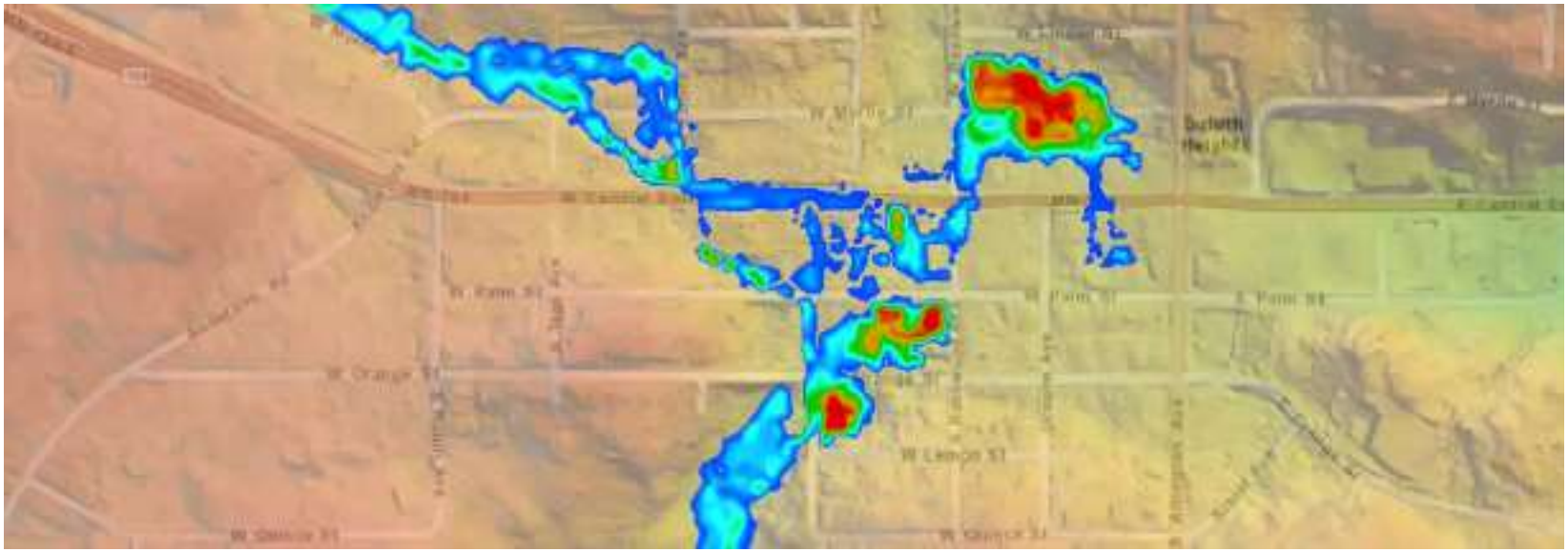
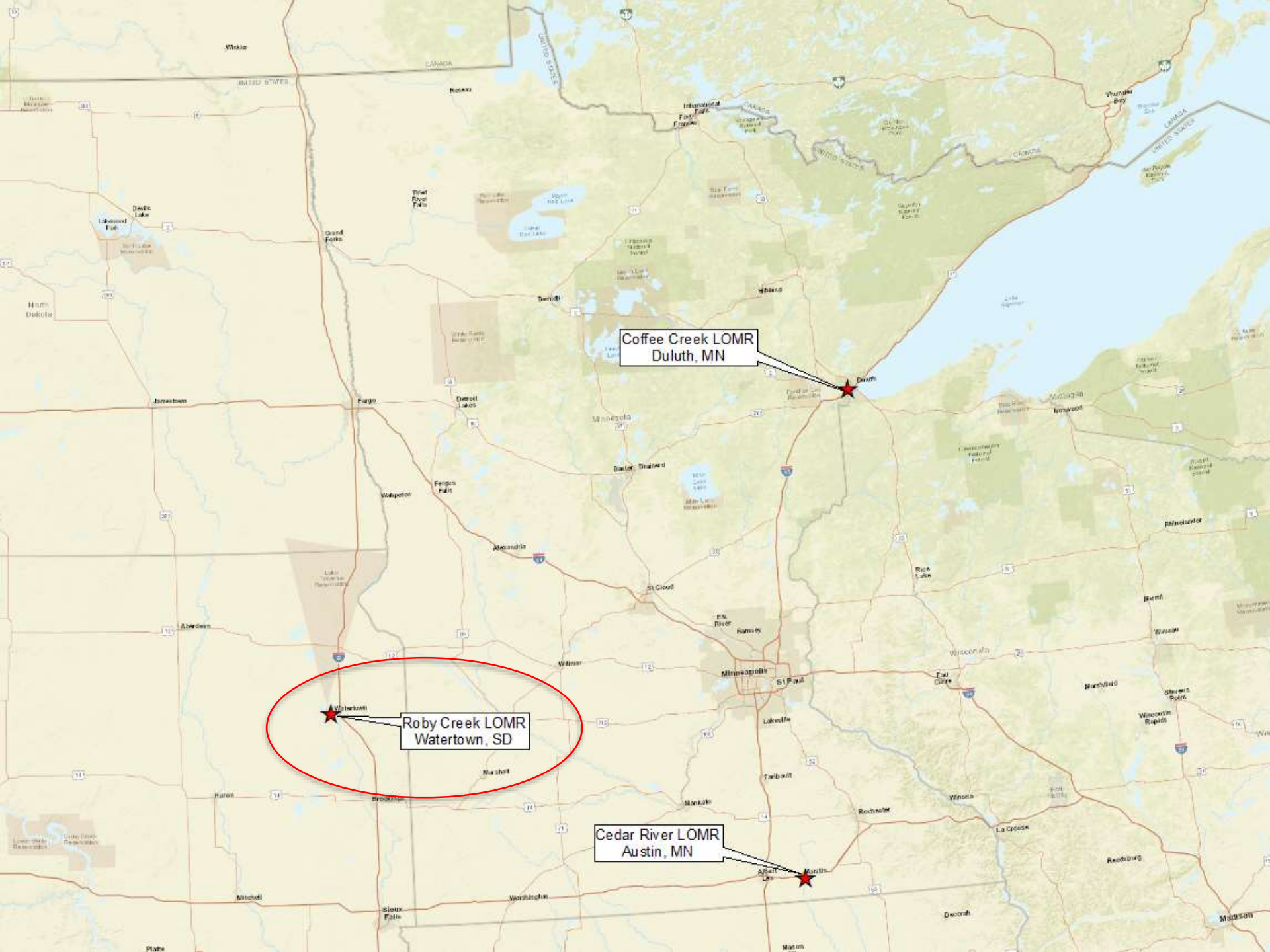


2D Modeling for a 1D LOMR in a 3D World: Three "Simple" Stories

2017 ASFPM Annual Conference

Rachel Pichelmann, PE, CFM


Coffee Creek LOMR
Duluth, MN
Roby Creek LOMR
Watertown, SD
Cedar River LOMR
Austin, MN
Minneapolis
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Fargo
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Watertown
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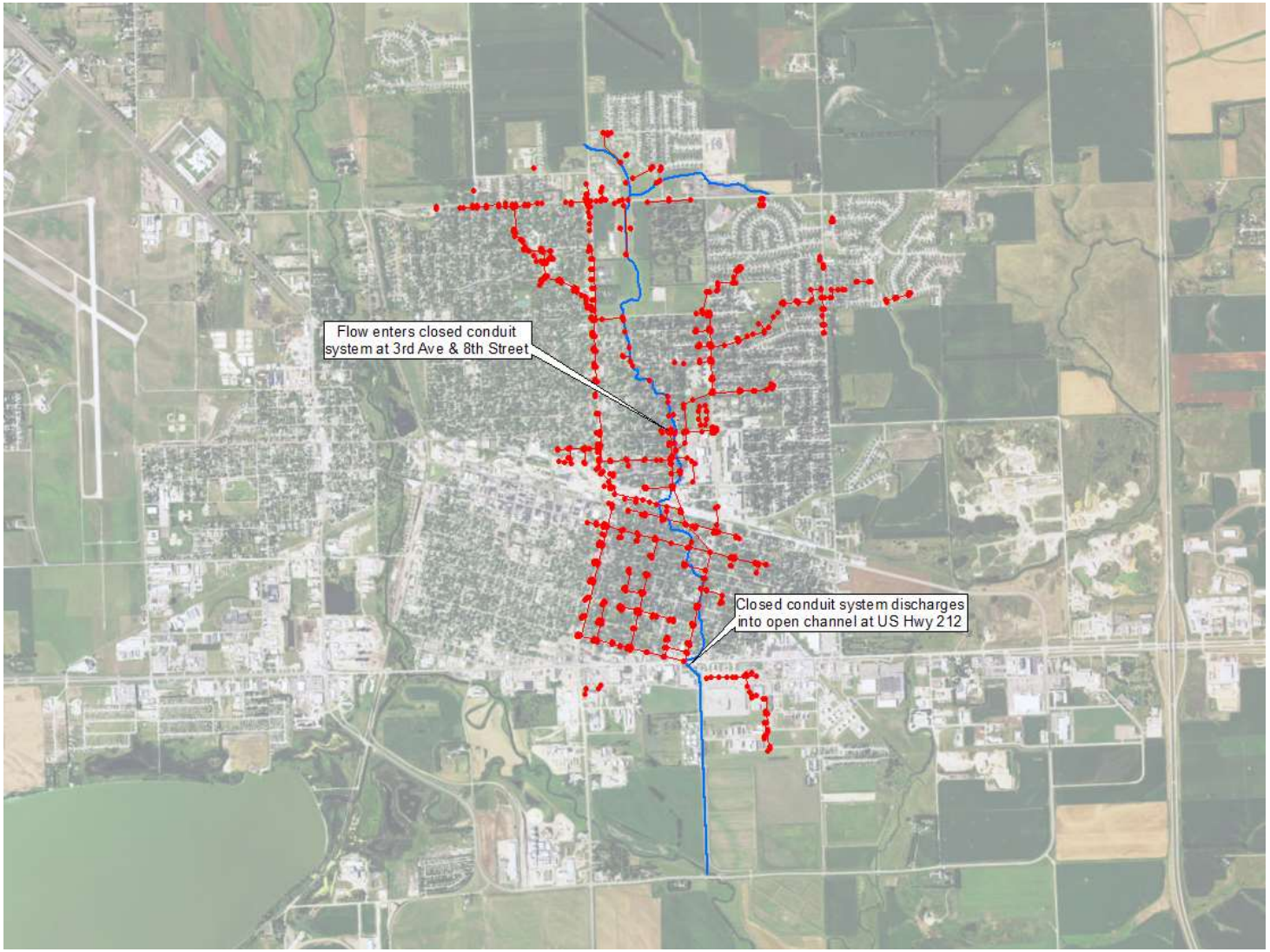
Wisconsin
Michigan
North Dakota
CANADA
UNITED STATES

Roby Creek LOMR – Watertown, SD



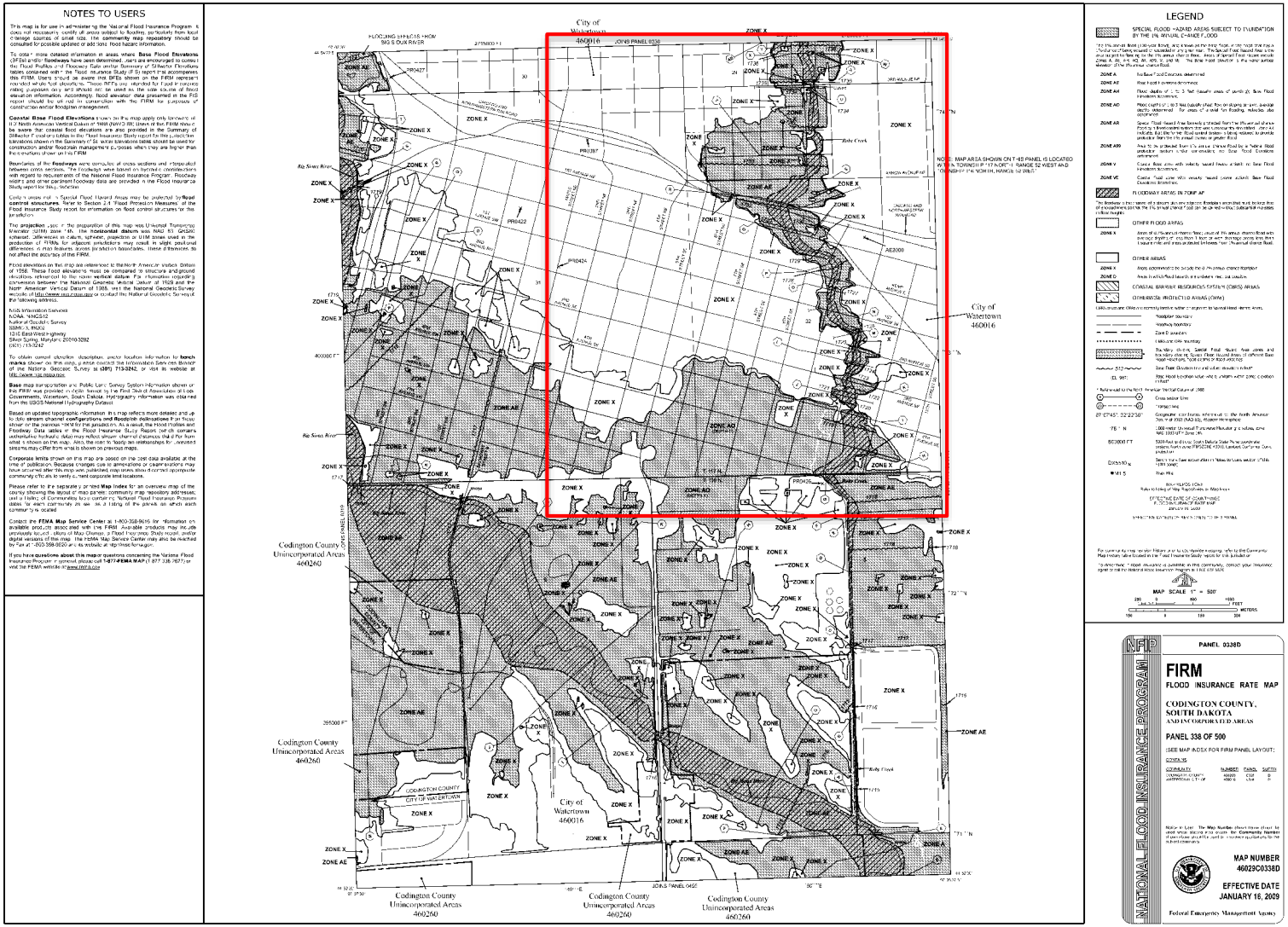
Roby Creek LOMR – Watertown, SD

- 2009 FIS & FIRM Update
  - New Detailed Study for Roby Creek
    - Hydrologic Model: HEC-HMS
    - Hydraulic Model: HEC-RAS (1D, steady)
    - StormCAD also used to estimate flow split
  - Changed Zone A Floodplain to Zone AE
  - Introduced Floodway for much of Roby Creek
    - Several Structures now in Floodway
    - Allowable surcharge not maximized

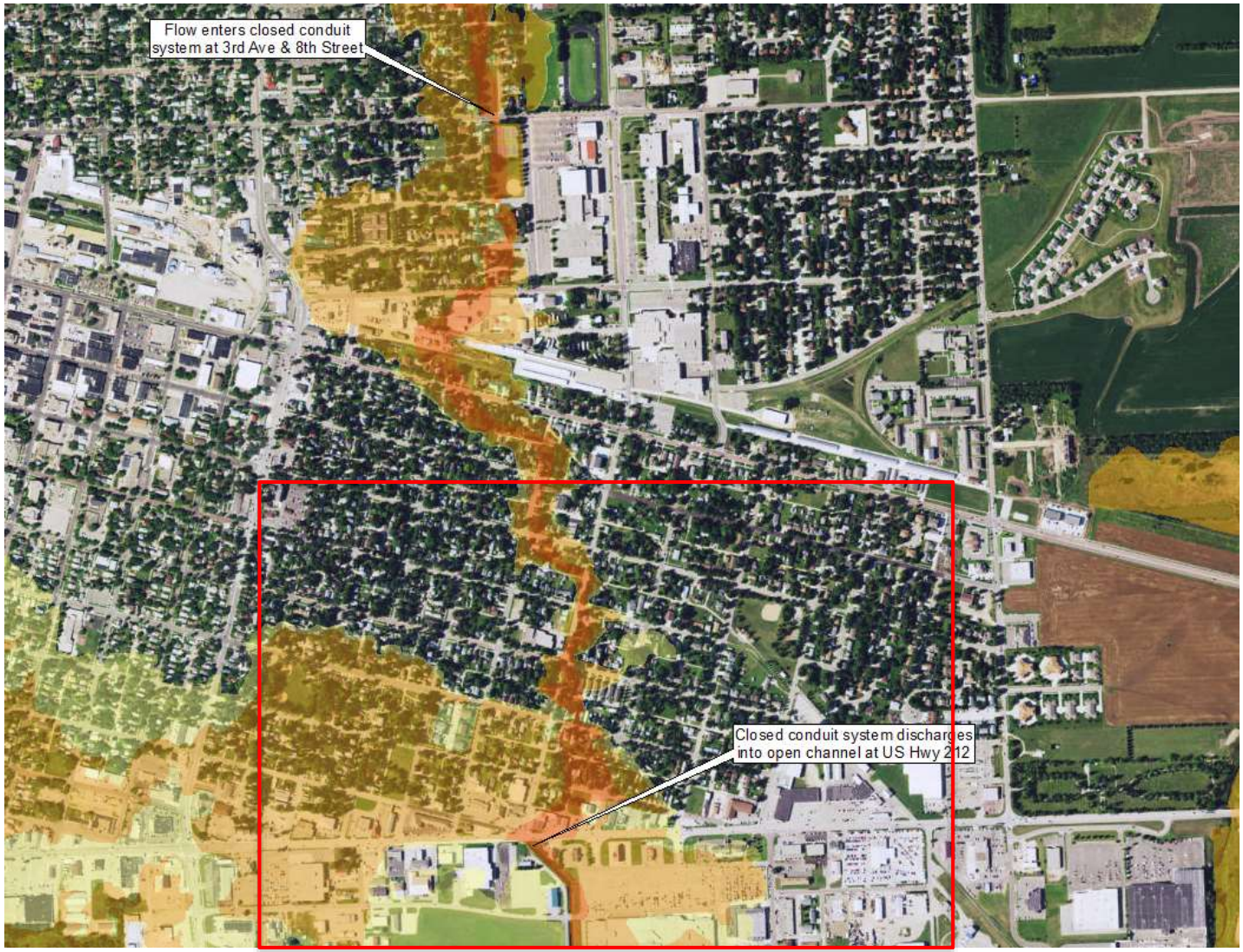
Roby Creek LOMR – Watertown, SD

- Impacts of mapping roadway and adjacent buildings as Floodway:
  - No-rise evaluation would be needed for any proposed changes within the floodway
  - Existing buildings become non-conforming structures
  - Property owners with federally-backed loans would be required to purchase flood insurance
  - May place hardship on owners, since selling properties in floodplain/floodway will be more difficult

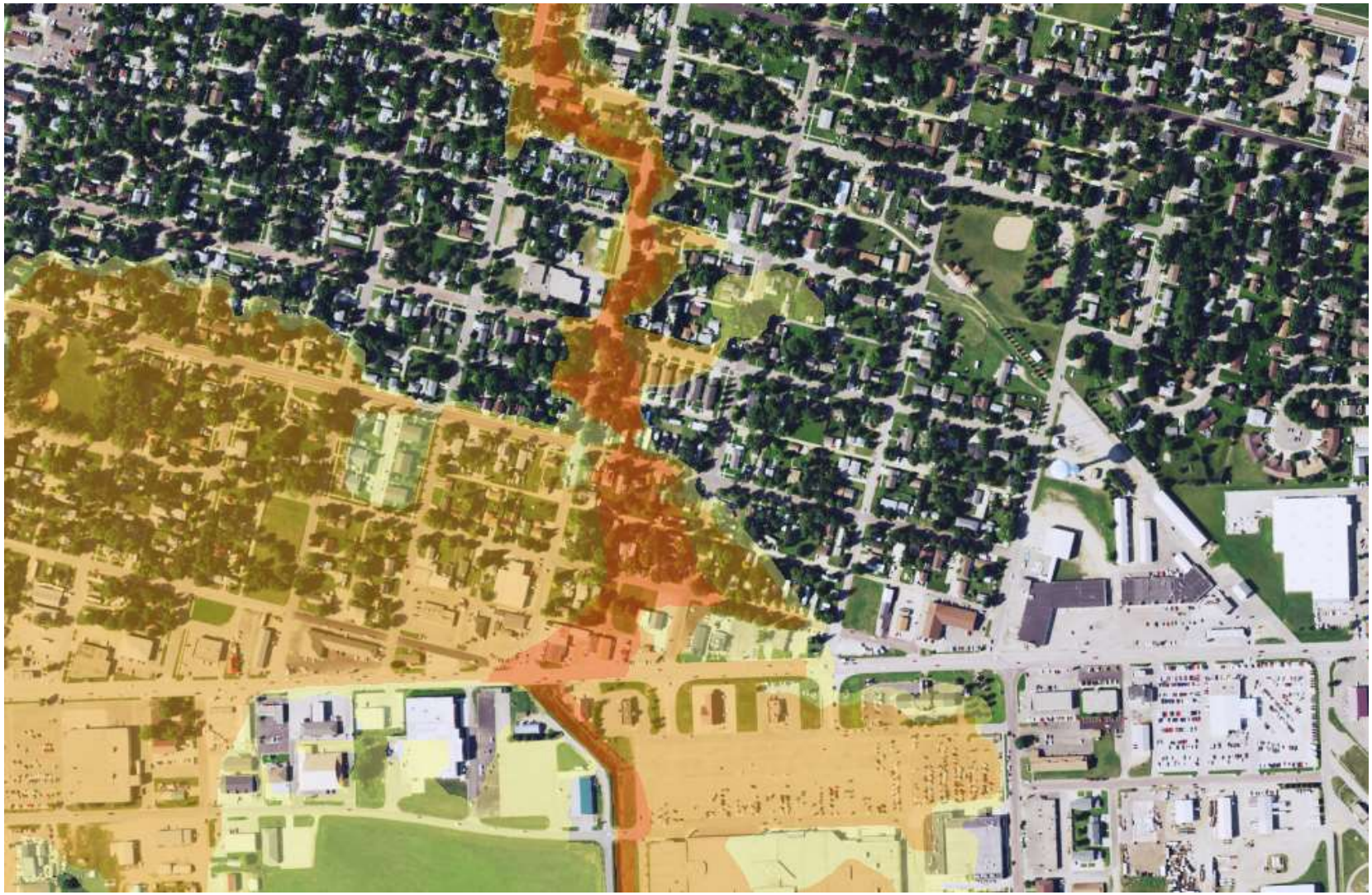
Roby Creek LOMR – Watertown, SD



Roby Creek LOMR – Watertown, SD



Roby Creek LOMR – Watertown, SD



Roby Creek LOMR – Watertown, SD

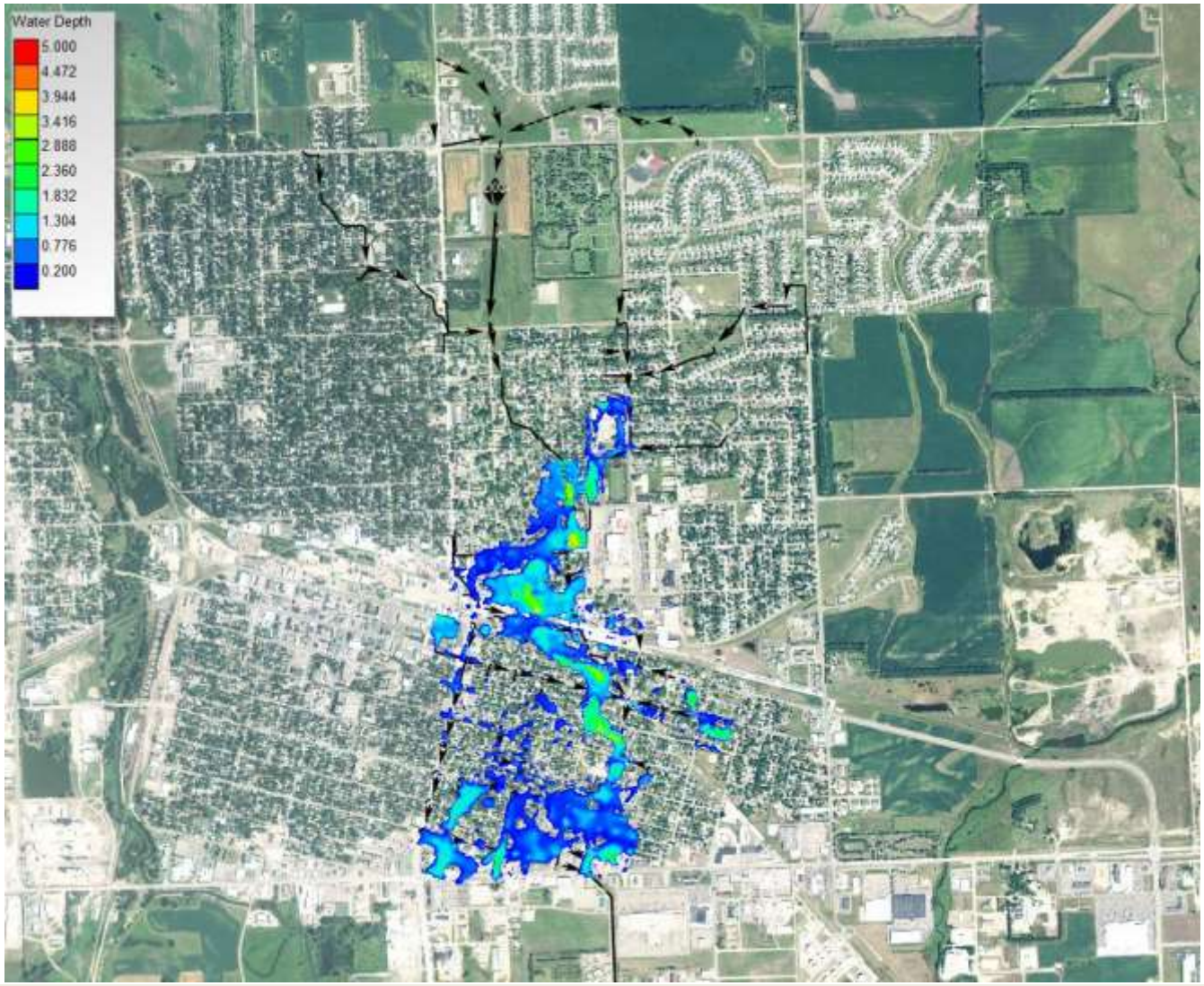
- Update hydrologic analysis
  - Increase level of detail
    - Incorporate interaction between open channel and storm sewer system, overland flow
    - Use City survey data of culverts, channels
  - Evaluate impacts on peak discharge rates
- Update hydraulic analysis
  - Incorporate revised peak discharge rates
  - Use City survey data of culverts, channels
  - Conduct floodway encroachment analysis
- Update FIRM

Roby Creek LOMR – Watertown, SD

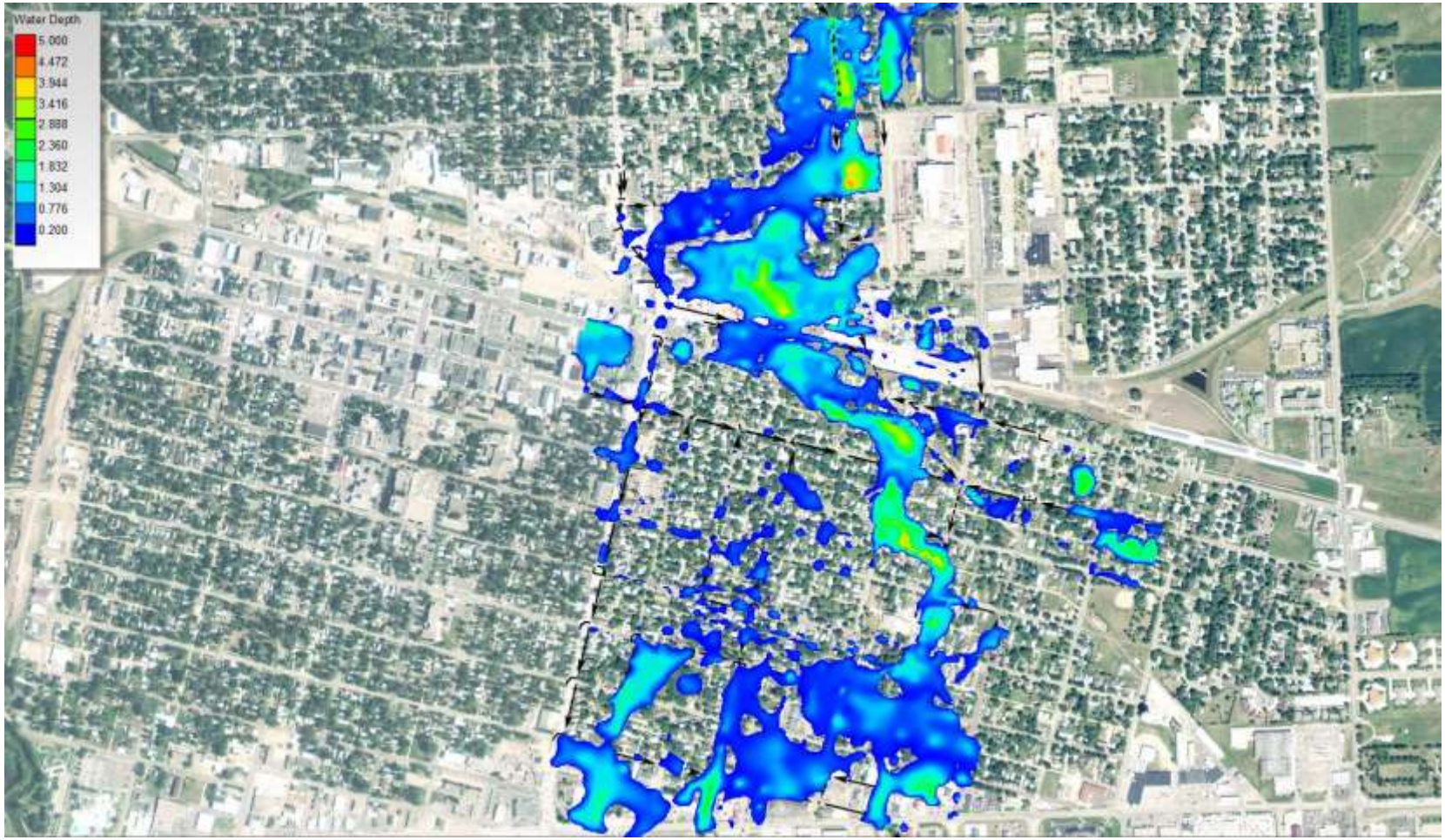
- 1D/2D XPSWMM Model Created
  - Included both open channel & closed conduit segments of Roby Creek
    - Included updated pipe, culvert data
    - Flow diversion at inlet of closed conduit system
    - Interaction between surface & subsurface flow throughout closed conduit system
    - 2D computations of surcharged and diverted flow
  - Peak Discharge Rates on Roby Creek

Roby Creek LOMR – Watertown, SD

Roby Creek LOMR – Watertown, SD



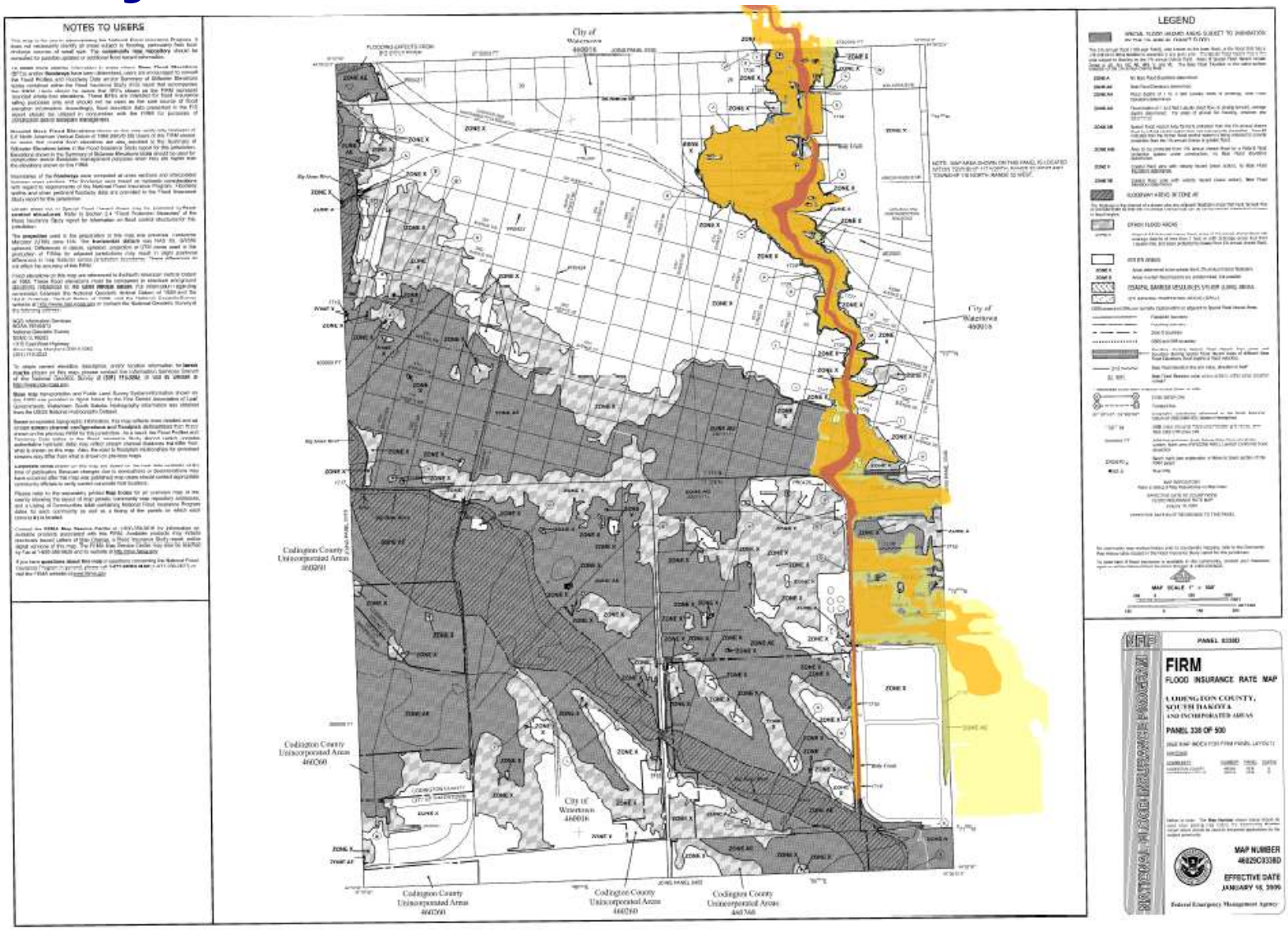
Roby Creek LOMR – Watertown, SD



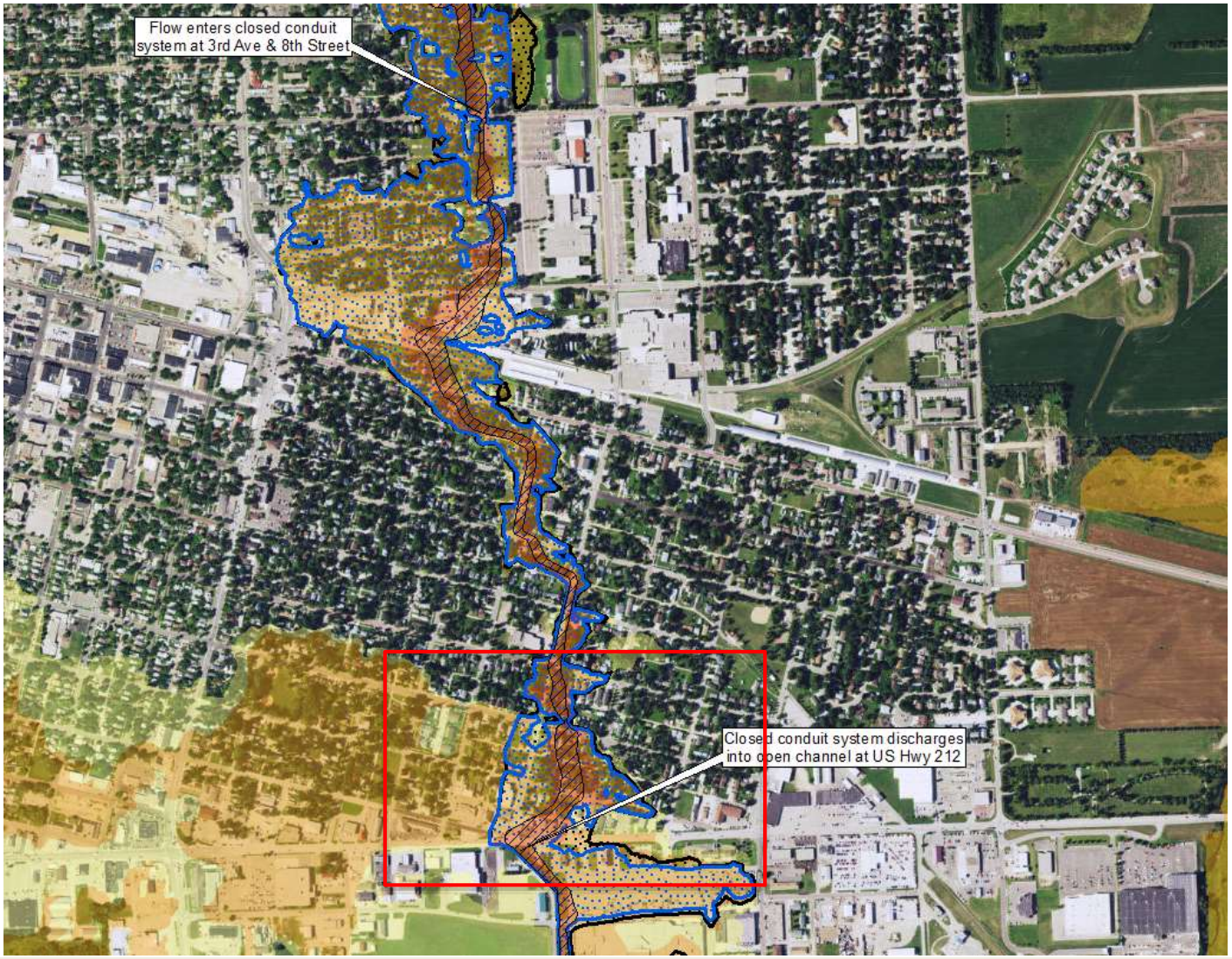
Roby Creek LOMR – Watertown, SD

- 1D Steady-State RAS Model Updated
  - Incorporated updated peak discharge rates from 1D/2D xpswmm analysis
  - Cross section and culvert crossing data updated, consistent with 1D/2D xpswmm model
  - Floodway encroachment analysis conducted to maximize 1’ allowable surcharge
- FIS & FIRMs updated using HEC-RAS updated results.

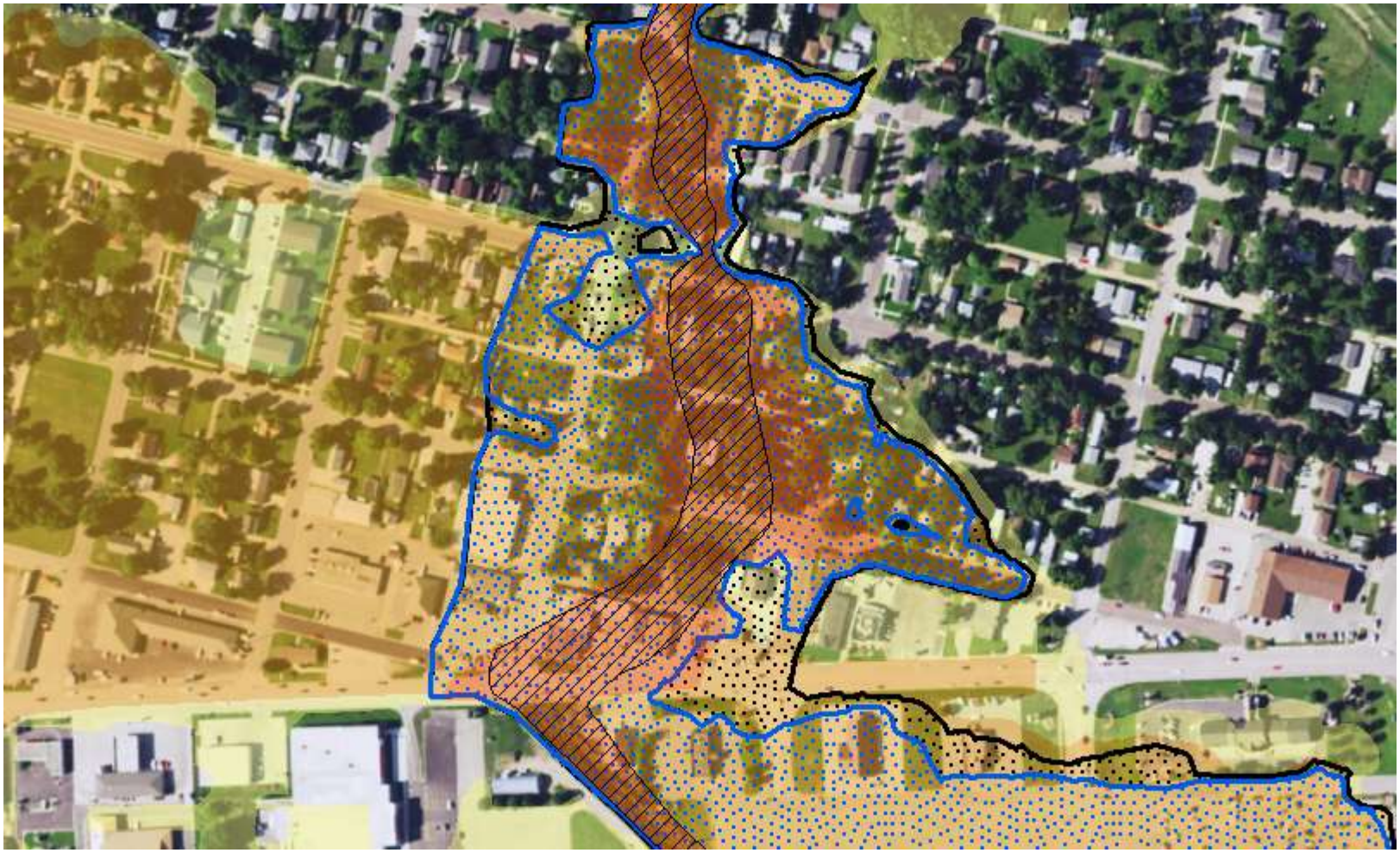
Roby Creek LOMR – Watertown, SD

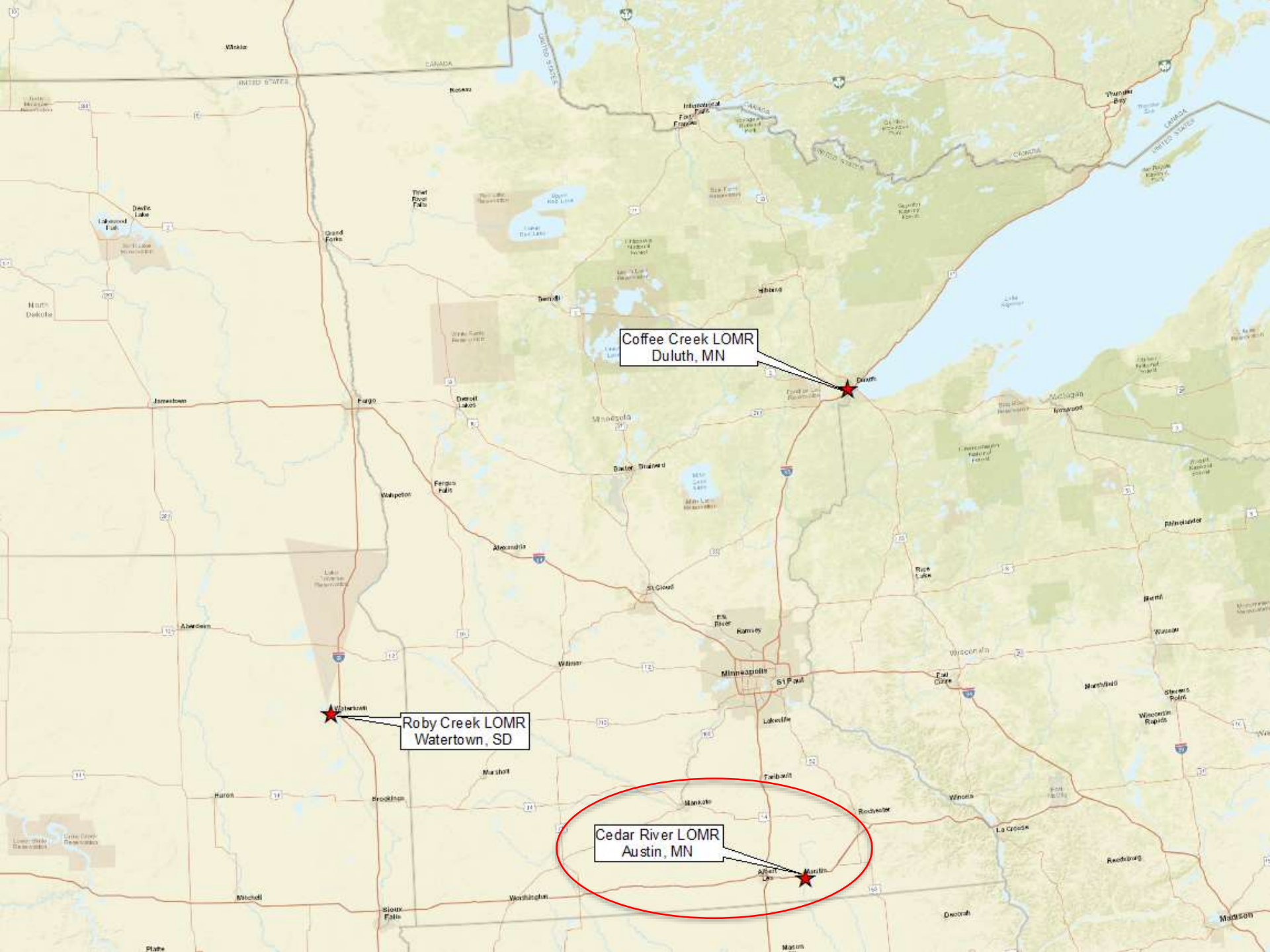


Roby Creek LOMR – Watertown, SD



Roby Creek LOMR – Watertown, SD

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Mankato
Rochester
St Cloud
Eau Claire
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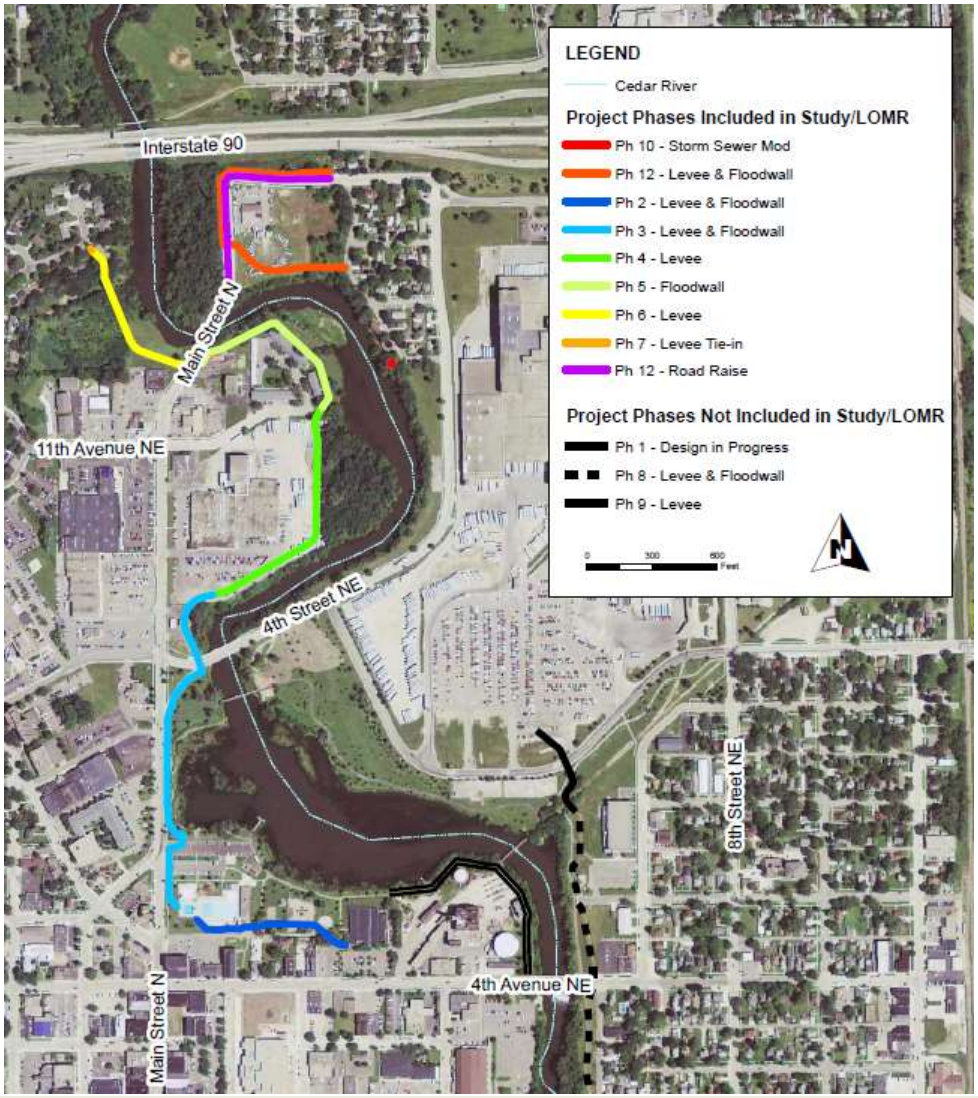
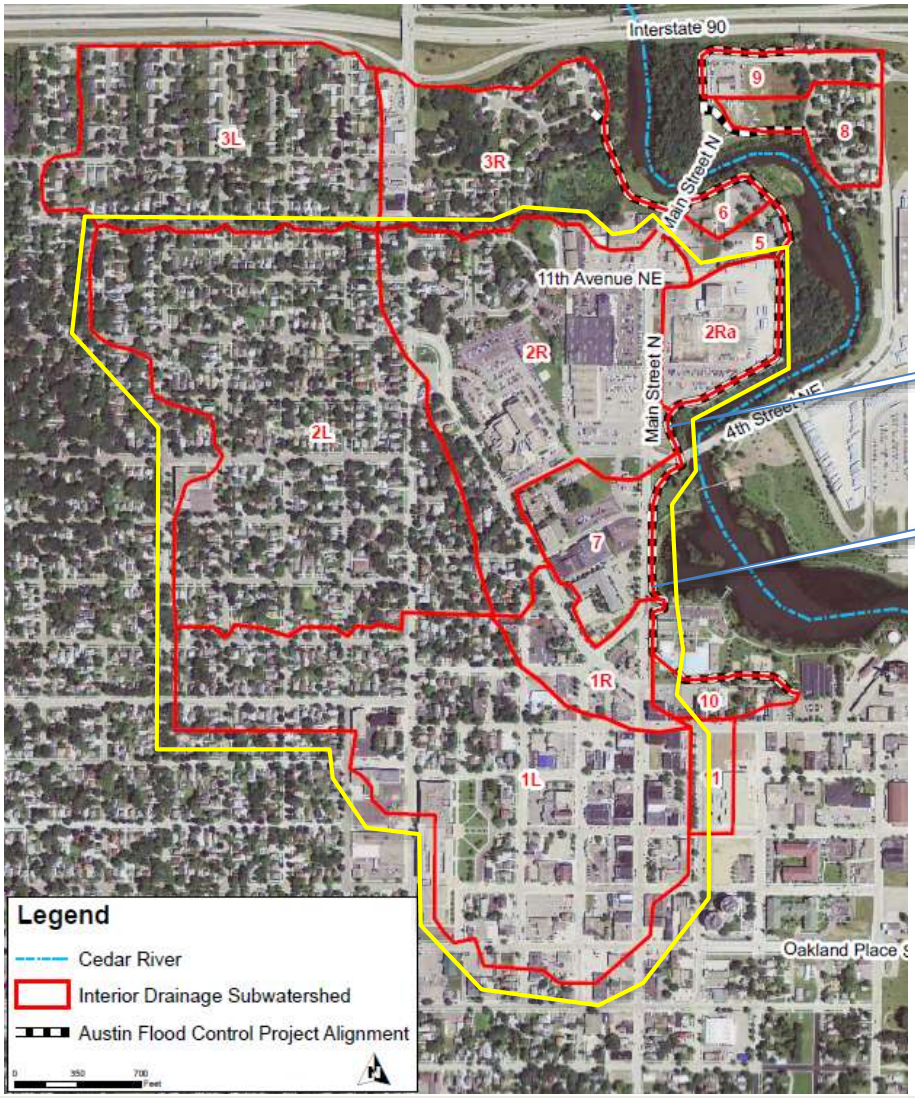
Cedar River LOMR – Austin, MN



Cedar River LOMR – Austin, MN

- Flood Risk Reduction Project LOMR
  - Riverine Hydrology & Hydraulics
    - No Change to Hydrology
    - Hydraulics Updated
  - Riverine Structures
    - Hydraulic, Structural & Geotechnical Designs
    - Interior Drainage Design
  - Revised FIRM and FIS for Cedar River to reflect completed floodwall/levee project.

Cedar River LOMR – Austin, MN



Pump Station

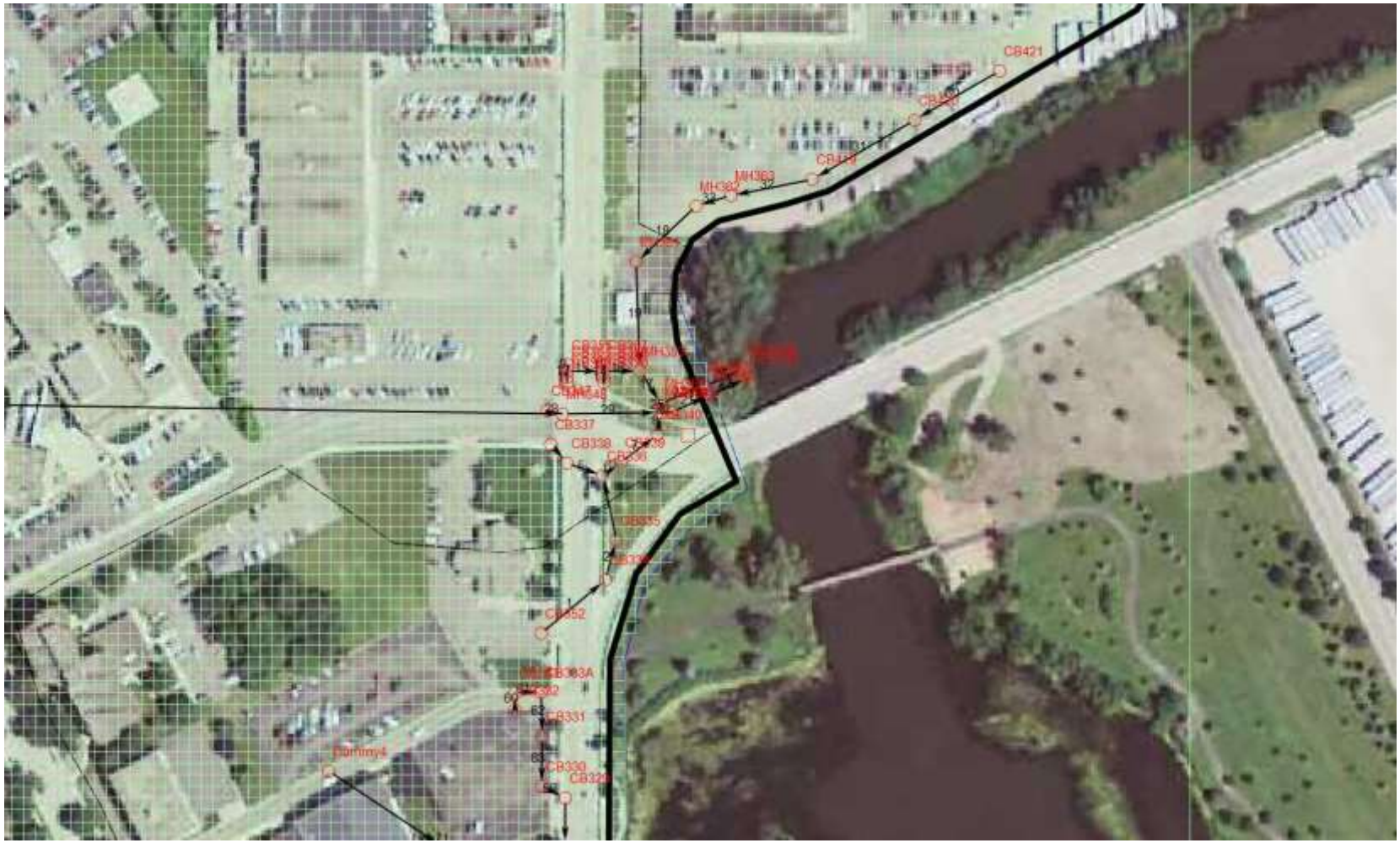
Pump Station

Cedar River LOMR – Austin, MN

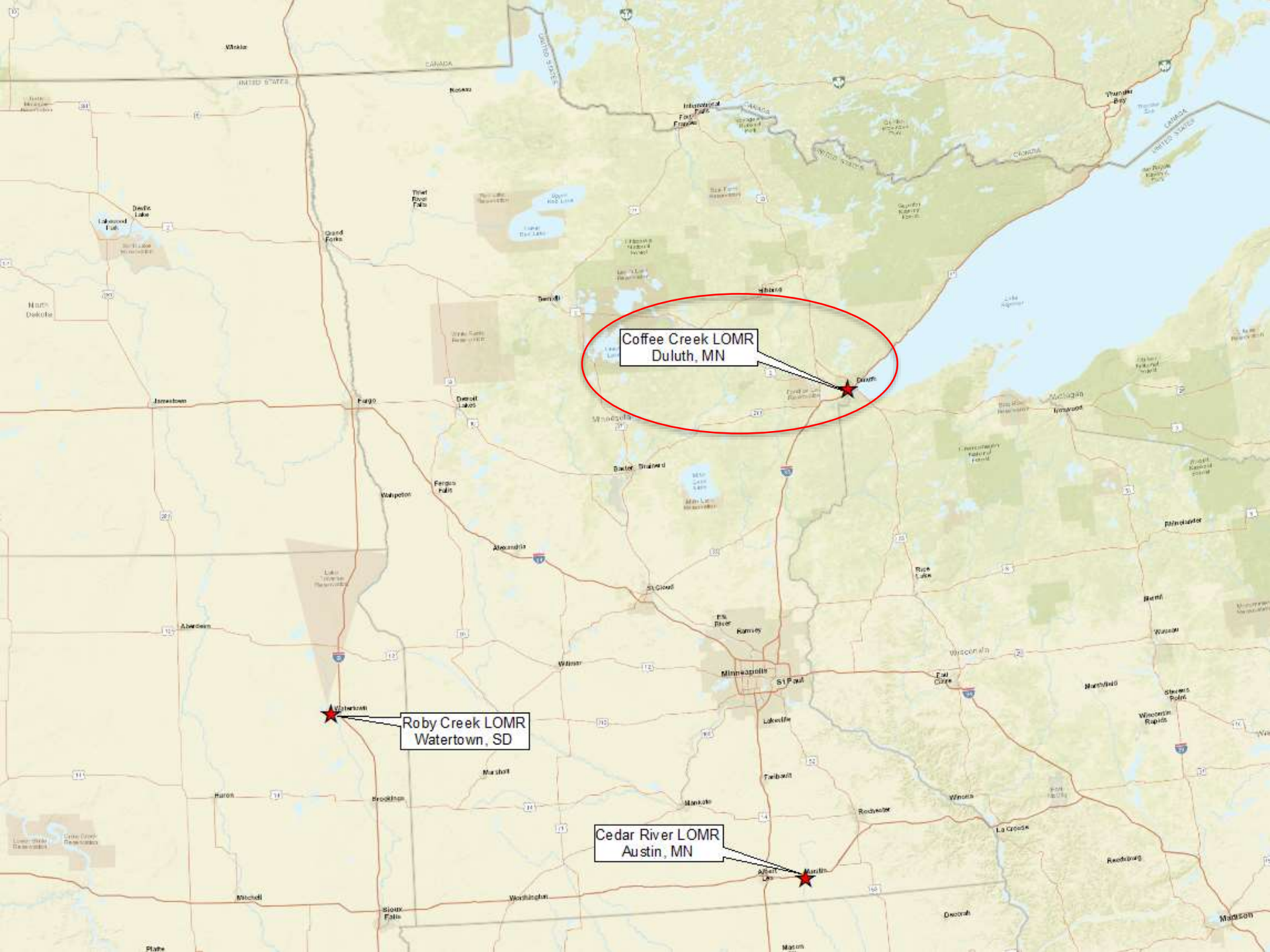
- Original Model: HEC-HMS
  - Both gravity & pressure systems
  - Interaction between ponding areas, inlets
- New Model: 1D/2D XPSWMM
  - Same underlying surface as for RAS model
    - Fill area used to represent floodwall
  - Direct rainfall for selected events
    - Coincident frequency analysis
  - Inlet controls
    - Rating curves developed for each casting type

Cedar River LOMR – Austin, MN

Cedar River LOMR – Austin, MN



Cedar River LOMR – Austin, MN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Marshall
Willmar
Winona
La Crosse
Eau Claire
Rhinelander
Wausau
Stevens Point
Wisconsin Rapids
Madison
Reedsburg
Lakeville
Faribault
Albert Lea
Fergus Falls
Walpeton
Detroit Lakes
Thief River Falls
Ironwood
Hibbing
Virginia
Superior
Ashland
Thunder Bay
Nelson
Winkler
Dauphin
Lake Superior
Lake Winnipeg
Lake Manitoba
Lake Dauphin
Lake Traverse
Big Stone Lake
Lake Kabetogama
Rice Lake
Mellen
Michigan
Wisconsin
Minnesota
North Dakota
CANADA
UNITED STATES

Coffee Creek LOMR – Duluth, MN

SEH

Project: DULUT 130008
Print Date: 4/13/2016

Study Reach
Coffee Creek LOMR
Duluth, Minnesota

Figure 1

SEH

Coffee Creek LOMR – Duluth, MN

- June 2012 Flooding

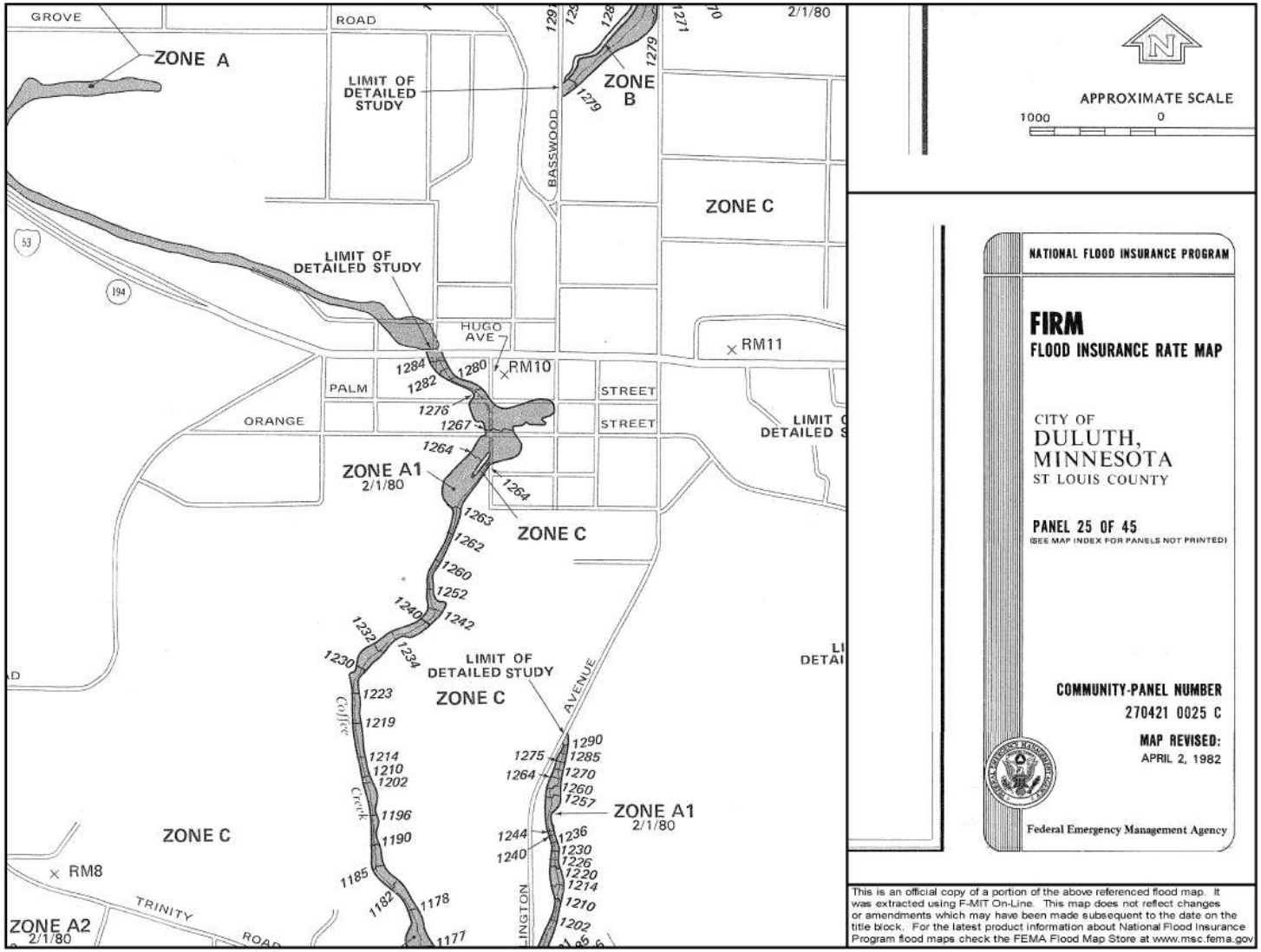
In this aerial photo, floodwaters surround the Burning Tree Plaza shopping area in Duluth, Minn., Wednesd
King/AP)

In this aerial photo, waters from an overflowing nearby creek inundate homes in the Irving Park neighborhood of Duluth, Minn., Wednesday afternoon, June 20, 2012. (Bob King/AP)

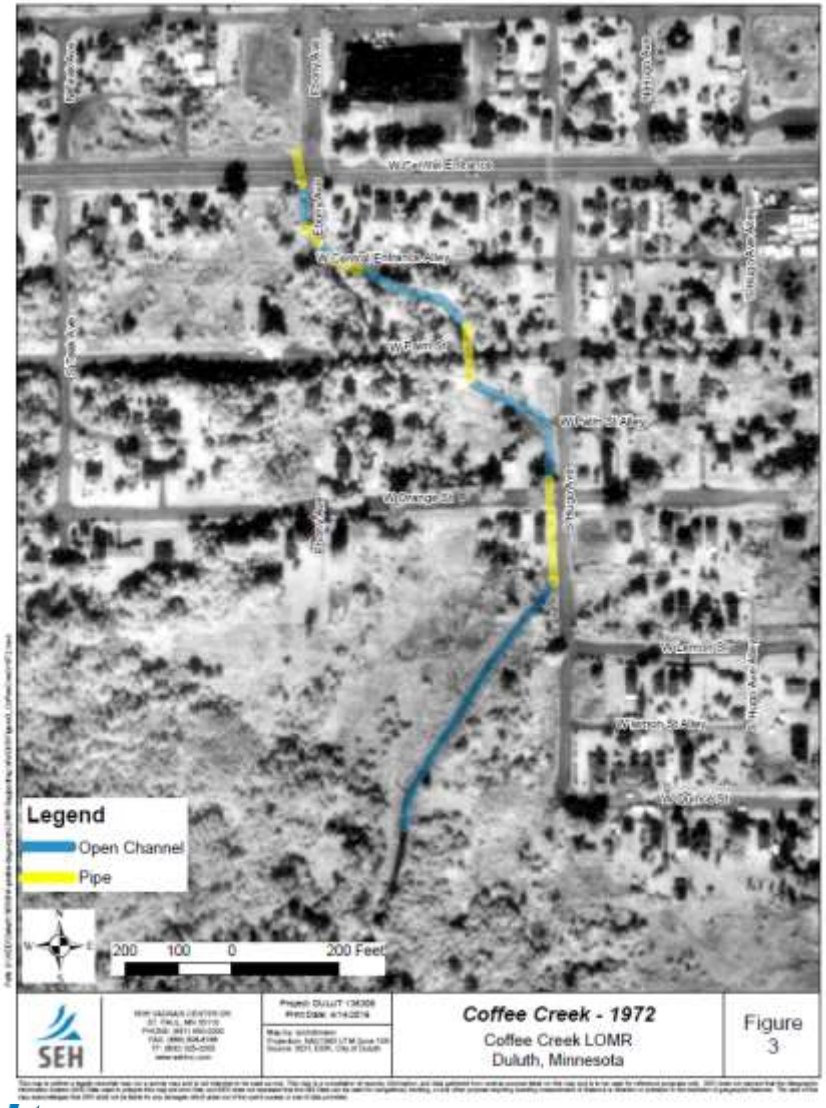
Coffee Creek LOMR – Duluth, MN

- Revise hydrologic and hydraulic studies completed for effective FIRM in late 1970s
  - Incorporate existing flow “diversion” at Central Entrance (TH 194) and Palm Street
  - Incorporate data for existing storm sewer system, which was not in place in the 1970s
- Update floodplain and floodway boundaries on FEMA maps
  - Area between Orange Street and Central Entrance (TH 194)

Coffee Creek LOMR – Duluth, MN



Coffee Creek LOMR – Duluth, MN



Coffee Creek LOMR – Duluth, MN

- HEC-HMS Model Created
  - Atlas 14 Rainfall Data w/ MSE-4 Distribution
  - Central Entrance diversion and Palm Street diversion using rating curves
- HEC-RAS Model Created
  - New topographic data and survey data of culverts, pipes
  - Revised discharge rates from HEC-HMS

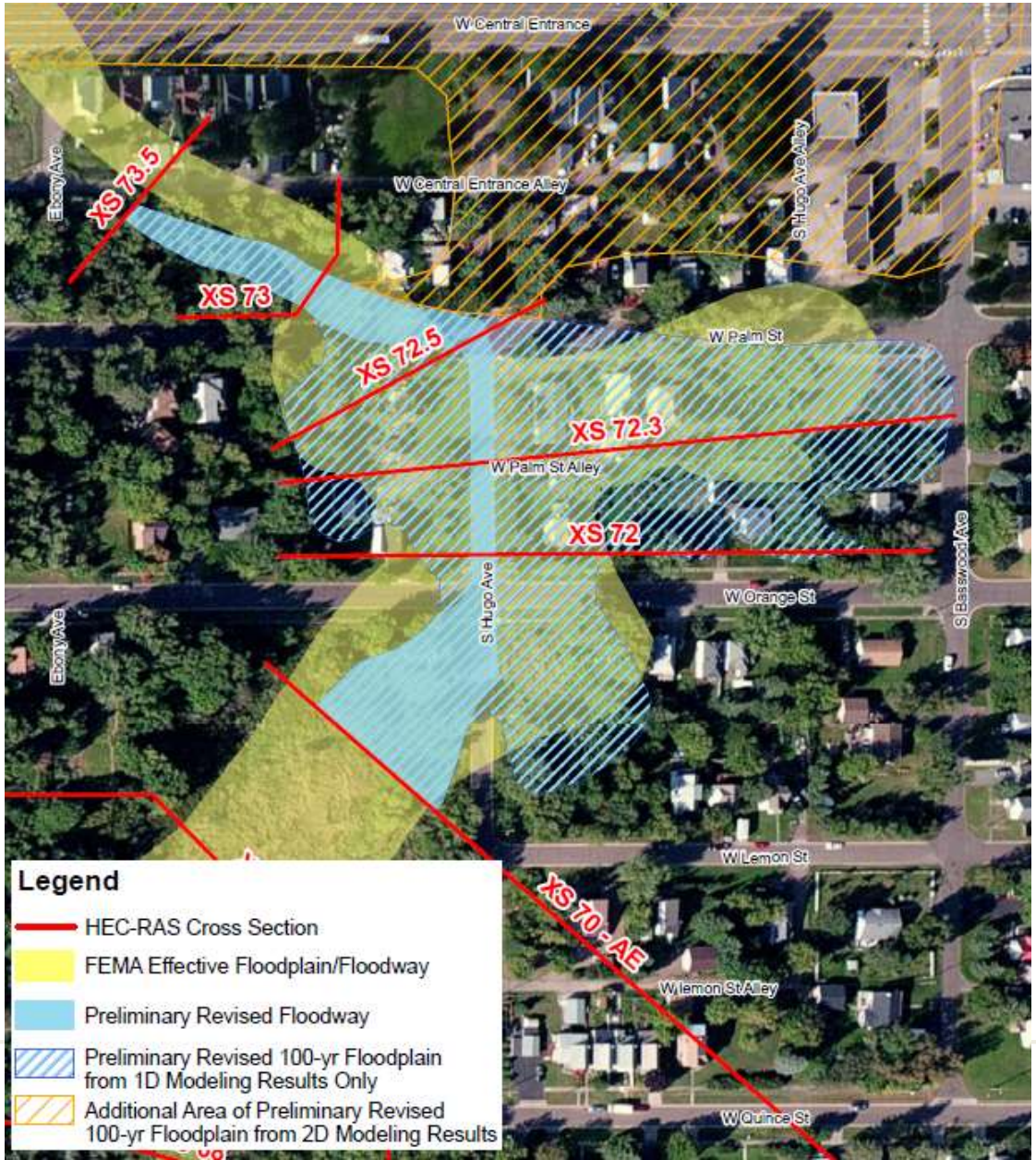
Coffee Creek LOMR – Duluth, MN

- Flow Diversion at Central Entrance:
  - During 100-year Event:
    - 266 cfs upstream of Central Entrance, 144 cfs diverted down Central Entrance
    - Duration of diversion: 2 Hrs, 40 Min
    - FIS: 240 cfs for Brewery Creek
  - DNR would require that the breakout flow be mapped as Floodway.
  - Impacts of mapping Floodway as-is similar to Watertown

Coffee Creek LOMR – Duluth, MN

- SRH-2D Results for Existing Conditions:

Coffee Creek LOMR – Duluth, MN



SEH

Coffee Creek LOMR – Duluth, MN

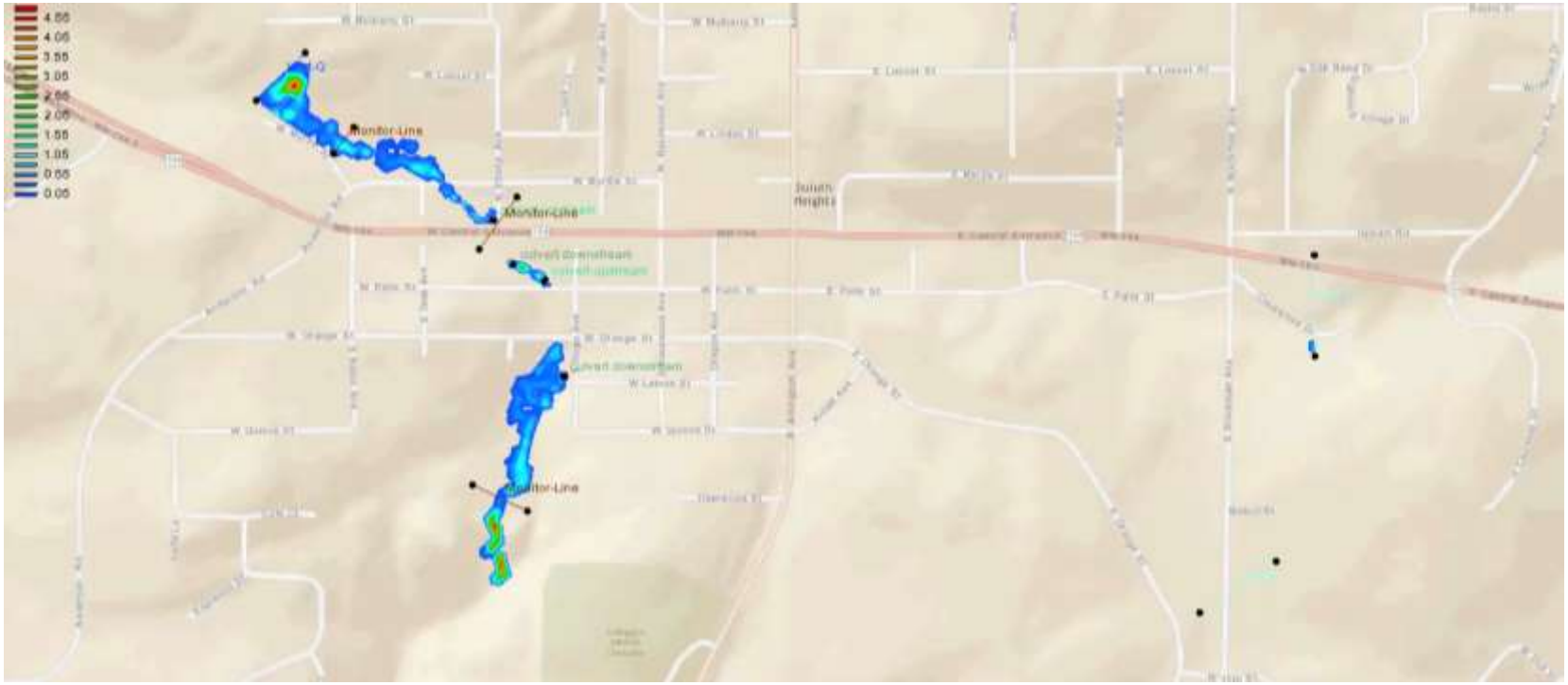
- Culvert replacement considered
  - Current Pipe: 36” x 58” RCAP & 48” RCP
  - Possible Replacement: 3’ x 8’ RC Box Culvert with tapered inlet, lowered inverts.
  - Maintain or increase same cover as existing, increase capacity.
  - Need to continue replacement down to south side of Central Entrance Alley, approx. 310 LF

Coffee Creek LOMR – Duluth, MN

- SRH-2D Results with Culvert Replacement:

Coffee Creek LOMR – Duluth, MN

- SRH-2D Results without Breakout Flow:



Coffee Creek LOMR – Duluth, MN

- Next Steps:
  - Evaluate Opportunities to Prevent Breakout Flow:
    - Upstream Storage
    - Culvert Replacement at Central Entrance
    - Channel Restoration between Palm St & Orange St
      - Home Buyouts
      - Bridges at Palm Street & Orange Street
      - Trout Stream
  - Continue to use SRH-2D Model to Improve HEC-RAS 1D Model of Coffee Creek