Announcements

- Assignment: HW#8 and read chapter 5 in text
- HW#6 due today
- HW#7 due 9/29
- Test #1 will be mid-October

Today’s topics

- SCS Curve Number Method
Estimating Rainfall Excess
SCS Curve Number Method

- The most commonly used method
- SCS method for rainfall excess
  - combines infiltration losses and other initial losses (interception / surface storage / etc)
  - estimate of excess rainfall (surface runoff)
  - \[ Q = \frac{[(P - 0.2S)^2]}{(P + 0.8S)} \text{ for } P > 0.2S \]
    - \( Q \) = accumulated runoff volume
    - \( P \) = accumulated precipitation
    - \( S \) = max soil water retention constant
    - \( S = (1000 / \text{CN}) - 10 \) (\( Q, P \) and \( S = \text{in.} \))
    - \( S = (25400 / \text{CN}) - 254 \) (\( Q, P \) & \( S = \text{mm} \))
The 0.2S Factor

- The precipitation must exceed 0.2S before runoff occurs
- 0.2S = Initial abstraction (I_a) that includes:
  - Surface depressions
  - Vegetation interception
  - Evaporation
  - Infiltration
- S = Potential maximum retention after surface runoff begins
Hydrologic Soil Groups (HSG)

- 4 hydrologic soil groups => A, B, C, D
  - A = sand, loamy sand or sandy loam
  - B = silt loam or loam
  - C = sandy clay loam
  - D = clay loam, silty clay loam, sandy clay, silty clay or clay
    - based on surface soil texture
- when choosing a group must consider:
  - compaction by heavy equipment, exposure of subsoil, etc.
HSGs based on Saturated Hydraulic Conductivity ($K_{sat}$)

- **A soil** (high infiltration rates)
  - $K_{sat} > 0.30$ in./hr
- **B soil** (moderate infiltration rates)
  - $0.15$ in./hr < $K_{sat}$ < $0.30$ in./hr
- **C soil** (slow infiltration rates)
  - $0.05$ in./hr < $K_{sat}$ < $0.15$ in./hr
- **D soil** (very slow infiltration rates)
  - $K_{sat} < 0.05$ in./hr
- See Appendix D for a list of the most common soils in each state with HSG type (A, B, C or D)
Curve Numbers (CN) and Antecedent Moisture Conditions

- **CN** = SRO potential of area
  - Table 5.1 (very limited)
    - See other references for more extensive listing
    - CN's developed for land use / land treatment combinations
  - Antecedent moisture conditions I, II, III
    - condition I => initially dry soil
    - condition II => average soil moisture
      - condition II => Table 5.1
    - condition III => initially wet soil
<table>
<thead>
<tr>
<th>Land Use Description</th>
<th>Hydrologic Soil Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Commercial, row houses and townhouses</td>
<td>80</td>
</tr>
<tr>
<td>Fallow, poor condition</td>
<td>77</td>
</tr>
<tr>
<td>Cultivated with conventional tillage</td>
<td>72</td>
</tr>
<tr>
<td>Cultivated with conservation tillage</td>
<td>62</td>
</tr>
<tr>
<td>Lawns, poor condition</td>
<td>58</td>
</tr>
<tr>
<td>Lawns, good condition</td>
<td>39</td>
</tr>
<tr>
<td>Pasture or range, poor condition</td>
<td>68</td>
</tr>
<tr>
<td>Pasture or range, good condition</td>
<td>39</td>
</tr>
<tr>
<td>Meadow</td>
<td>30</td>
</tr>
<tr>
<td>Pavement and roofs</td>
<td>100</td>
</tr>
<tr>
<td>Woods or forest thin stand, poor cover</td>
<td>45</td>
</tr>
<tr>
<td>Woods or forest, good cover</td>
<td>25</td>
</tr>
<tr>
<td>Farmsteads</td>
<td>59</td>
</tr>
<tr>
<td>Residential 1/4 acre lot, poor condition</td>
<td>73</td>
</tr>
<tr>
<td>Residential 1/4 acre lot, good condition</td>
<td>61</td>
</tr>
<tr>
<td>Residential 1/2 acre lot, poor condition</td>
<td>67</td>
</tr>
<tr>
<td>Residential 1/2 acre lot, good condition</td>
<td>53</td>
</tr>
<tr>
<td>Residential 2 acre lot, poor condition</td>
<td>63</td>
</tr>
<tr>
<td>Residential 2 acre lot, good condition</td>
<td>47</td>
</tr>
<tr>
<td>Roads</td>
<td>74</td>
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</tbody>
</table>
Curve Numbers (CN) and Antecedent Moisture Conditions

- CN for conditions I and III can be adjusted using condition II CN's
  - See Table 5.2
  - Adjustment based on 5-day antecedent rain
- CN develop from experimental plots
  - Lots of measured rainfall / runoff data
    - Throughout the U.S.
    - CN's correlated w/ land use
- Good for higher infiltration rates
- Not so good for lower infiltration rates
<table>
<thead>
<tr>
<th>Curve Number for Condition II</th>
<th>Factors to convert curve number for AMC II to AMC I or AMC III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AMC I (dry)</td>
</tr>
<tr>
<td>10</td>
<td>0.40</td>
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<tr>
<td>20</td>
<td>0.45</td>
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<td>30</td>
<td>0.50</td>
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<tr>
<td>40</td>
<td>0.55</td>
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<td>50</td>
<td>0.62</td>
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<td>60</td>
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<td>70</td>
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<td>80</td>
<td>0.79</td>
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<td>90</td>
<td>0.87</td>
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<tr>
<td>100</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Curve Numbers for Impervious Surfaces

- Impervious areas
  - Impervious areas $\implies$ CN = 98 to 100
  - expressed as % of total area
  - directly connected $\implies$ flow directly to a drainage system (gutters, sewers, etc)
Area Weighted Curve Number

- Mixed land uses and HSG's
  - Calculate an area-weighted CN
  - Get a single CN for the entire area
    - \( CN = \sum_{i} A_i CN_i / (\sum_{i} A_i) \)
    - \( CN_i = CN \) for the part of catchment having area \( A_i \)
Example Problem

- **Given:**
  - Precipitation \((P) = 4.04\) in.
  - A watershed that has:
    - 35% cultivated with a D soil group
    - 30% meadow with a B soil group
    - 35% thin forest with a C soil group

- **Required:**
  - Calculate the surface runoff (excess rainfall)
Watershed with Land Use %
And HSGs Listed

35% Cultivated
HSG = D

35% Thin Forest
HSG = C

30% Meadow
HSG = B
Example Problem

- First find the curve numbers
  - Use HSG % CN*
    - Cultivated D 35 91
    - Meadow B 30 58
    - Thin Forest C 35 77
  *Table 5.1 text (reference is important)

- Second calculate a weighted CN
  - Weights based on % area
  - \( \text{CN}_{\text{avg}} = 0.35(91) + 0.30(58) + 0.35(77) \)
  - \( \text{CN}_{\text{avg}} = 76.2 = 76 \)
Example Problem

- Third calculate the S term
  - \( S = \frac{1000}{CN} - 10 = \left(\frac{1000}{76}\right) - 10 \)
  - \( S = 3.16 \) in.

- Fourth check to see if \( P > 0.2S \)
  - \( 0.2S = 0.2(3.16) = 0.63 \) in. \( \Rightarrow P > 0.2S \)

- Fifth calculate surface runoff (Q)
  - \( Q = \frac{(P - 0.2S)^2}{P + 0.8S} \)
  - \( Q = \frac{(4.04 - 0.2(3.16))^2}{4.04 + ((0.8)3.16)} \)
  - \( Q = 1.77 \) in.
  - For a rainfall event = 4.04 in. on the given watershed with average soil moisture conditions
Class Wrap-up

- Assignment: HW#8 and read chapter 5
- Lab #3 on Thursday
  - Lab report #2 due