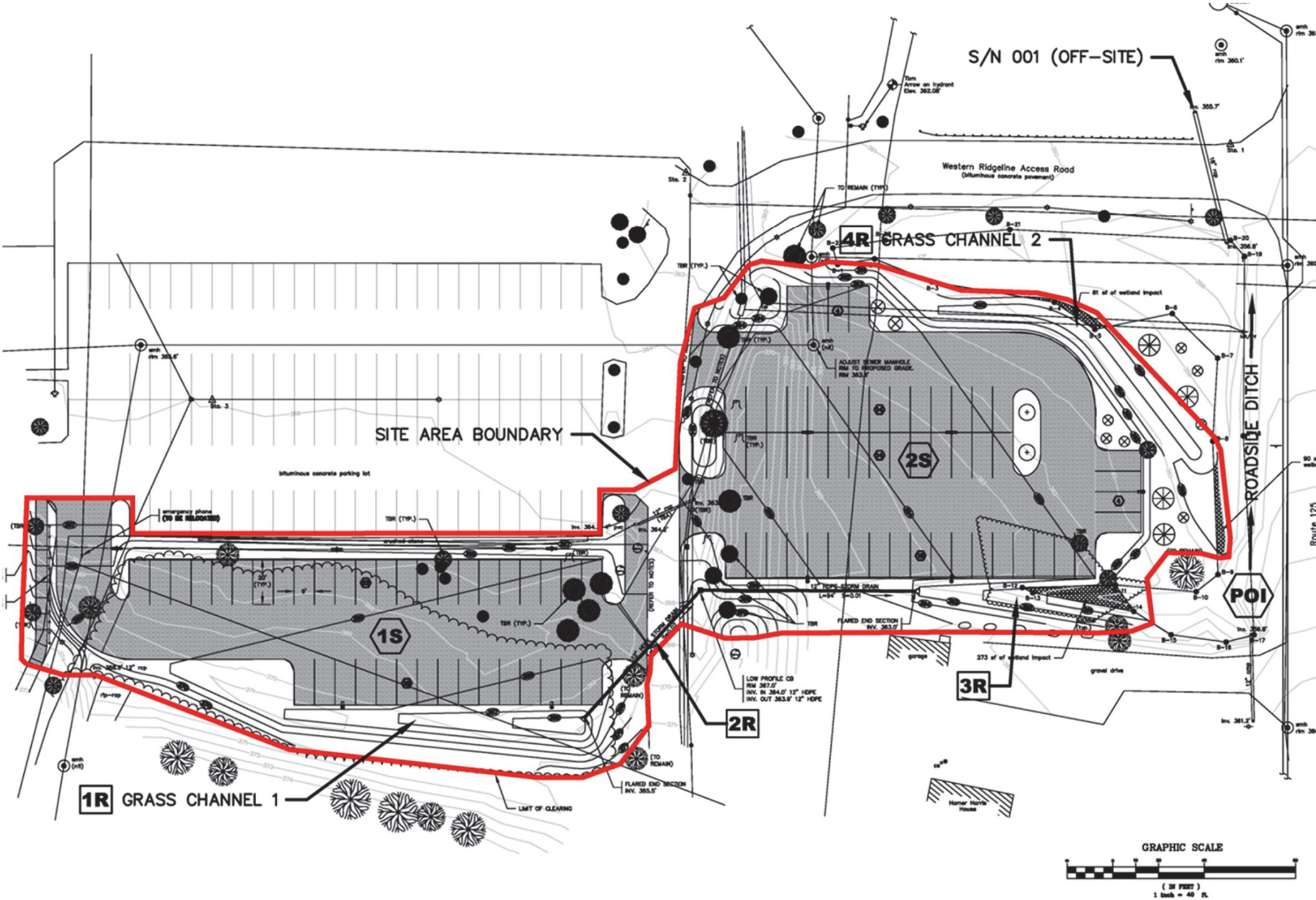
- Section 5 – Limited Applicability Structural STPs

Step 1: Site Planning

- Project Layout and Site Design
  - Natural Area Conservation: not applicable to this already developed site
  - Buffer/Floodplain Protection: there are no streams, wetlands, or other sensitive areas on or adjacent to this site.
  - Limit Site Clearing/Grading: grading activities will be limited to the minimum needed to construct the parking lot (0.99 acres of the 1.37 acre parcel).
  - Post-Construction Soil Depth and Quality: This standard will be met for any portion of the cleared/graded area that remains pervious (landscaped, lawn, etc.) after the project is complete.


S/N 001 (OFF-SITE)
Western Ridgeline Access Road
(bituminous concrete pavement)
4R
GRASS CHANNEL 2
SITE AREA BOUNDARY
bituminous concrete parking lot
2S
1S
ROADSIDE DITCH
POI
2R
3R
1R
GRASS CHANNEL 1
LIMIT OF CLEARING
garage
gravel drive
Homer Harris House
GRAPHIC SCALE
(IN FEET)
1 inch = 40 ft.

Step 1a: Determine Stormwater Management Goal

- Pre-development conditions:

HSG	RCN†	Site Area (acres)	% of Site Area
A	38	-	-
B	55	-	-
C	70	20.0	100%
D	77	-	-

- Since the site is entirely underlain by HSG D soils, RCN = 77

Step 1a: Determine Stormwater Management Goal

- To determine target rainfall for sizing practices (PE), first calculate proposed imperviousness (%I):

- %I = Impervious Area (acres)/ Drainage Area (acres)

  - DA #1 %I = 0.28 acres / 0.42 acres = 67%
  - DA #2 %I = 0.45 acres / 0.57 acres = 79%

- Using the area-weighted CN for woods in “good condition”

Step 1a:
Determine Stormwater Management Goal

HydroGroup D

Predevelopment CN: 77

woods "in good condition"

		Storm Depth Treated by Runoff Reduction Practices (inches)								
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Step 1a:
Determine Stormwater Management Goal

HydroGroup D

Predevelopment CN 77

woods "in good condition"

DA #1 %I = 67%

		Storm Depth Treated by Runoff Reduction Practices (inches)								
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$P_E >= 1.4$ inches will reduce the RCN to reflect woods in "good condition"

Step 1a:
Determine Stormwater Management Goal

HydroGroup D

Predevelopment CN 77

woods "in good condition"

DA #2 %I = 79%

		Storm Depth Treated by Runoff Reduction Practices (inches)								
%I	CN	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6
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95%	97	85	82	77						
100%	98	86	82	78						

$P_E >= 1.4$ inches will reduce the RCN to reflect woods in "good condition"

Step 1a: Determine Stormwater Management Goal

- Stormwater management target for the Overflow Parking Lot project is P_E = 1.4 inches
- Target rainfall then needs to be translated into a volume target (V_{PE}):

$$V_{PE} = \frac{(P_E)(R_V)(A)}{12}$$

where:

V_{PE} = Target volume (acre-feet)

P_E = Rainfall depth (inches)

R_V = Runoff coefficient [0.05 + 0.009(I)], unitless

I = Impervious cover (whole number percent)

A = Site area (acres)

Step 1a:
Determine Stormwater Management Goal

$$V_{PE\ DA\ \#1} = \frac{(P_E)(R_V)(A)}{12} = \frac{(1.4)(.653)(.42)}{12} = 0.032 \text{ ac-ft}$$

$$= 1{,}394 \text{ ft}^3$$

$$V_{PE\ DA\ \#2} = \frac{(P_E)(R_V)(A)}{12} = \frac{(1.4)(.761)(.57)}{12} = 0.051 \text{ ac-ft}$$

$$= 2{,}204 \text{ ft}^3$$

Step 1: Site Planning

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Step 2:
Apply Non-Structural Practices

- Non-Rooftop Disconnection:
  - A portion (25’ x 120’, or 0.07 acres) of Overflow Parking Lot DA #1 will be disconnected into a vegetated area that is 25’ wide and has an average slope of less than 5%.
- Assume disconnection flow path length will be 25 feet

Step 2:
Apply Non-Structural Practices

Buffer Slope	<5%	5-10%	10-15%
Minimum Buffer Width (feet)	20	35	50
Contributing Impervious Surface Width (feet)	Up to 20	Up to 20	Up to 20
Contributing Impervious Surface Widths Over 20 feet	+ 5 feet of width must be added for additional 5 feet of contributing width or fraction thereof, up to a maximum of 75 feet of total contributing width		
Maximum Buffer Width (feet)	75	90	105

Hydrologic Soil Group (HSG)	PE (in.)
A/B	0.5
C/D	0.25

Step 2:
Apply Non-Structural Practices

- Non-Rooftop Disconnection:
  - Need to "translate" P_E to and equivalent V_{PE} so that the cumulative volume for structural and non-structural practices

$$\mathbf{V_{PE}} = \frac{(P_E)(R_V)(A)}{12} = \frac{(0.25)(.95)(0.07)}{12} = 0.001 \text{ ac-ft}$$

$$= \mathbf{60\ ft^3}$$

Step 2:
Apply Non-Structural Practices

- Non-Rooftop Disconnection:
  - The remaining V_{PE} that must be captured and treated for DA #1 is:

$$V_{PE\ DA\ \#1} = 1{,}394\ ft^3 - 60\ ft^3 = \mathbf{1{,}334\ ft^3}$$

Step 1: Site Planning

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Step 3:
Apply Structural (GSI) Practices

- Swales:
  - Remaining V_{PE} in DA #1 (1,334 ft^3) will be treated using a dry swale, installed along the edge of the parking lot
  - The swale will:

    Capture and treat runoff from 0.35 acres of parking lot

    Have 2' of soil media

    Incorporate check dams to have a maximum effective slope of 1%, and allow water to pond to a maximum depth of 6 inches

    Have an underdrain, with a 12-inch stone sump below the invert

Step 3:
Apply Structural (GSI) Practices

- Swales are ultimately designed for some amount of conveyance, in addition to treatment, the treatment volume will need to be reduced
  - For dry swales with an effective slope between 1% and 2% (with or without an underdrain), the treatment volume will need to be reduced by a factor of 0.4 (VA DCR 2011):

$$V_{PE\ (adj)} = 0.4(V_{PE})$$

  - For dry swales with a maximum effective slope of not more than 1%, which are underlain by soils suitable for infiltration or where a minimum 12-inch stone sump is provided below the invert of the underdrain, the treatment volume will only need to be reduced by a factor of 0.6 (VA DCR 2011):

$$V_{PE\ (adj)} = 0.6(V_{PE})$$

Step 3:
Apply Structural (GSI) Practices

- Because our design includes an underdrain it will be reduced by a factor of 0.6.
- Adjusted volume of runoff that must be treated and captured is:

$$V_{PE\ adj} = V_{PE\ DA\ \#1} / 0.6 = 1{,}334\ ft^3 / 0.6 = 2{,}223\ ft^3$$

Step 3:
Apply Structural (GSI) Practices

- In order to calculate the surface area (SA) of a swale able to treat this volume, we must first calculate the storage void volume available within the swale ($V_{PE\ adj}$).
- The accepted void ratios (V_r) for the materials being employed are:
  - Soil Media $V_r = 0.25$
  - Gravel $V_r = 0.40$
  - Surface Storage $V_r = 1.0$
- And:

$$V_{PE\ adj} = [\ (V_r \times D) + (V_r \times D) \ldots\ ]$$

where D = media depth in feet

Step 3:
Apply Structural (GSI) Practices

- So:

$$V_{PE\ adj} = [(0.25 \times 2) + (0.40 \times 1) + (1.0 \times 0.5)] = 1.4$$

$$SA = V_{PE\ adj} / 1.4 = 2{,}223 / 1.4 = 1{,}590\ ft^2$$

- If we then assume the bottom of our swale is 6 feet wide, the length required to treat the balance $V_{PE\ DA\ \#1}$ and meet the Hydrologic Condition Standard is:

$$1{,}590\ ft^2 / 6\ ft = 265\ feet.$$

Step 3:
Apply Structural (GSI) Practices

- Bioretention:
  - DA #2 will be treated using a bioretention facility
  - Total area draining to the facility is 0.57 acres, of which 0.45 acres is impervious
  - The volume of runoff that must be captured and treated is 2,204 ft^3
  - The bioretention practice will:

    Have 2' of soil media

    Allow water to pond to a maximum depth of 12 inches

    Have an underdrain, supported by 6-inches of stone

Step 3:
Apply Structural (GSI) Practices

- Bioretention:
  - In order to calculate the surface area (SA) of a swale able to treat this volume, we must first calculate the storage void volume available within the swale ($V_{PE\ adj}$).
  - The accepted void ratios (V_r) for the materials being employed are:

$$\text{Soil Media } V_r = 0.25$$

$$\text{Gravel } V_r = 0.40$$

$$\text{Surface Storage } V_r = 1.0$$

- And:

$$V_{PE\ adj} = [\ (V_r \times D) + (V_r \times D) \ldots\ ]$$

where D = media depth in feet

Step 3:
Apply Structural (GSI) Practices

- Bioretention:
  - For bioretention practices employing an underdrain (e.g., any site unable to demonstrate a minimum infiltration rate of 0.5 in/hour), the treatment volume will need to be reduced by a factor of 0.6 (ISBD 2011):

$$V_{PE\ adj} = 0.6(V_{PE\ DA\ \#2})$$

  - Adjusted volume of runoff that must be treated and captured is:

$$V_{PE\ adj} = V_{PE\ DA\ \#2} / 0.6 = 2{,}204\ ft^3 / 0.6 = 3{,}673\ ft^3$$

Step 3:
Apply Structural (GSI) Practices

- Bioretention:

So:

$$V_{PE\ adj} = [(0.25 \times 2) + (0.40 \times 0.5) + (1.0 \times 0.5)] = 1.2$$

$$SA = V_{PE\ adj} / 1.2 = 3{,}673 / 1.2 = 2{,}625\ ft^2$$

Or roughly 40’ x 65’

Questions?