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# Module 9

## Evaluating Water Quantity Compliance

Virginia Department of Environmental Quality

# Module 9. Content

- 9a. Effective CNs *(review)*
- 9b. Routing vs. CN Adjustment *(practical training)*
- 9c. Enhancing Storage at Practices *(practical training)*
- 9d. Traditional CNs
- 9e. Rational Method *(review)*

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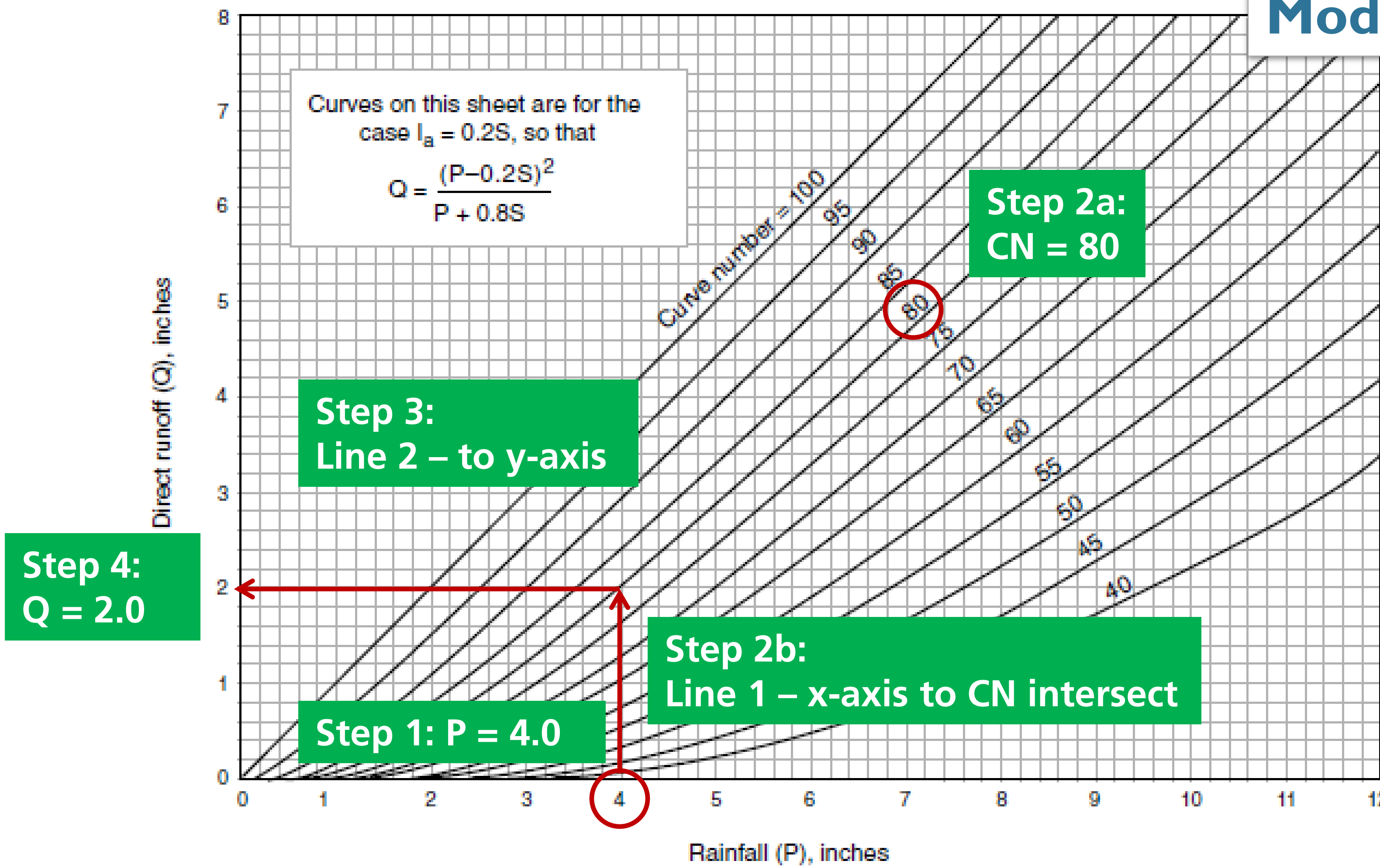
# Review – *Graphical Solution*

**Mod 3, p. 19**
**Mod 5, p. 19**




**Given a watershed with a CN of 80, what would be the direct runoff (Q) from a rainfall (P) of 4.0 inches?**

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# Review – *Tabular Solution*

**Mod 3, p. 20**

**Table 2-1** Runoff depth for selected CN's and rainfall amounts [1/]

| Rainfall | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Runoff depth for curve number of— (inches) | | | | | | | | | | | | |
| 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.08 | 0.17 | 0.32 | 0.56 | 0.79 |
| 1.2 | .00 | .00 | .00 | .00 | .00 | .00 | .03 | .07 | .15 | .27 | .46 | .74 | .99 |
| 1.4 | .00 | .00 | .00 | .00 | .00 | .02 | .06 | .13 | .24 | .39 | .61 | .92 | 1.18 |
| 1.6 | .00 | .00 | .00 | .00 | .01 | .05 | .11 | .20 | .34 | .52 | .76 | 1.11 | 1.38 |
| 1.8 | .00 | .00 | .00 | .00 | .03 | .09 | .17 | .29 | .44 | .65 | .93 | 1.29 | 1.58 |
| [illegible] | .00 | .00 | .00 | .02 | .06 | .14 | .24 | .38 | .56 | .80 | 1.09 | 1.48 | 1.77 |
| [illegible] | .00 | .00 | .02 | .08 | .17 | .30 | [illegible] | [illegible] | .89 | 1.18 | 1.53 | 1.96 | 2.27 |
| [illegible] | .00 | .02 | .09 | .19 | .33 | .51 | [illegible] | [illegible] | 1.25 | 1.59 | 1.98 | 2.45 | 2.77 |
| 3.5 | .02 | .08 | .20 | .35 | .53 | .75 | [illegible] | [illegible] | 1.64 | 2.02 | 2.45 | 2.94 | 3.27 |
| 4.0 | .06 | .18 | .33 | .53 | .76 | 1.03 | 1.33 | 1.67 | 2.04 | 2.46 | 2.92 | 3.43 | 3.77 |
| 4.5 | .14 | .30 | .50 | .74 | 1.02 | 1.33 | 1.67 | 2.05 | 2.46 | 2.91 | 3.40 | 3.92 | 4.26 |
| 5.0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 4.42 | 4.76 |

**Step 1: P = 4.0**

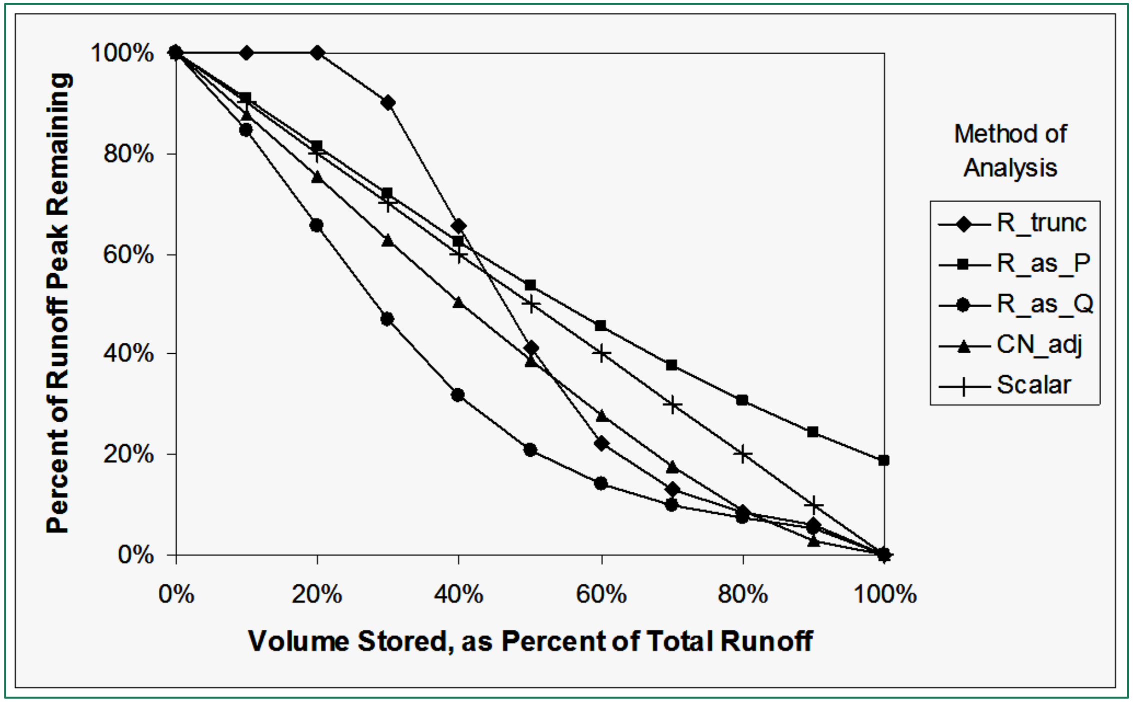
**Step 2: CN = 80**

**Step 3: Q = 2.04**

**Given a watershed with a CN of 80, what would be the direct runoff (Q) from a rainfall (P) of 4.0 inches?**

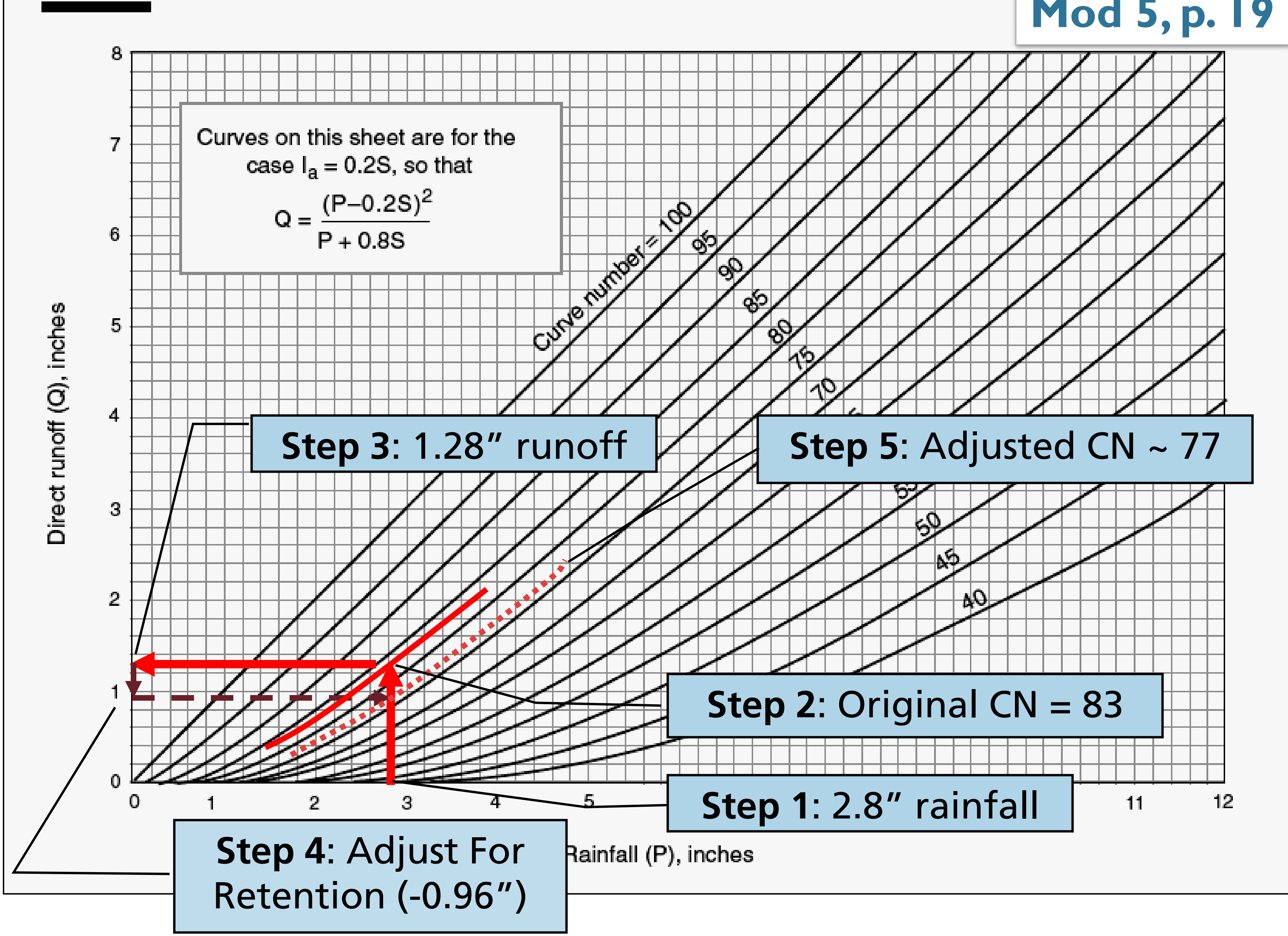
# Why are CN Adjustments Useful?

- Simplified view of small storage amounts distributed on landscape
- Minimize complex modeling




Excerpted from work by Paul R. Koch, Ph.D., P.E.

**Figure 2-1** Solution of runoff equation.



# How Does the Spreadsheet Determine (retention) Storage?

Residual volume from upstream BMP contributes to next BMP in treatment train for sizing

| Practice | on of Credit | Credit | Credit Area (acres) | Volume from Upstream RR Practice (cf) | Runoff Reduction (cf) | Remaining Runoff Volume (cf) | Phosphorus Efficiency (%) | Phosphorus Load from Upstream RR Practices (lbs) | Untreated Phosphorus Load to Practice (lbs.) | Phosphorus Removed By Practice (lbs.) | Remaining Phosphorus Load (lbs.) | Downstream Treatment to be Employed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.a. Infiltration #1 (Spec #8) | lume reduction | 0.50 | 0.00 | 0 | 0 | 0 | 25 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 7.b. Infiltration #2 (Spec #8) | lume reduction | 0.90 | 1.00 | 0 | 3104 | 345 | 25 | 0.00 | 2.16 | 2.00 | 0.16 | 8.b. ED #2 |
| | lume reduction | 0.90 | 1.00 | 0 | 719 | 80 | 25 | 0.00 | 0.50 | 0.46 | 0.04 | 8.b. ED #2 |
| **8. Extended Detention Pond** | | | | | | | | | | | | |
| 8.a. ED #1 (Spec #15) | lume reduction | 0.00 | 0.00 | 0 | | 0 | [illegible] | [illegible] | [illegible] | [illegible] | .00 | |
| | lume reduction | 0.00 | 0.00 | 0 | | 0 | 15 | [illegible] | [illegible] | [illegible] | .00 | |
| 8.b. ED #2 (Spec #15) | lume reduction | 0.15 | 1.00 | 345 | 569 | 3224 | 15 | [illegible] | [illegible] | [illegible] | .68 | |
| | lume reduction | 0.15 | 0.00 | 80 | 12 | 68 | 15 | 0.04 | 0.00 | 0.01 | 0.03 | |

**Runoff Reduction Volume**

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# What Does that Volume Mean?

- That volume is the estimated fraction of the runoff (annually) that is reduced
- Multiplied by a 1-inch rainfall

| Practice | on of Credit | Credit | Credit Area (acres) | Volume from Upstream RR Practice (cf) | Runoff Reduction (cf) | Remaining Runoff Volume (cf) | Phosphorus Efficiency (%) | Phosphorus Load from Upstream RR Practices (lbs) | Untreated Phosphorus Load to Practice (lbs.) | Phosphorus Removed By Practice (lbs.) | Remaining Phosphorus Load (lbs.) | Downstream Treatment to be Employed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.a. Infiltration #1 (Spec #8) | lume reduction | 0.50 | 0.00 | 0 | 0 | 0 | 25 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 7.b. Infiltration #2 (Spec #8) | lume reduction | 0.90 | 1.00 | 0 | 3104 | 345 | 25 | 0.00 | 2.16 | 2.00 | 0.16 | 8.b. ED #2 |
| | lume reduction | 0.90 | 1.00 | 0 | 719 | 80 | 25 | 0.00 | 0.50 | 0.46 | 0.04 | 8.b. ED #2 |
| **8. Extended Detention Pond** | | | | | | | | | | | | |
| 8.a. ED #1 (Spec #15) | lume reduction | 0.00 | 0.00 | 0 | | 0 | | | | | .00 | |
| | lume reduction | 0.00 | 0.00 | 0 | | 0 | 15 | | | | .00 | |
| 8.b. ED #2 (Spec #15) | lume reduction | 0.15 | 1.00 | 345 | 569 | 3224 | 15 | | | | .68 | |
| | lume reduction | 0.15 | 0.00 | 80 | 12 | 68 | 15 | 0.04 | 0.00 | 0.01 | 0.03 | |

**Runoff Reduction Volume**

# What are the limitations?

- *Storage-based* practices
  - Volume often much smaller than actual storage provided
  - Designers may also customize storage characteristics to reduce flows (more than spreadsheet can account)

# Bioretention Level 1 - Example

- Given:
  - Level 1 bioretention
  - B type soils
  - 2 Acre DA (50% Imp, 50% Turf)
- Sizing:
  - Tv = volume
  - Surface area is 1 Tv divided by storage depth
  - Storage depth ~ 1.4 ft. (typical)

# Bioretention Level 1 - Example

- Size:
  - Tv = 4175 c.f.
  - SA = 4175/1.4 = 2982 s.f.

| 6. Bioretention | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6.a. Bioretention #1 or Urban Bioretention (Spec #9) | impervious acres draining to bioretention | 40% runoff volume reduction | 0.40 | 1.00 | 0 | 1379 | 2069 | 25 |
| | turf acres draining to bioretention | 40% runoff volume reduction | 0.40 | 1.00 | 0 | 290 | 436 | 25 |

  - RR "Credit" = 1379 + 290 = 1669 c.f.
    - 40% of volume draining to facility

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| | 1-year storm | 2-year storm | 10-year storm |
|---|---|---|---|
| Target Rainfall Event (in) | 2.60 | 3.60 | 4.60 |

| Drainage Area A | |
|---|---|
| Drainage Area (acres) | 2.00 |
| Runoff Reduction Volume (cf) | 1,670 |

| Drainage Area B | |
|---|---|
| Drainage Area (acres) | 0.00 |
| Runoff Reduction Volume (cf) | 0 |

| Drainage Area C | |
|---|---|
| Drainage Area (acres) | 0.00 |
| Runoff Reduction Volume (cf) | 0 |

| Drainage Area D | |
|---|---|
| Drainage Area (acres) | 0.00 |
| Runoff Reduction Volume (cf) | 0 |

| Drainage Area E | |
|---|---|
| Drainage Area (acres) | 0.00 |
| Runoff Reduction Volume (cf) | 0 |

Based on the use of Runoff Reduction practices in the selected drainage areas, the spreadsheet calculates an adjusted $RV_{Developed}$ and adjusted Curve Number.

| Drainage Area A | | A soils | B Soils | C Soils | D Soils |
|---|---|---|---|---|---|
| Forest/Open Space -- undisturbed, protected forest/open space or reforested land | Area (acres) | 0.00 | 0.00 | 0.00 | 0.00 |
| | CN | 30 | 55 | 70 | 77 |
| Managed Turf -- disturbed, graded for yards or other turf to be mowed/managed | Area (acres) | 0.00 | 1.00 | 0.00 | 0.00 |
| | CN | 39 | 61 | 74 | 80 |
| Impervious Cover | Area (acres) | 0.00 | 1.00 | 0.00 | 0.00 |
| | CN | 98 | 98 | 98 | 98 |

| Weighted CN | S |
|---|---|
| 80 | 2.50 |

| | 1-year storm | 2-year storm | 10-year storm |
|---|---|---|---|
| $RV_{Developed}$ (in) with no Runoff Reduction | 0.96 | 1.72 | 2.55 |
| $RV_{Developed}$ (in) with Runoff Reduction | 0.73 | 1.49 | 2.32 |
| Adjusted CN | 75 | 77 | 77 |

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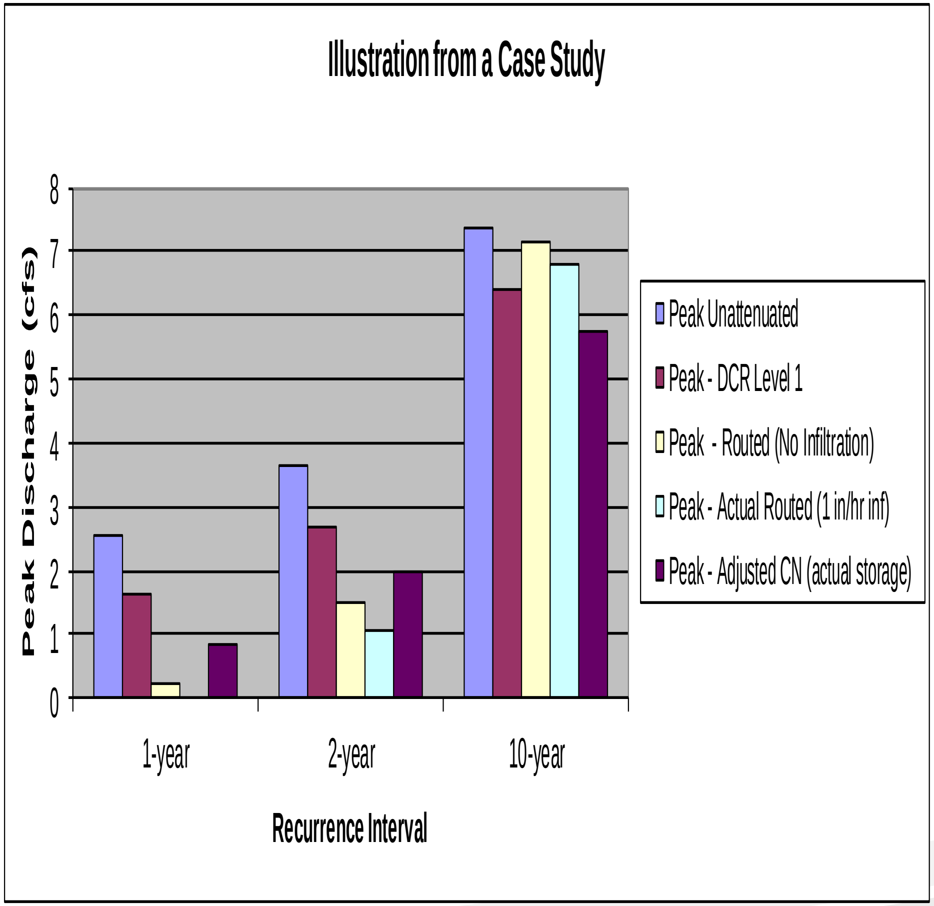
# Interim Summary

- Practice is calculated to reduce:
  - 1 year storm volume
    - from 0.96 in
    - to 0.73 in
  - For the 2 acre catchment
    - 0.96 x 2 x 43560/12 = 6970 c.f.
    - 0.72 x 2 x 43560/12 = 5227 c.f.
- Given total runoff 1-yr = 6970c.f.
- Actual storage greater than 4175 c.f.
- Credit is only 1669 c.f.

# So what does this mean?

- Often practices that are storage-based generate **much lower discharges than the CN adjustment**, if routed
- Expect that designers will route these practices
- CN Reduction for the given practice **AND** Routing are not allowed…..so be careful to **discount the routed practice from CN adjustments ONLY)**

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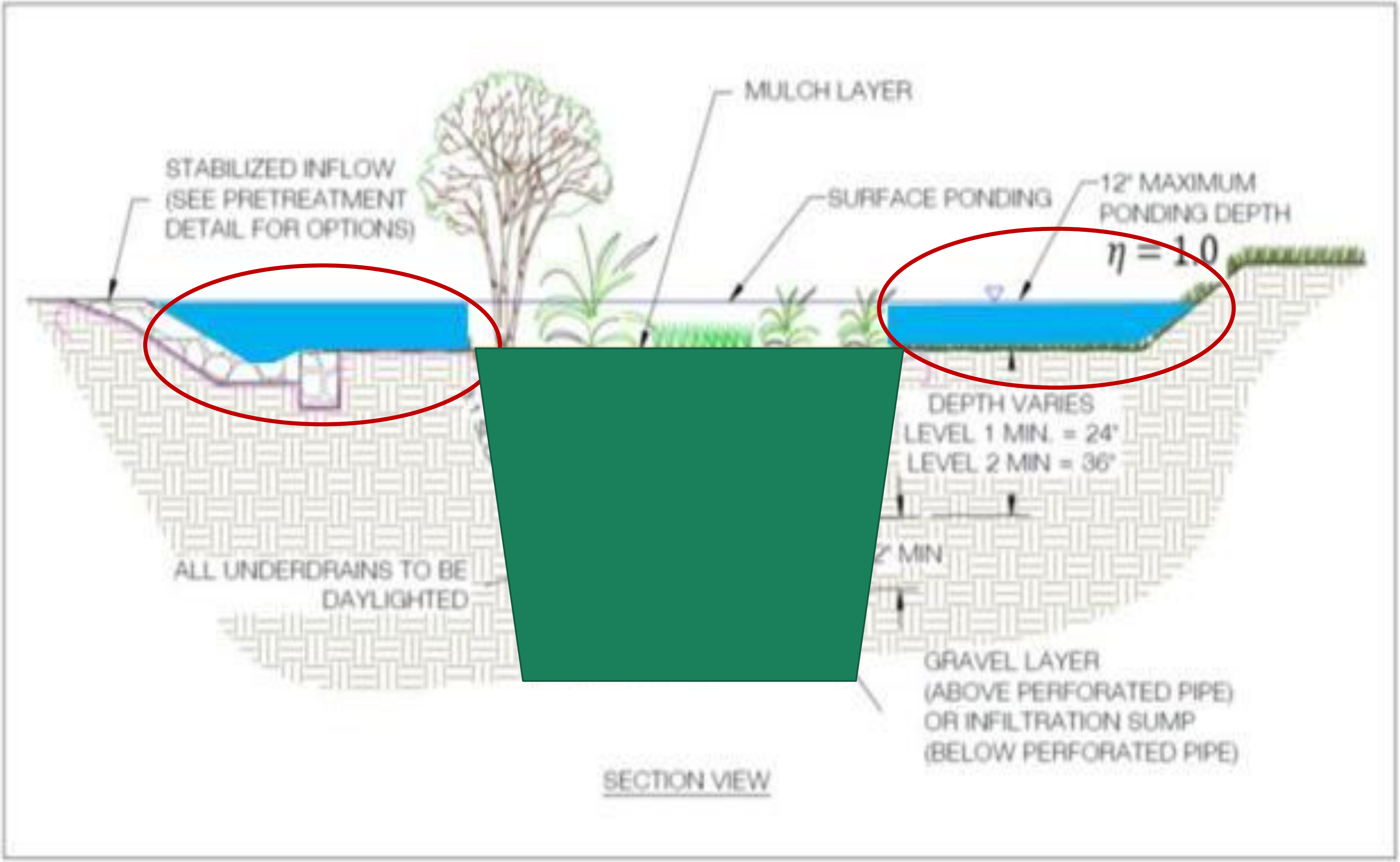
# Storage Optimization

- Storage can be customized to reduce discharges for water quantity design
- Examples for bioretention customization include:
  - Increasing media thickness
  - Increasing sump depth
  - Increasing ancillary surface storage

# Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

## Optimization and Storage:



# Curve Numbers (Spreadsheet vs Lookup Table)

- Reviewers may see differences between CNs developed in spreadsheet vs CN Tables in TR-55
- Designers may use either in designs
- Designers may use spreadsheet CNs
- Be careful to understand which CN you are dealing with and why

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**Table 2-2a** Runoff curve numbers for urban areas [1]

| Cover description | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|
| Cover type and hydrologic condition | Average percent impervious area [2] | A | B | C | D |
| *Fully developed urban areas (vegetation established)* | | | | | |
| Open space (lawns, parks, golf courses, cemeteries, etc.) [3]: | | | | | |
| Poor condition (grass cover < 50%) | | 68 | 79 | 86 | 89 |
| Fair condition (grass cover 50% to 75%) | | 49 | 69 | 79 | 84 |
| Good condition (grass cover > 75%) | | 39 | 61 | 74 | 80 |
| Impervious areas: | | | | | |
| Paved parking lots, roofs, driveways, etc. (excluding right-of-way) | | 98 | 98 | 98 | 98 |
| Streets and roads: | | | | | |
| Paved; curbs and storm sewers (excluding right-of-way) | | 98 | 98 | 98 | 98 |
| Paved; open ditches (including right-of-way) | | 83 | 89 | 92 | 93 |
| Gravel (including right-of-way) | | 76 | 85 | 89 | 91 |
| Dirt (including right-of-way) | | 72 | 82 | 87 | 89 |
| Western desert urban areas: | | | | | |
| Natural desert landscaping (pervious areas only) [4] | | 63 | 77 | 85 | 88 |
| Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders) | | 96 | 96 | 96 | 96 |
| Urban districts: | | | | | |
| Commercial and business | 85 | 89 | 92 | 94 | 95 |
| Industrial | 72 | 81 | 88 | 91 | 93 |
| Residential districts by average lot size: | | | | | |
| 1/8 acre or less (town houses) | 65 | 77 | 85 | 90 | 92 |
| 1/4 acre | 38 | 61 | 75 | 83 | 87 |
| 1/3 acre | 30 | 57 | 72 | 81 | 86 |
| 1/2 acre | 25 | 54 | 70 | 80 | 85 |
| 1 acre | 20 | 51 | 68 | 79 | 84 |
| 2 acres | 12 | 46 | 65 | 77 | 82 |
| *Developing urban areas* | | | | | |
| Newly graded areas (pervious areas only, no vegetation) [5] | | 77 | 86 | 91 | 94 |

# Rational and Modified Rational Method

- Drainage areas $\leq$ 200 acres
  - VSMP authority can allow use of Rational Method for evaluating peak discharges
  - VSMP authority can allow use of Modified Rational Method for evaluating volumetric flows to stormwater conveyances

# Rational and Modified Rational Method (continued)

- Designers will likely continue to use Rational Method for drainage infrastructure sizing
- Although permitted by regulation, it is unlikely (in the near term) that these methods will be used for SWM compliance purposes, because tools have not yet been developed

# Questions?