Improvement at the Iowa River Crossing - 2D Hydraulic Analysis

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Organization

- Background and Purpose
- Model Development
- Calibration and Validation
- Design Features
- Results and Conclusions
- Recent History
Background and Purpose

- CRANDIC connects to four railroads in eastern Iowa (Amana Line)
- 1.5 mile crossing in Iowa River bottom near Amana, Iowa
- Three major structures – main channel bridge, north overflow bridge and south overflow bridge
- Crossing constructed in late 1800s
- CRANDIC purchased Amana line in 1980 from the Milwaukee Road and was flooded out of service in 1993 and 2008
Background and Purpose

- Major floods in 1993 and 2008 took CRANDIC line out of service
- Lateral bank erosion constant battle
- CRANDIC embarked on five year improvement plan to replace track and structures
- CRANDIC wanted to use their limited construction dollars the most effectively as possible
- 2D hydraulic analysis considered 2-4 ft. embankment raise, increased bridge opening to compensate for grade raise, and spur dikes
Hydraulic Criteria and Design Issues

- Environmental
  - Increase in footprint of embankment impacts wetlands requires mitigation

- Design
  - Higher embankment blocks overtopping flow
  - Increase size of relief bridges/main bridge to compensate
  - CRANDIC desired at least 100-year level of service but also evaluated performance at 2008 discharge

- Floodplain Permit
  - Meet backwater criteria (State of Iowa)
  - No increase in property damage upstream at the 1-percent annual chance flood (100-year)
2D Model Development

Pre-Processing
(SMS + GIS)

Mesh

Floodplain + Channel
Bathymetry

Surface Roughness

Boundary Conditions

Code Execution
SRH-2D

Post-Processing
(SMS, Tecplot)

SMS
2D Modeling Approach – Land Surface Model - LiDAR

- State of Iowa provides LiDAR data throughout entire state
- Vertically +/- 4 inches
2D Modeling Approach – Land Surface Model – LiDAR Filtering

- Floodplain Filtered
- Embankment Original Density
2D Modeling Approach – Land Surface Model – Channel Bathymetry

- LiDAR doesn’t penetrate water surface
2D Modeling Approach – Adding Channel Bathymetry

- Single-Beam echo-sounder
- Collected by IIHR-Hydroscience and Engineering
- Integrated with LiDAR based DTM
2D Modeling Approach – Combine LiDAR + Bathymetry

- Combine LiDAR + Bathymetry in GIS
2D Model Approach – Combine LiDAR + Bathymetry

- Finished surface includes channel
2D Modeling Approach – Computational Mesh in SMS

Elements sized according to required solution, velocity gradients, changes in bathymetry, and computational power

Structured

Un-Structured
SMS map module allows for excellent control of structured/unstructured mesh.
2D Modeling Approach – Computational Mesh + Bridge Piers

Bridge piers are modeled explicitly in mesh
2D Modeling Approach – Surface Roughness

Feature Object Legend
- Feature Arc
  - Feature Vertex
  - Feature Point/Node

Cattle Pass
3-72" CMPs
HWY 151 R Bridge
HWY 151 Box Culvert
HWY 151 Main Bridge
CRANDIC Bridge R S
CRANDIC Bridge Main
CRANDIC Bridge R N
CRANDIC Bridge 19_4
HWY 220 R Bridge S
HWY 220 Main Bridge
HWY 220 R Bridge N
Industrial
Developed
Pasture
Light Woodland
Wetland
Railroad
Road
Canal
River
Soybeans
Corn
Forest
2D Modeling Approach – Boundary Conditions

- Implemented along node strings at boundaries
- Simulated until steady-state discharge
- Stage boundary at d/s

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Flow at Marengo (cfs)</th>
<th>Flow at CRANDIC Crossing (cfs)</th>
<th>Downstream Water Surface Elevation (ft)</th>
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<td>12,350</td>
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Calibration and Validation

- 1993 Event and 2008 Event
- Considered both peak flow and peak tail water events
2D Modeling Approach – Calibration and Validation

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Design Features

- Balance between raising embankment and increasing overflow bridge capacity
- Lower velocities through overflow structures
- Minimize cost and environmental impact
- Looked at individual openings and combinations of openings
- Final design included embankment increased 4 ft., South overflow bridge increased two times and North overflow bridge increased 3 times
- Did not increase water surface elevations upstream from project at 100-year and kept Amana Line in service during 100-year event
Spur Dikes

- Lateral bank erosion a maintenance problem
- Designed submerged spur dikes arrest lateral bank erosion and promote infill
- Design confirmed with hydraulic model
- Permitting documents prepared with information from modeling
Post Construction

- Spurs Constructed in 2013
- North and South Overflow constructed in 2013
Recent History and Conclusions

- Pre-Iowa River Crossing Improvements – overtopping occurred at 32,000 cfs (25 year event)
- 2008 – Peak was 51,500 cfs
- 35,000 cfs (Top)
- 2013 ~ 35,000 cfs (Bottom) – stayed in service
- 2014 ~ 35,000 cfs - stayed in service
- Crossing updated to over 100-year design

**TIMELY IMPROVEMENTS.** Since construction CRANDIC and the Iowa River have experienced 2 approximately 50-year events at the site and have stayed in service through both

- The 2D hydraulic analysis provided the level of detail necessary to plan, design, permit and build the project
Thank you.
Questions?