2D Large Scale Automated Engineering for FEMA Floodplain Development in South Dakota

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Project Acknowledgments

FEMA Region 8 Staff

Terrain Data Sources:
• USGS National Elevation Dataset
• South Dakota Department of Environment and Natural Resources
Overview

• 2D LSAE Defined
• South Dakota Project Background
• Technical Approach
• Calibration and Results
• Challenges and Key Takeaways
• Benefits to the Risk MAP program
What is 2D LSAE?

• Terminology Note:
  – Large Scale Automated Engineering (LSAE) is now referred to as Large Scale Base Level Engineering (LSBLE)

• 2D LSAE/LSBLE
  – Rain-on-Grid hydrology
  – Two-dimensional (2D) hydraulic models covering large basins
  – Floodplain results for every drainage covered by model grid cell mesh

• Requires high resolution terrain data
• Scalable products
South Dakota 2D LSAE Application

• Perform 2D LSAE for 27 eastern South Dakota Counties
• Increase and enhance the flood risk products in South Dakota
Project Scope

• Hydrologic and hydraulic modeling
  – 10% through 0.2% annual chance exceedance (ACE) events

<table>
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<th>Annual Chance Exceedance</th>
<th>H&amp;H Modeling</th>
<th>Floodplain Mapping</th>
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Technical Workflow

- Terrain Data Development
- Model Area Delineation
- Hydrology Development
- Hydraulic Considerations
- Calibration
Conceptual Overview
Terrain Data Overview

• High resolution 1-meter LiDAR available for entire project area (except half of Clark County)

Non-model backed Zone A’s on 10m DEM

2D HEC-RAS 5.0.1 on high-res LiDAR
Model Area Delineation

- Main considerations for model areas:
  1. **SIZE**: Max model area ~ 1,300 sq mi
  2. **DRAINAGE**: Account for all contributing basin area (Rain-on-Grid + external inflows)
  3. **DATA**: Leverage gage data for inflows and calibration

- 26 total model areas
Hydrology Components

- **Rain-on-Grid**
  - Developed for each model area
  - Applied in HEC-RAS to generate runoff from 2D model area

- **Upstream Basin Contributions**
  - Inflow hydrograph required for upstream basins not accounted for by Rain-on-Grid
Rain-on-Grid

- No losses in HEC-RAS 5.0
- Simple HMS model to develop excess precipitation hyetograph
- SCS CN Method
  - NOAA Atlas 14 precip raster
  - NRCS Soils + National Land Cover Data (NLCD) = Average CN
Upstream Basin Contributions

• External inflow options:
  1. Unit hydrograph approach where gage data available
  2. Flow transfer from upstream 2D LSAE model
  3. Simple HMS runoff model
Hydraulic Considerations

HEC-RAS 5.0 Inputs
- Manning’s n
- Boundary Conditions
- Computational Parameters

Breaklines Offsets
- Flow impediments
- Structures and crossings
HEC-RAS 5.0 Hydraulic Parameters

- Grid cell mesh
  - 200-foot nominal cell size
- Manning’s n
  - NLCD 2011 spatial coverage
- Boundary Conditions
  - Upstream: Inflow hydrographs
  - Downstream: Normal depth
- Computational options
  - Diffusion Wave Equation
  - 30-second timestep
Breaklines

• Refine mesh to define topographic features
  – Flow impediments defined to prevent water from passing across high points
Offsets

• Refine mesh to define topographic features
  – Offset breaklines to allow water to pass across unprocessed high points
Model Calibration

• USGS gage data (period of record >20 years) to develop discharge targets
• Adjusted Curve Numbers and/or hydrograph timing
• 33 total calibration gages
Depth Results
Water Surface Elevation Results
Velocity Results
Velocity Results

Risk communication (three feet of swiftly flowing water is more dangerous than five feet of standing water)
2D LSAE Challenges

- Data limitations
- Structures
- Model run times ➔ 12 to 120 hours
- File sizes ➔ Single model ~ 20 to 100 GB
- Total deliverable ➔ ~7 TB!
Key Takeaways

• 2D LSAE methodology provides efficient, accurate option for floodplain hazard identification
• There are still engineering challenges
• Process will continue to evolve and improve
Benefits to the Risk MAP Program

• Delivering high-quality risk data
  – Coordinated Needs Management Strategy (CNMS)
  – New, Validated, or Updated Engineering (NVUE)

• Increasing awareness of flood risk
  – Percent of local officials aware of flood risk affecting their communities

• Promoting community mitigation action
  – Percent of population acting on community planned mitigation strategies

• Building towards Technical Mapping Advisory Council (TMAC) recommendations
  – Structure-based risk and flood frequency determination
  – Database driven, digital display environment

• Reduce risk to lives and property
Changes Since Last FIRM

- Spatial layer used to inform communities where changes exist between new product
Best Available Data Use

• Uses
  – Where no effective special flood hazard area (SFHA) exists
  – Where there is an effective Zone A

• Cannot Use
  – Effective AE
  – If alternate sources have more detailed data/information
    • e.g. storm water master plan, bridge design
Other uses of 2d LSBLE Best Available Information

- Update State/Local Mitigation Plan
- Emergency Response
- Evacuation Planning
- Critical Facilities in or near flood hazard area
- Residential/Commercial Development Planning
- Hazard Mitigation Grant Program
Questions

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