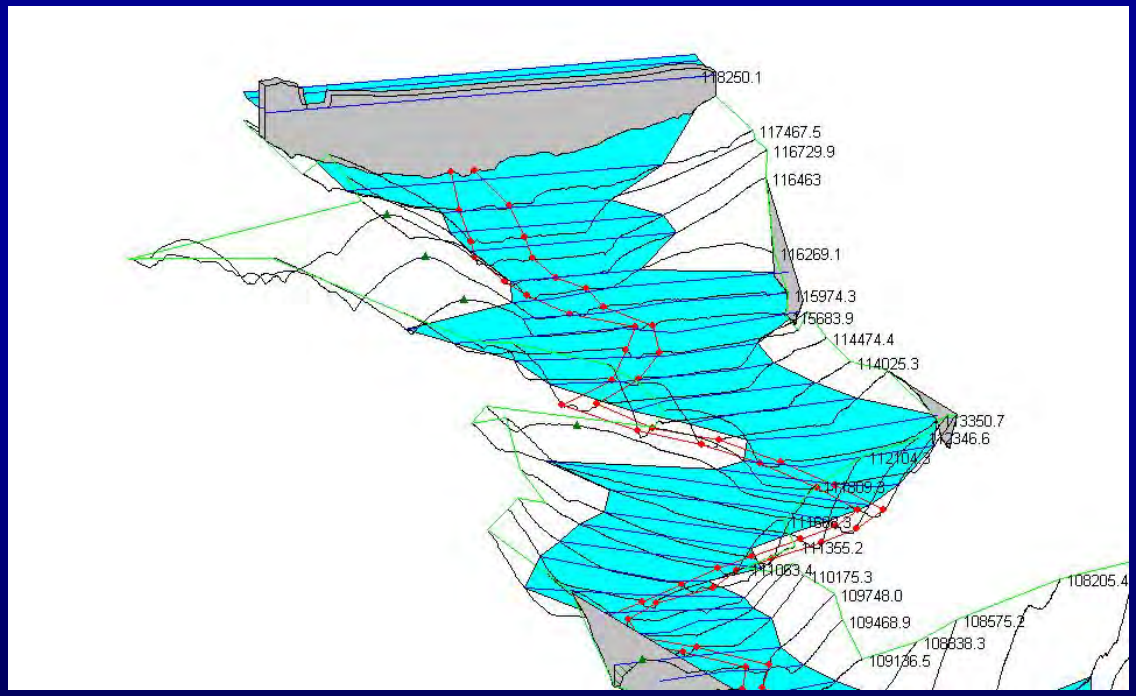
Using LiDAR to Performing Dam Breach Inundation Studies

Missouri GIS Advisory Committee's

Advanced LiDAR Workshop



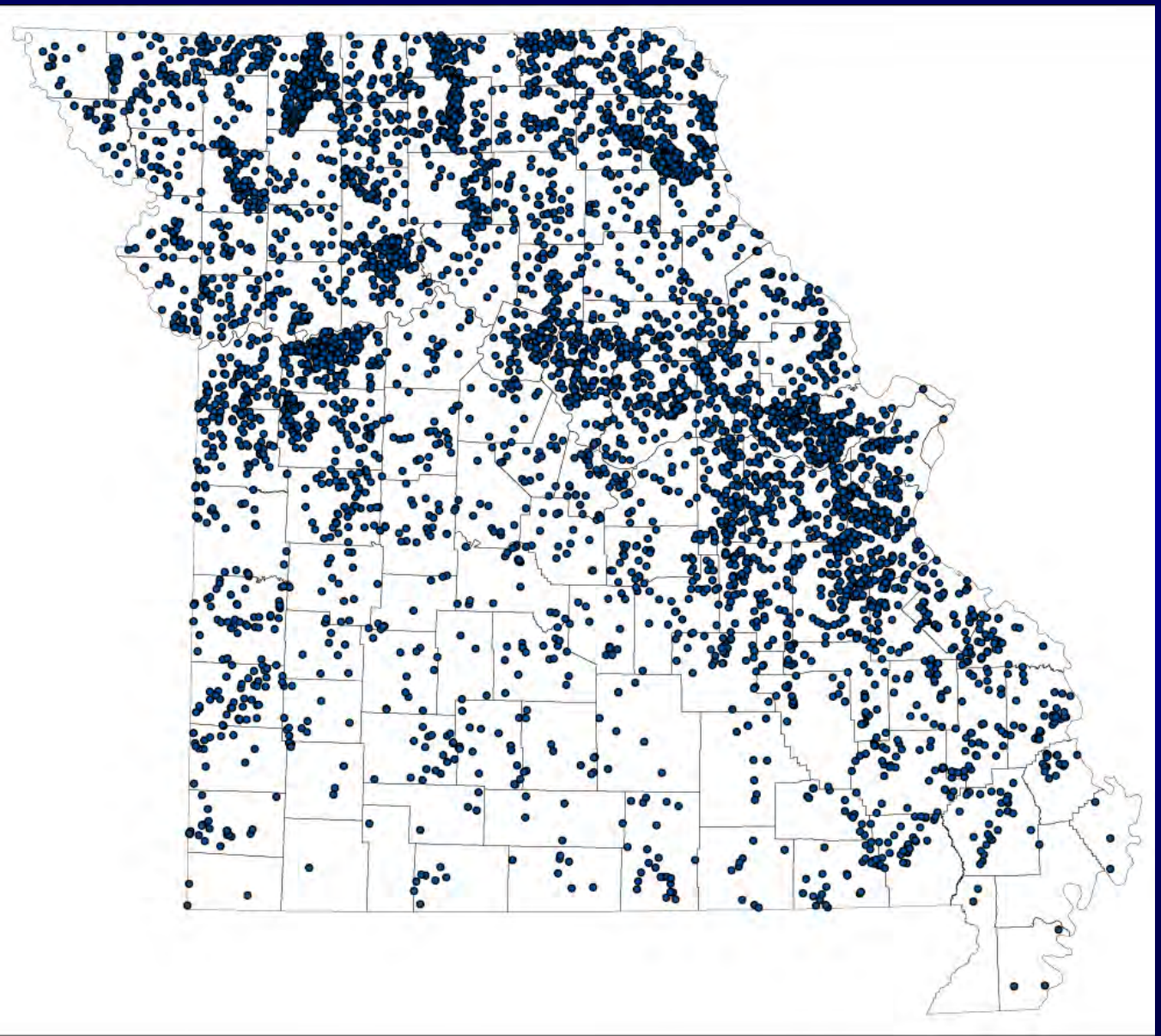
Missouri Department of Natural Resources

Michael Weller, P.E.

Water Resources Center

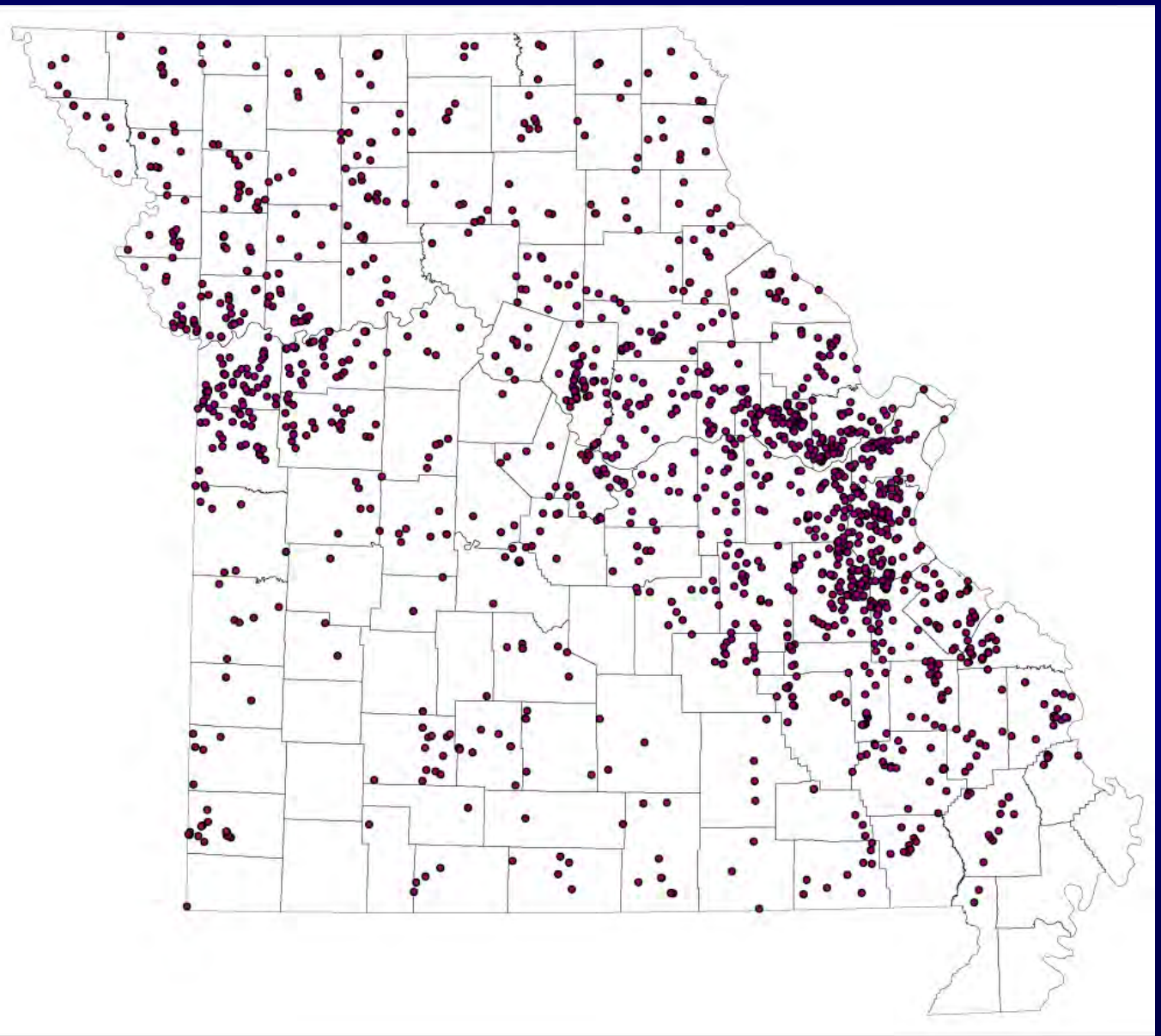
August 21, 2012

Inventoried Dams



- There are over 5200 inventoried dams in Missouri
- It is estimated that over 1500 “high hazard” dams exist throughout the state
- Missouri currently regulates over 660 dams. The regulated dams are 35 feet tall and higher.

High Hazard Dams



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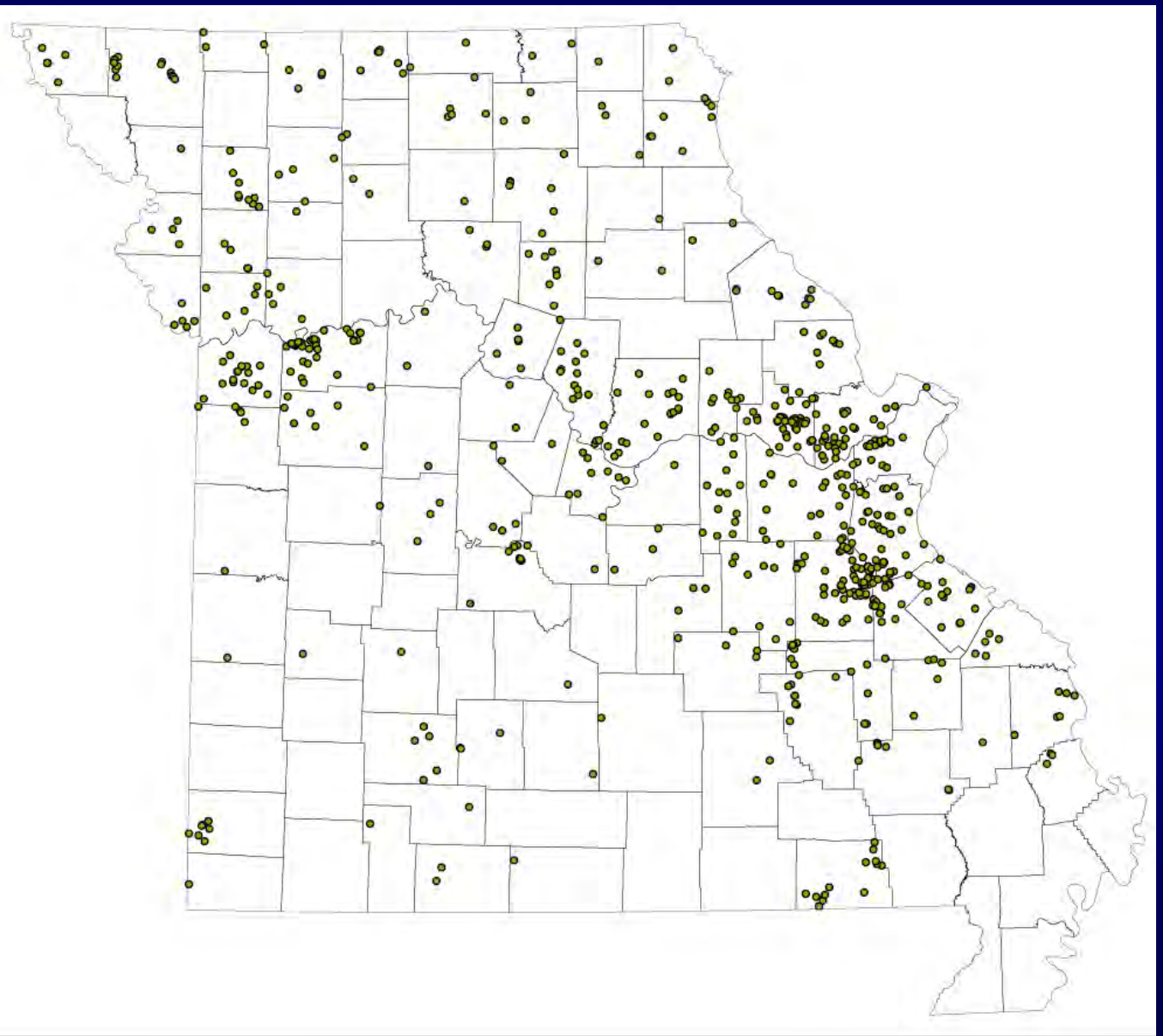
DNR Regulated Dams



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Silverlake Enterprizes Dam MO20051

Height: 30 ft
Storage: 851 ac-ft
near Raymore, Cass County

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Project Goals

- Enhance breach inundation mapping using LiDAR
- Refine methodology for production of inundation maps
- Use inundation maps to produce EAPs.

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- Enhance breach inundation mapping using LiDAR
- Refine methodology for production of inundation maps
- **Use inundation maps to produce EAPs.**

An inundation map is not an Emergency Action Plan

An EAP is a written plan which provides guidance for evaluation, evacuation, and emergency response.

Main focus is to reduce likelihood of property damage and loss of life.

- State requirement to have an emergency action plan

  CSR 22-3.030 (B)

Dam Breach Characteristics

Photo by Mrs. Eunice Olson, 5 June 1976.

- Rapid release of water
- Surging wave traveling downstream
- Includes debris
- Generally exceeds normal flood elevation

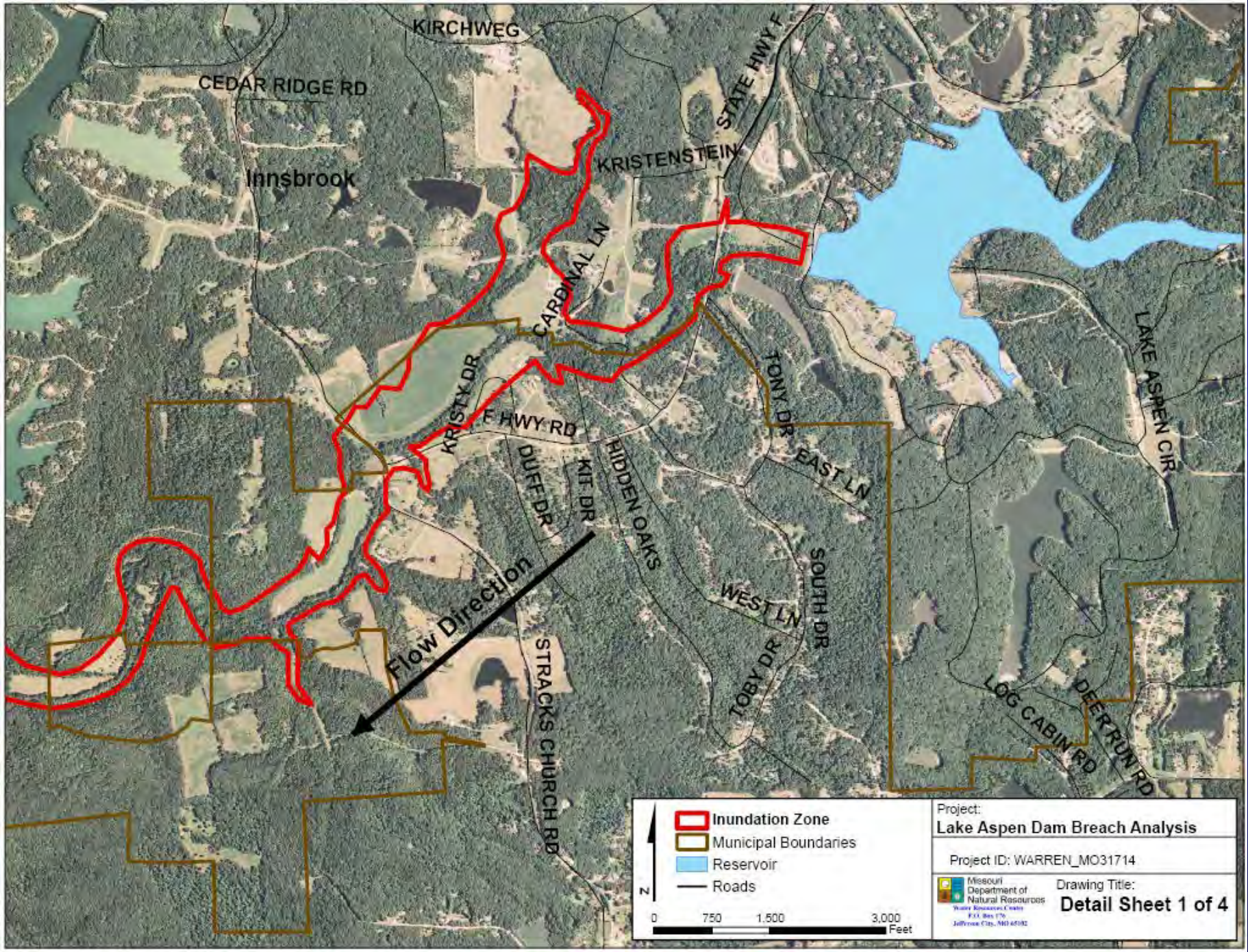
Warren County, Missouri, May 27, 2008

Maries County, Missouri, June 11, 2009

Maries County, Missouri, June 11, 2009

Inundation Maps

- Maps are conservative estimates
- Maps are approximate and have limitations
  - Example of one possible scenario
- Maps are not snapshots of a certain time
- Maps show extent of flooding, not evacuation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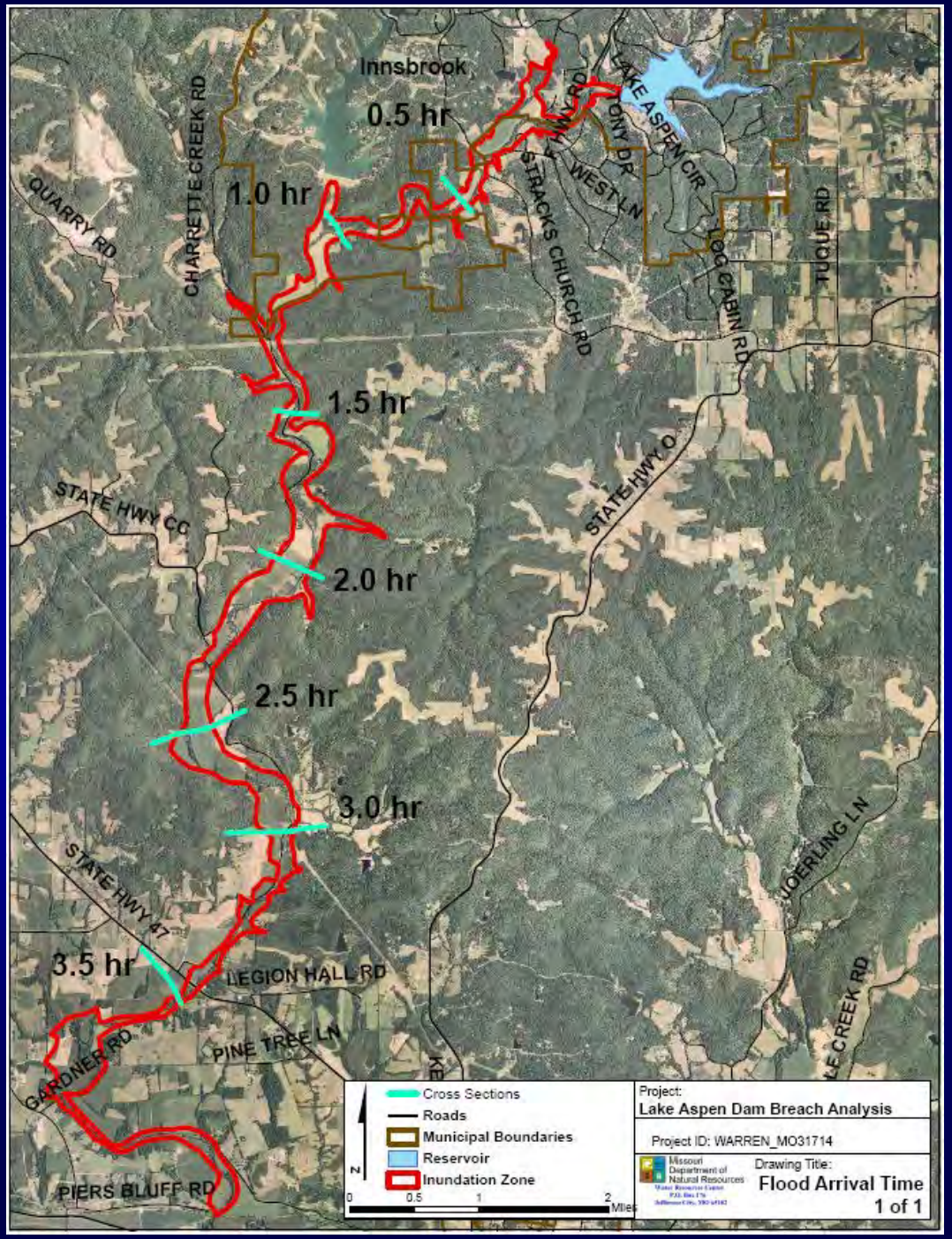
Lake Aspen Dam Breach Analysis
Project ID: WARREN_MO31714
Missouri Department of Natural Resources
Drawing Title:
Detail Sheet 1 of 4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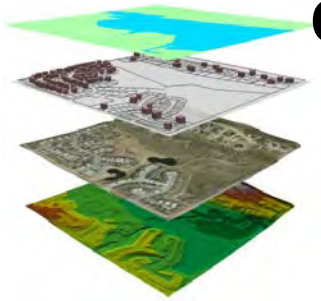
Flood Arrival Time
1 of 1



GIS

Map Layers

GeoDatabase

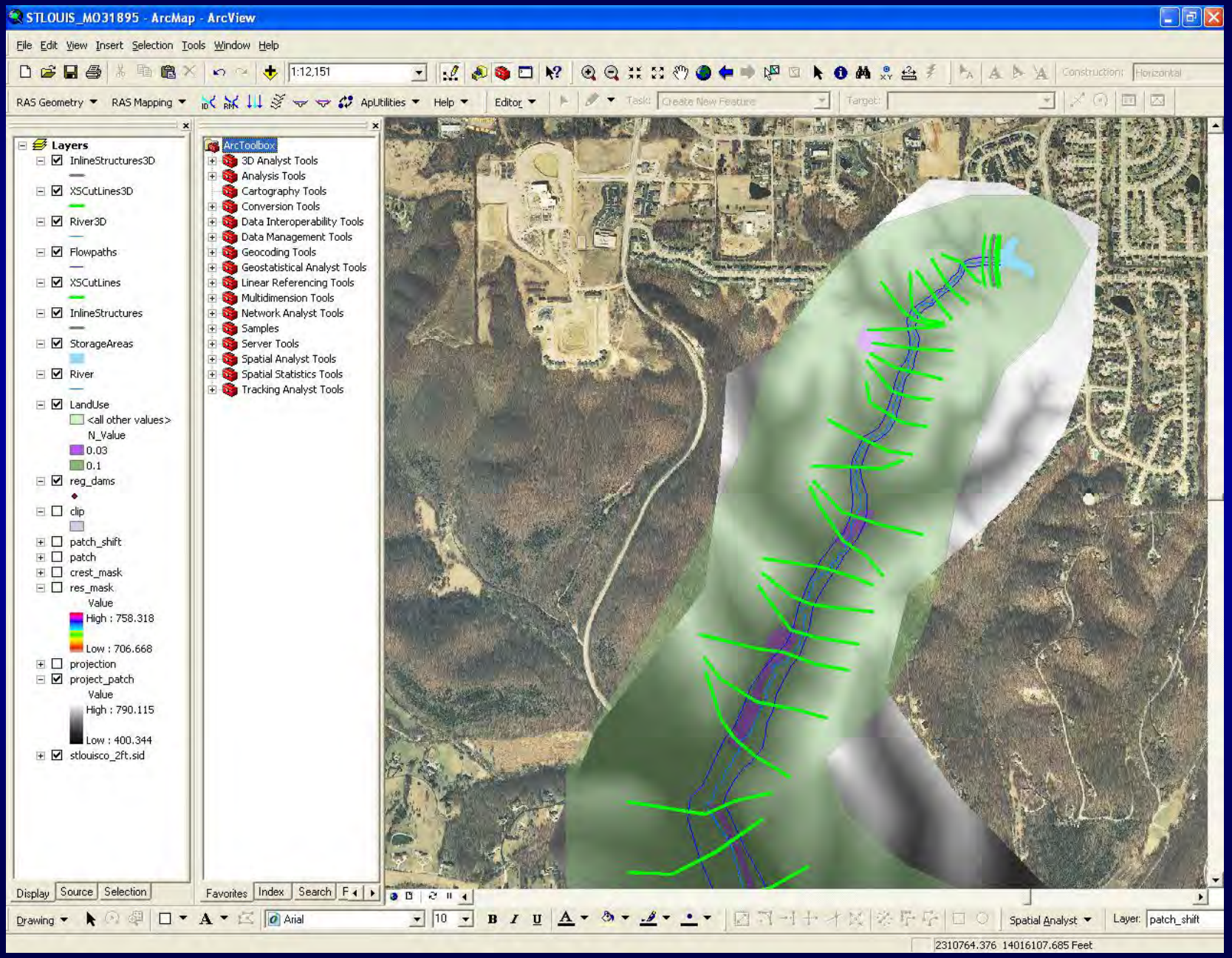
Data Extraction

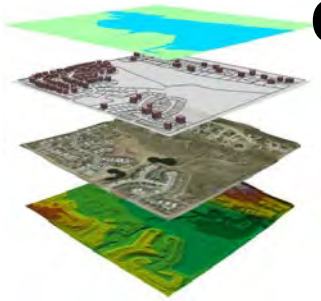
GeoRAS extension

Data Extraction

Breach Parameters → Develop Hydrograph → Downstream Routing

ESRI ArcView





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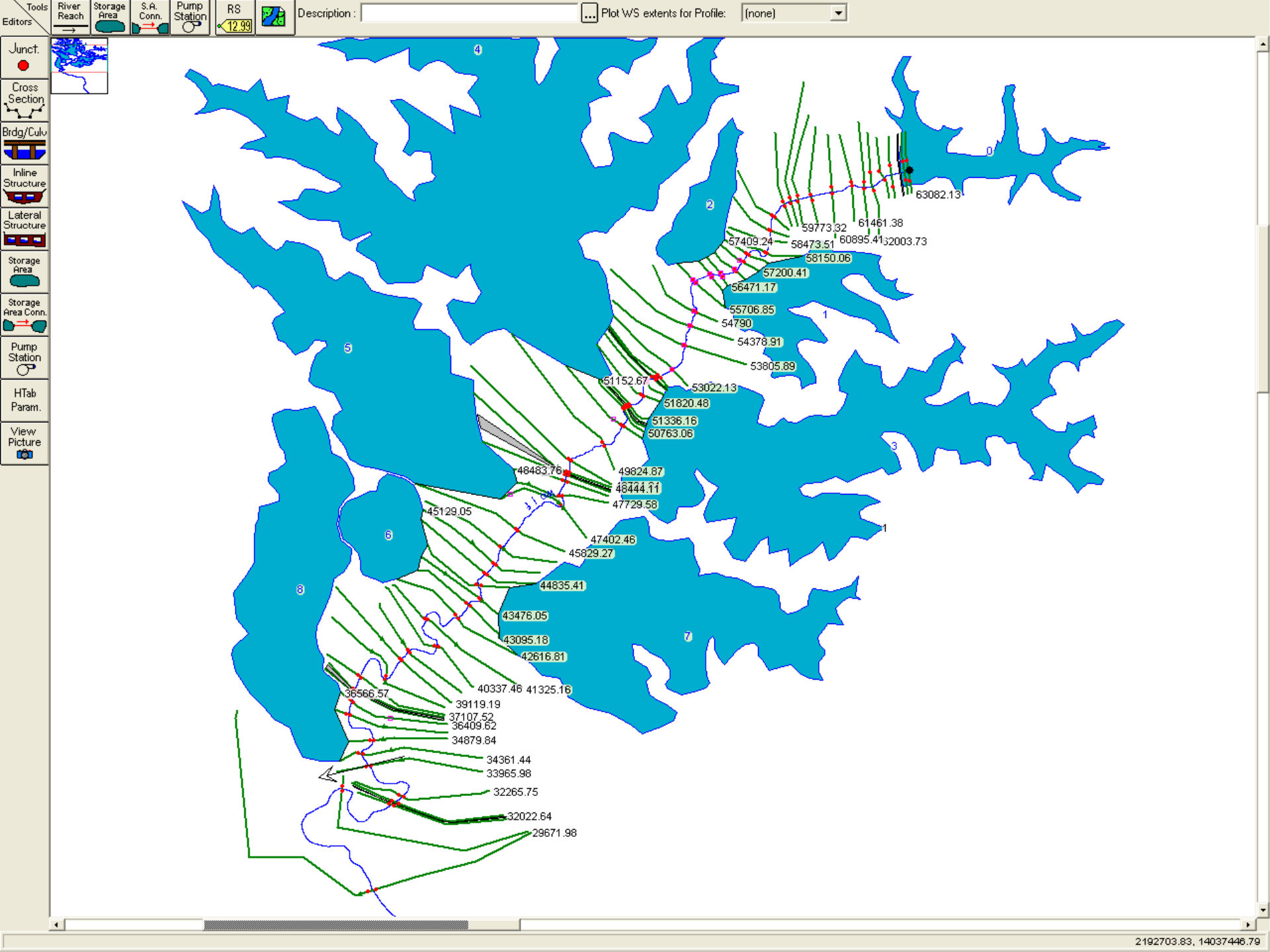
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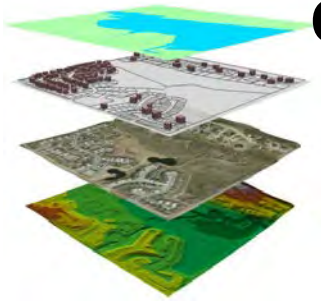

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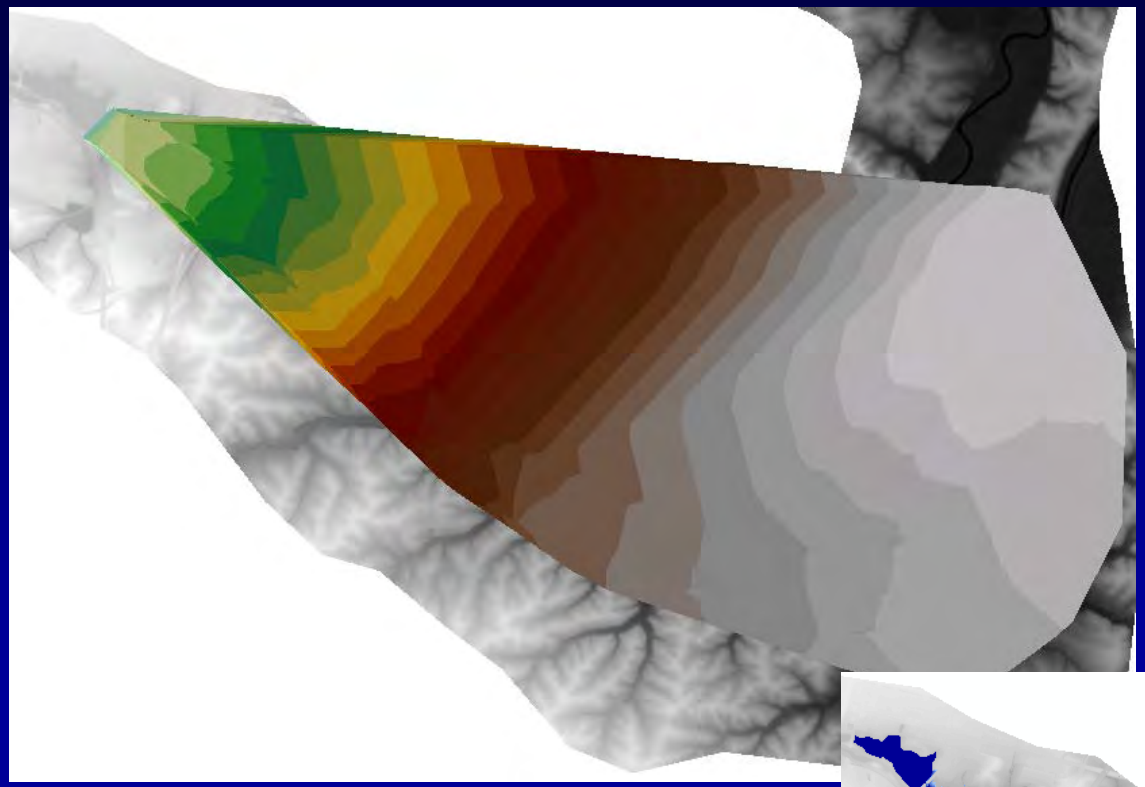

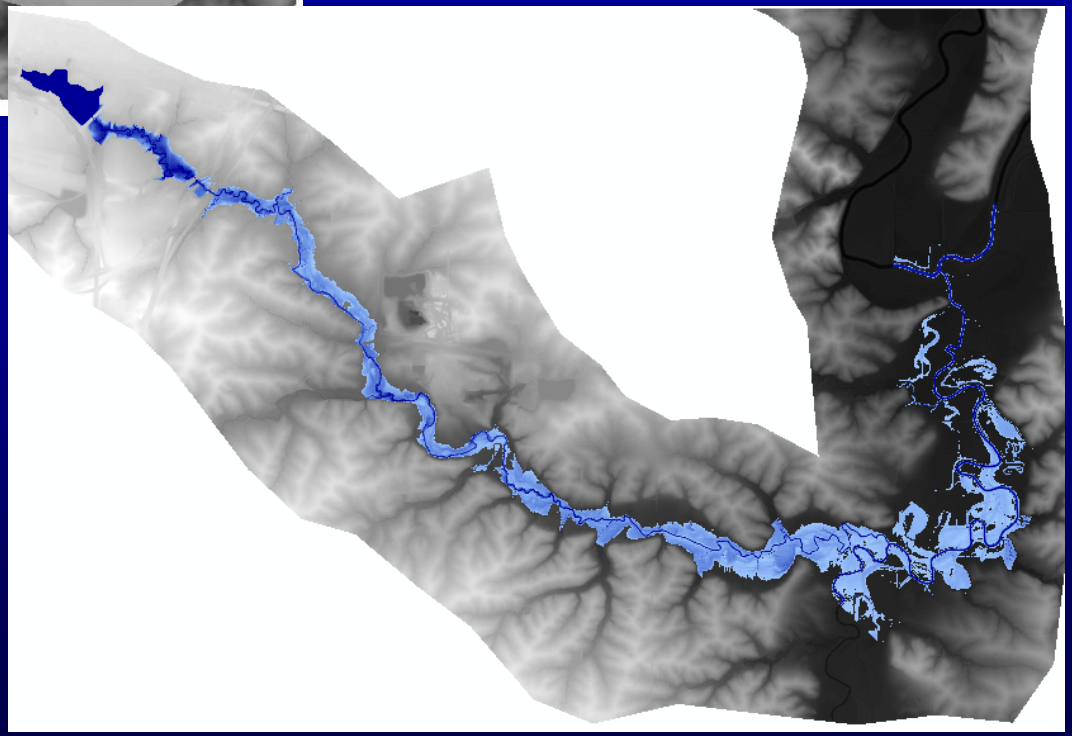

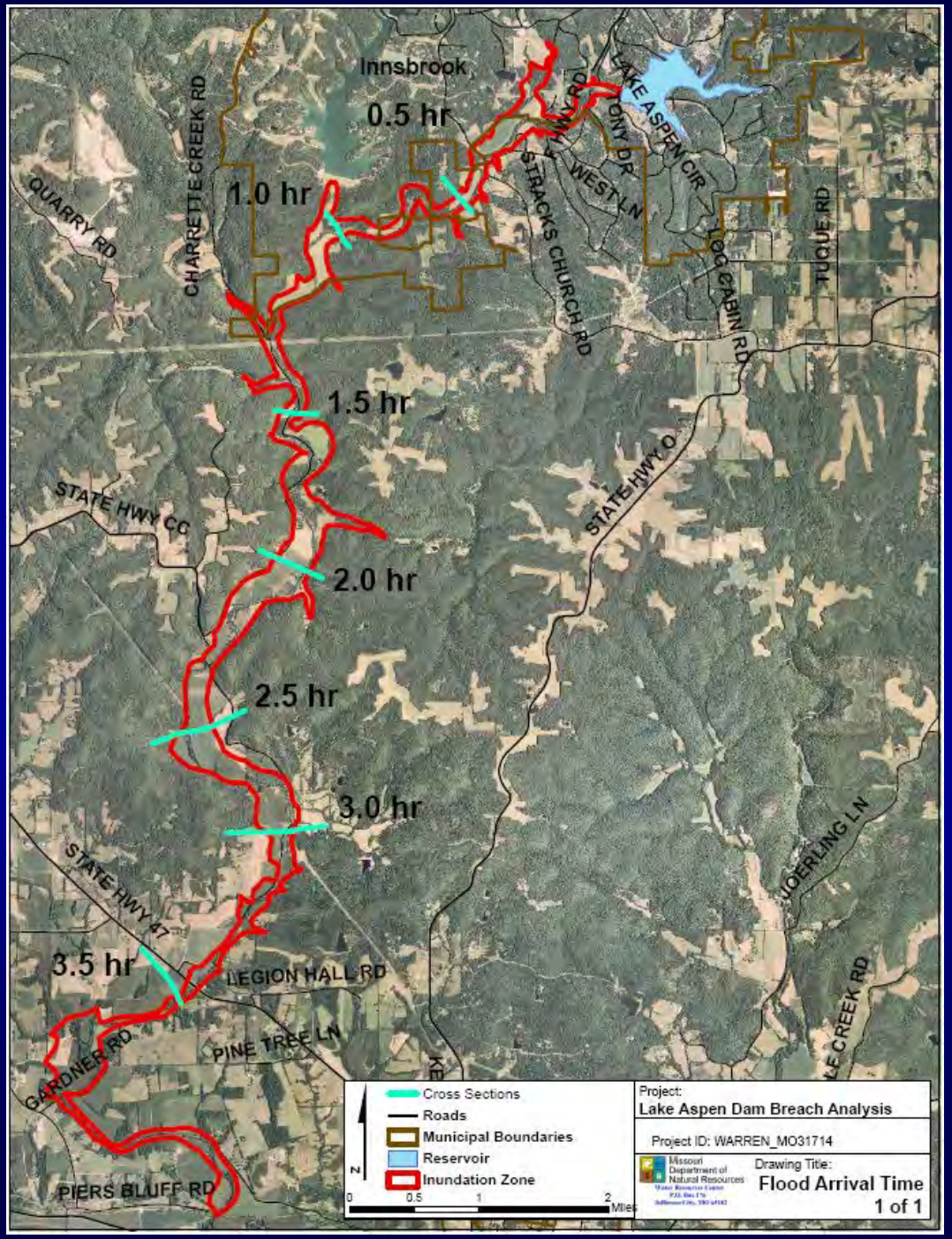
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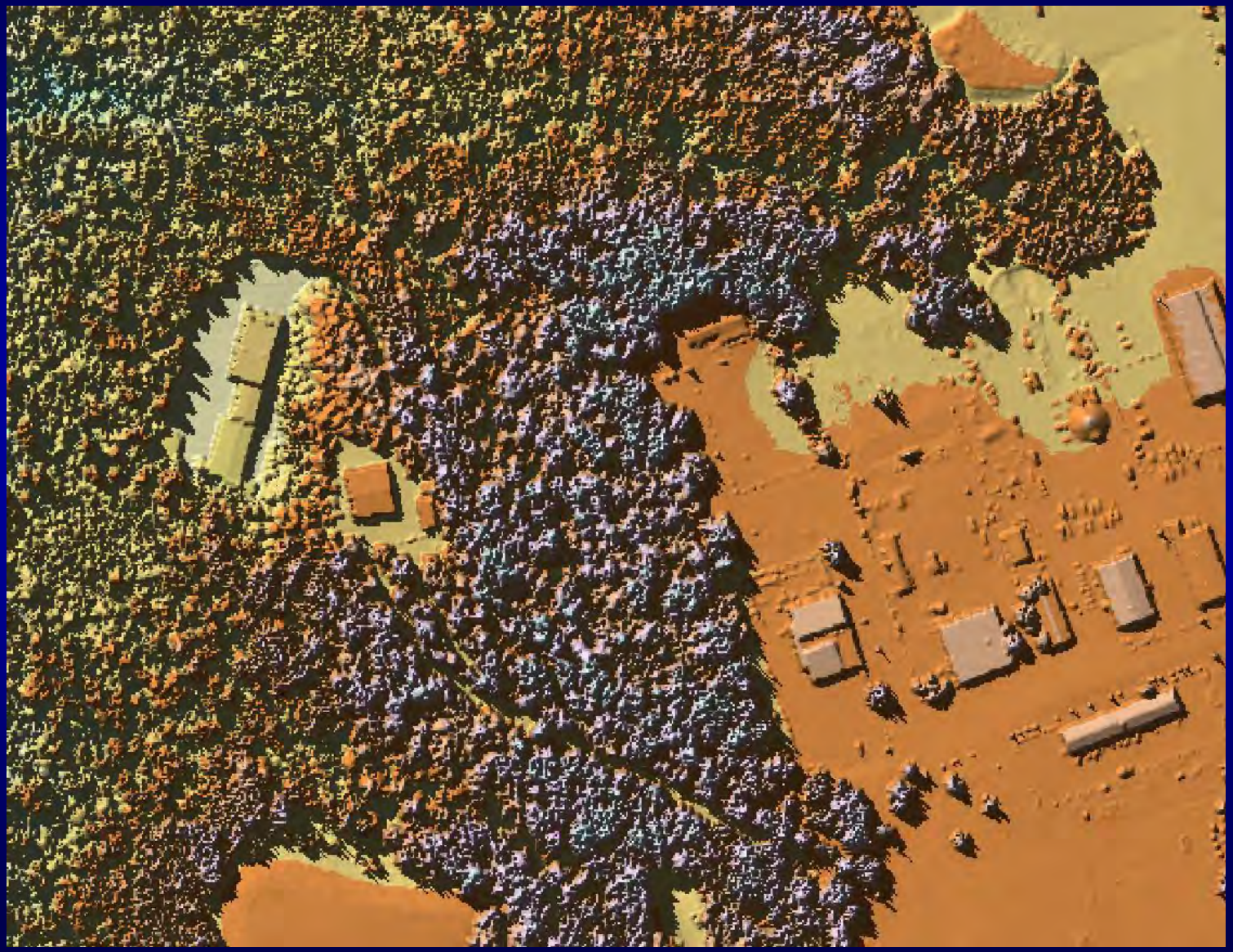
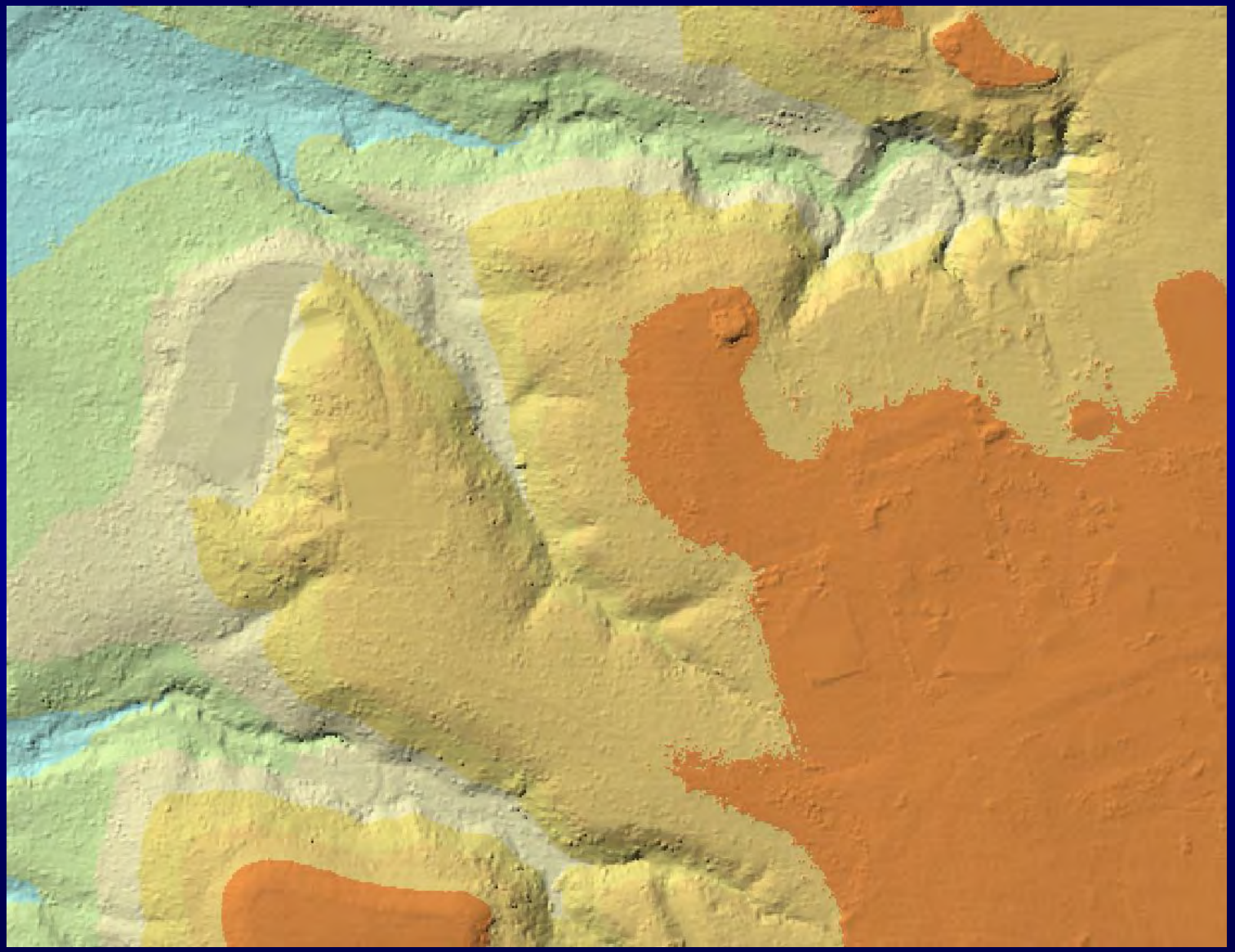
LiDAR First Return



Courtesy Surdex Corp

LiDAR Bare Earth



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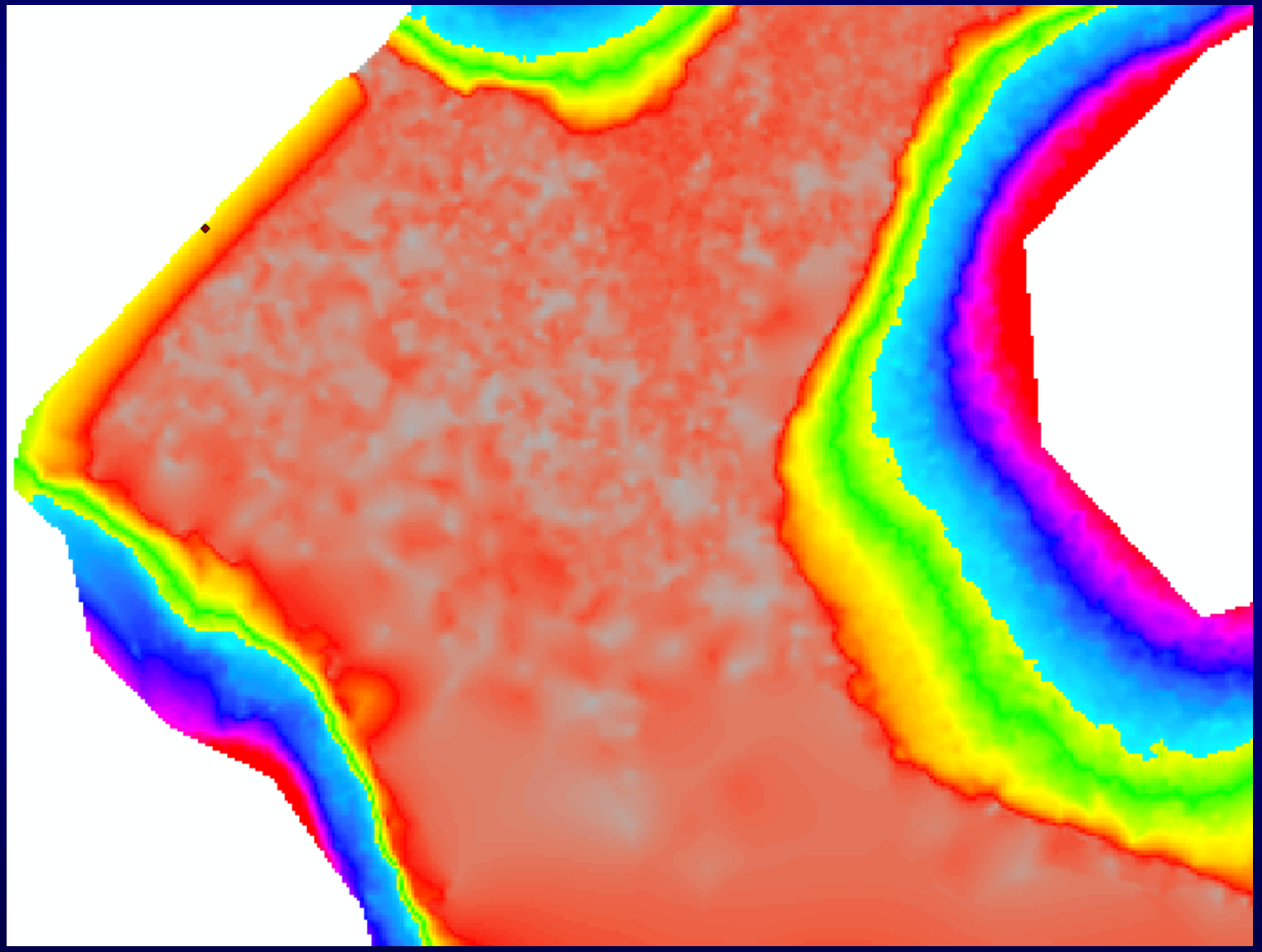
Flattening



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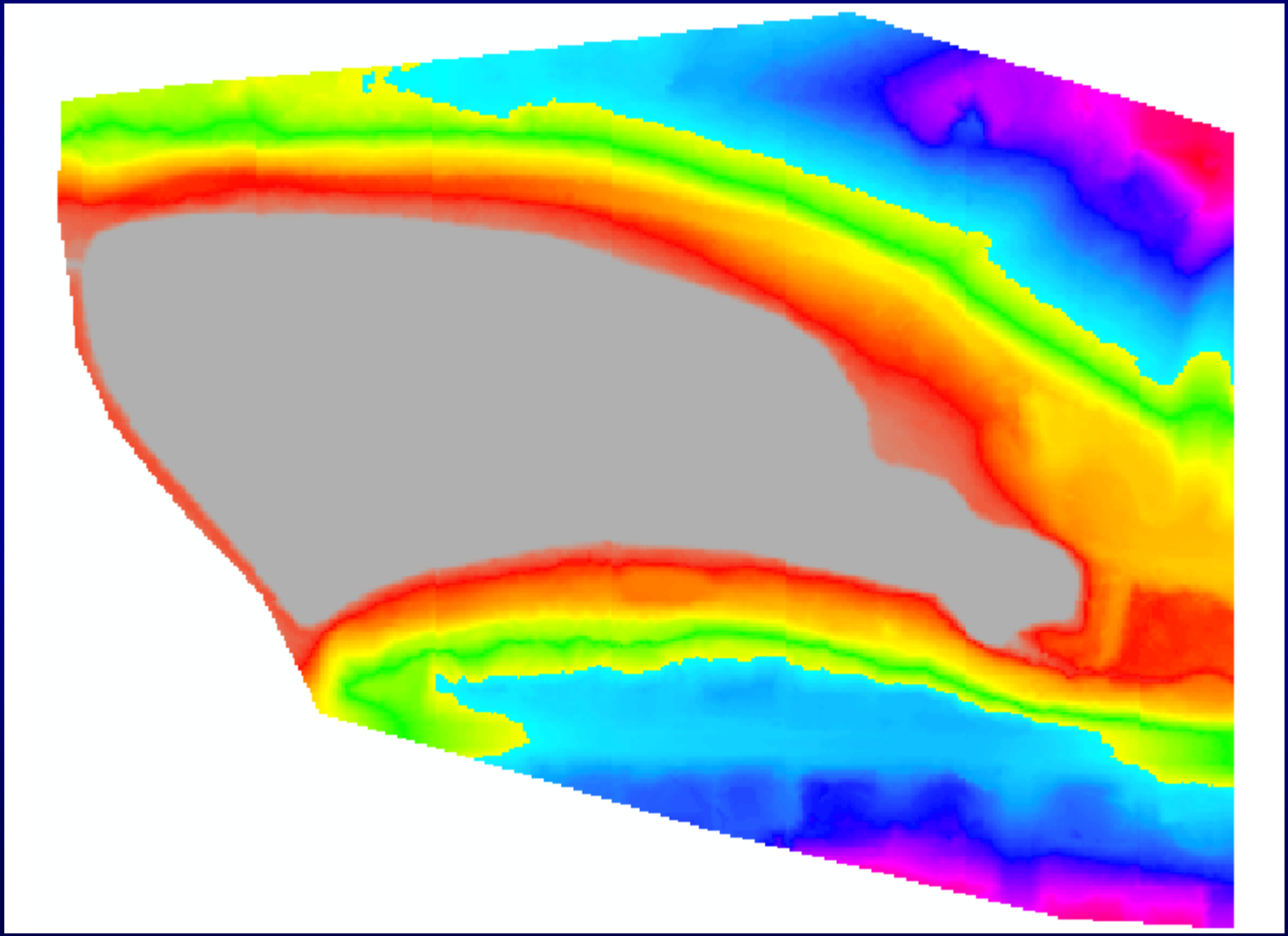

LiDAR Hydro-Enforcement

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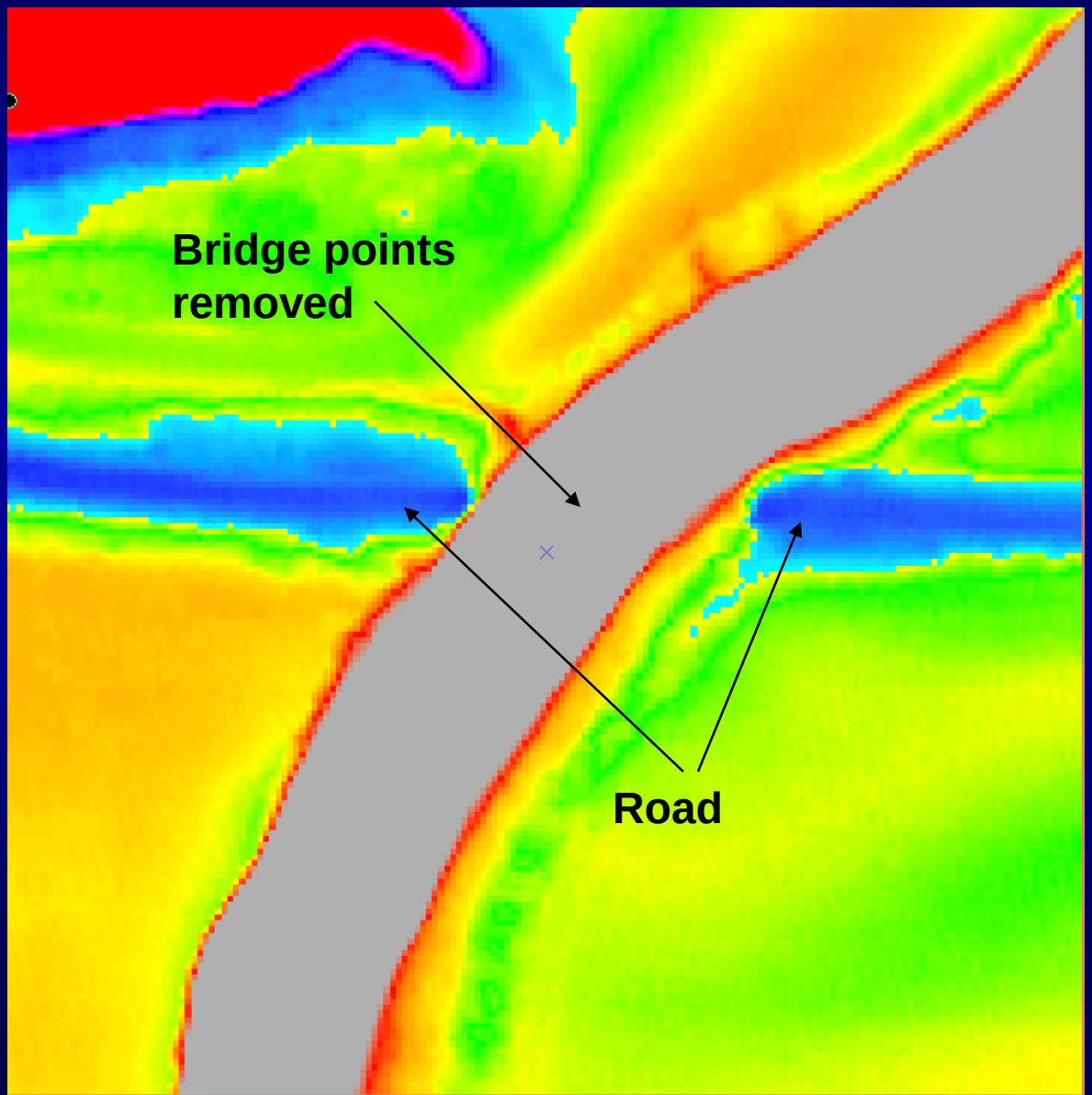
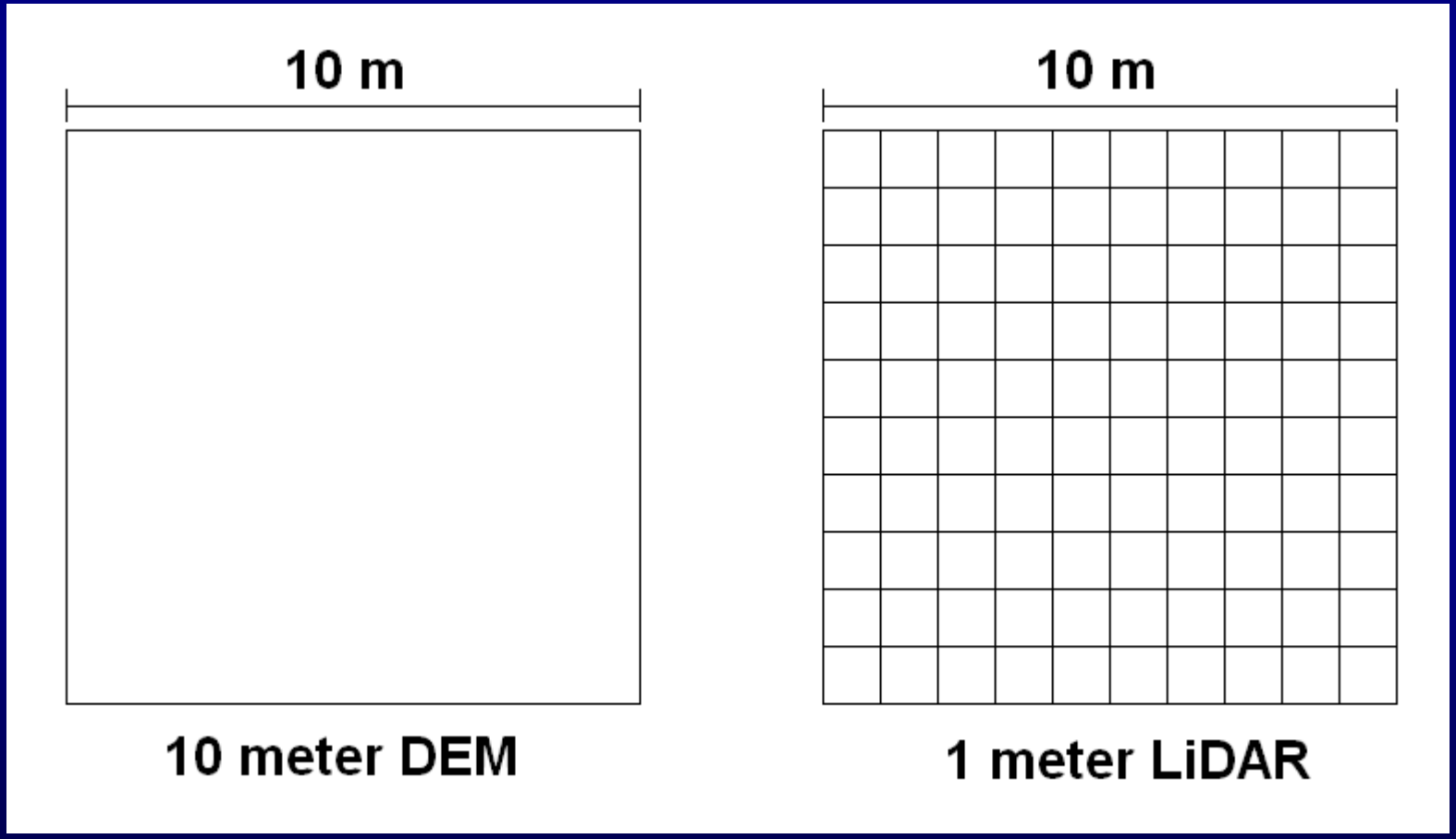


LiDAR vs 10m DEM



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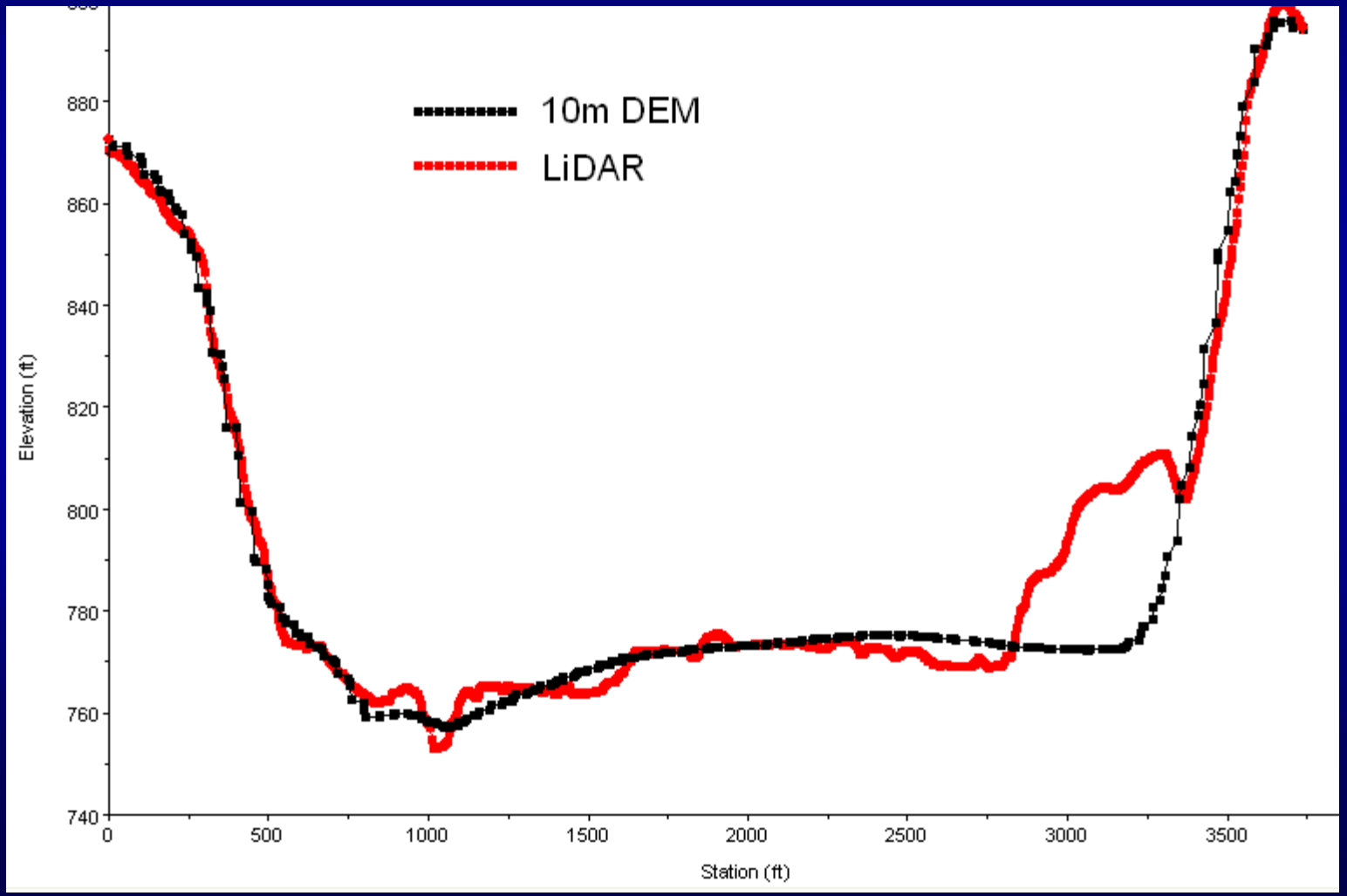

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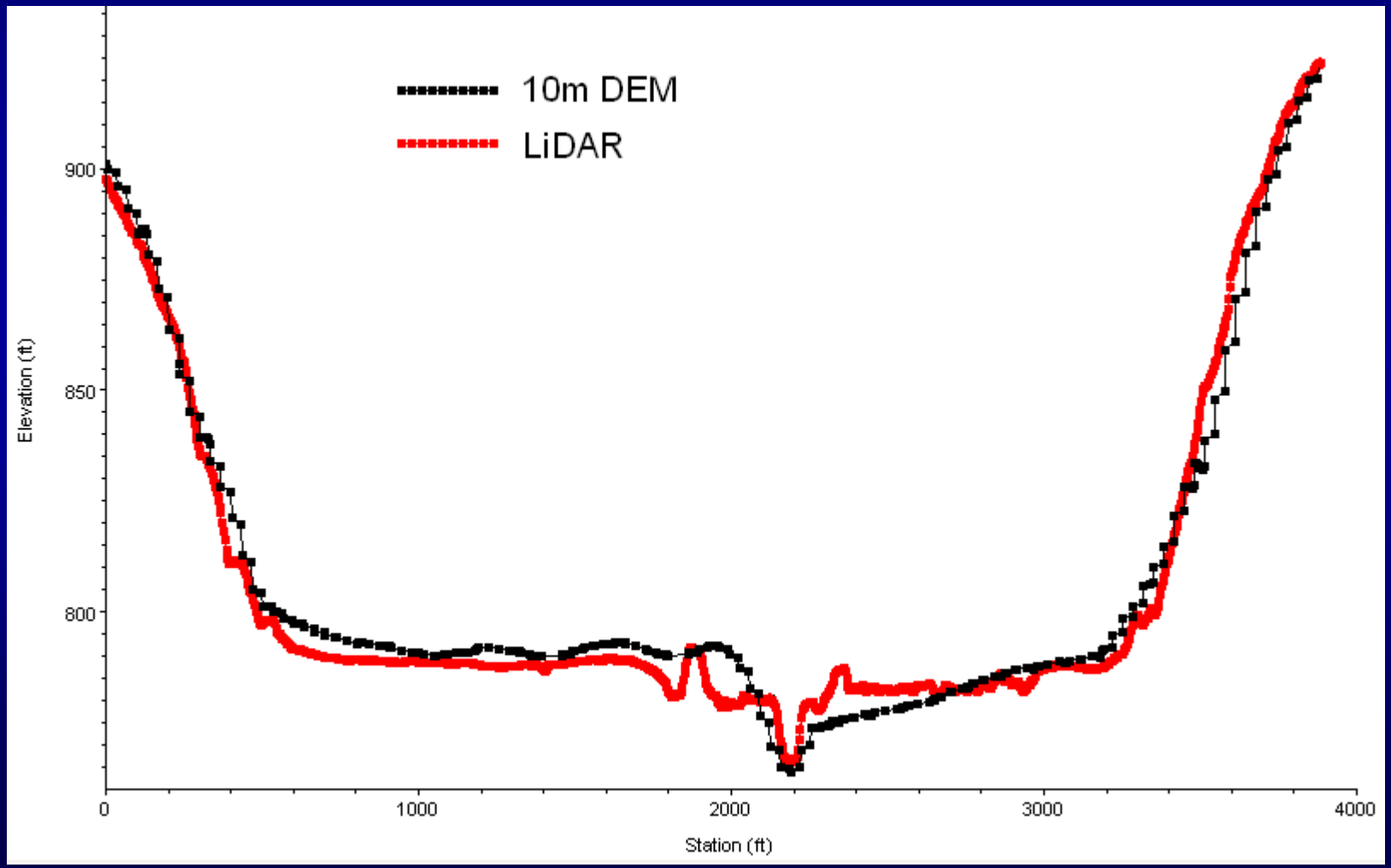
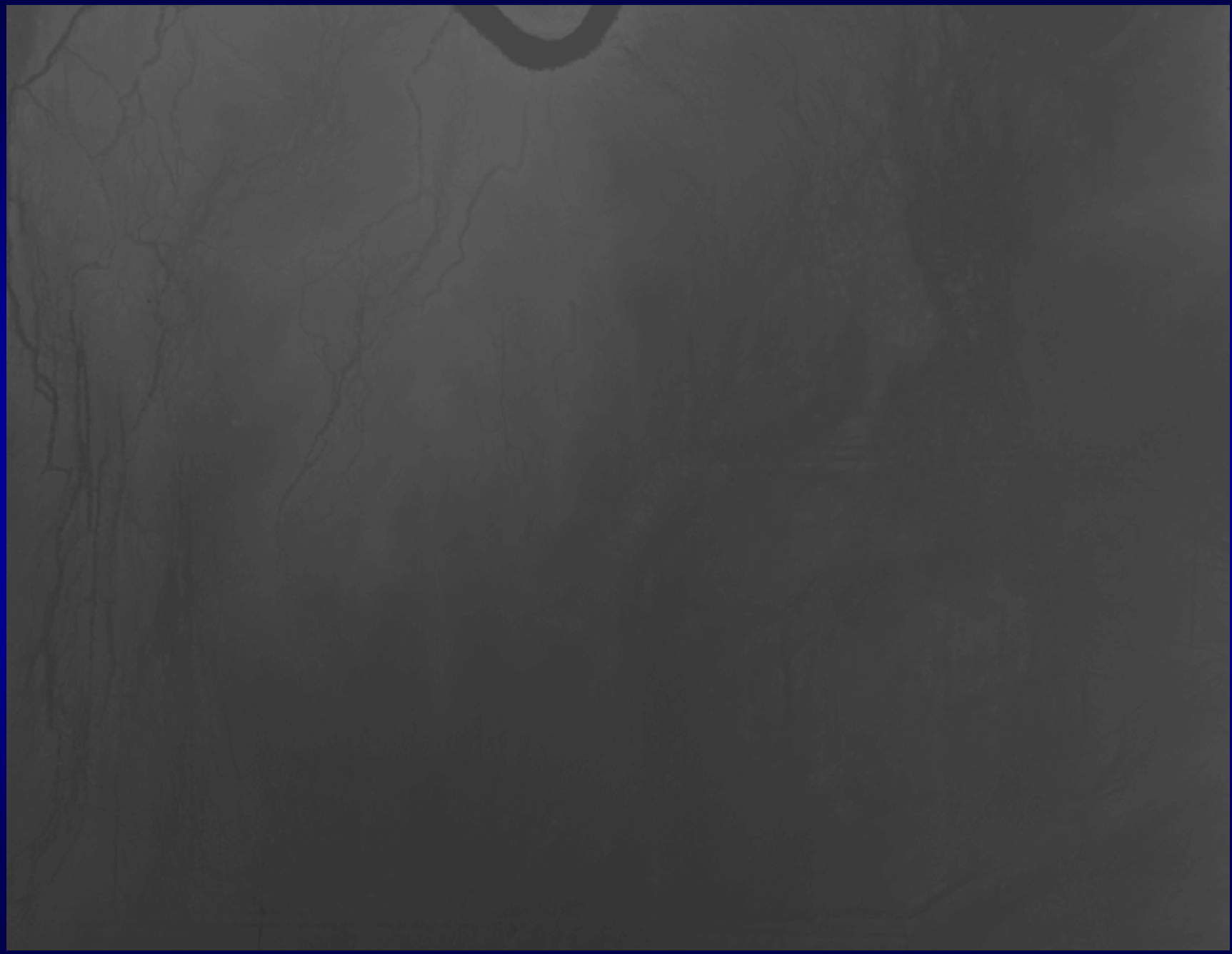
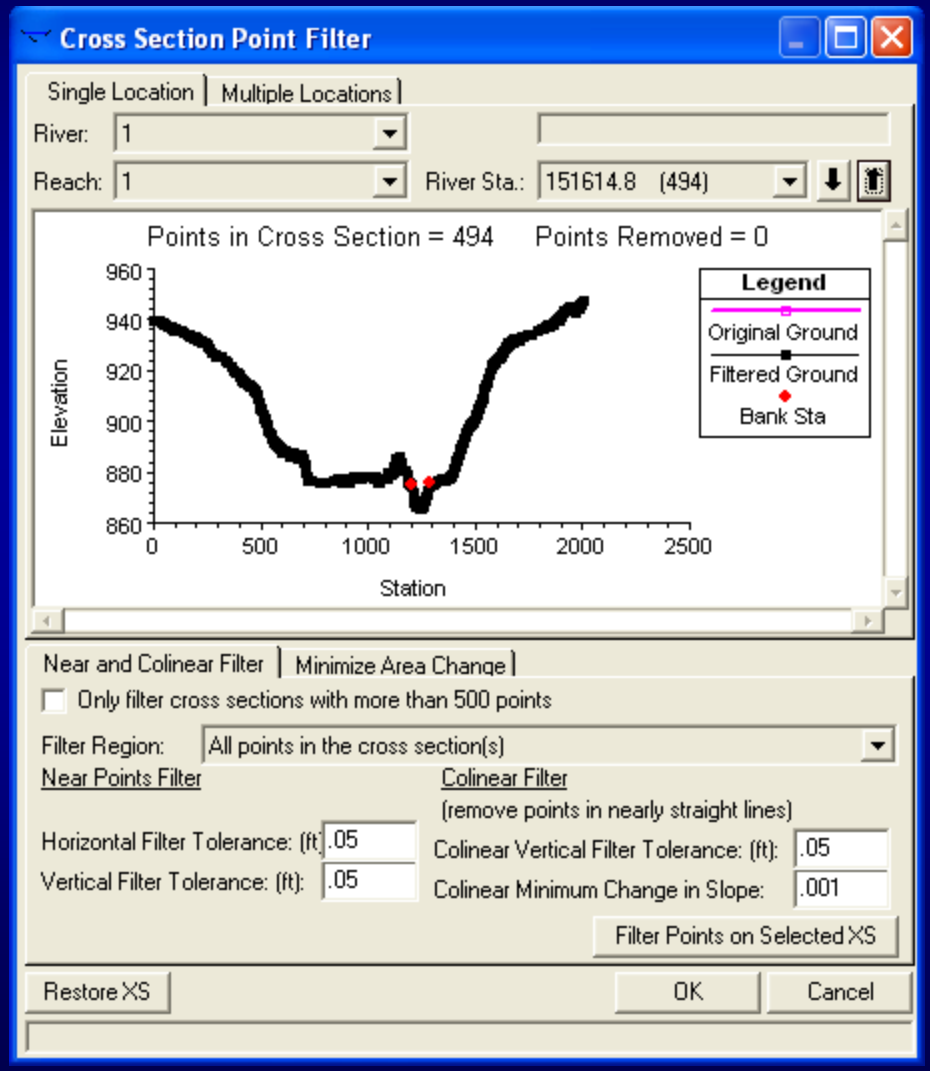




Cross Section Points Filtering



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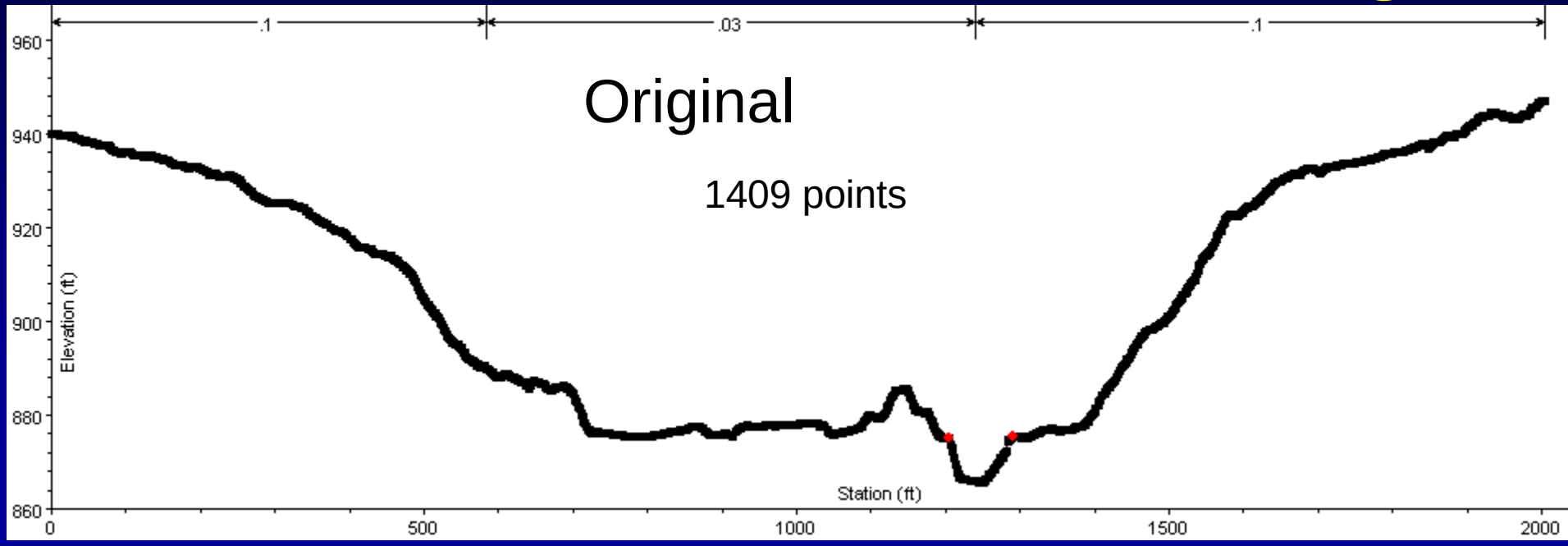

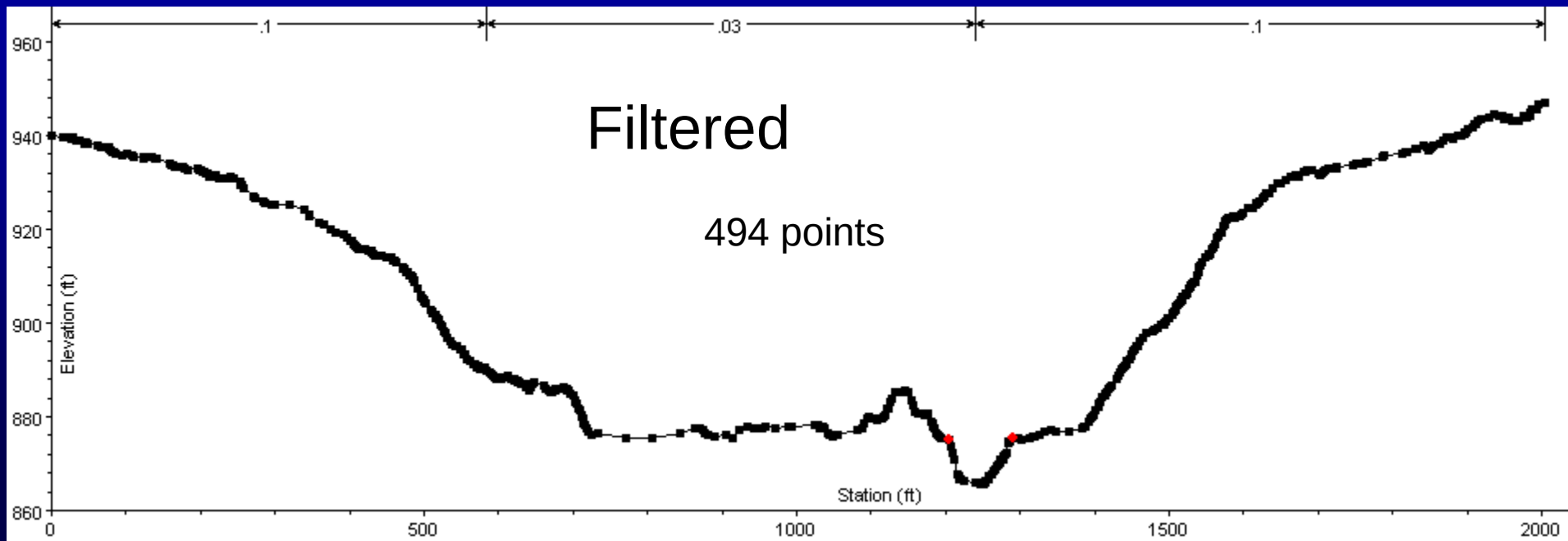

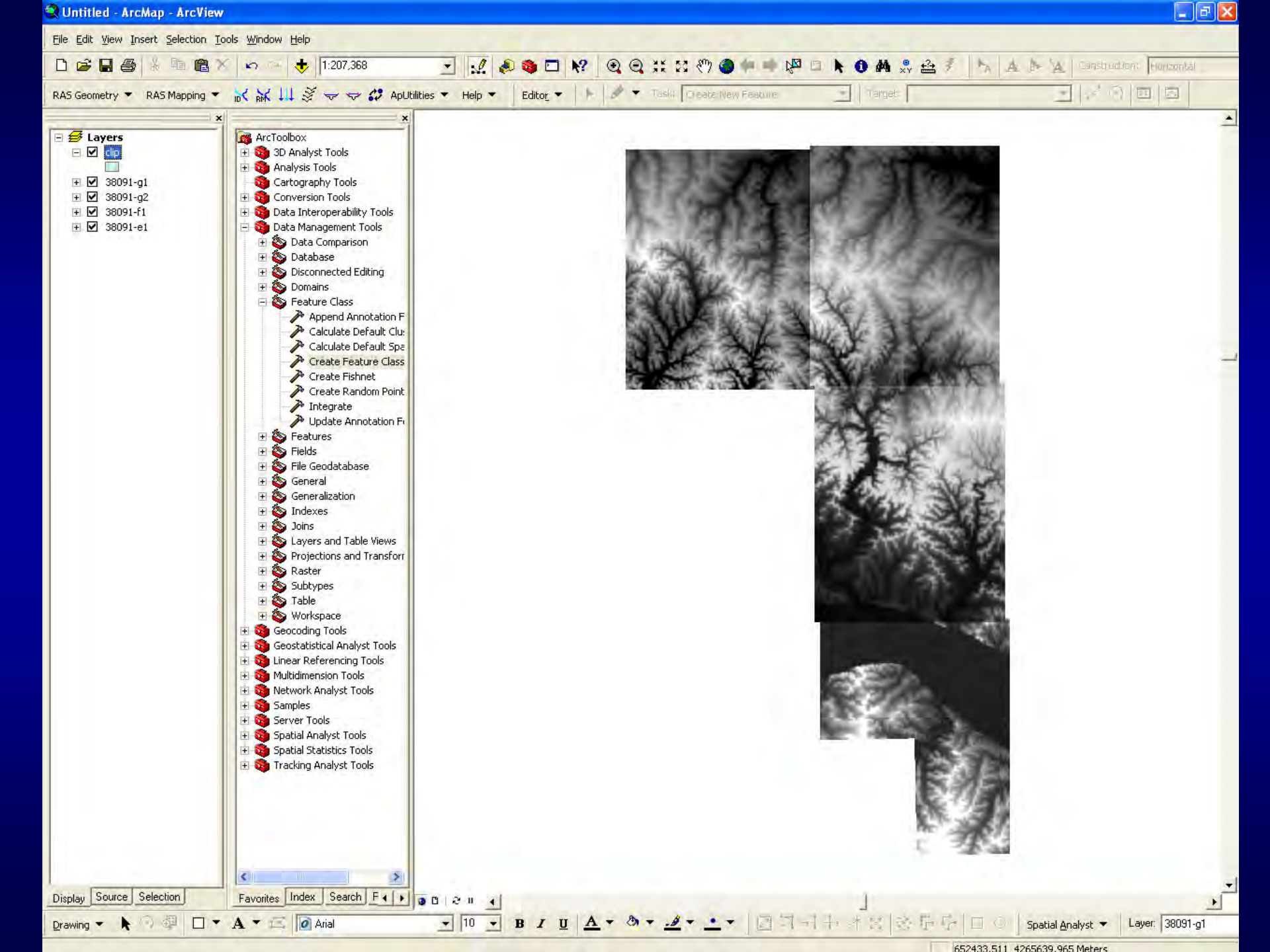
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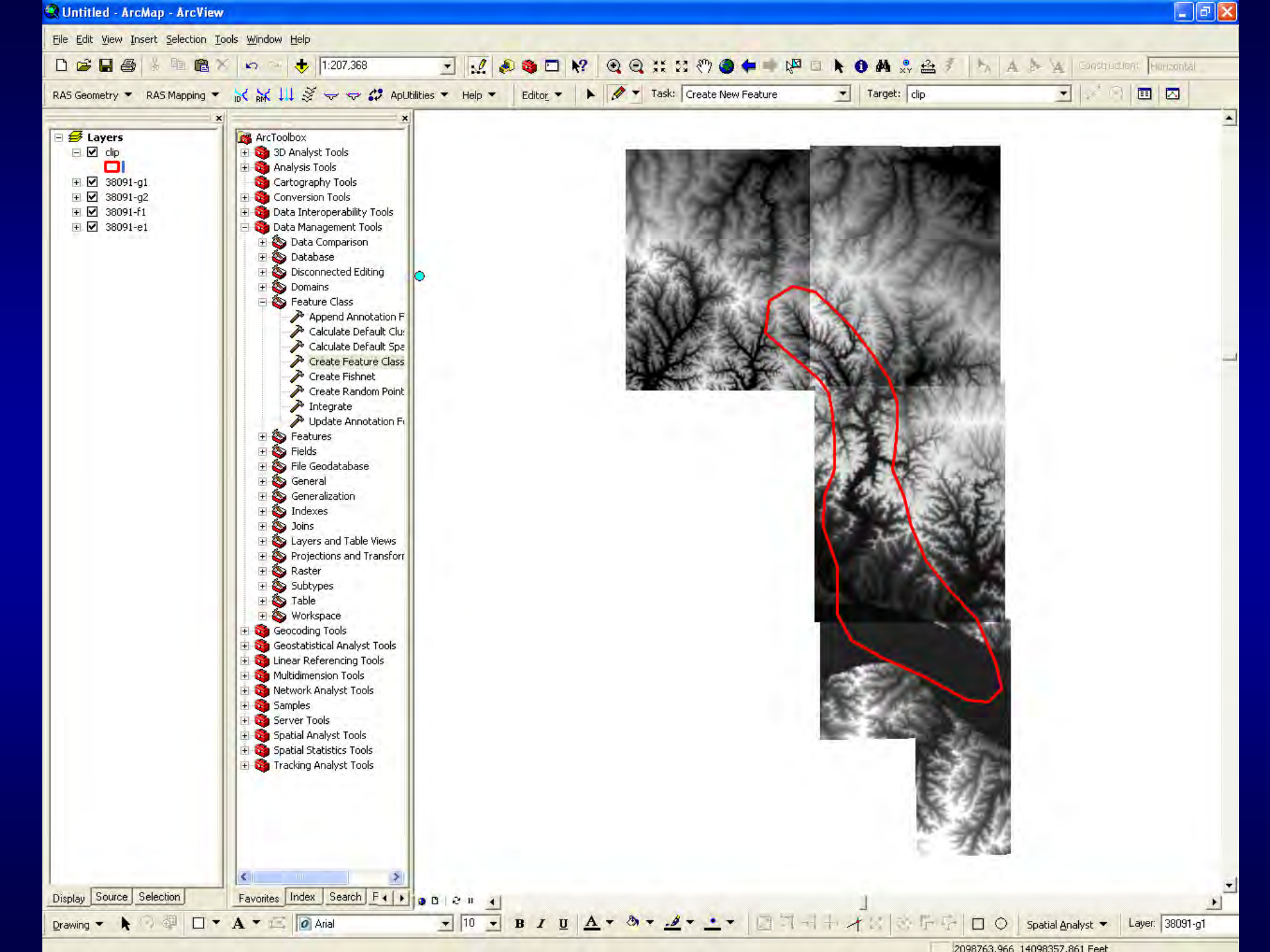
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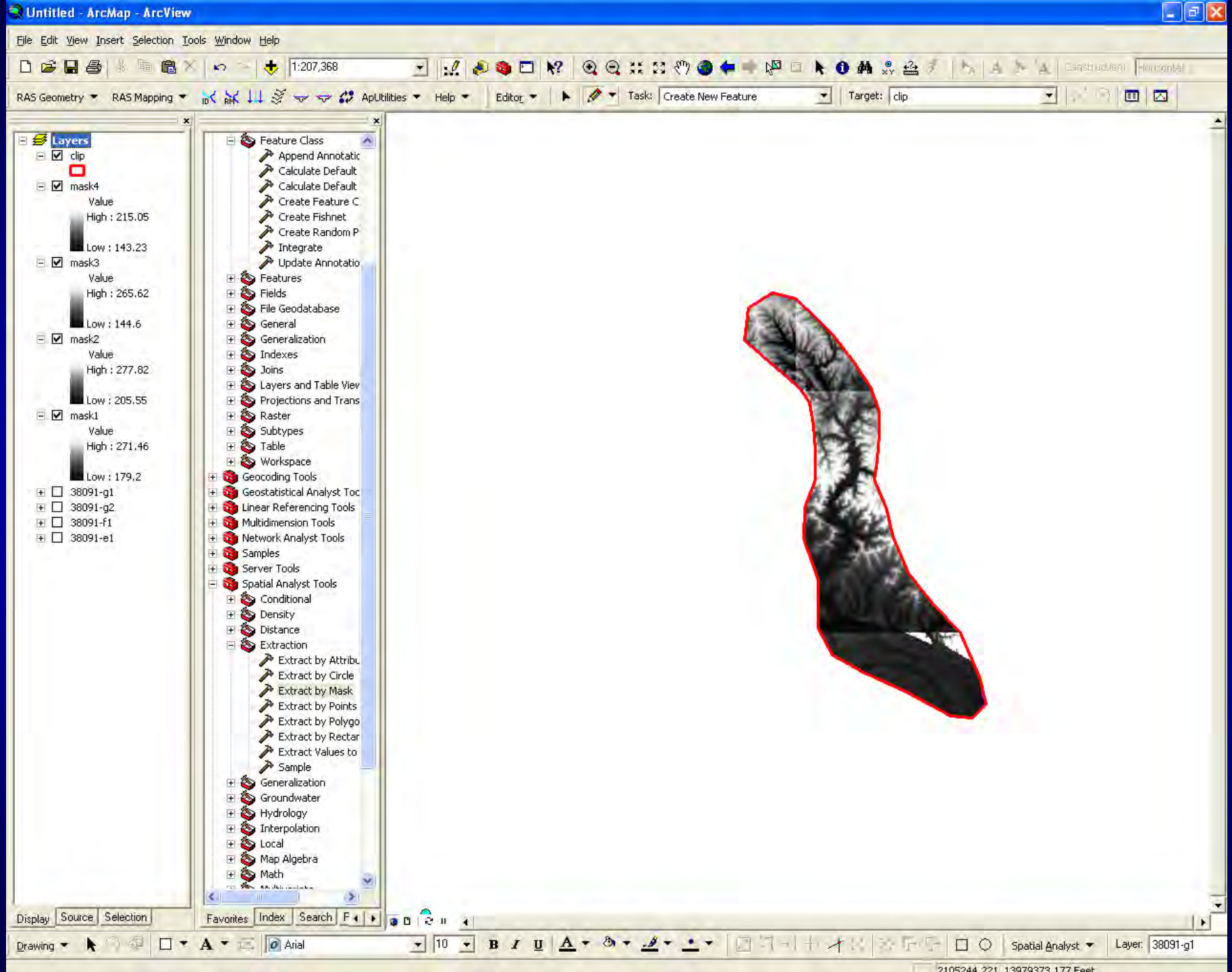
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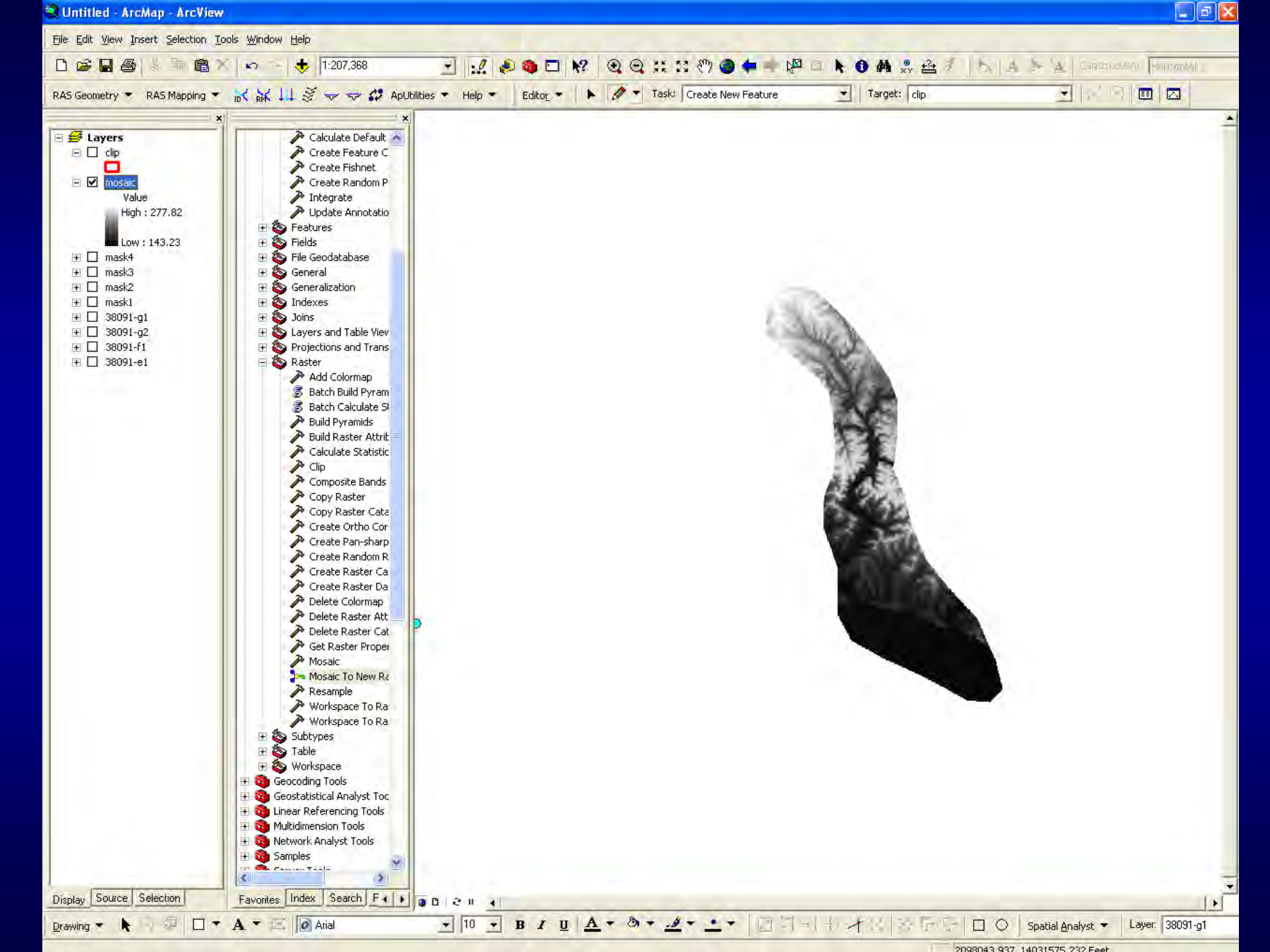
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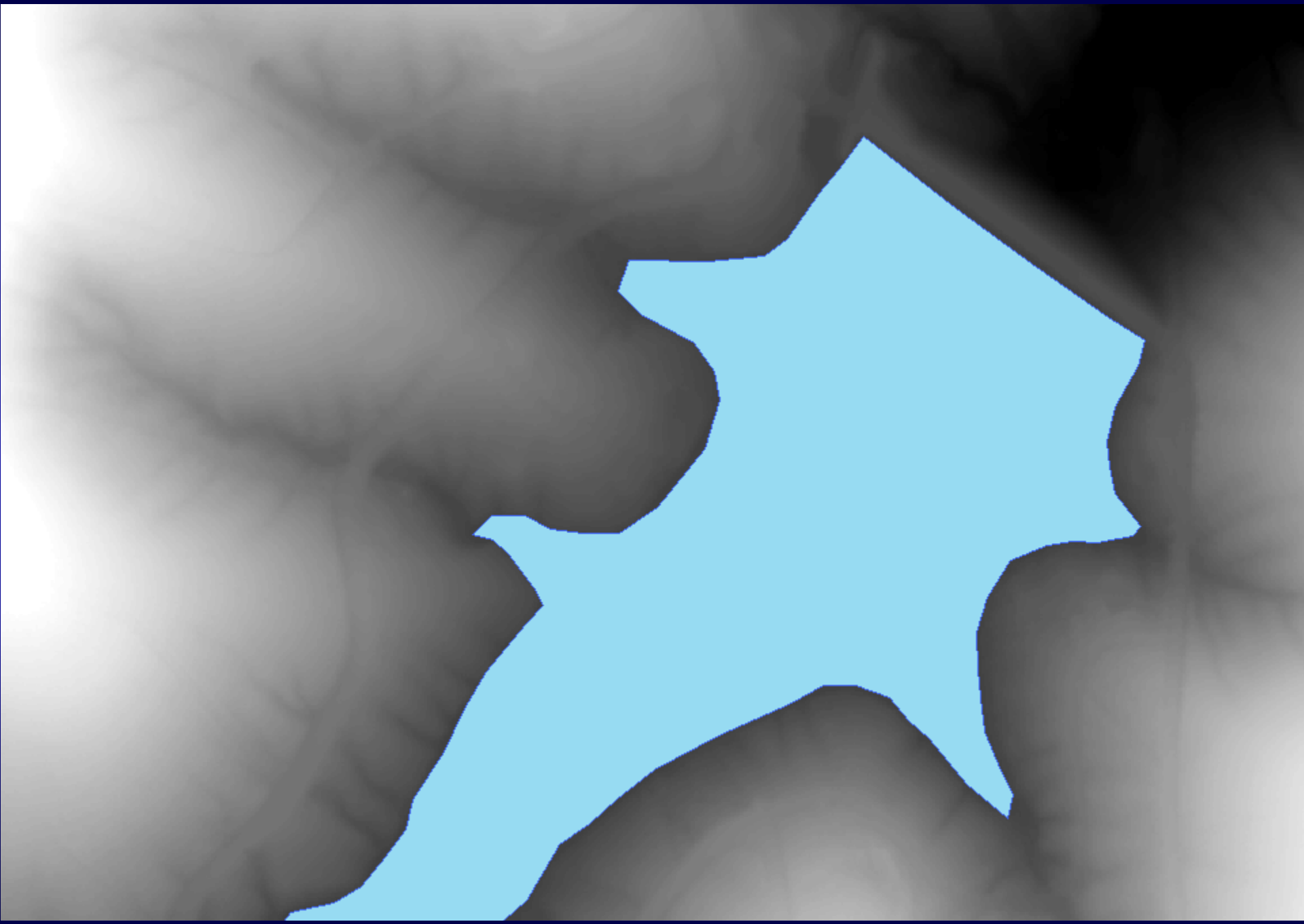

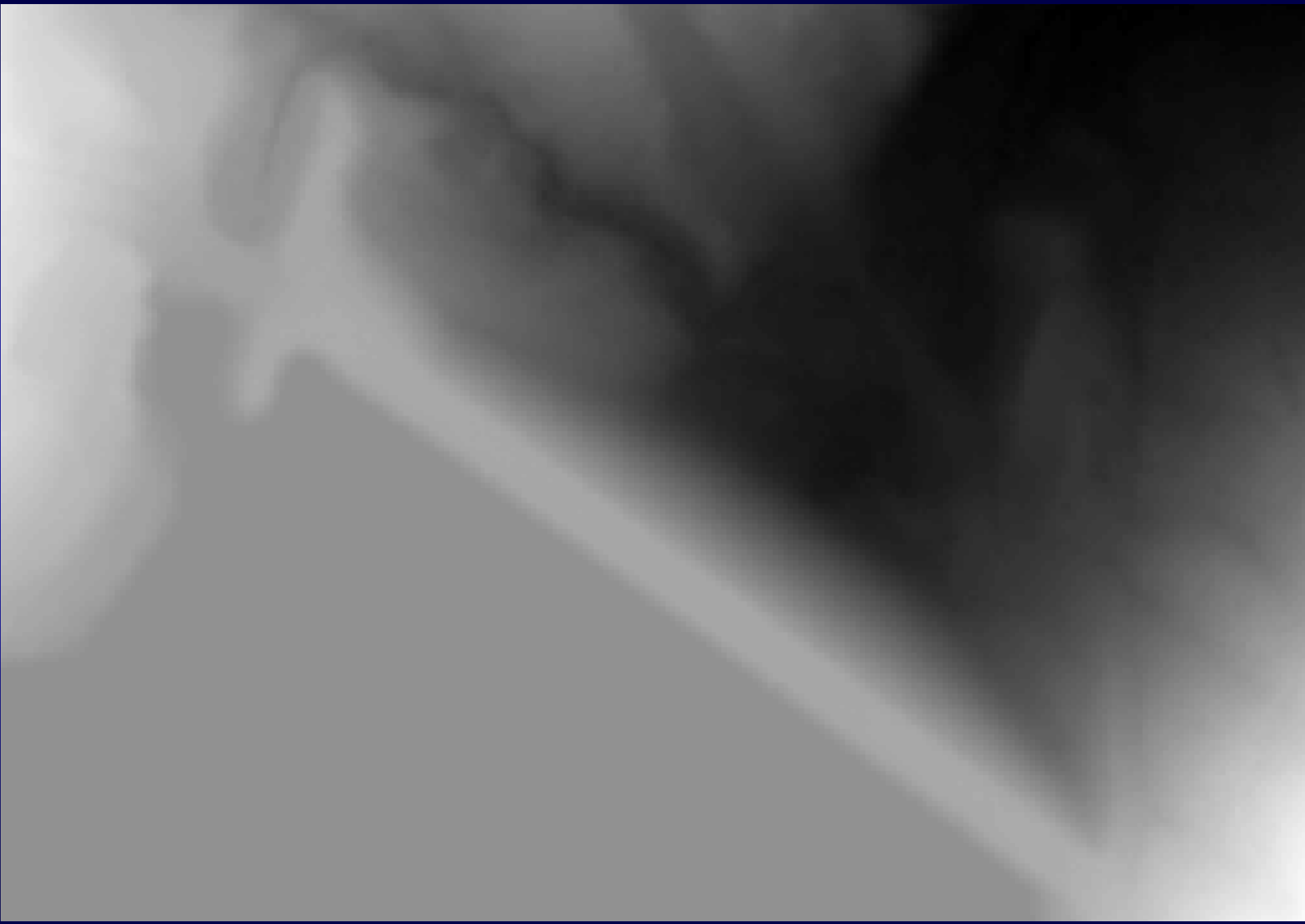

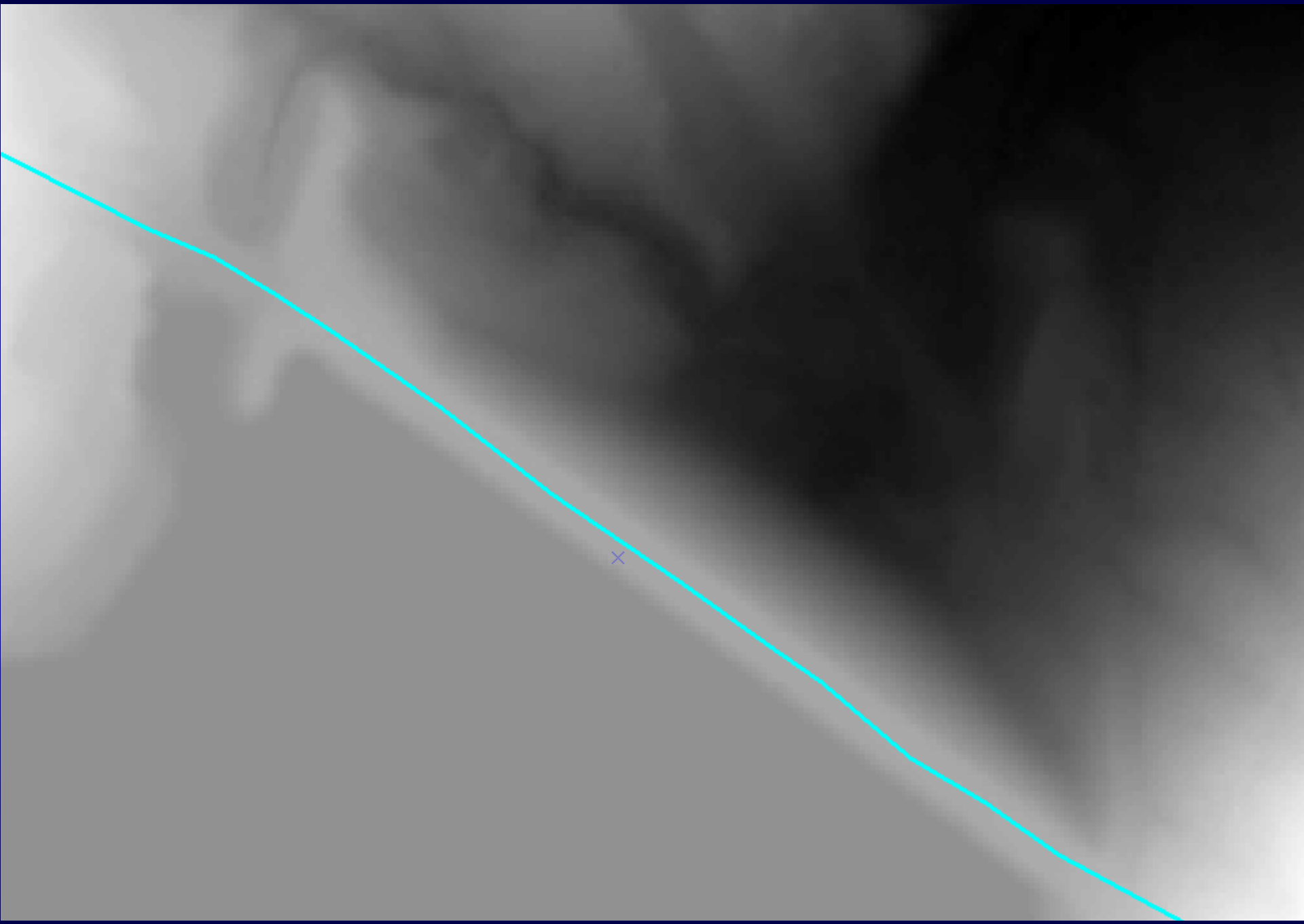

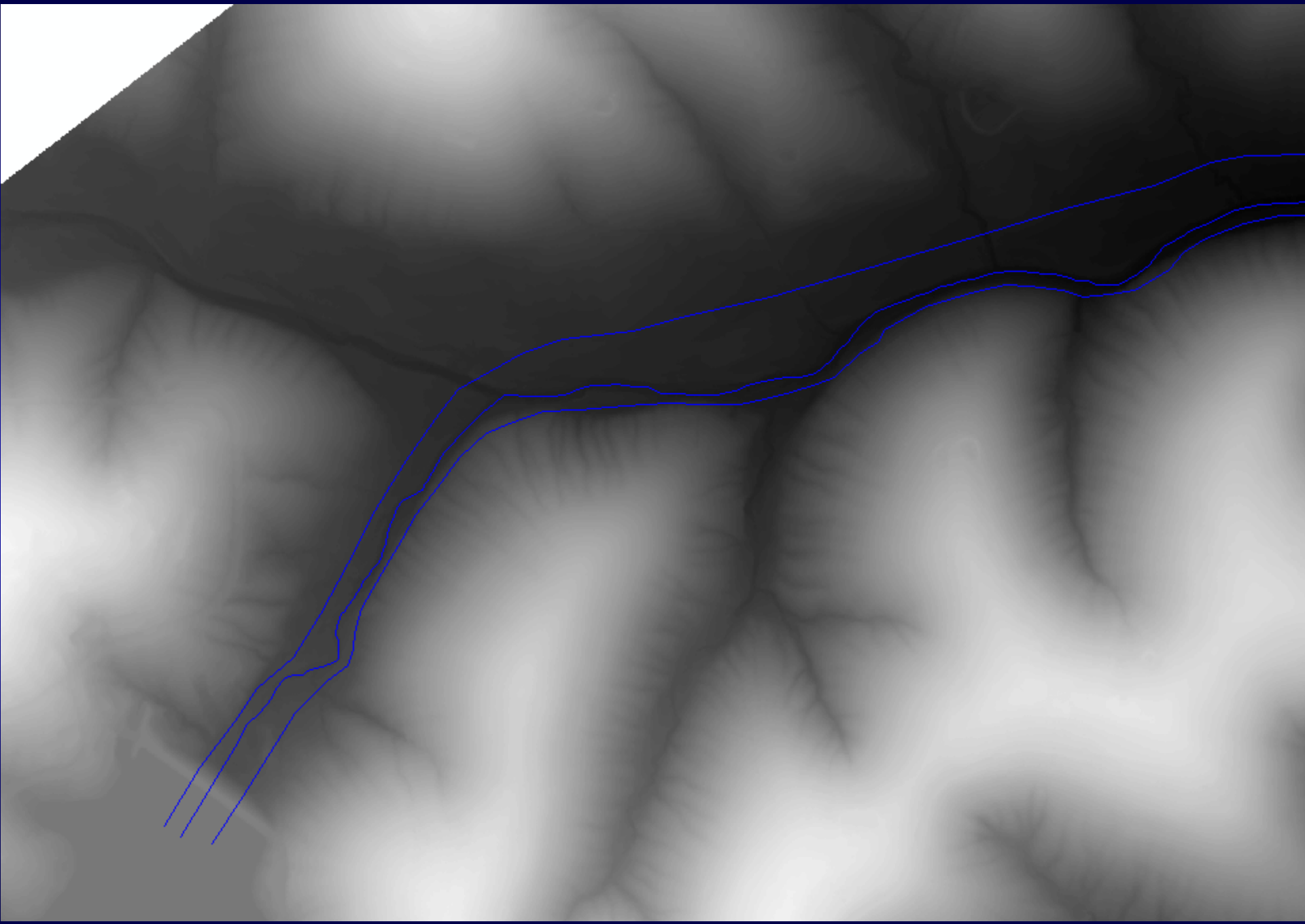

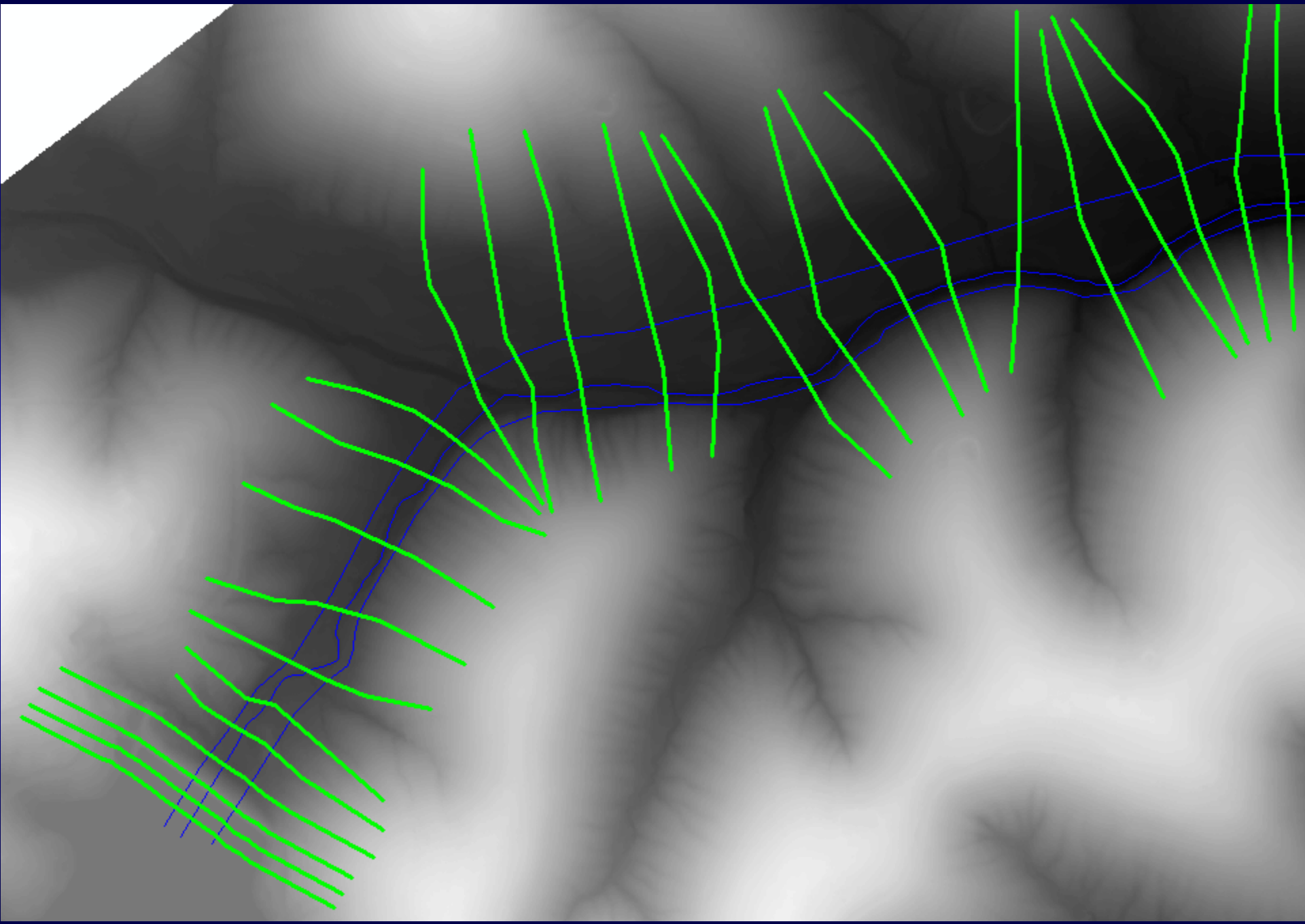

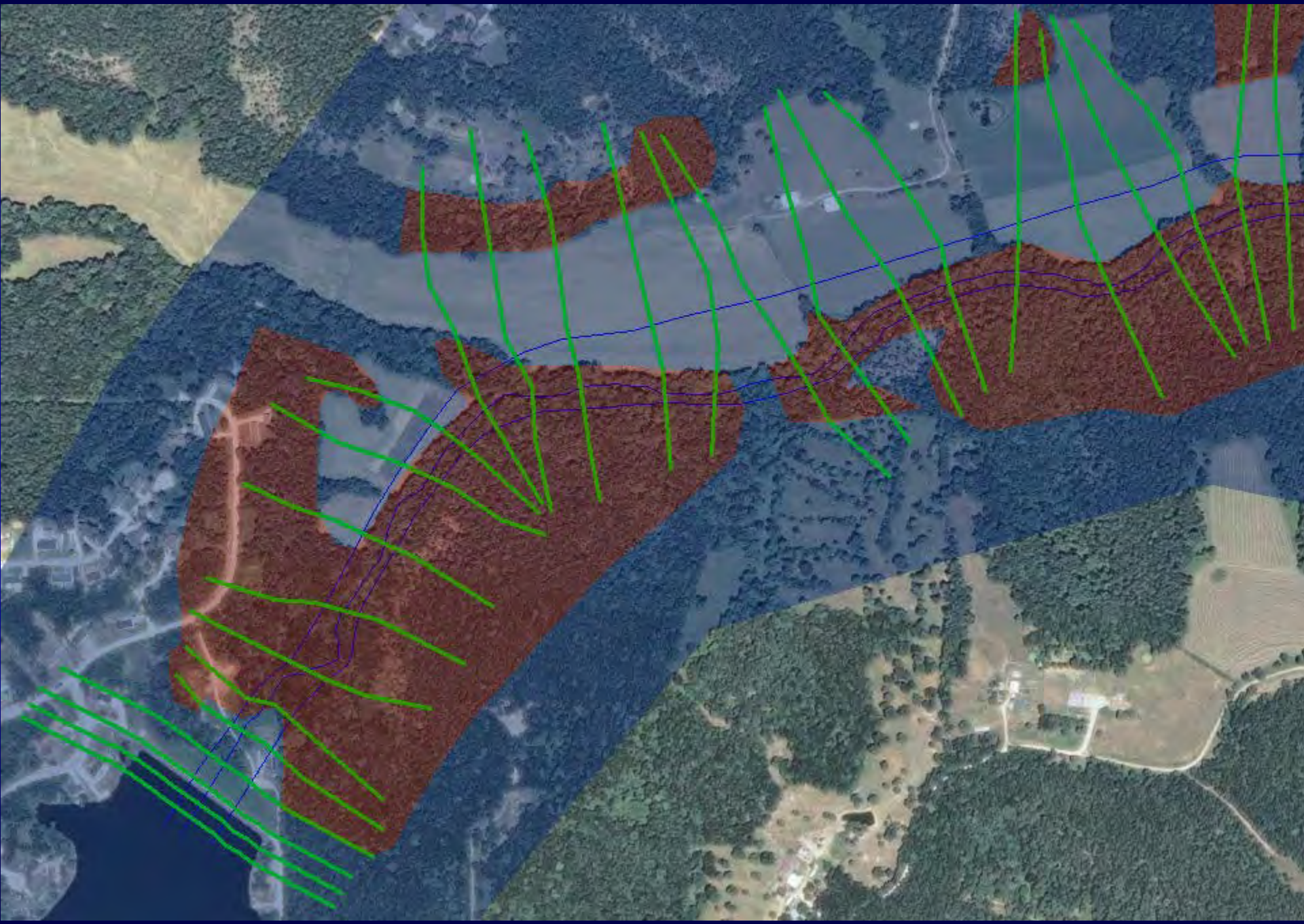

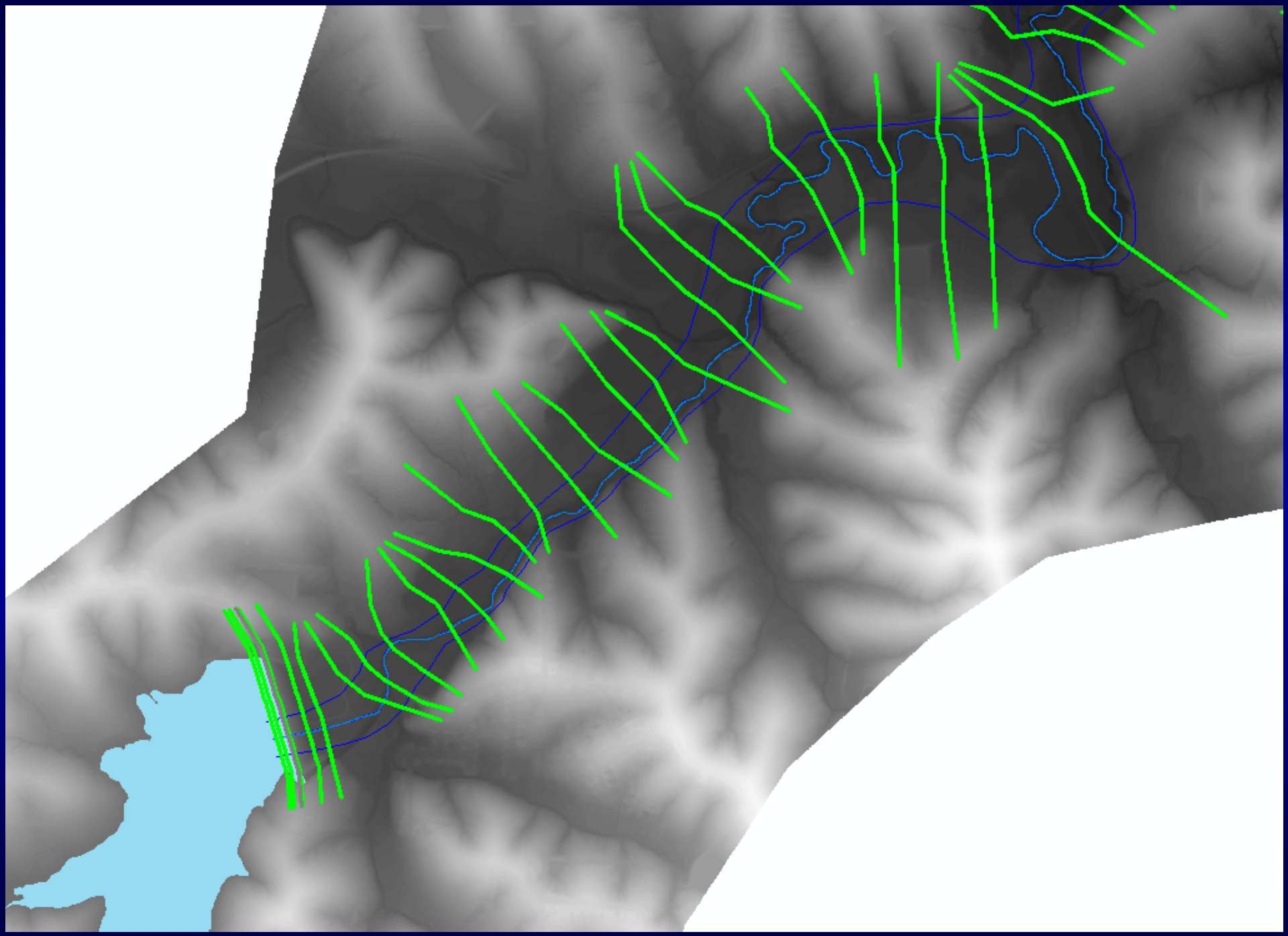

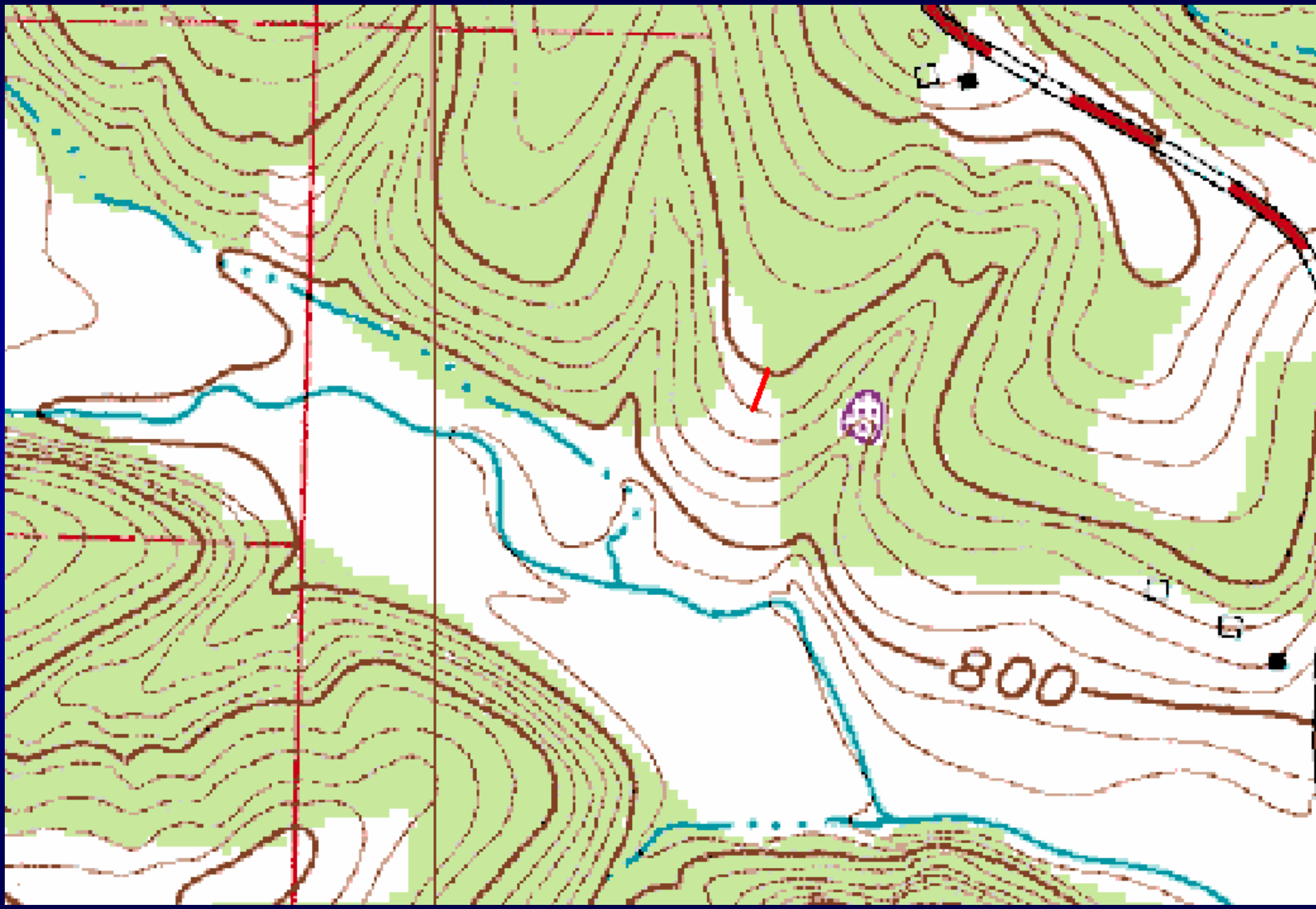
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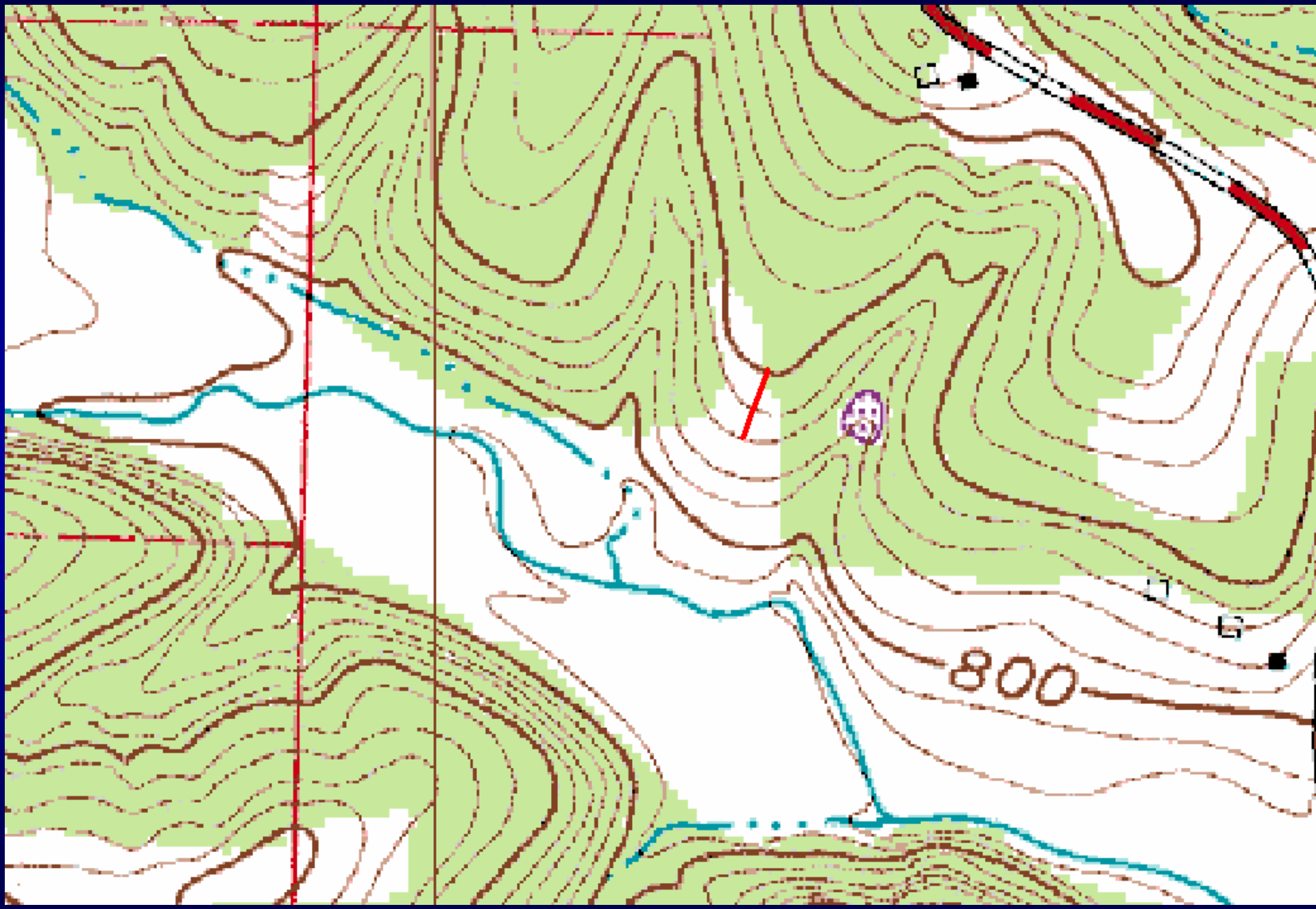
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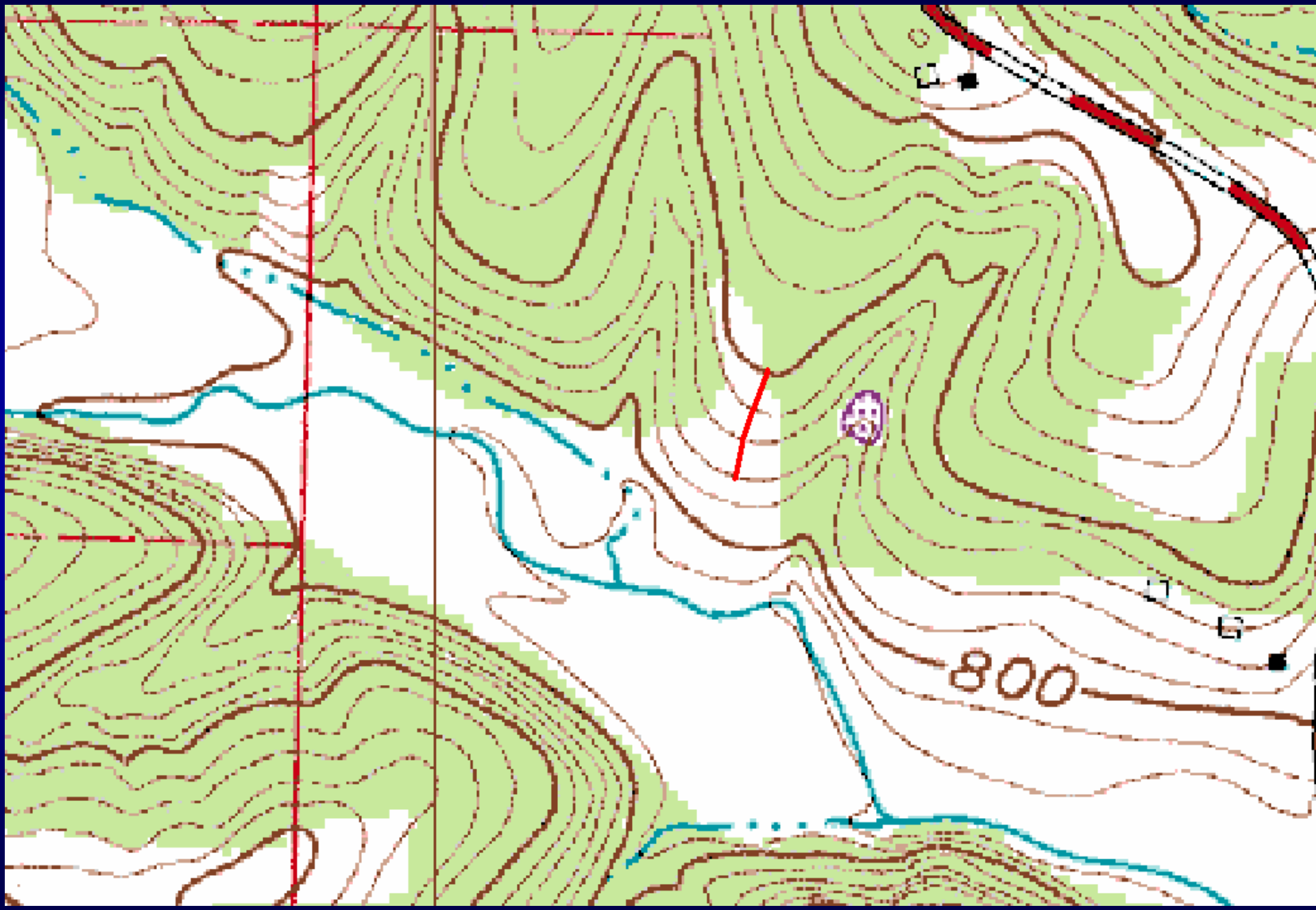
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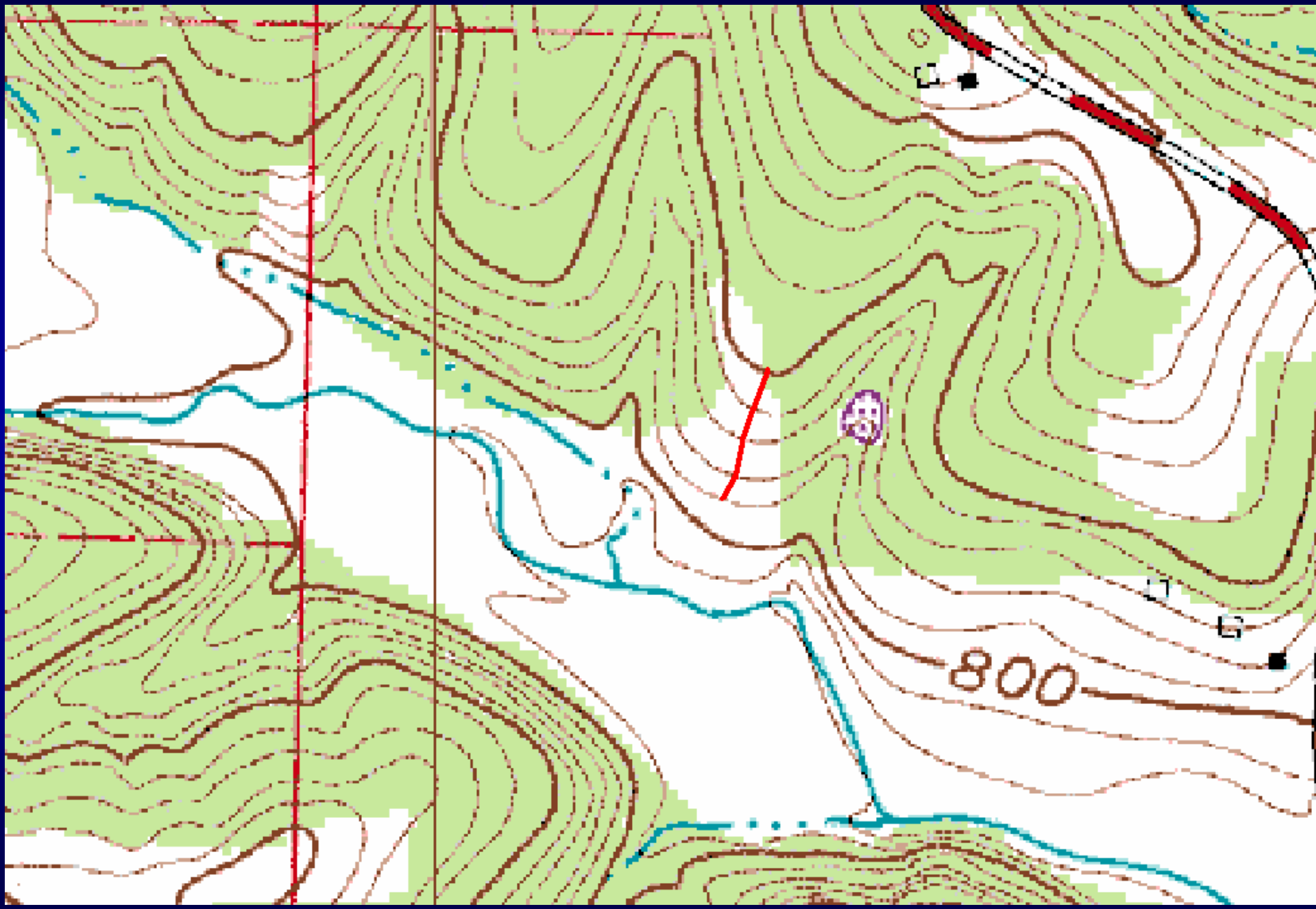
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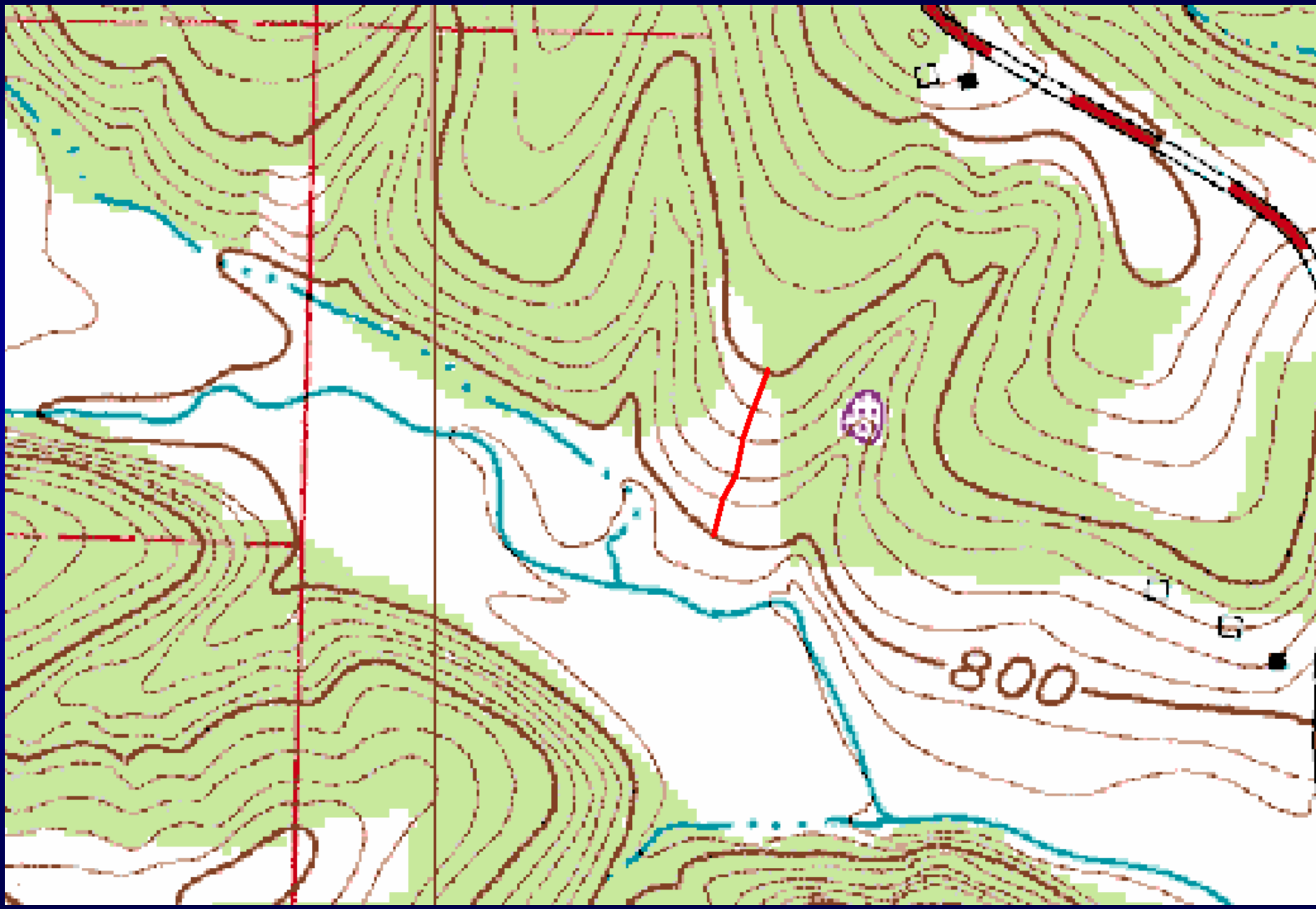
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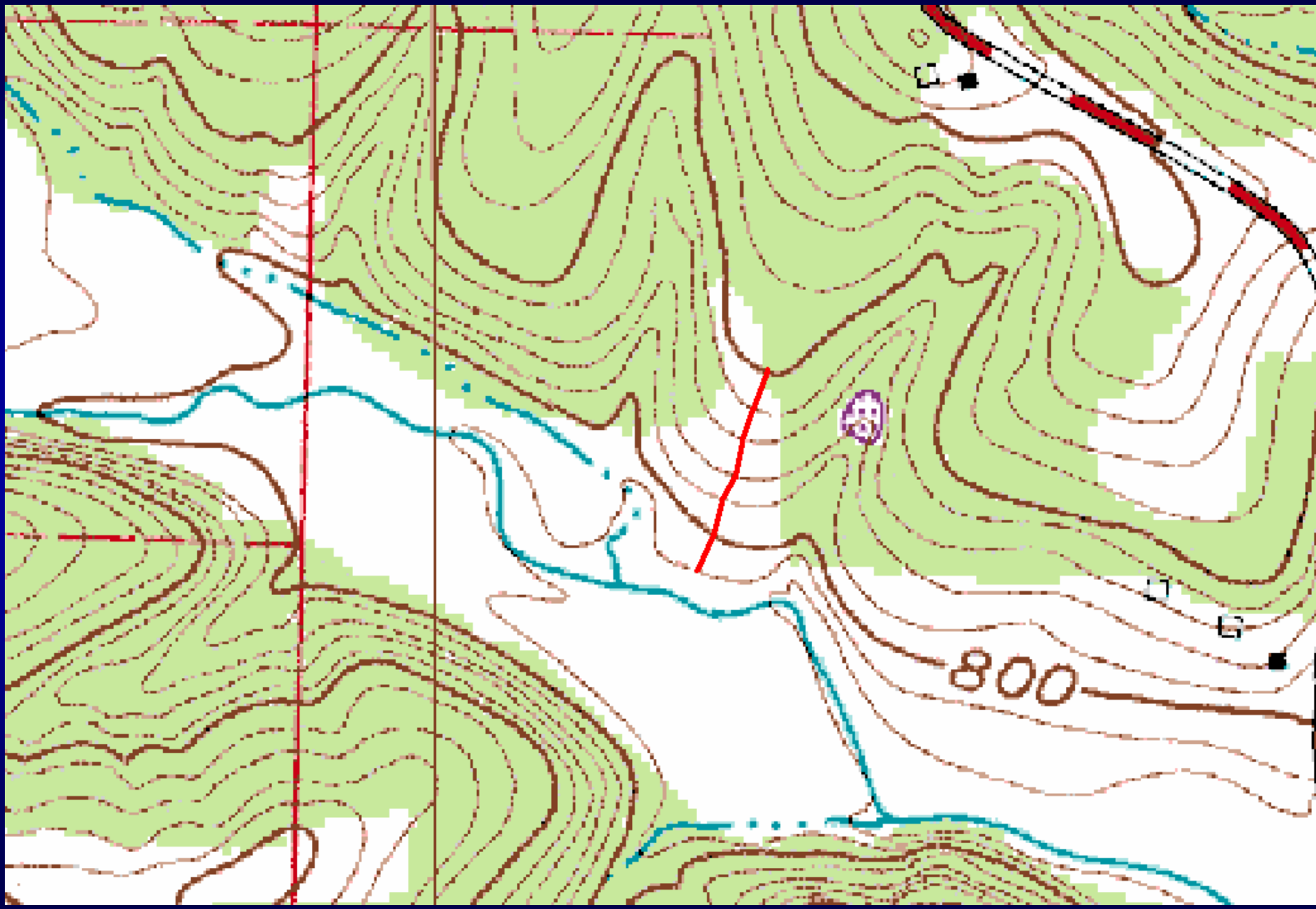
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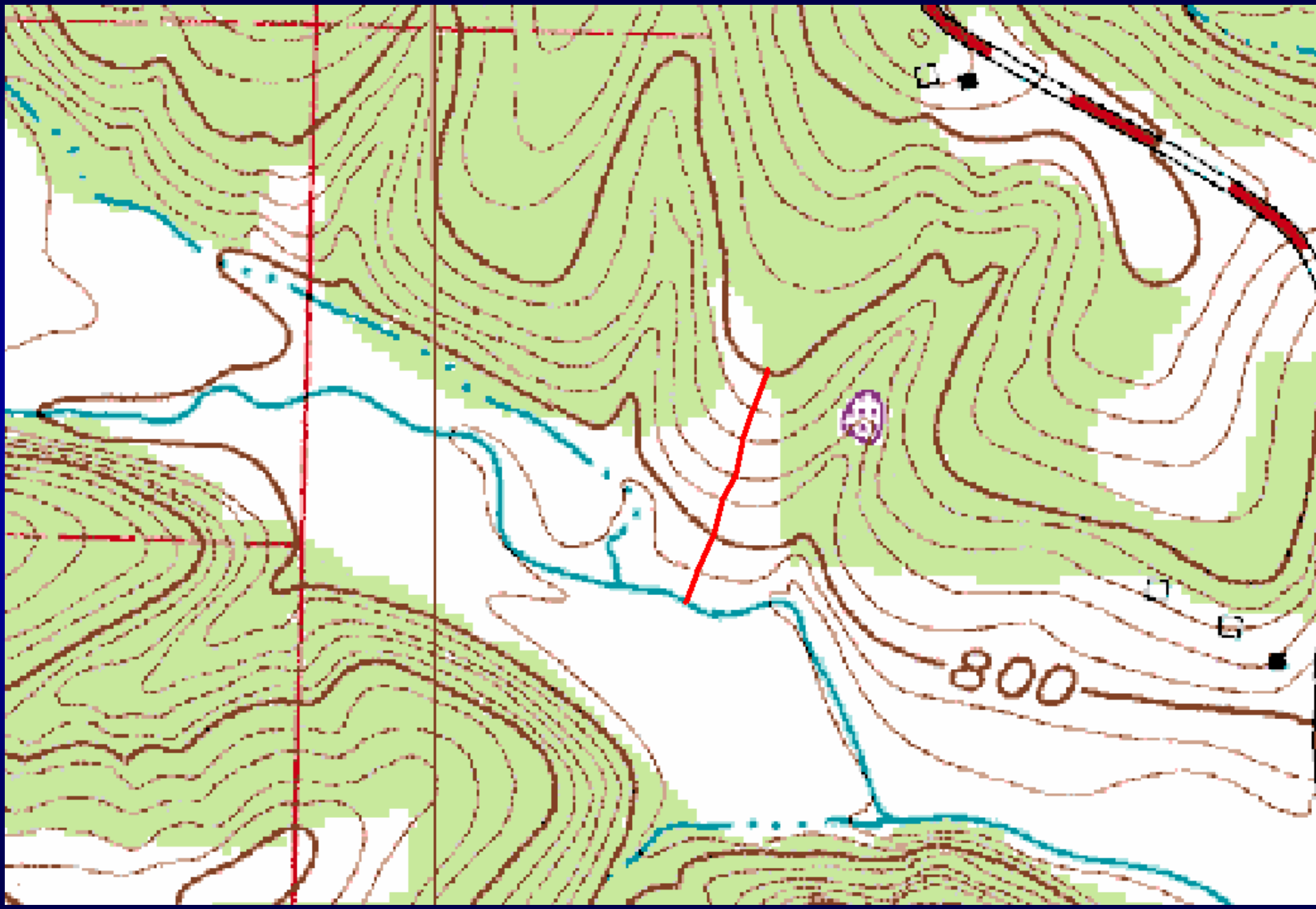
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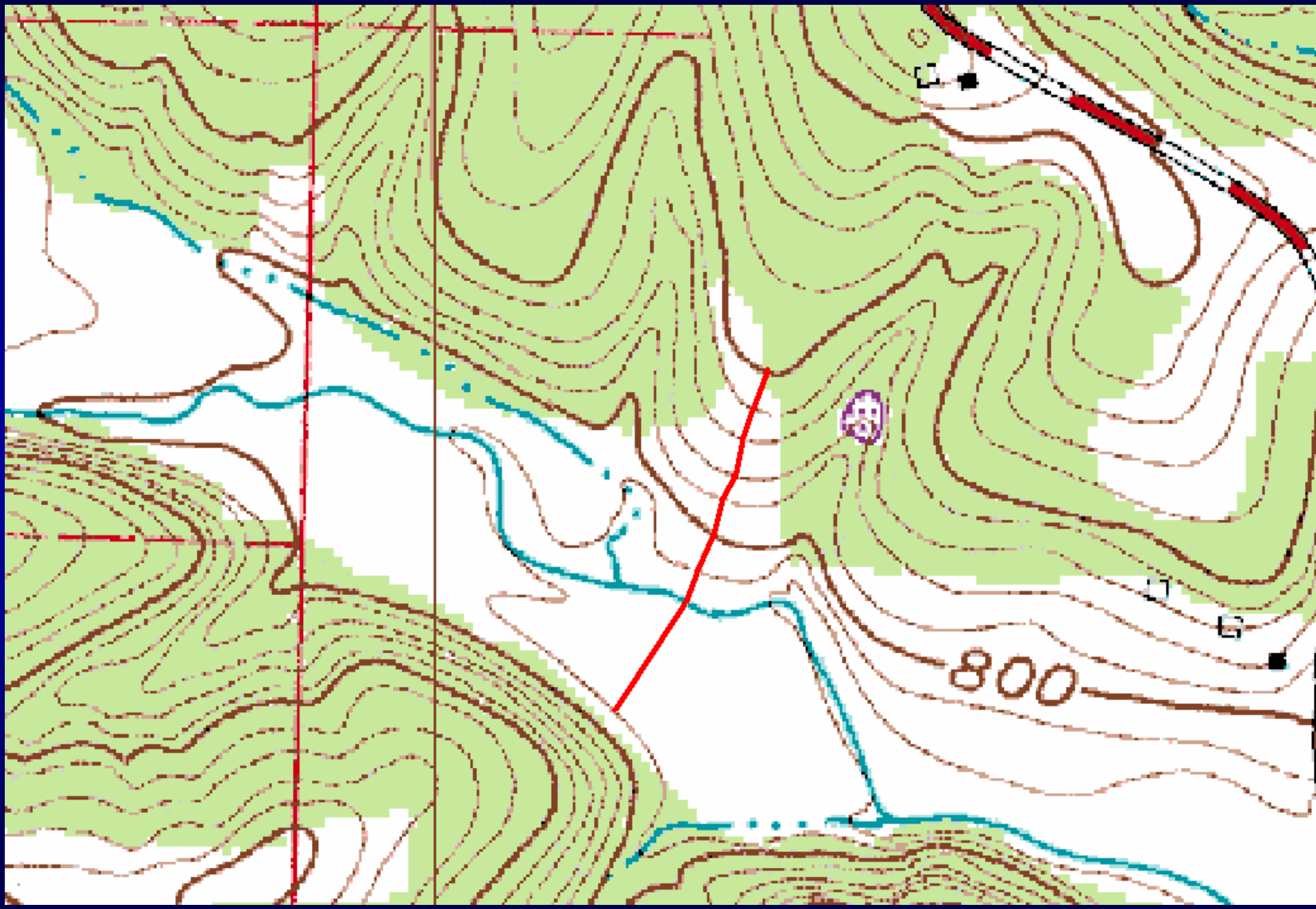
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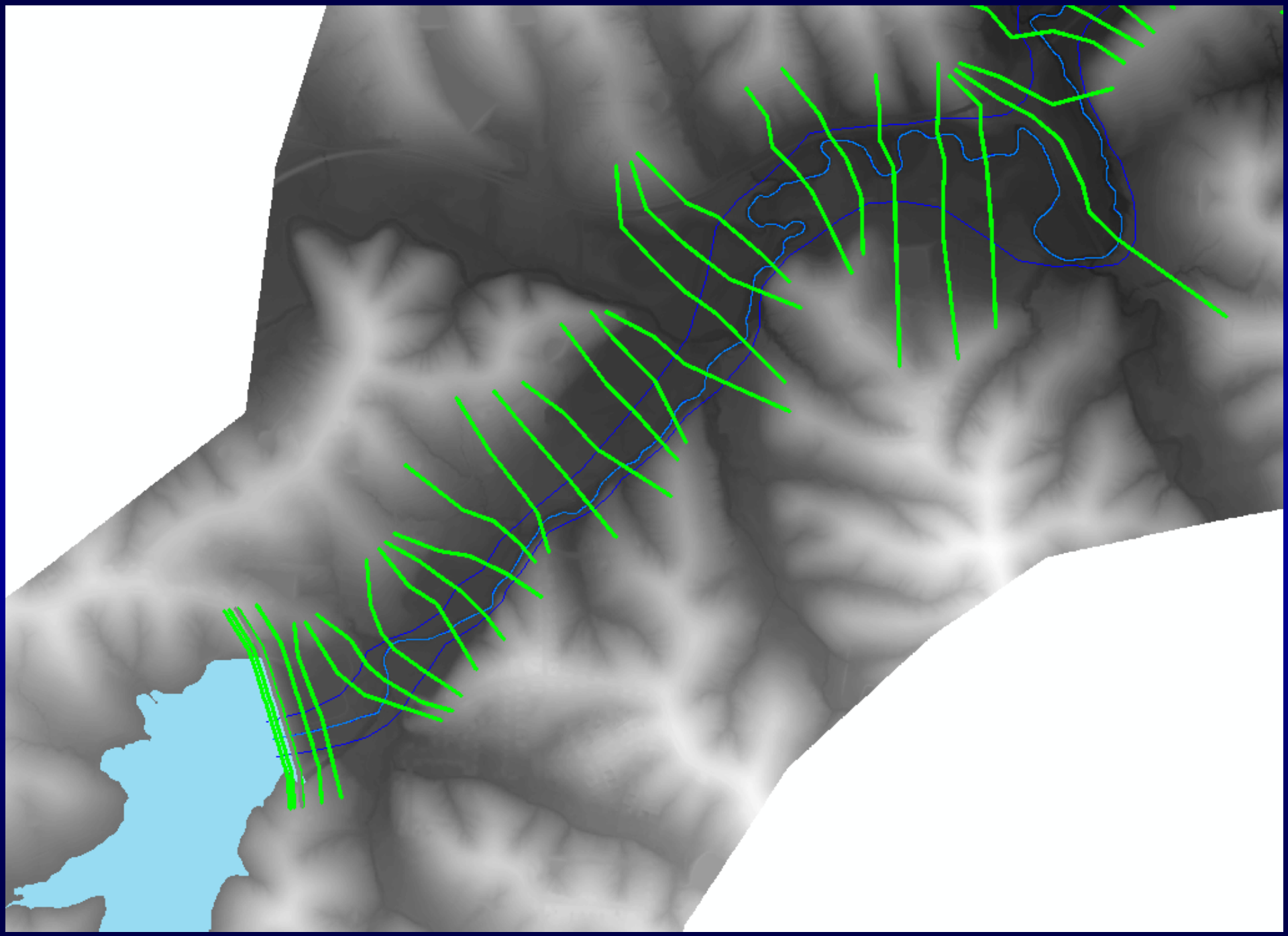
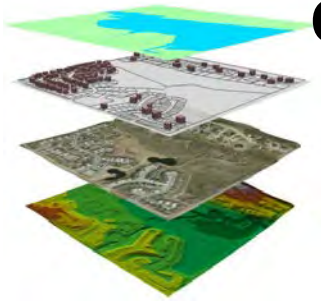




GIS

Map Layers

GeoDatabase

Data Extraction

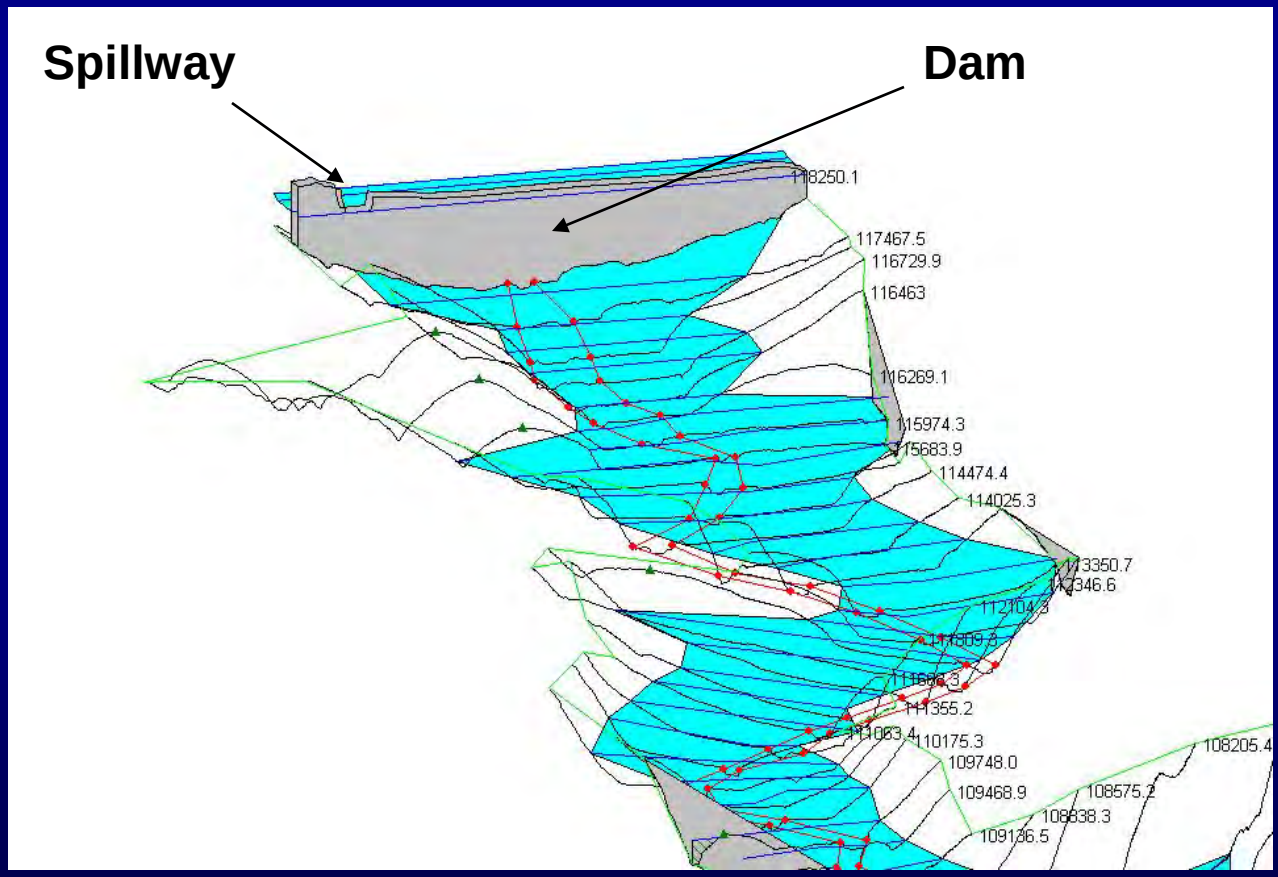
GeoRAS extension

Data Extraction

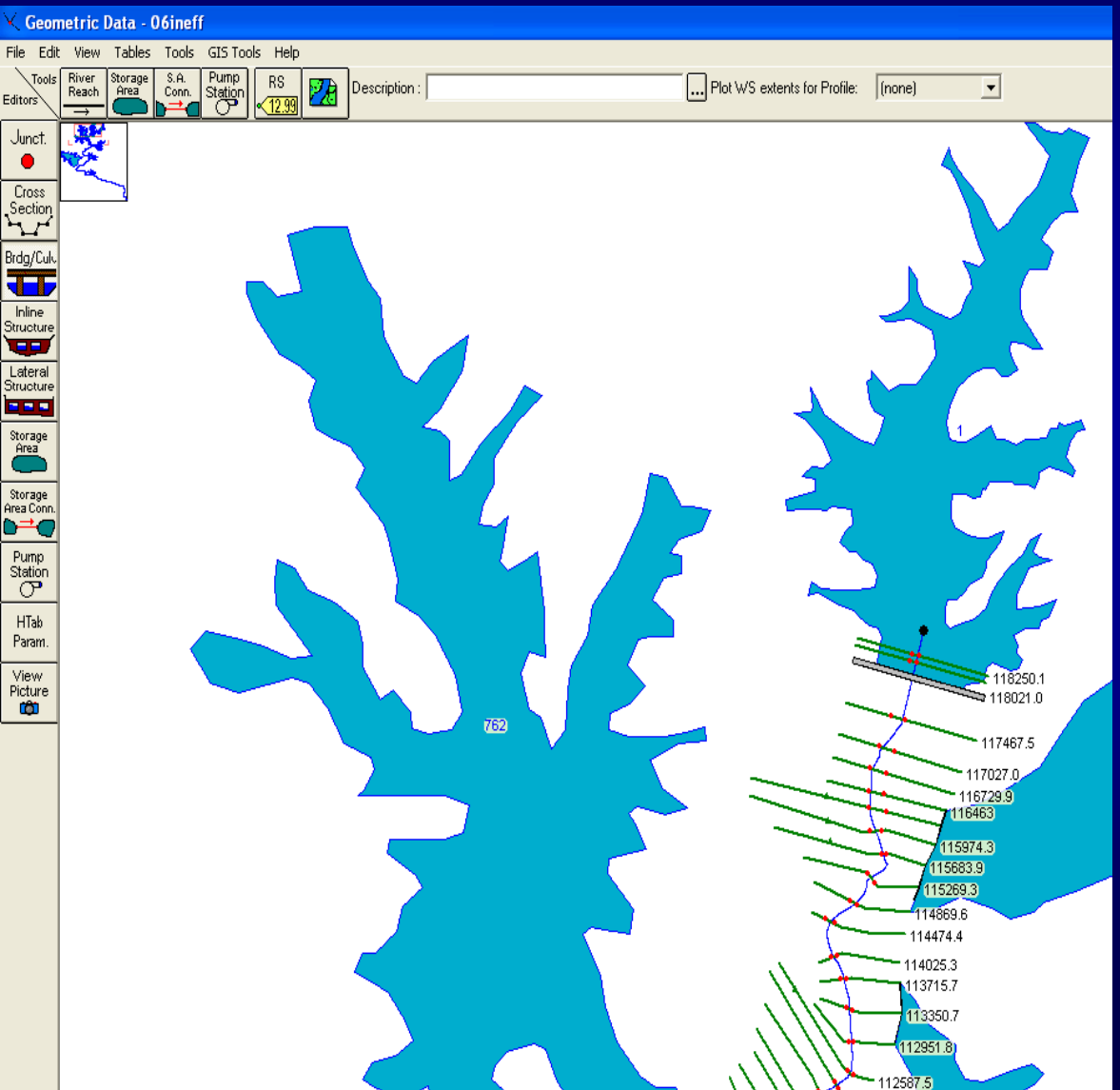
Breach Parameters → Develop Hydrograph → Downstream Routing

HEC-RAS

- Free download from USACE
- One dimensional model
- Steady and Unsteady flow
- Widely used and accepted
- Flexible, but consistent



Hydraulic Modeling



Geometric Data

- Reservoir
- Inline structures (Dam)
- Cross sections
- Bridges/culverts
- Lateral structures
- Storage areas

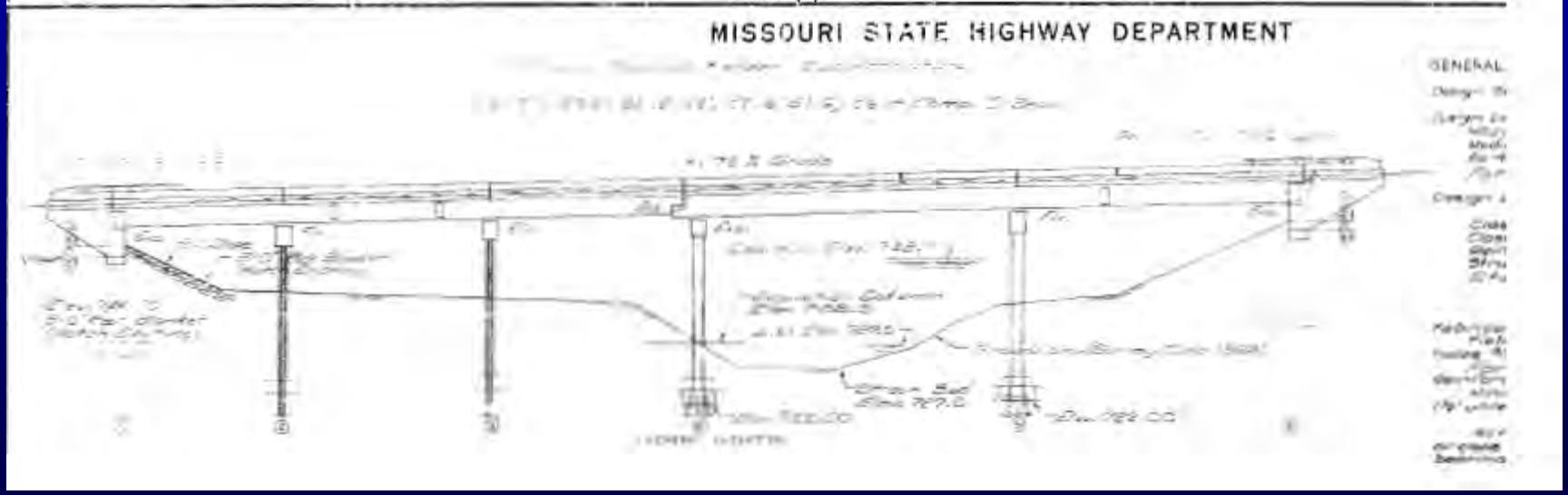
Modeling Assumptions

- Water surface elevation at failure (CSR 22-2.020)
- Failure criteria (overtopping)
- No additional flow from tributaries
- No rainfall event associated with the failure
- Initial flow
- No debris, only water in analysis
- Channel roughness based on aerial photography

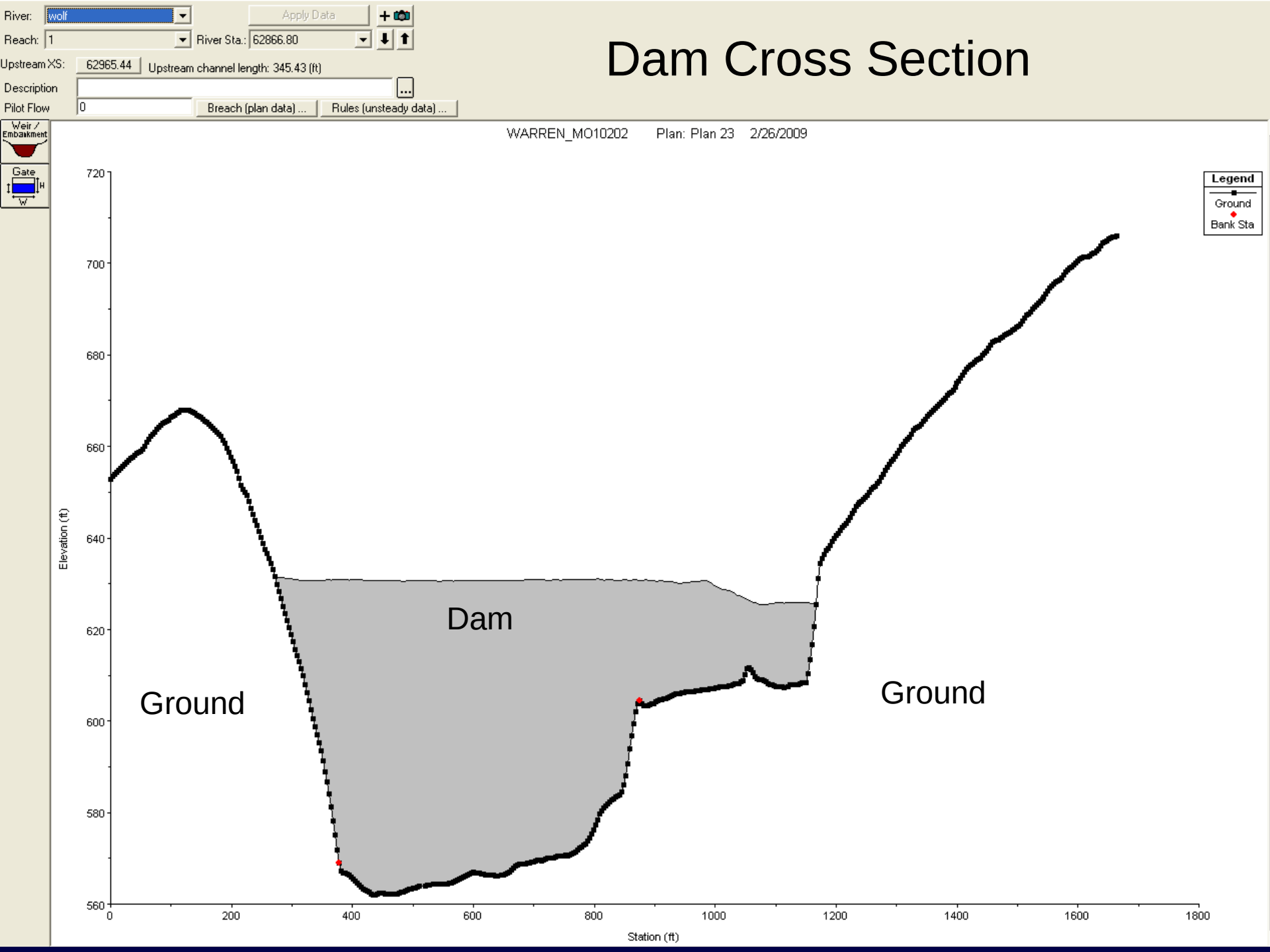
Field Work

- Type of structure
- Deck width
- Deck length
- Headwall location and orientation
- Total chord depth
- Pier size and location (bridge only)
- Length (culvert only)

Bridge Modeling



Dam Cross Section

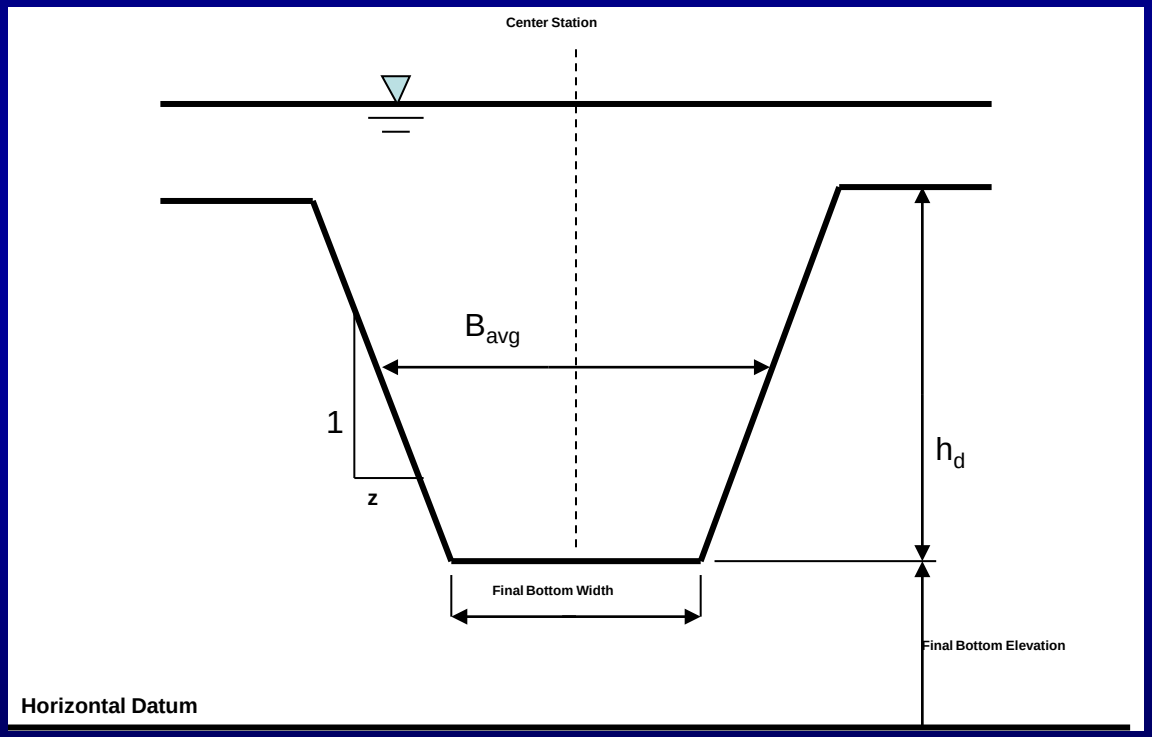


Breach Parameters

Froehlich 1995

Average Breach Width
- Height of Dam
- Volume of Water

Breach Formation Time
- Height of Dam
- Volume of Water



Side Slope Factor

Z = 1.4 for overtopping

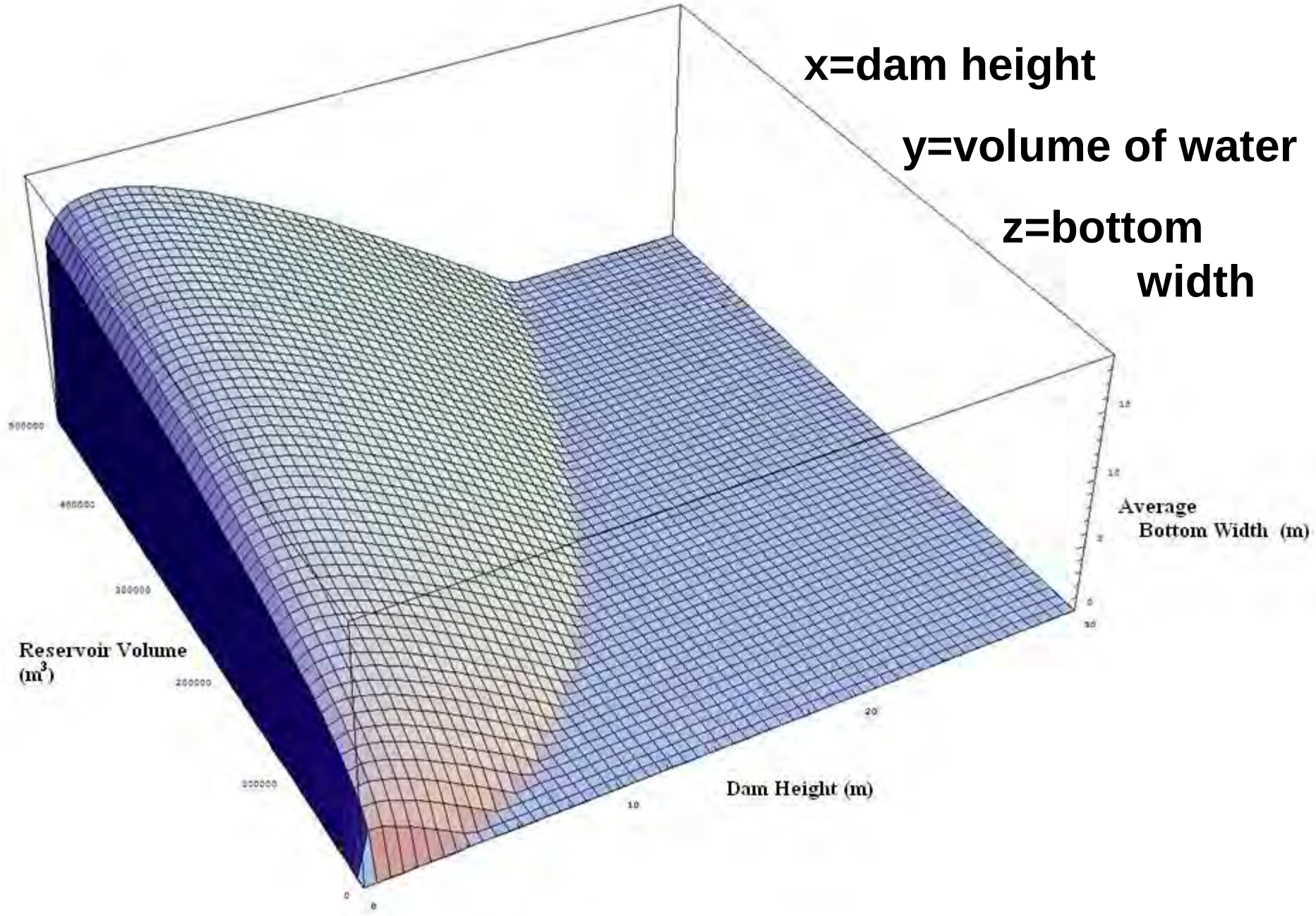
Z = 0.9 other failure modes

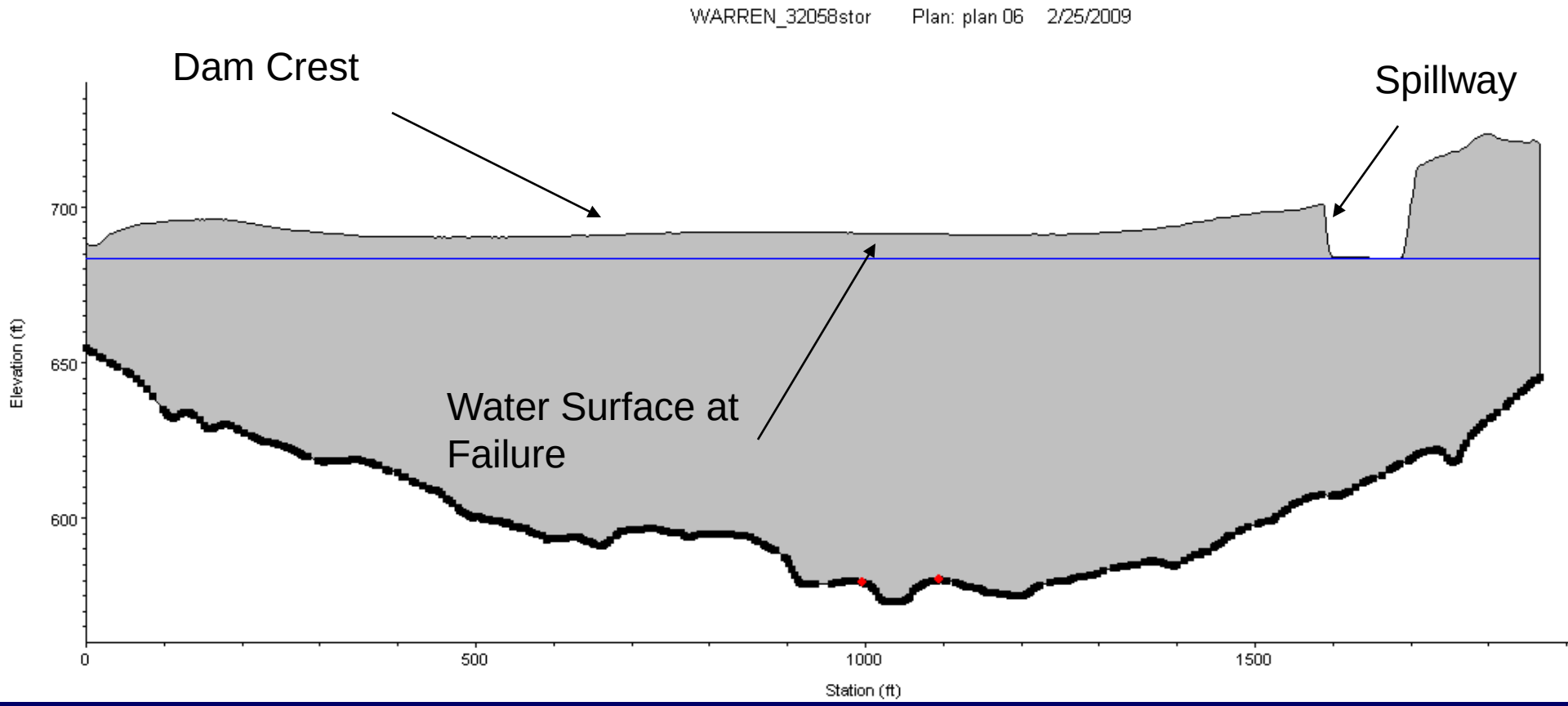
Froehlich 1995

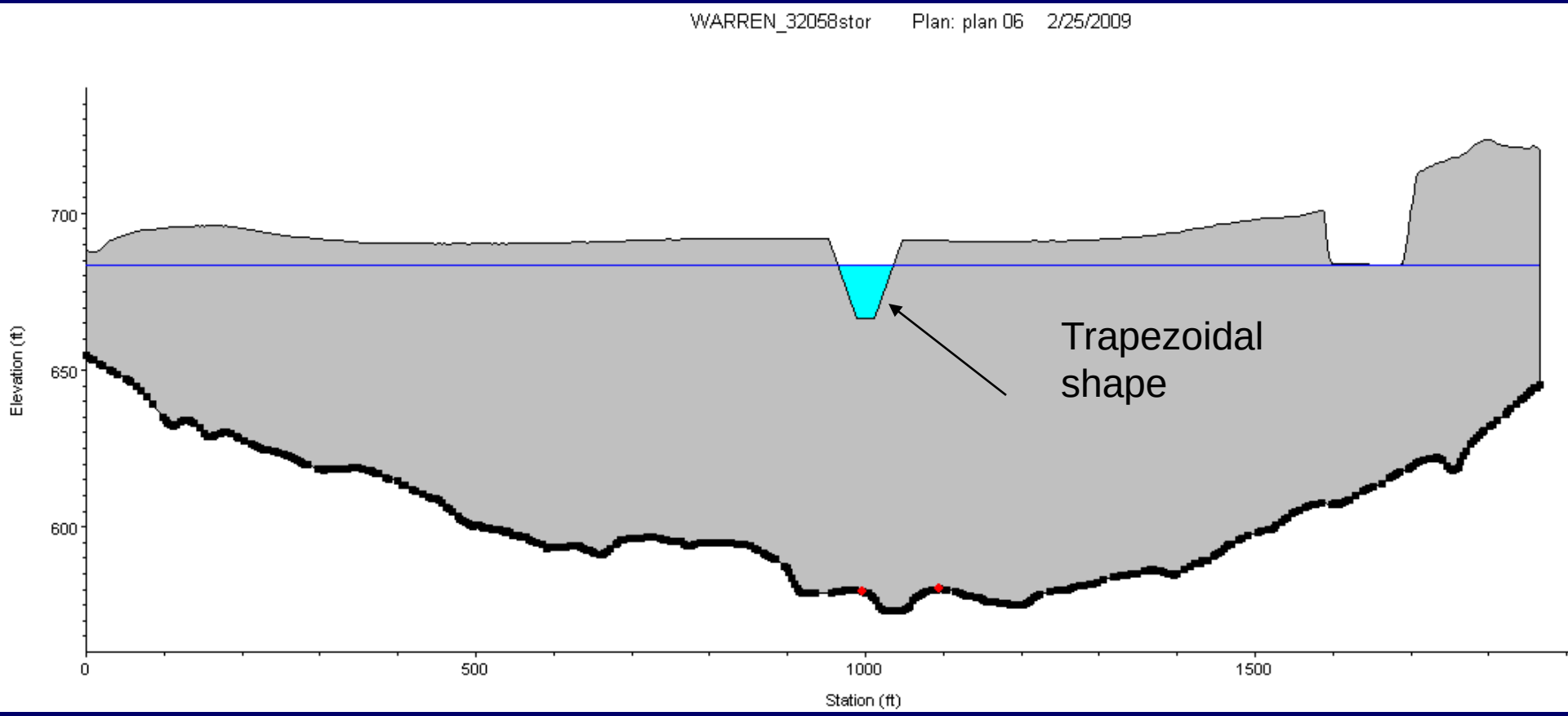
x=dam height

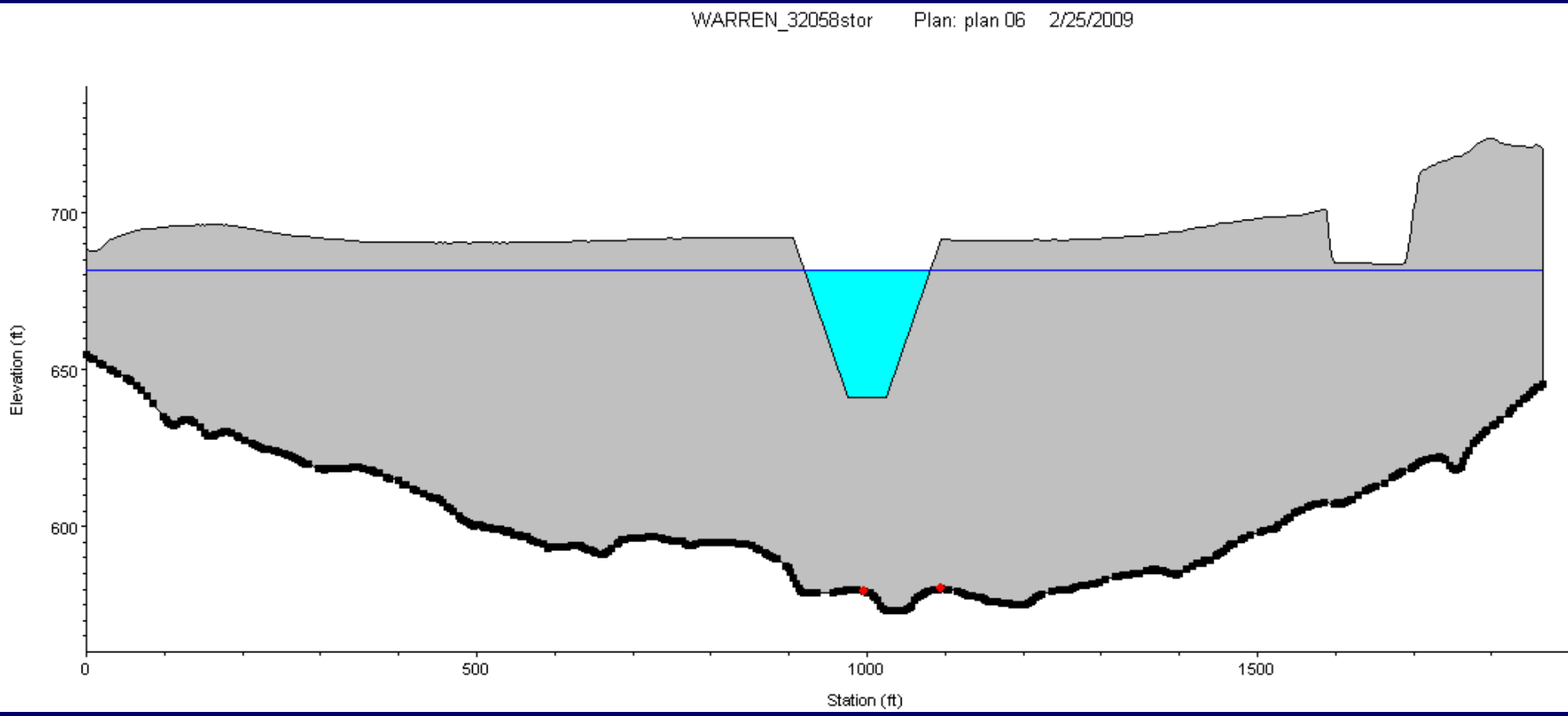
y=volume of water

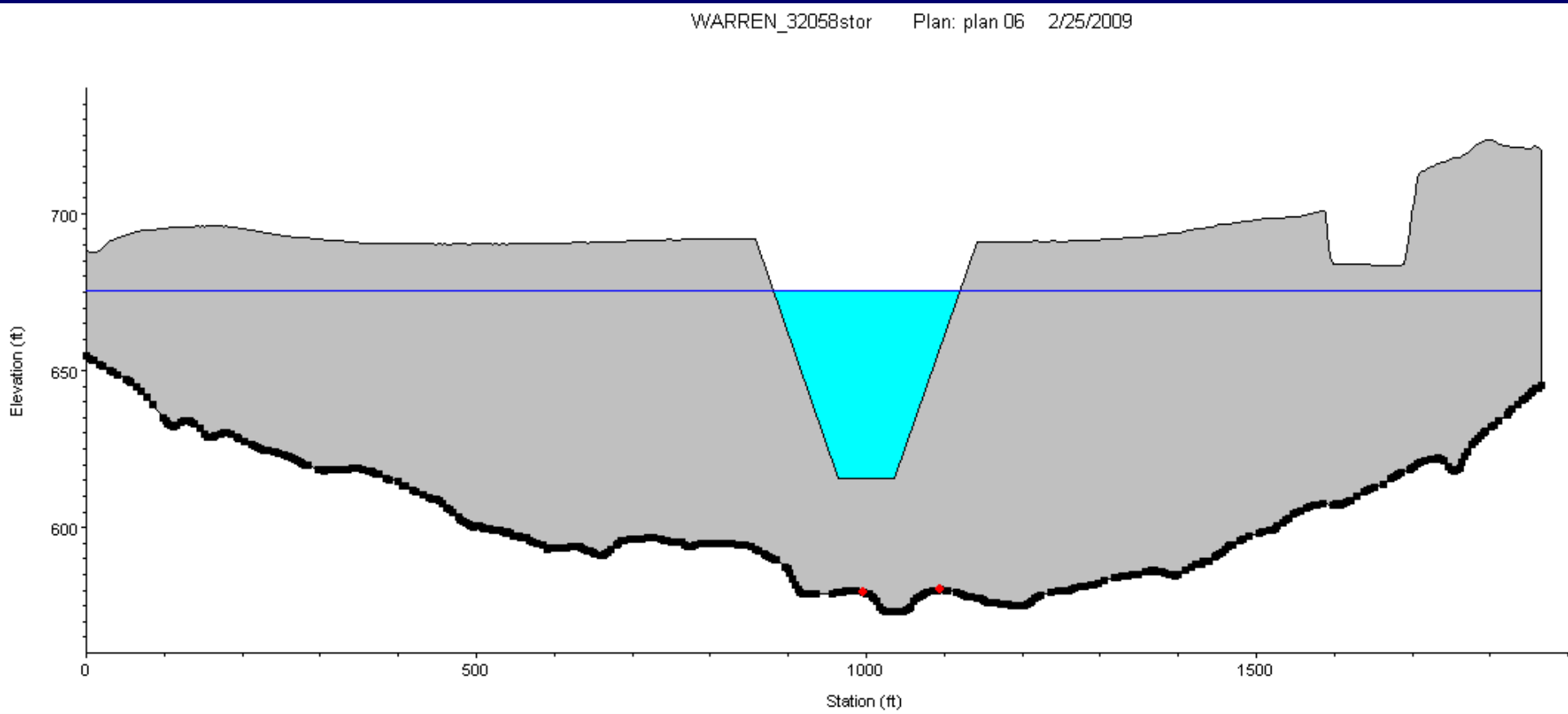
z=bottom width

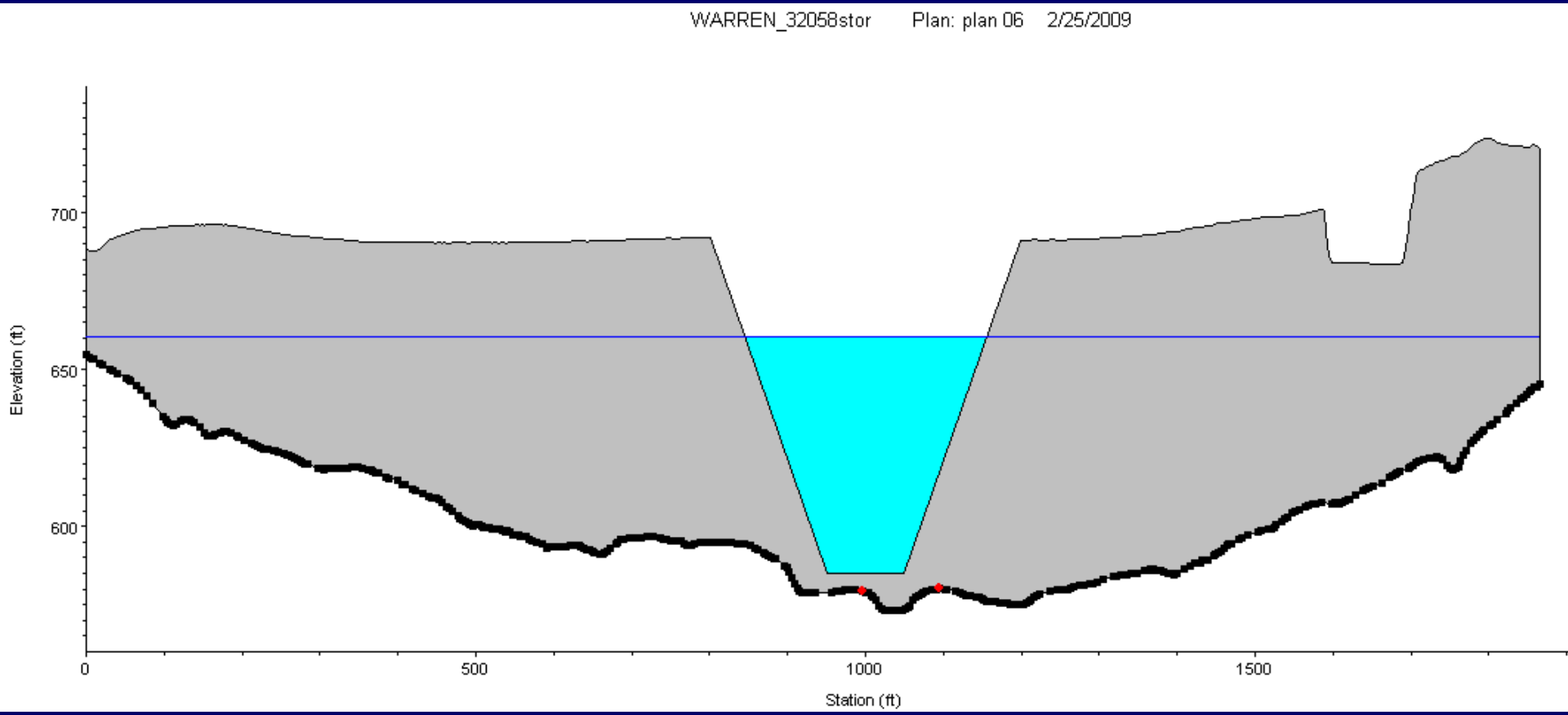



WARREN_32058stor Plan: plan 06 2/25/2009
Dam Crest
Spillway
Water Surface at Failure
Elevation (ft)
700
650
600
0
500
1000
1500
Station (ft)

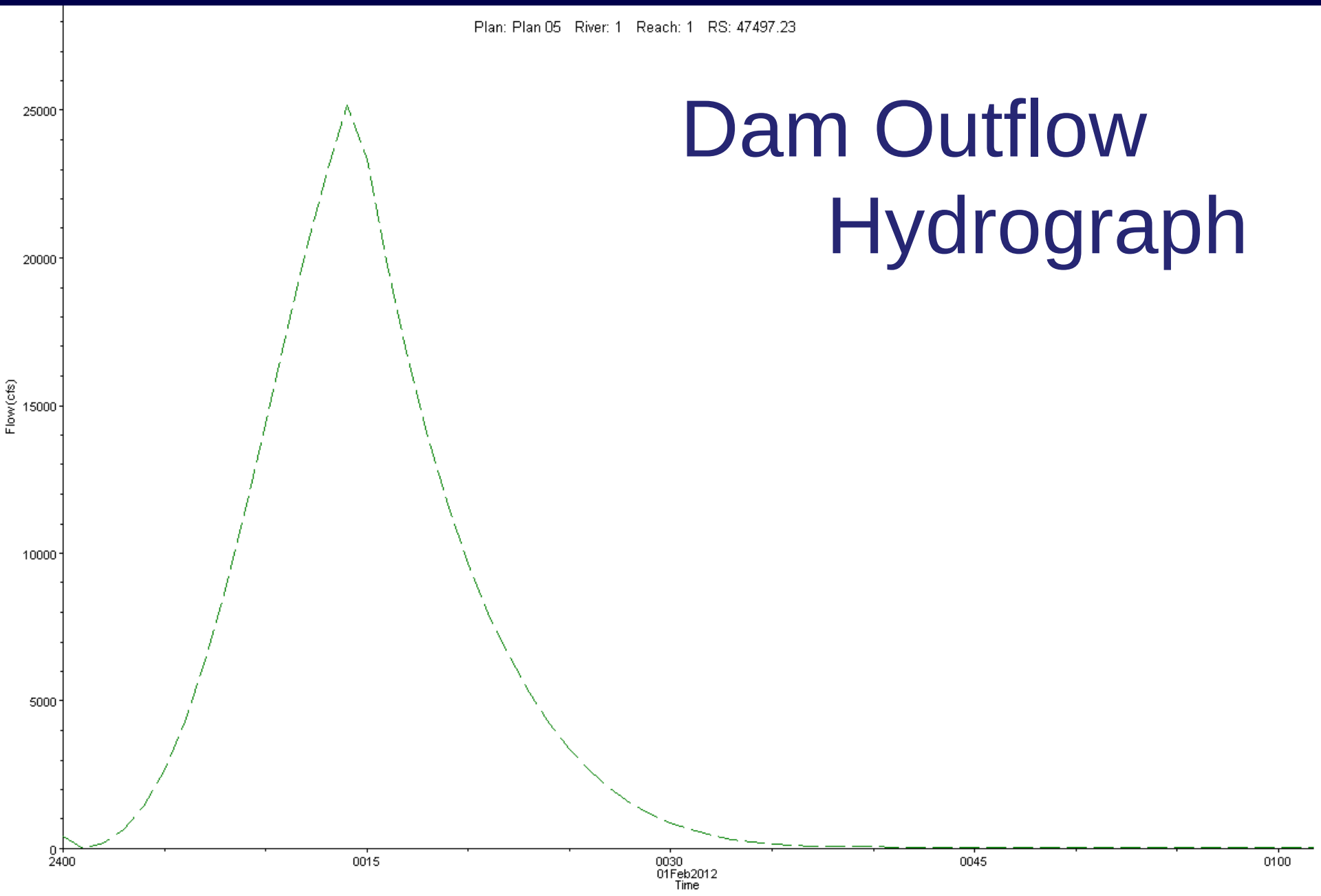

WARREN_32058stor Plan: plan 06 2/25/2009
Elevation (ft)
700
650
600
0
500
1000
1500
Station (ft)
Trapezoidal shape

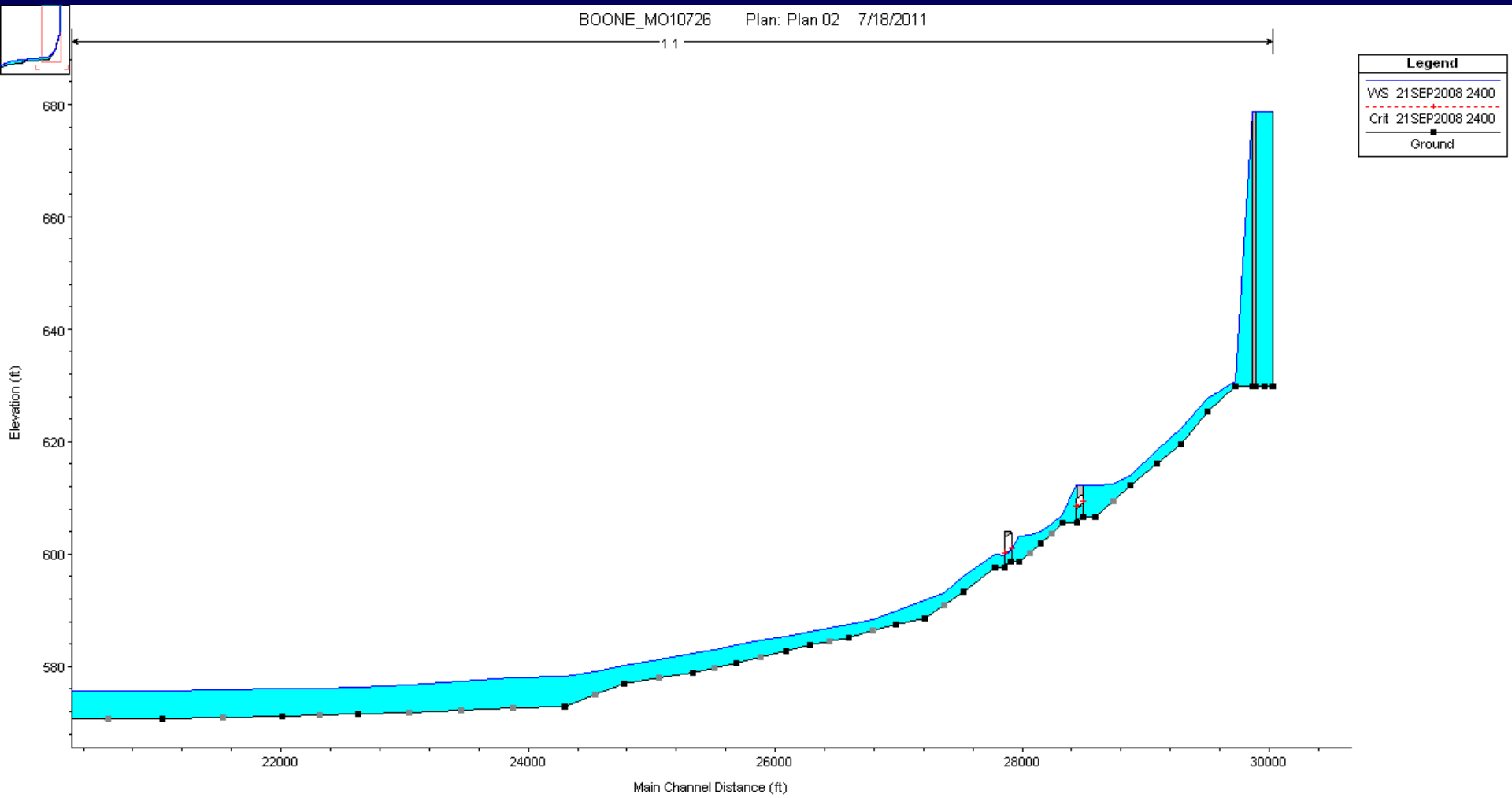

WARREN_32058stor Plan: plan 06 2/25/2009
700
650
600
Elevation (ft)
0
500
1000
1500
Station (ft)


WARREN_32058stor Plan: plan 06 2/25/2009
Elevation (ft)
700
650
600
0
500
1000
1500
Station (ft)


WARREN_32058stor Plan: plan 06 2/25/2009
Elevation (ft)
700
650
600
0
500
1000
1500
Station (ft)

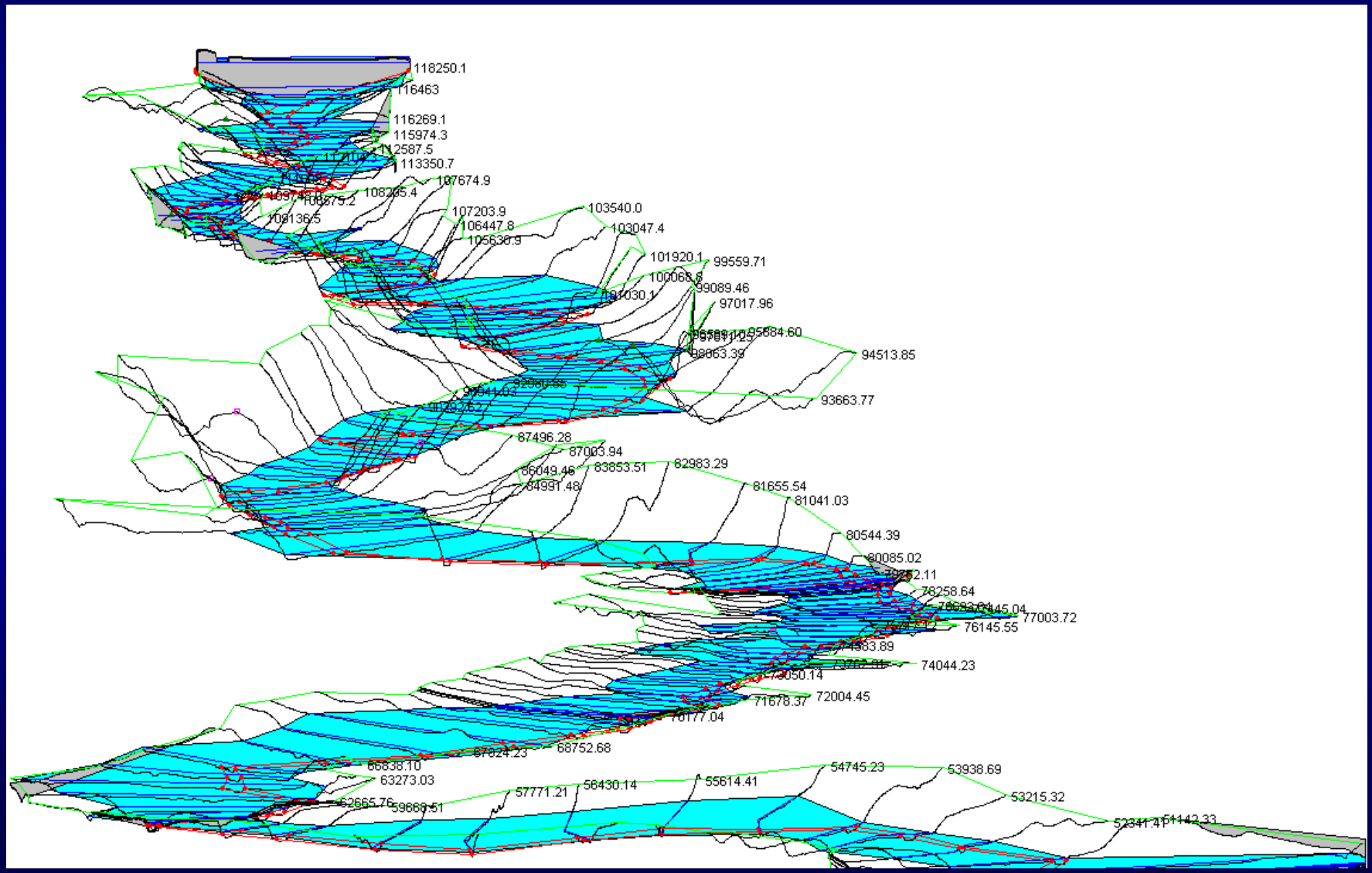
Dam Outflow Hydrograph

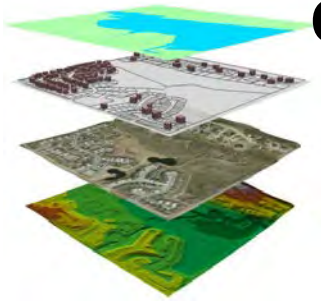



BOONE_MO10726 Plan: Plan 02 7/18/2011
1 1
Legend
WS 21SEP2008 2400
Crit 21SEP2008 2400
Ground
680
660
640
620
600
580
Elevation (ft)
22000
24000
26000
28000
30000
Main Channel Distance (ft)

Missouri
Department of
Natural Resources

HEC-RAS Maximum WS





GIS

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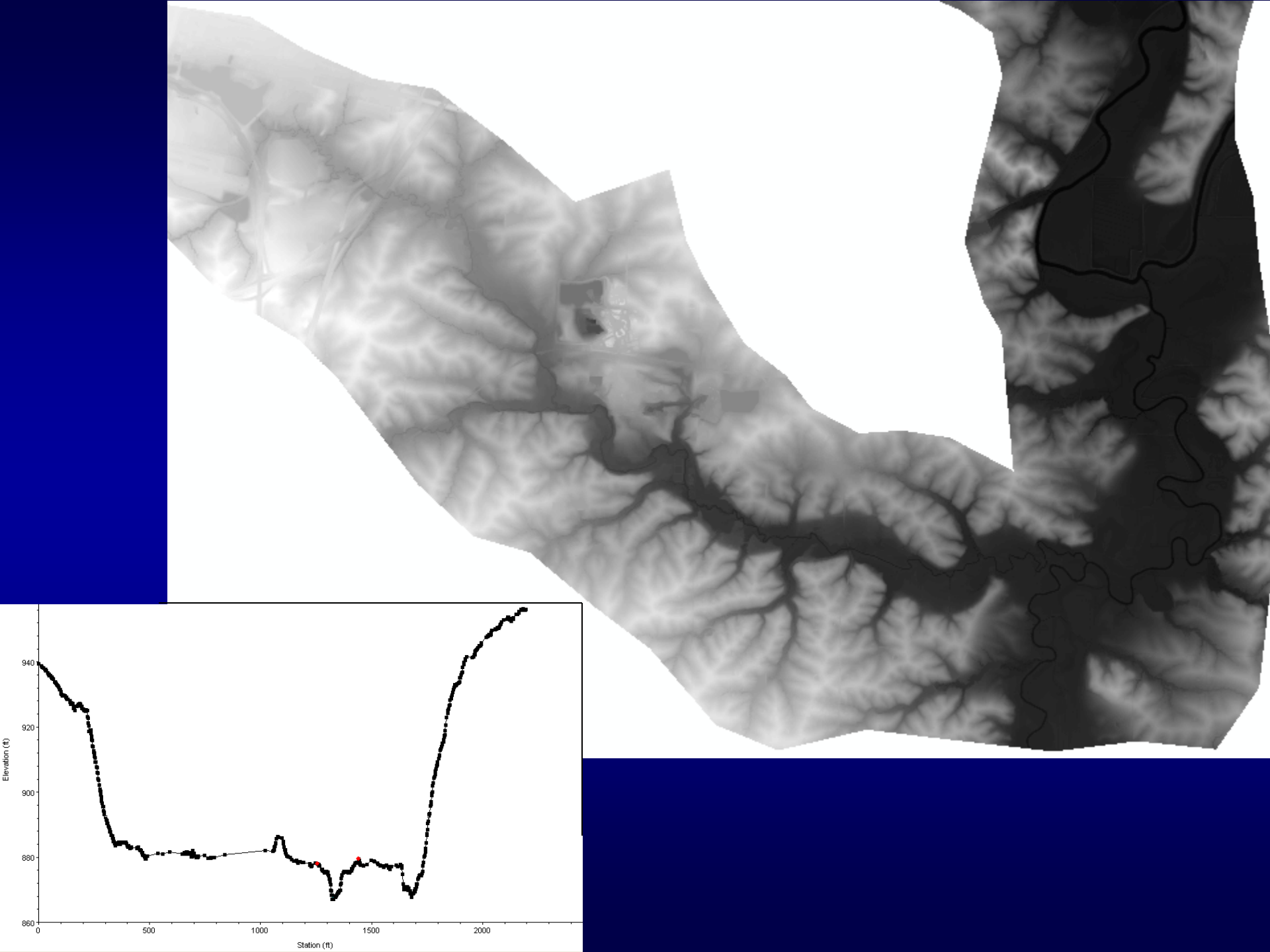
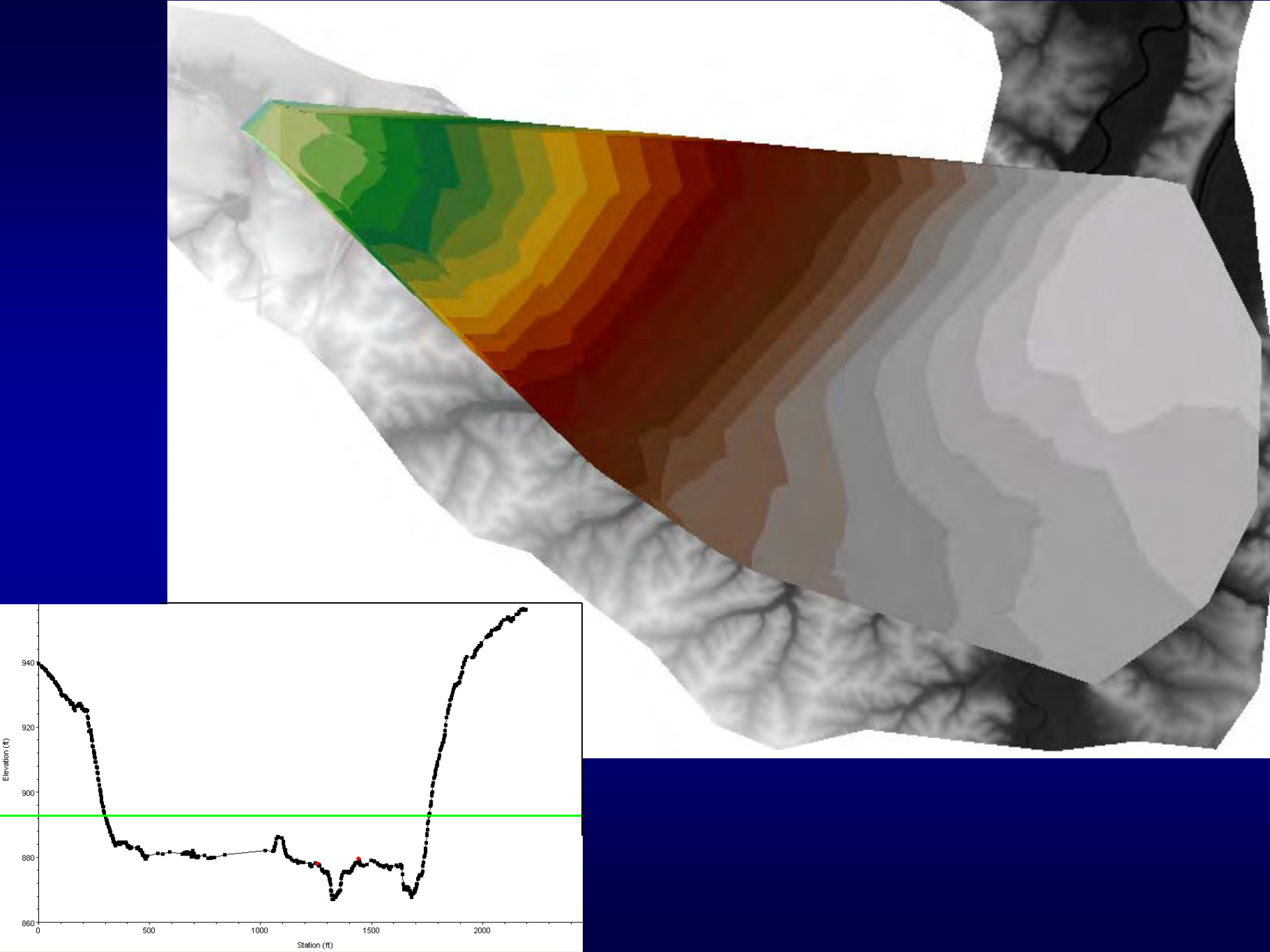
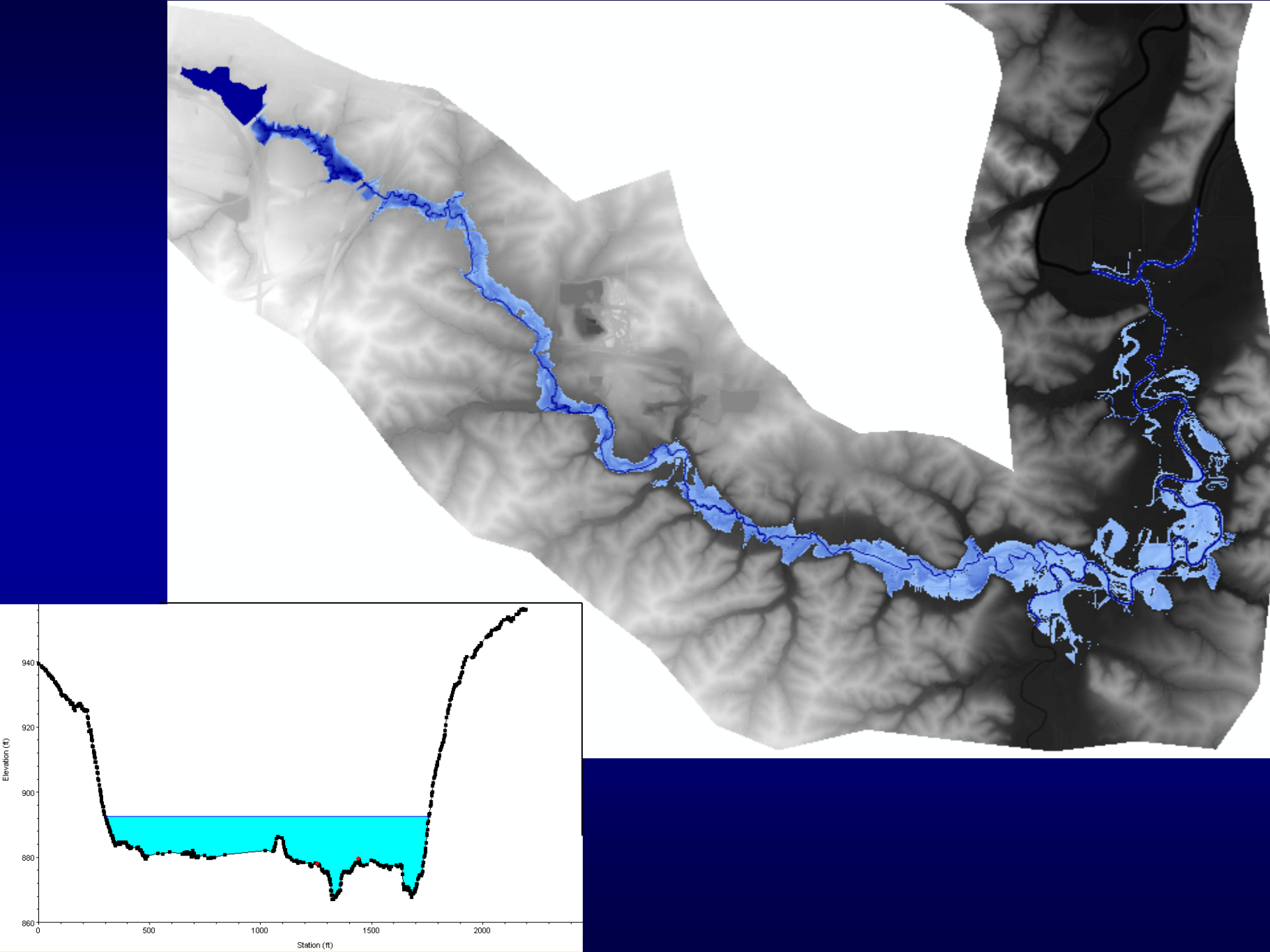
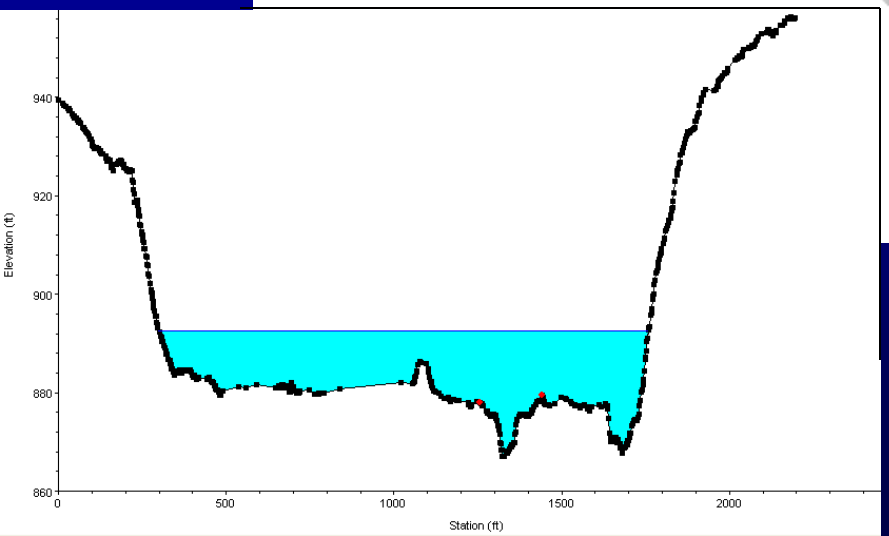
Data Extraction

Breach Parameters → Develop Hydrograph → Downstream Routing

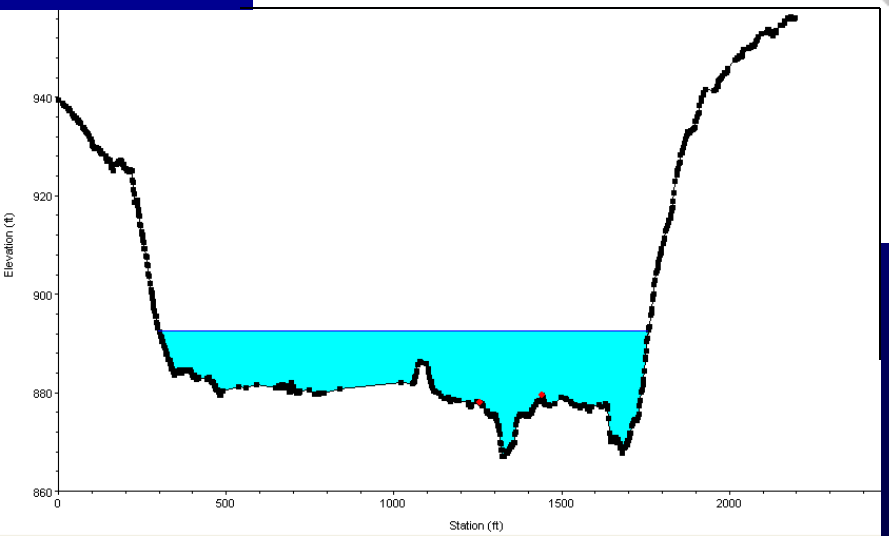

940
920
900
880
860
Elevation (ft)
0
500
1000
1500
2000
Station (ft)


940
920
900
880
860
Elevation (ft)
0
500
1000
1500
2000
Station (ft)

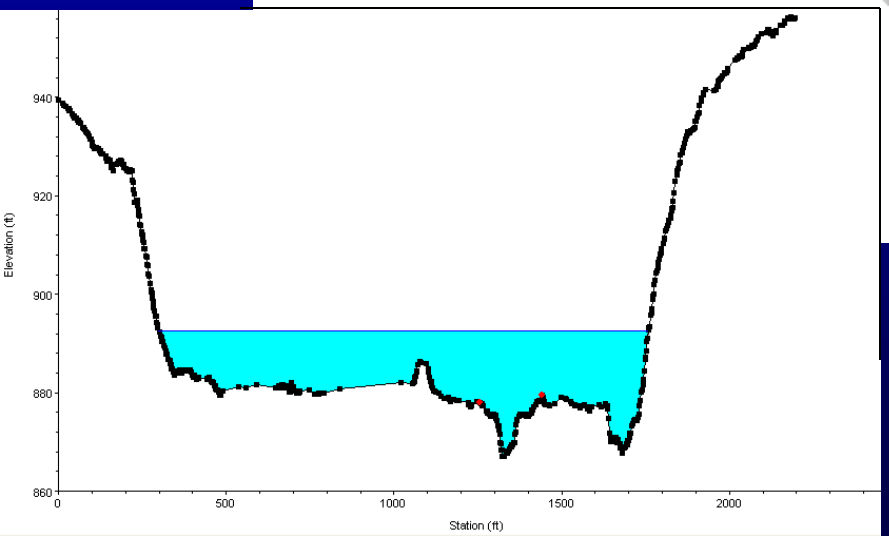

940
920
900
880
860
Elevation (ft)
0
500
1000
1500
2000
Station (ft)


940
920
900
880
860
Elevation (ft)
0
500
1000
1500
2000
Station (ft)

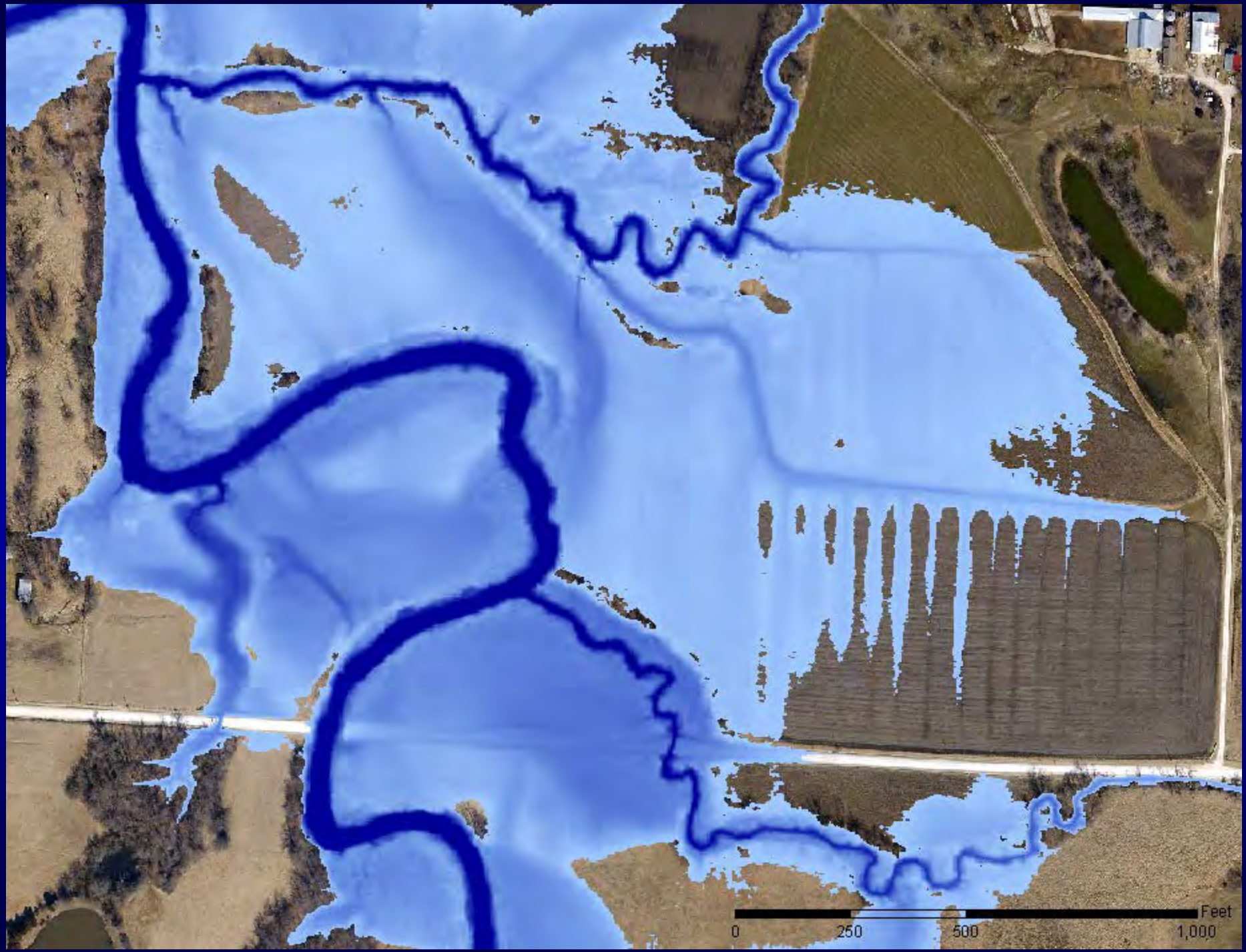
892.63


940
920
900
880
860
Elevation (ft)
0
500
1000
1500
2000
Station (ft)

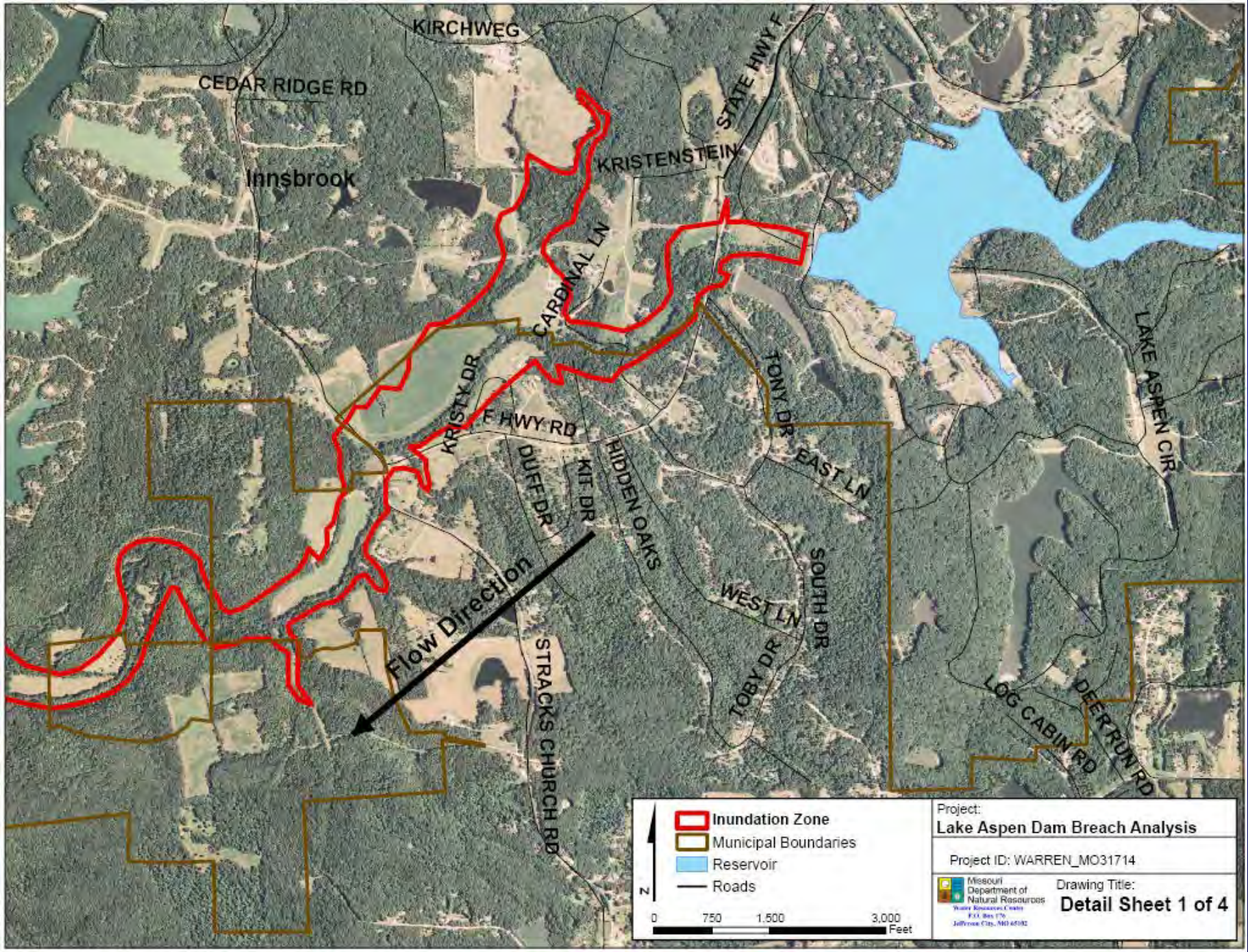
892.63 – 881.09

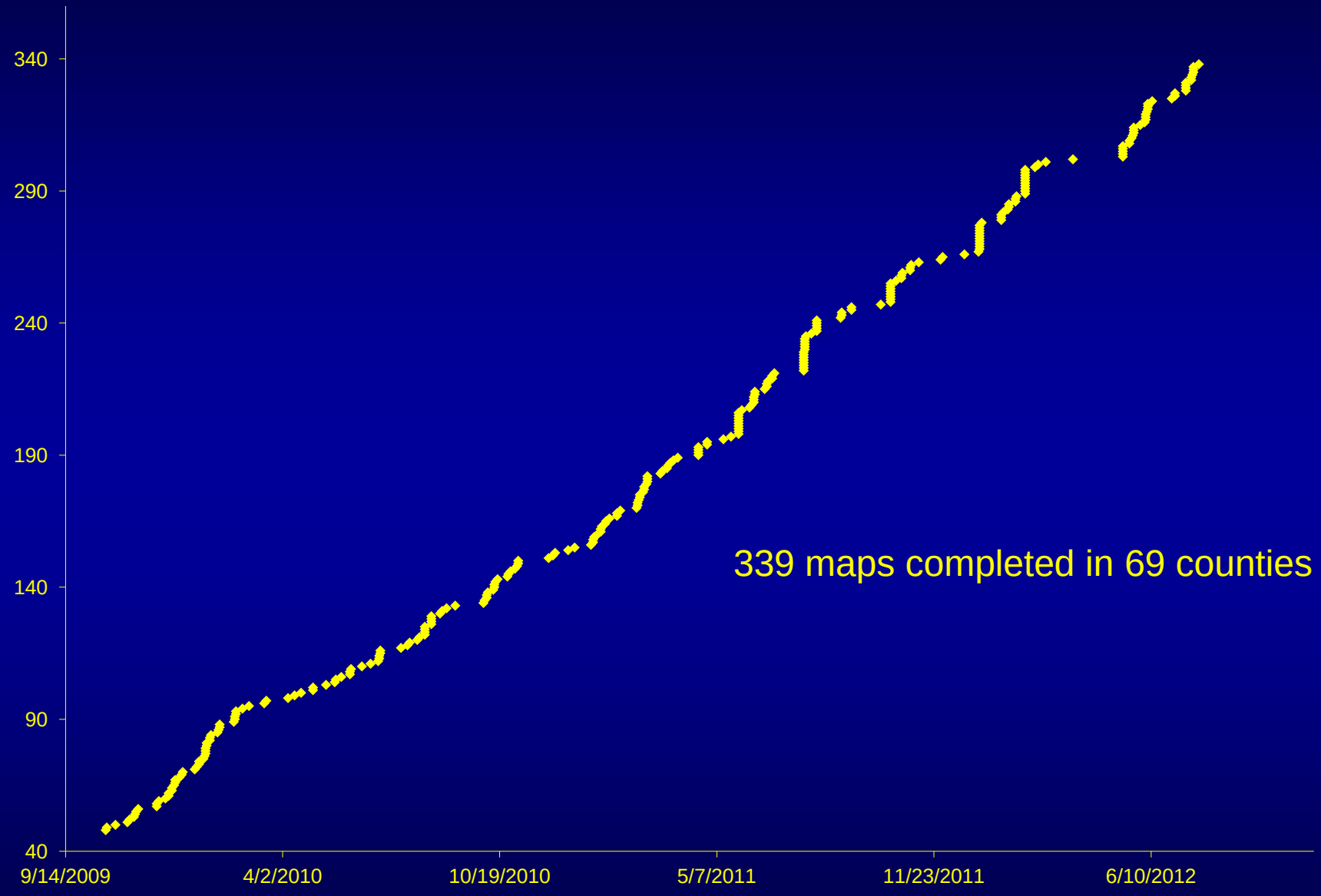


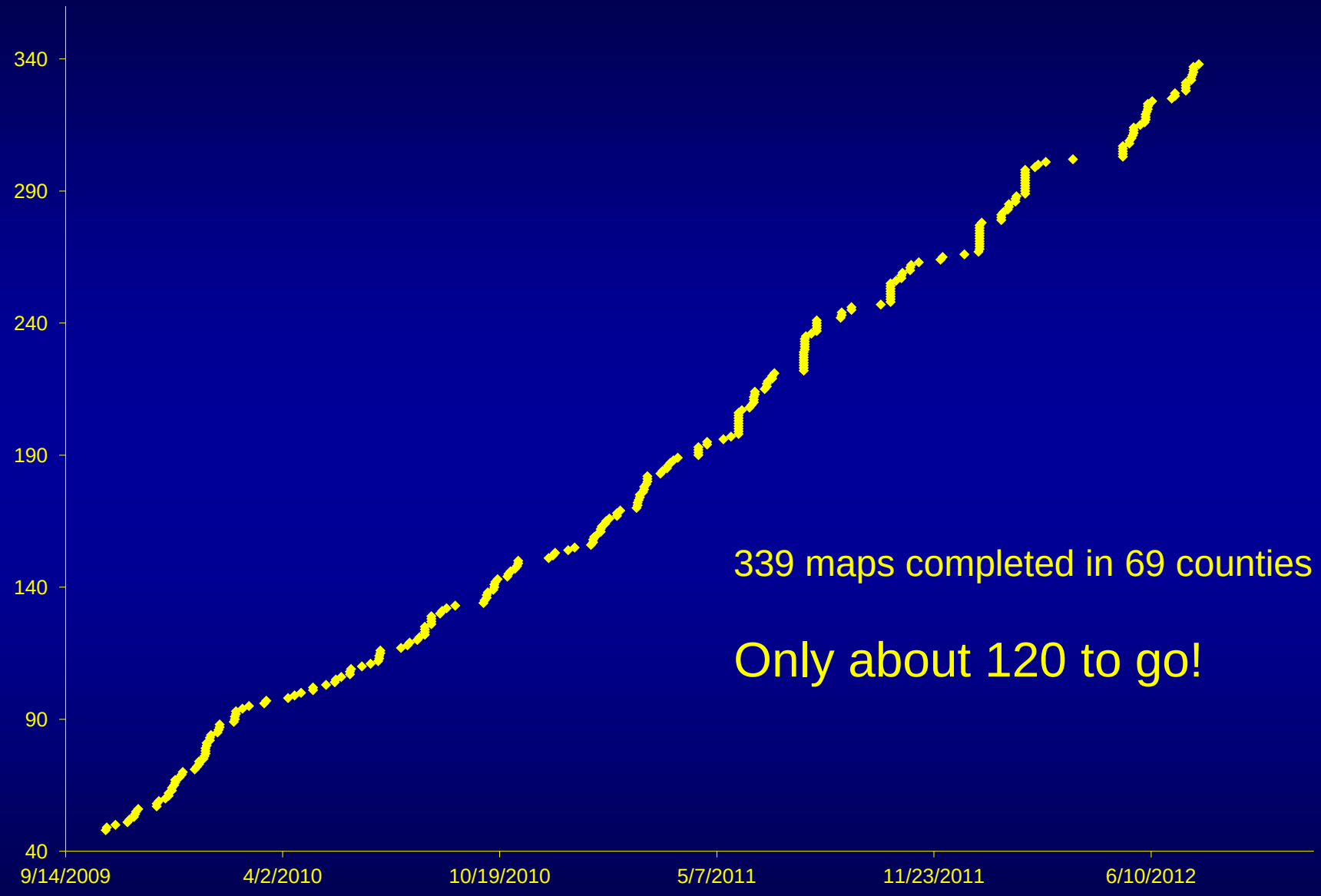
892.63 – 881.09 = 11.54 ft


0
250
500
1,000
Feet


0
250
500
1,000
Feet


KIRCHWEG
CEDAR RIDGE RD
Innsbrook
STATE HWY F
KRISTENSTEIN
CARDINAL LN
KRISTY DR
F HWY RD
DUFF DR
KIT DR
HIDDEN OAKS
TONY DR
EAST LN
LAKE ASPEN CIR
SOUTH DR
WEST LN
TOBY DR
LOG CABIN RD
DEER RUN RD
STRACKS CHURCH RD
Flow Direction
Inundation Zone
Municipal Boundaries
Reservoir
Roads
N
0
750
1,500
3,000
Feet
Project:
Lake Aspen Dam Breach Analysis
Project ID: WARREN_MO31714
Missouri Department of Natural Resources
Drawing Title:
Detail Sheet 1 of 4


340
290
240
190
140
90
40
9/14/2009
4/2/2010
10/19/2010
5/7/2011
11/23/2011
6/10/2012
339 maps completed in 69 counties


340
290
240
190
140
90
40
9/14/2009
4/2/2010
10/19/2010
5/7/2011
11/23/2011
6/10/2012
339 maps completed in 69 counties
Only about 120 to go!

Contact Information

michael.weller@dnr.mo.gov

Missouri
Department of
Natural Resources

Water Resources Center

www.dnr.mo.gov/env/wrc

Thank You

Missouri
Department of
Natural Resources