Hydraulic Modeling of Streams and Rivers in Illinois and Indiana
1D or 2D, Which Approach is Better for Your Project?

Nabil Ghalayini, PE, D.WRE, PMP, CFM

Senior Supervising Engineer, WSP USA

Krashan Singhal, PE, CFM, CPESC, LEED AP BD+C, ENV SP, DECIE

Supervising Drainage Engineer, WSP USA

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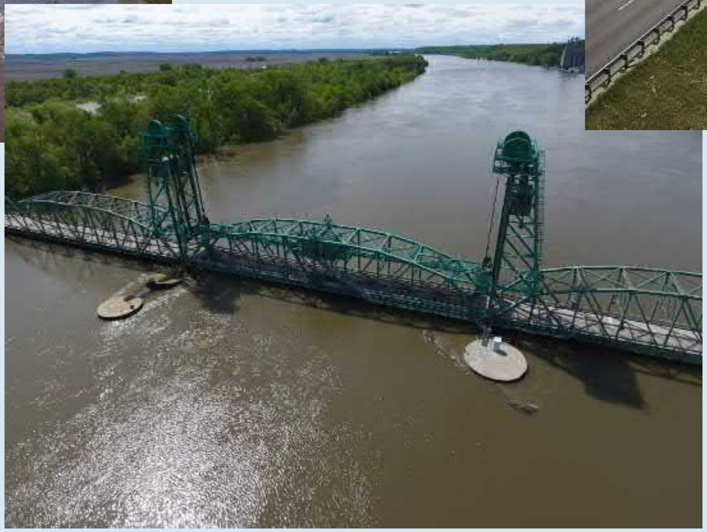
IL Route 178 over the Illinois River



IL Route 100-106 over the Illinois River

I-290 Salt Creek

1D / 2D Selection

Table 4.1. Bridge Hydraulic Modeling Selection.		
Bridge Hydraulic Condition	Hydraulic Analysis Method	
	One-Dimensional	Two-Dimensional
Small streams	●	◗
In-channel flows	●	◗
Narrow to moderate-width floodplains	●	◗
Wide floodplains	◗	●
Minor floodplain constriction	●	◗
Highly variable floodplain roughness	◗	●
Highly sinuous channels	◗	●
Multiple embankment openings	◗/○	●
Unmatched multiple openings in series	◗/○	●
Low skew roadway alignment (<20˚)	●	◗
Moderately skewed roadway alignment (>20˚ and <30˚)	◗	●
Highly skewed roadway alignment (>30˚)	○	●
Detailed analysis of bends, confluences and angle of attack	○	●
Multiple channels	◗	●
Small tidal streams and rivers	●	◗
Large tidal waterways and wind-influenced conditions	○	●
Detailed flow distribution at bridges	◗	●
Significant roadway overtopping	◗	●
Upstream controls	○	●
Countermeasure design	◗	●

● well suited or primary use
◗ possible application or secondary use
○ unsuitable or rarely used
◗/○ possibly unsuitable depending on application

Source: 2012 FHWA, Hydraulic Design of Safe Bridges (HDS-7)

1D / 2D Selection

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2D Modeling Examples

- Road and Bridge Parallel to Floodplain (Lost River at SR 337, Orange County)
- Bendway Weirs in the Floodway (West Fork White River at Stotts Creek, Morgan County)
- Multiple Bridges in Floodplain (East Fork White River at I-65, Jackson County)

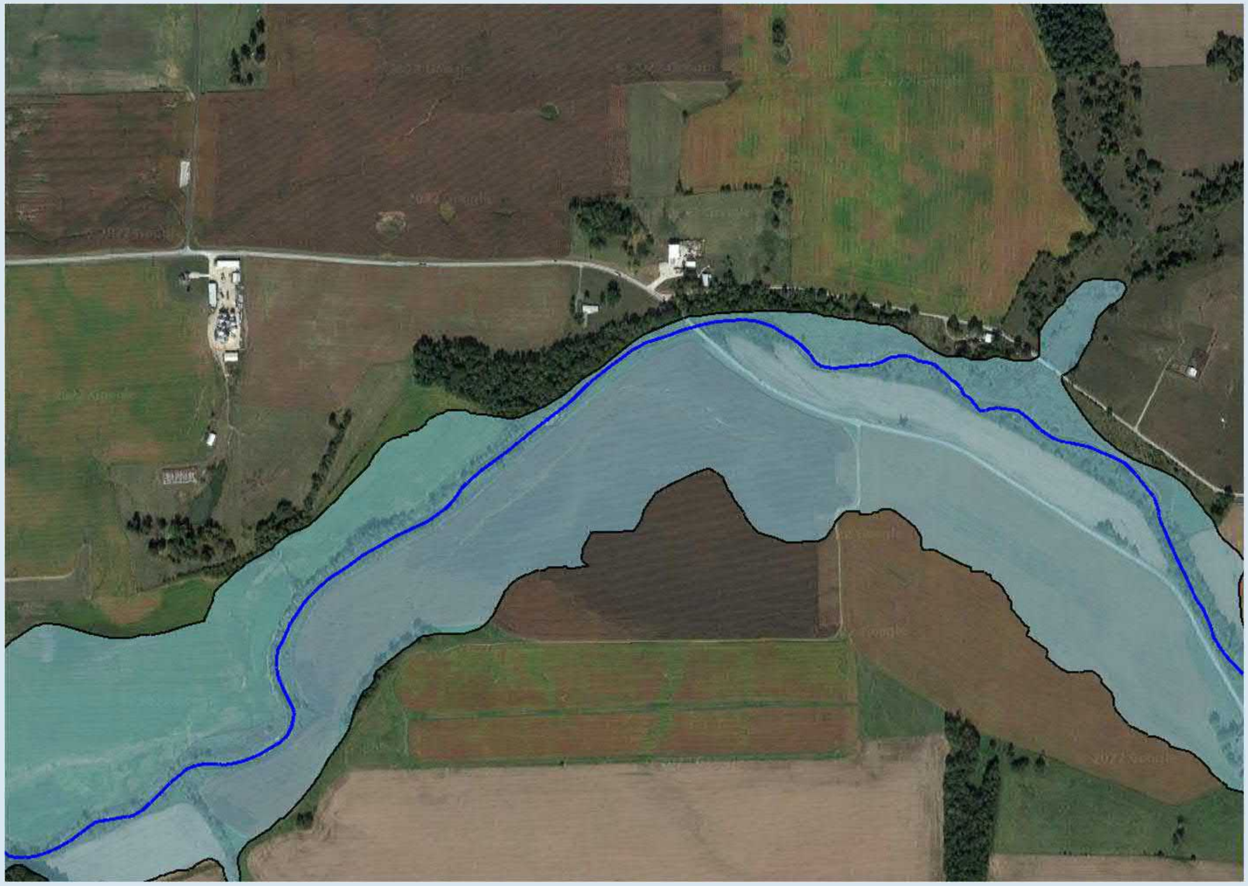
2D Modeling Examples

- Development / construction projects vs. watershed studies
- Limited Study Reach
- Hydrology established separately (Regulatory)
- Steady state / Constant discharge
- Boundary Conditions / Tie-ins
- 2D can inform 1D models

2D Modeling Example

- Road and Bridge Parallel to Floodplain (Lost River at SR 337, Orange County)

BRIDGE REPLACEMENT & SCOUR ANALYSIS
LOST RIVER AT SR 337
APPROXIMATE ZONE A (HEC-RAS 1D STEADY STATE)



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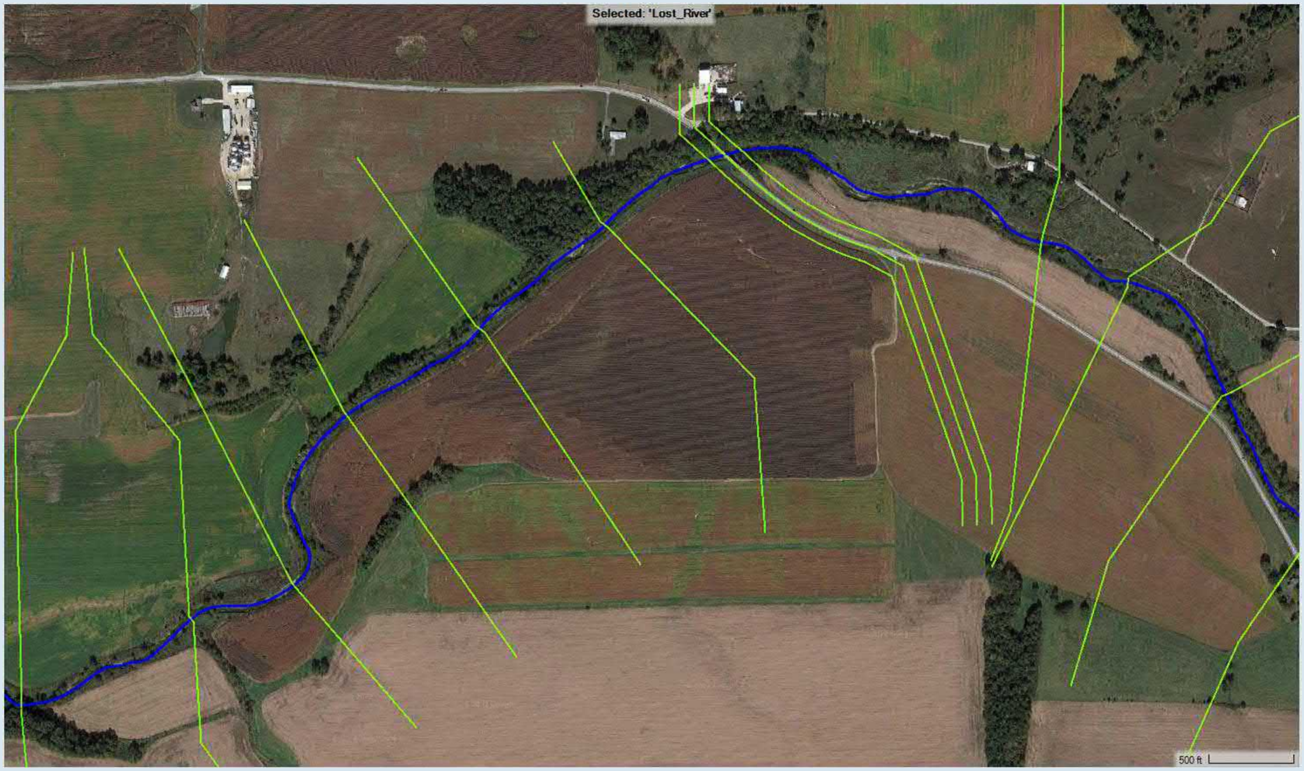
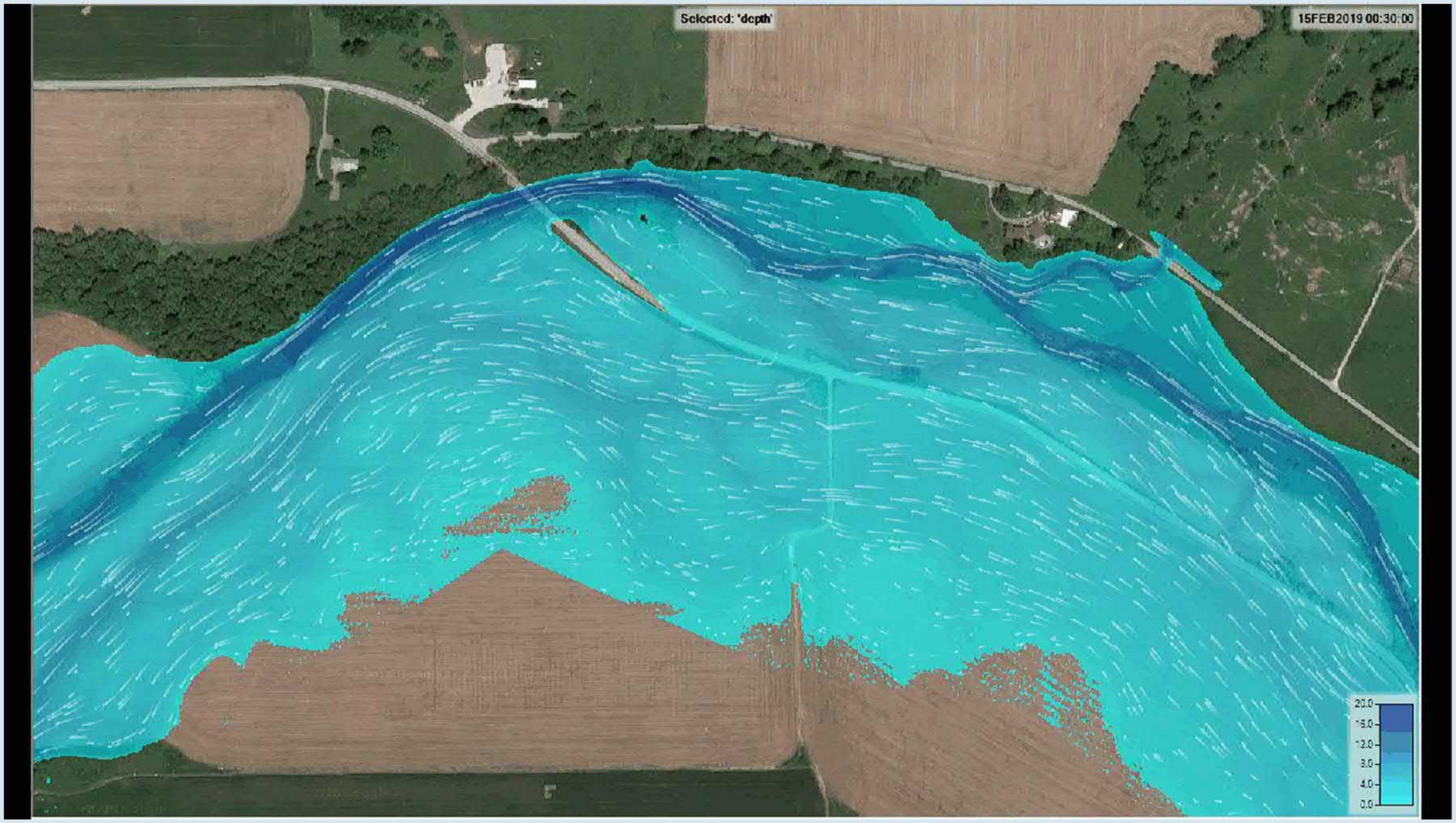


LOST RIVER AT SR 337 – 1% AEP FLOOD



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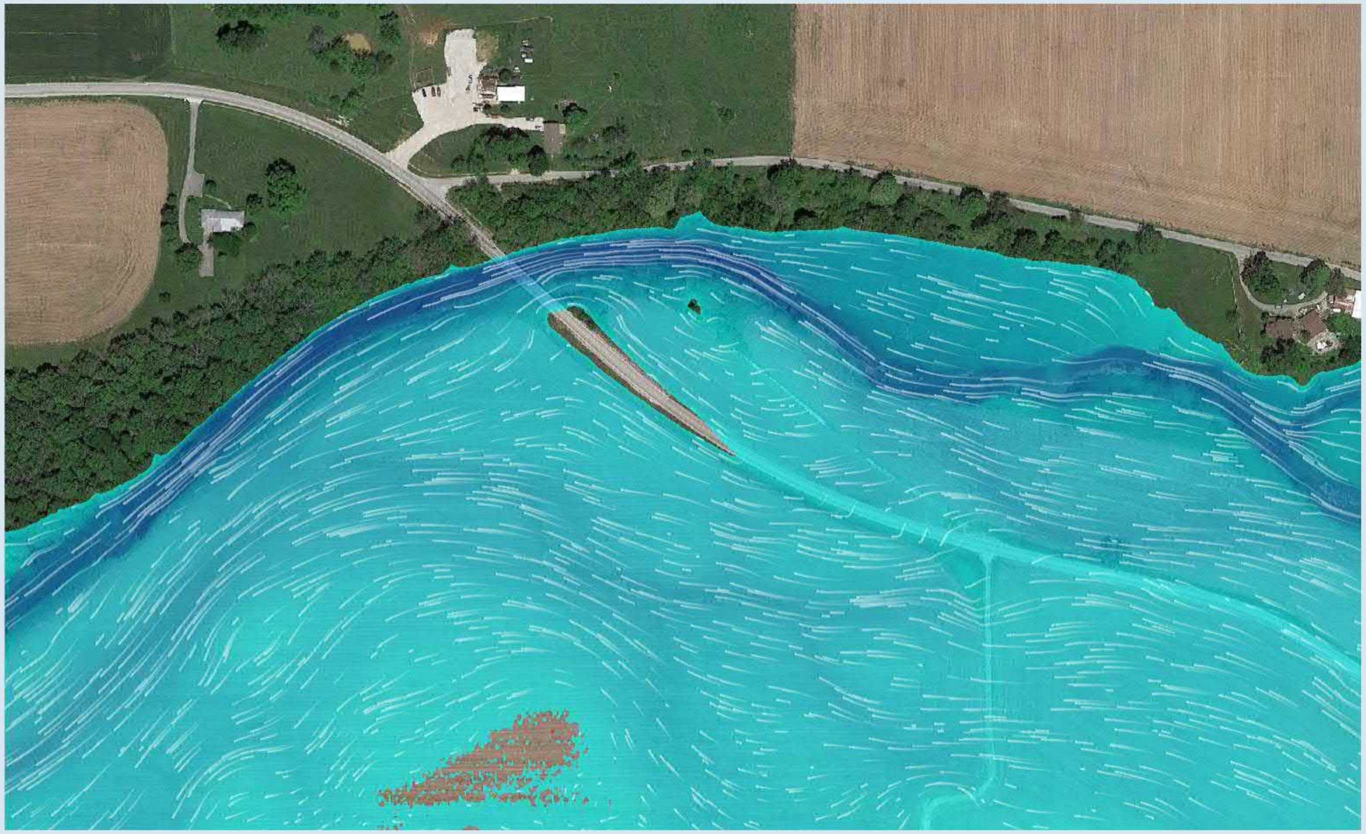


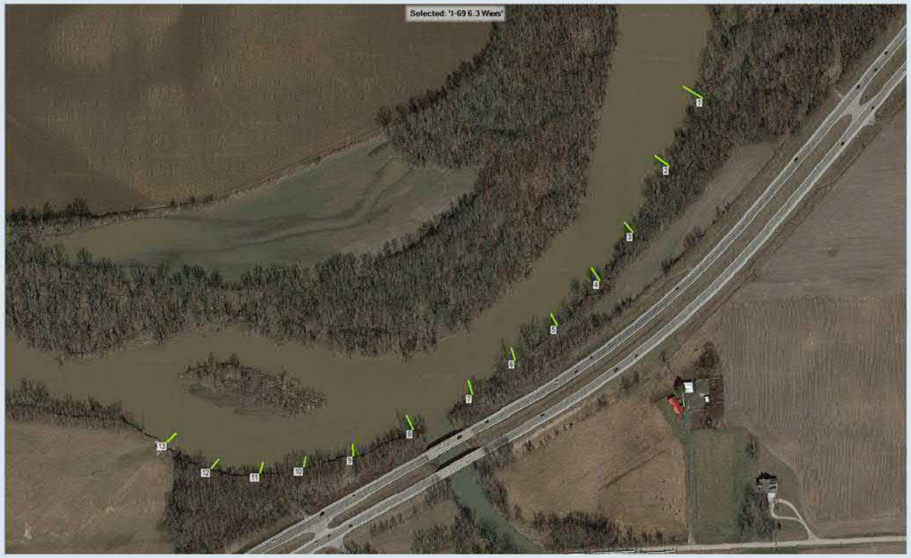
2D Modeling Examples

- Bendway Weirs in the Floodway (West Fork White River at Stotts Creek, Morgan County)

FLUVIAL EROSION HAZARD (FEH)

WHITE RIVER CUT BANK UPSTREAM OF STOTTS CREEK CONFLUENCE

BENDWAY WEIRS

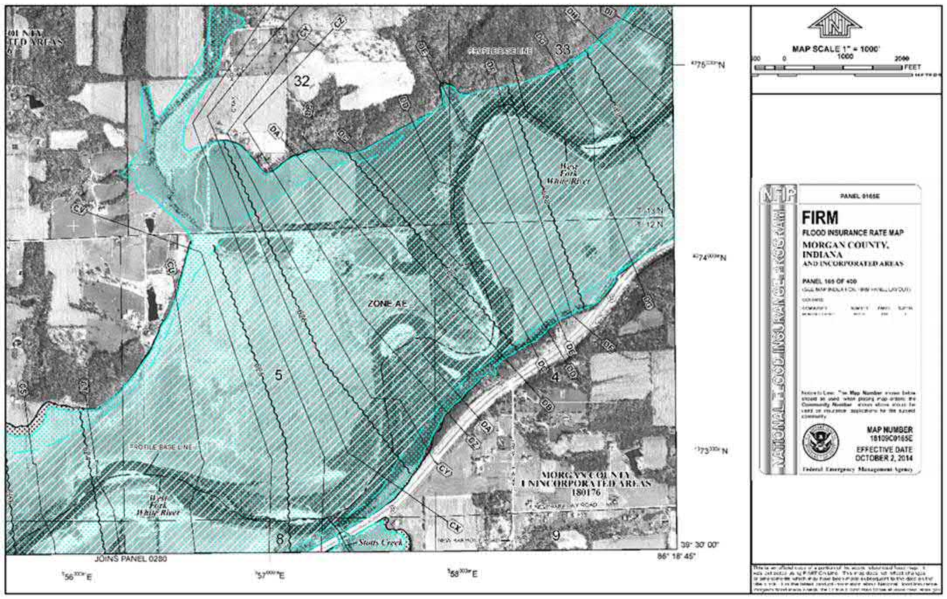


Source: Aerial from Google Earth

Source: Indiana Department of Transportation, 2021

1D HYDRAULIC MODEL

FIS FLOODWAY DATA TABLE



FLOODING SOURCE		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
West Fork White River								
CA	198.01	3,988	34,412	2.1	612.8	612.8	612.9	0.1
CB	198.23	4,010	31,759	2.2	613.0	613.0	613.1	0.1
CC	198.38	4,286	31,512	2.3	613.3	613.3	613.4	0.1
CD	198.63	4,790	31,048	2.3	613.6	613.6	613.7	0.1
CE	198.82	4,439	28,852	2.5	614.2	614.2	614.3	0.1
CF	199.47	5,029	33,027	2.1	616.5	616.5	616.6	0.1
CG	200.07	6,096	39,496	1.8	617.5	617.5	617.5	0.0
CH	200.11	6,121	40,984	1.7	617.7	617.7	617.8	0.1
CI	200.38	6,935	62,967	1.0	618.7	618.7	618.8	0.1
CJ	200.85	7,298	73,089	0.9	619.0	619.0	619.1	0.1
CK	201.12	7,400	81,194	0.8	619.2	619.2	619.3	0.1
CL	201.30	6,512	73,207	0.9	619.4	619.4	619.5	0.1
CM	201.57	6,602	71,481	0.9	619.6	619.6	619.7	0.1
CN	201.76	5,906	64,719	1.0	619.8	619.8	619.9	0.1
CO	202.11	5,429	54,872	1.2	620.2	620.2	620.3	0.1
CP	202.33	4,898	45,718	1.4	620.6	620.6	620.7	0.1
CQ	202.55	4,666	32,792	2.0	621.2	621.2	621.3	0.1
CR	202.69	4,286	34552	1.9	622.6	622.6	622.7	0.1
CS	202.96	4,087	29975	2.2	623.5	623.5	623.6	0.1
CT	203.19	4,625	35655	1.8	624.0	624.0	624.1	0.1
CU	203.48	5,648	38090	1.7	624.5	624.5	624.6	0.1
CV	203.75	5,456	30,950	2.1	624.8	624.8	624.9	0.1
CW	203.93	5,533	31,391	2.1	625.2	625.2	625.3	0.1
CX	204.17	5,286	30,726	2.1	625.7	625.7	625.8	0.1
CY	204.42	4,773	27,375	2.3	626.1	626.1	626.2	0.1
CZ	204.58	4,430	28,567	2.2	626.5	626.5	626.6	0.1

[1]Miles above confluence with Wabash River

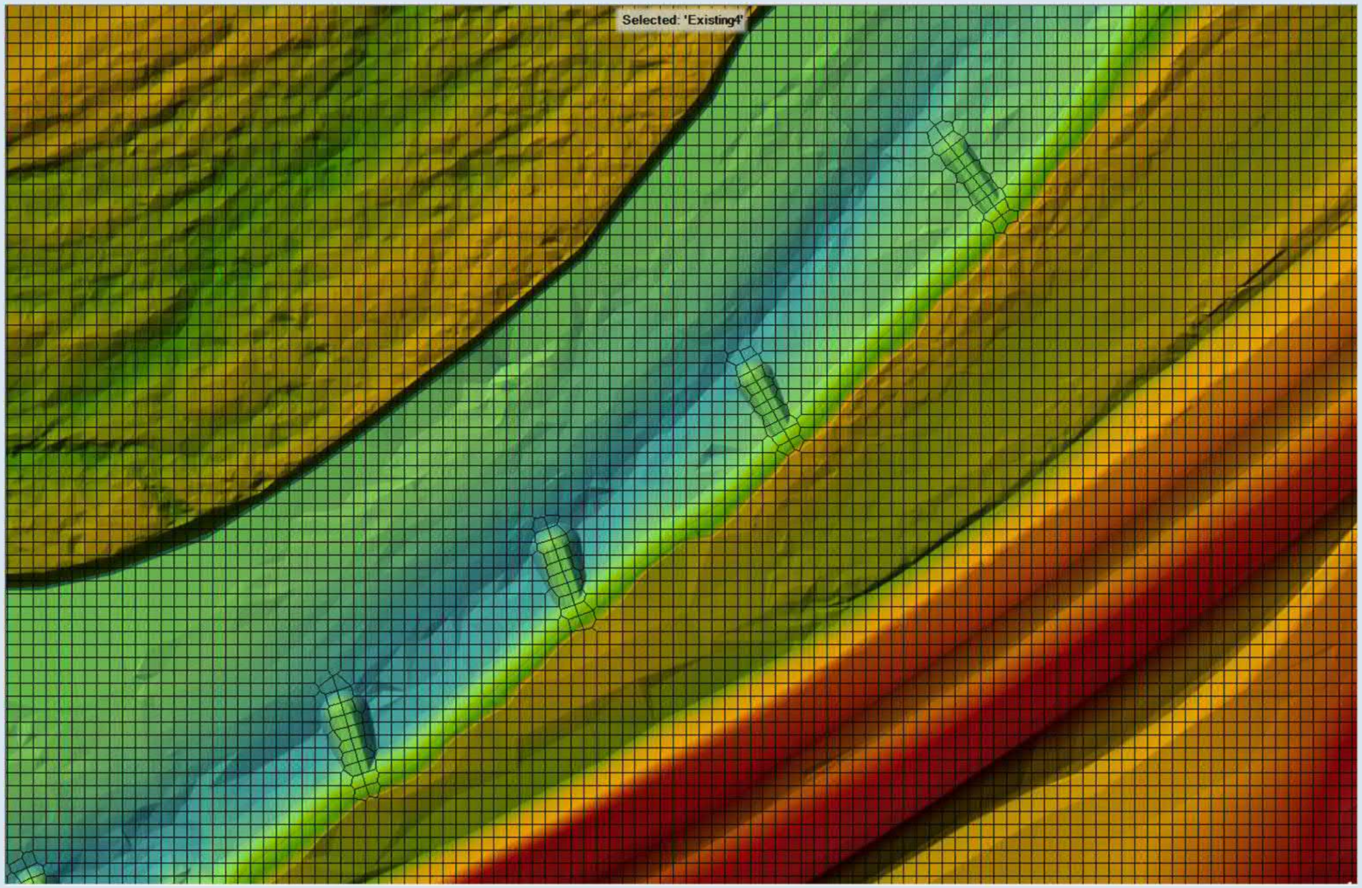
TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY

MORGAN COUNTY, IN AND INCORPORATED AREAS

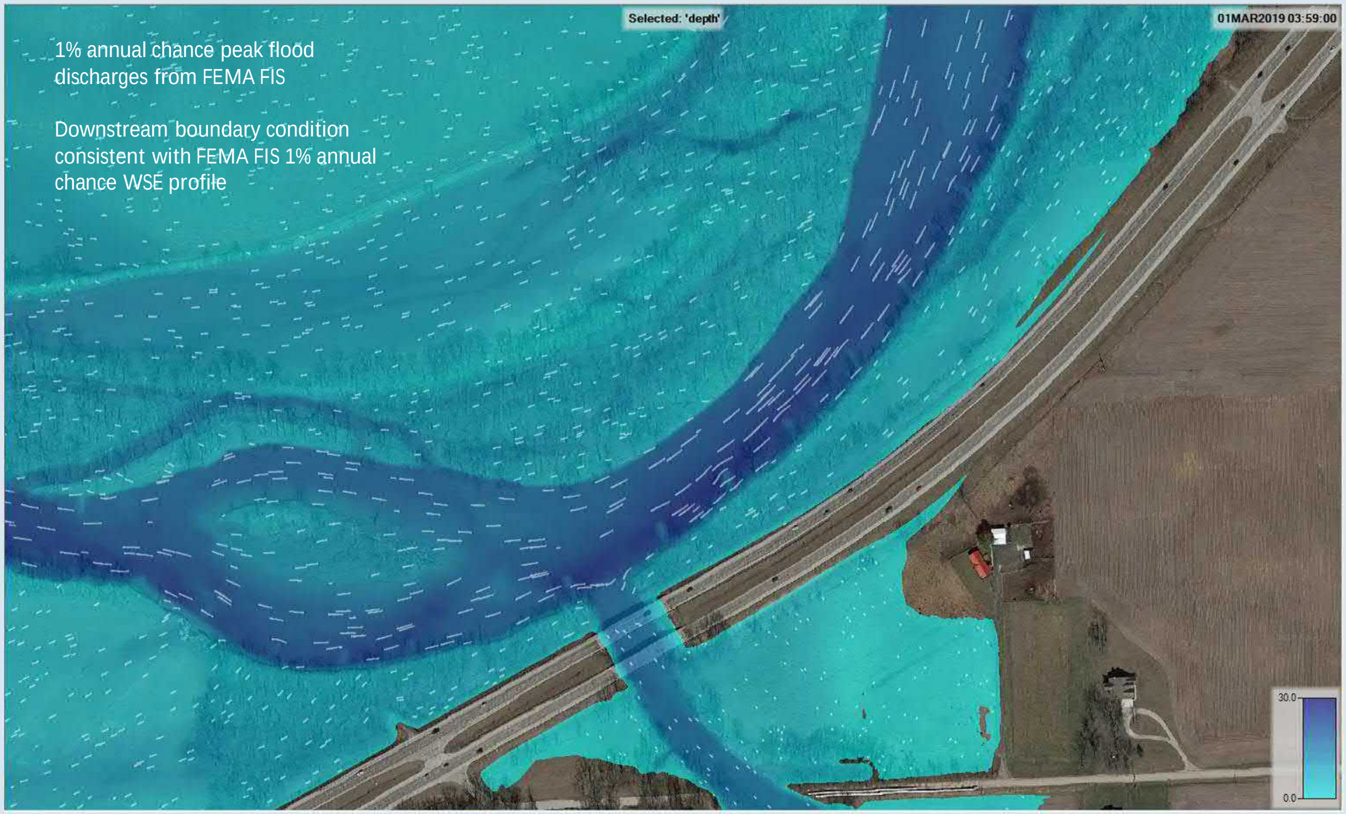
FLOODWAY DATA

WEST FORK WHITE RIVER

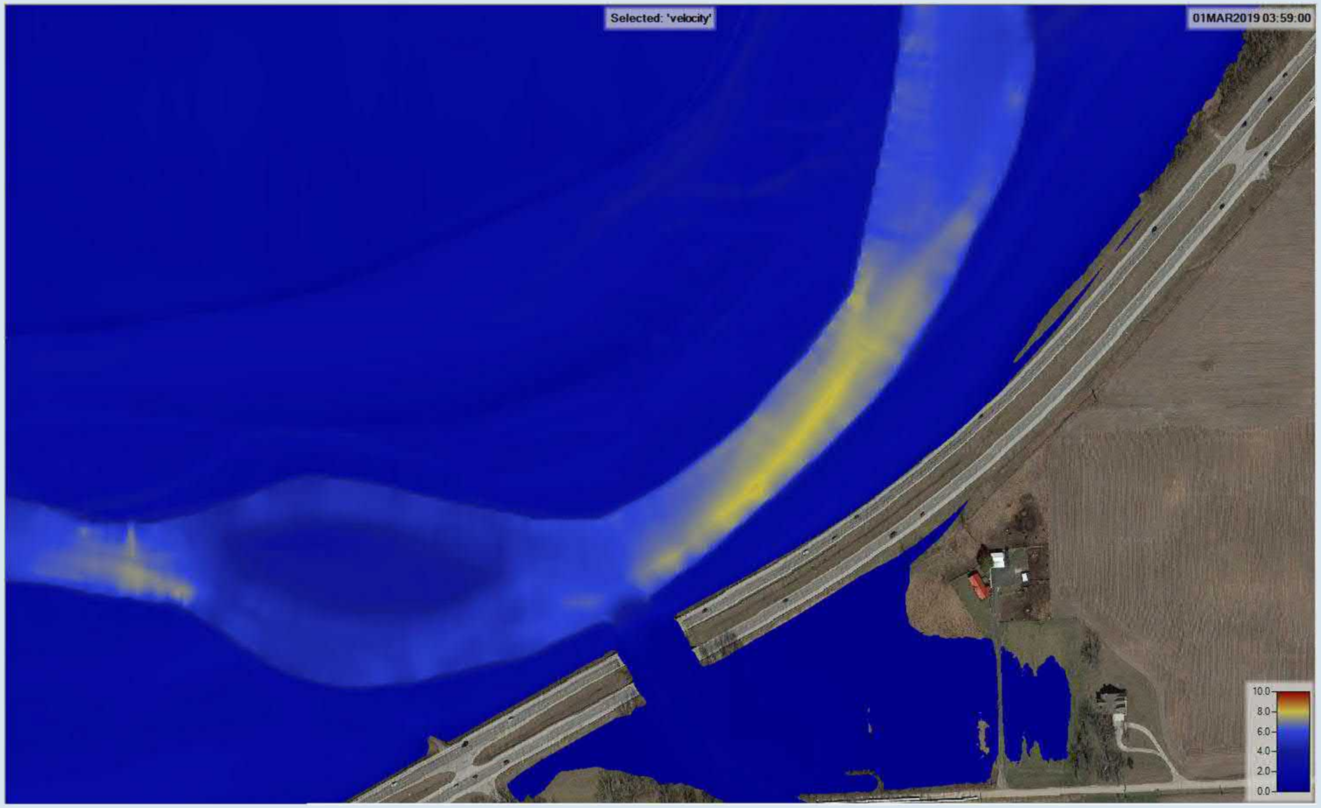


2D Computational Grid Breaklines

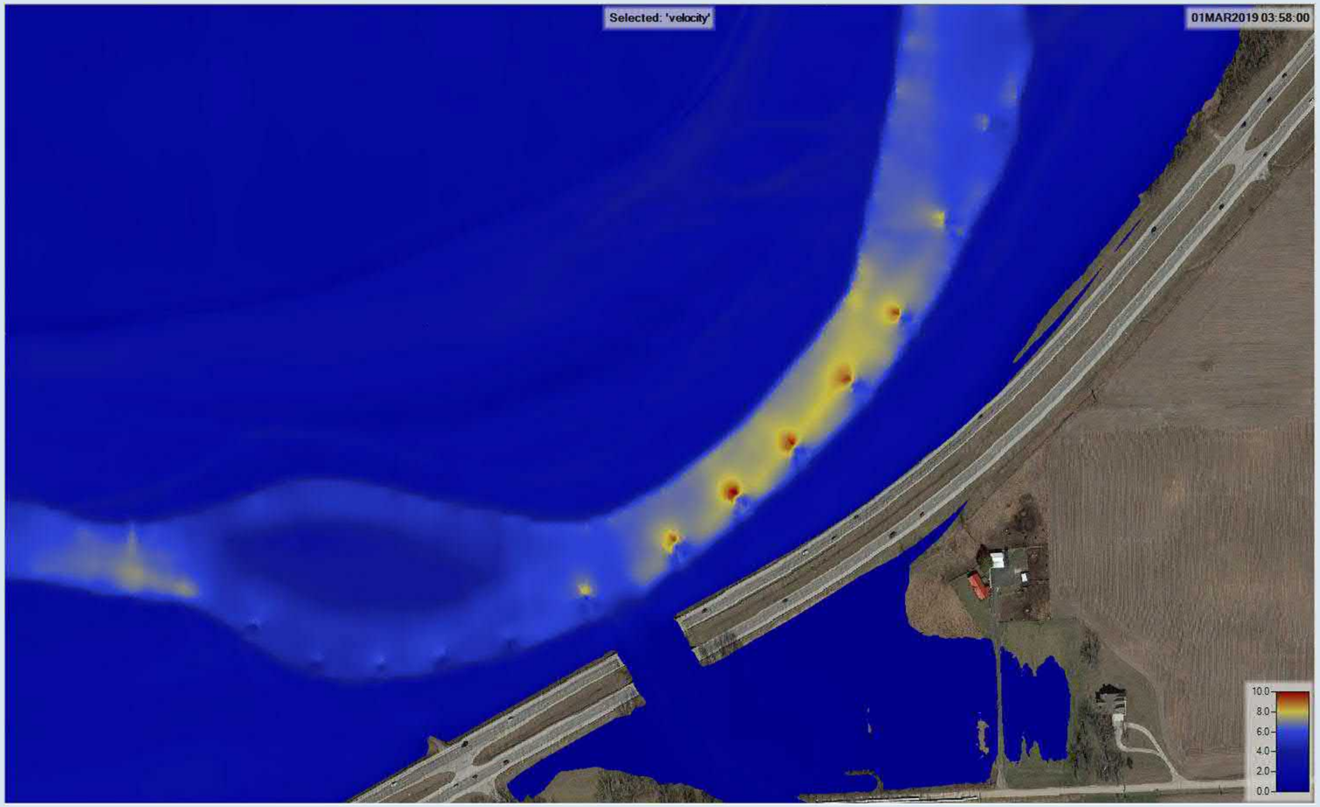
1% AEP FLOOD - FLOW DIRECTION & DEPTH GRID



1% ANNUAL CHANCE VELOCITY GRID
EXISTING CONDITIONS



1% AEP FLOOD - VELOCITY GRID
PROPOSED CONDITIONS



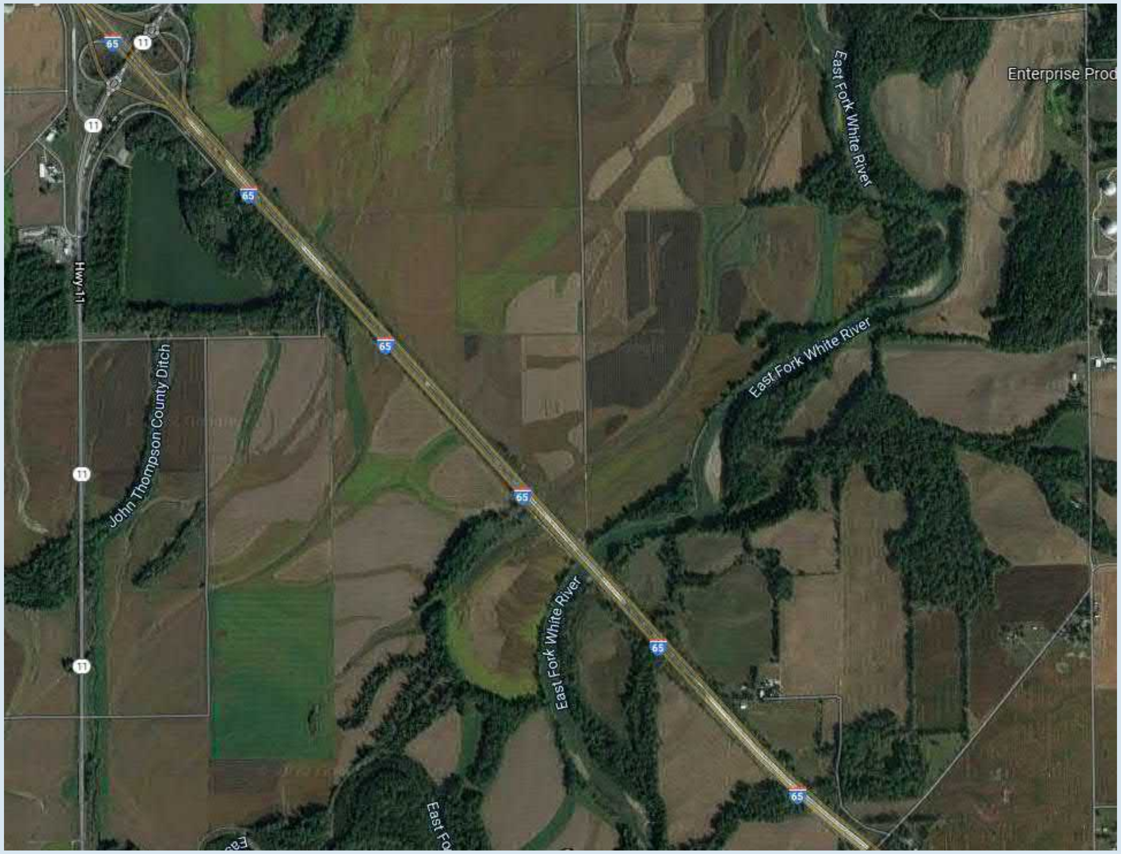
1D VS. 2D VELOCITY COMPARISON

	1% AEP Velocity (ft/s)	
	Existing Conditions	Proposed Conditions
HEC-RAS 1D (Average Channel)	6.0	6.4
HEC-RAS 1D with flow distribution option (Maximum Channel)	6.7	7.8
HEC-RAS 2D (At Weir Tip)	8.0	10.2

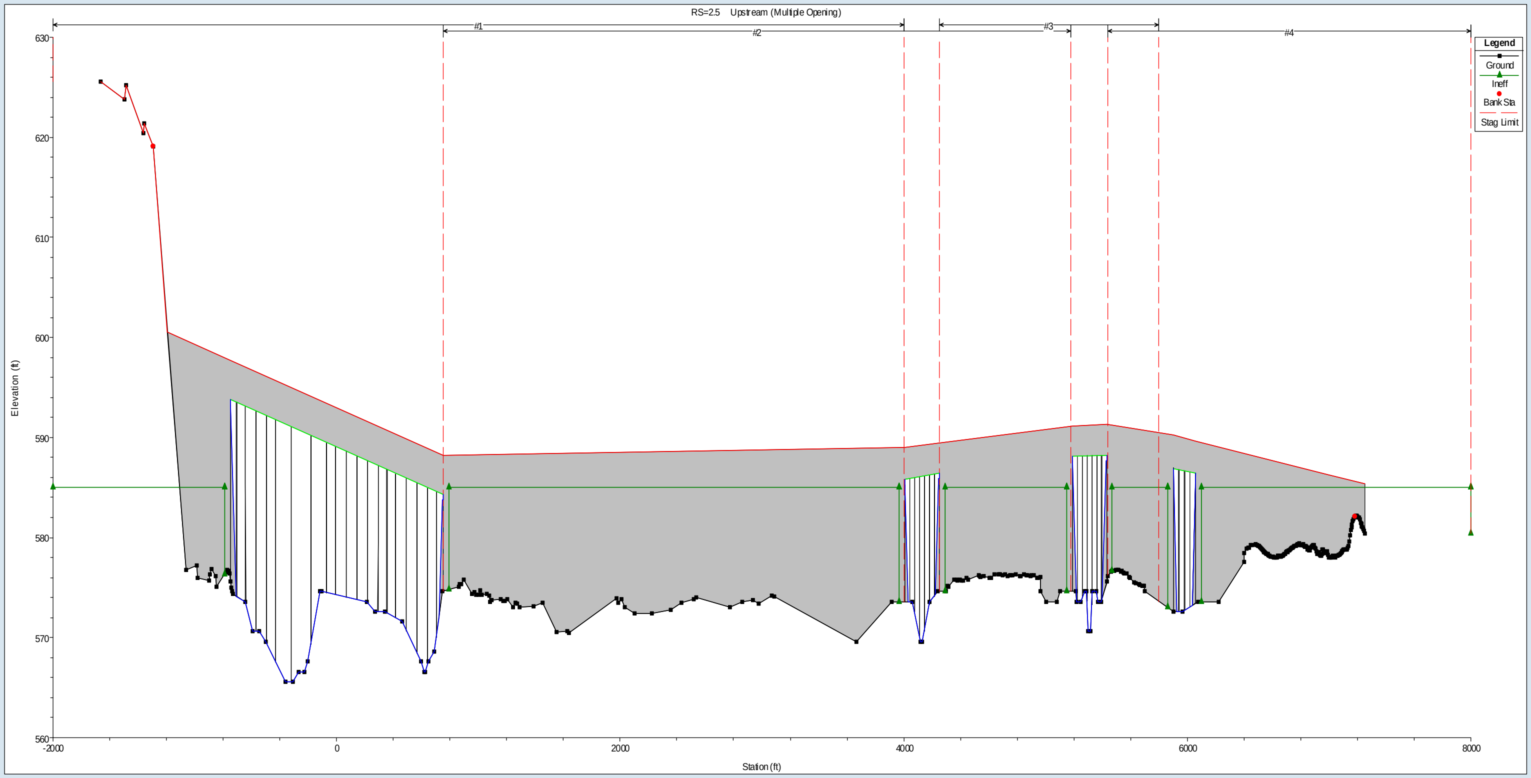
2D Modeling Example

- Multiple Bridges in Floodplain (East Fork White River at I-65, Jackson County)

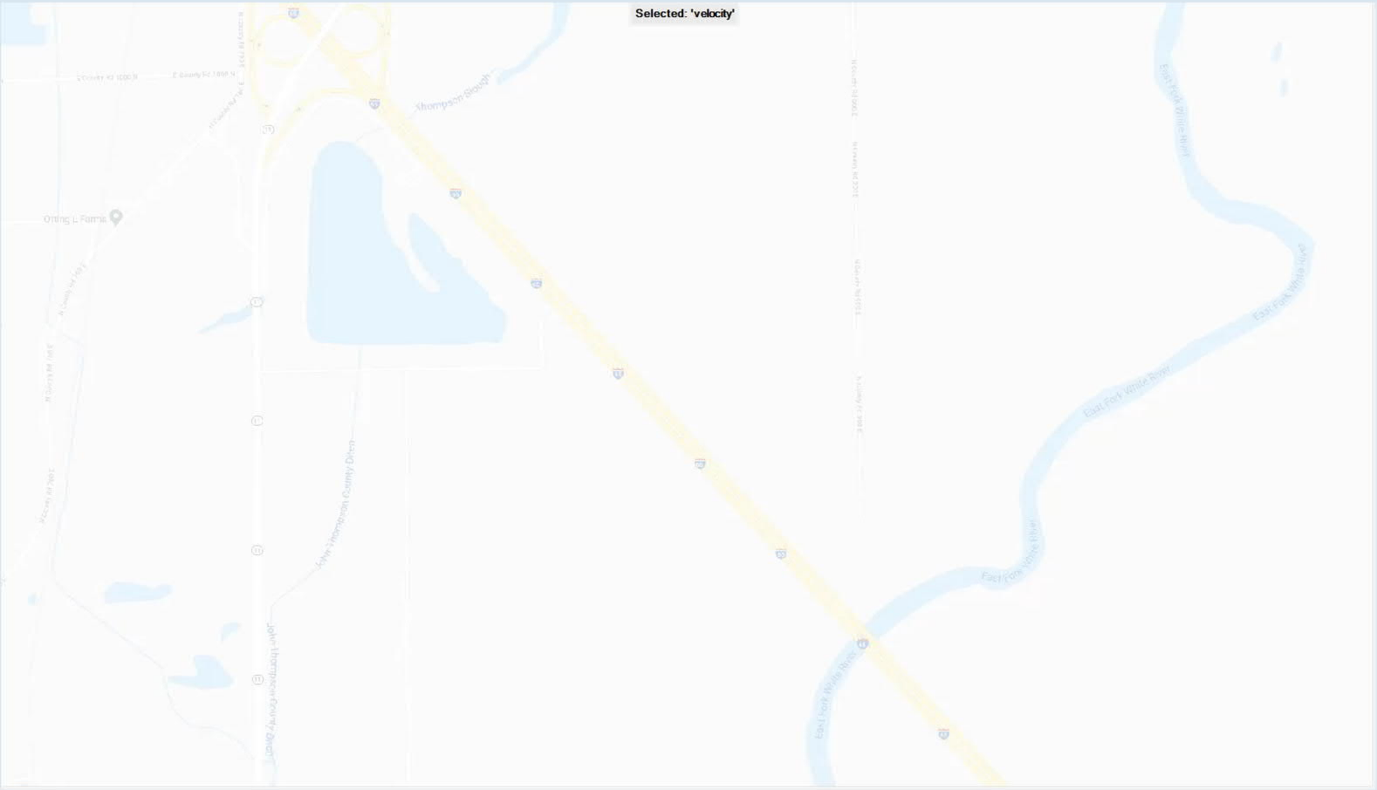
East Fork White River at I-65



Multiple Bridge Opening in HEC-RAS 1D

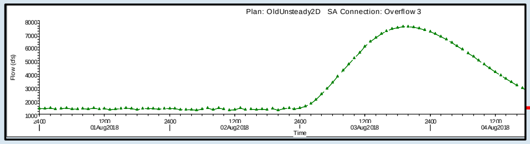


1D vs 2D Flow Distribution

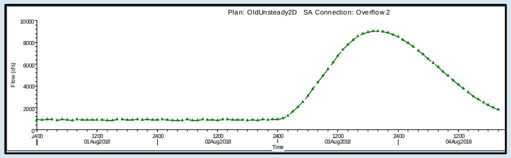


Flow Distribution in HEC-RAS 2D

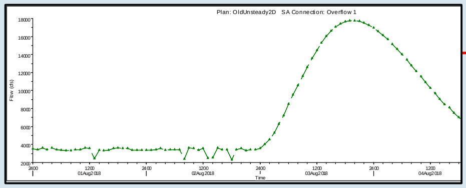
$Q_{Overflow\,3}$ = 7,500 cfs



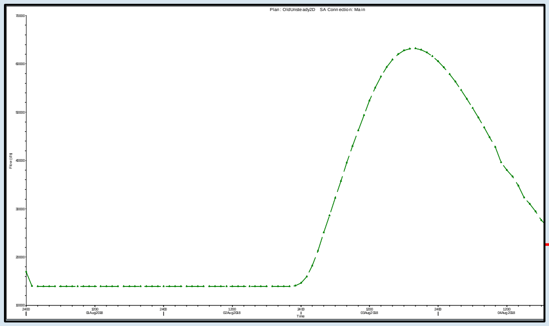
$Q_{Overflow\,2}$ = 9,000 cfs

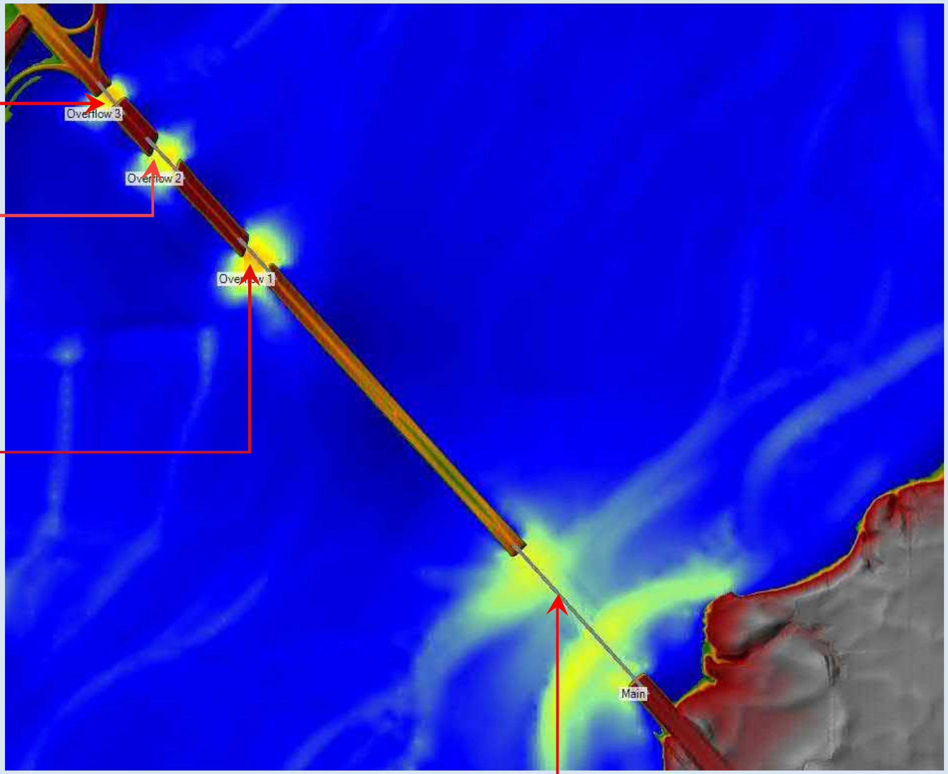


$Q_{Overflow\,1}$ = 17,800 cfs

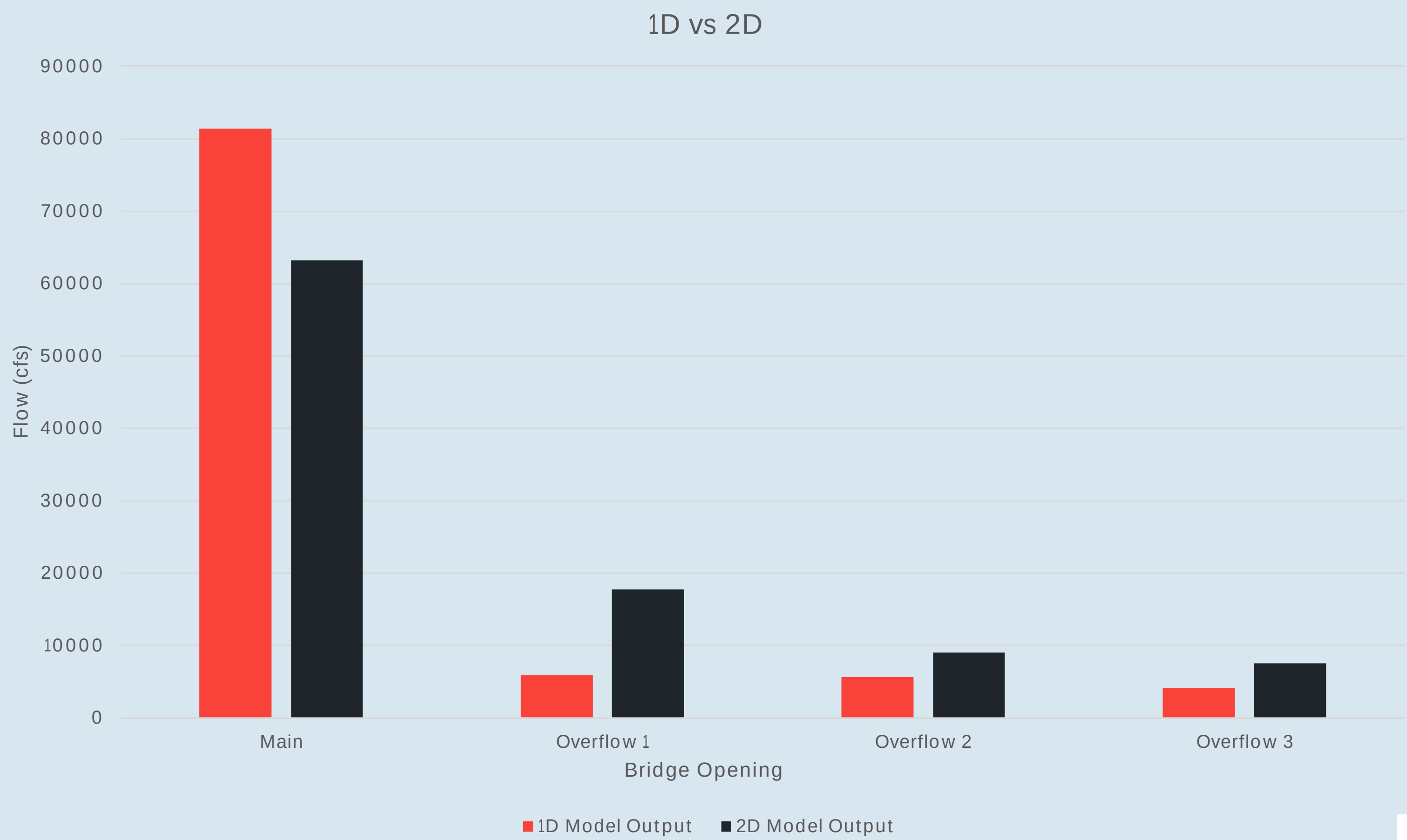


Q_{Main} = 63,200 cfs





1D vs 2D Flow Distribution



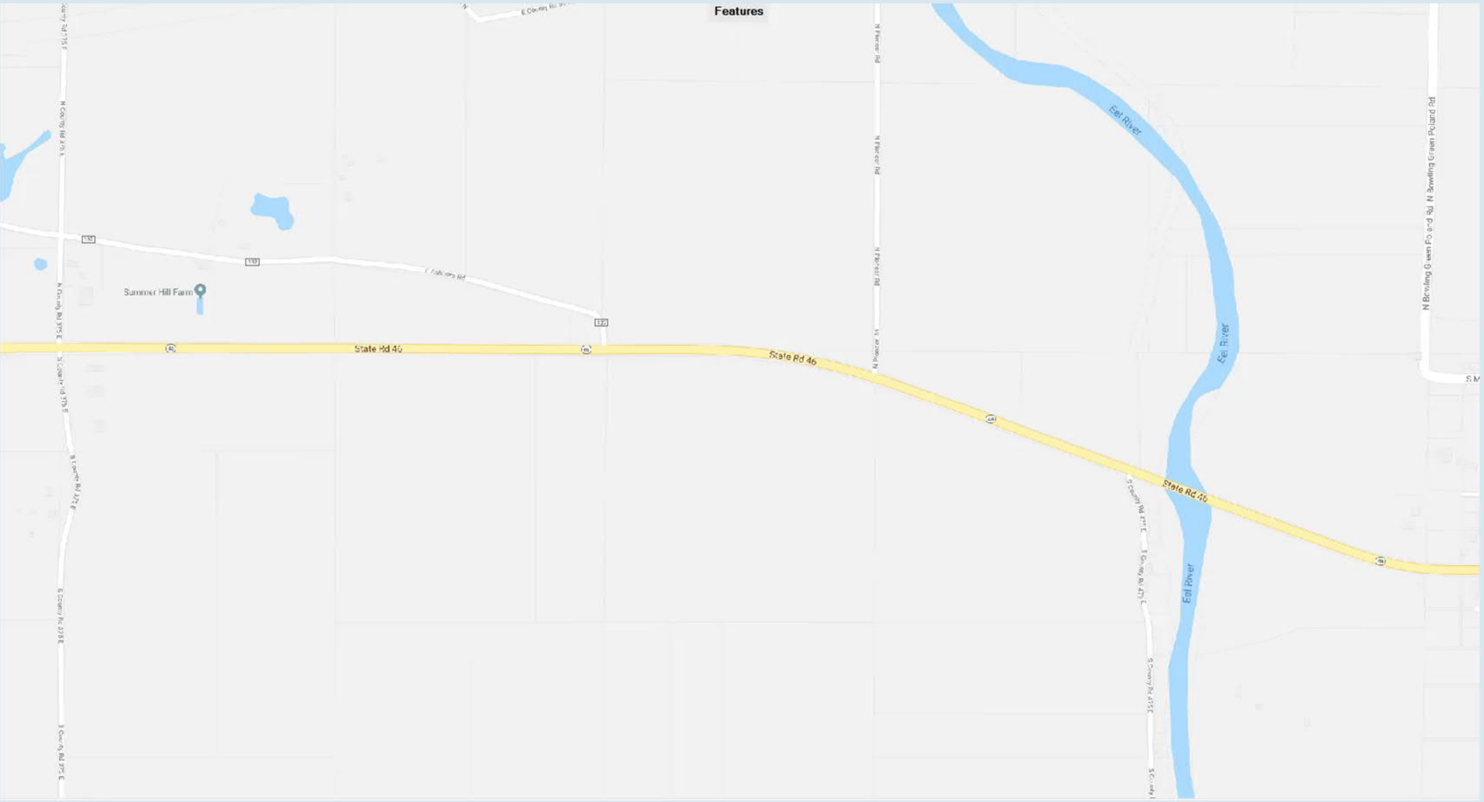
1D vs 2D Flow Distribution

In 2019, the Indiana DOT Office of Hydraulics, made a presentation at Purdue University titled *A Comparison Between 1D and 2D Hydraulic Modeling for Bridge Replacement Projects*.

The presentation was based on the findings of a study that compared flow gage data collected by the Indiana DOT with HEC-RAS 1D, HEC-RAS 2D and SRH-2D hydraulic models.

The study concluded that 2D can better estimate flow distribution at multiple bridges than 1D.

1D vs 2D Flow Distribution



Cautionary Notes

Calibrated vs. Regulatory

- Most models are not calibrated.
- At a minimum, model should tie in with a regulatory model.

Steady-state vs. Unsteady state

- Peak discharges are treated as design discharges.
- If the project significantly alters peak discharges, unsteady state modeling is necessary

Depth-Averaged results

- Results are depth-averaged at each computational cell.
- By definition of the 2D approach.

Q & A

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