DESIGN EXAMPLES: COMPUTING STORMWATER TREATMENT PRACTICE SIZING CRITERIA

Design examples are provided to illustrate how stormwater sizing criteria are computed. Examples are drawn from actual Vermont projects, to the extent possible.

Design Example #3: Commercial Development – Lacustrine Lodge

The layout of the Lacustrine Lodge is shown in Figure 1.

Site Data:

Location:	Chittenden County, VT
Parcel Area:	7.7 acres
Site Area:	2.0 acres
Drainage Area:	2.0 acres
Soils:	20% C, 80% D
Impervious Area:	1.5 acres

Step 1: Project Layout and Site Design

In this design example, several project layout and site design practices will be applied to meet the Environmental Site Design Standard:

- **Natural Area Conservation**: not applicable to this small and already-developed site.
- **Buffer/Floodplain Protection**: Setbacks to wetland areas will be protected; there are no streams, steep slopes, or other sensitive areas on or adjacent to the site.
- **Limit Site Clearing/Grading**: Grading activities will be limited to the minimum needed to construct the project (2.0 acres of the 7.7 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.

Step 1a: Determine Stormwater Management Goals

Once project layout and site design concepts have been applied and the Site Area is known, the following basic steps should be followed to develop initial targets for stormwater management that will achieve the Water Quality Treatment Standard and the Hydrologic Conditions Standard.

A. Determine Pre-Development Conditions:

The goal for new development projects is to manage stormwater in such a way as to mimic pre-development runoff characteristics – "woods in good condition."

HSG	RCN†	Site Area (acres)	% of Site Area
A	38	-	-
B	55	-	-
C	70	0.4	20%
D	77	1.6	80%

† RCN for "woods in good condition" (Table 2-2c, TR-55, USDA NRCS 1986)

The next step is to calculate a composite RCN for "woods in good condition" for the site:

$$RCN_{woods} = \frac{(70 \text{ x } 0.4 \text{ acres}) + (77 \text{ x } 1.6 \text{ acres})}{2.0 \text{ acres}} = 75.6$$

To be conservative, the target RCN "woods in good condition" used at this project site should be 76.

B. Determine Target P_E Using Table 1:

P_E = Rainfall used to size ESD practices

During project planning and preliminary design, site soils and proposed imperviousness are used to determine the target P_E for sizing practices to mimic wooded conditions.

Proposed Imperviousness = Impervious Area / Drainage Area
= 1.5 acres / 2.0 acres = 75%

For this example, assume imperviousness is distributed proportionately (80/20) in C and D soils. From Table 1, using %I = 75%:

For C soils: $P_E >= 1.6$ inches will reduce the RCN to reflect "woods in good condition"

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

Because the site is predominated by D soils, use $P_E = 1.4$ inches as the target for ESD implementation.

If a combination of non-structural and structural stormwater management practices can be used to meet these targets, both the Water Quality Treatment Standard and the Hydrologic Conditions Standard will be satisfied.

Step 2: Apply Non-Structural Stormwater Treatment Practices and
Step 3: Apply Structural (GSI) Stormwater Treatment Practices

Potential practices that could be used at this site include disconnection of runoff, swales, or bioretention—but for this example, we have assumed that only a portion of P_E – the first inch of rainfall over the entire site area – can be managed using non-structural and structural stormwater management practices, meaning limited applicability practices will need to be utilized in order to meet the Hydrologic Conditions Standard.

Step 4: Apply Other / Limited-Applicability Structural Stormwater Treatment Practices

For this example, because the non-structural and structural stormwater management practices implemented were only able to treat only the first inch of rainfall (e.g., $P_E = 1.0$ inches, which is also the Water Quality Treatment Standard), the following basic steps would be followed to determine how much additional stormwater management is needed to meet the Hydrologic Conditions Standard.

A. Calculate Reduced RCN

To determine the Reduced RCN for P_E = 1.0 inches, use Table 1 and %I = 75%:

For C soils: P_E = 1.0 inches and %I = 75 %, Reduced RCN = 79

For D soils: P_E = 1.0 inches and %I = 75 %, Reduced RCN = 82

A composite Reduced RCN is then calculated as follows for P_E = 1.0 inches:

$$RCN_{reduced} = \frac{(79 \times 0.4 \text{ acres}) + (82 \times 1.6 \text{ acres})}{2 \text{ acres}} = 81.4$$

To be conservative use RCN = 82.

B. Calculate Cp_v Requirements

The composite RCN for "woods in good condition" is 76 (see Step 1.A above).

The design RCN (82) does not reflect the composite RCN for "woods in good condition" (76) and, therefore, CP_v must be addressed. However, P_E >= 1.0 inches and CP_v requirements are based on the runoff from the 1-year, 24-hour design storm calculated using the Reduced RCN (82). Using P_E = 1.0 inches and RCN = 82:

CP_v = Q_1 x A, where Q_1 is the runoff from the 1-year, 24-hour design storm

$$Q_1 = \frac{(P - (0.2 \times S)^2)}{(P + (0.8 \times S))}$$ *(Equation 2-3, TR-55, USDA NRCS 1986)*

where: P = 1-year, 24-hour design storm = 2.1 inches for Chittenden County

S = (1000 / RCN) – 10 *(Equation 2-4, TR-55, USDA NRCS 1986)*

S = (1000 / 82) – 10 = 2.2

$$Q_1 = \frac{(P - (0.2 \times S))^2}{(P + (0.8 \times S))} = \frac{(2.1 - (0.2 \times 2.2))^2}{(2.1 + (0.8 \times 2.2)} = \frac{2.76}{3.86}$$ =0.72 inches*(1 foot/12 inches)=0.06 ft.

CP_v = 0.06 ft. x 2 acres = 0.12 ac-ft*(43,560 ft^3/ 1 ac-ft) = 5,227 ft^3

Cp_v Storage Requirements for Lacustrine Lodge

Rainfall (P_E)	Additional CP_v Required		Notes:
	(ac-ft)	(ft^3)	
P_E >= 1.4 inches	NA	NA	Target P_E for RCN = woods
P_E = 1.0 inches	0.12	5,227	Design P_E based on reduced RCN
Conventional Design	0.25	10,890	

In sum, stormwater management requirements for the Lacustrine Lodge project include using non-structural and structural stormwater management practices to treat 1.0 inches of rainfall, and limited applicability stormwater management practices to treat the reduced CP_v of 5,227 cubic feet.

Figure 1: Lacustrine Lodge Site Plan

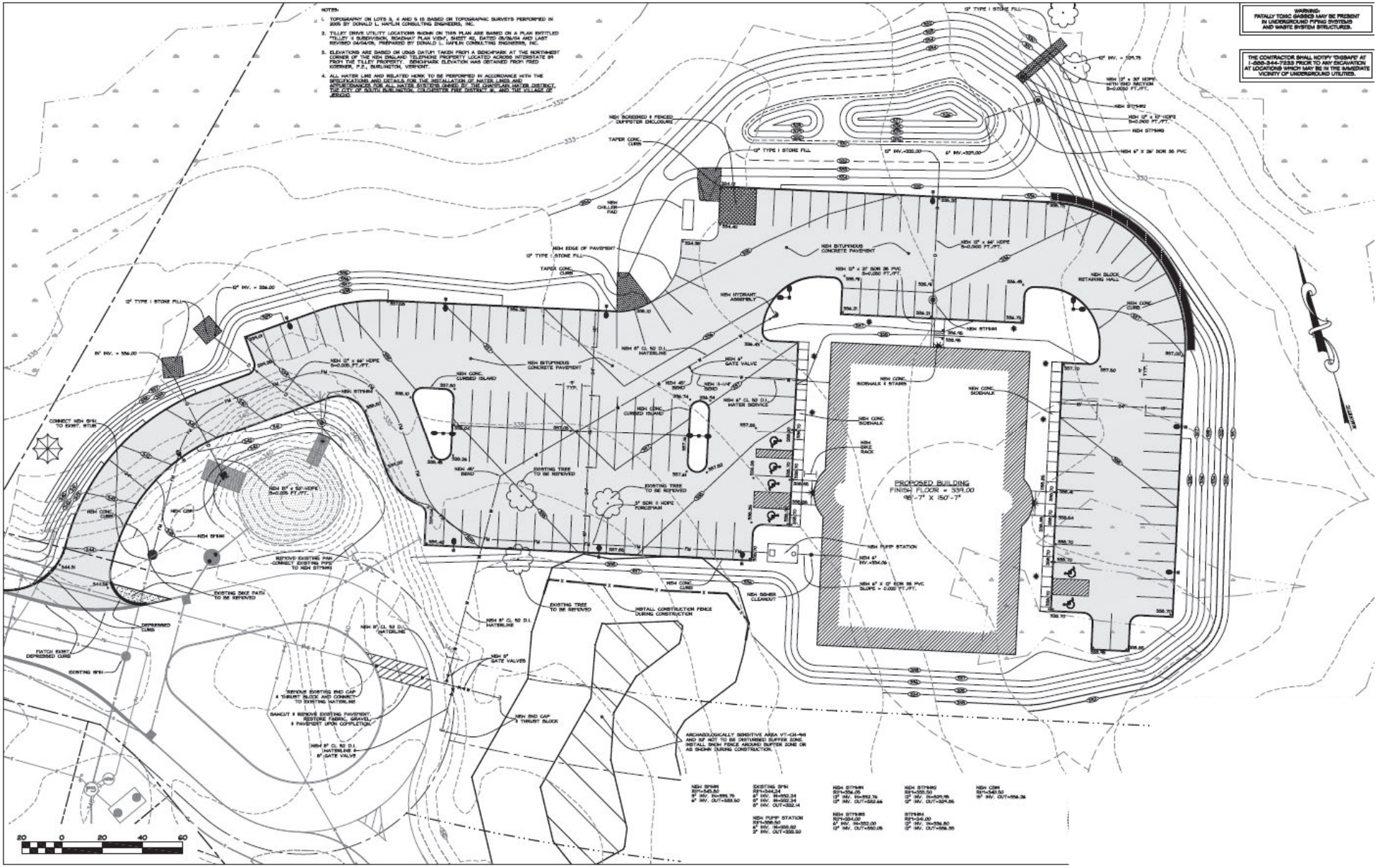

Table 1: RCN Reductions for HSG C and D Soils

HydroGroup C

Predevelopment CN 70

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%	74									
5%	75									
10%	76									
15%	78									
20%	79	72								
25%	80	72								
30%	81	73	71							
35%	82	73	71							
40%	84	74	71							
45%	85	74	71							
50%	86	75	72							
55%	87	76	72							
60%	88	76	73							
65%	90	77	74							
70%	91	78	75	70						
75%	92	79	76	71						
80%	93	81	77	72						
85%	94	82	78	74						
90%	96	83	79	75						
95%	97	85	81	76	71					
100%	98	86	82	78	73					

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								
30%	85	79								
35%	86	79								
40%	87	79	77							
45%	88	79	77							
50%	89	80	77							
55%	90	80	77							
60%	91	81	78							
65%	92	81	78							
70%	93	82	78							
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						