Comparison of 1D and 2D Surface Water Models for Solid Waste Facilities

Garth R. Bowers, P.E., Carl E. Bueter, P.E., Larry Henk

Introduction – Importance of Accurate Floodplain Delineation

- Required by Federal Regulations (40 CFR 258.11) and local floodplain regulations
- Optimize use of site – Maximize airspace within a given property area
- Proper design of perimeter surface water management facilities
- Typically utilize computer modeling for floodplain delineation

Types of Surface Water Models

- One-Dimensional Models
  - Create multiple cross-sections perpendicular to anticipated flow path
  - Use **step-backwater** methodology to determine water surface elevation and average flow velocity within each cross-section
- Two-Dimensional Models
  - Discretize study area into grid/mesh
  - Use **finite difference** methodology to determine water surface elevation within each grid element and flow into each adjacent grid element

One-Dimensional Modeling – Advantages and Disadvantages

- Advantages
  - Requires less input data – Watercourse can be modeled with relatively small number of cross-sections
  - Quick run-time
  - Easy to compare a number of design storms/ configurations
- Disadvantages
  - Less detailed, especially between modeled cross-sections
  - Does not model changing flow directions at different flow depths
    - Flow assumed perpendicular to cross-section

Two-Dimensional Modeling – Advantages and Disadvantages

- Advantages
  - More detailed – finer resolution of flow conditions within study area
  - Addresses changing flow directions at different flow depths
  - Incorporates design of surface water controls that are not parallel to main flow direction
  - Quick run-time
- Disadvantages
  - More data input required – topography and flow resistance for each grid element
  - Slower run-time
  - More time required to model/compare various design storms/configurations

Case Study

- Proposed Municipal Solid Waste (MSW) landfill in southern Arizona, USA
- Site formerly used for row-crop agriculture
  - Leveled fields
- Portions of site in floodplain of ephemeral watercourse
  - Floodplain area determined by approximate methods by FEMA
- Surface water modeling performed using one- and two-dimensional models to delineate floodplain and determine flow velocities and potential surcharging

Comparison of 1-Dimensional and 2-Dimensional Models

	1-Dimensional Model (HEC-RAS)	2-Dimensional Model (FLO-2D)
Flow Rate Range (ft^3/sec)	14,000 – 21,000	3,656 – 18,890
Flow Depth Range (100-year RI) (ft)	0 – 8.19	0 – 10.03
Flow Velocity Range (100-year RI) (ft/sec)	1.25 – 6.04	0 – 9.17
Top Width (100-year RI - Typical Section) (ft)	1,505	1,534
Number of Data Elements	39 cross-sections	107,920 grid cells
Run Time Range	0.09 – 0.89 sec	6.90 – 13.52 hr
Note: 100-year RI is the 100-year return interval; i.e., the flood with a 1% chance of occurrence in a given year		

[Add HEC-RAS Model Cross-Sections]

- Caption – Alignment of 1D model cross-sections perpendicular to anticipated flow direction during design storm. Cross-sections were more closely spaced in areas of rapid changes in hydraulic conditions.

[Add HEC-RAS Delineation Figure]

- Caption – 1D model predicted floodplain limits for the design storm (100-year event) under existing and proposed conditions. Although the main flow area had capacity to convey the design storm flows, sheet flows were anticipated to occur in areas outside of the predicted floodplain limits. This was due to upstream breakouts not directed back into main flow area because of flat topography resulting from agricultural use.

[Add FLO-2D Grid Figure]

- Caption – 2D model grid elements on 50-foot by 50-foot grid spacing. Grid elements shaded in red are taken out of flow in proposed model due to proposed landfill construction. Blue cells indicate proposed diversion channel construction to redirect sheet flows, or grading changes to maintain conveyance capacity. Ground surface elevations were the same in existing and proposed conditions in other cells.

[Add Existing Conditions FLO-2D Delineation Figure]

- Caption – 2D Model floodplain delineation and water surface elevation contours (2-foot contour interval) for existing conditions.

[Add Proposed Conditions FLO-2D Delineation Figure]

- Caption – 2D Model floodplain delineation and water surface elevation contours (2-foot contour interval) for proposed conditions.

[Add FLO-2D Depth of Flow Figure]

- Caption – 2D model predicted depth of flow under proposed conditions during a 500-year design storm (0.1-foot contour interval).

Conclusions

- Both one-dimensional and two-dimensional modeling techniques useful for solid waste facility design
- One-dimensional techniques more appropriate for simpler/more defined flow geometry and/or for initial evaluation of multiple options
- Two-dimensional techniques more appropriate for more complex flow geometries (including non-parallel sheet flows) and/or final detail design