PROVIDING BETTER INFORMATION:

THE TWO DIMENSIONAL HYDRAULIC MODELING ERA

MONTANA MDT DEPARTMENT OF TRANSPORTATION

OVERVIEW

The Difference between 1-D and 2-D Modeling

Why 2-D Modeling is Increasing in Use

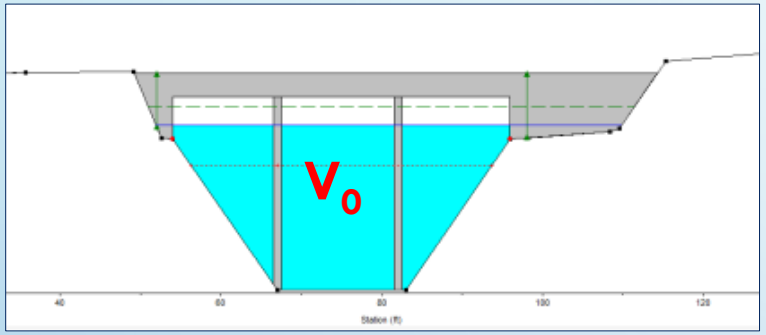
How The Hydraulic Engineering Community is Progressing

- Case Study – Shell Creek, Nebraska

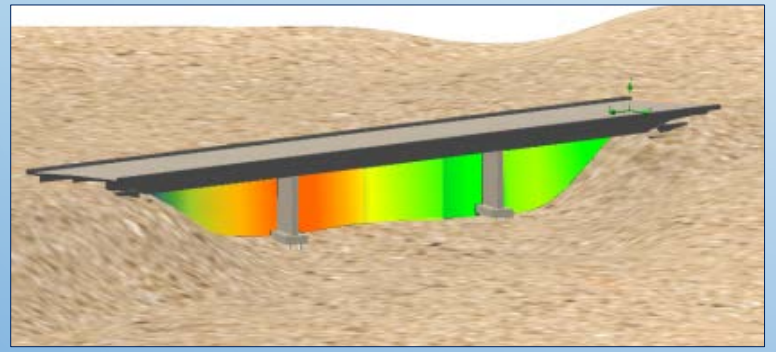
How 2-D Modeling Can Help the Floodplain Community

An Example Submittal and Challenges

WHAT DO YOU MEAN BY TWO DIMENSIONAL MODELING



- **1D MODELING**
- 1 FLOW DIRECTION
- COMPUTES ONE VELOCITY/ONE WATER SURFACE



- **2D MODELING**
- 2 FLOW DIRECTIONS
- COMPUTES LATERAL, DEPTH AVERAGED VELOCITY
- VARYING WATER SURFACE

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1-D VS. 2-D

Table 4.1. Bridge Hydraulic Modeling Selection.

Wide floodplains	◗	□□
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	◗	□□

◗/○ possibly unsuitable depending on application

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

Small strean

In-channel fl

Narrow to m

d

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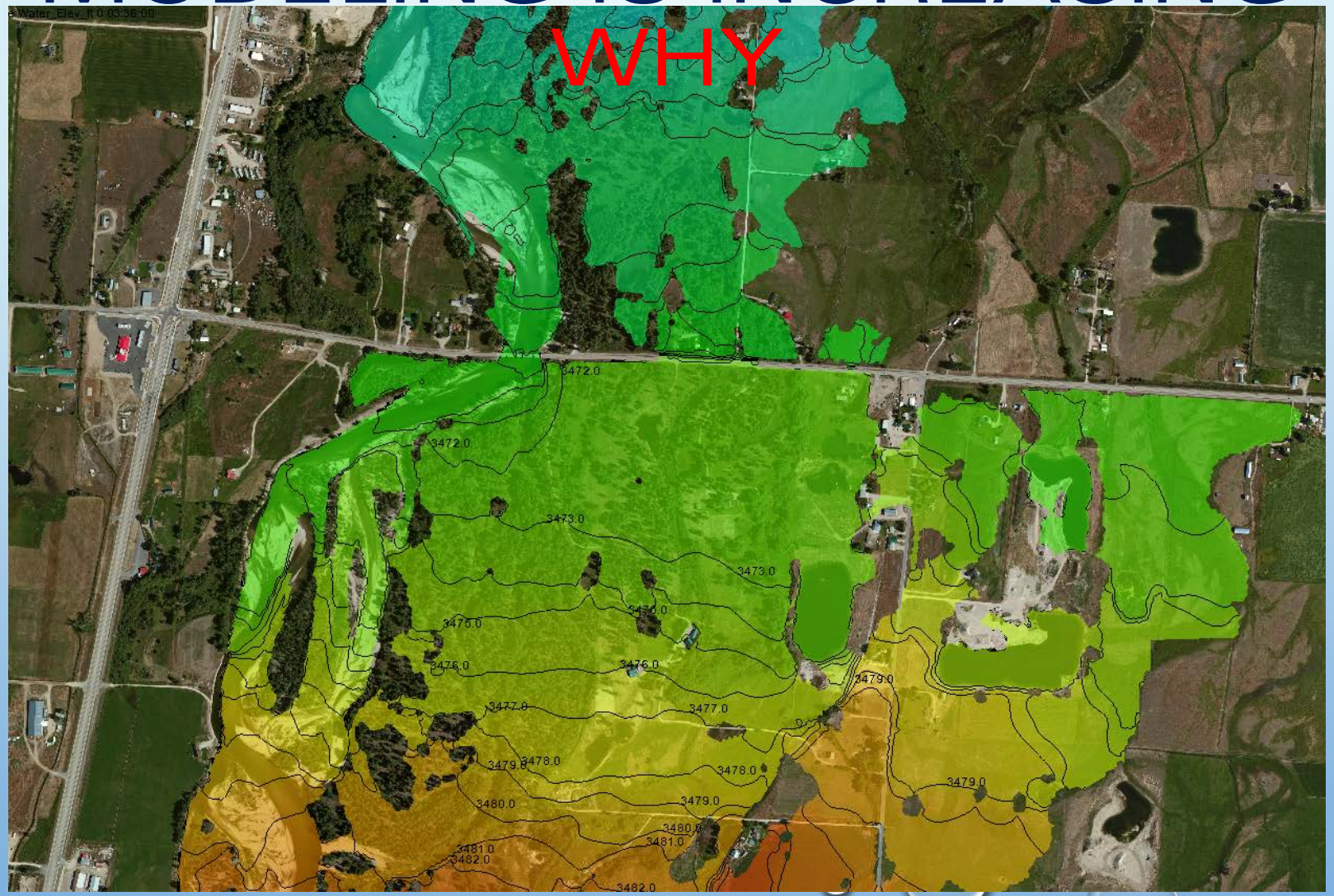
THE USE OF 2-D HYDRAULIC MODELING IS INCREASING



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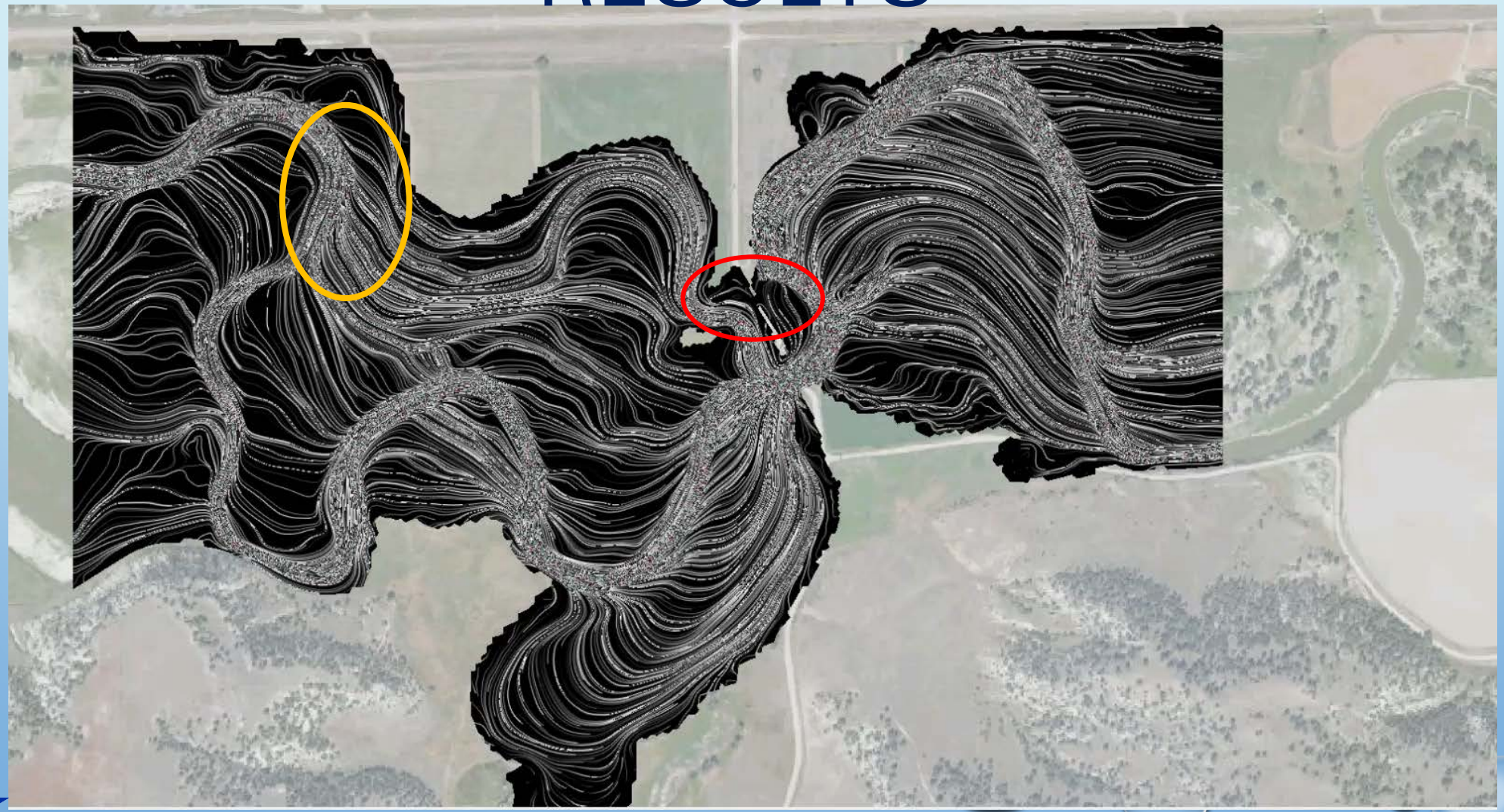
MORE ACCURATE AND REALISTIC RESULTS



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REPLACES SIMPLIFYING ASSUMPTIONS NECESSARY IN 1-D MODELING

Single Water Surface Elevation

Estimate Flow Splits/Changes in Flow Direction

Where Flows Leave and Return to a System

- How Much Flow Leaves the System

Estimating Ineffective Flow Areas

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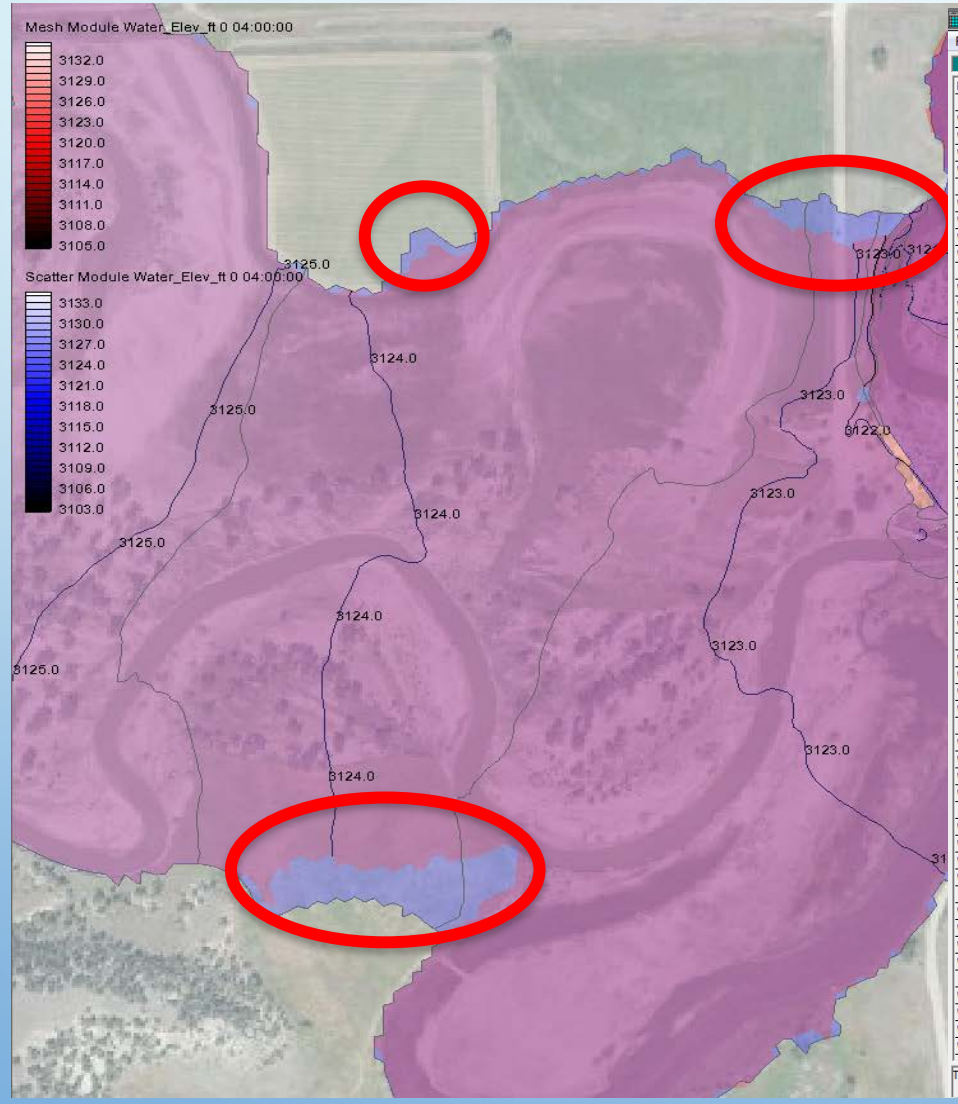
GREATLY ENHANCED COMMUNICATION TOOLS



Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS F

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Woodside	10025.33	25-Year	17600.00	3470.32	3476.30	3475.96	3476.71	0.006794	6.46	4619.51	2806.98	0.78
Woodside	10025.33	50-Year	19300.00	3470.32	3476.51		3476.89	0.006064	6.25	5243.38	2943.19	0.73
Woodside	10025.33	100-Year	21000.00	3470.32	3476.80		3477.11	0.004773	5.71	6107.58	3009.34	0.64
Woodside	10025.33	500-Year	24500.00	3470.32	3477.38		3477.62	0.003311	5.07	7941.97	3391.99	0.52
Woodside	9265.759	25-Year	17600.00	3464.68	3474.96	3470.11	3475.14	0.000961	3.51	7308.05	3938.87	0.30
Woodside	9265.759	50-Year	19300.00	3464.68	3475.47	3470.35	3475.62	0.000746	3.33	8920.39	4163.02	0.27
Woodside	9265.759	100-Year	21000.00	3464.68	3475.98	3470.57	3476.11	0.000589	3.16	10577.74	4346.78	0.24
Woodside	9265.759	500-Year	24500.00	3464.68	3476.74	3471.01	3476.86	0.000472	3.09	13032.60	4450.07	0.22
Woodside	8605.98	25-Year	17600.00	3461.11	3474.47	3470.13	3474.63	0.000588	3.52	8016.38	4398.99	0.25
Woodside	8605.98	50-Year	19300.00	3461.11	3475.05	3470.39	3475.20	0.000506	3.46	9150.01	4475.27	0.23
Woodside	8605.98	100-Year	21000.00	3461.11	3475.62	3470.67	3475.76	0.000439	3.40	10265.87	4519.43	0.22
Woodside	8605.98	500-Year	24500.00	3461.11	3476.40	3471.19	3476.55	0.000406	3.49	11811.32	4623.45	0.21
Woodside	8081.008	25-Year	17600.00	3460.96	3473.96	3469.53	3474.25	0.000823	4.90	6458.48	3921.29	0.30
Woodside	8081.008	50-Year	19300.00	3460.96	3474.60	3470.00	3474.87	0.000723	4.83	7280.53	4354.99	0.29
Woodside	8081.008	100-Year	21000.00	3460.96	3475.20	3470.98	3475.47	0.000650	4.79	8066.03	4413.91	0.28
Woodside	8081.008	500-Year	24500.00	3460.96	3475.99	3471.44	3476.27	0.000638	5.01	9084.53	4518.30	0.28
Woodside	7013.039	25-Year	17600.00	3454.78	3472.77	3467.01	3473.30	0.000902	5.80	3033.67	6108.24	0.32
Woodside	7013.039	50-Year	19300.00	3454.78	3473.41	3467.33	3473.97	0.000892	6.00	3217.54	6592.22	0.32
Woodside	7013.039	100-Year	21000.00	3454.78	3474.00	3467.65	3474.60	0.000888	6.20	3389.56	6878.11	0.32
Woodside	7013.039	500-Year	24500.00	3454.78	3476.03	3468.28	3476.04	0.000044	1.42	37902.45	7498.74	0.07
Woodside	6959.093		Bridge									
Woodside	6917.823	25-Year	17600.00	3454.80	3469.91	3468.29	3471.56	0.005235	10.32	1705.85	3475.22	0.68
Woodside	6917.823	50-Year	19300.00	3454.80	3470.10	3468.63	3471.98	0.005779	11.02	1751.33	3609.13	0.72
Woodside	6917.823	100-Year	21000.00	3454.80	3470.27	3468.98	3472.40	0.006346	11.72	1792.37	3837.51	0.75
Woodside	6917.823	500-Year	24500.00	3454.80	3470.72	3469.67	3473.30	0.007134	12.89	1901.24	4573.42	0.81
Woodside	6912.823	25-Year	17600.00	3454.90	3469.74	3468.37	3471.52	0.005897	10.70	1644.75	3193.84	0.72
Woodside	6912.823	50-Year	19300.00	3454.90	3469.88	3468.73	3471.93	0.006653	11.51	1677.37	3409.69	0.77
Woodside	6912.823	100-Year	21000.00	3454.90	3469.98	3469.08	3472.34	0.007524	12.34	1701.15	3524.15	0.82
Woodside	6912.823	500-Year	24500.00	3454.90	3470.09	3469.76	3473.21	0.009734	14.18	1727.98	3602.91	0.93
Woodside	6902.823	25-Year	17600.00	3455.11	3470.63	3464.67	3471.11	0.000841	5.55	3169.38	6015.35	0.31
Woodside	6902.823	50-Year	19300.00	3455.11	3470.92	3464.97	3471.46	0.000923	5.92	3257.55	6546.43	0.32
Woodside	6902.823	100-Year	21000.00	3455.11	3471.18	3465.29	3471.80	0.001005	6.29	3340.60	6766.71	0.34
Woodside	6902.823	500-Year	24500.00	3455.11	3471.72	3465.90	3472.48	0.001161	6.98	3508.54	7209.50	0.37
Woodside	6768.57*	25-Year	17600.00	3457.81	3469.81	3467.34	3470.78	0.002777	7.96	2349.19	4527.03	0.53
Woodside	6768.57*	50-Year	19300.00	3457.81	3470.00	3467.64	3471.09	0.003023	8.46	2438.86	4819.51	0.56
Woodside	6768.57*	100-Year	21000.00	3457.81	3470.18	3467.96	3471.39	0.003283	8.96	2518.27	5084.04	0.58
Woodside	6768.57*	500-Year	24500.00	3457.81	3470.54	3468.68	3472.01	0.003745	9.88	2686.12	5885.27	0.63
Woodside	6619.335	25-Year	17600.00	3460.81	3468.32	3468.29	3469.85	0.012099	9.93	1772.10	3220.80	0.99
Woodside	6619.335	50-Year	19300.00	3460.81	3468.54	3468.51	3470.15	0.011621	10.18	1896.64	3473.49	0.98
Woodside	6619.335	100-Year	21000.00	3460.81	3468.76	3468.71	3470.44	0.011095	10.38	2023.14	3635.07	0.97
Woodside	6619.335	500-Year	24500.00	3460.81	3469.13	3469.08	3471.01	0.010877	10.97	2232.41	3781.49	0.98
Woodside	6145.328	25-Year	17600.00	3457.81	3467.63		3467.96	0.001455	4.79	4714.66	5221.86	0.37
Woodside	6145.328	50-Year	19300.00	3457.81	3467.88		3468.24	0.001481	4.99	5004.56	5430.52	0.38
Woodside	6145.328	100-Year	21000.00	3457.81	3468.13		3468.51	0.001507	5.19	5299.49	6102.76	0.39
Woodside	6145.328	500-Year	24500.00	3457.81	3468.57		3469.00	0.001566	5.56	5822.72	6548.83	0.40

Total flow in cross section.

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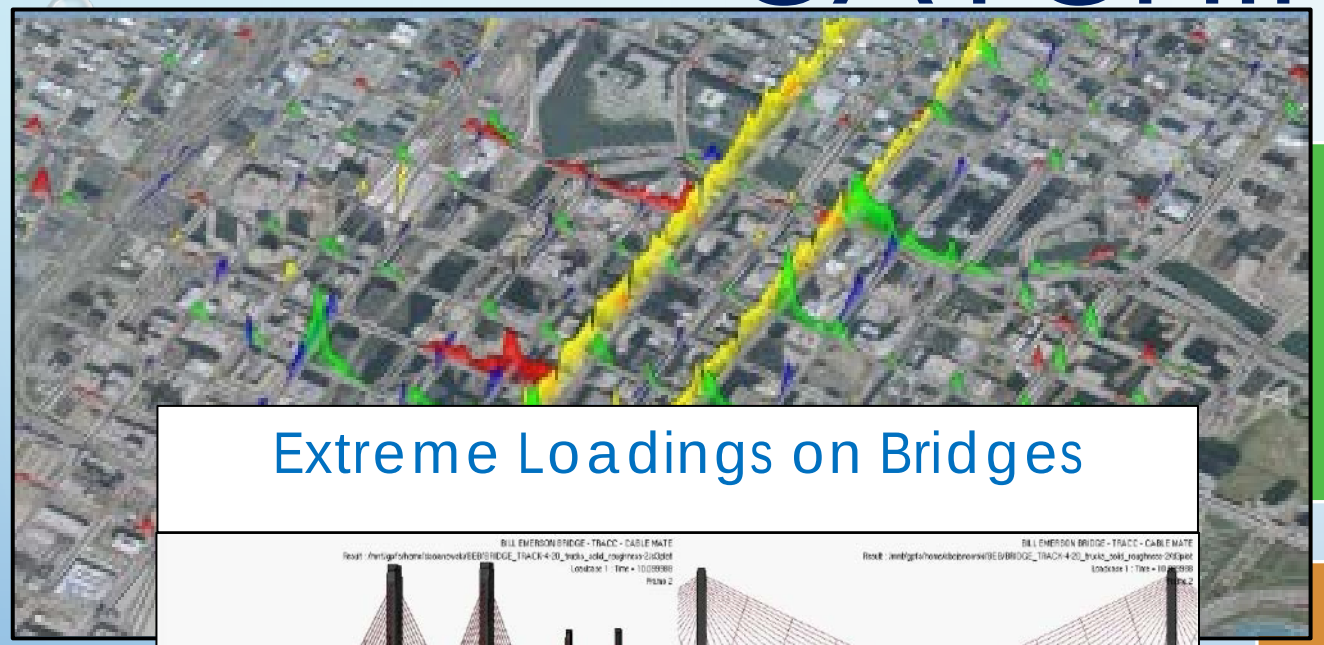
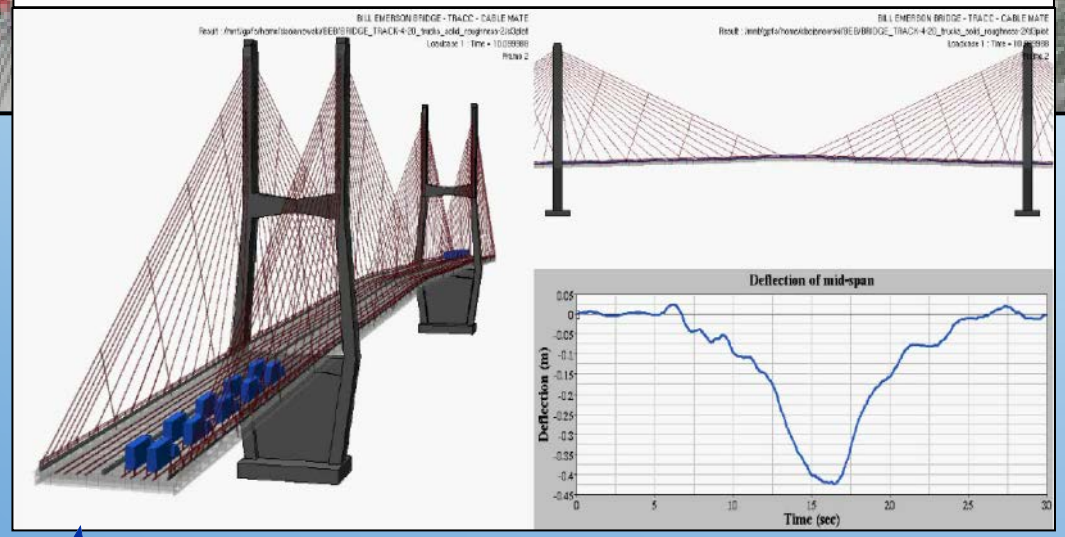
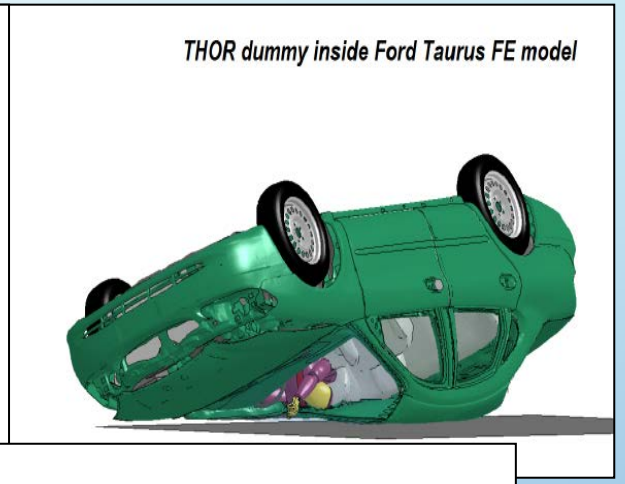
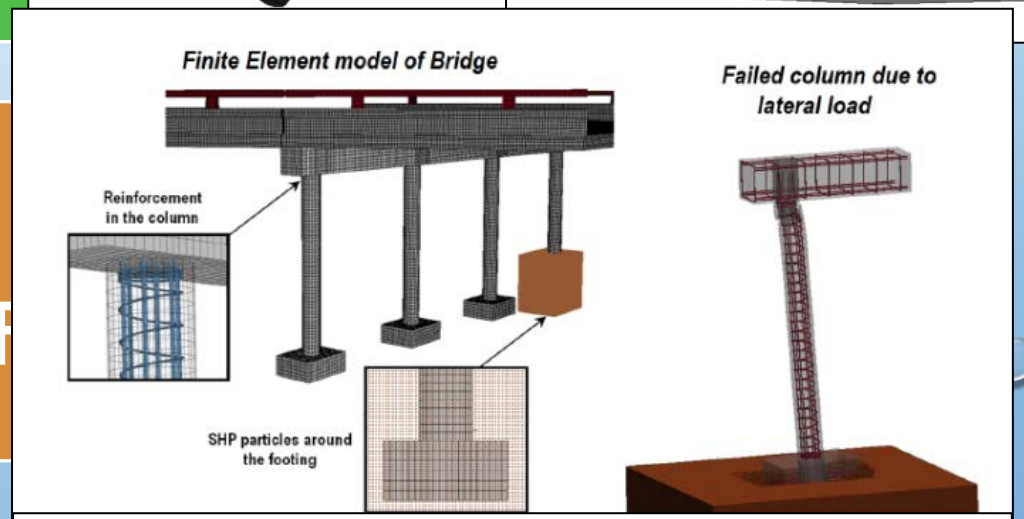
CATCHING UP



Extreme Loadings on Bridges







Lateral Load on Bridge Column

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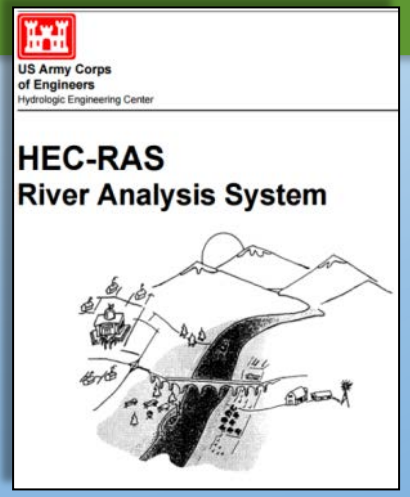
WHY CHANGE TO 2-D



FHWA – EVERY DAY COUNTS (EDC)

- **Time for CHANGE!**
  - **Collaborative**
  - **Hydraulics:**
  - **Advancing to the**
  - **Next**
  - **Generation of**
  - **Engineering**

EDC

SOFTWARE

SMS/SRH-2D

- In Use Since 2004
- Works well for Any Type of River Encroachment

HEC-RAS 2D

- In Use Since 2014
- Works Well for Floodplain Modeling

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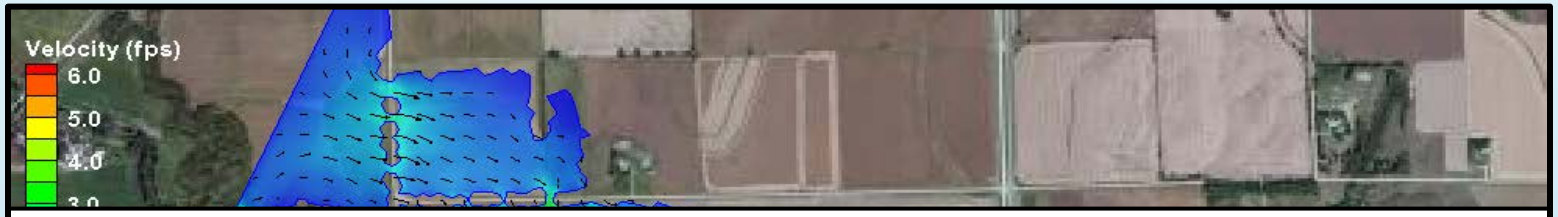
SHELL CREEK, NE

FLOODPLAIN ANALYSIS AND DESIGN

Image Source: Nebraska Department of Roads

SHELL CREEK, NE

FLOODPLAIN ANALYSIS AND DESIGN



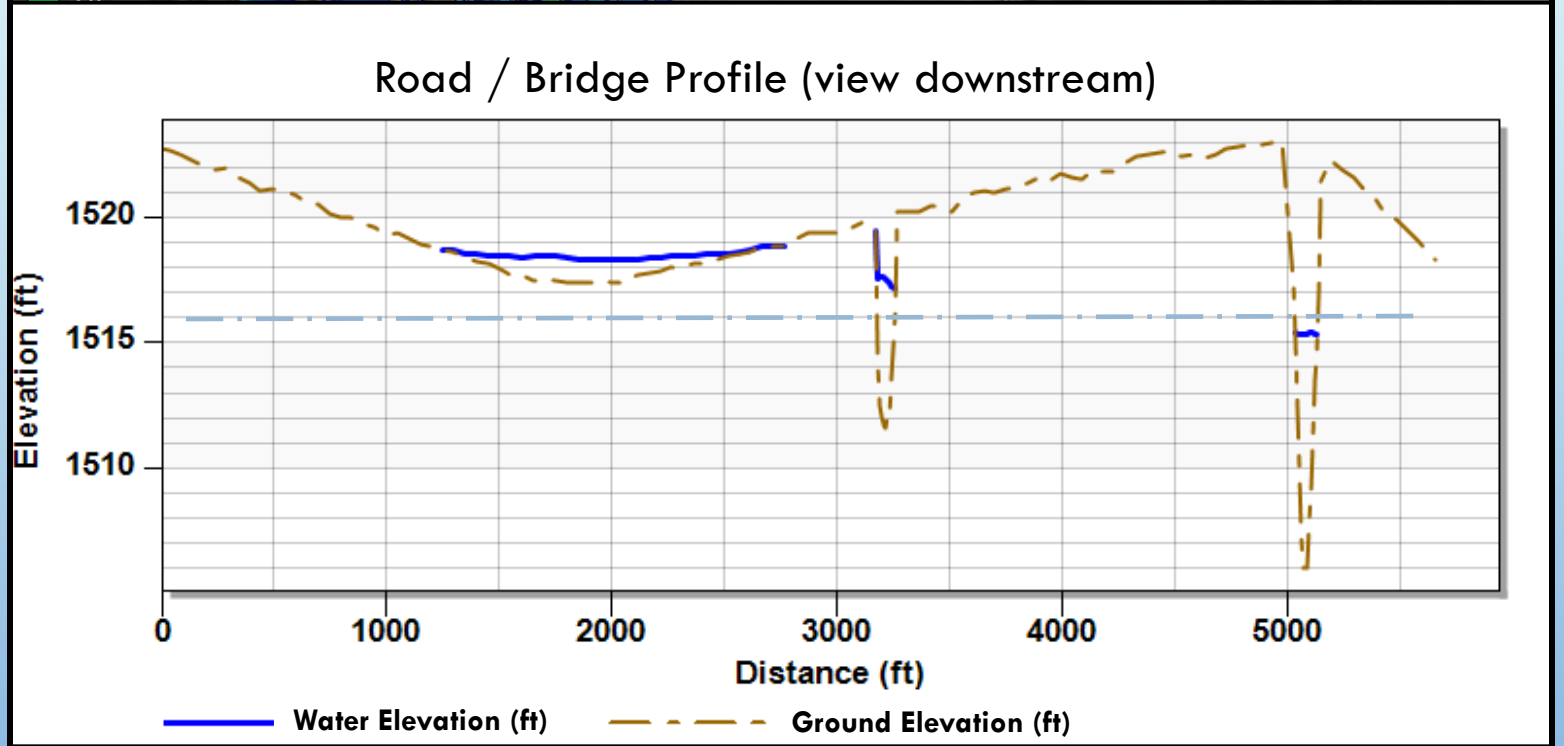


Image Source: Earthstar Graphics (Aerial Image)

HOW CAN 2-D MODELING BENEFIT THE FLOODPLAIN COMMUNITY

ASSOCIATION OF Montana FLOODPLAIN MANAGERS

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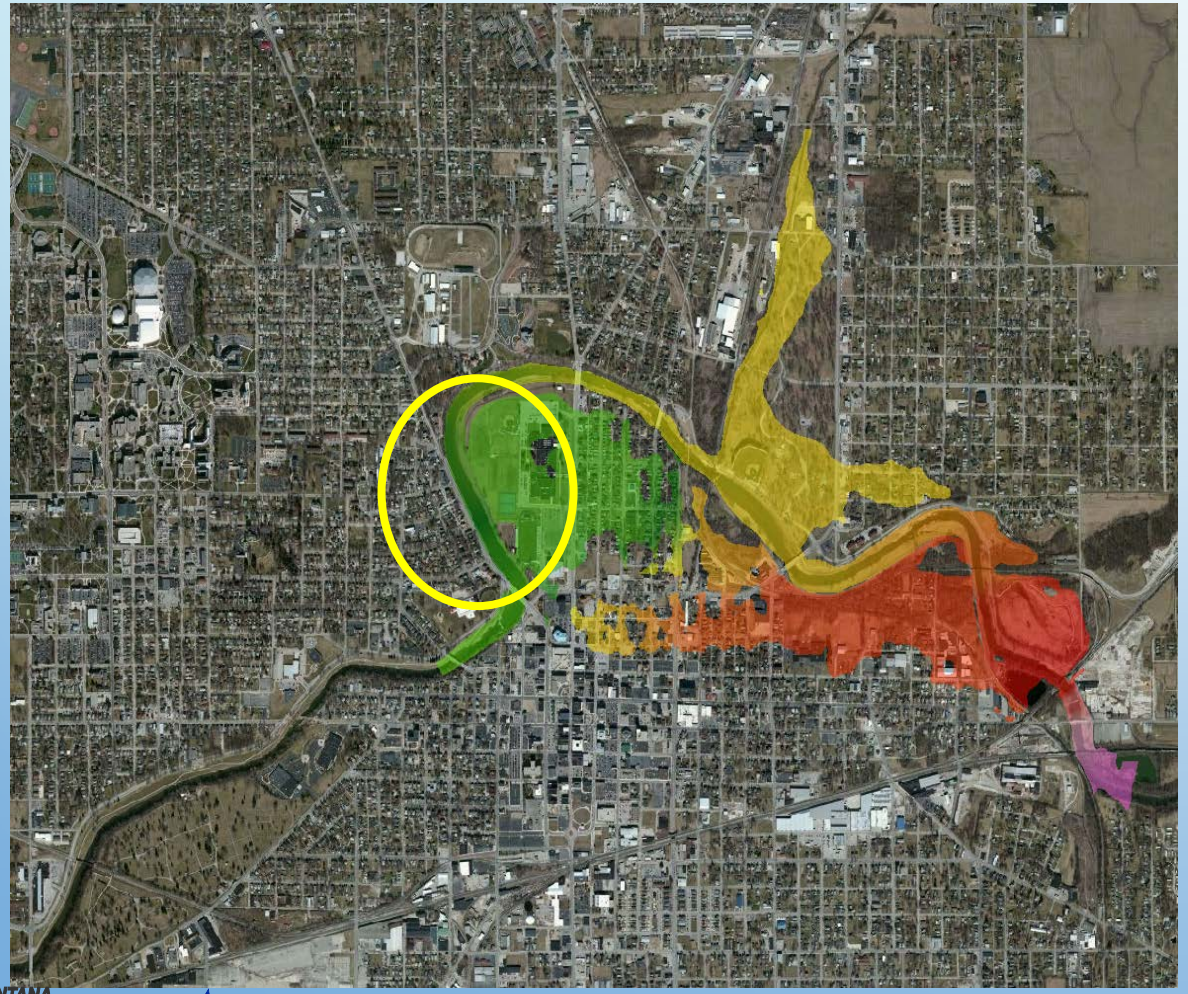
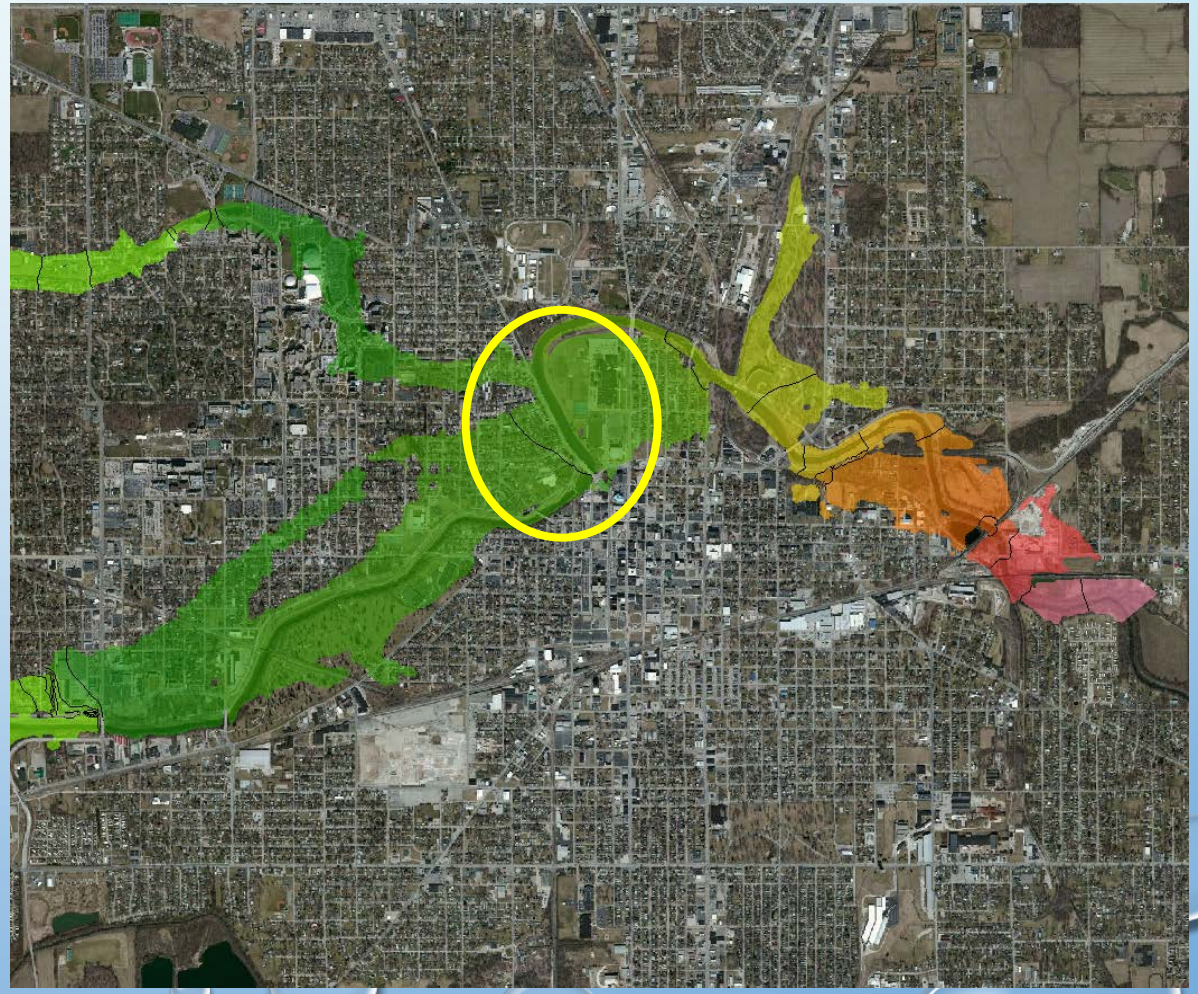
MORE ACCURATE ESTIMATIONS OF FLOODPLAIN LIMITS





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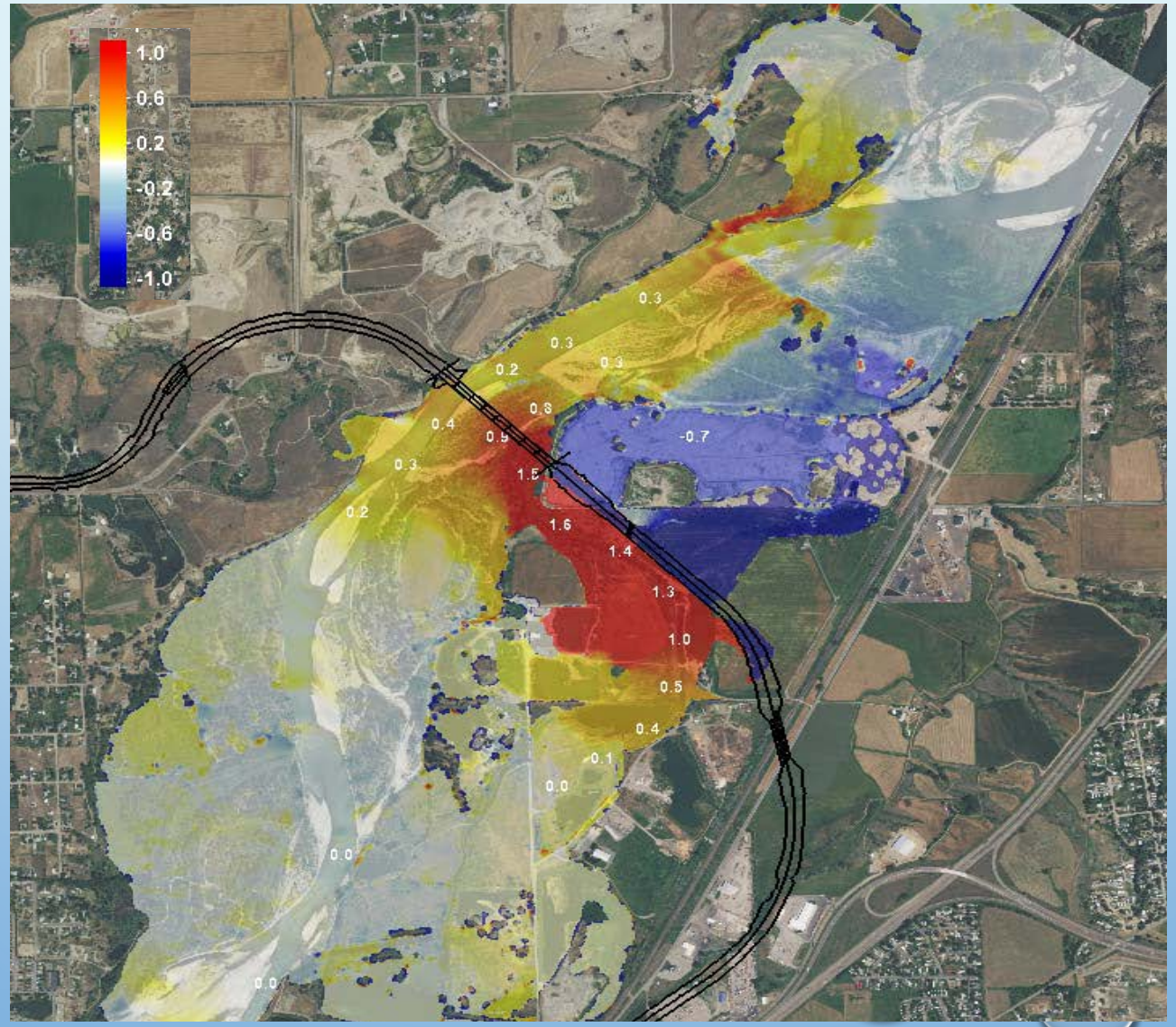
ENHANCED GRAPHICAL AIDS TO IMPROVE COMMUNICATION



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EXAMPLE SUBMITTAL – ZONE A FLOODPLAIN WITH A 2-D HYDRAULIC MODEL

Revised: 6/5/15 (310 form 2/0). Form may be downloaded from: www.dnrc.mt.gov/licenses-and-permits/stream-permitting

AGENCY USE ONLY: Application # _____ Date Received _____
Date Accepted _____/ Initials _____ Date Forwarded to DFWP _____

This space is for all Department of Transportation and SPA 124 permits (government projects).
Project Name: Bridge Replacement over No Name Creek
Control Number: 9999000 Contract letting date: January 2019
MEPA/NEPA Compliance ☒ Yes ☐ No If yes, #14 of this application does not apply.

JOINT APPLICATION FOR PROPOSED WORK IN MONTANA'S STREAMS, WETLANDS, FLOODPLAINS, AND OTHER WATER BODIES

Use this form to apply for one or all local, state, or federal permits listed below. The applicant is the responsible party for the project and the point of contact unless otherwise designated. "**Information for Applicant**" includes agency contacts and instructions for completing this application. **To avoid delays**, submit all required information, including **a project site map and drawings**. Incomplete applications will result in the delay of the application process. **Other laws may apply**.

The applicant is responsible for obtaining all necessary permits and landowner permission before beginning work.

✓	PERMIT	AGENCY	FEE
	310 Permit	Local Conservation District	No fee
	SPA 124 Permit	Department of Fish, Wildlife and Parks	No fee
✓	Floodplain Permit	Local Floodplain Administrator	Varies by city/county ($25 - $500+)
	Section 404 Permit, Section 10 Permit	U. S. Army Corps of Engineers	Varies ($0 - $100)
	318 Authorization 401 Certification	Department of Environmental Quality	$250 (318); $400 - $20,000 (401)
	Navigable Rivers Land Use License, Lease, or Easement	Department of Natural Resources and Conservation, Trust Lands Management Division	$50, plus additional fee

A. APPLICANT INFORMATION

NAME OF **APPLICANT** (person responsible for project): Jeremy R. Taylor, PE
Has the landowner consented to this project? ☒ Yes ☐ No
Mailing Address: P.O. Box 201000
Physical Address: 2701 Prospect Ave.
Day Phone: 406-444-7636 Evening Phone: _____ E-Mail: jertaylor@mt.gov

NAME OF **LANDOWNER** (if different from applicant): _____
Mailing Address: _____
Physical Address: _____
Day Phone: _____ Evening Phone: _____ E-Mail: _____

NAME OF **CONTRACTOR/AGENT** (if one is used): _____
Mailing Address: _____
Physical Address: _____
Day Phone: _____ Evening Phone: _____ E-Mail: _____

B. PROJECT SITE INFORMATION

NAME OF **STREAM** or **WATER BODY** at project location _____ Nearest Town _____
Address/Location: _____ Geocode (if available): _____
____1/4 ____1/4 ____1/4, Section _____, Township _____, Range _____ County _____
Longitude _____, Latitude _____

The state owns the beds of certain state navigable waterways. Is this a state navigable waterway? Yes or No.
If yes, send copy of this application to appropriate DNRC land office – see Information for Applicant.

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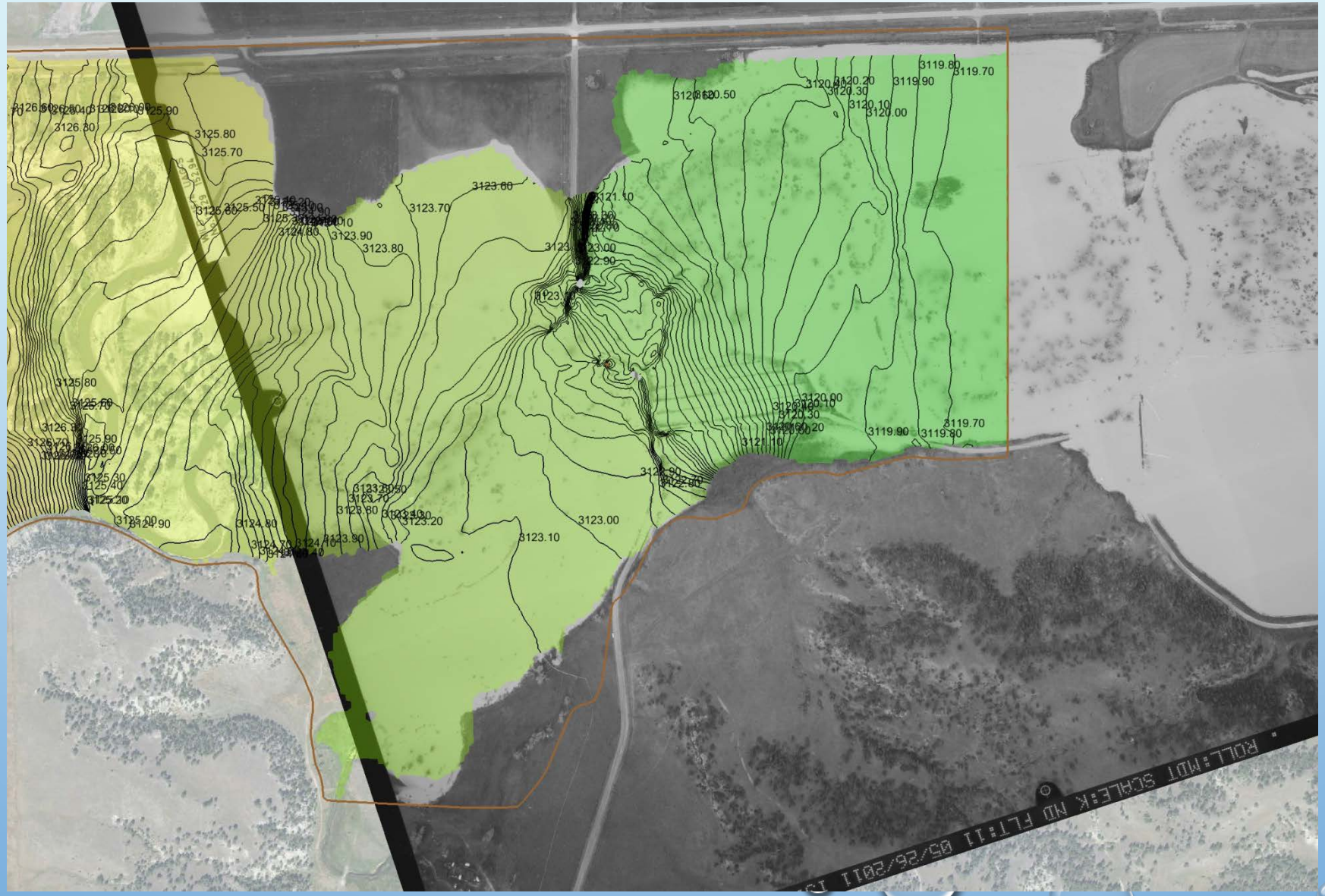
CALIBRATION



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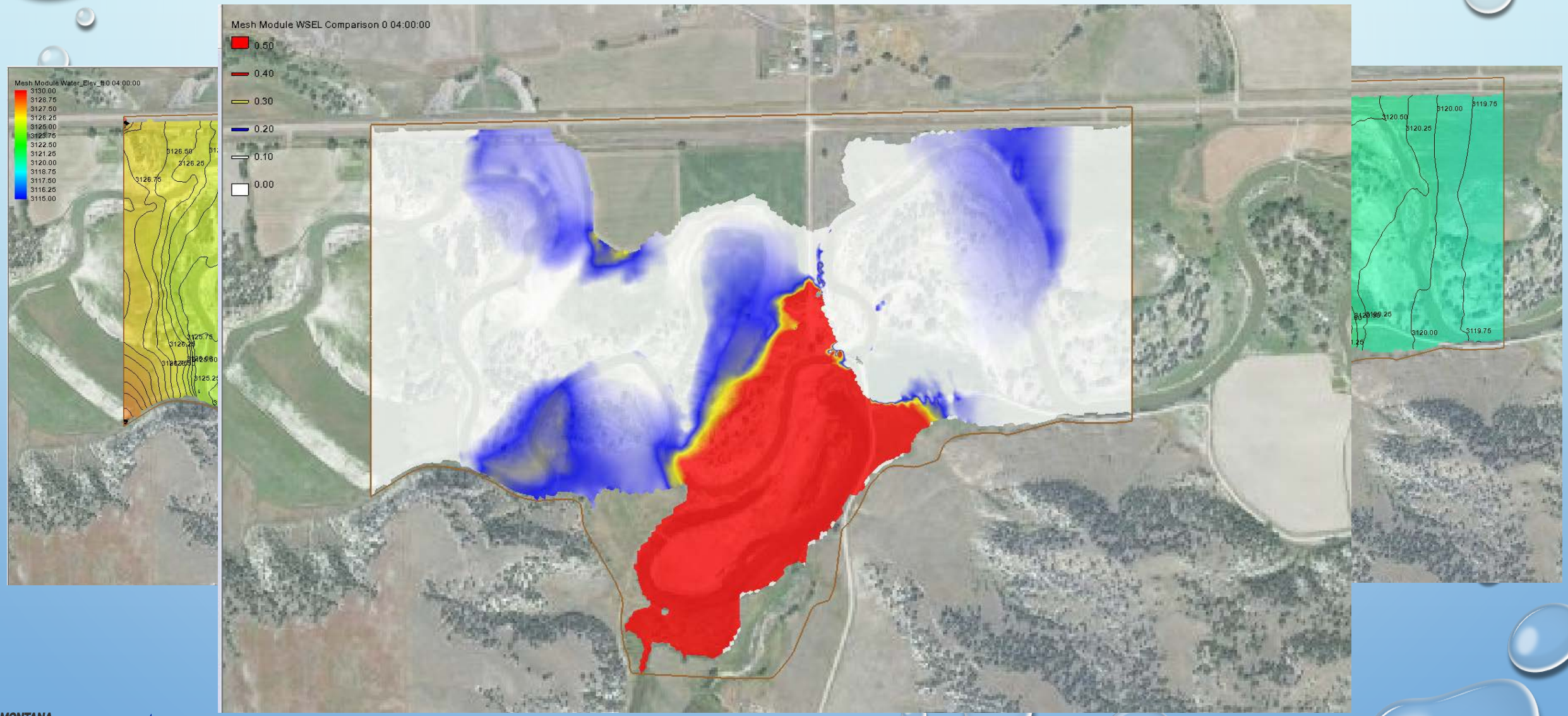
WATER SURFACE ELEVATION COMPARISON



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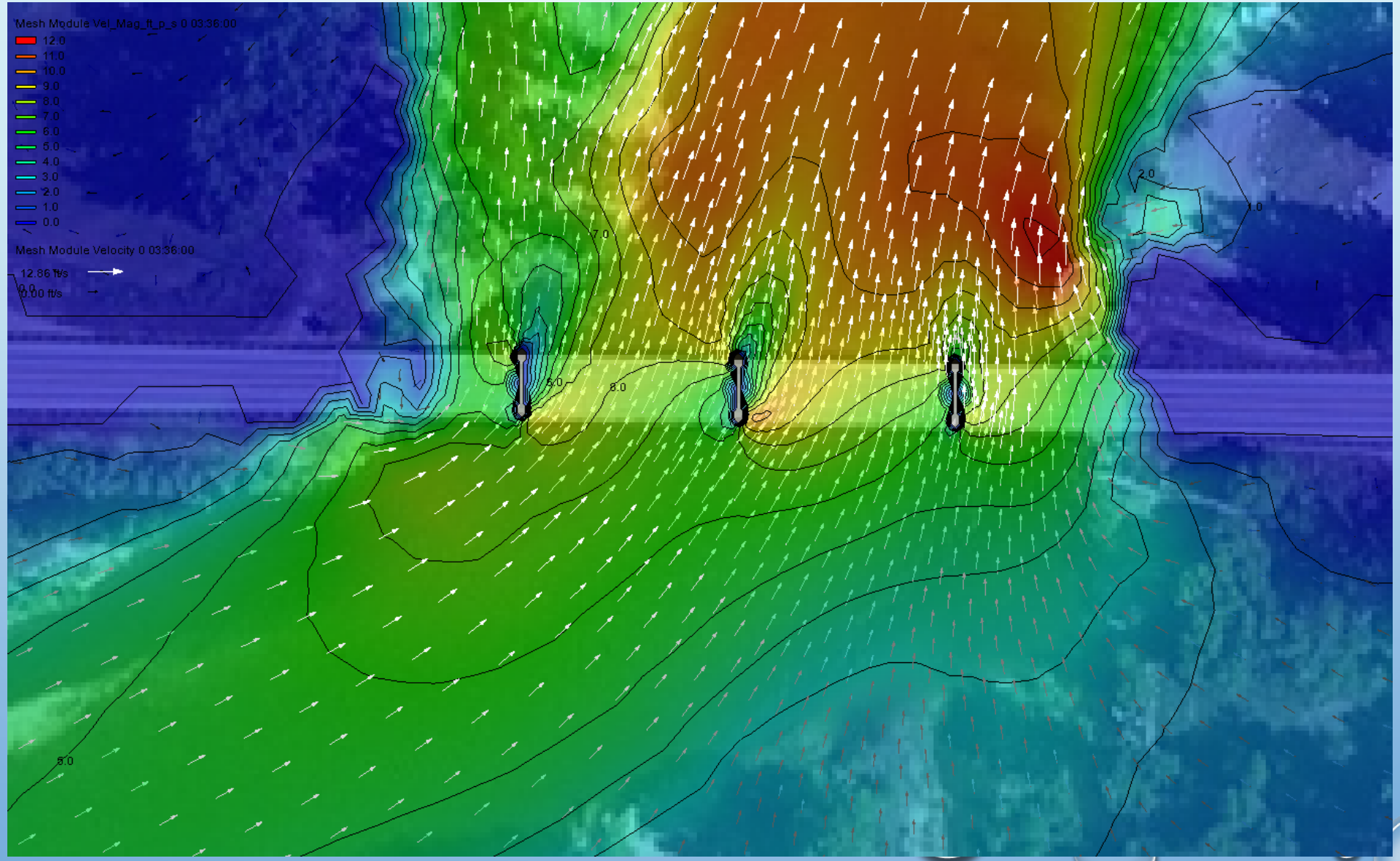
VELOCITY MAP WITH FLOW ARROWS



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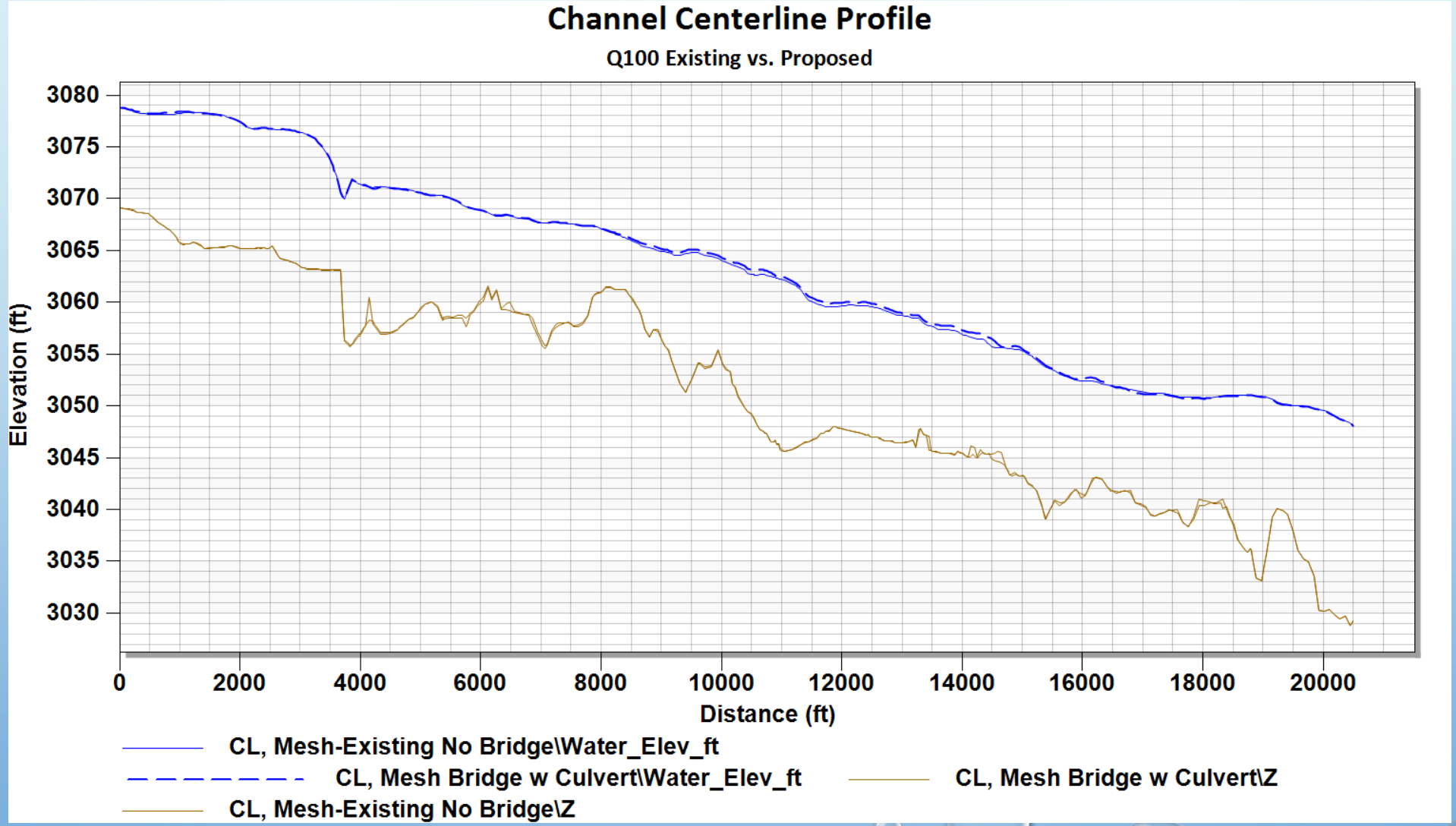
PROFILE COMPARISON



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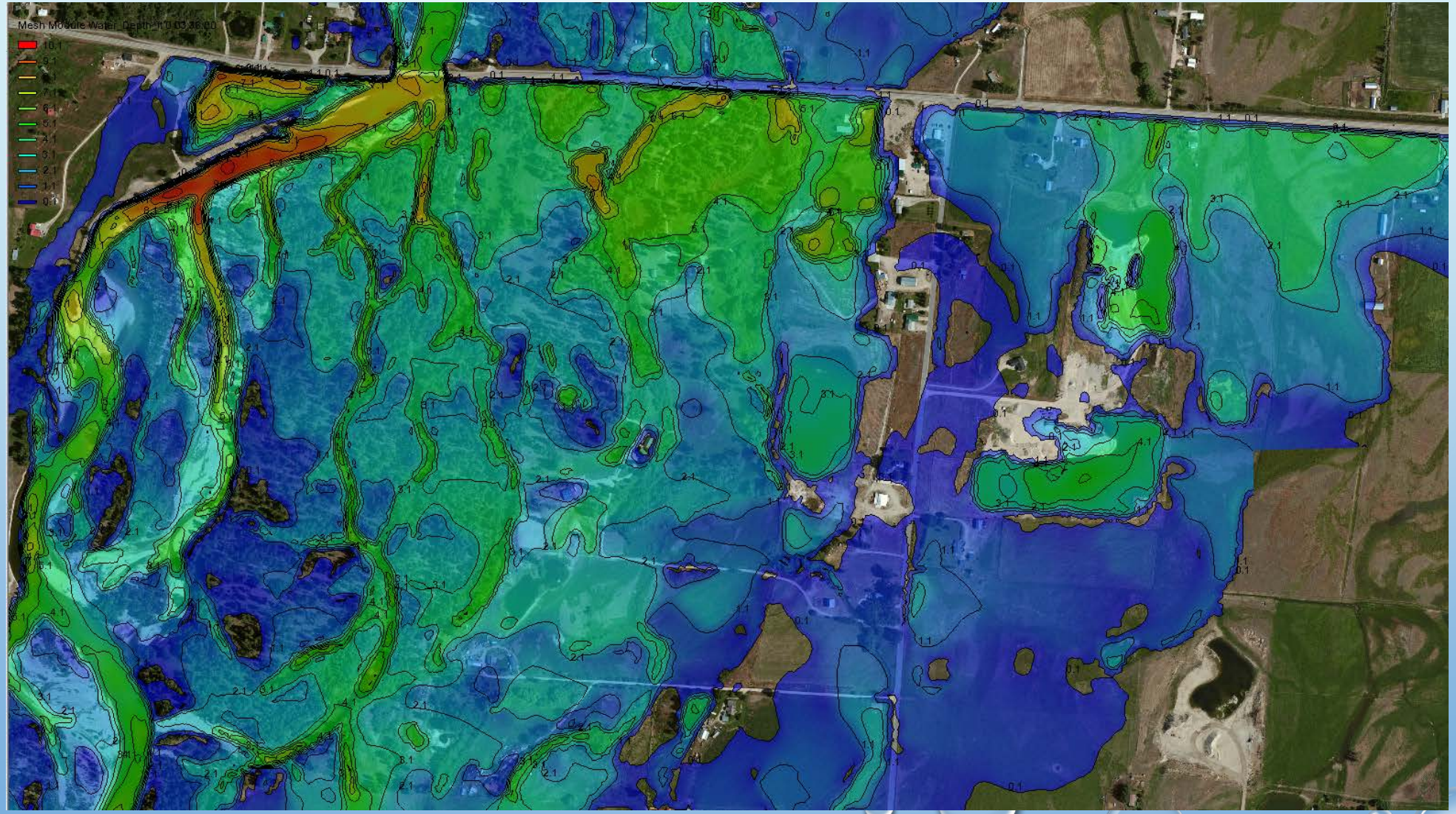
DEPTH OF FLOW CONTOUR MAP



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WHAT ABOUT A DETAILED FLOODPLAIN

- FEMA Guidelines
- Floodway vs. Floodplain Determination
- Providing a Single Averaged Water Surface Elevation
- Development of Updated Floodplain Maps
- Common Practice Today

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HELPFUL FIGURES FOR A FLOODPLAIN PERMIT

- Existing & Proposed Water Surface Elevation Maps
- Existing and Proposed Depth of Flow Maps
- Velocity Contour Maps with Flow Arrows
- Calibration Figures
- Floodplain Extent Maps
- Froude Number Maps
- Flow Trace Videos

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HELP

MDT Hydraulics

- J.R. Taylor, District Hydraulics Engineer/FHWA CHANGE Champion – jertaylor@mt.gov
  - Every Day Counts Innovation: CHANGE

Helpful Software Links

- SMS/ SRH-2D Free Reviewers License
  - www.aquaveo.com/regulatory-review
- SMS/SRH-2D: Supported by FHWA Resource Center, MDT, Aquaveo
  - http://www.xmswiki.com/wiki/SMS:SRH-2D
  - http://www.aquaveo.com/software/sms-learning
- HEC-RAS 5.0 Current Version
  - http://www.hec.usace.army.mil/software/hec-ras/downloads.aspx
- HEC-RAS 5.0: HEC-RAS Users Blog – "The RAS Solution"
  - http://hecrasmodel.blogspot.com/

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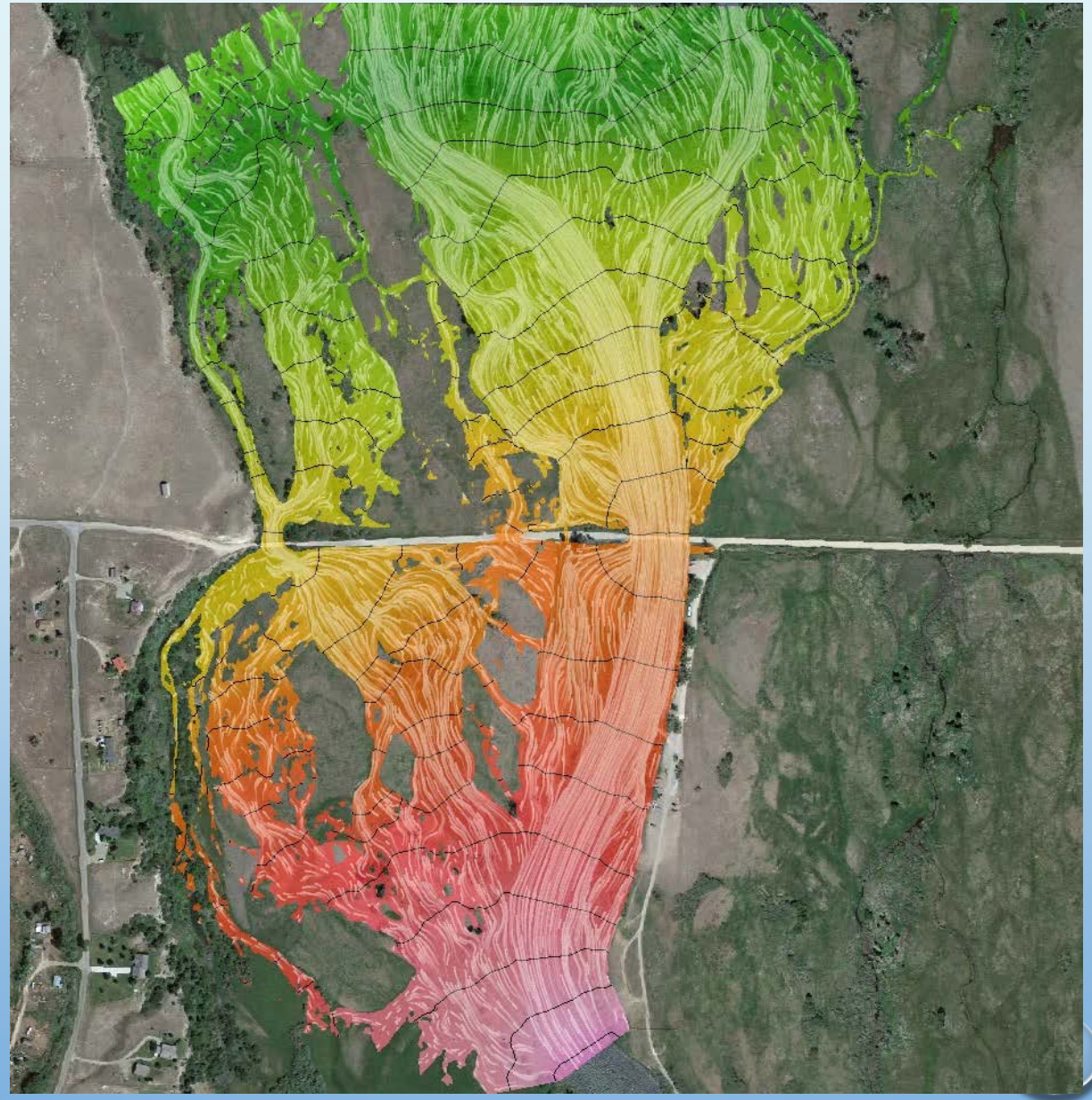
QUESTIONS?



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