

Sherlock Hydro

Unlocking Hydrologic Secrets Using Rain-on-Mesh Models

Alan Dennis

March 14, 2024

Transportation Engineers' Association of Missouri (TEAM)
2024 Conference

“The game is afoot”

- Rain on mesh modeling
- Application to roadway corridors



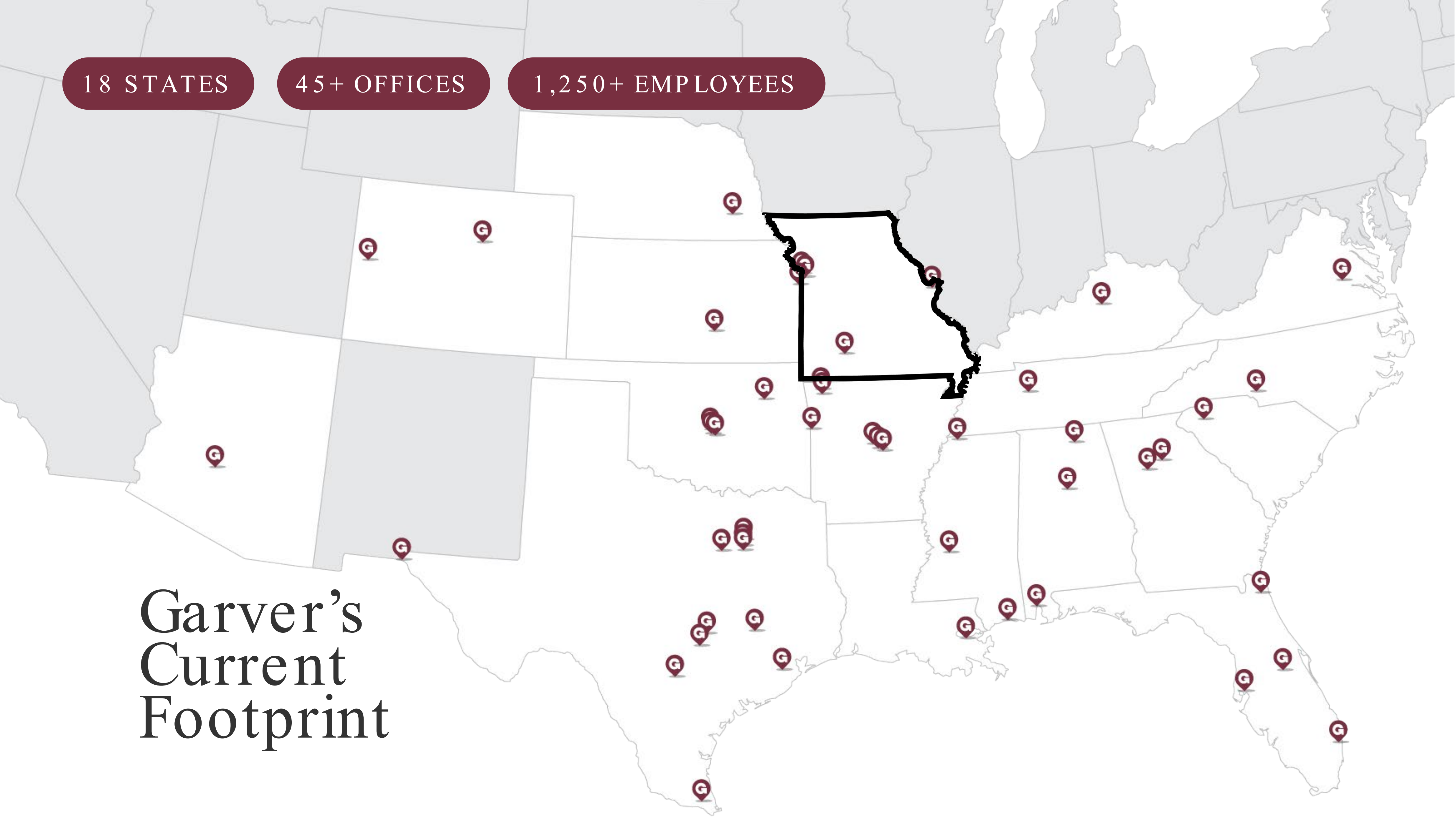
Get to know us



18 STATES

45+ OFFICES

1,250+ EMPLOYEES



Garver's Current Footprint

Presentation Outline

Topic Introduction

Methodology

Technical Details

Results

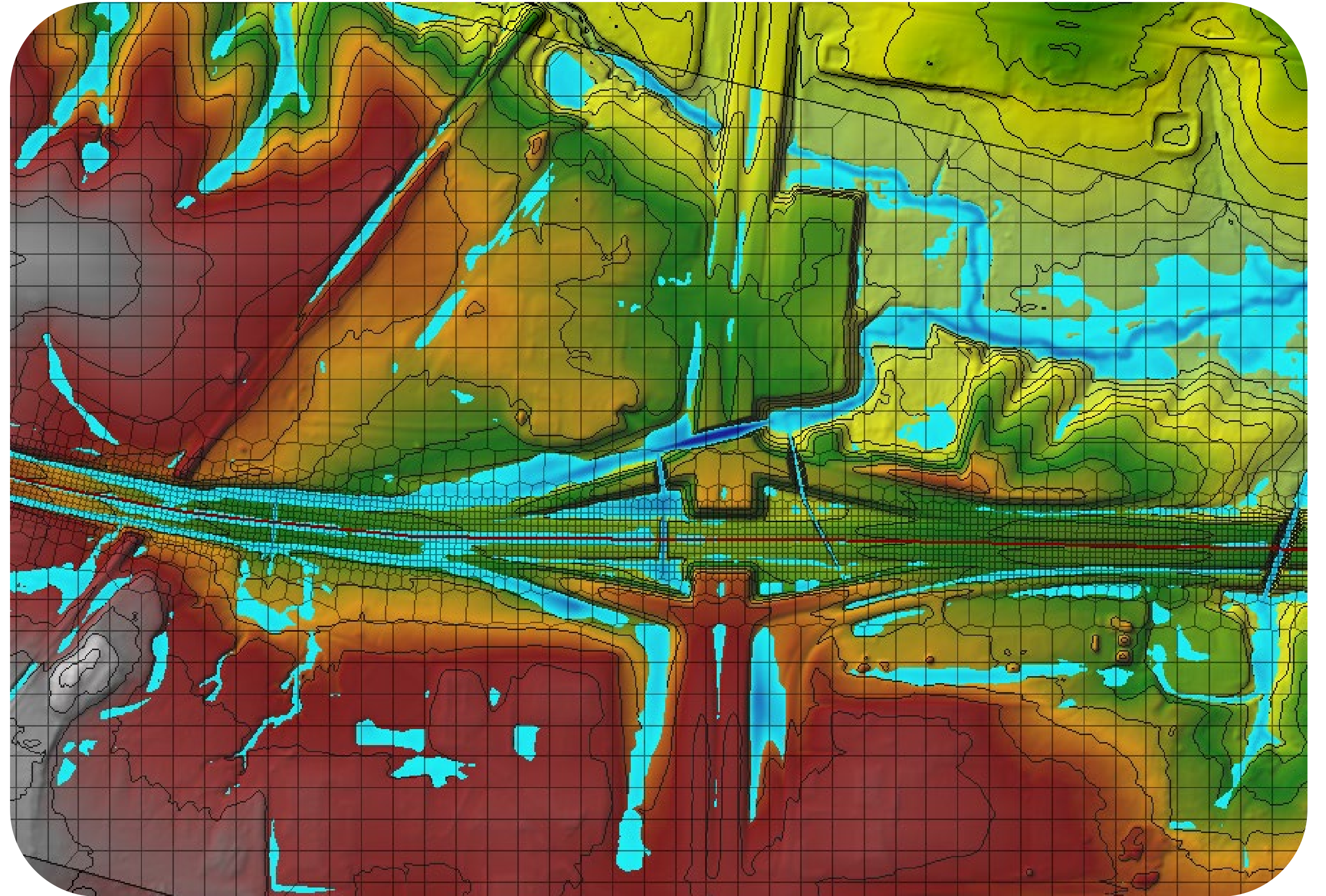
Challenges and Solutions

Future Work

Conclusion and Questions

“You see, but you do not observe”

- Objectives:
 - Understand 2D Rain on Mesh Hydraulic Modeling Concepts
 - Understand Application to Roadway Engineering
 - Consider Additional Applications Of Methodology

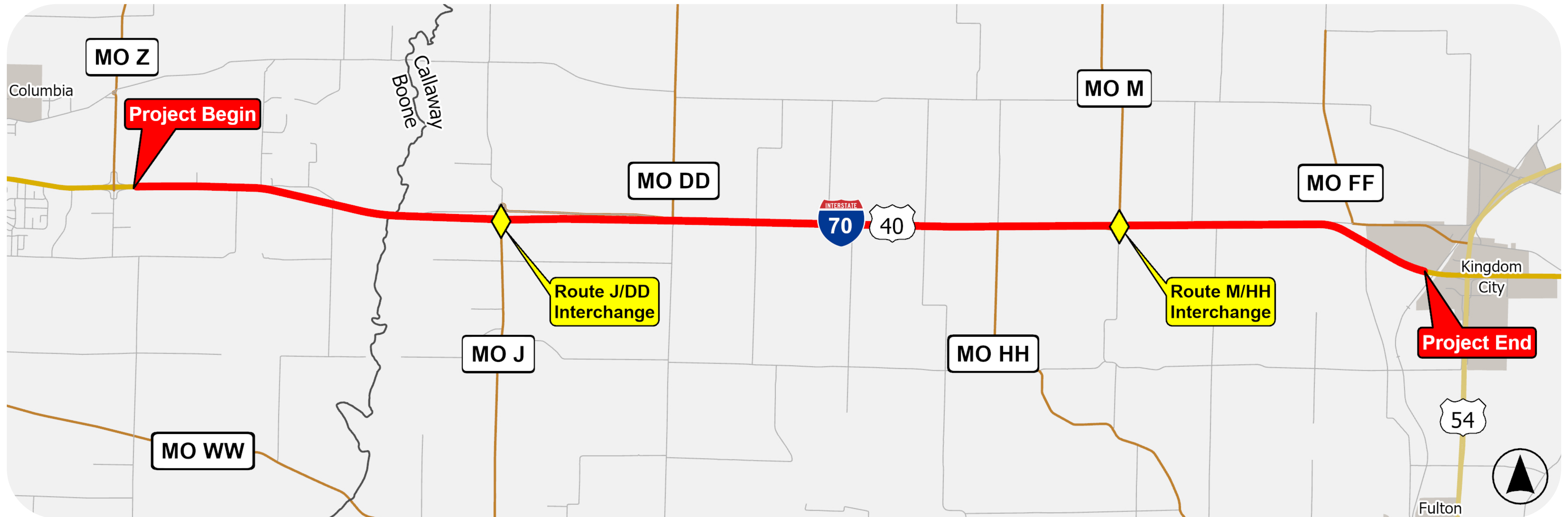




“All models are wrong, but some are useful”

GEORGE P. BOX

I-70 SIU 5 Corridor – Case Study

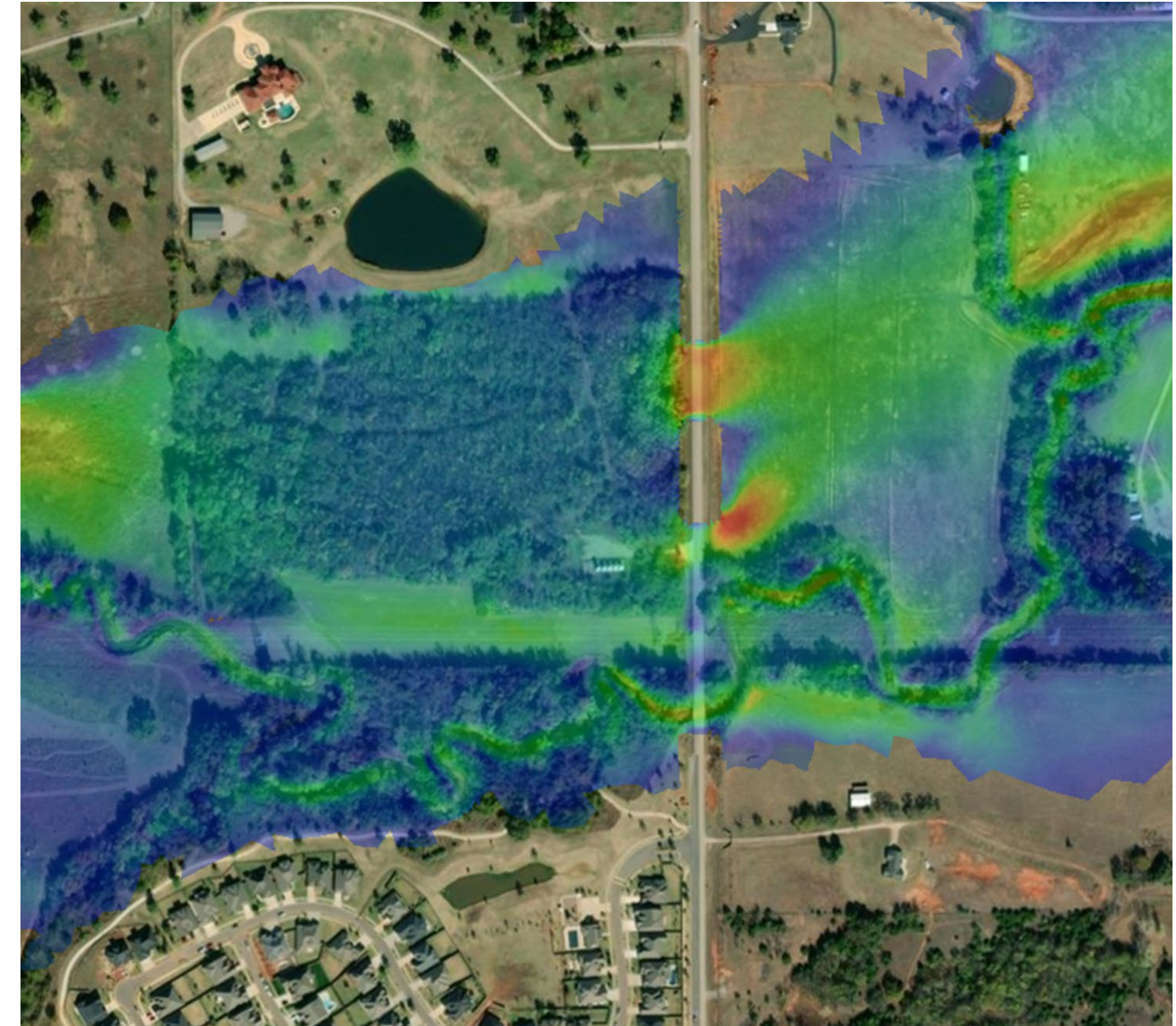


I-70 SIU 5 Corridor – FEMA Floodplains



Key Concepts in 2D Hydraulics

- Flow in both X-Y directions
- Depth Averaged velocity at each cell
- More data points
 - WSEL and Velocity/ Shear Stress
- Easy to make something that looks good and means nothing



Key Concepts in Rain-on-Mesh Modeling

- Additional Layers Required:
 - Precipitation
 - Atlas 14
 - Infiltration
 - SCS Curve Number
 - Hydraulic Roughness
 - Manning's n Layer

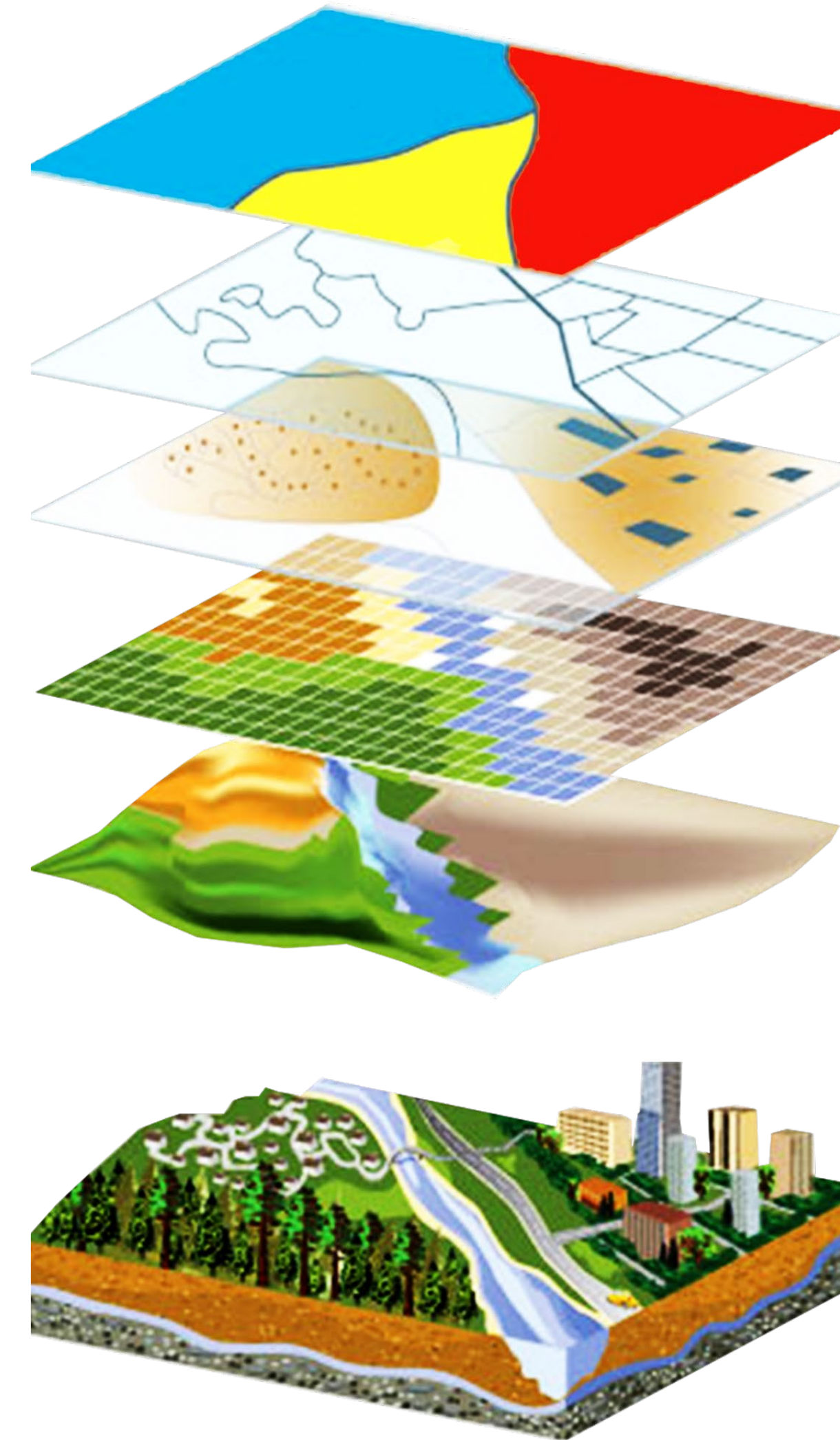


Image courtesy of INTOSAI Journal, 2016

"Data! Data! Data!
I can't make bricks
without clay."

- Technical Details related to
R-O-M Study of I-70 Corridor

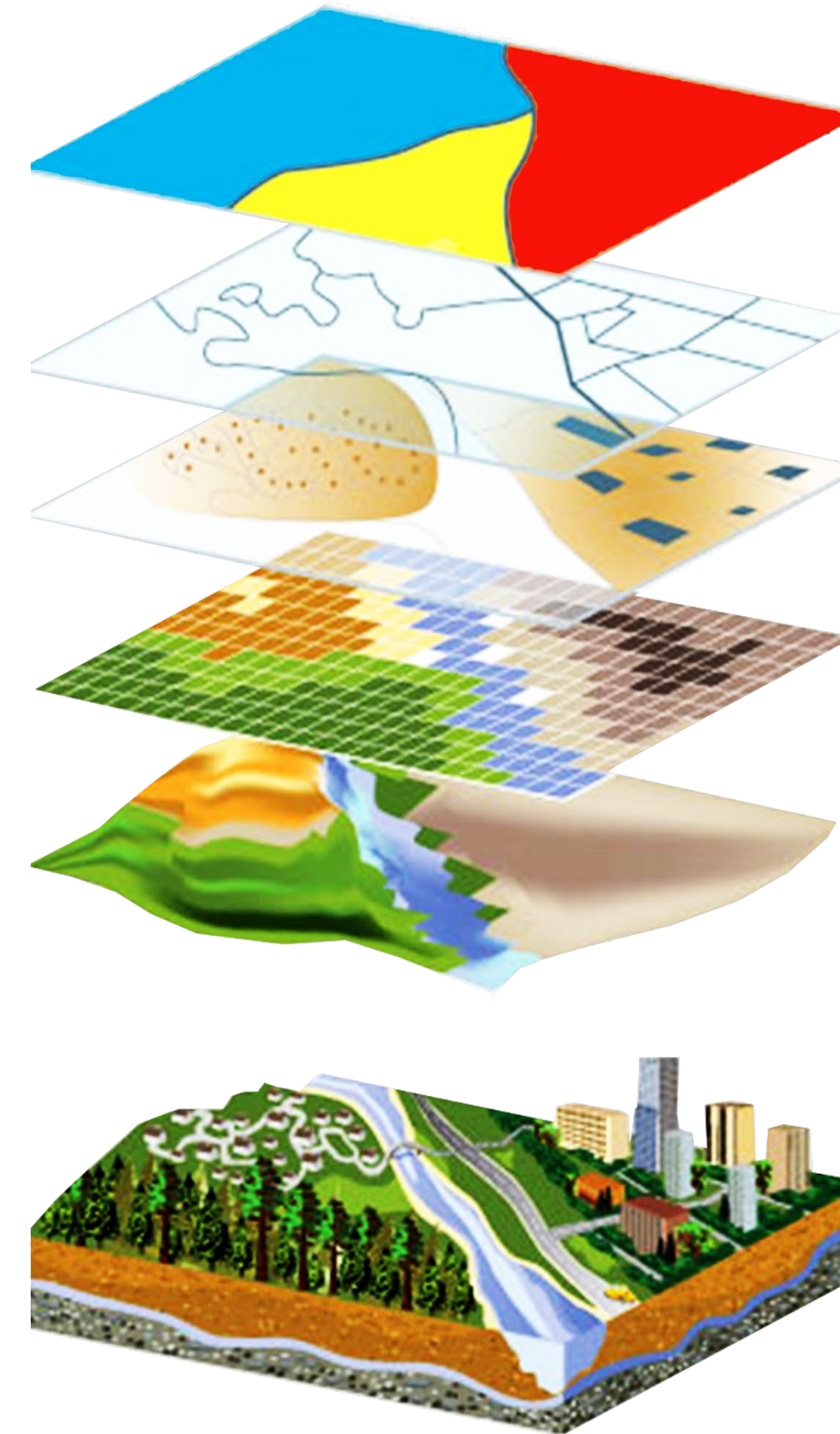


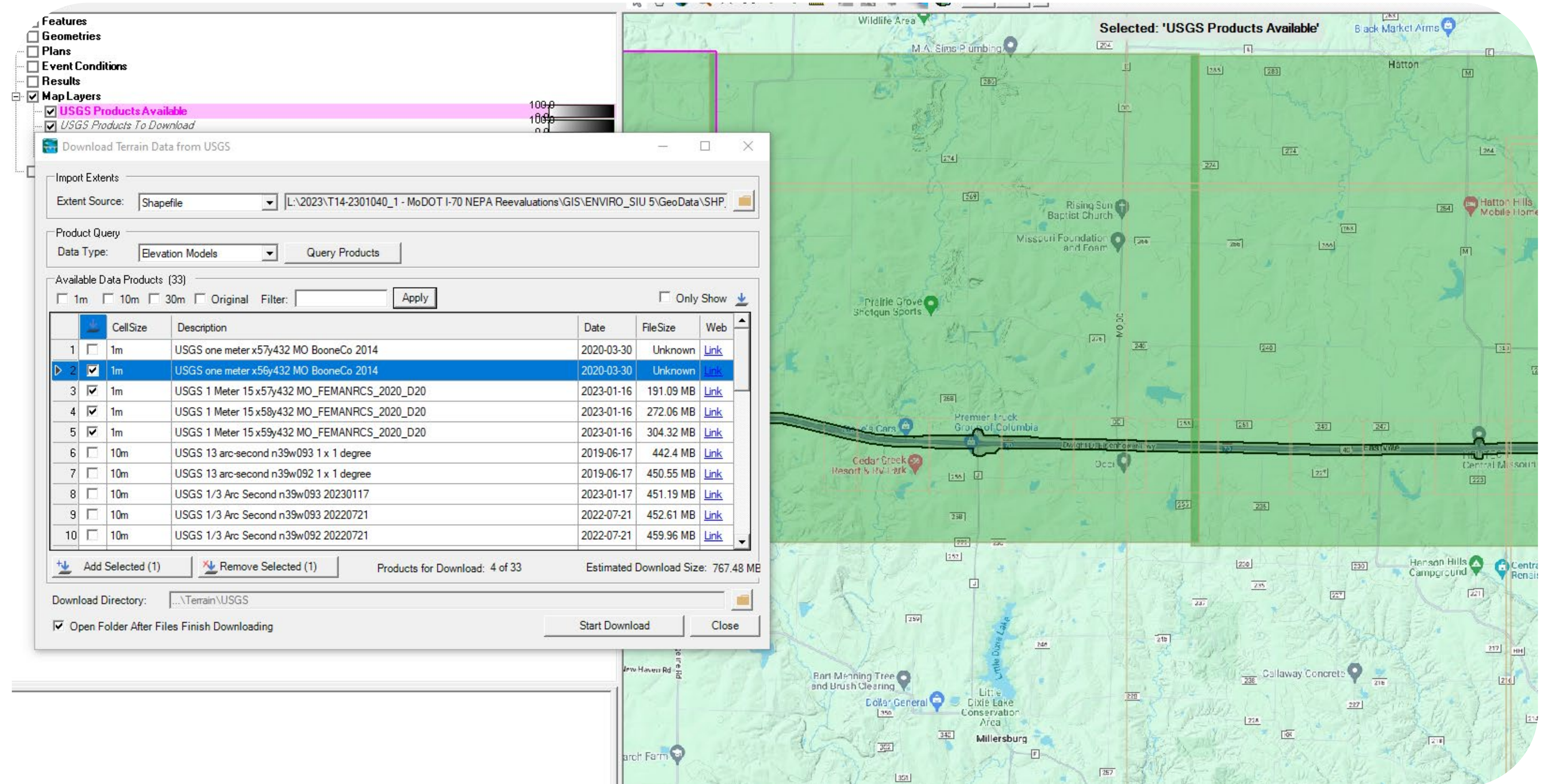
Image courtesy of INTOSAI Journal, 2016

I-70 SIU 5 Corridor – Where Are the Cross Drains?



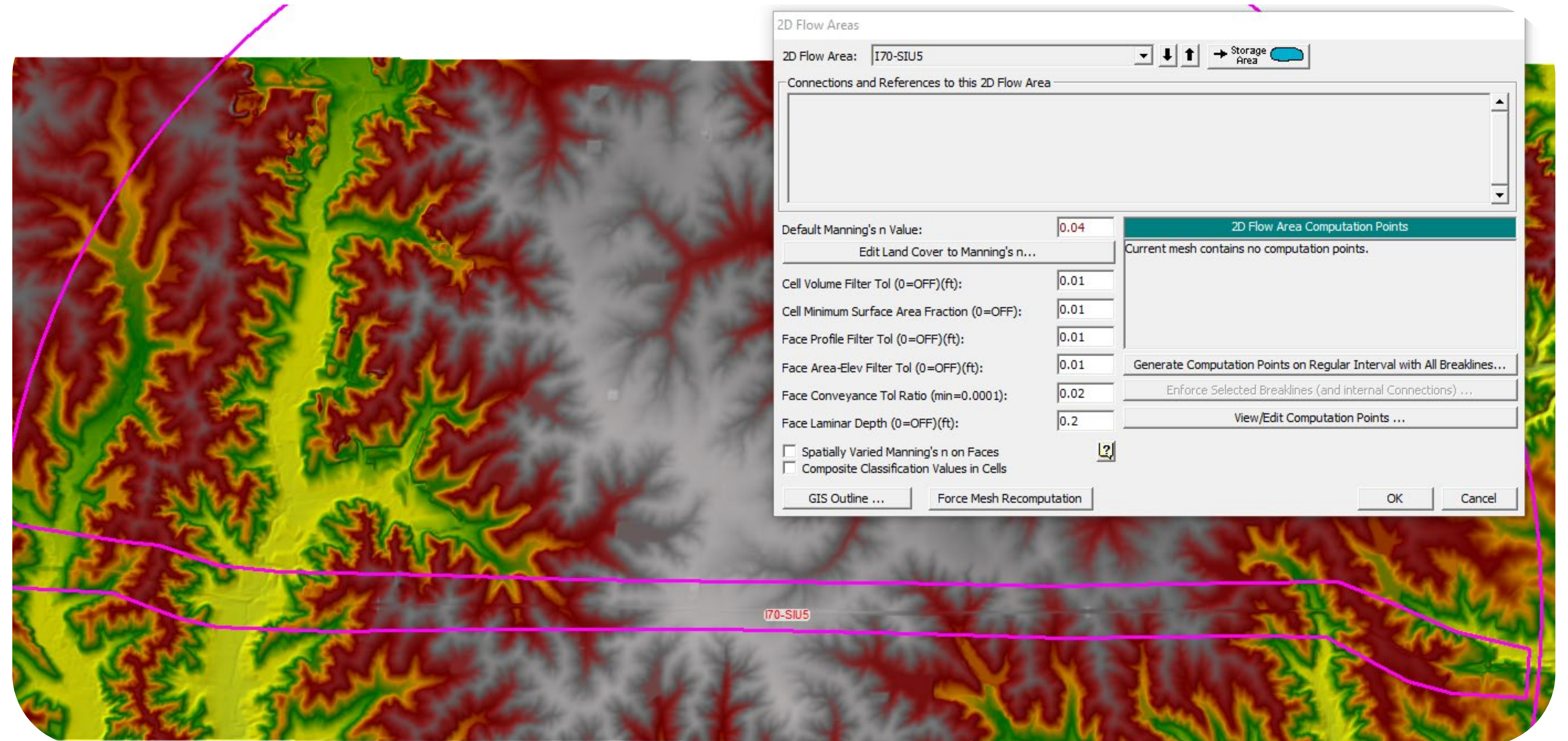
Data Collection

- Topography
 - USGS Lidar
 - Downloaded within RASMapper



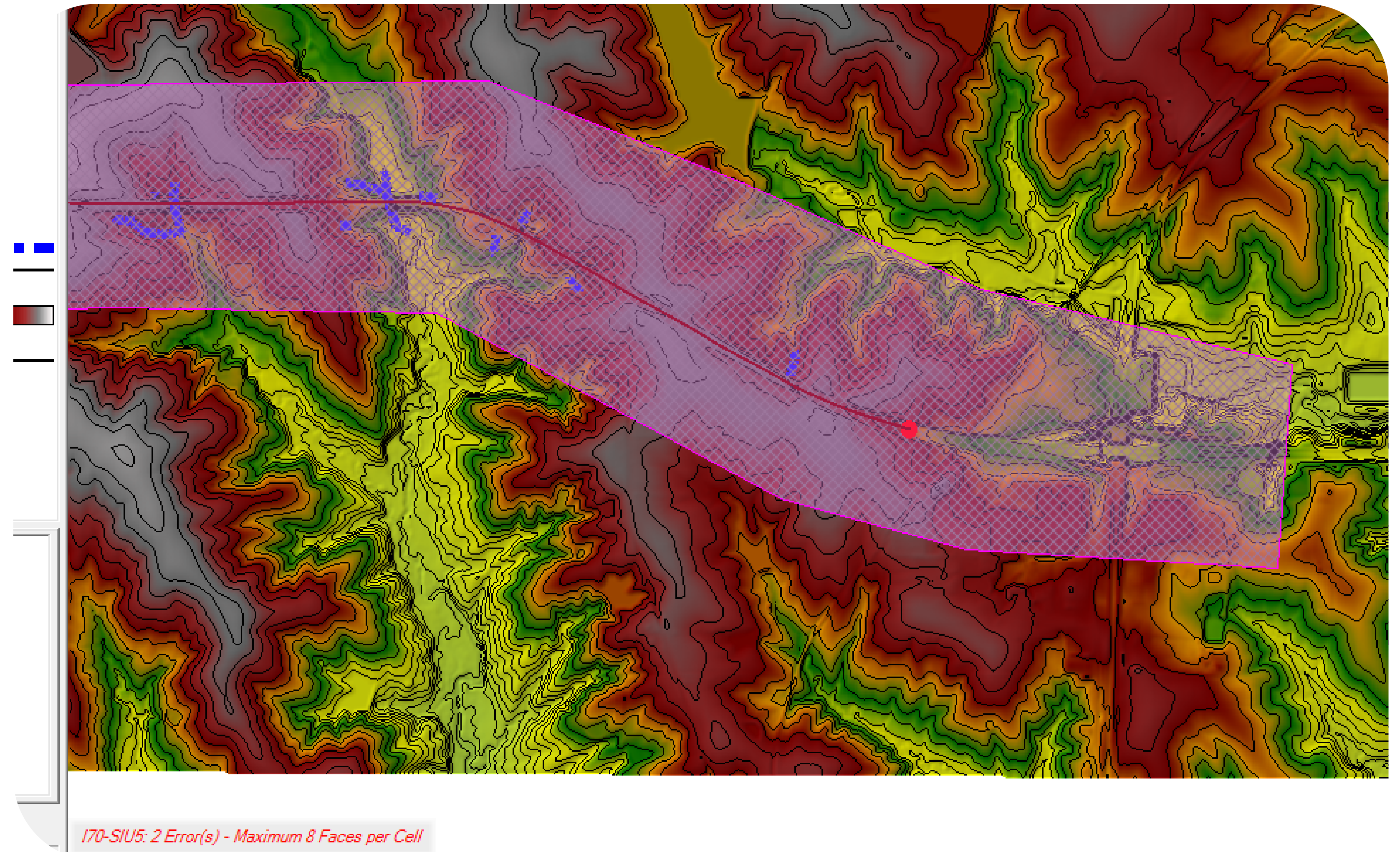
2D Computational Mesh Development

- Includes Entire Corridor



2D Computational Mesh Development

- Add Breaklines
- Address Errors (See Next Slide)



2D Computational Mesh Development

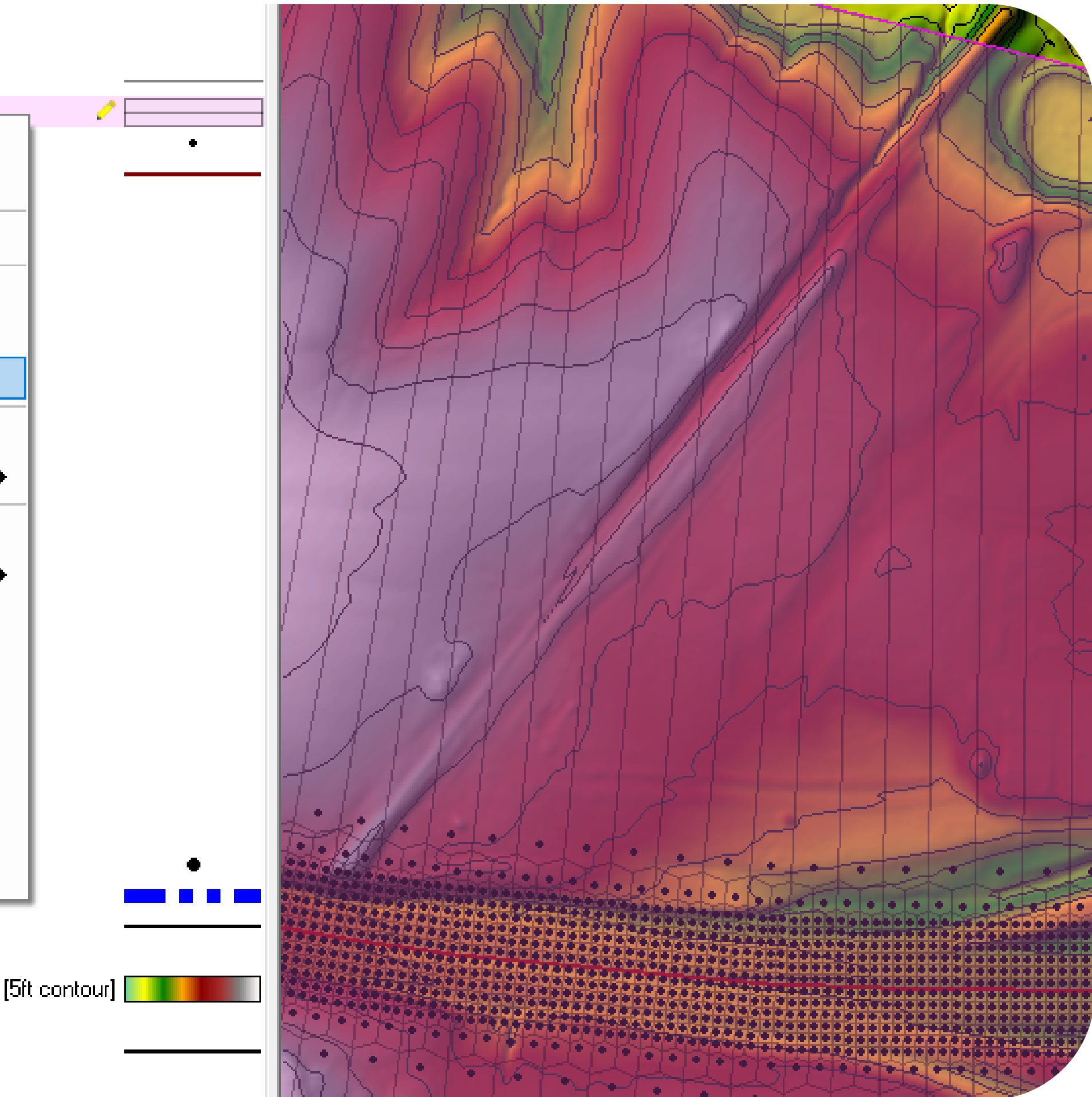
- Address Errors

Layer List:

- Loss Sections
- Storage Areas
- 2D Flow Areas
 - Perimeters
 - Computational
 - Breakline
 - Refinement
- Bridges/Culverts
- Inline Structures
- Lateral Structures
- SA/2D Connections
- Pump Stations
- Boundary Conditions
- Initial Conditions
- Reference Points
- Reference Lines
- Reference Areas
- Manning's n
- Infiltration
- Percent Impervious
- Errors

Context Menu:

- Layer Properties
- Open Attribute Table
- Stop Editing
- Edit 2D Area Properties
- Generate Computation Points with Breaklines for All Meshes
- Try to Fix All Meshes**
- Zoom to Layer
- Move Layer
- Import Features From Shapefile
- Export Layer
- Open Folder in File Explorer
- Remove Duplicate Perimeters
- Select All (Ctrl+A)
- Copy Selected Features (Ctrl+C)
- Find... (Ctrl+F)
- Select Polygons With Area Less Than...
- Select Polygons With Area Greater Than...



Precipitation Input

- Atlas 14
 - Precip Depth

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: MO

Data description

Data type: Units: Time series type:

Select location

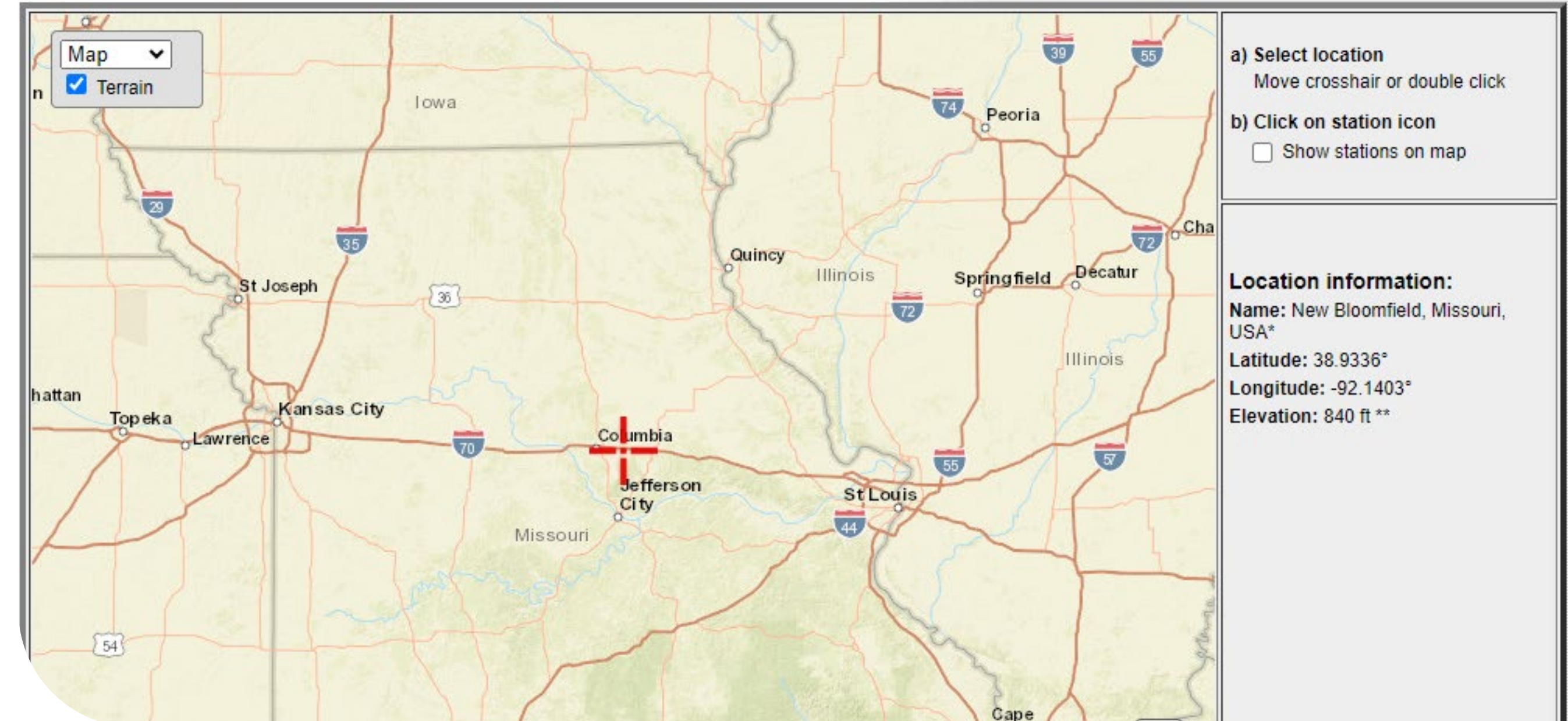
1) Manually:

a) By location (decimal degrees, use "-" for S and W): Latitude: Longitude:

b) By station ([list of MO stations](#)):

c) By address

2) Use map:



a) Select location
Move crosshair or double click

b) Click on station icon
 Show stations on map

Location information:
Name: New Bloomfield, Missouri, USA*
Latitude: 38.9336°
Longitude: -92.1403°
Elevation: 840 ft **

Precipitation Input

- Atlas 14
 - Precip Depth

The screenshot displays a software interface for configuring precipitation input. The main window, titled 'Boundary Condition Types', shows a grid of options with 'Precipitation' selected. Below this, a table lists '2D Flow Areas' with 'Precipitation' as the boundary condition. A 'Hydrograph Data' table shows precipitation values over time. A 'NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY' dialog is open, and a plot shows a sharp peak in precipitation.

Reach	RS	Boundary Condition
2D Flow Areas		Boundary Condition
IU5	BCLine: BC Line 2	Normal Depth
IU5	BCLine: BC Line 1	Normal Depth
IU5		Precipitation

Simulation Time (hours)	Precipitation (in)
11:28:00	0.02
11:29:00	0.02
11:30:00	0.02
11:31:00	0.03
11:32:00	0.03
11:33:00	0.03
11:34:00	0.03
11:35:00	0.03
11:36:00	0.03
11:37:00	0.03
11:38:00	0.03
11:39:00	0.03
11:40:00	0.03
11:41:00	0.04
11:42:00	0.04
11:43:00	0.04
11:44:00	0.04
11:45:00	0.04
11:46:00	0.06
11:47:00	0.06

Make The Model Useful

- Additional Layers Required:
 - Precipitation
 - Atlas 14
 - ~~- Infiltration~~
 - ~~SCS Curve Number~~
 - ~~- Hydraulic Roughness~~
 - ~~Manning's n Layer~~

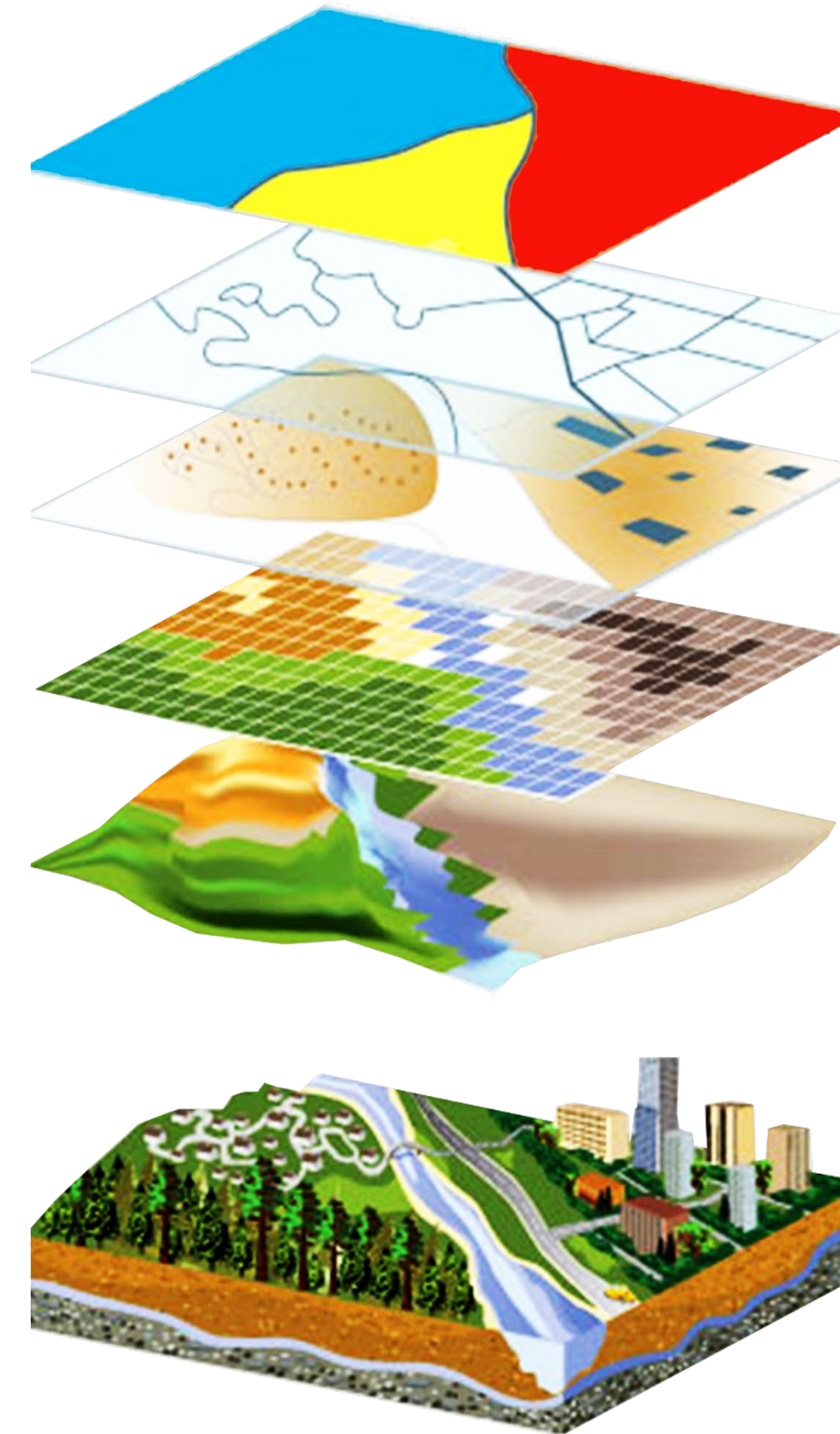


Image courtesy of INTOSAI Journal, 2016

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"It's a three-pipe problem"

Results Visualization
Case Study at I-70 -- SIU 5

Preliminary Results I-70 SIU 5 Corridor

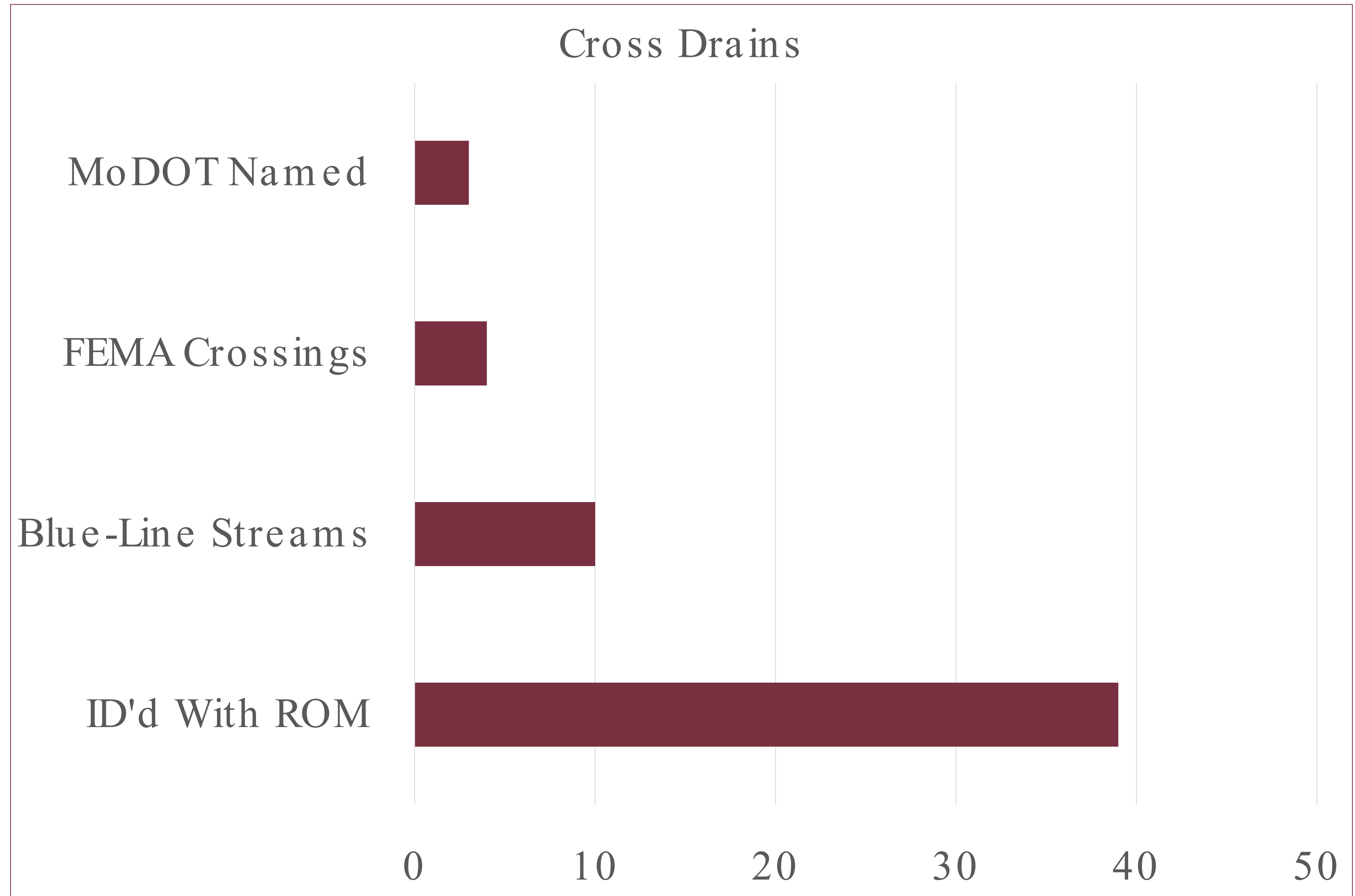


Preliminary Results I-70 SIU 5 Corridor

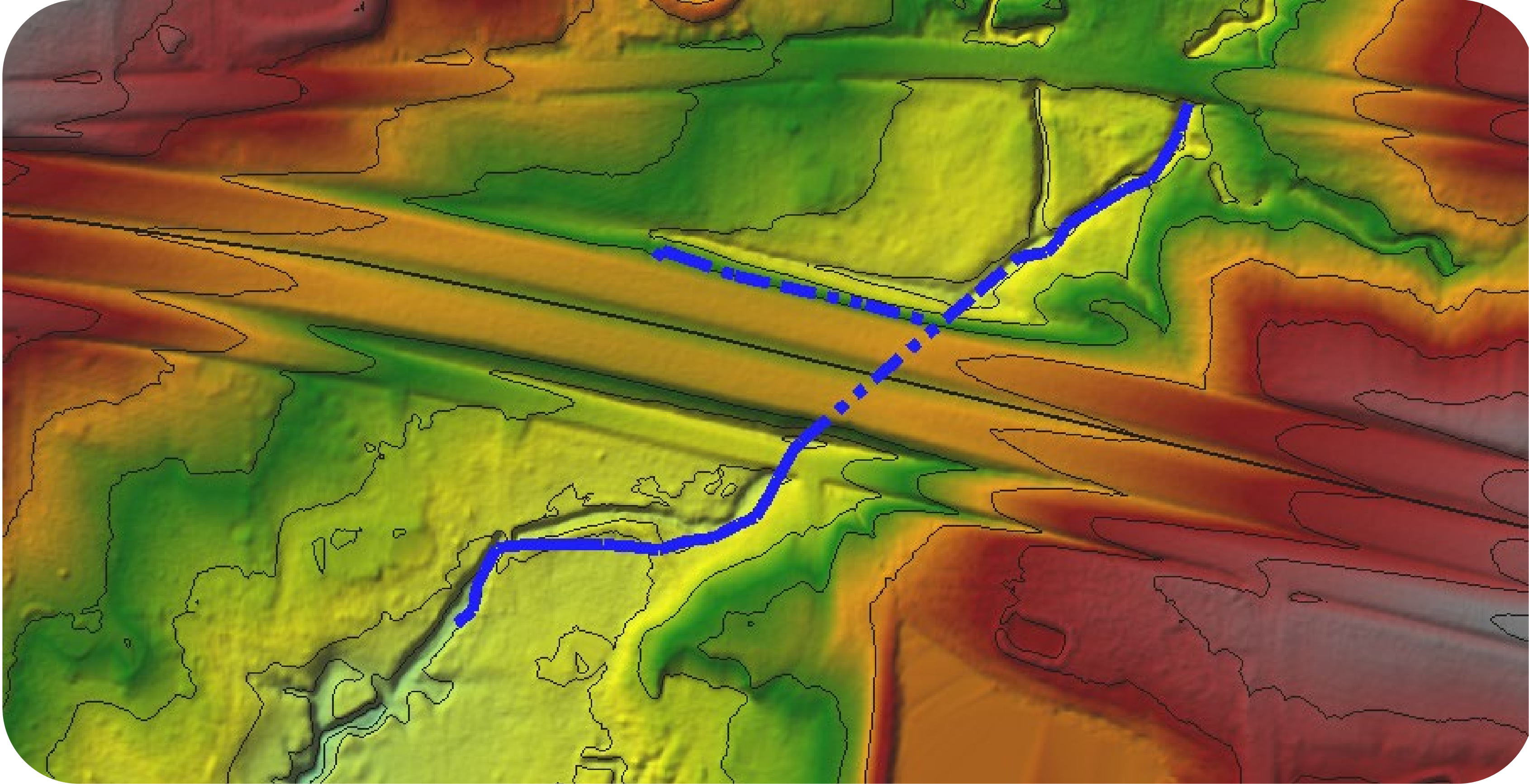


Utilize Results

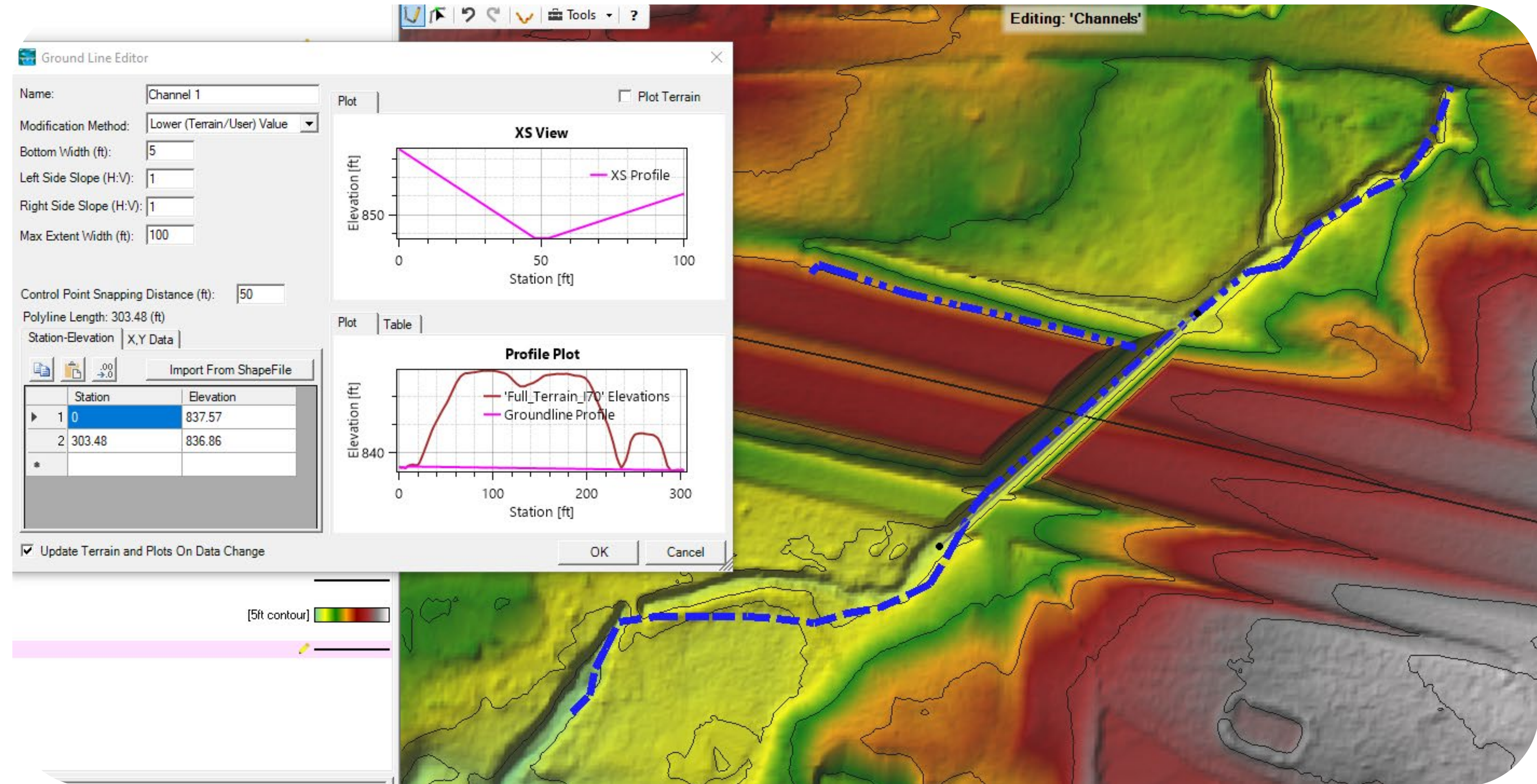
- Make the model useful
- Identify cross culverts
- Identify side drains



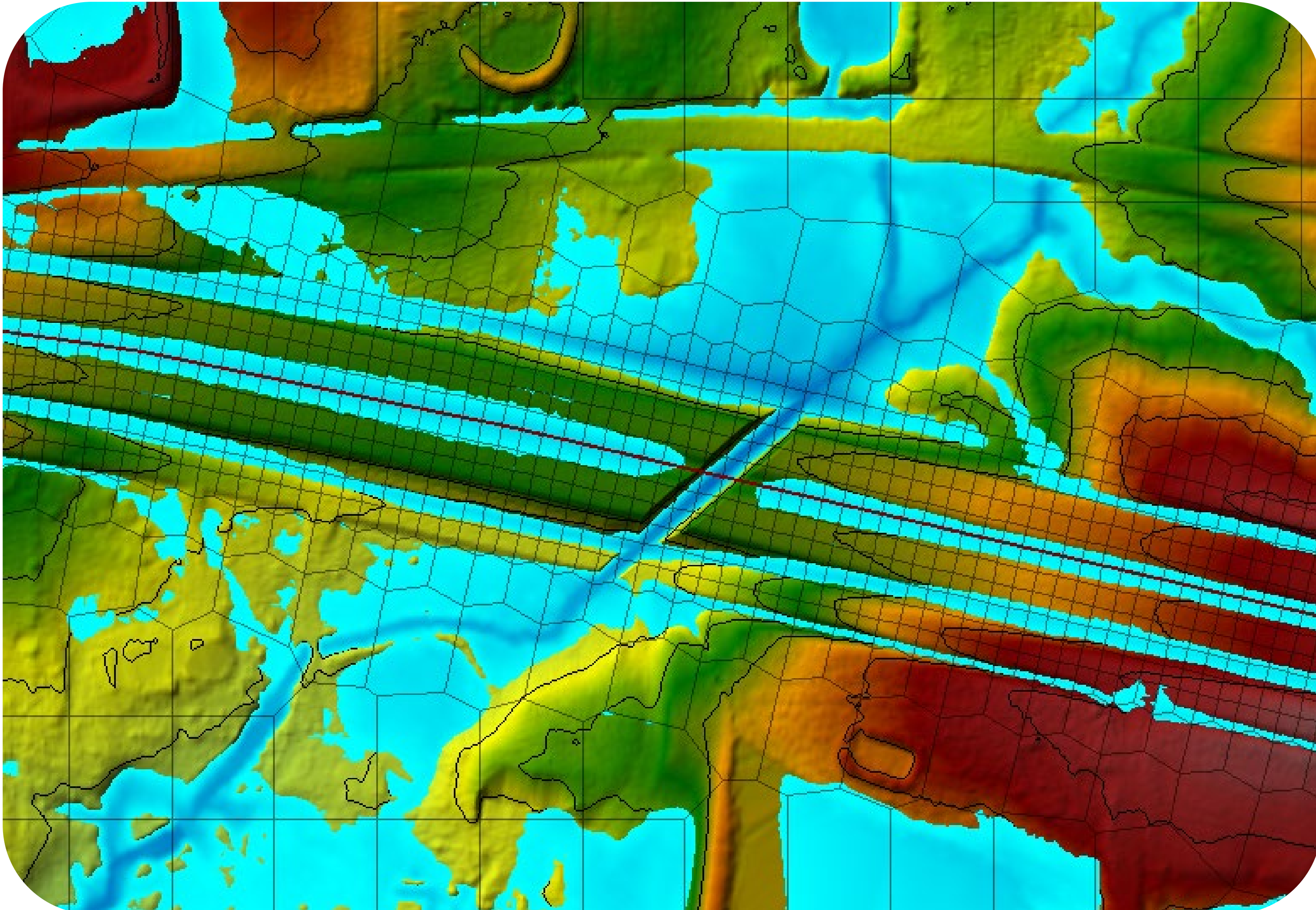
Iterate Hydroconnectors



Iterate Hydroconnectors

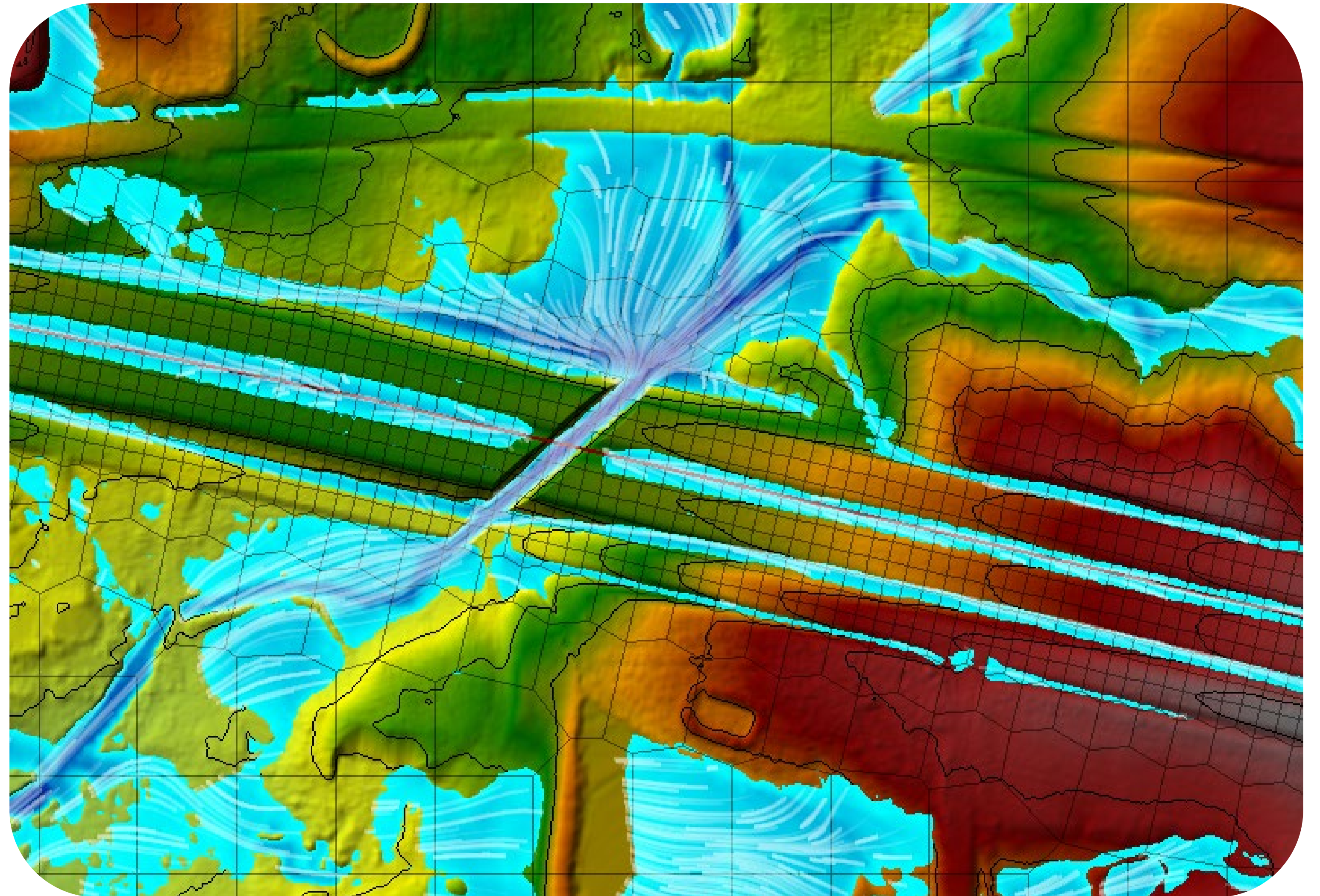


Iterate Hydroconnectors



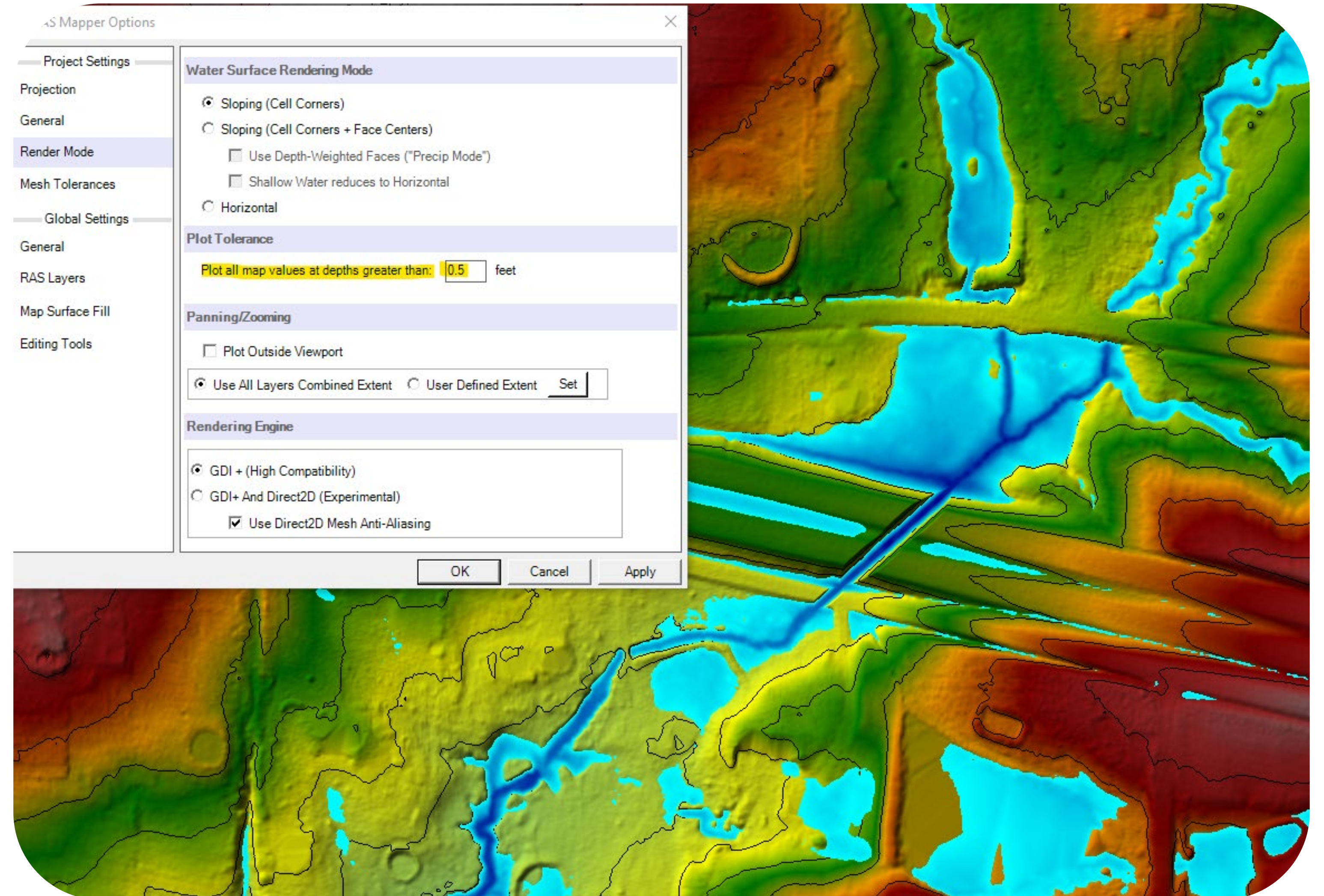
Visualize Results

"The world is full of obvious things which nobody by any chance ever observes."



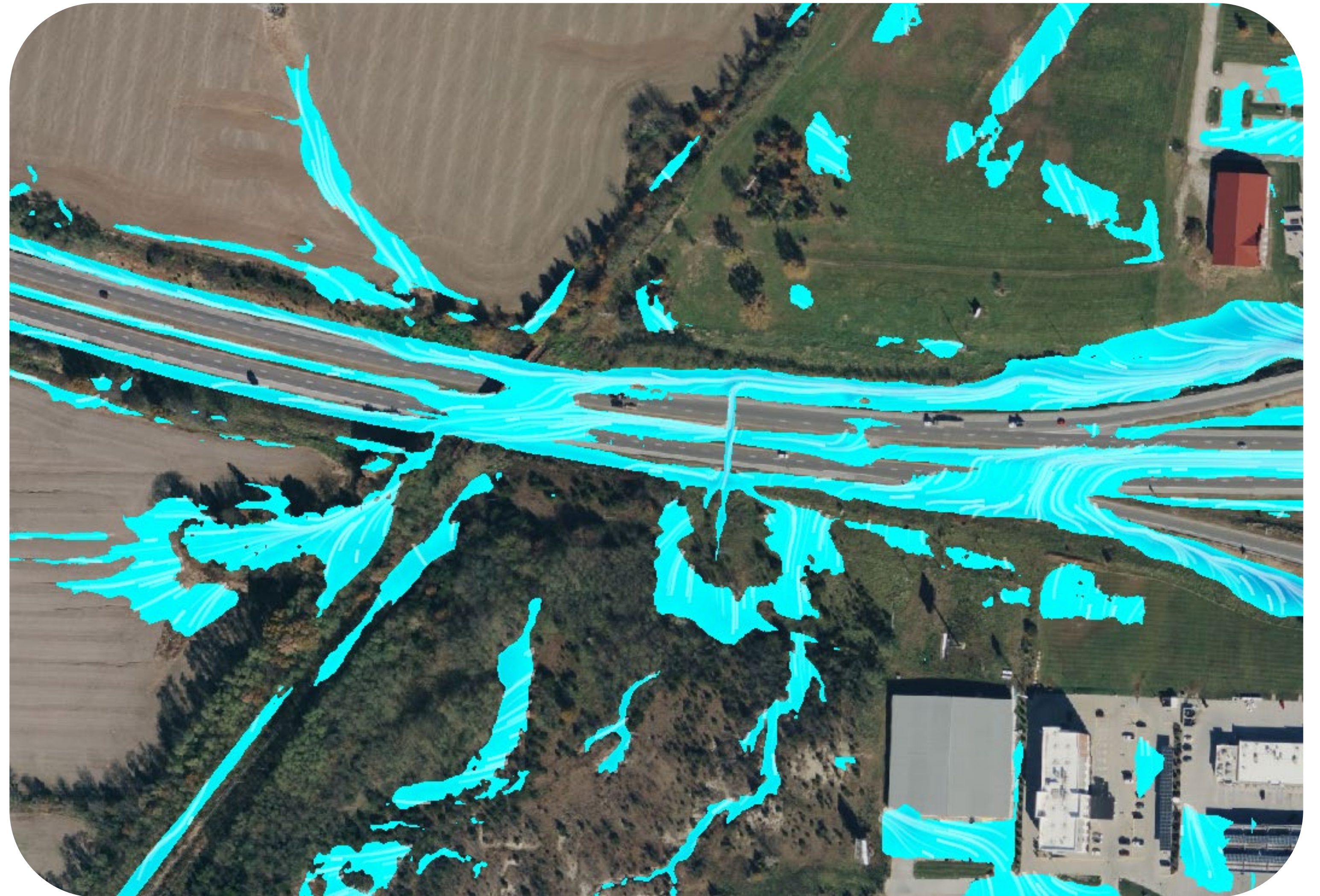
Visualize Results

"The world is full of obvious things which nobody by any chance ever observes."



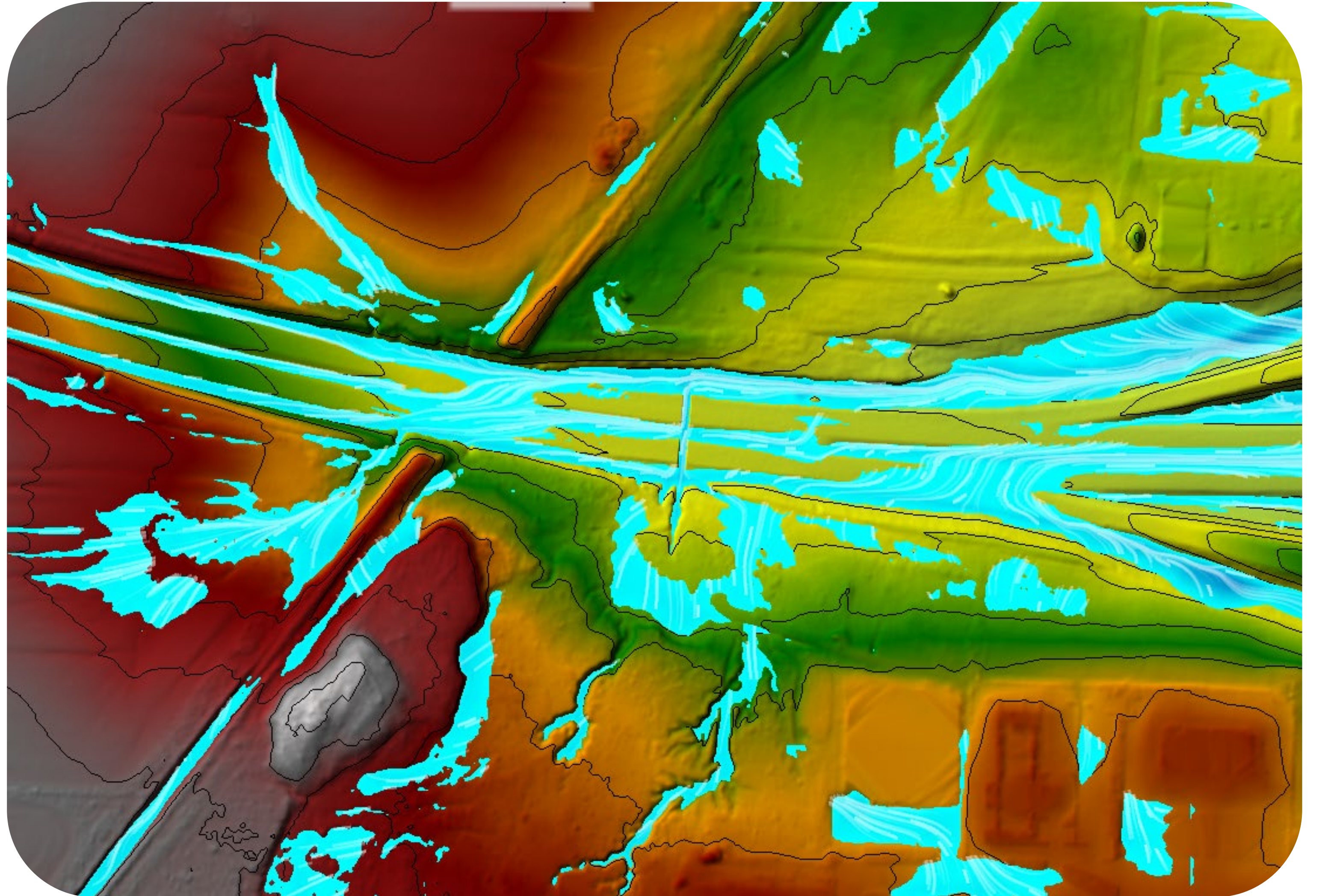
Virtual Site Visit

"The world is full of obvious things which nobody by any chance ever observes."



Virtual Site Visit

"The world is full of obvious things which nobody by any chance ever observes."

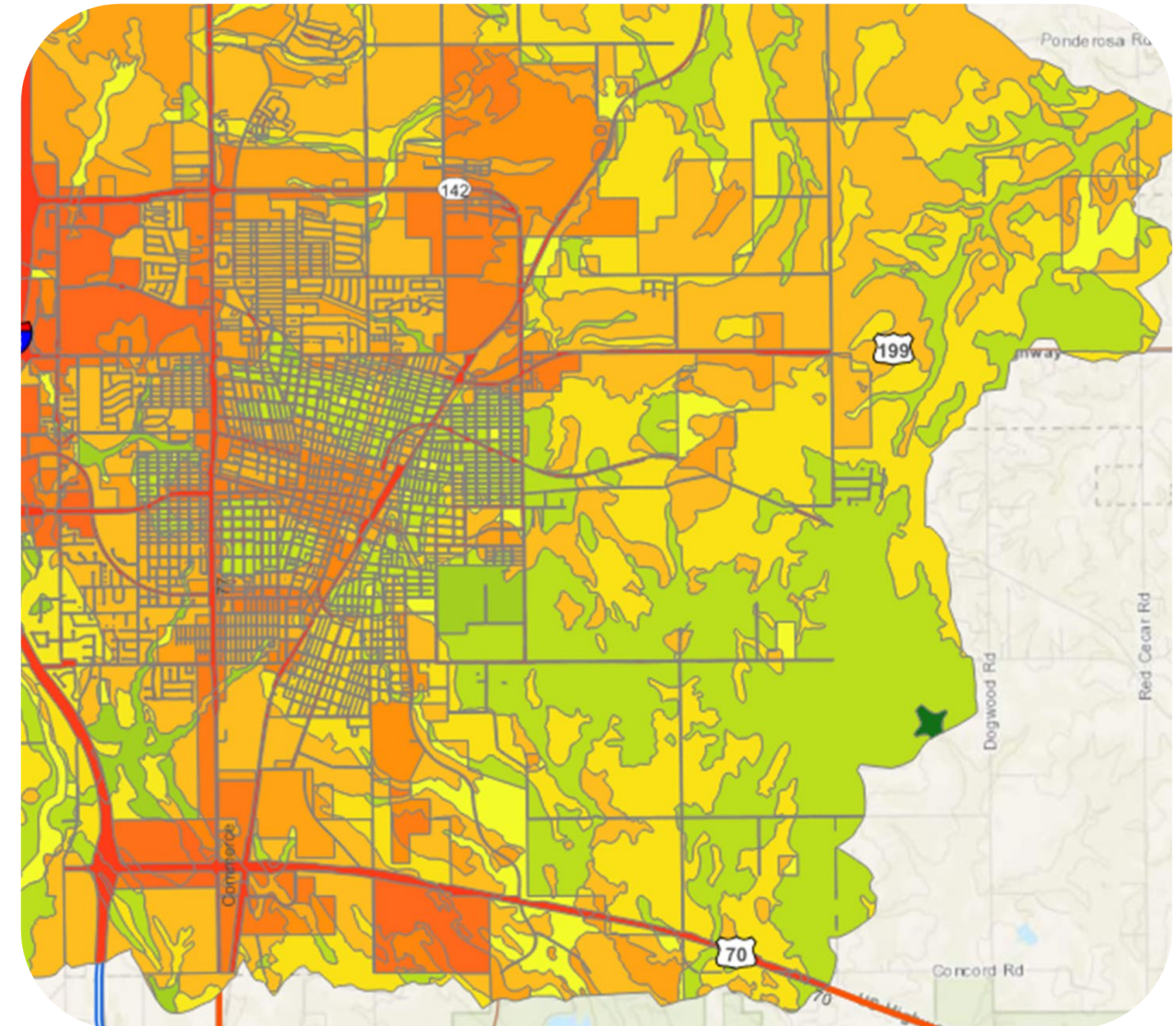


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“My mind rebels against stagnation;
give me problems;
give me work”

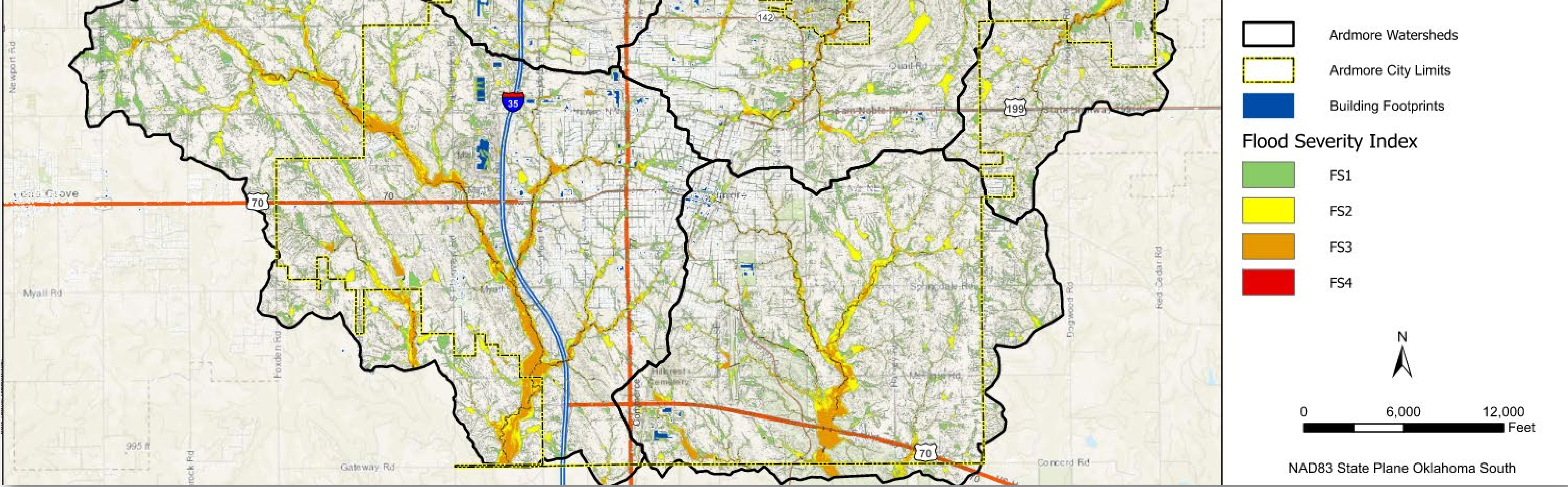
Challenges and Future Improvements
Rain on Mesh Modeling

Best Practices in 2D Modeling

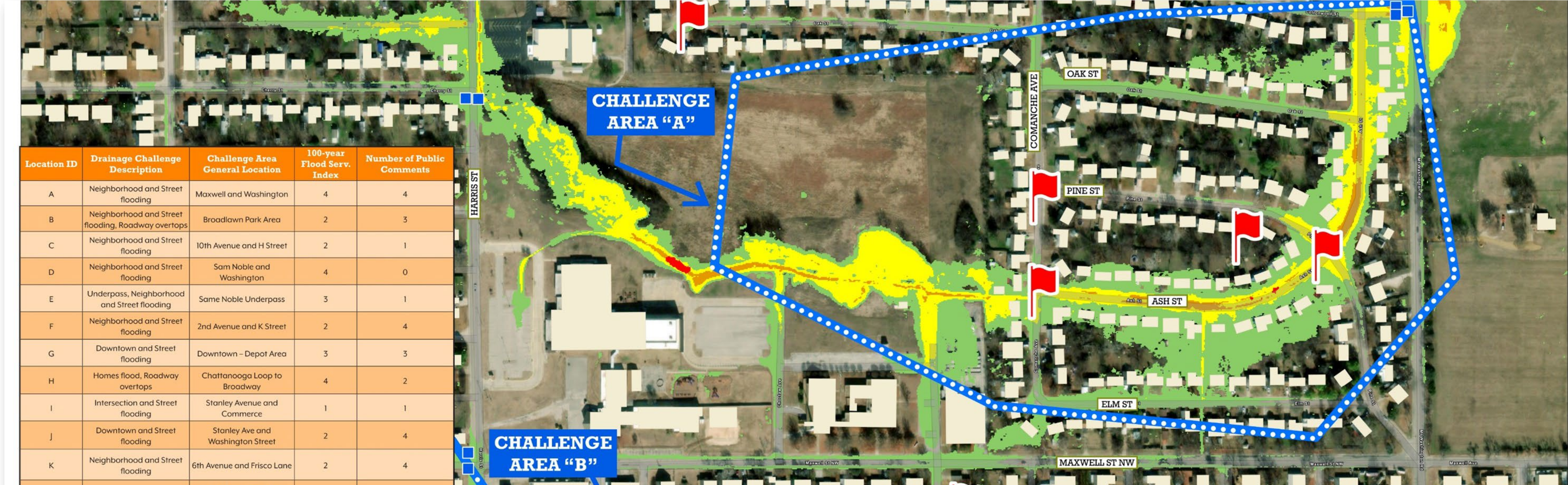
- **Make all of your input useful for the end goal**
 - **Topography with Hydroconnectors**
 - **Routing Parameters**
 - **Precipitation Input**
 - **Atlas 14?**
 - **What is next?**



The Future of Rain-on-Mesh 2D Modeling Is Complex



The Future of 2D Modeling is Exciting



Questions?

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“Elementary, my dear Watson.”

SHERLOCK HOLMES;
SIR ARTHUR CONAN DOYLE

Image design by alex.mathews.984 – Threadless.com

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Thank you!

Alan Dennis, PE CFM
acdennis@garverusa.com



Sherlock-Hydro

