Lecture 7A: Surface Irrigation Systems

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Surface Irrigation

- Water flows across the soil surface to the point of infiltration
- Oldest irrigation method and most widely used world-wide (90%)
- Used primarily on agricultural or orchard crops

Types of Systems

- **Water Spreading or Wild Flooding**
  - Relatively flat fields -- allow water to find its own way across the surface
  - Minimal preparation and investment

- **Basin**
  - Dikes used to surround an area and allow for water ponding (no runoff)
  - Basins are usually level
Rice Field
Types of Systems, Contd…

- **Border**
  - Strips of land with dikes on the sides
  - Usually graded but with no cross slope
  - Downstream end may be diked

- **Furrow**
  - Small channels carry the water
  - Commonly used on row crops
  - Lateral as well as vertical infiltration
  - Furrows are usually graded
Water Supply

• Methods of water supply
  – Head ditch with siphon tubes or side-opening gates
  – Gated pipe (aluminum or plastic pipe with small gates that can be opened and closed)
  – Buried pipeline with periodically spaced valves at the surface

Water Management

• Runoff recovery systems
  – Drainage ditches for collecting and conveying runoff to the reservoir
  – Reservoir for storing the runoff water
  – Inlet facilities to the reservoir
  – Pump and power unit
  – Conveyance system for transporting water (to same or different field)
Runoff recovery systems
Surface Irrigation Hydraulics

• **Advance**: Movement of water from the inlet end to the downstream end.
  
  – Curve of Time vs. Distance is NOT linear

  – Rule-of-Thumb: 1/3 of the total advance time is needed to reach midpoint of the furrow length

• **Recession** (الترقب/الركود): Process of water leaving the surface (through infiltration and/or runoff) after the inflow has been cut off

  – Usually begins to recede at the upstream end

  – Can also be plotted as Time vs. Distance

  – “Flatter" curve than the Advance Curve
Surface Irrigation Hydraulics, Cont’d

**Infiltration**

- Opportunity Time: difference between Recession and Advance curves

- Infiltration Depth: a function of the opportunity time and the infiltration rate of the soil
Curve of Time Vs. Distance

Distance from inlet end (ft)

Advance and recession curves for surface irrigation.
Opportunity time for surface irrigation.
Infiltration vs. Opportunity Time

Infiltration (ln) vs. Opportunity Time (h)

<table>
<thead>
<tr>
<th>Opportunity Time (h)</th>
<th>Infiltration (ln)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1.7</td>
</tr>
<tr>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td>6</td>
<td>2.2</td>
</tr>
<tr>
<td>8</td>
<td>3.4</td>
</tr>
<tr>
<td>10</td>
<td>3.6</td>
</tr>
<tr>
<td>12</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Infiltration vs. opportunity time.
Infiltration Profile

Distance from Inlet End (ft)

Infiltration profile.
Uniformity

• Inherent non-uniformity because recession and advance curves are not parallel
• Factors affecting
  – Inflow rate
  – Slope
  – Soil infiltration
  – Roughness
  – Channel shape
  – Inflow time
  – Length of run
Efficiency

- Volume balance
  - \( V_g = V_z + V_s + V_r \)
  - \( g \rightarrow \) gross
  - \( z \rightarrow \) infiltration
  - \( s \rightarrow \) surface storage
  - \( r \rightarrow \) runoff
- (or depth basis): \( d_g = d_z + d_s + d_r \)
- Part of infiltration may go to deep percolation
Calculating $d_g$ (Gross Application Depth)

- Single furrow:
  $$d_g = 1155 \left( \frac{q_s t_{co}}{W L} \right)$$

- Furrow set:
  $$d_g = 1155 \left( \frac{Q t_{co}}{N W L} \right)$$

- Basin/border:
  $$d_g = 96.3 \left( \frac{Q t_{co}}{W_b L_b} \right)$$

$W =$ spacing between raw, $L =$ Length of raw, $N =$ number of raw, $W_b =$ basin width
Example:

For the furrow-irrigation field with a loam soil described in the attached figures. Determine the gross application depth, runoff depth and percentage of runoff. \( Q_t = 760 \text{ gpm}, L = 1200 \text{ ft}, t = 12 \text{ hours}, 70 \text{ furrow watered per set}, \) raw spacing 30 inches.

\[
d_g = 1155 \left( \frac{Q_{t_{co}}}{NWL} \right) \rightarrow d_g = 1155 \left( \frac{760 \times 12}{70 \times 30 \times 1200} \right) = 4.2 \text{ inch}
\]

\[
d_g = d_z + d_s + d_r
\]

\[
d_r = d_g - d_z - d_s = 4.2 - 3.6 - 0 = 0.6 \text{ inch}
\]

Percent runoff = \( \frac{0.6}{4.2} = 14\% \)
Infiltration profile.

Distance from Inlet End (ft)

Average depth in the Low Quarter

$d_{LQ} = 2.8 \text{ in}$

$d_z = 3.6 \text{ in}$