HEC-RAS 2d Modeling US 20 Bridge

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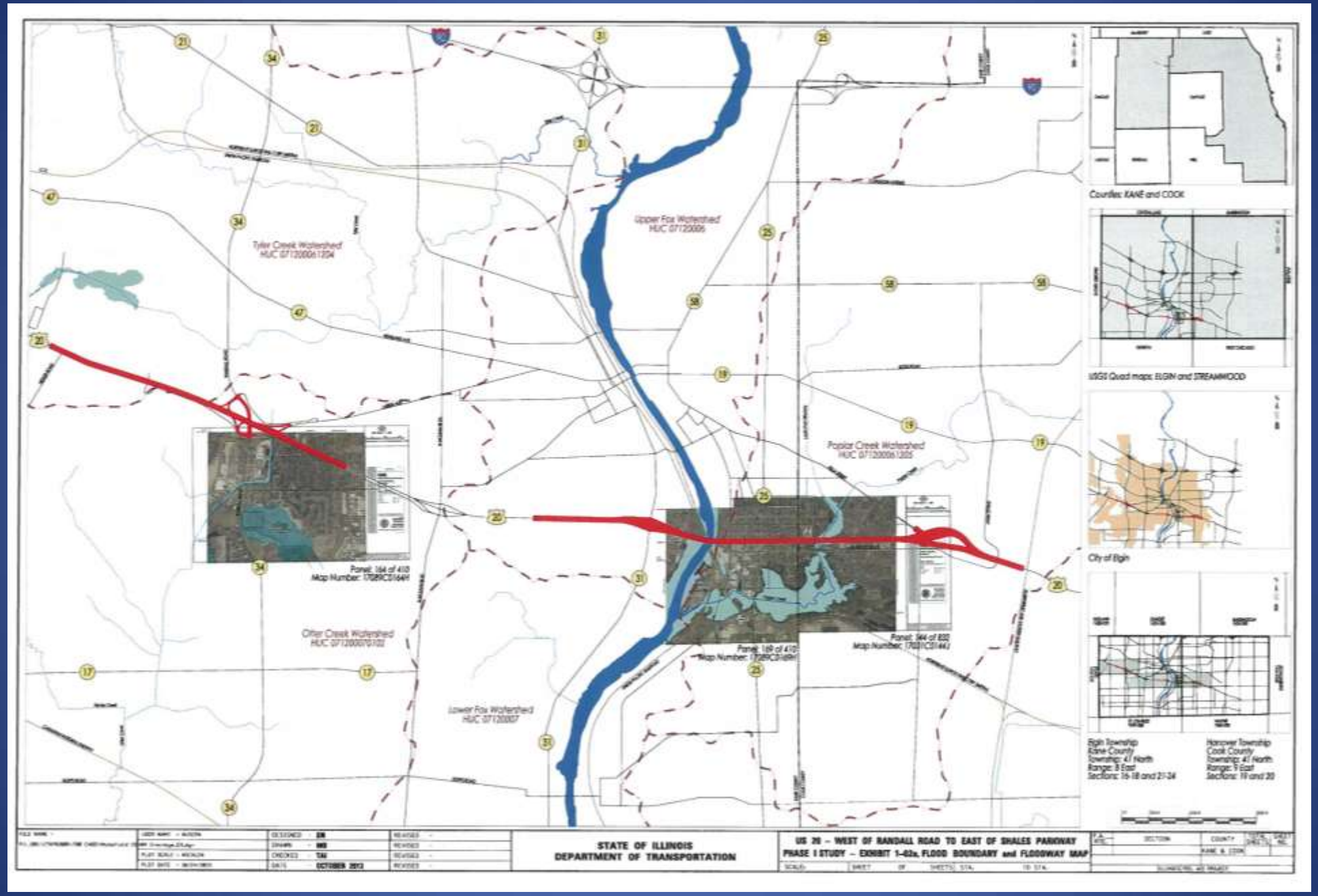
Phase 1 Study of US 20, Nesler Road to Shales Parkway

- 5.7 miles of roadway improvement design with target completion for Phase 1 Engineering in Fall 2018.
- Five bridge replacement/rehabilitation at estimated cost of $42.7 million.
- US 20 bridge over Fox River replacement at estimated cost of $26.8 million.

Phase 1 Study of US 20, Nesler Road to Shales Parkway

- Intersection and roadway improvements at estimated cost of $30.5 million.
- McLane Boulevard Interchange Omission.
- Not included in the Department's FY 2018-2023 Proposed Highway Improvement Program.


Tyler Creek Watershed
HUC 07120006120
Upper Fox Watershed
HUC 07120006
Poplar Creek Watershed
HUC 07120006120
Otter Creek Watershed
HUC 07120007010
Lower Fox Watershed
HUC 07120007
Counties: KANE and COOK
USGS Quad maps: ELGIN and STREAMWOOD
City of Elgin
Elgin Township
Kane County
Township: 41 North
Range: 8 East
Sections: 16-18 and 21-24
Hanover Township
Cook County
Township: 41 North
Range: 9 East
Sections: 19 and 20
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION
US 20 – WEST OF RANDALL ROAD TO EAST OF SHALES PARKWAY
PHASE I STUDY – EXHIBIT 1-02a, FLOOD BOUNDARY and FLOODWAY MAP

IDOT Prepares Waterway Hydraulic Reports

- At mapped floodplains draining over one square mile, and
- More detailed evaluation required for projects involving:
  a. Replacement of Bridge, Culvert, or Bridge Superstructure
  b. New Bridge or Culvert
  c. Longitudinal Encroachment

Why are Hydraulic Reports Prepared?

- To document project impacts and compliance with IDOT drainage criteria (e.g., created head, free board, and clearance.
- Estimate the scour depth.
- To meet the IDNR permit requirements (e.g., Created head and Compensatory storage for fill in Floodway).
- To set the roadway profile and ROW footprint.
- To document hydrologic and hydraulic analyses.

Hydraulic Report Approval Process

District 1 has a Qualified Hydraulic Engineer, District 1 approves certain Hydraulic Reports:

- All Culverts not in a Public Body of Water
- Bridges in a designated floodway (Part 3708 Rules) not in a Public Body of Water

Bureau of Bridges & Structures (BB&S) approves other Hydraulic Reports:

- Bridges requiring an individual IDNR/OWR permit (Part 3700 Rules)
- All projects in a Public Body of Water (Part 3704 Rules)

2-D Modeling
Completed or Ongoing Projects

District 2: US52 over Elkhorn Creek

District 4: IL150\US24 over Illinois River

District 9 I-64 over Wabash River

District 8: I 270 over Mississippi River

District 1: US 20 over Fox River

FHWA Approach Toward 2-D Modeling

- FHWA promotes SMS SRH-2D.
- FHWA has been offering training to the states as part of "Advancing to the Next Generation of Engineering (CHANGE)".
- IDOT is not requiring SRH-2D modeling at this time.
- IDNR-OWR does not accept SRH-2D for permitting at this time.

Scour Analysis Guidance

- HEC RAS/SRH-2D: Flow parameters
- HEC-18 (Hydraulics and Scour Analysis): Contraction, Abutment, and Pier Scour Depth
- HEC-20 (Stream Stability): Long Term Degradation Scour
- HEC-23 Scour Countermeasures

Scour Analysis Guidance (cont.)

- IDOT Memorandum 14.2, Revised Scour Policy, November 7, 2014
- Design/Check Flow: 10-y, 50-y, 100-y, and 200-y
- Design for the maximum scour depth
- District 1 Scour Analysis Guidance

http://www.idot.illinois.gov/Assets/uploads/files/IDOT-Forms/D1/D1%20PDPDF5.pdf

Scour Summary

Existing or Proposed Structure (circle one)

Structure Number: 047 -0029

Attach a brief narrative/summary of noting key findings such as the following:

Design Scour Event (such as 10-yr, 50-yr or 100-yr): 100 -yr Design

- ✓ Attach Total Scour Plot
- ✓ Superimpose scour check onto total scour plot

  Scour check event (typically 200-yr event): 200-yr check

- ✓ On plot identify elevation of bed before scour
- ✓ Add any other relevant notes
- Does the use of open abutments allow total scour to be used for design to be reduced: Yes or (No*)

  Note: *If Yes, then the total scour does not need to include abutment scour.

  If Yes, does the total scour plot reflect and note this adjustment: Yes or No N/A

- ✓ Include a summary table of the computed scour depths

Note: Design Scour Event and Extreme Event II are discussed in the November 7, 2014 All Bridge Designers (ABD) memorandum 14.2

Identify critical scour depths below and in narrative: (identify total scour and components such as contraction, pier...)

Summary: (100 yr Design / 200 yr check)

Contraction = 8.40' / 9.98'

Pier = 3.84' / 4.03' => Cont. + Pier = 12.24' / 14.01'

(L) Abut = 8.96' / 7.26' => Cont + (L) = 17.36' / 17.25'

(R) Abut = 21.22' / 23.77' => Cont + (R) = 29.62' / 33.75'

NCHRP = 11.47' / 13.10'

D1 PDPDF5 (02/03/17)

Bridge Facts

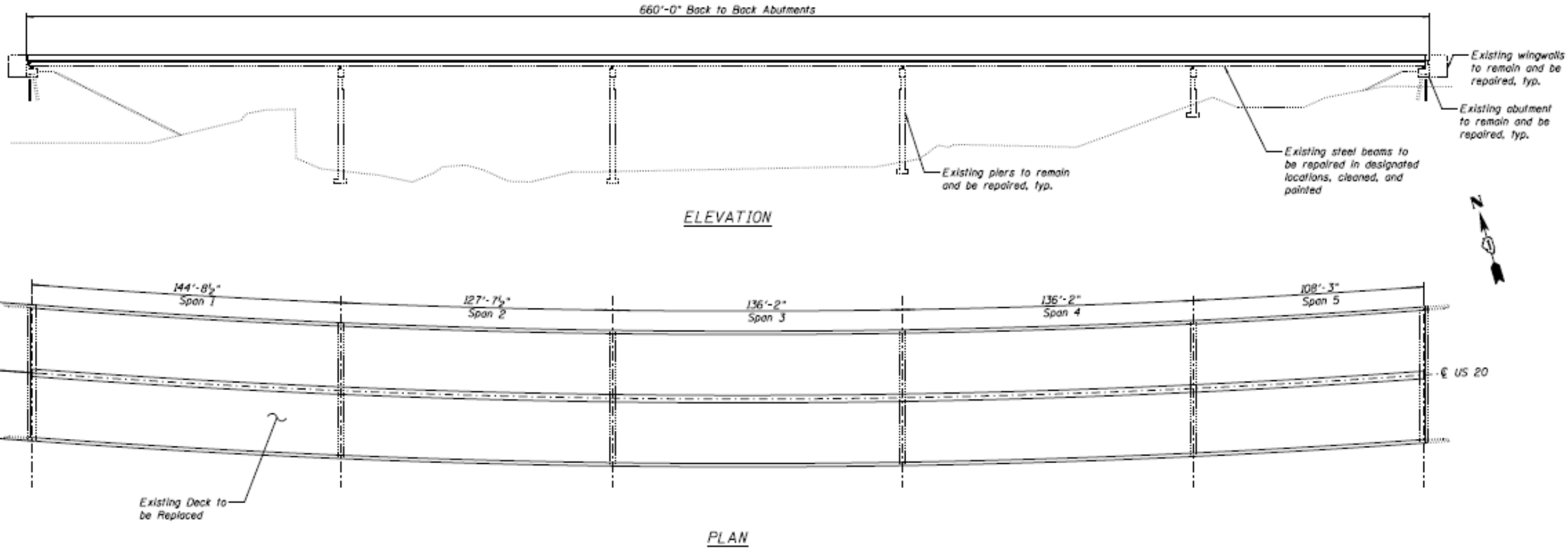
- Constructed in 1959
- 5-Span Steel Beam Structure – 660’ length
- Major Rehab in 1986 – Recent Minor Rehab in 2011
- Deck is in Poor condition – All other elements are Fair or Good condition

Year	Deck	Super	Sub
2017	4	5	7
2015	4	5	7
2013	4	5	7
2011	4	5	7
2009	4	5	7
2006	5	5	7

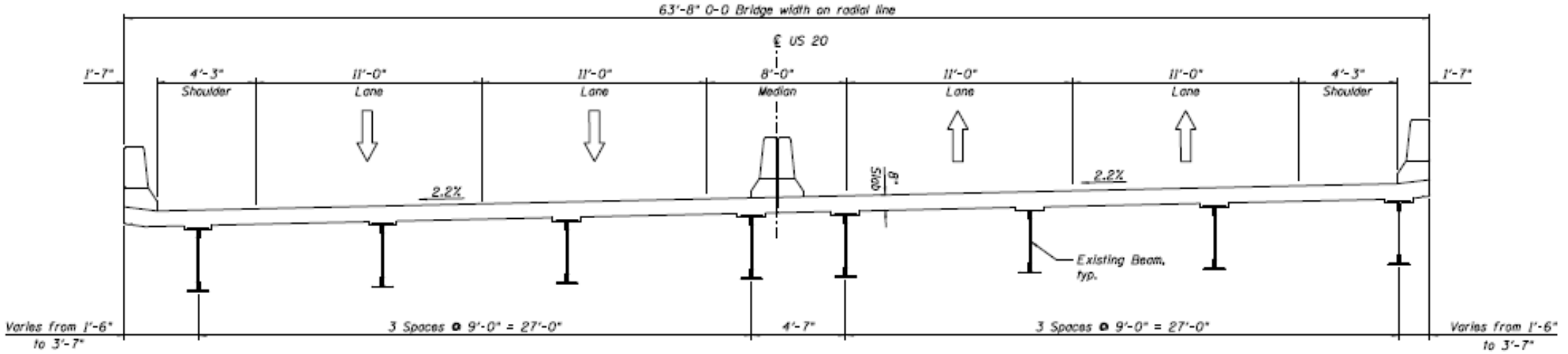
Bridge Replacement

- Community Advisory Group identified safety, mobility and pedestrian access across the Fox River as important issues
- Widening of existing bridge not possible due to limitations of existing spread footings
- Maintenance of Traffic a major factor in decision of design alternatives
- Improvements to meet current design standards for clearance over railroads

Existing Bridge

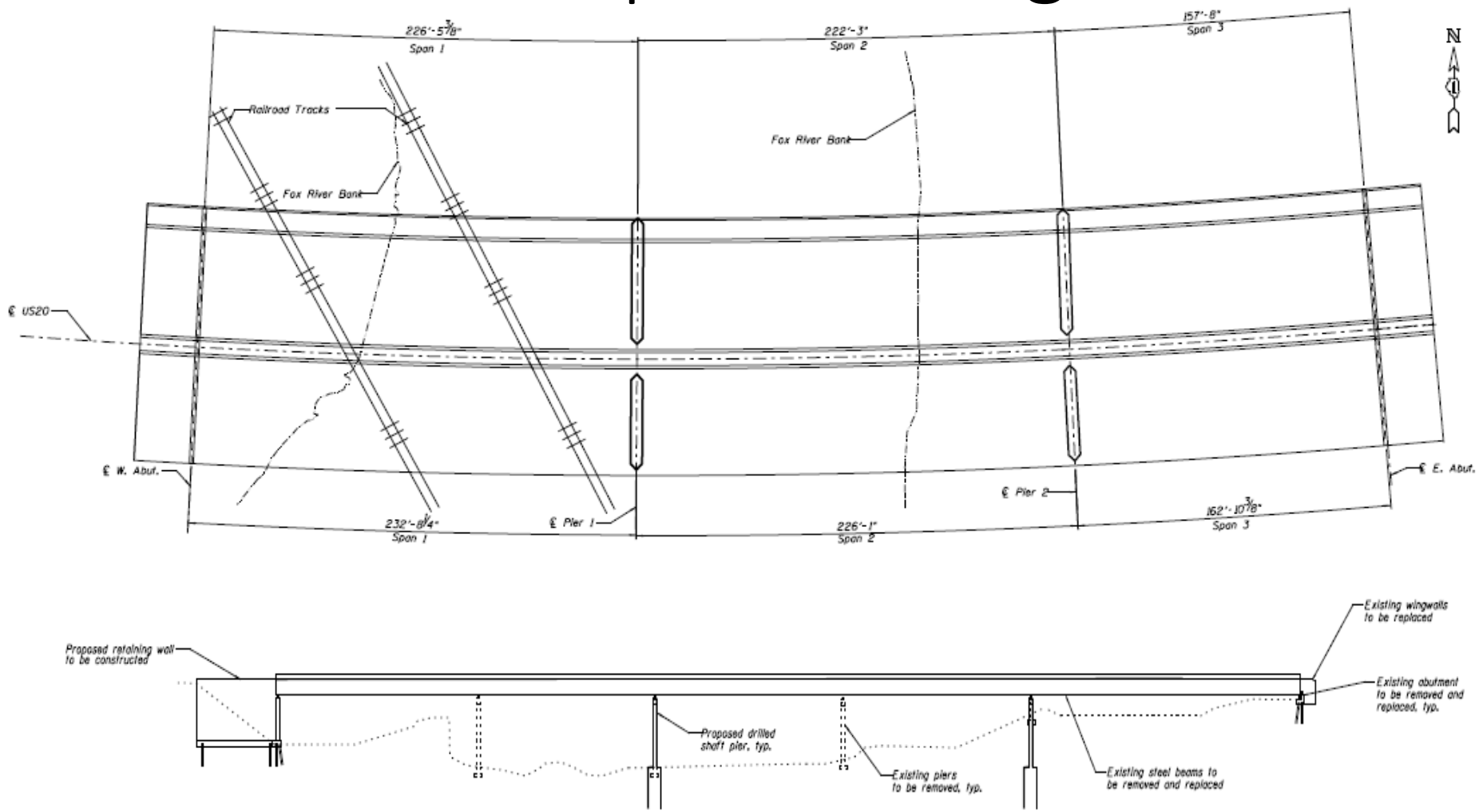


Existing Bridge



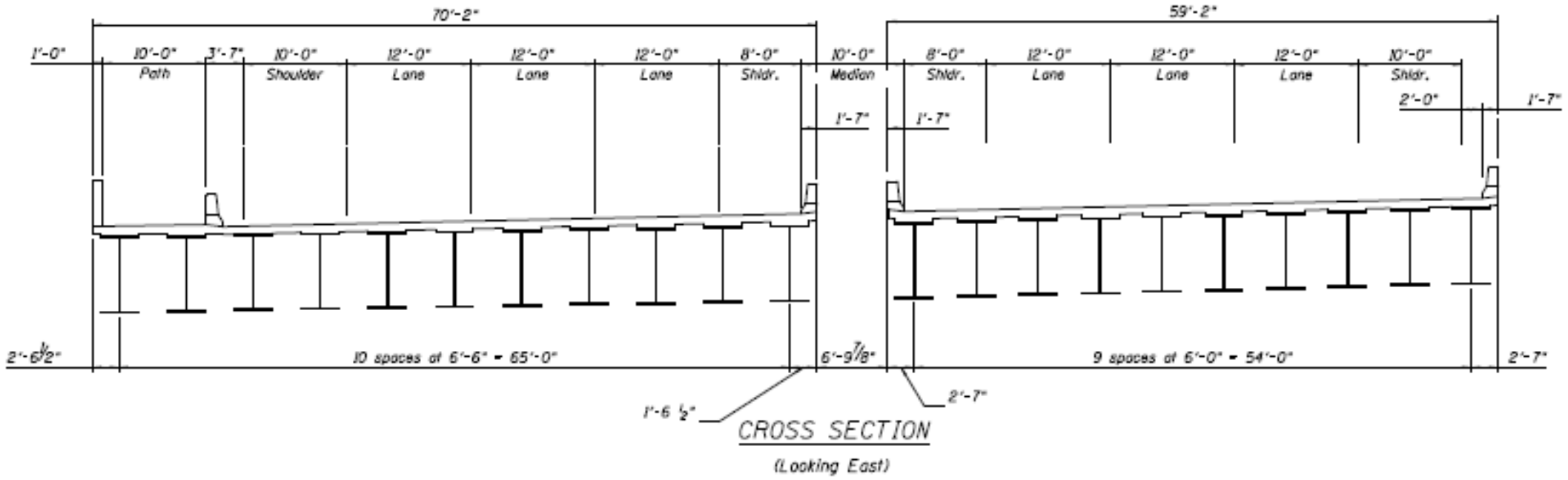
CROSS SECTION
Looking East
(All Dimensions are Radial)

Proposed Bridge

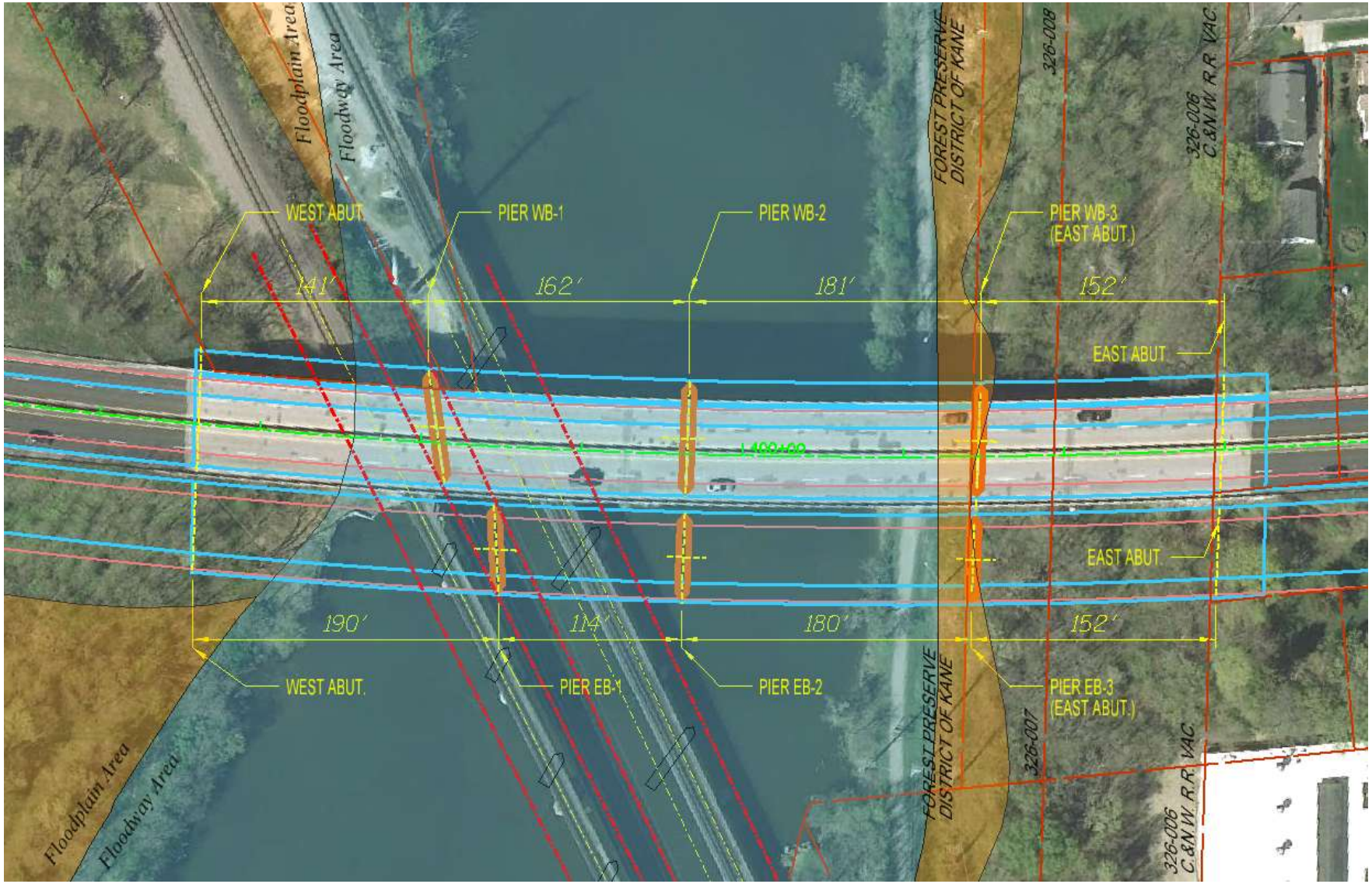


ELEVATION

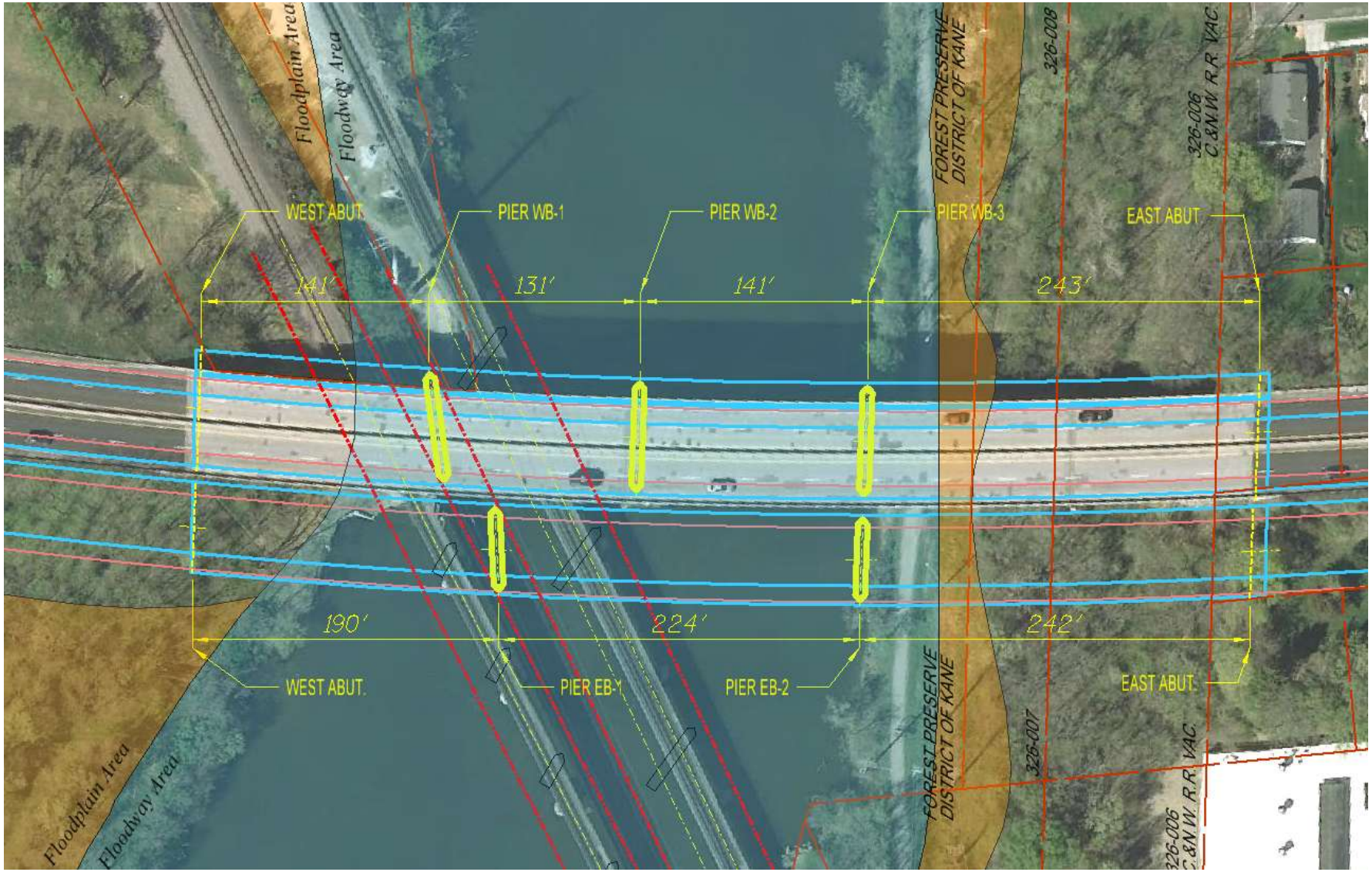
Proposed Bridge



Alternatives



Alternatives



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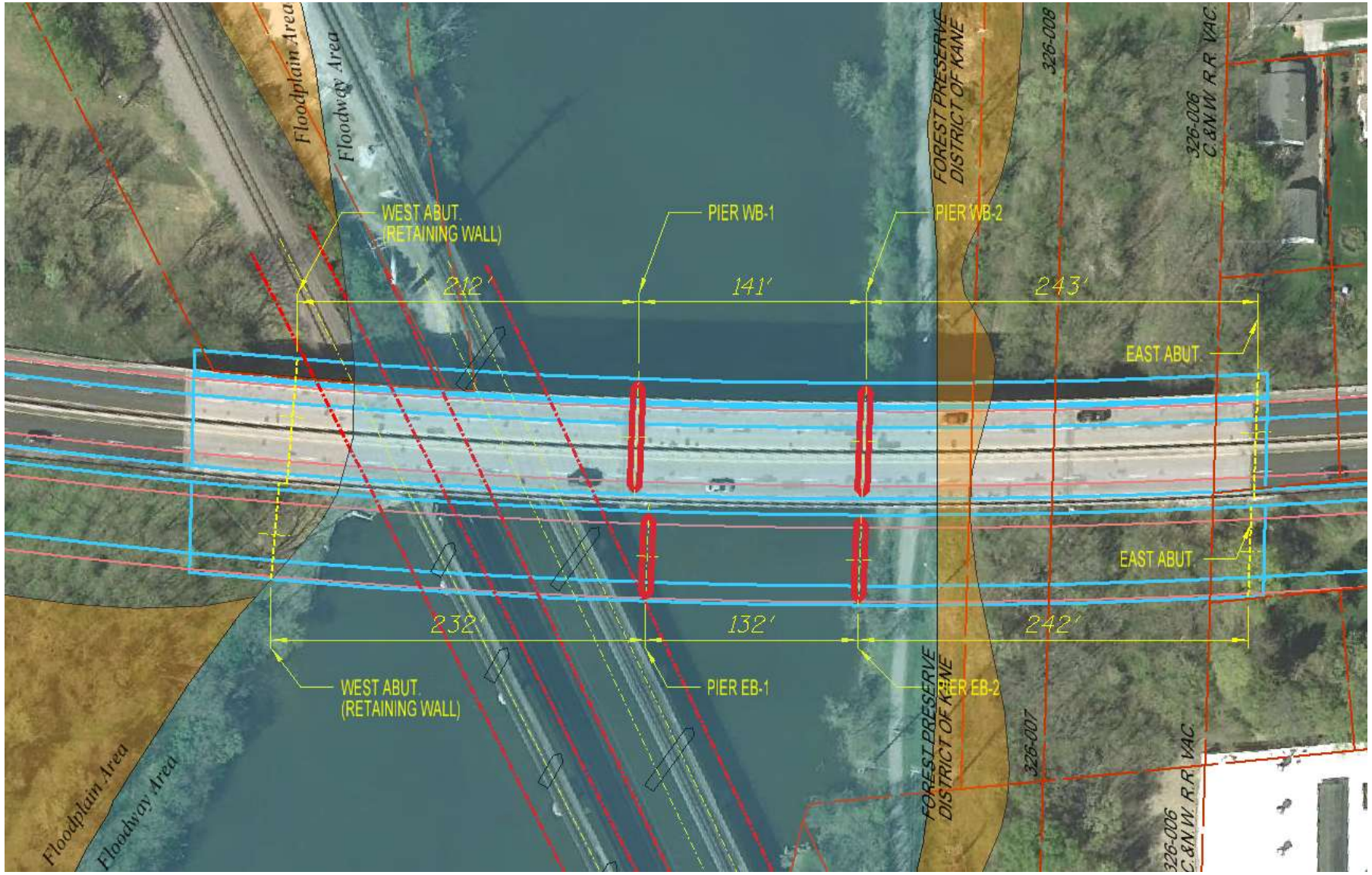
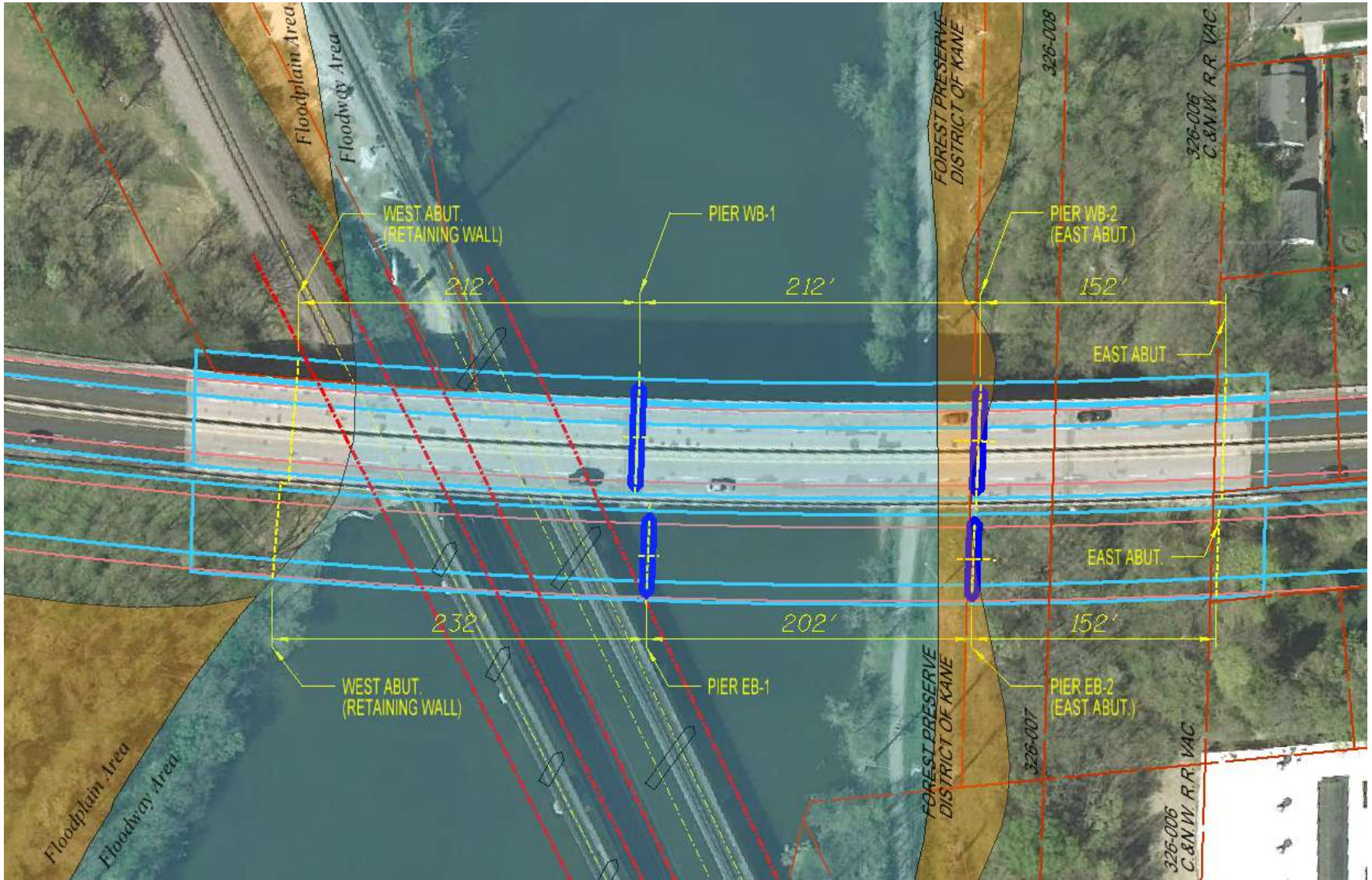


Alternatives

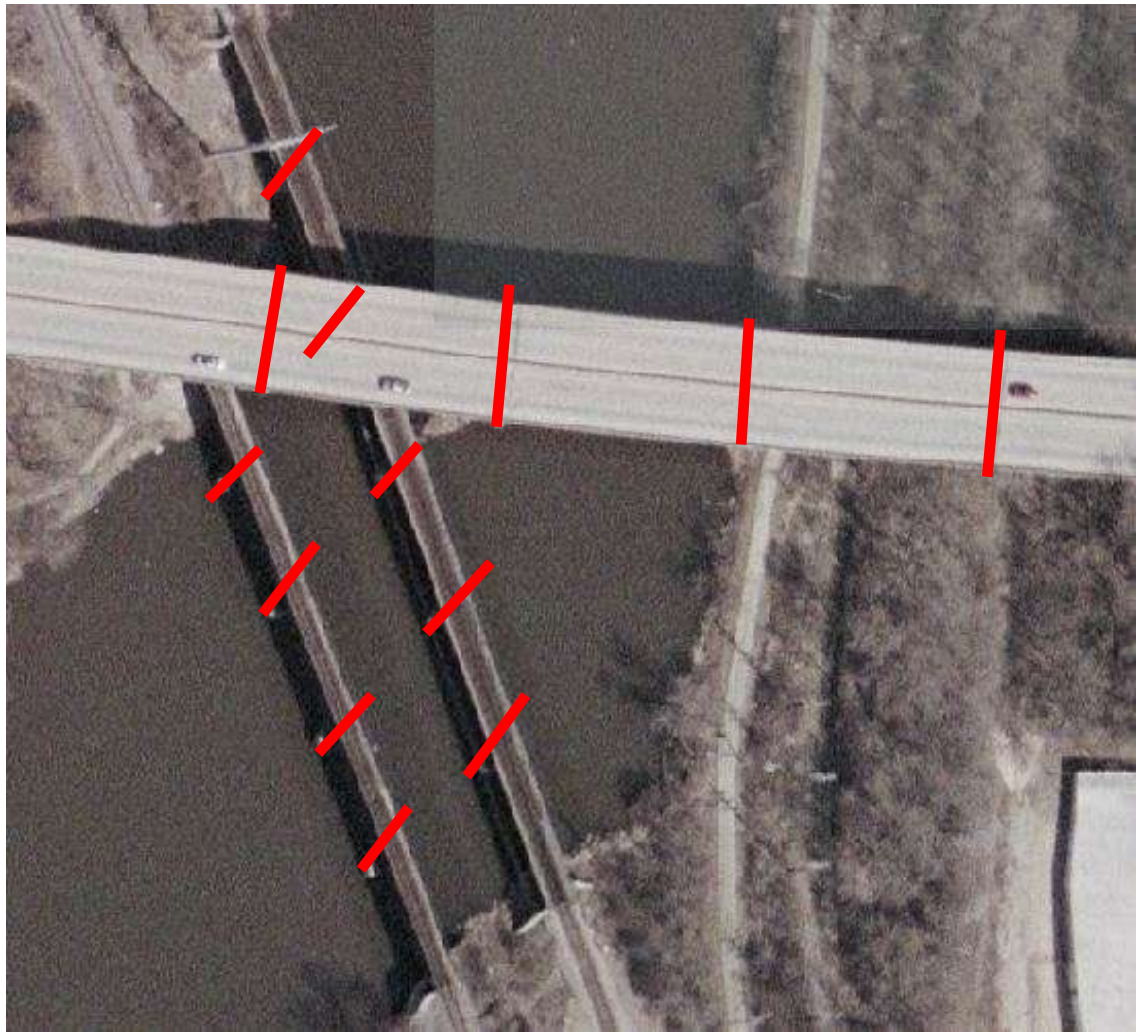


RAS 1d Modeling Limitations

- Can’t Represent all 3 Bridges in Model
- Velocity in 1d RAS is Perpendicular to Cross Section
- Can’t Evaluate Impact of Velocity on Adjacent Piers

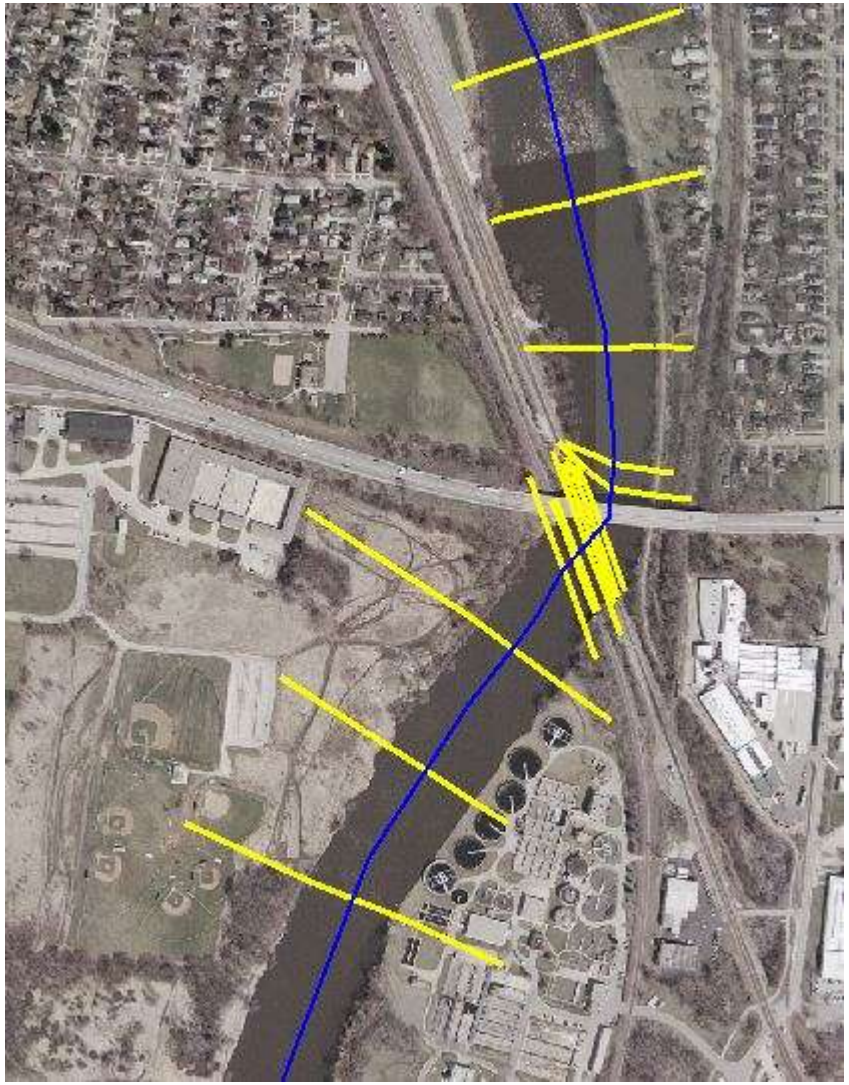
RAS 2d Modeling

- Advantages
  - Ability to Model Interaction of Adjacent Piers on Velocity
  - Bend in River
  - Ability to Model Alternative Pier Locations
- Limitations
  - Can’t Model Bridge Losses



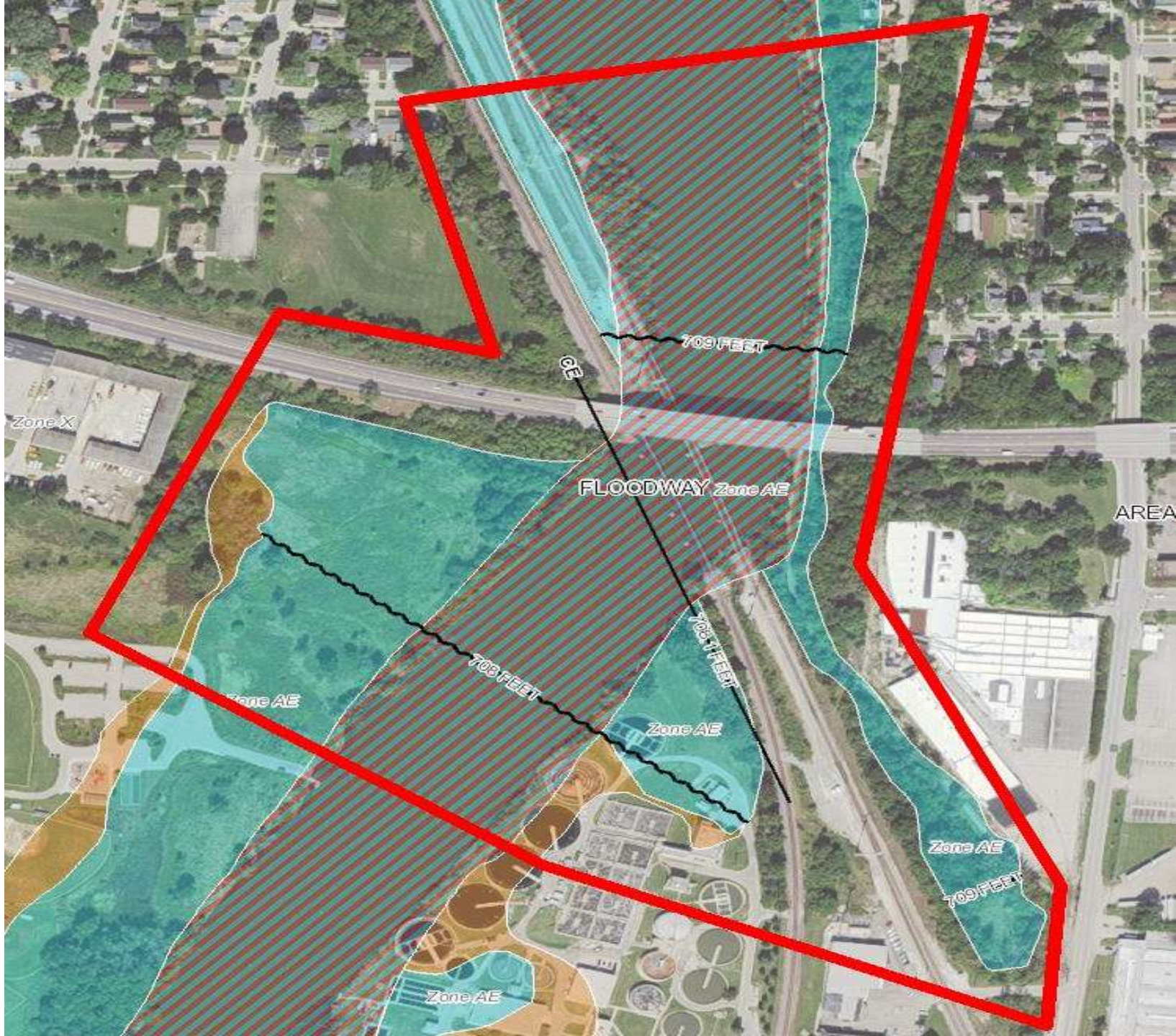
2d Model Setup – Data Sources

- Existing FEMA HEC-2 Model
- Bathymetry of River Bottom
- Field Survey
- Existing Kane County DEM
- FIS Flows – Constant Flow Hydrograph
- Existing US 20 Bridge Plans
- Proposed METRA Bridge Plans

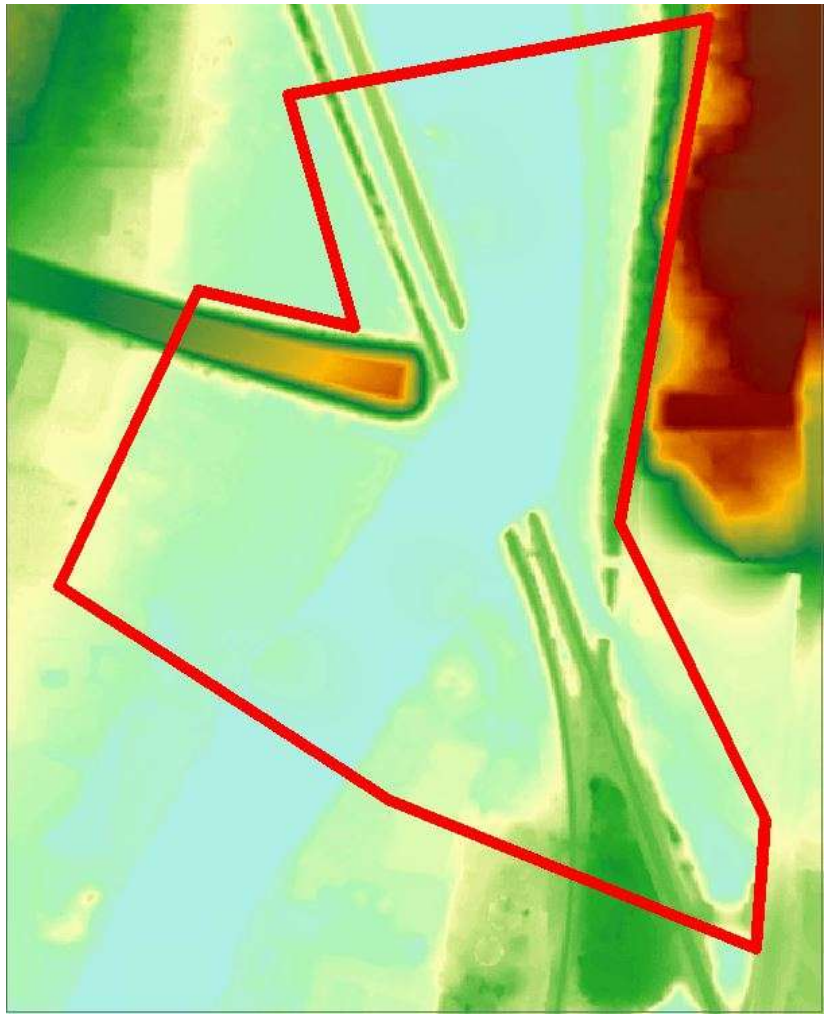


2d Boundary

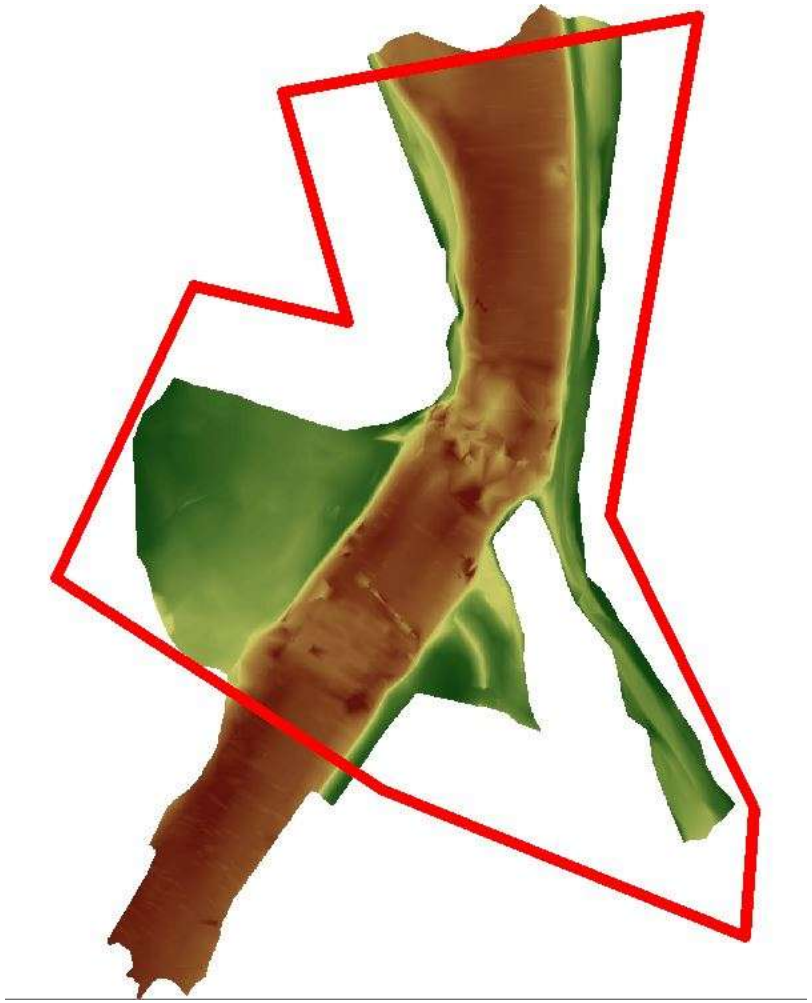
- Based on FIS Flood Plain Limits
- 1d Model Cross Section Locations
- Bathymetry Survey Limits



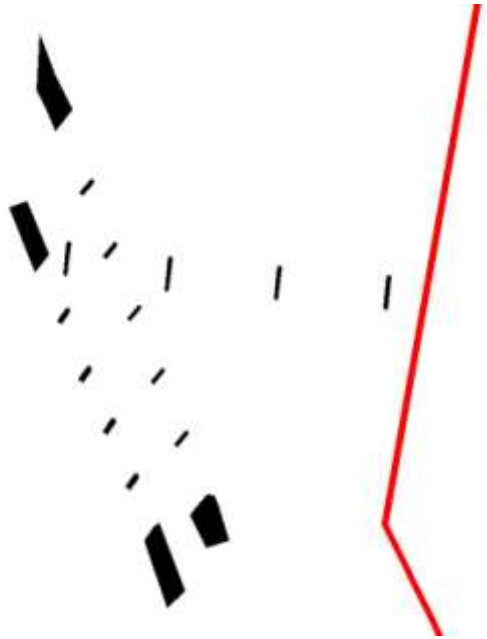
Terrain Creation



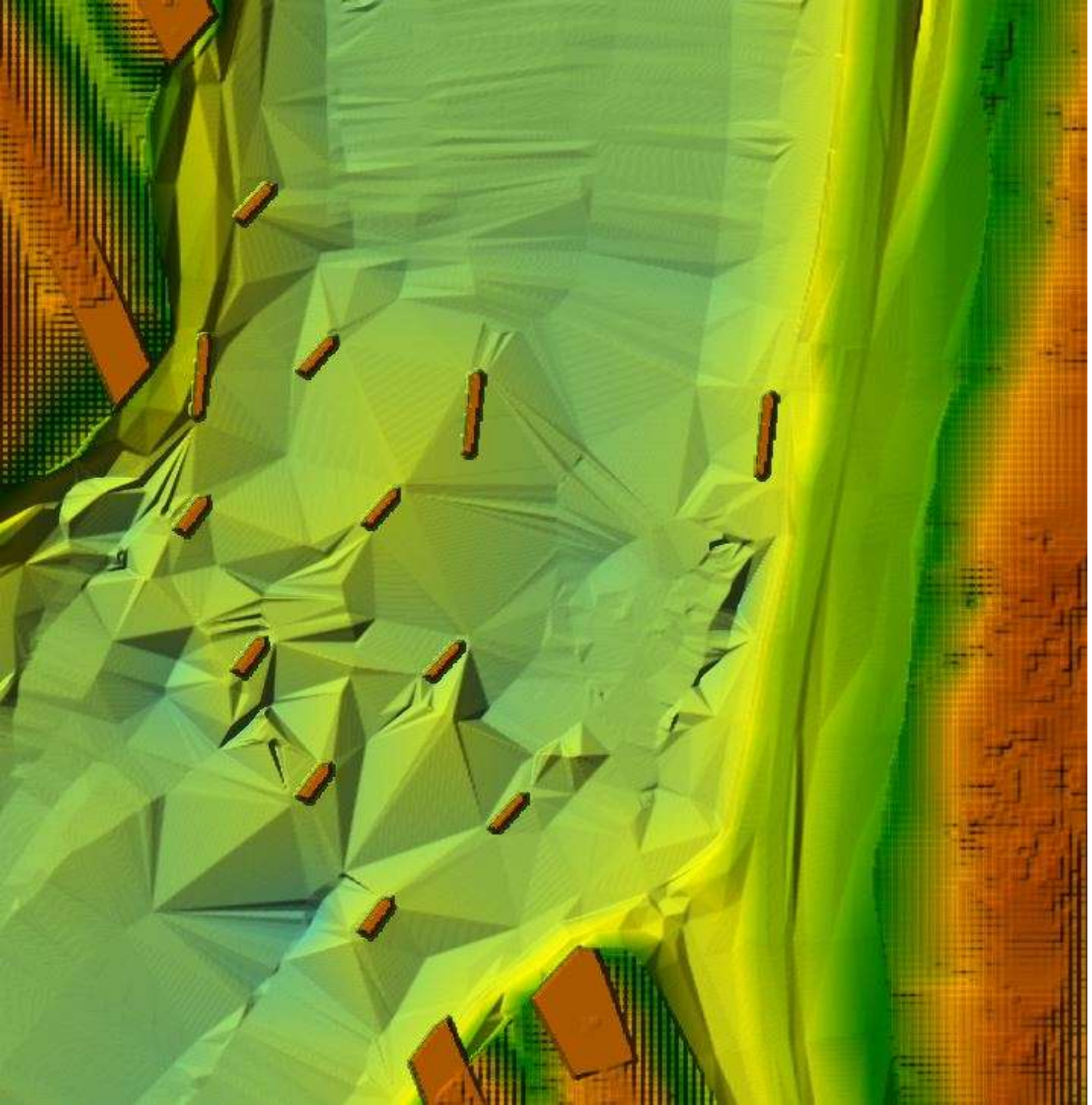
Kane County DEM



Survey TIN



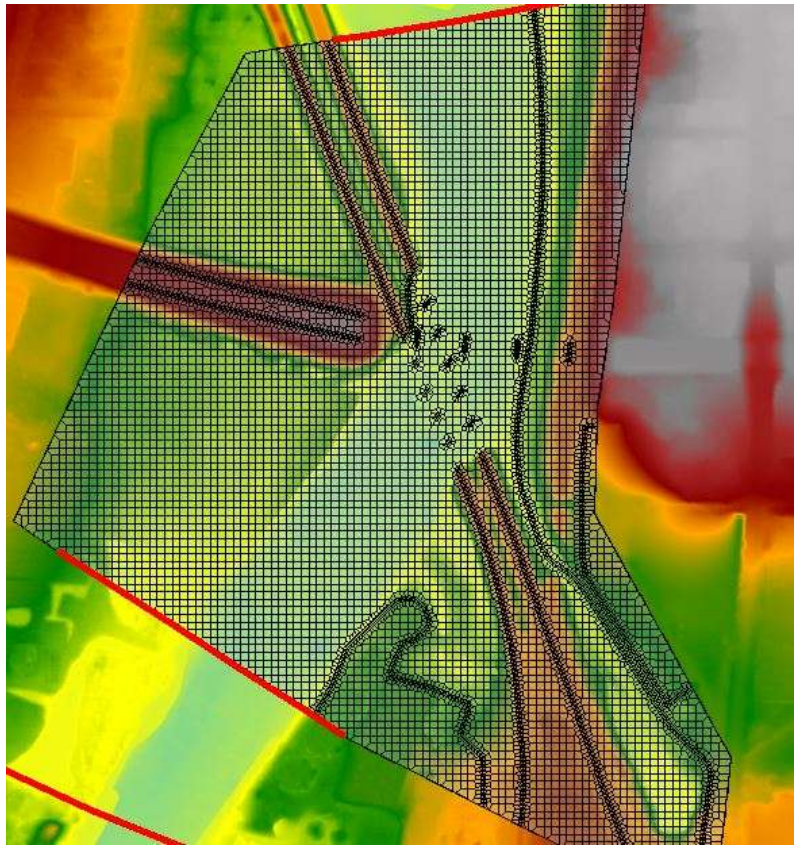
Pier and Abutment Footprint

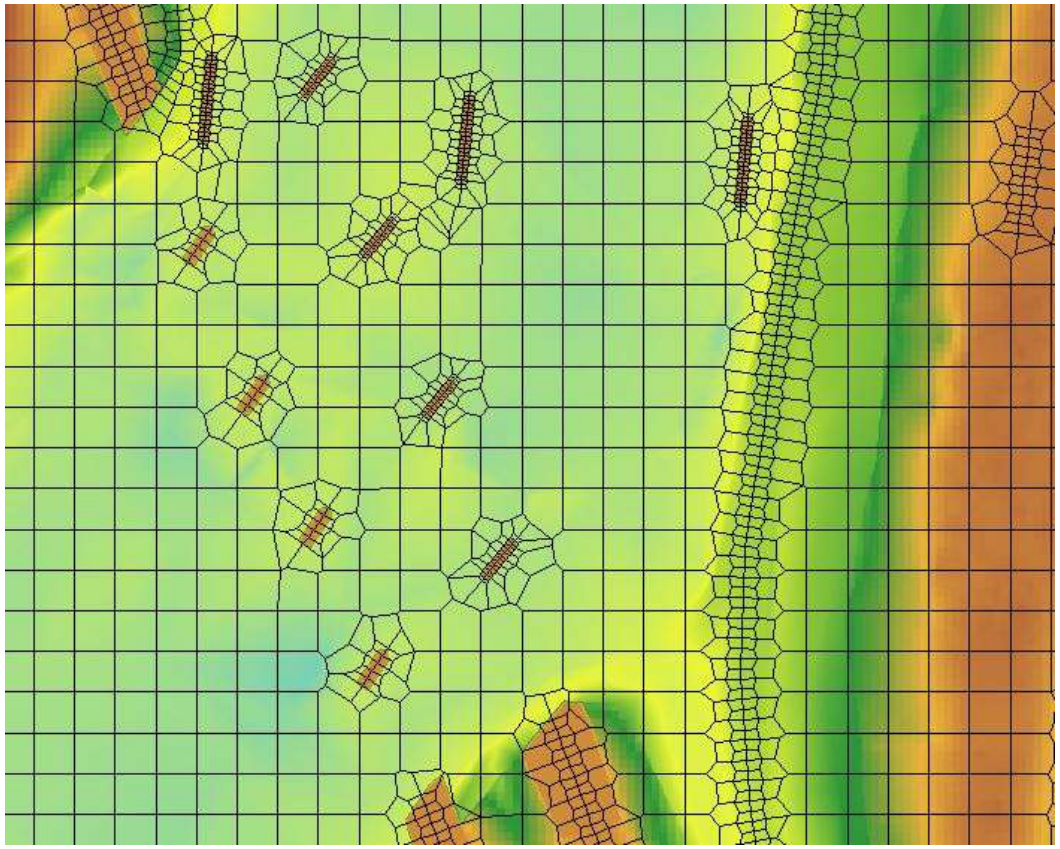


Existing Terrain

Breaklines

- Used to Align Cell Faces with Features





2d Model Layout

2d Sensitivity Analysis

- Created 12 Grids
  - 15 to 50 feet for Overall Grid
  - 5 to 15 along Breaklines
- 4 Time Steps
- Diffusion Wave and Saint Venant Equations
- 96 Total Runs

Sensitivity Analysis (cont’d)

- Tested N Value Variations
- Adjusted Theta
- Additional Grid Cells near Piers

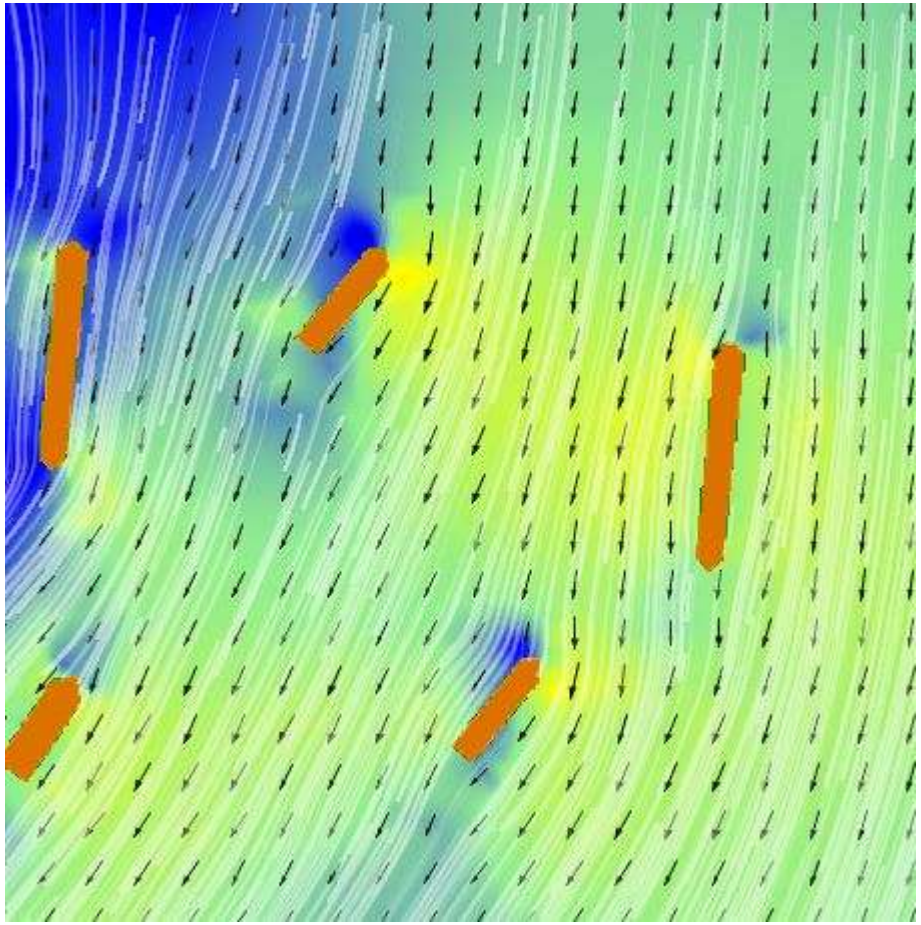
Comparison of FIS, 1-d, and 2-d Results

	FIS HEC-2	RAS 1d	RAS 2d
Downstream of 2d	707.47	706.77	706.82
US 20	708.54	708.16	707.56
Upstream of 2d	708.64	708.36	708.17

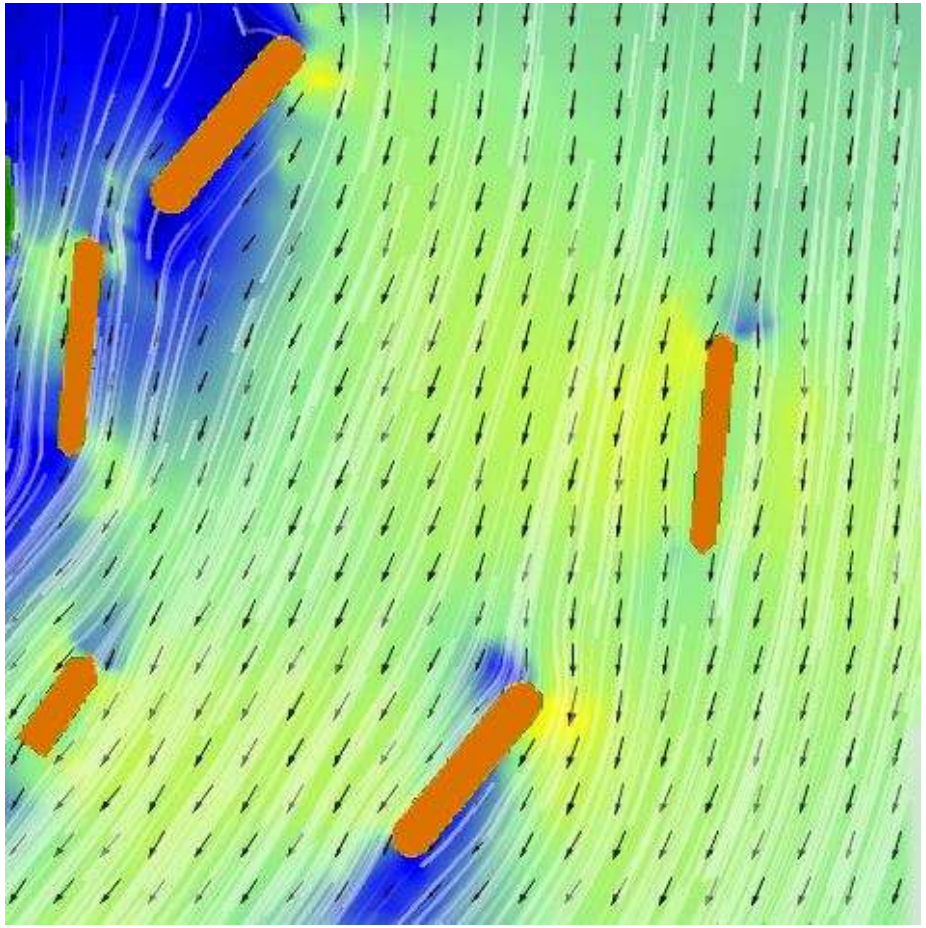
Conditions Modeled

- No Bridges
- UP RR Bridge Only
- Existing UP RR and METRA Bridges
- Existing UP RR and US 20 Bridges
- Existing UP RR, METRA, and US 20
- UP RR, Proposed METRA, and Existing US 20 Bridges
- UP RR, Proposed METRA, and Proposed US 20

Velocity Plot Comparing Existing and Proposed METRA Bridge Impacts on US 20

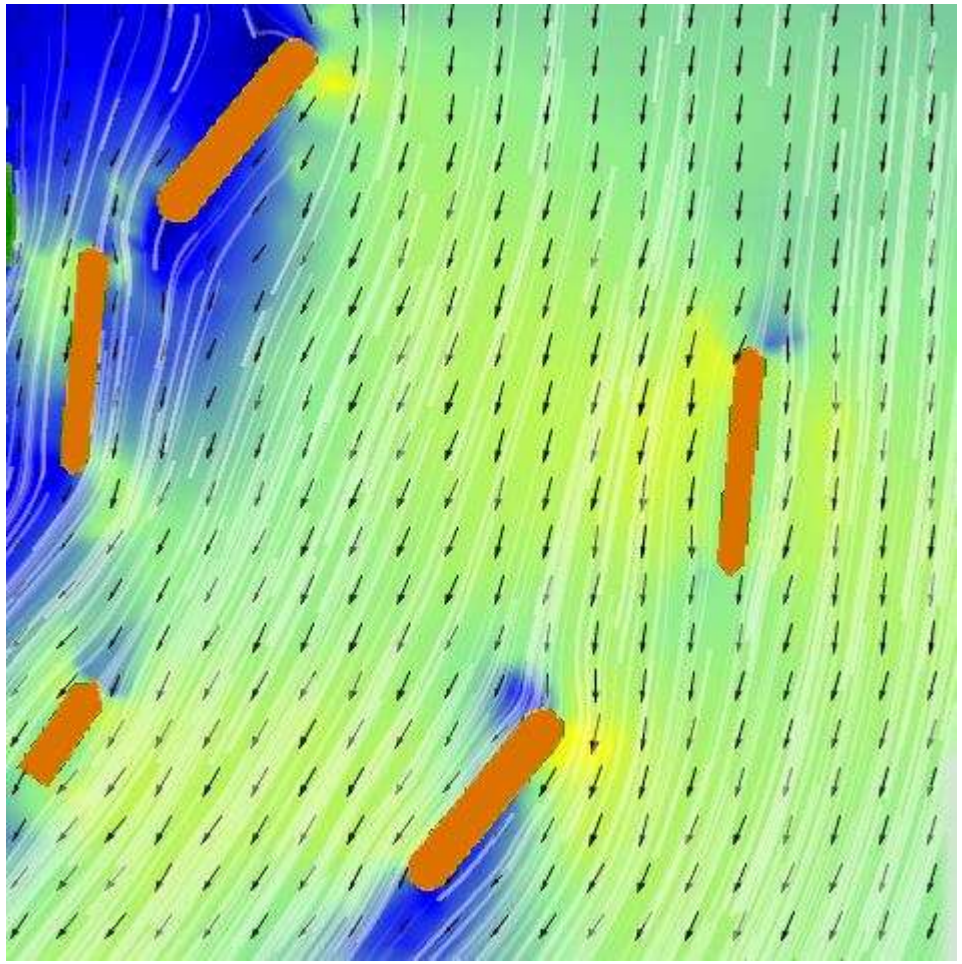


Existing METRA and US 20 Bridges

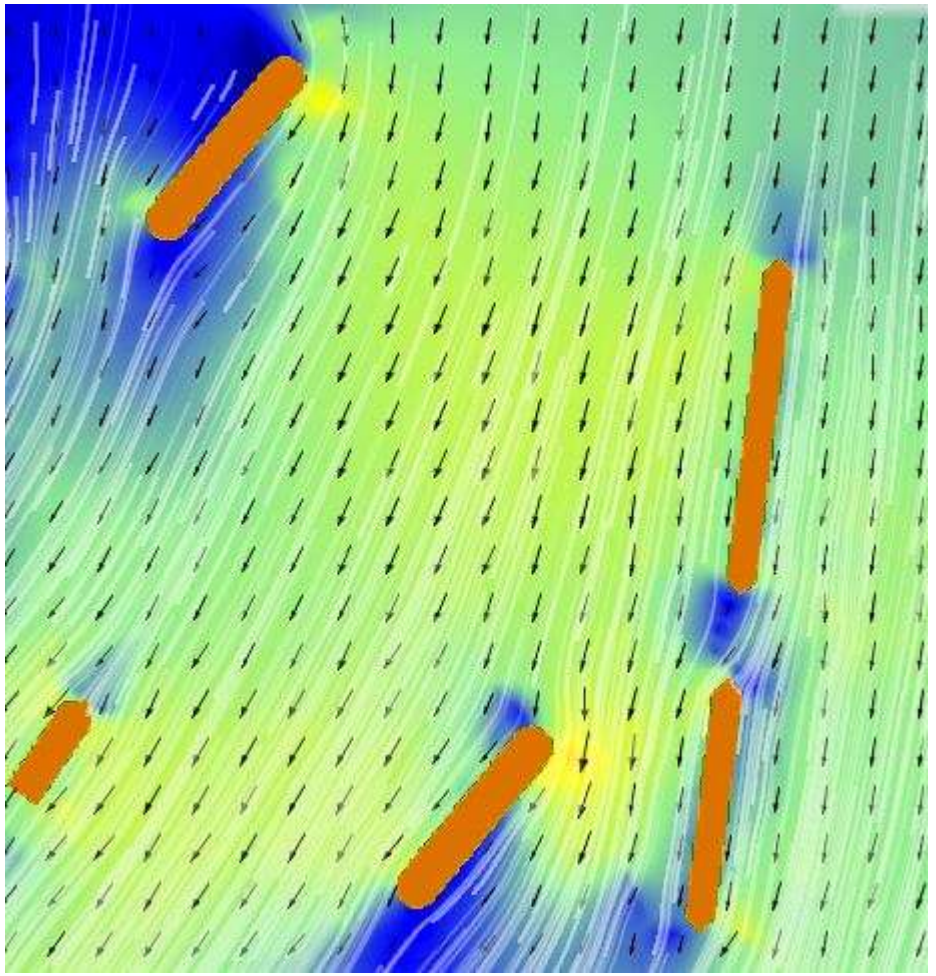


Proposed METRA and Existing US 20 Bridges

Velocity Plot Comparing with Proposed US 20 Bridge



Proposed METRA and Existing US 20 Bridges

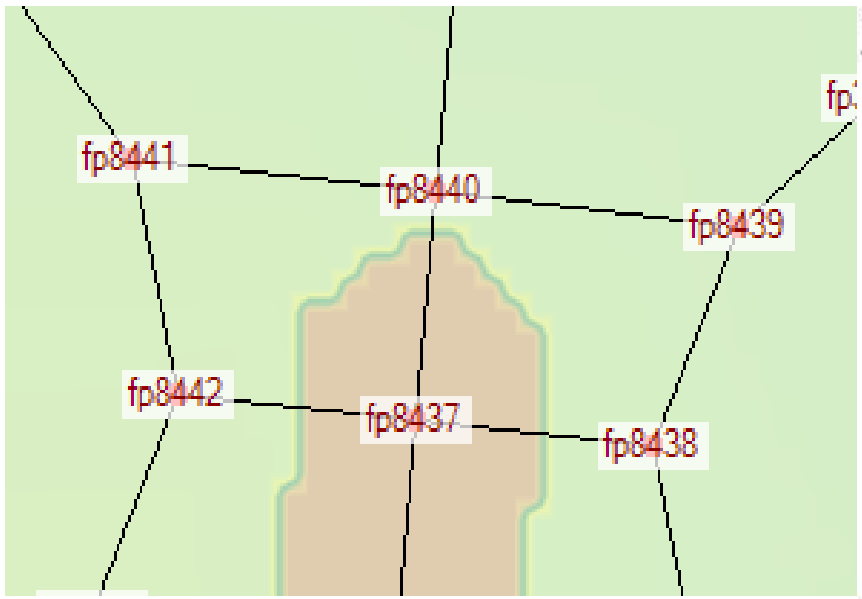


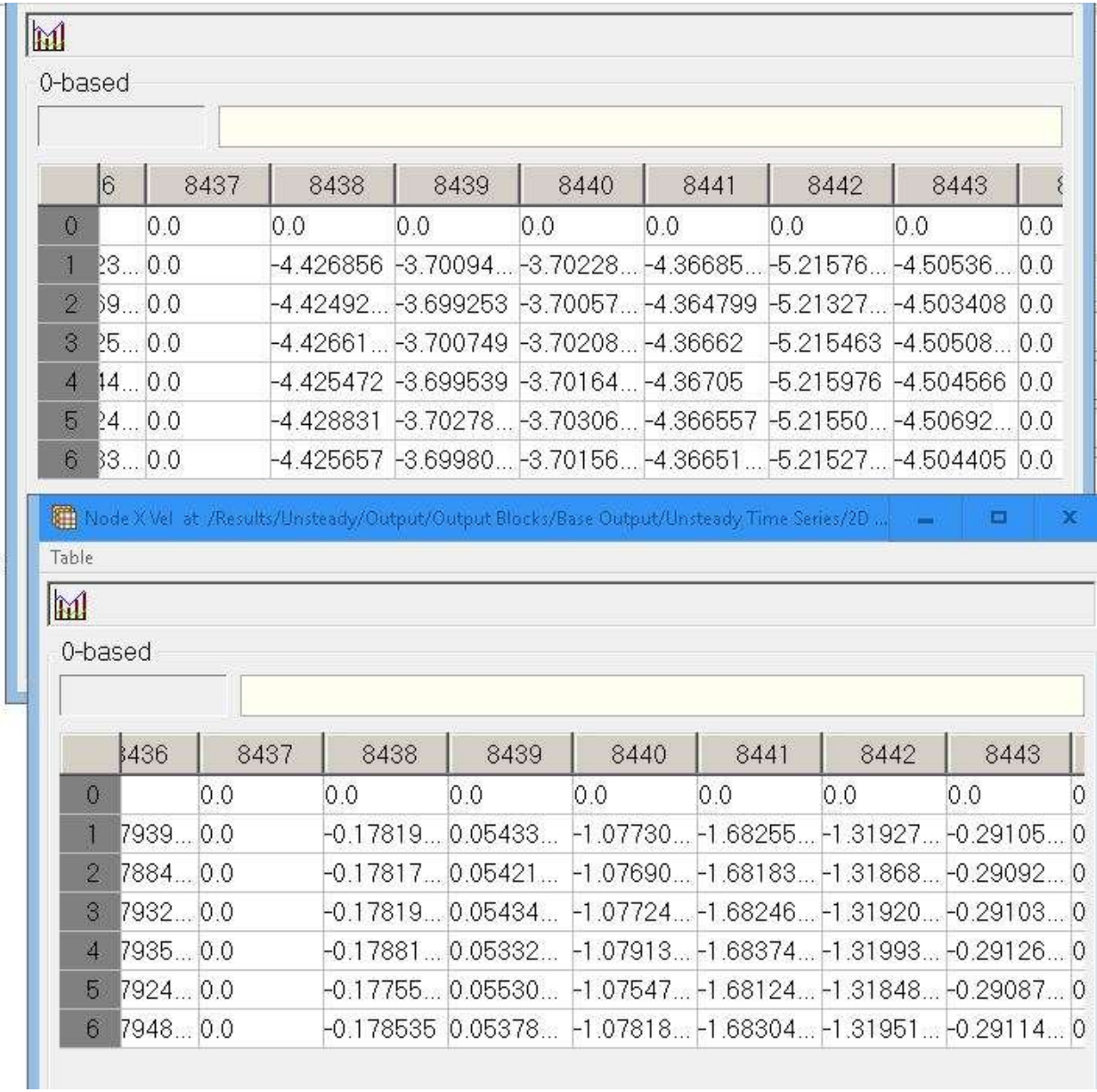
Proposed METRA and US 20 Bridges

Scour Analysis

- Scour Analysis using HEC-18
- 10-, 50-, 100-, and 200-yr Storms
- Existing US 20 and METRA Bridges
- Existing US 20 and Proposed METRA Bridges
- Proposed US 20 and METRA Bridges

Velocity, Depth, and Flow Angle from HDF-View and RAS Mapper





	6	8437	8438	8439	8440	8441	8442	8443	
0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	23...	0.0	-4.426856	-3.70094...	-3.70228...	-4.36685...	-5.21576...	-4.50536...	0.0
2	69...	0.0	-4.42492...	-3.699253	-3.70057...	-4.364799	-5.21327...	-4.503408	0.0
3	25...	0.0	-4.42661...	-3.700749	-3.70208...	-4.36662	-5.215463	-4.50508...	0.0
4	14...	0.0	-4.425472	-3.699539	-3.70164...	-4.36705	-5.215976	-4.504566	0.0
5	24...	0.0	-4.428831	-3.70278...	-3.70306...	-4.366557	-5.21550...	-4.50692...	0.0
6	33...	0.0	-4.425657	-3.69980...	-3.70156...	-4.36651...	-5.21527...	-4.504405	0.0

	8436	8437	8438	8439	8440	8441	8442	8443	
0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
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3	7932...	0.0	-0.17819...	0.05434...	-1.07724...	-1.68246...	-1.31920...	-0.29103...	0
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Scour Depth Comparison

- 1d vs 2d
- Existing Bridges
- Existing US 20 and Proposed METRA
- Proposed US 20 and METRA

Questions