Source: Pennsylvania State University

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Base Level Engineering Analysis – Application of rain-on-grid method, a case study using HECRAS-2D

Stantec

Agenda

1. 1D Modeling Methodology
2. 2D Rain-on-Grid Methodology
3. Comparison of Results
4. Conclusion

Source: Orlando Sentinel

1-D Modeling

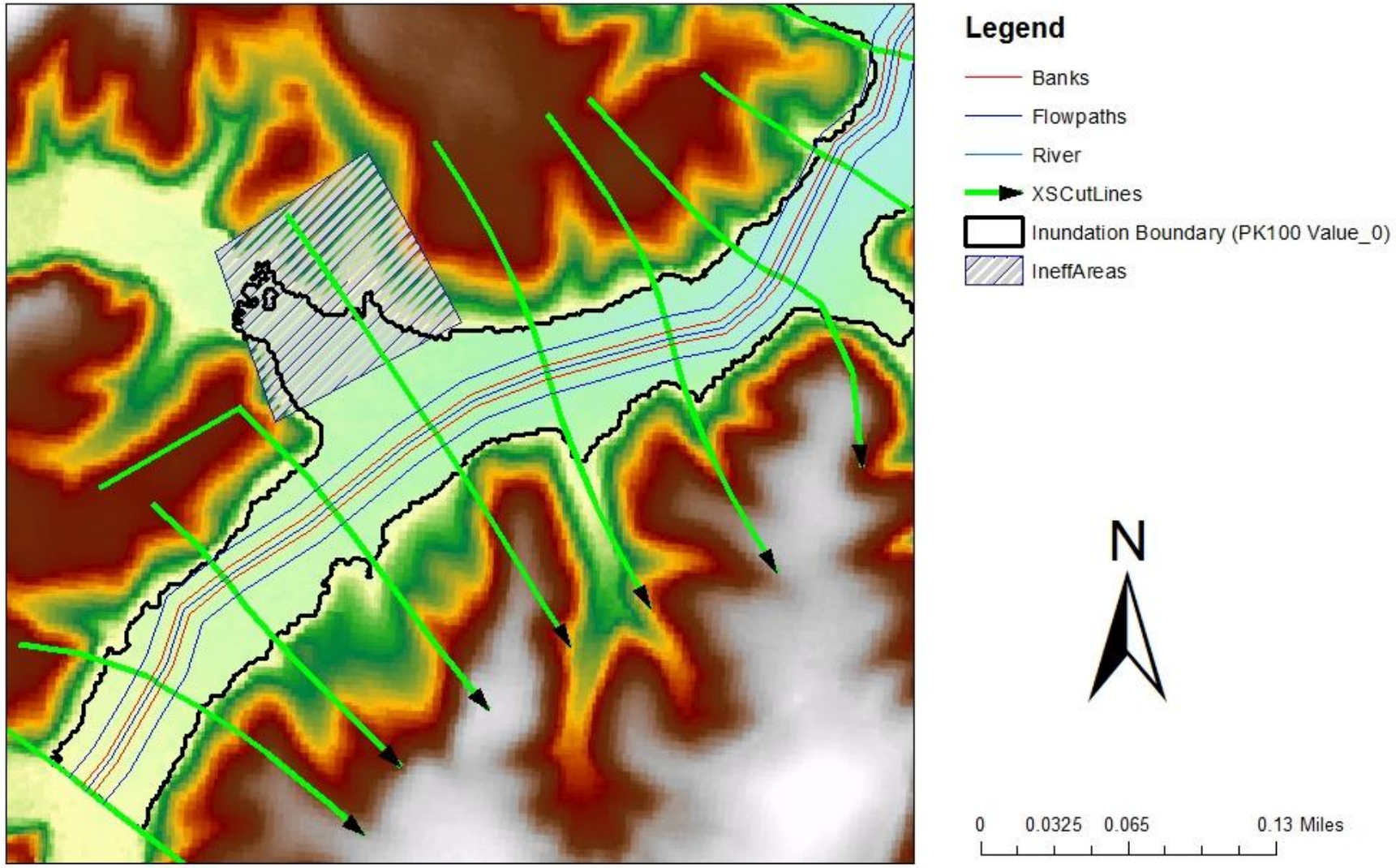
Source: San Diego Zoo

1-D Modeling Methodology

Geographic Information Systems (GIS)

- Create Features in GIS
  - Stream lines
  - Flow paths
  - Bank lines
  - Cross Sections
  - Ineffective areas
  - Manning's roughness coefficient
- Overlay features onto 3D terrain layer
- Run HEC-GeoRAS and export geometry to HEC-RAS
- Obtain flow data from regression equations

GIS Features

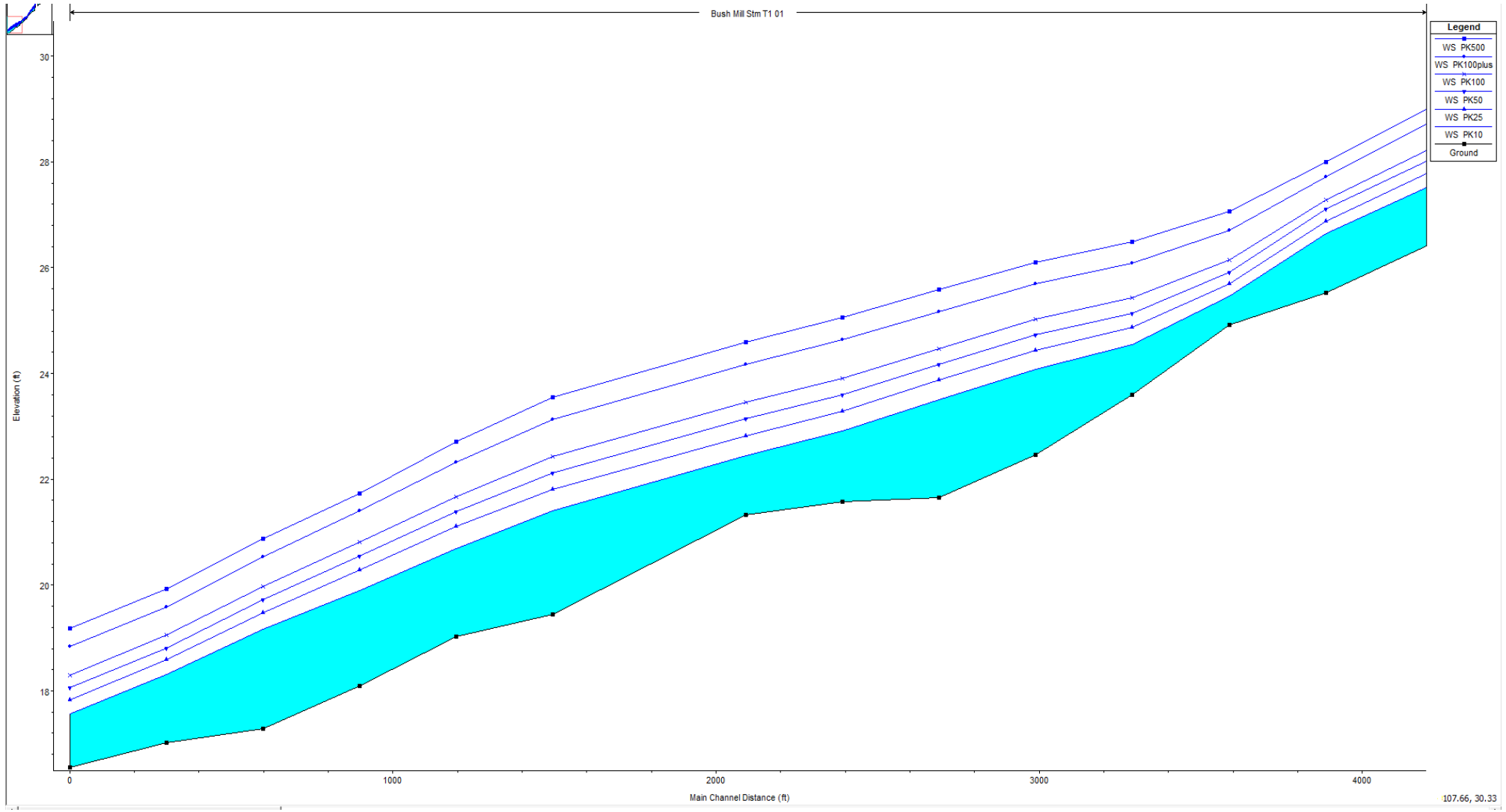


1-D Modeling Methodology (continued…)

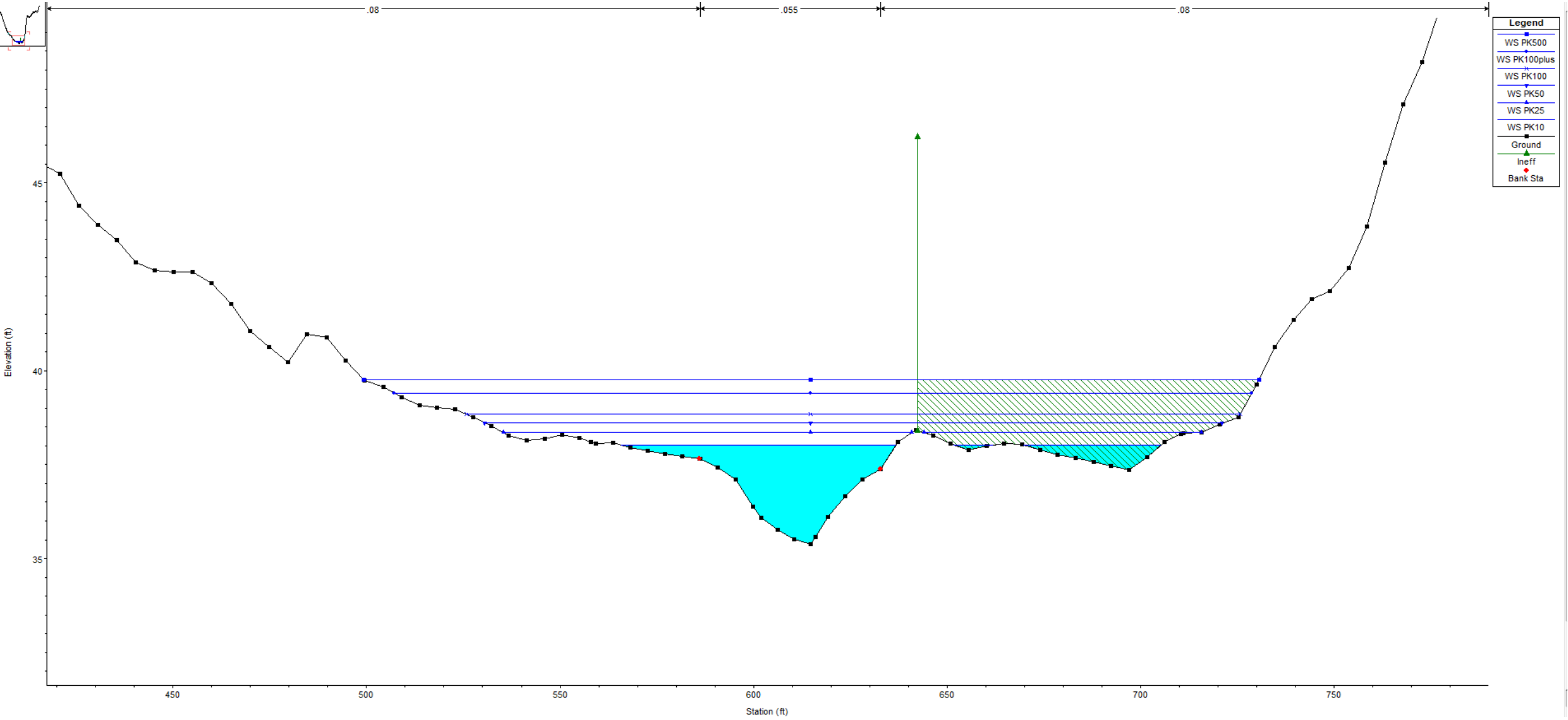
HEC-RAS

- Run steady-state flow
  - 500, 100-plus, 100, 100-minus, 50, 25, and 10
- Check stream water surface profiles
  - Drawdowns
  - Crossing profiles
  - Bank stations
  - Manning's Roughness coefficients
  - Reach lengths

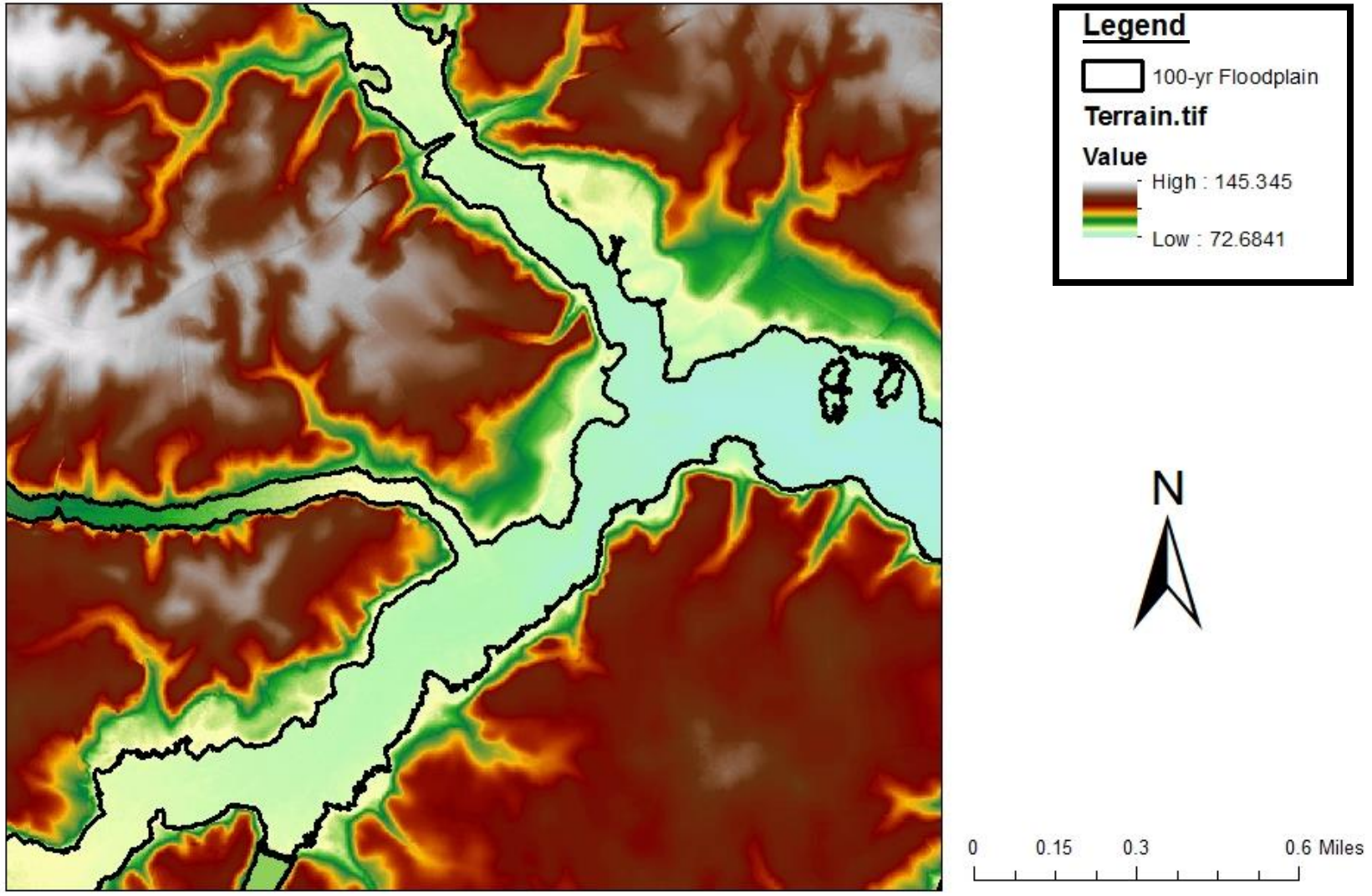
Water Surface Profiles



Cross Section



100-yr Floodplain



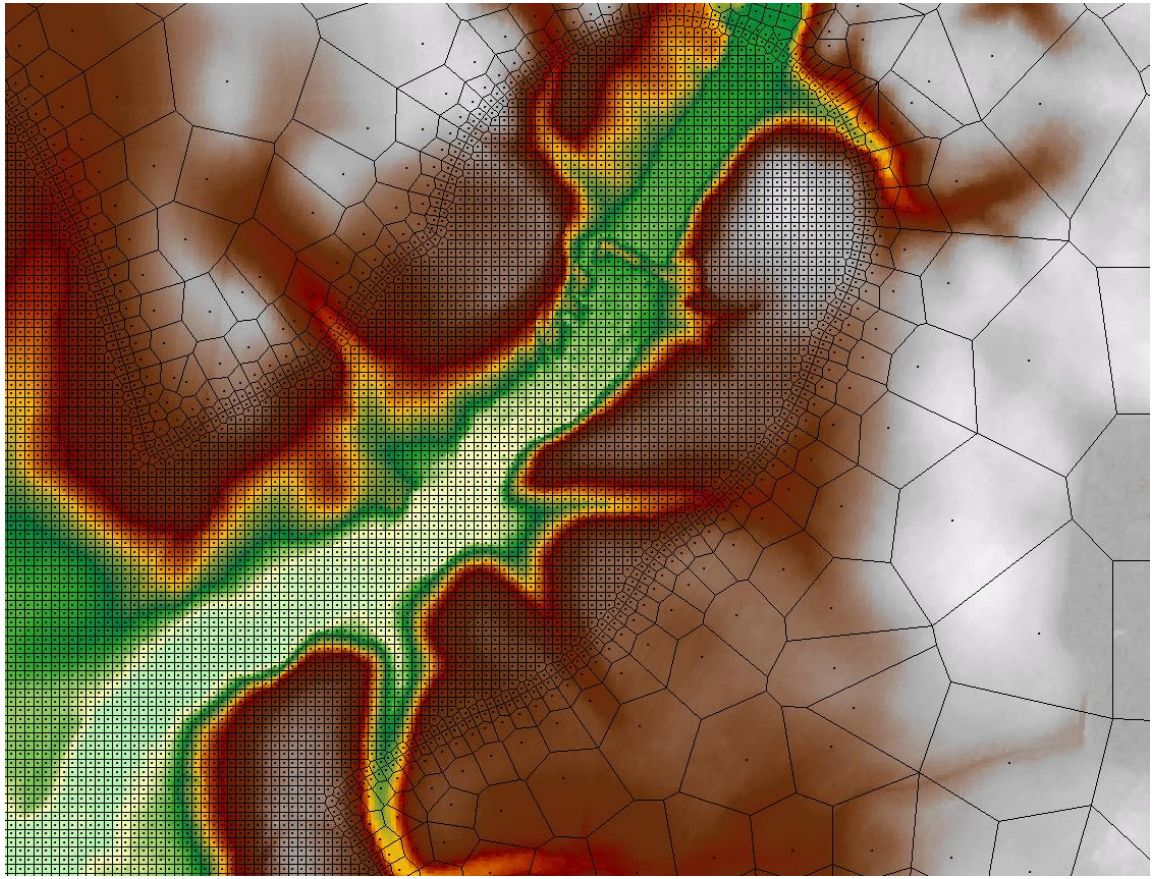
1D Modeling Limitations

- Flow needs be predominantly uni-directional
- Floodplain delineation is bounded by cross section length
- Well-defined channel and overbanks

When to Consider 2D Modeling

- Braided Channels
- Urbanized Areas
- Wetlands/Swamps
- Alluvial Fans

2D Modeling Basics

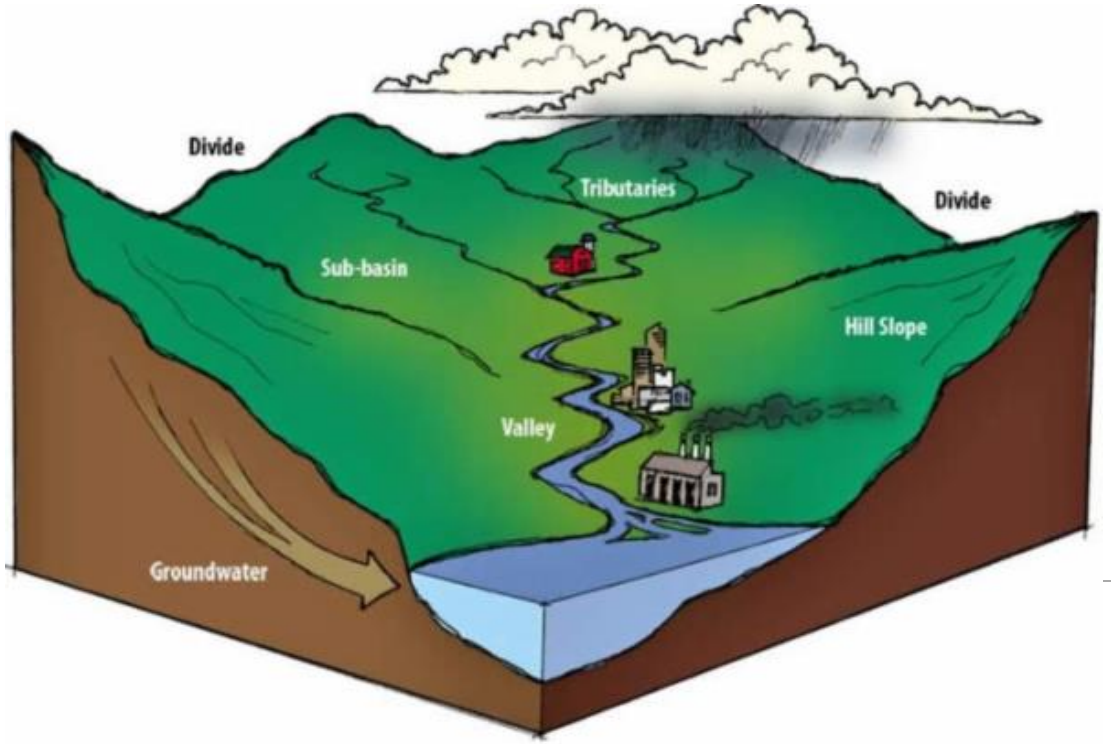


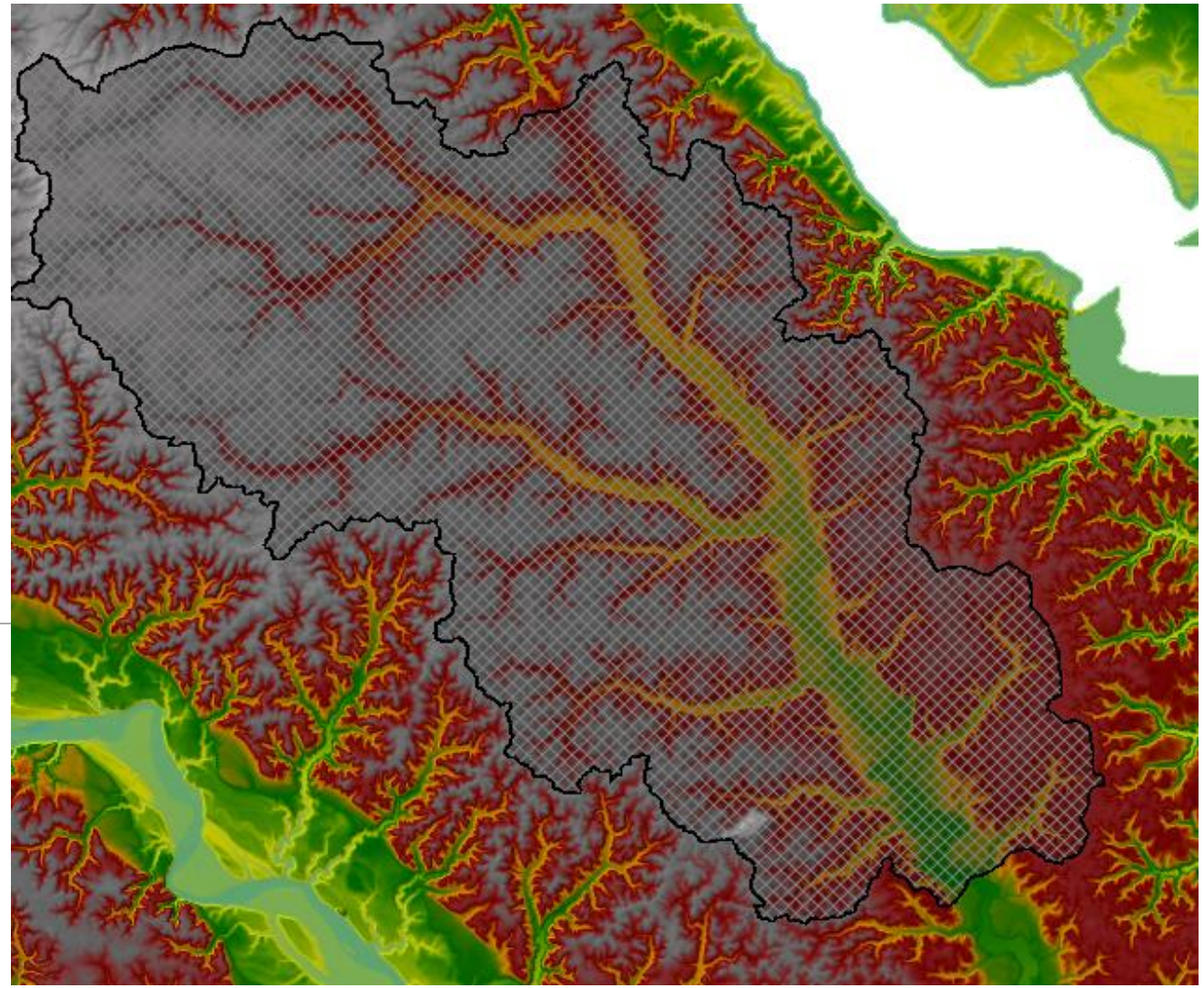
- Grid is used to represent the channel and floodplain
- Grid cells can compute flow velocities in the x and y direction
- Cell size can vary based on the desired model resolution

2D Modeling Using Rain-on-grid

- HEC-RAS allows a boundary condition of an excess rainfall hyetograph (excess rainfall depth as a function of time)
- Requires the 2D grid to extend to the basin divide of the area of interest
- Allows the modeler to develop a hydrologic input for the area of interest instead of developing flows at certain locations along the stream – flow routing is left to the model itself

2D Rain-on-Grid

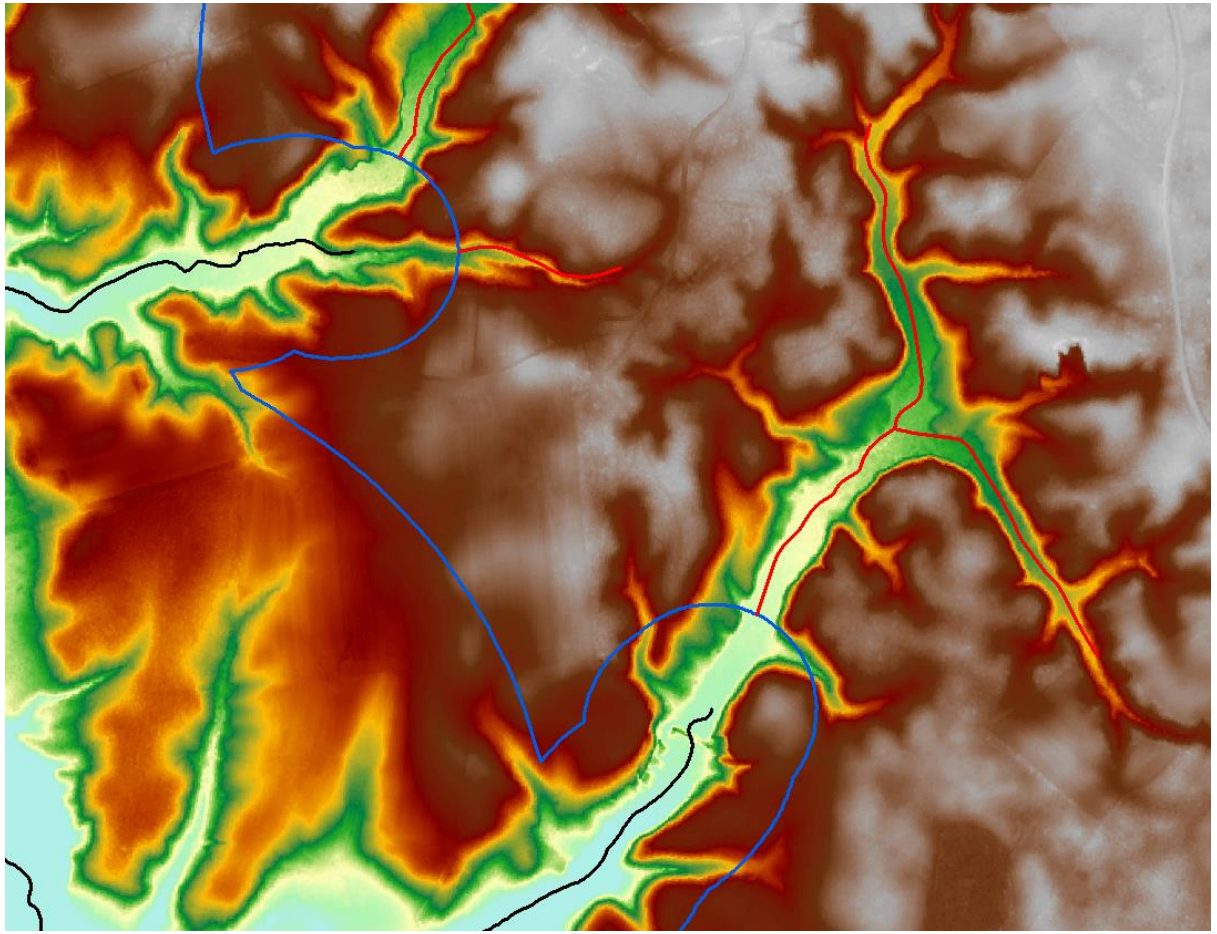


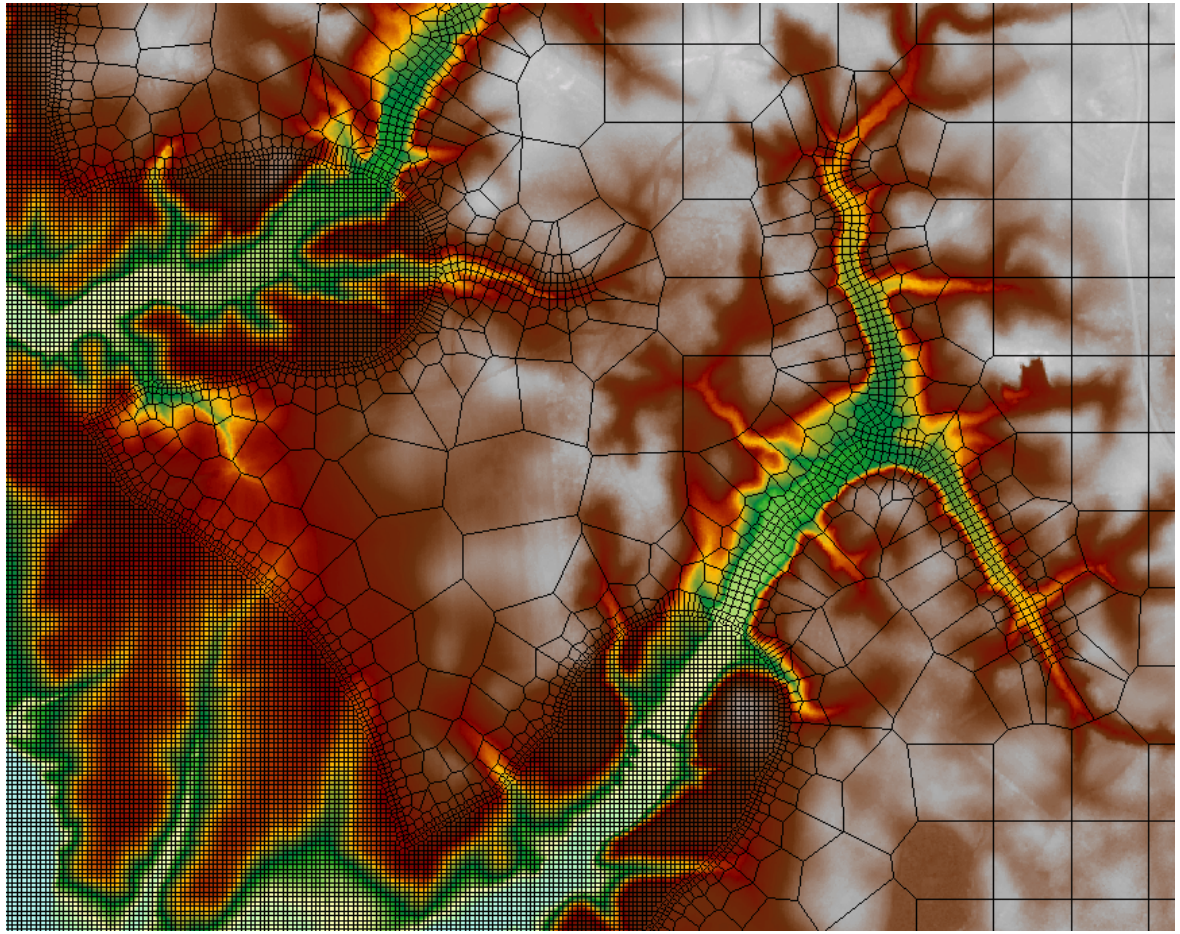


2D Approximate Study Methodology

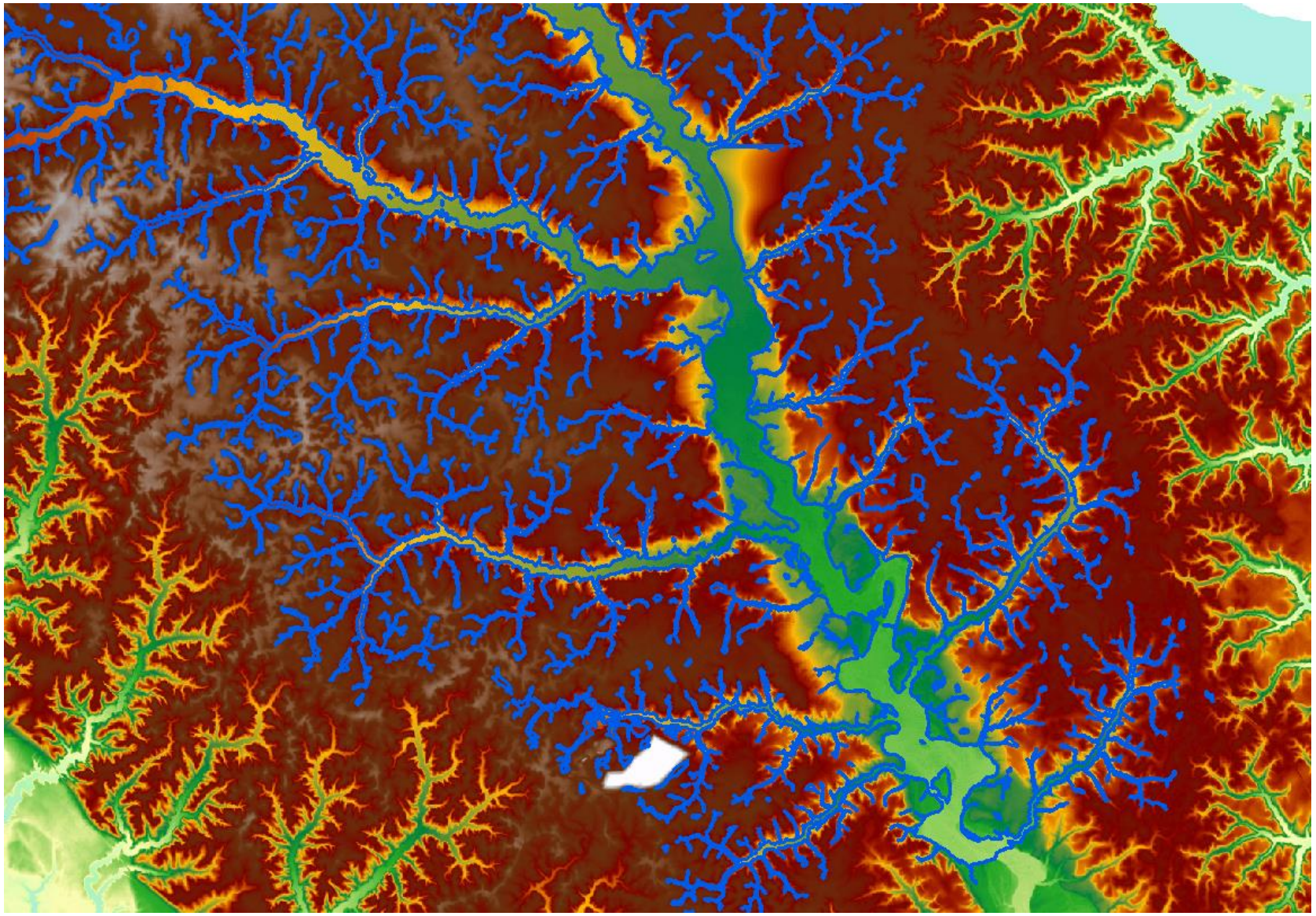
- Refined grid created around scoped streams
- Stream lines from the National Hydrography Dataset imported as break lines to increase model resolution near major flow paths
- Larger 500x500 foot grid cell used in other areas
- Hydrology derived by averaging sub basin curve numbers, using National Land Cover Dataset (NLCD) to provide data about land use

Grid and Break lines

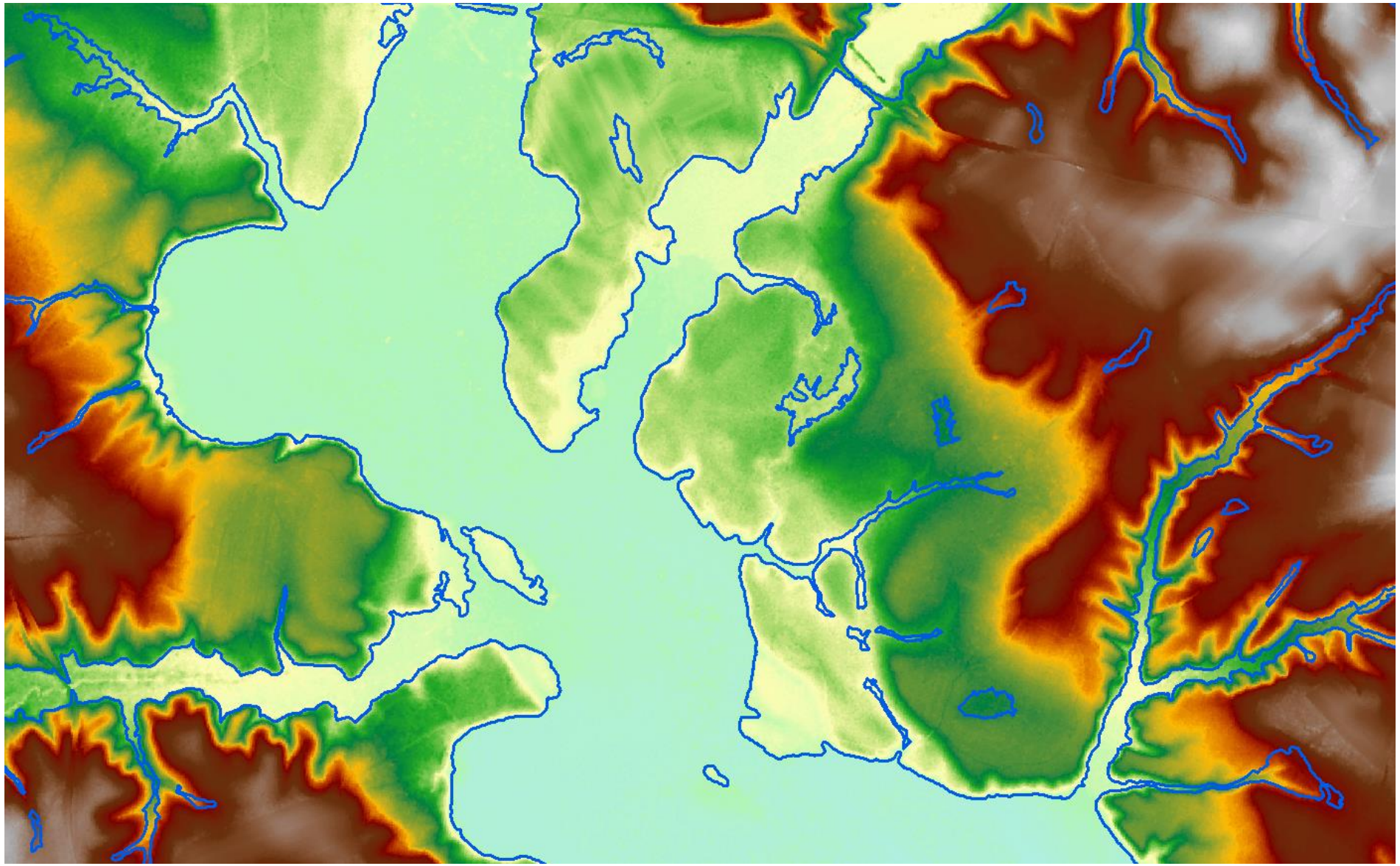




100-year Floodplain



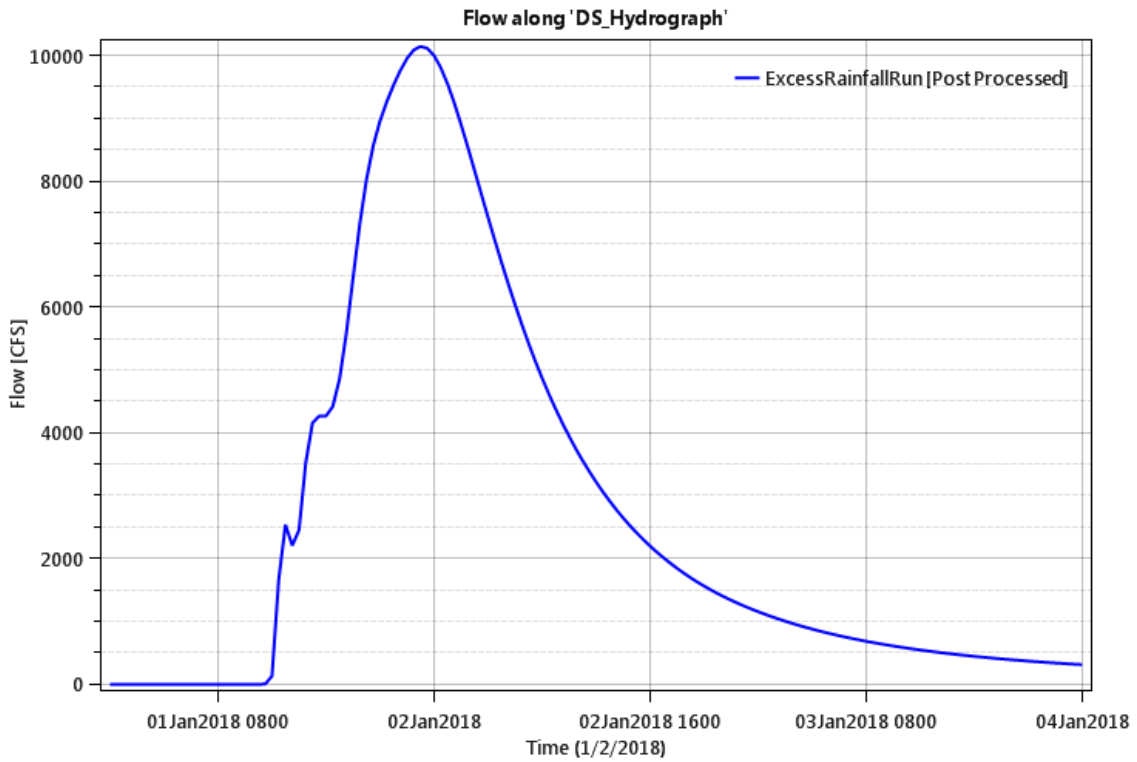
100-year Floodplain



Model Results

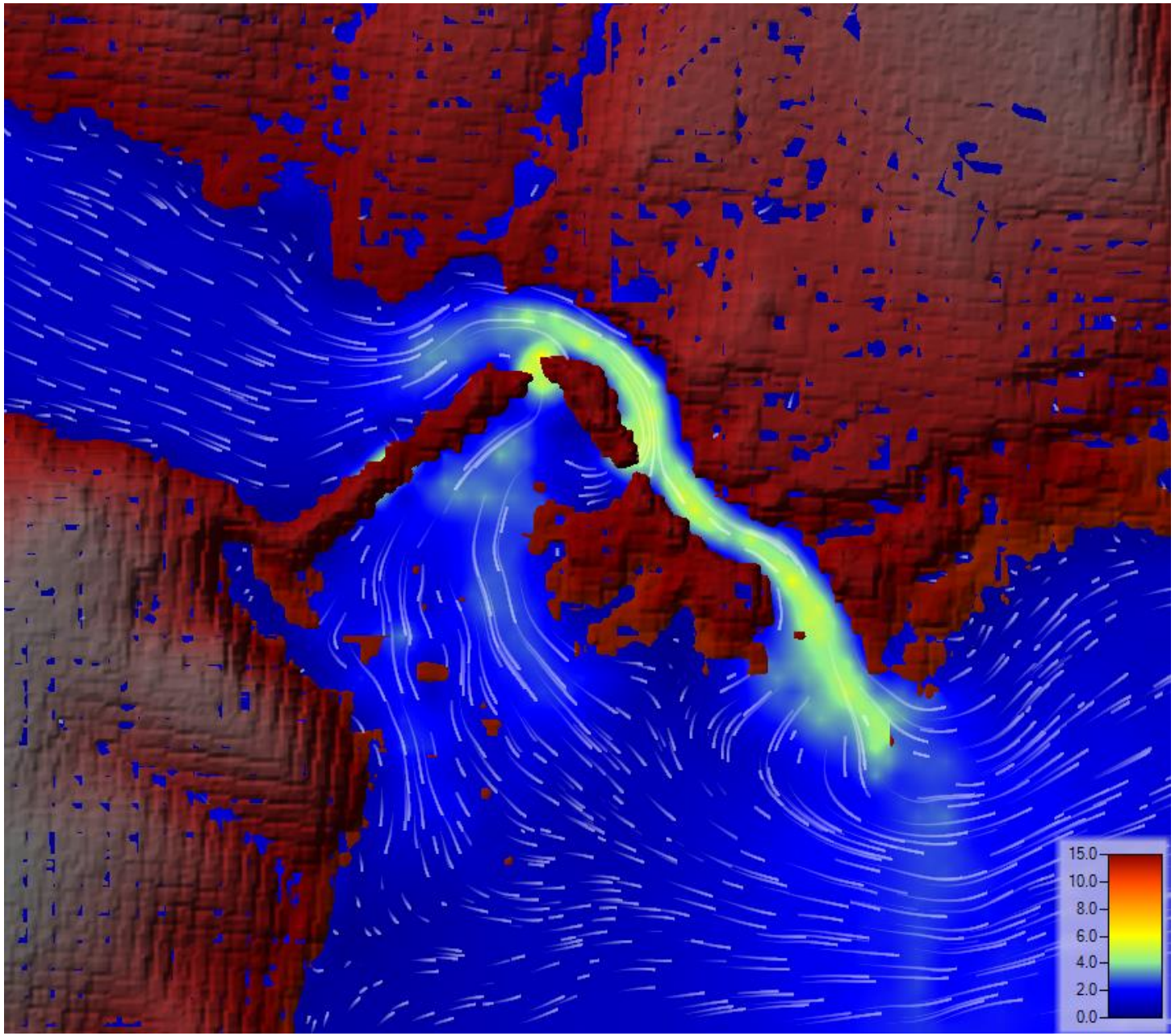
- Number of 2D Cells: 818,598 cells
- Smallest Cell size: 353 Square feet
- Largest Cell size: 663,880 square feet
- Average cell size: 3440 square feet
- Area: 101 square miles
- Runtime: 36 hours

Model Results

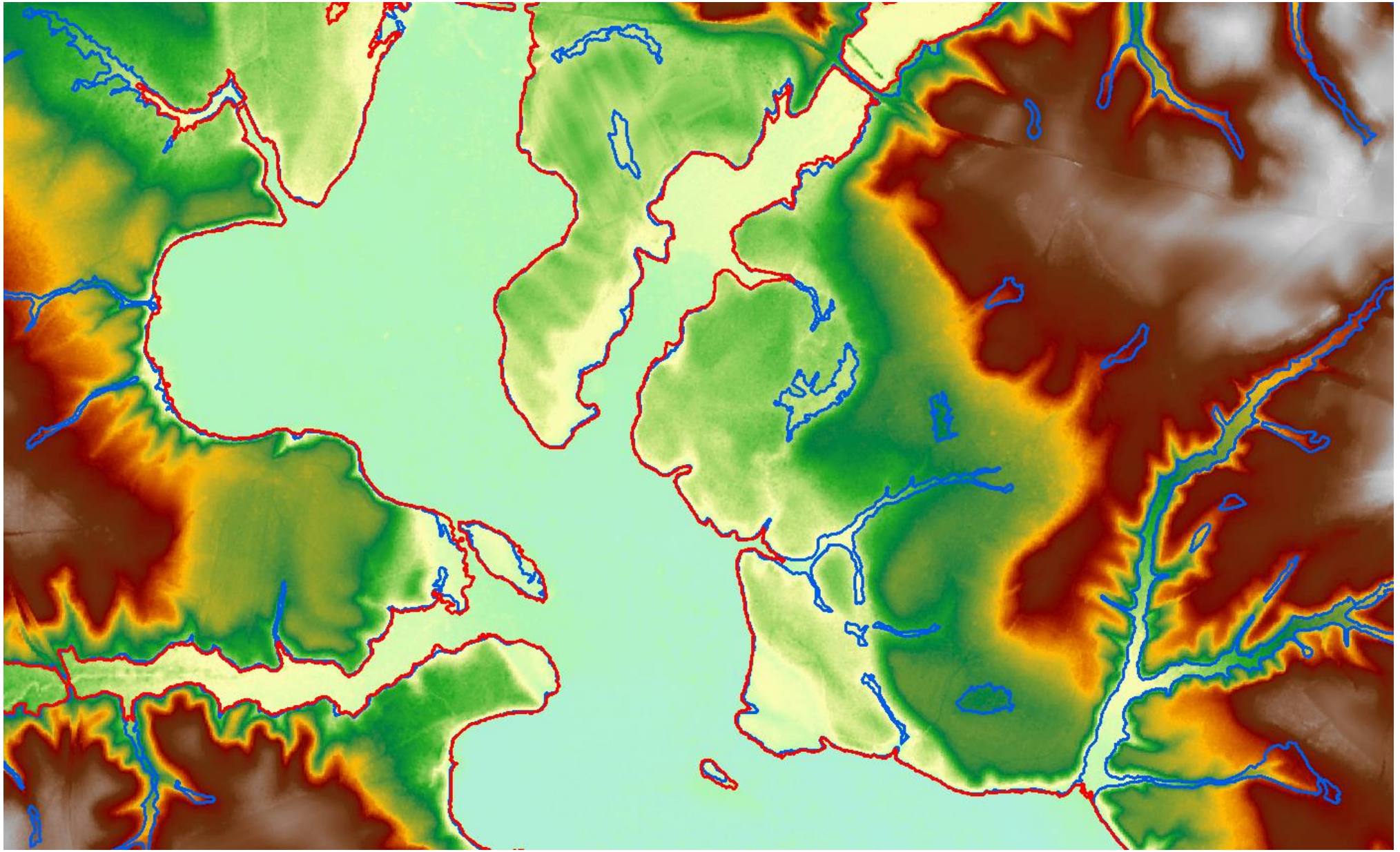


- Peak outflow at downstream end: 10,143 cfs
- Regression derived peak flow at this location: 6,091 ± 4181 cfs
- Upper Error Bounds: 10,272 cfs

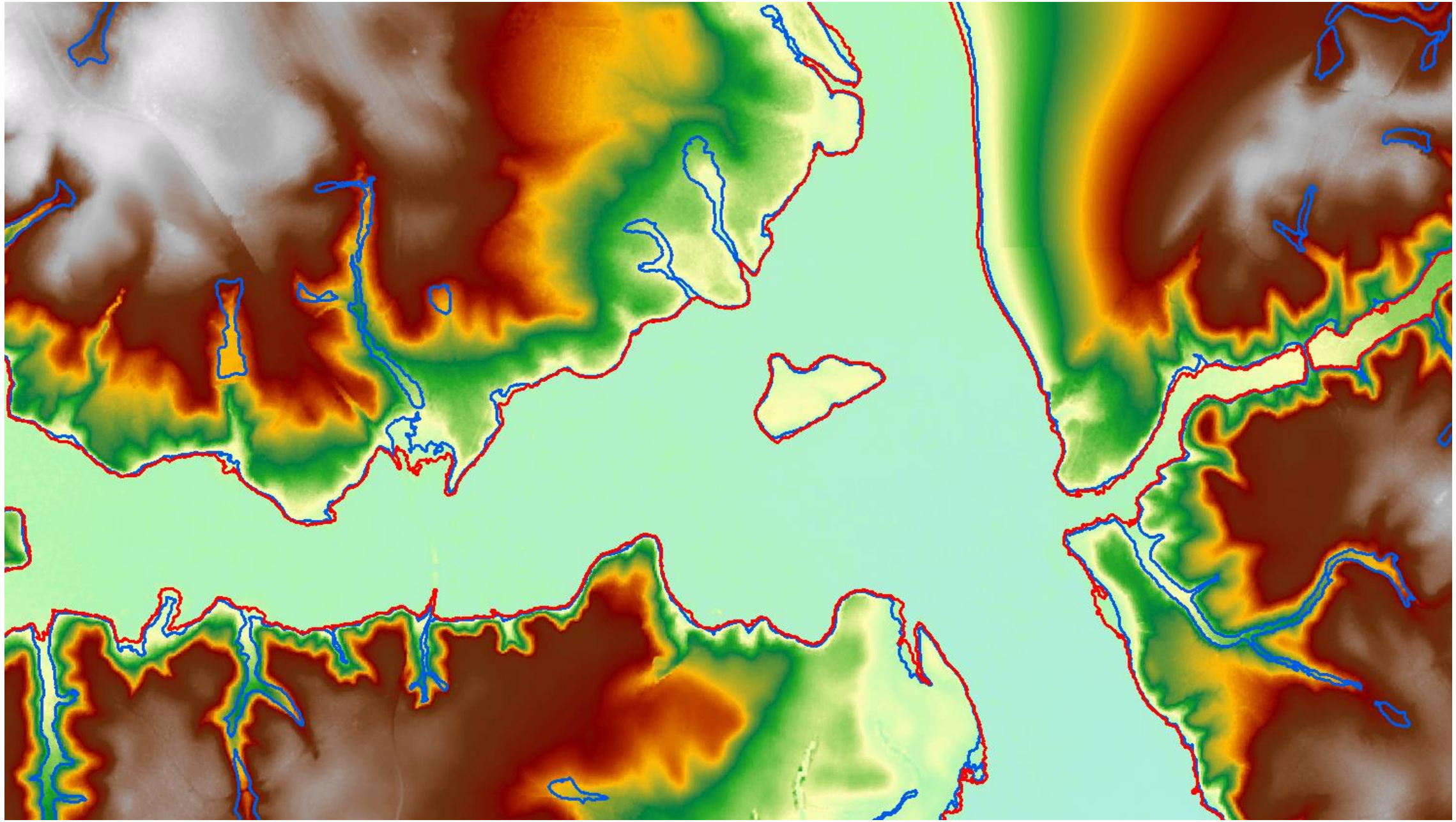
Velocity Tracing



Comparison of 1D and 2D Results



Comparison of 1D and 2D Results



Limitations

1D

- Considers only one dimension
- Labor intensive GIS setup
- Models often subjective
- Constant back and forth between GIS and HEC-RAS

2D

- Engineers, government officials and other stakeholders are experienced with 1D models
- Current regulations and FEMA guidance have been developed with 1D modeling in mind
- Long model run times

Advantages of 2D models

- Eliminates the need to model streams at the cross section level
- Confluences are captured inherently
- No need to manually add bank stations, blocked flow, or ineffective areas to the cross sections
- Can be easier to develop the hydrologic data for model input

Conclusion/Takeaways

- Further research into 2D rain-on-grid modeling
  - Adjust parameters
  - Perform hydrology on individual sub basins
- 2D rain-on-grid and 1D models produce accurate BLE base level floodplains
- More powerful computer, greatly accelerate 2D model run time

Questions?

Without change there is no innovation, creativity, or incentive for improvement. Those who initiate change will have a better opportunity to manage the change that is inevitable.

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