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A New Era in Inundation Mapping

Using GIS to Develop Dam Breach Modeling and Mapping

Scott Arends, P.E., Dam Safety / Water Resources Engineer

Hanson Professional Services Inc.

Inundation Mapping

- Emergency Planning

Inundation Mapping

- Resource Allocation

Inundation Mapping

- Evacuation

AP Photo/Dave Martin

Inundation Mapping

- How to convert

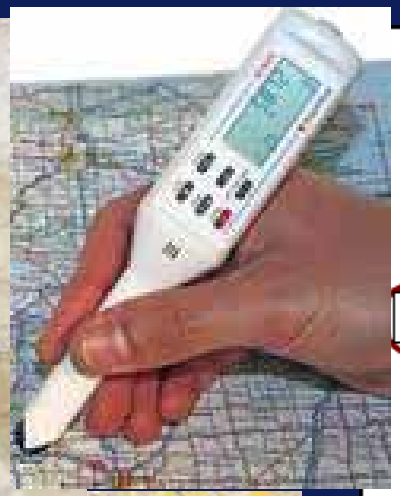
  Data → Illustration

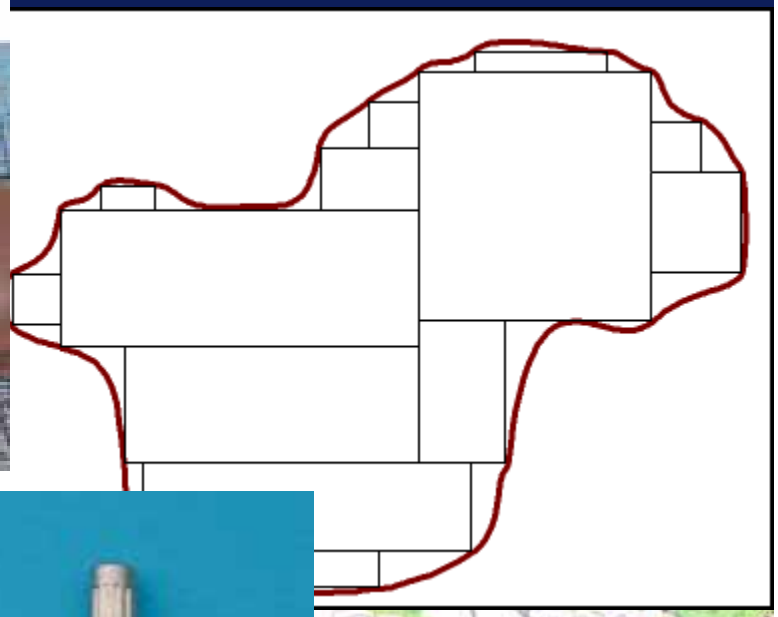
  Dam Breach Model → Dam Breach Map

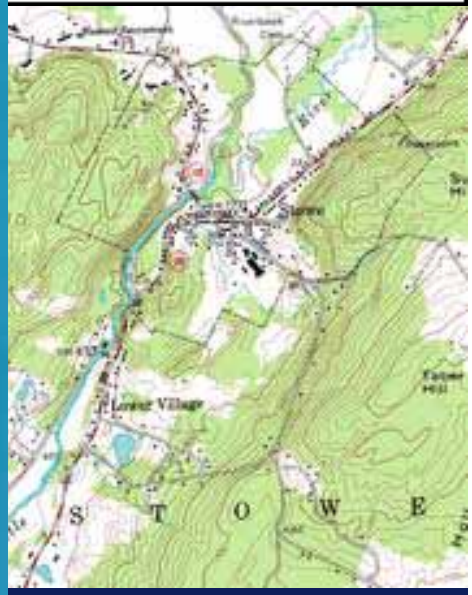
  Floodplain Model → Flood Plain Map

Start with Hydrologic and Hydraulic Analysis

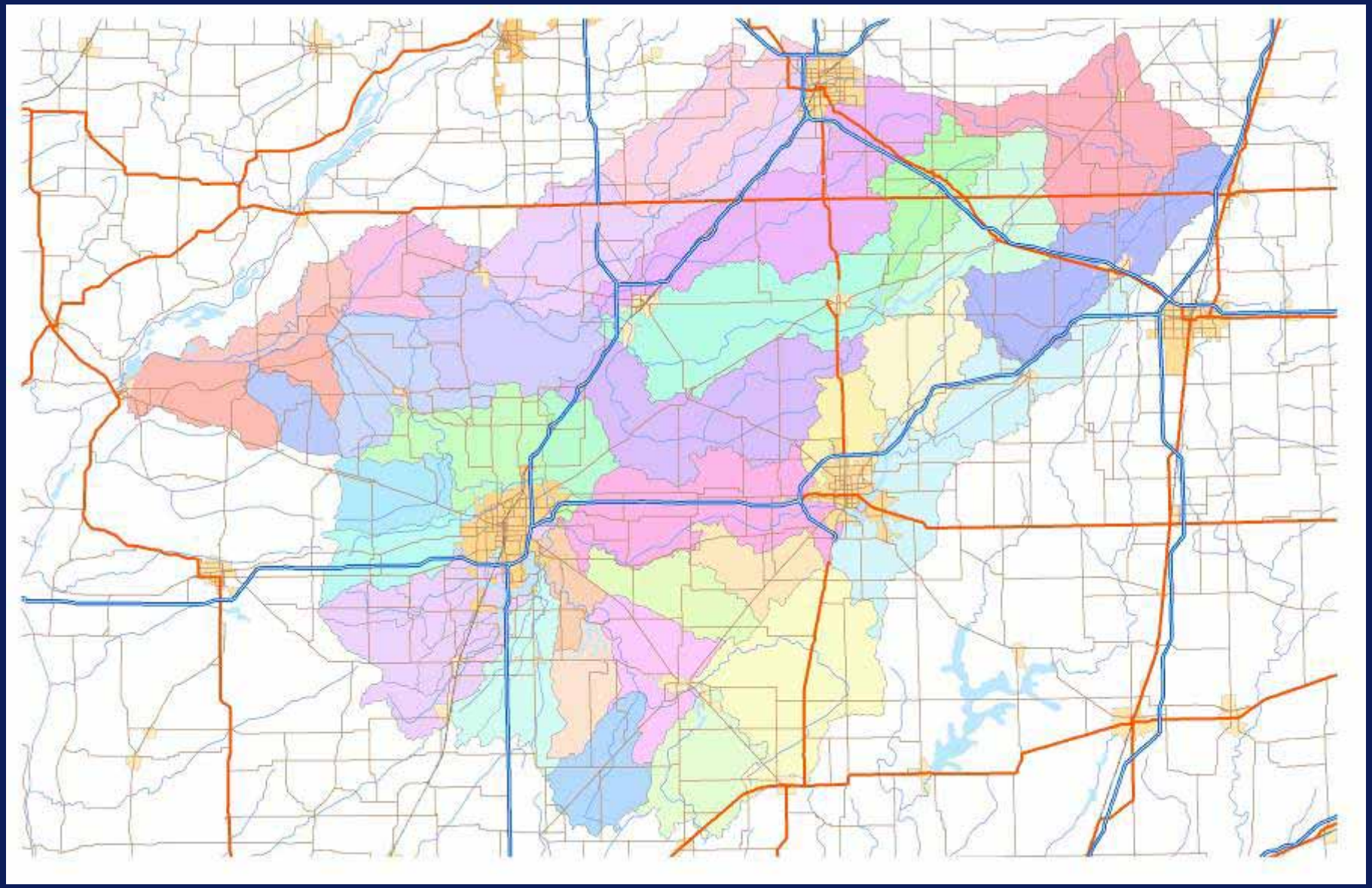
Tools of the Trade



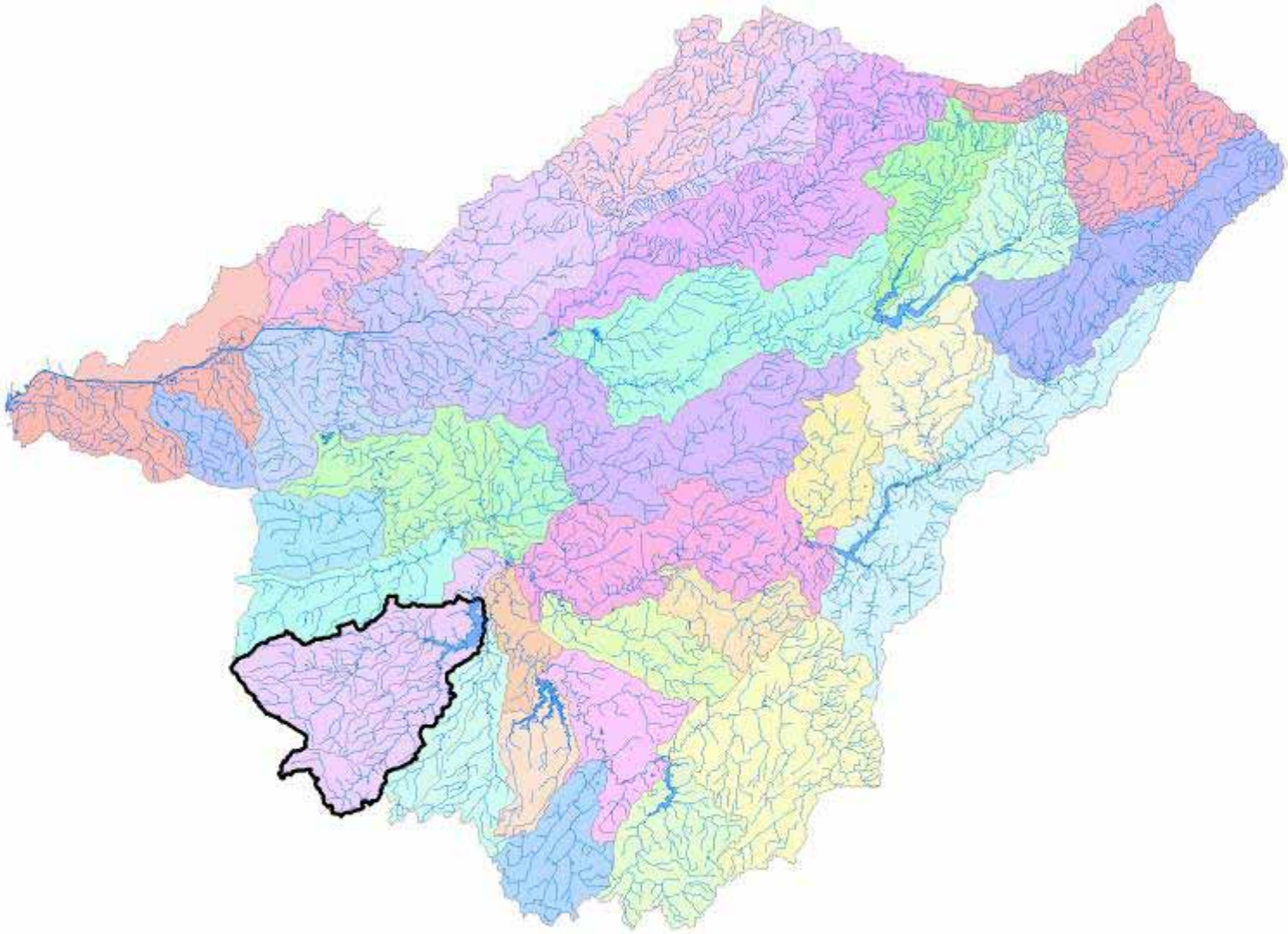




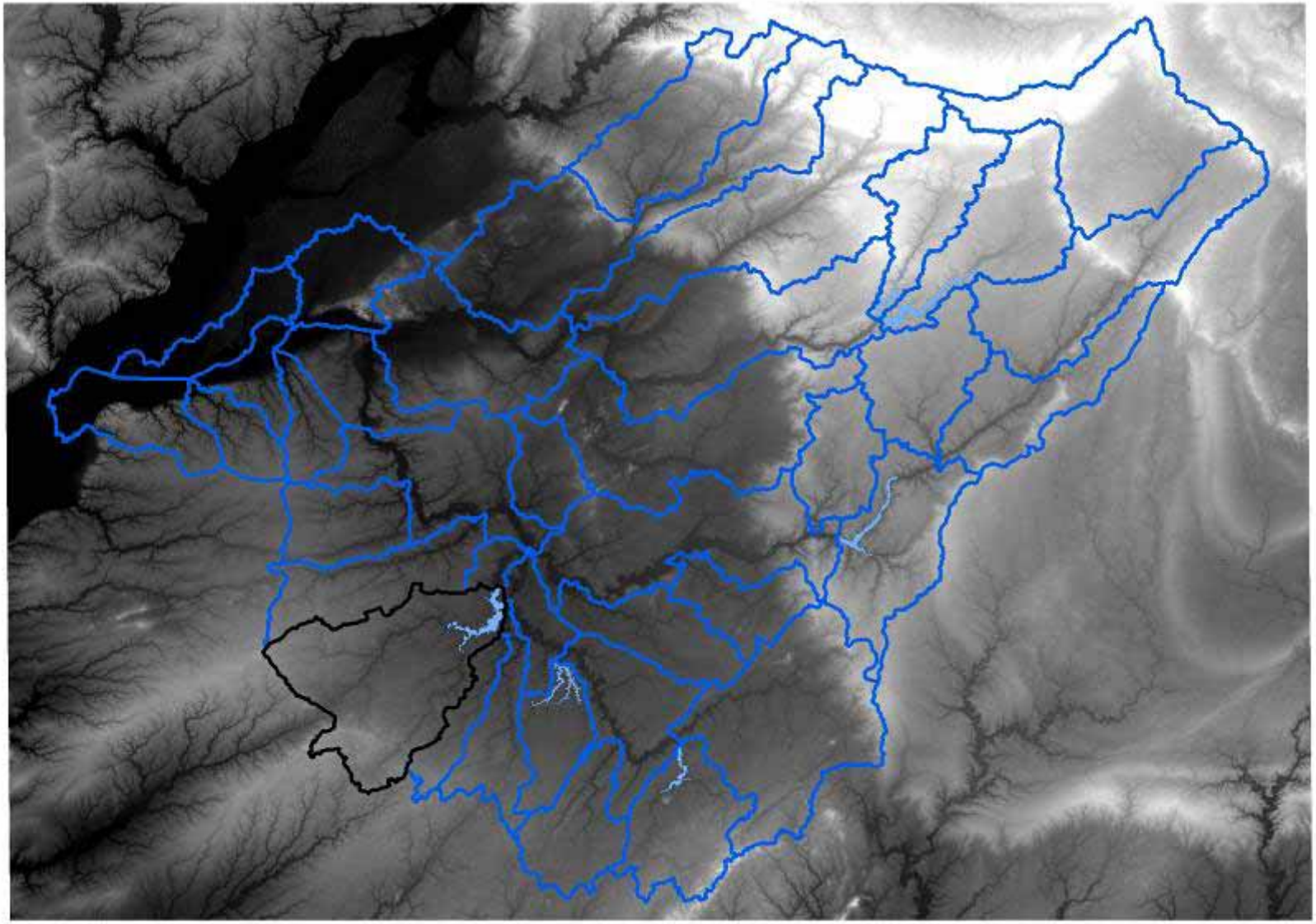
Total Watershed > 5,000 sq miles



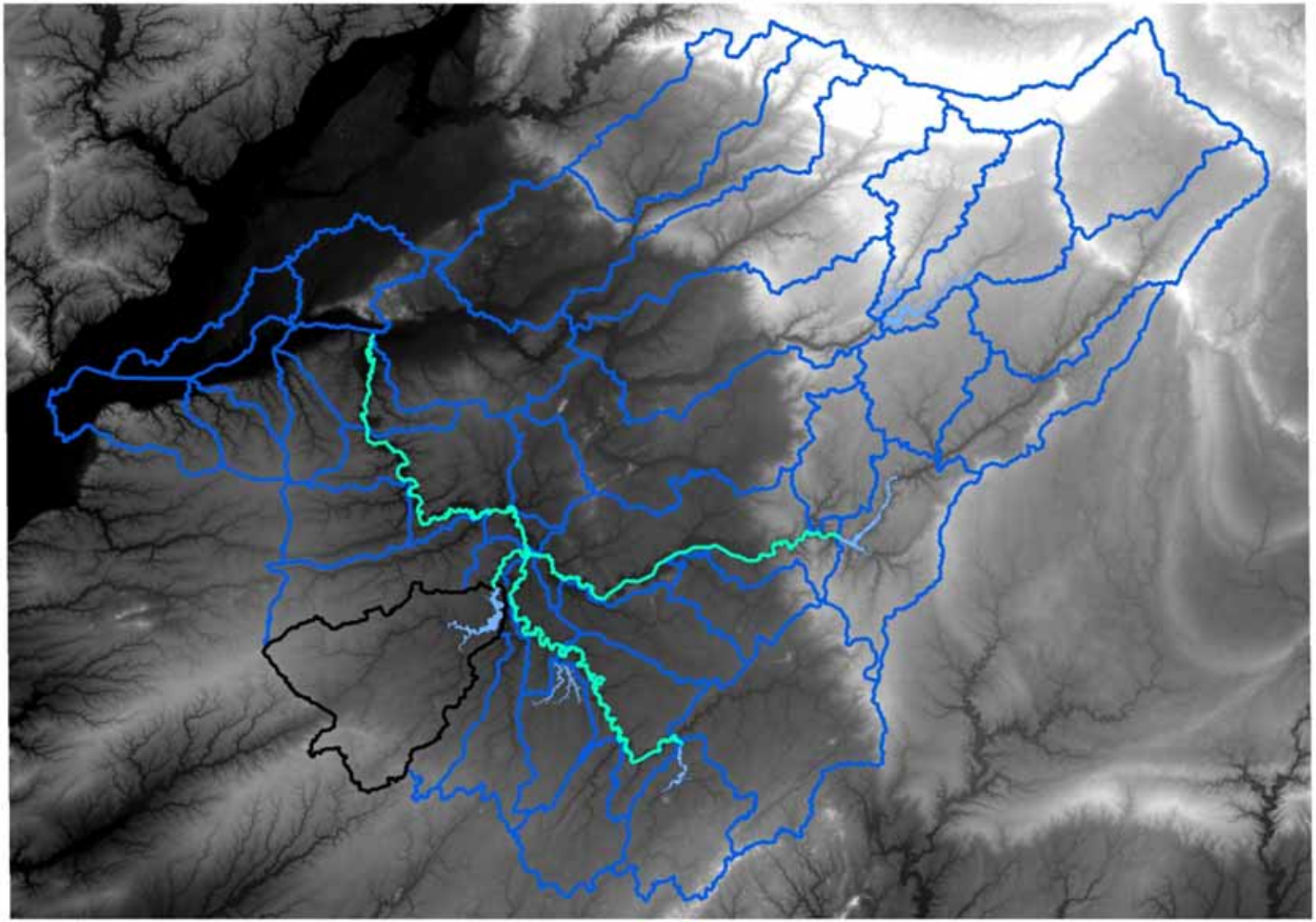
Hydrography – stream network



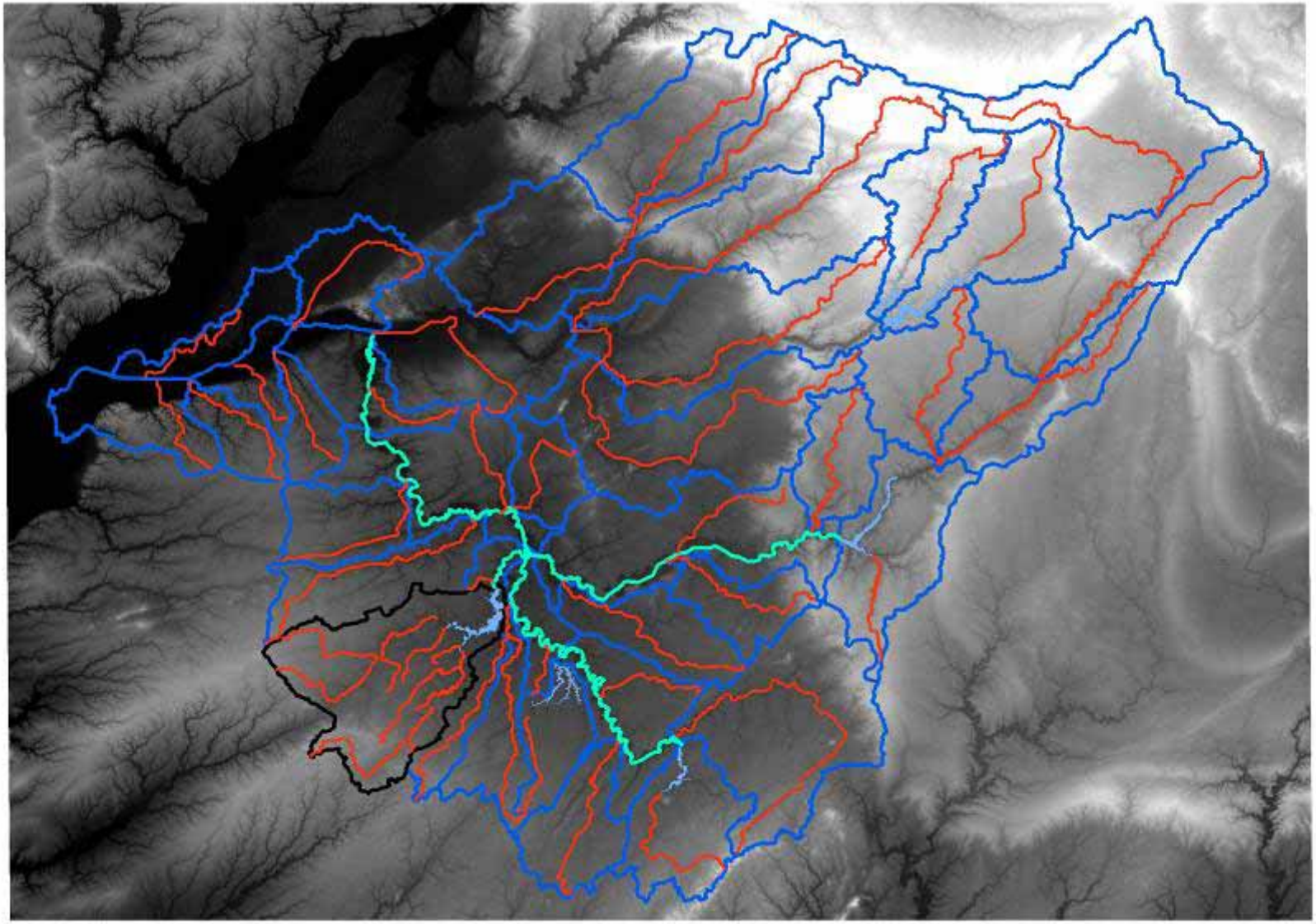
DEM – Digital Elevation Model



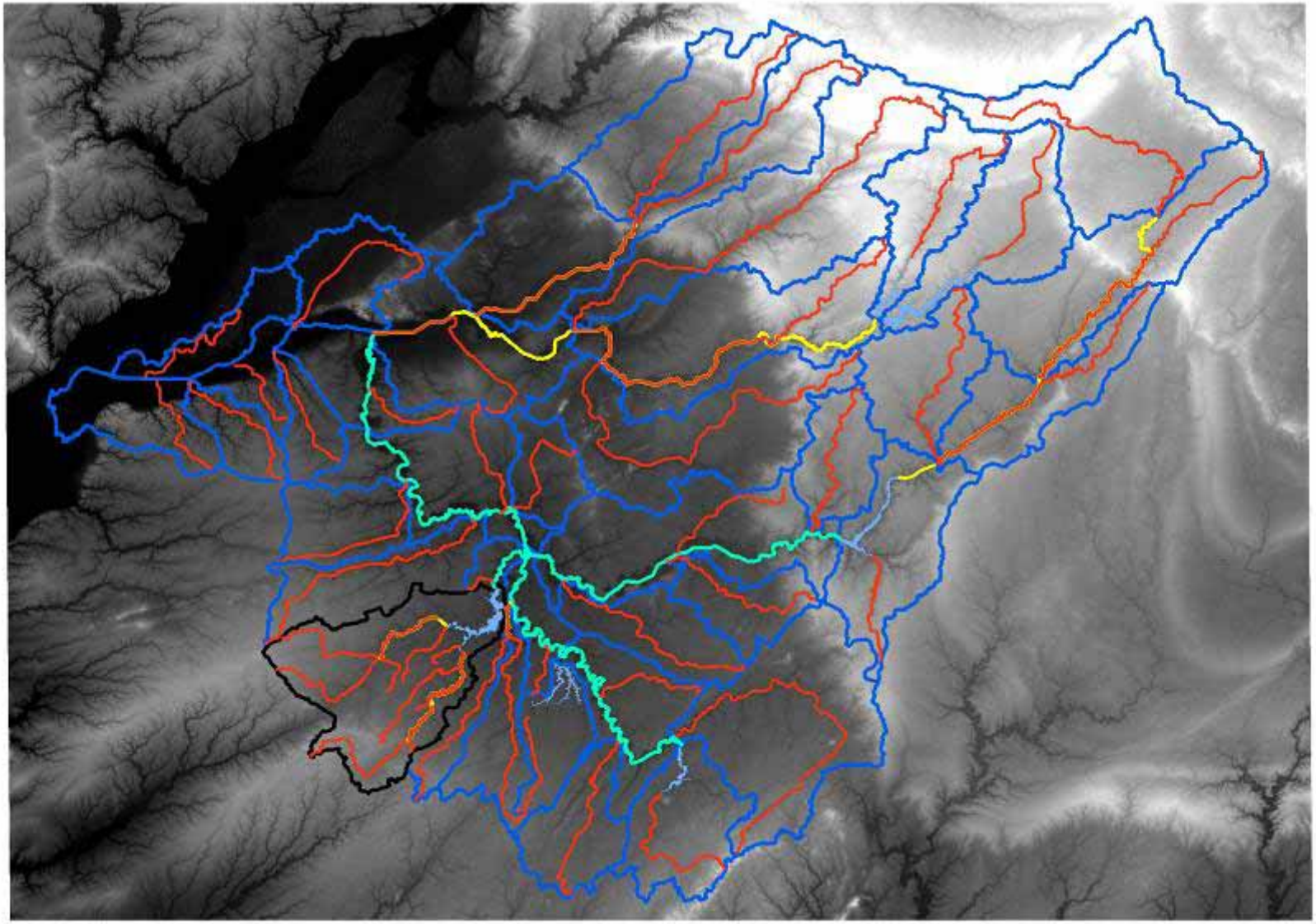
Reach to be modeled extracted from Hydrography



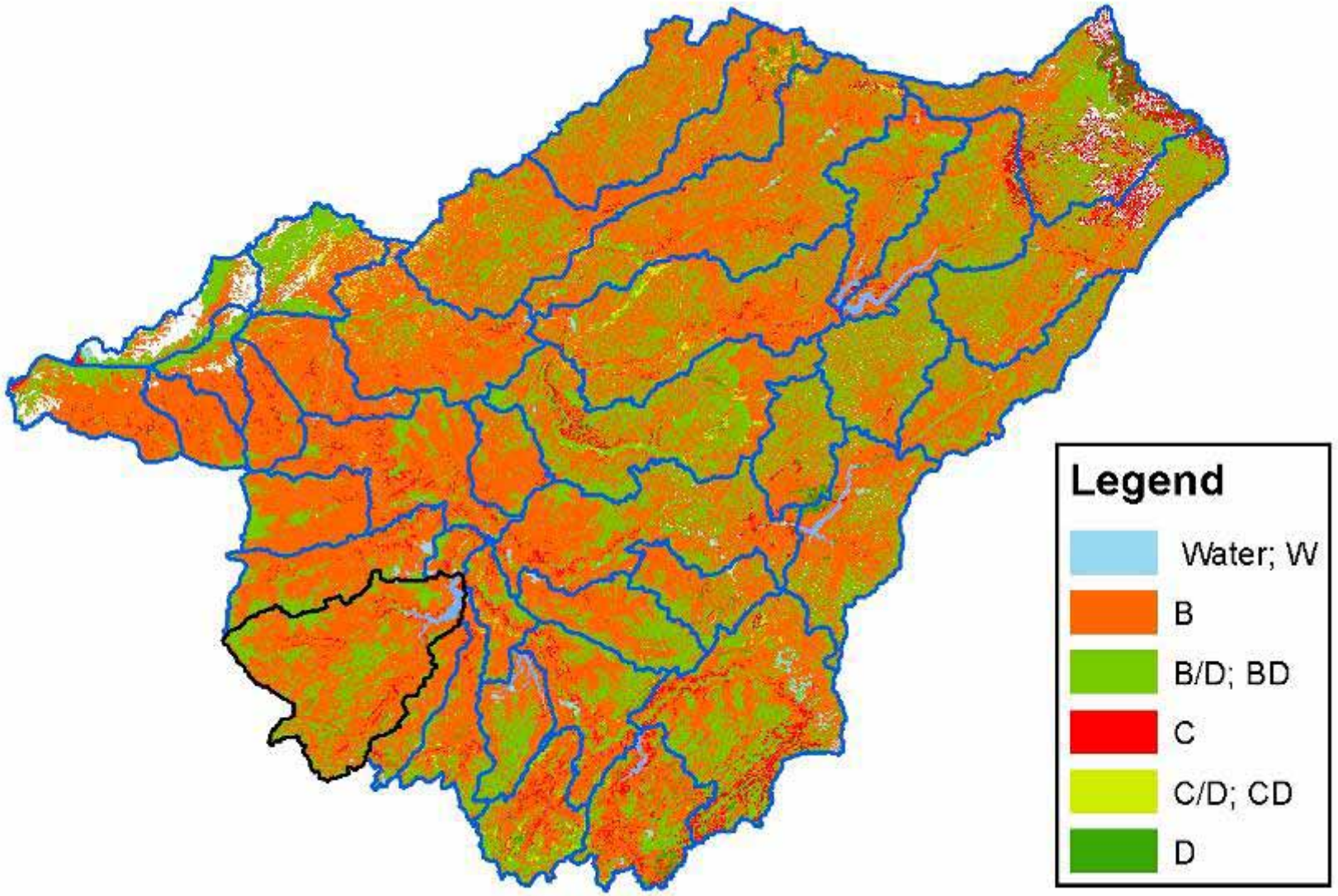
Longest Flow Path (ArcHydro)



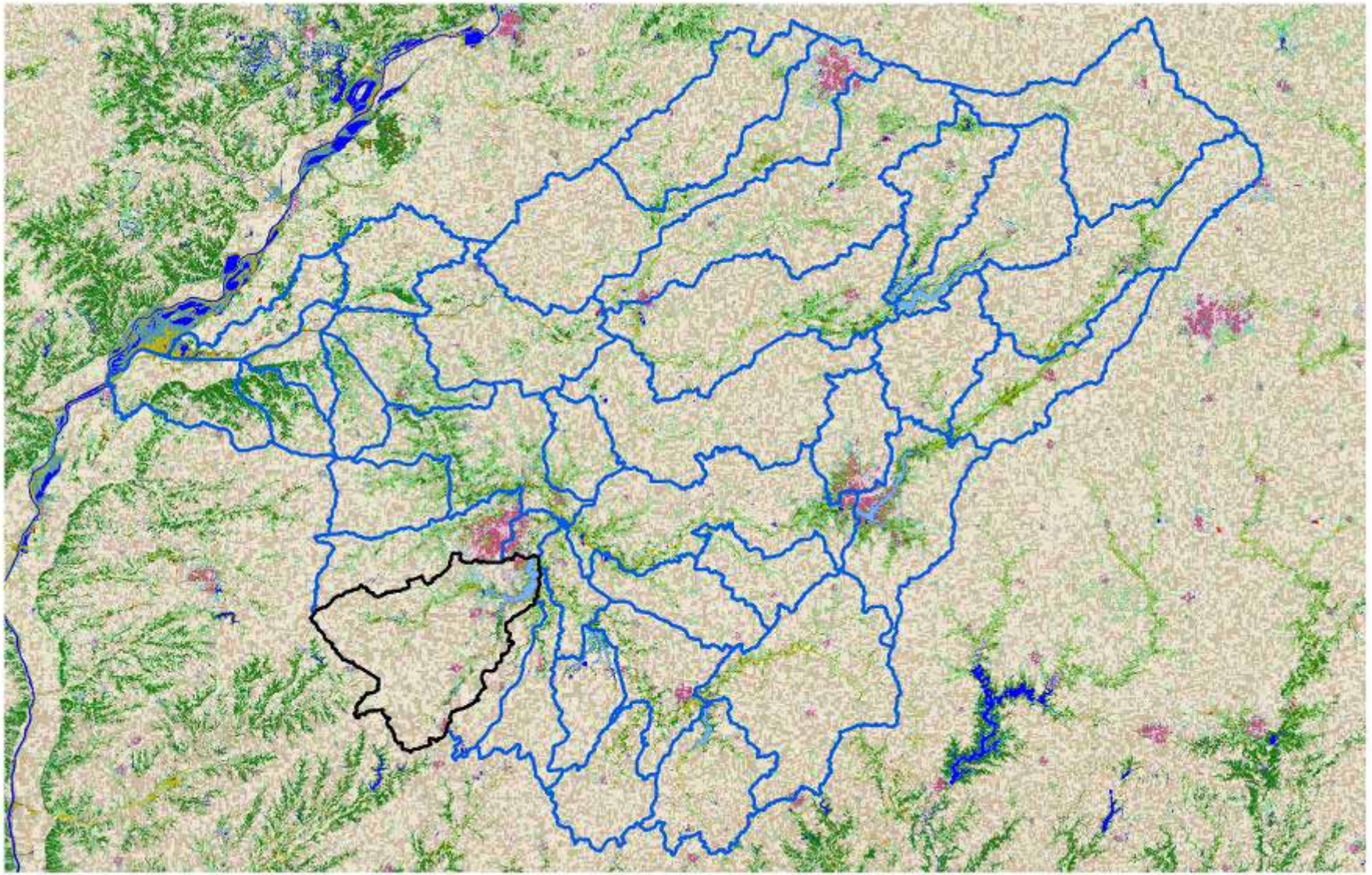
Reach Lengths for routing hydrographs from distant basins



Hydrologic Soil Groups



Land Cover



Link & cross-reference data

Attributes of Watershed_LC_SoilHydro_EastFINAL

OBJECTID	Shape *	FID_Waters	ID	GRIDCODE	MUKEY	musym_1	muname	hydgrpdcd	HYDRO_LC	Shape_Leng	CN
1	Polygon	84362	3608858	12	261778	3073A	Ross silt loam, 0 to 2 percent slopes, frequently flooded	B	B12	3688.264723	76
2	Polygon	91496	3622668	12	261753	131C2	Alvin fine sandy loam, 5 to 10 percent slopes, eroded	B	B12	6715.200741	76
3	Polygon	91497	3622668	12	261678	134B	Camden silt loam, 2 to 5 percent slopes	B	B12	3109.034444	76
4	Polygon	91498	3622668	12	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B12	2727.25333	76
5	Polygon	91499	3622668	12	261783	7242A	Kendall silt loam, 0 to 2 percent slopes, rarely flooded	B	B12	837.745664	76
6	Polygon	91509	3622673	17	261745	3074A	Radford silt loam, 0 to 2 percent slopes, frequently flooded	B	B17	765.407465	58
7	Polygon	91886	3623492	44	261753	131C2	Alvin fine sandy loam, 5 to 10 percent slopes, eroded	B	B44	4166.876855	60
8	Polygon	91888	3623492	44	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B44	3728.040615	60
9	Polygon	91890	3623493	17	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B17	3035.381294	58
10	Polygon	82422	3604257	12	261764	3107A	Sawmill silty clay loam, 0 to 2 percent slopes, frequently flooded	BD	BD12	1442.801732	81
11	Polygon	82423	3604257	12	261767	3284A	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded	B	B12	3642.414894	76
12	Polygon	82434	3604263	32	261750	43A	Ipava silt loam, 0 to 2 percent slopes	B	B32	391.56653	75
13	Polygon	82437	3604265	31	261750	43A	Ipava silt loam, 0 to 2 percent slopes	B	B31	1719.086312	92
14	Polygon	82786	3605113	12	261767	3284A	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded	B	B12	1370.451861	76
15	Polygon	82797	3605114	17	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B17	8047.986451	58
16	Polygon	82799	3605114	17	261761	242A	Kendall silt loam, 0 to 2 percent slopes	B	B17	5959.688985	58
17	Polygon	83185	3605959	17	261778	3073A	Ross silt loam, 0 to 2 percent slopes, frequently flooded	B	B17	2259.349912	58
18	Polygon	83187	3605960	17	261764	3107A	Sawmill silty clay loam, 0 to 2 percent slopes, frequently flooded	BD	BD17	1189.111956	68
19	Polygon	83188	3605960	17	261767	3284A	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded	B	B17	1790.153071	58
20	Polygon	83190	3605962	17	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B17	1689.169231	58
21	Polygon	83491	3606761	17	261764	3107A	Sawmill silty clay loam, 0 to 2 percent slopes, frequently flooded	BD	BD17	587.33762	68
22	Polygon	83639	3607200	12	261764	3107A	Sawmill silty clay loam, 0 to 2 percent slopes, frequently flooded	BD	BD12	737.290625	81
23	Polygon	84573	3609263	17	261678	134B	Camden silt loam, 2 to 5 percent slopes	B	B17	2675.84295	58
24	Polygon	84825	3609719	12	261767	3284A	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded	B	B12	1535.40009	76
25	Polygon	84830	3609721	12	261678	134B	Camden silt loam, 2 to 5 percent slopes	B	B12	3475.356315	76
26	Polygon	84833	3609723	31	261736	W	Water	W	W31	586.130863	100
27	Polygon	85040	3610185	12	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B12	5487.499112	76
28	Polygon	85043	3610185	12	261769	152A	Drummer silty clay loam, 0 to 2 percent slopes	BD	BD12	1795.379971	81
29	Polygon	85269	3610609	21	261678	134B	Camden silt loam, 2 to 5 percent slopes	B	B21	1370.454712	55
30	Polygon	85502	3611035	17	261678	134B	Camden silt loam, 2 to 5 percent slopes	B	B17	3870.131132	58
31	Polygon	85503	3611035	17	261730	865	Pits, gravel	W	W17	3193.947704	100
32	Polygon	85511	3611038	11	261753	131C2	Alvin fine sandy loam, 5 to 10 percent slopes, eroded	B	B11	3845.17787	76
33	Polygon	85512	3611038	11	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B11	2892.106473	76
34	Polygon	85667	3611478	21	261678	134B	Camden silt loam, 2 to 5 percent slopes	B	B21	1310.648322	55
35	Polygon	85694	3611481	31	261730	865	Pits, gravel	W	W31	948.140547	100
36	Polygon	85703	3611485	17	261773	68A	Sable silty clay loam, 0 to 2 percent slopes	BD	BD17	1174.697887	68
37	Polygon	85899	3611929	17	261753	131C2	Alvin fine sandy loam, 5 to 10 percent slopes, eroded	B	B17	1032.813058	58
38	Polygon	85900	3611929	17	261758	570D2	Martinsville sandy loam, 10 to 18 percent slopes, eroded	B	B17	1743.60022	58
39	Polygon	85906	3611931	31	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B31	1174.680998	92
40	Polygon	85913	3611935	11	261773	68A	Sable silty clay loam, 0 to 2 percent slopes	BD	BD11	782.744299	81
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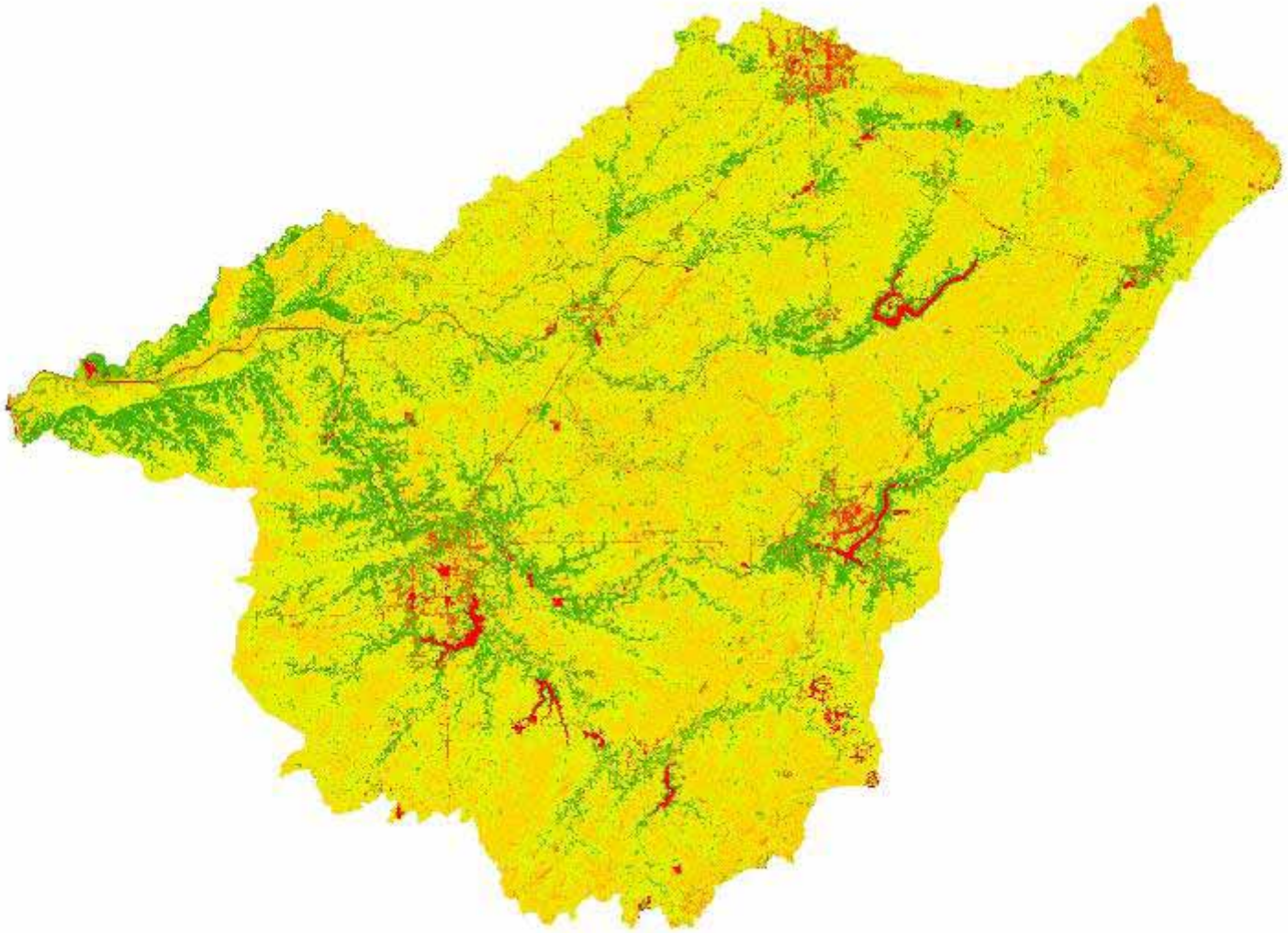
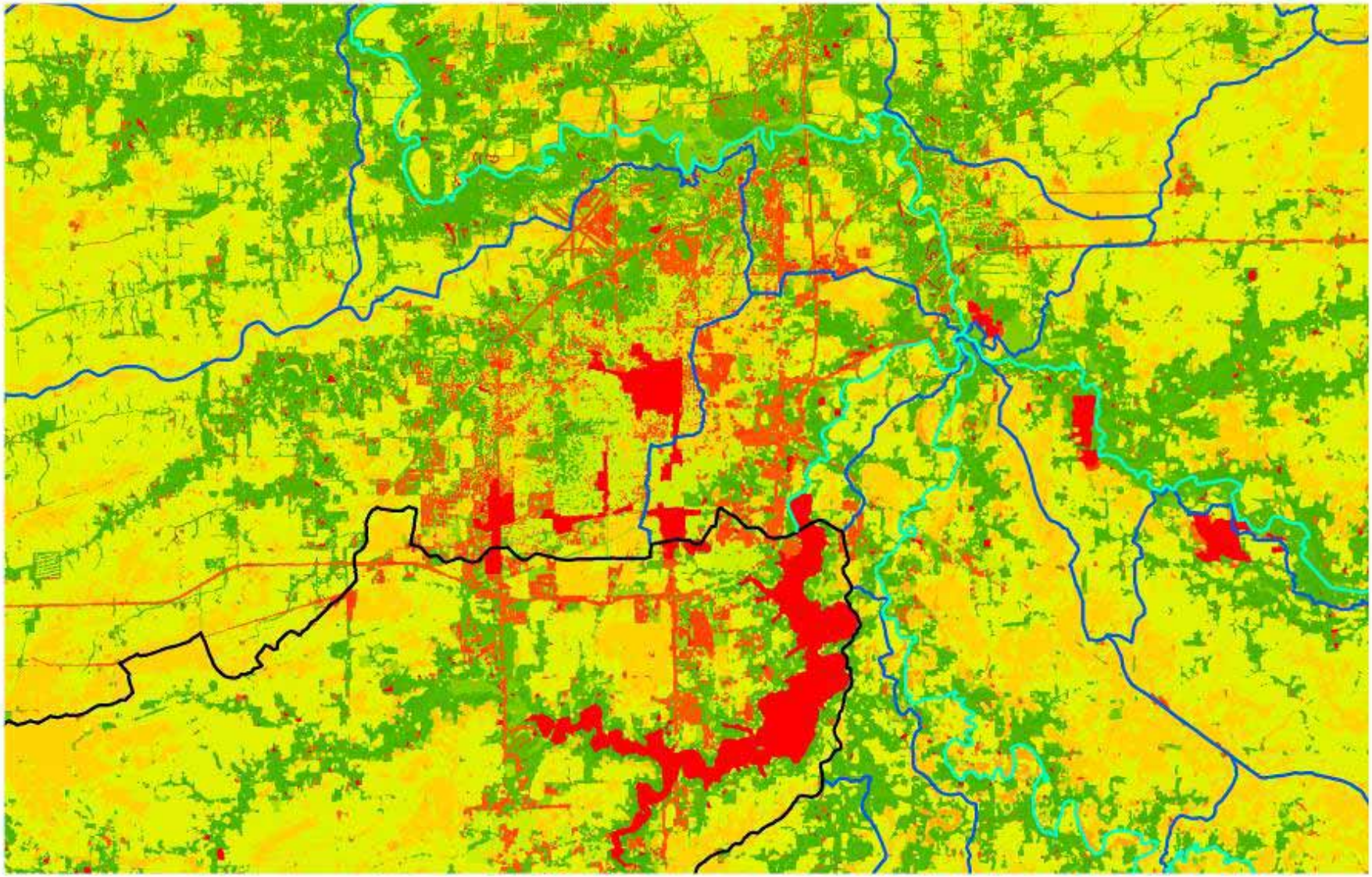
42	Polygon	85933	3611936	17	261720	684B	Broadwell silt loam, 2 to 5 percent slopes	B	B17	2964.12353	58
43	Polygon	85934	3611936	17	261773	68A	Sable silty clay loam, 0 to 2 percent slopes	BD	BD17	5047.487047	68
44	Polygon	85935	3611936	17	261773	68A	Sable silty clay loam, 0 to 2 percent slopes	BD	BD17	785.187154	68
45	Polygon	85936	3611936	17	261750	43A	Ipava silt loam, 0 to 2 percent slopes	B	B17	3802.198301	58
46	Polygon	85937	3611936	17	261746	244A	Hartsburg silty clay loam, 0 to 2 percent slopes	BD	BD17	2577.915247	68

Record: 1 Show: All Selected Records (0 out of *2000 Selected) Options

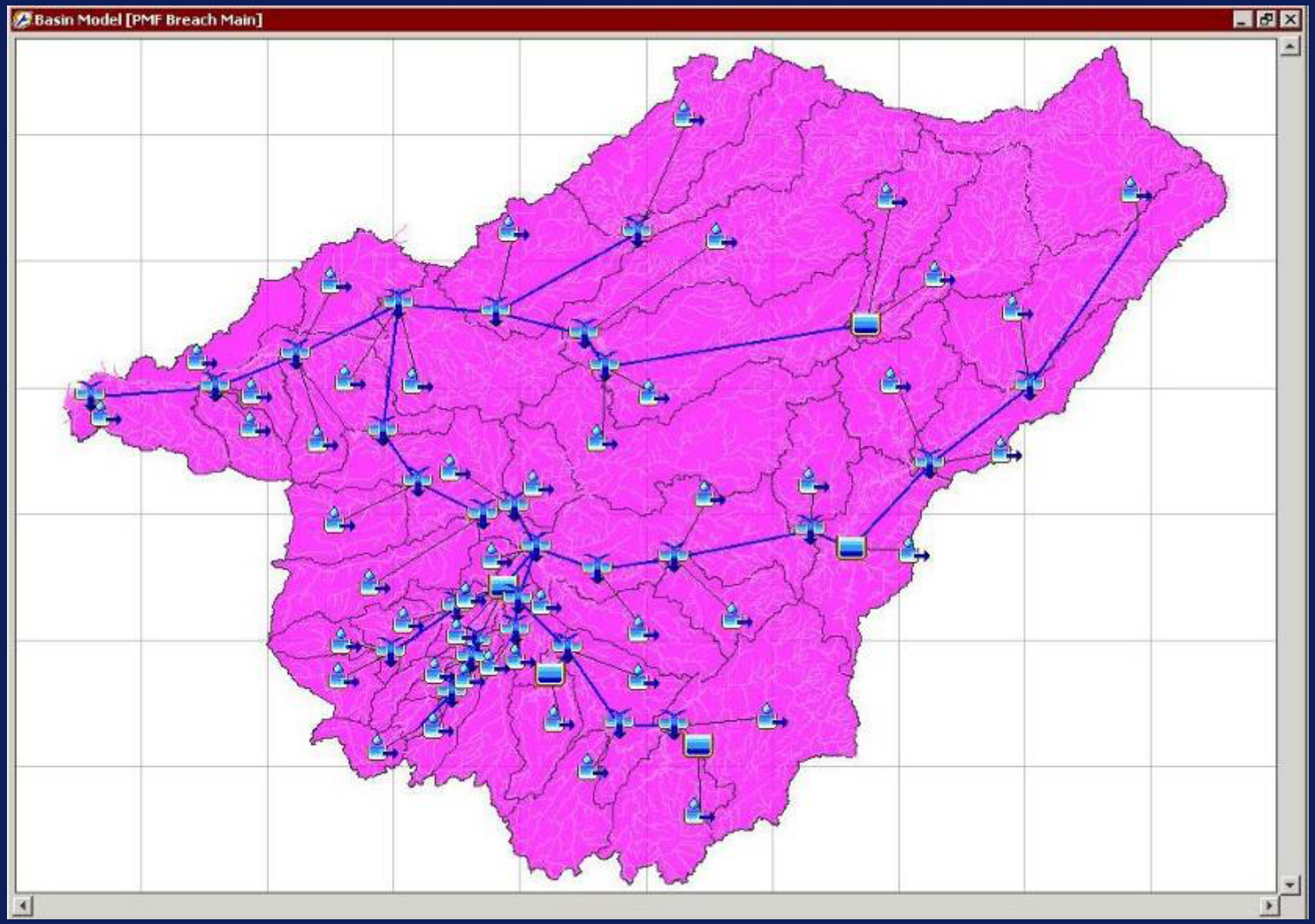
Convert Soils/Land Data to Curve Numbers



Curve numbers - closeup

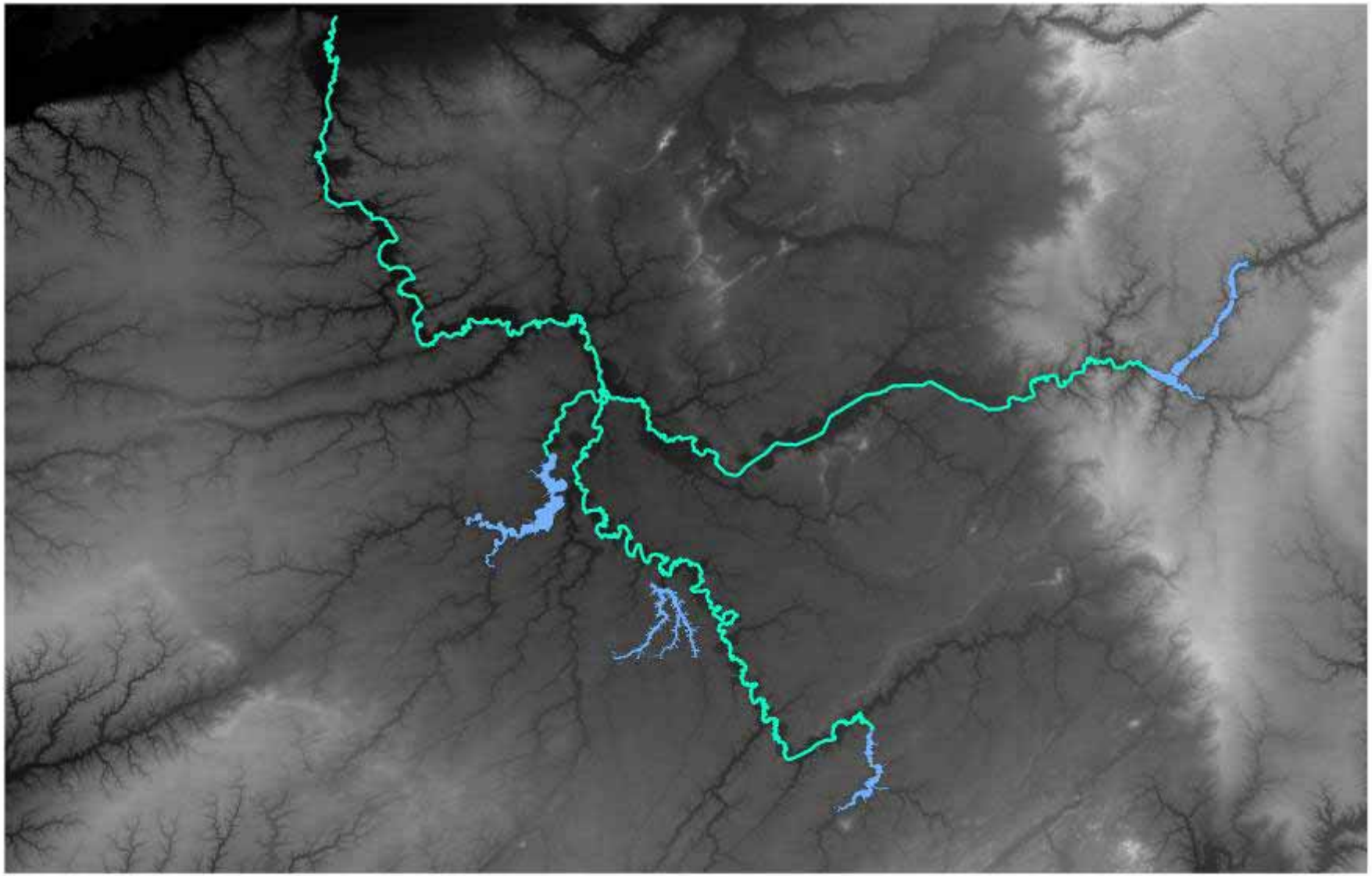


Build HEC-HMS hydrology model

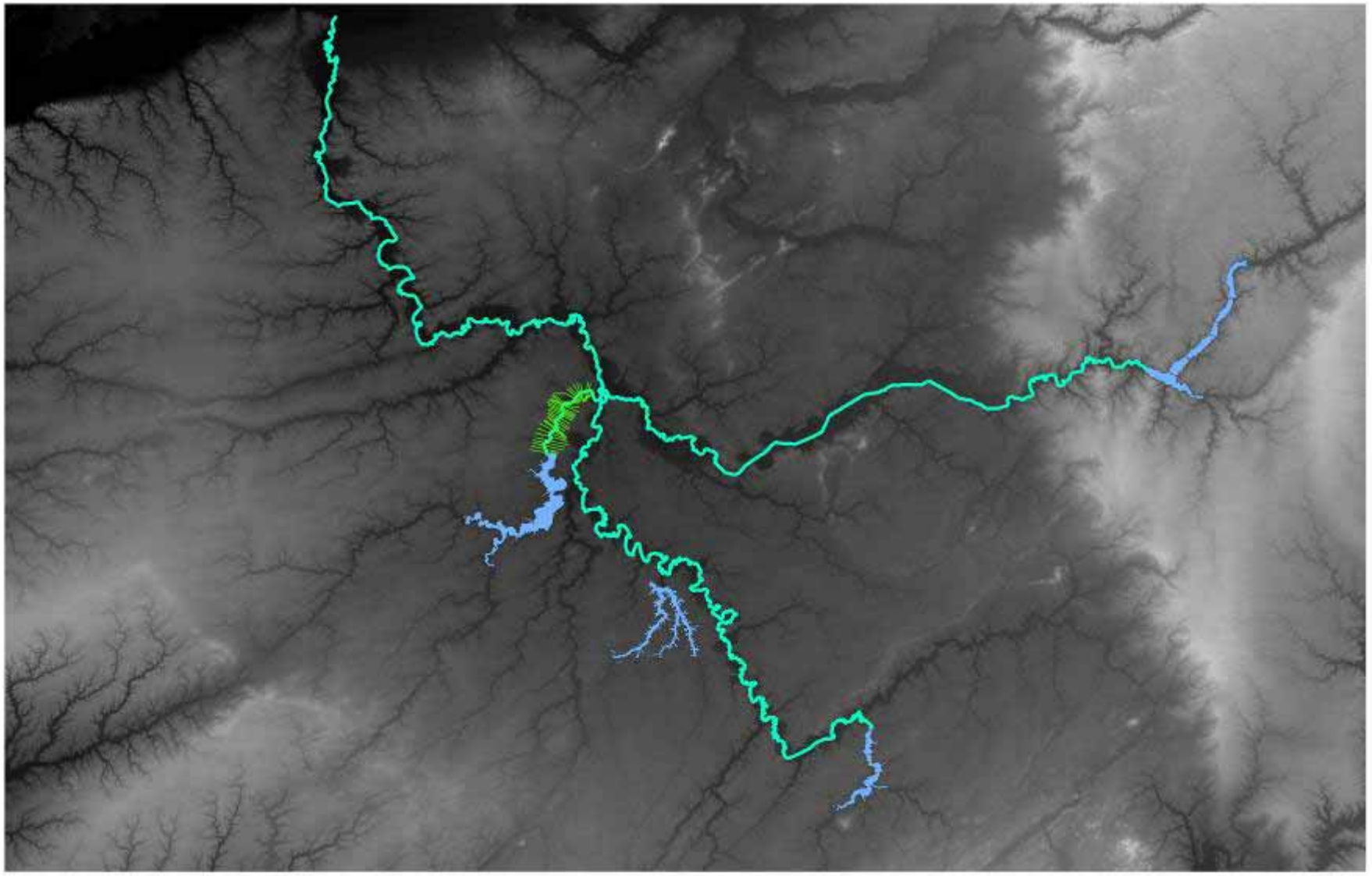


Steps to Building HEC-RAS model

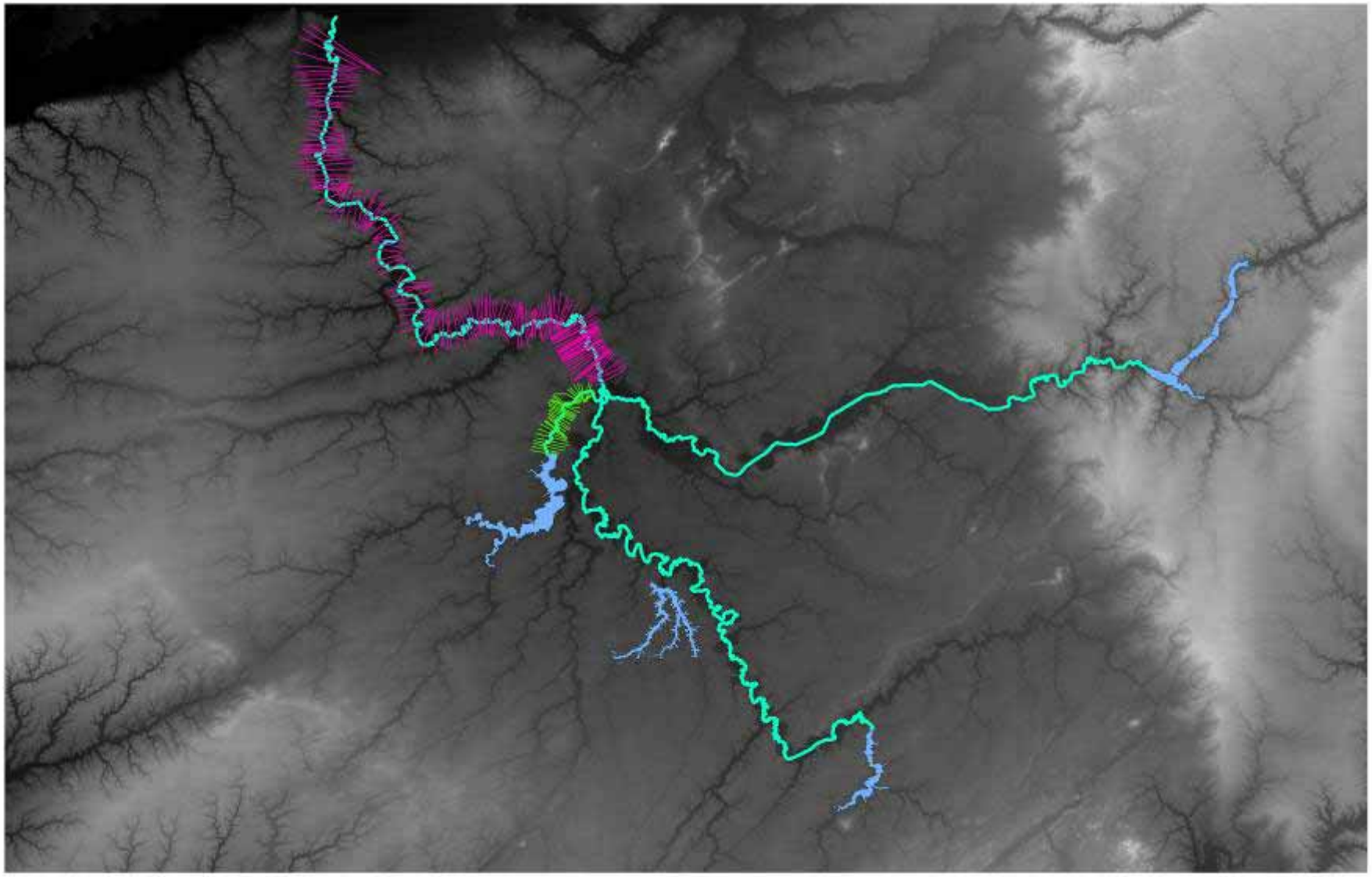
Reaches (Rivers to be modeled)



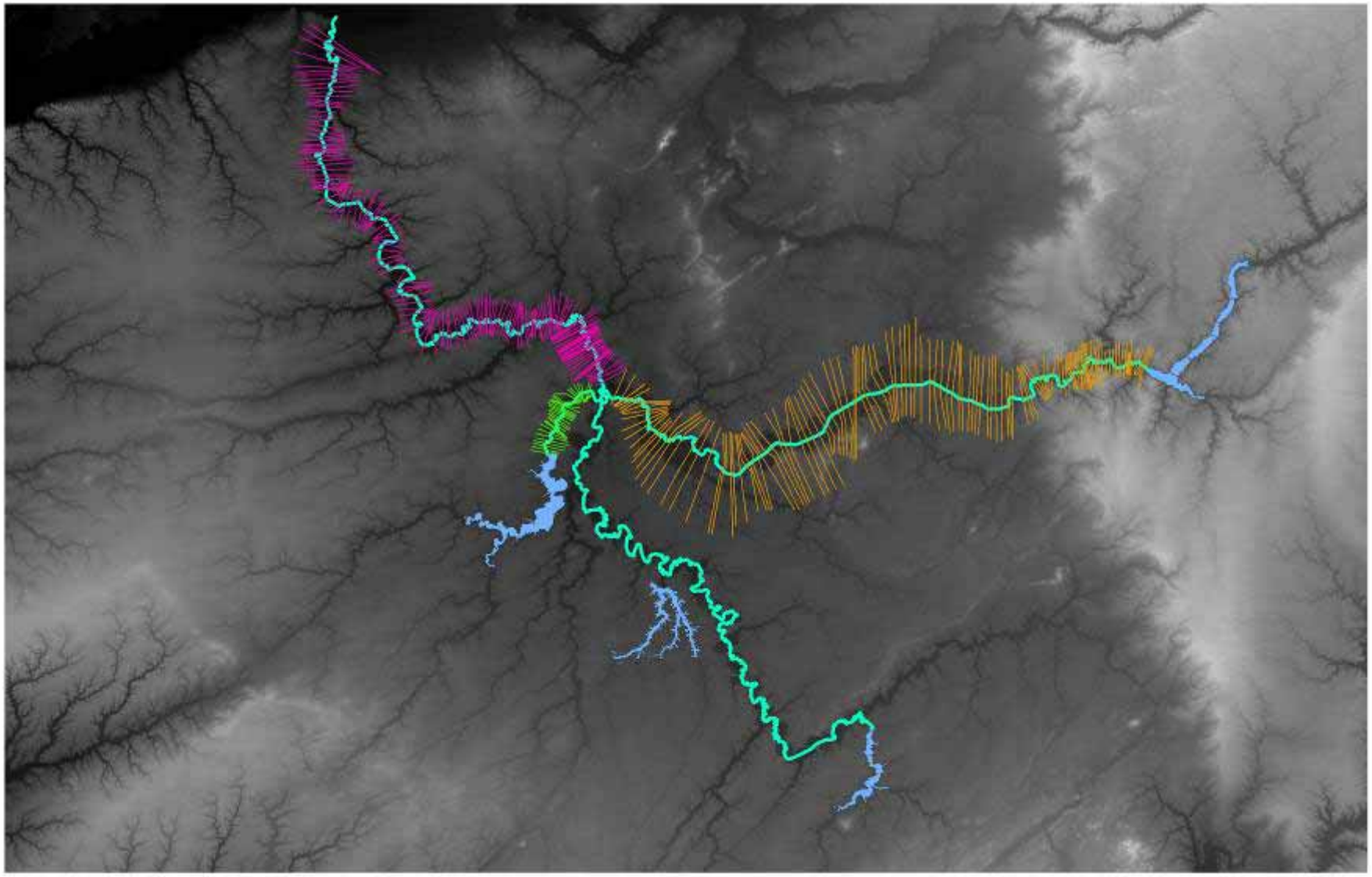
Cross-Sections



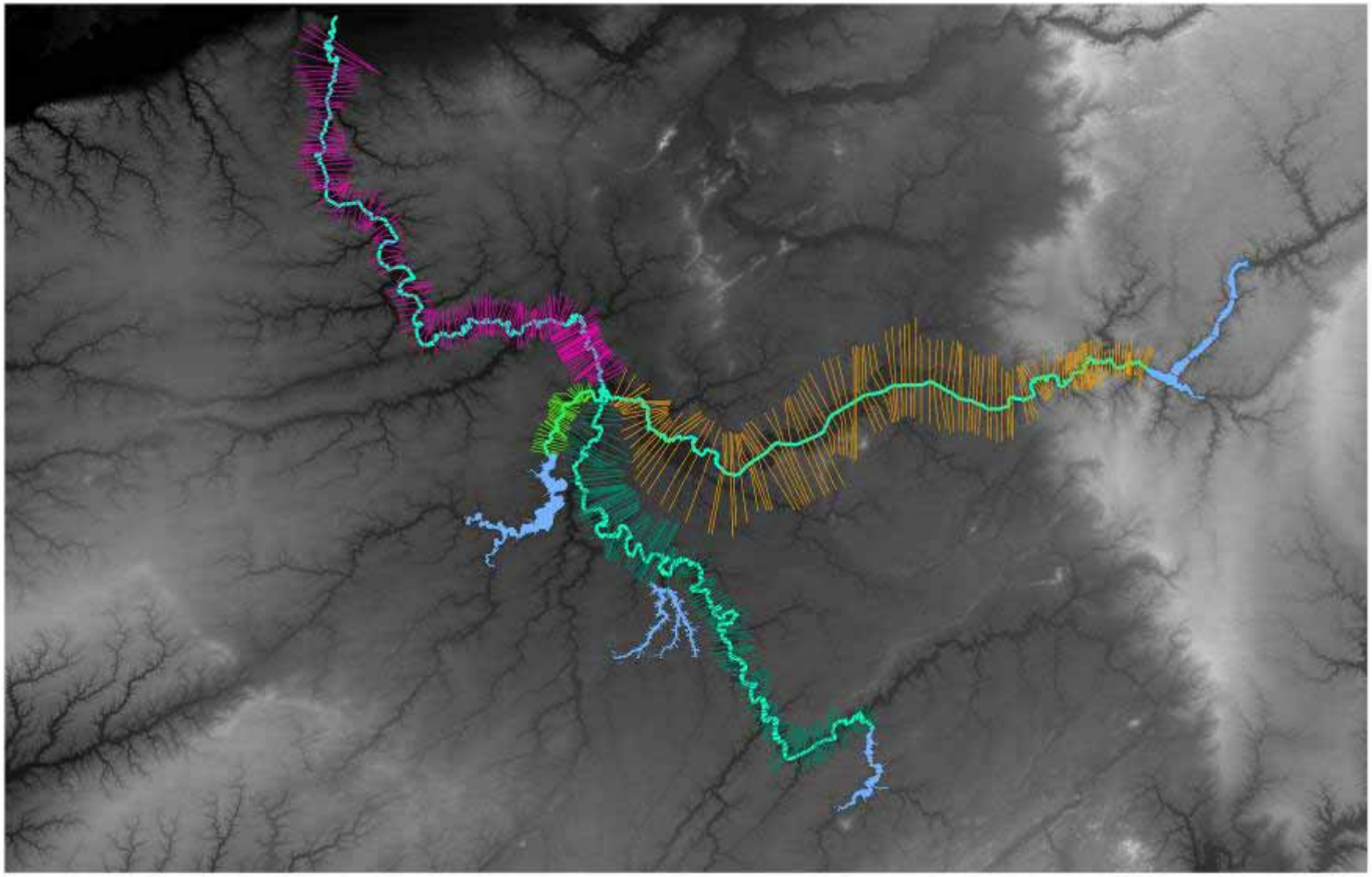
More Cross-Sections



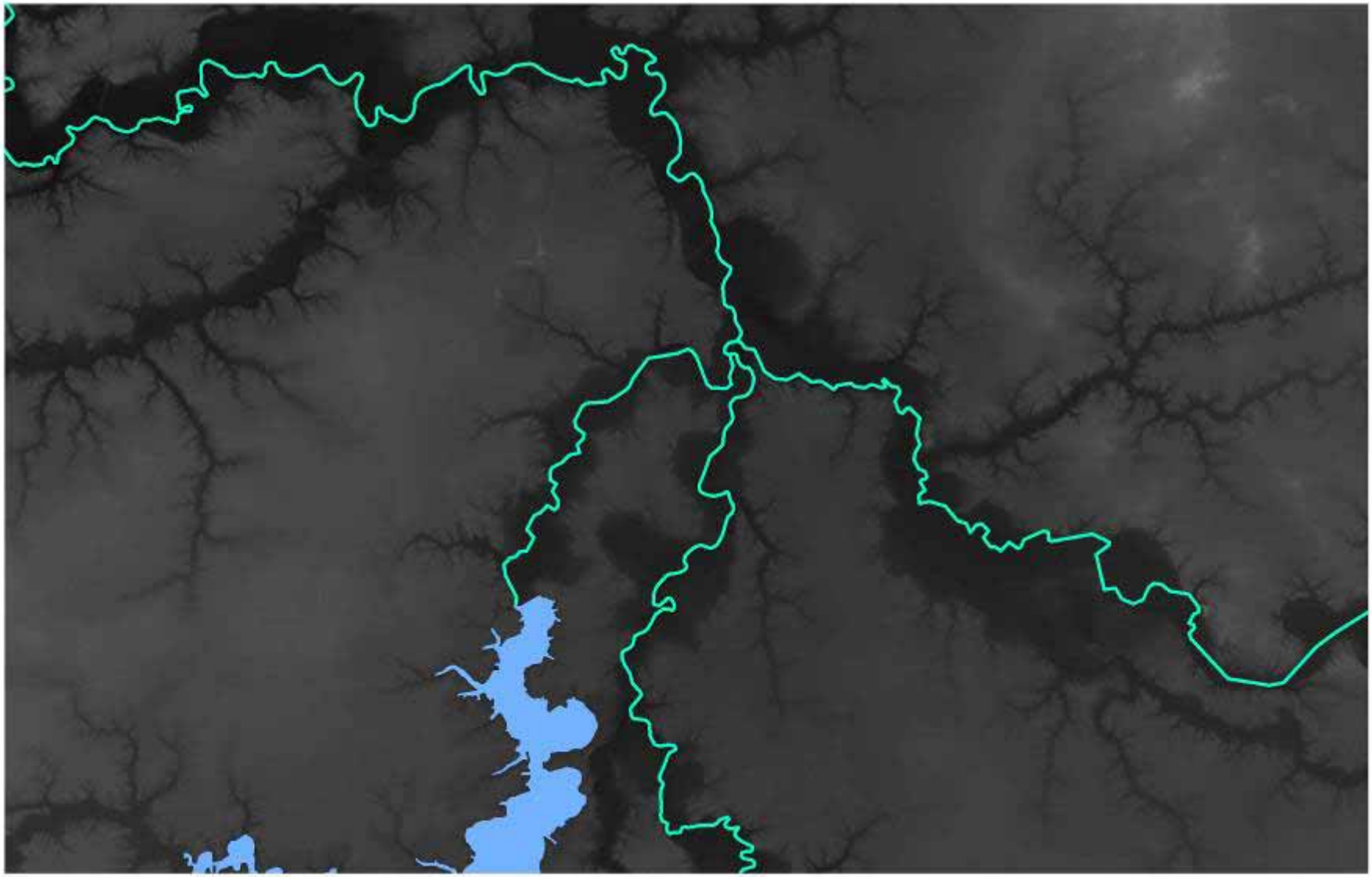
Even more Cross-Sections



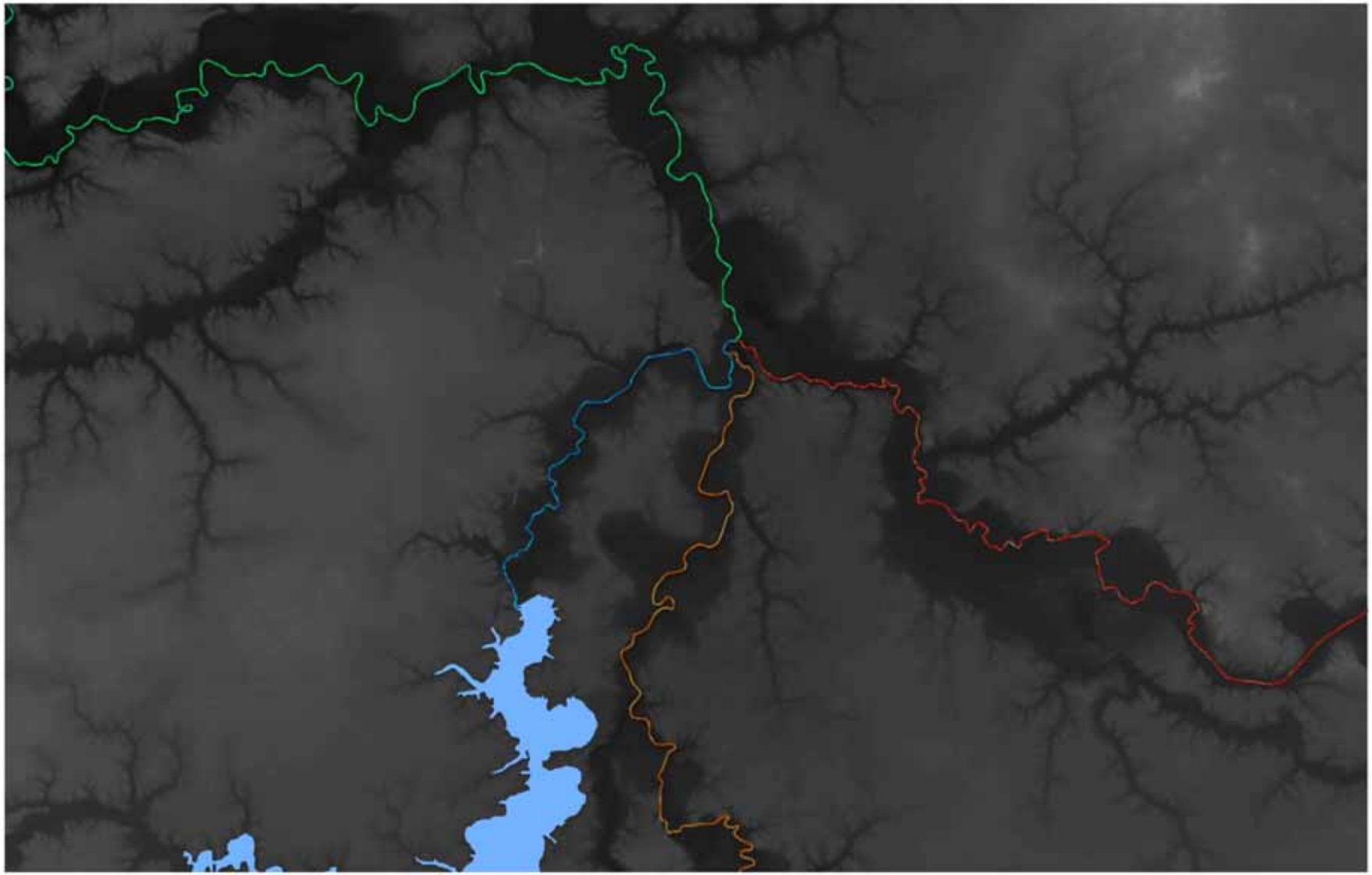
Stop! Enough Cross-Sections!!



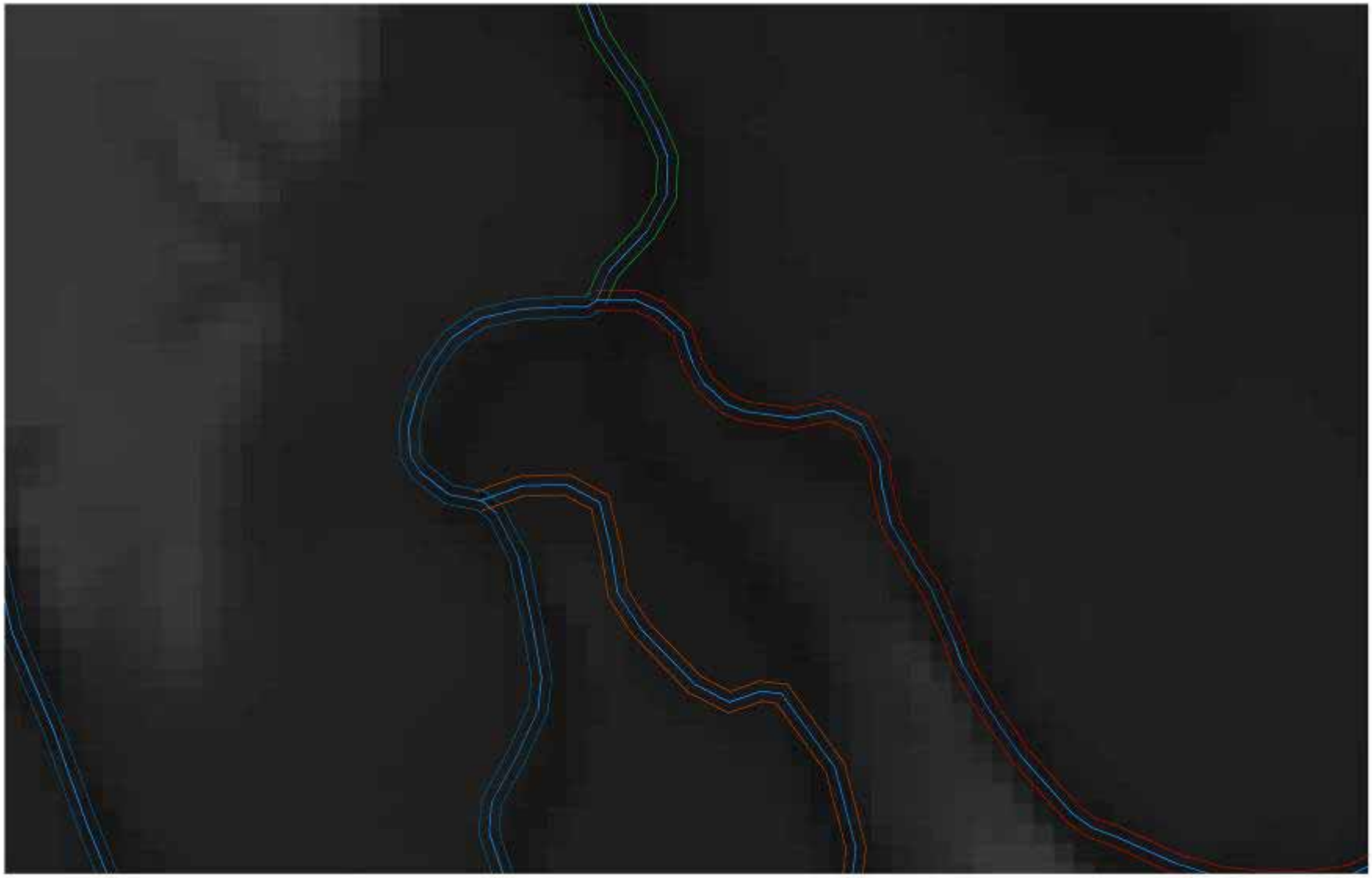
Now to add bank stations



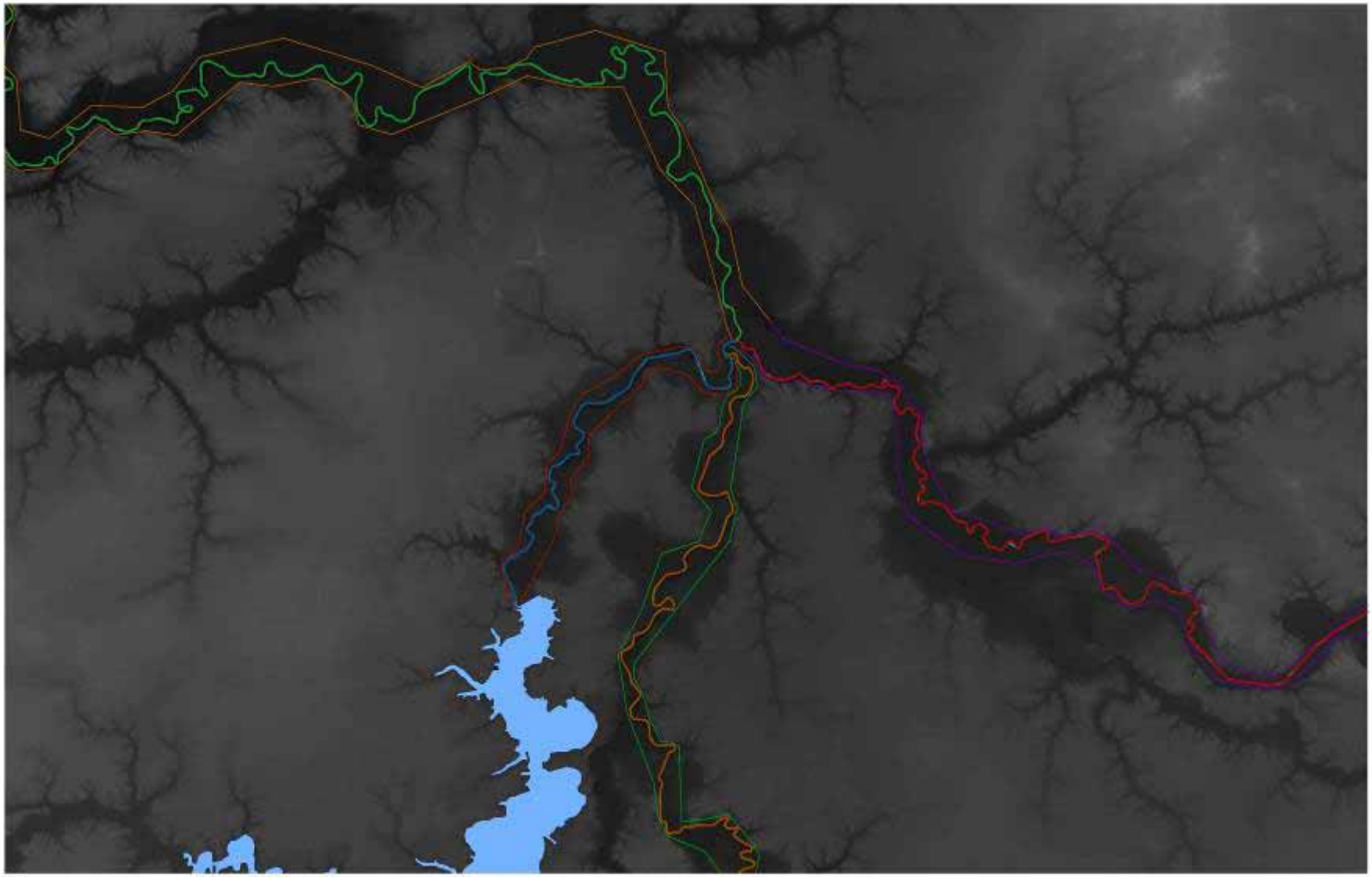
Channel Bank Lines – can you see them



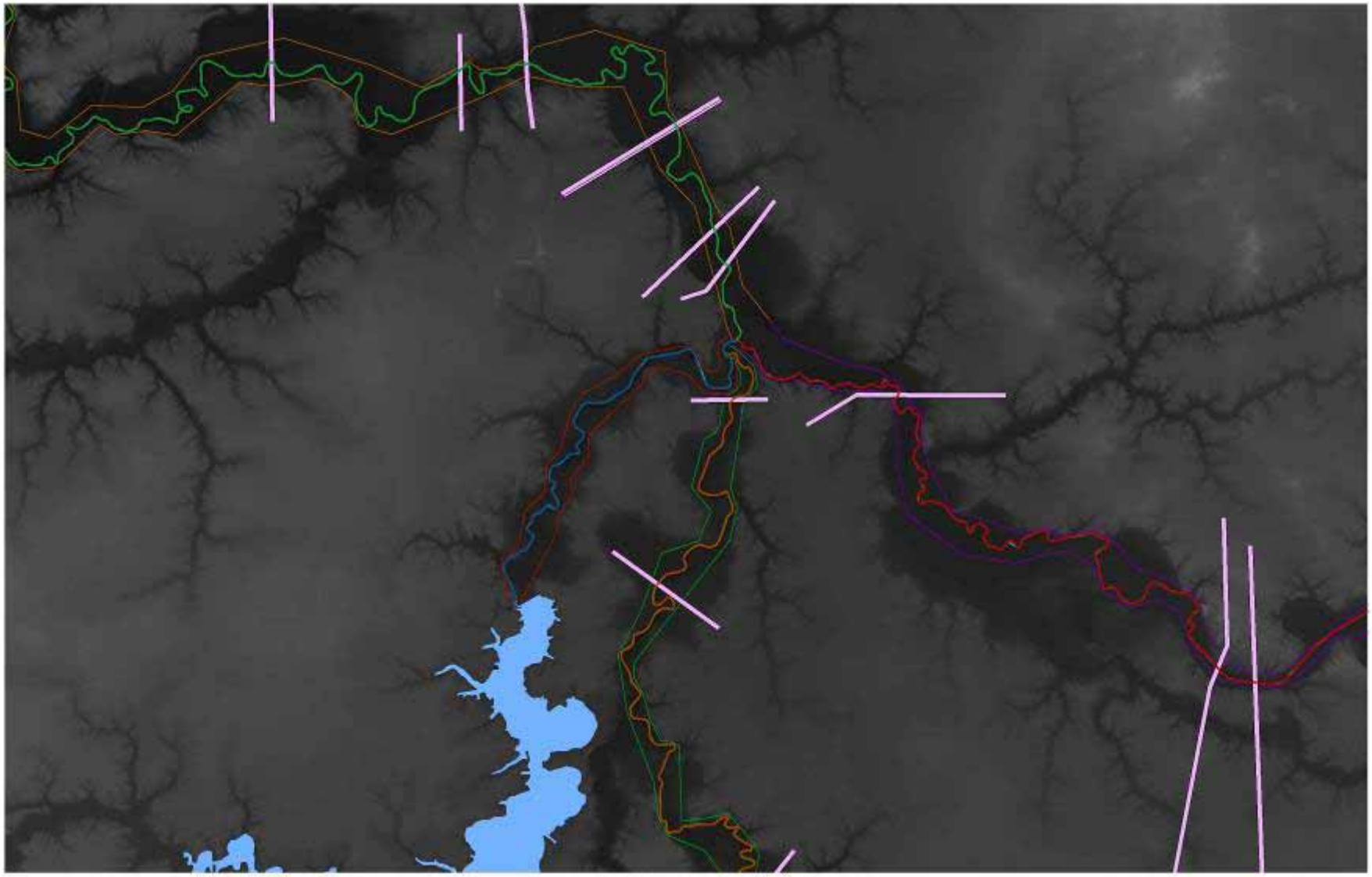
How about now?



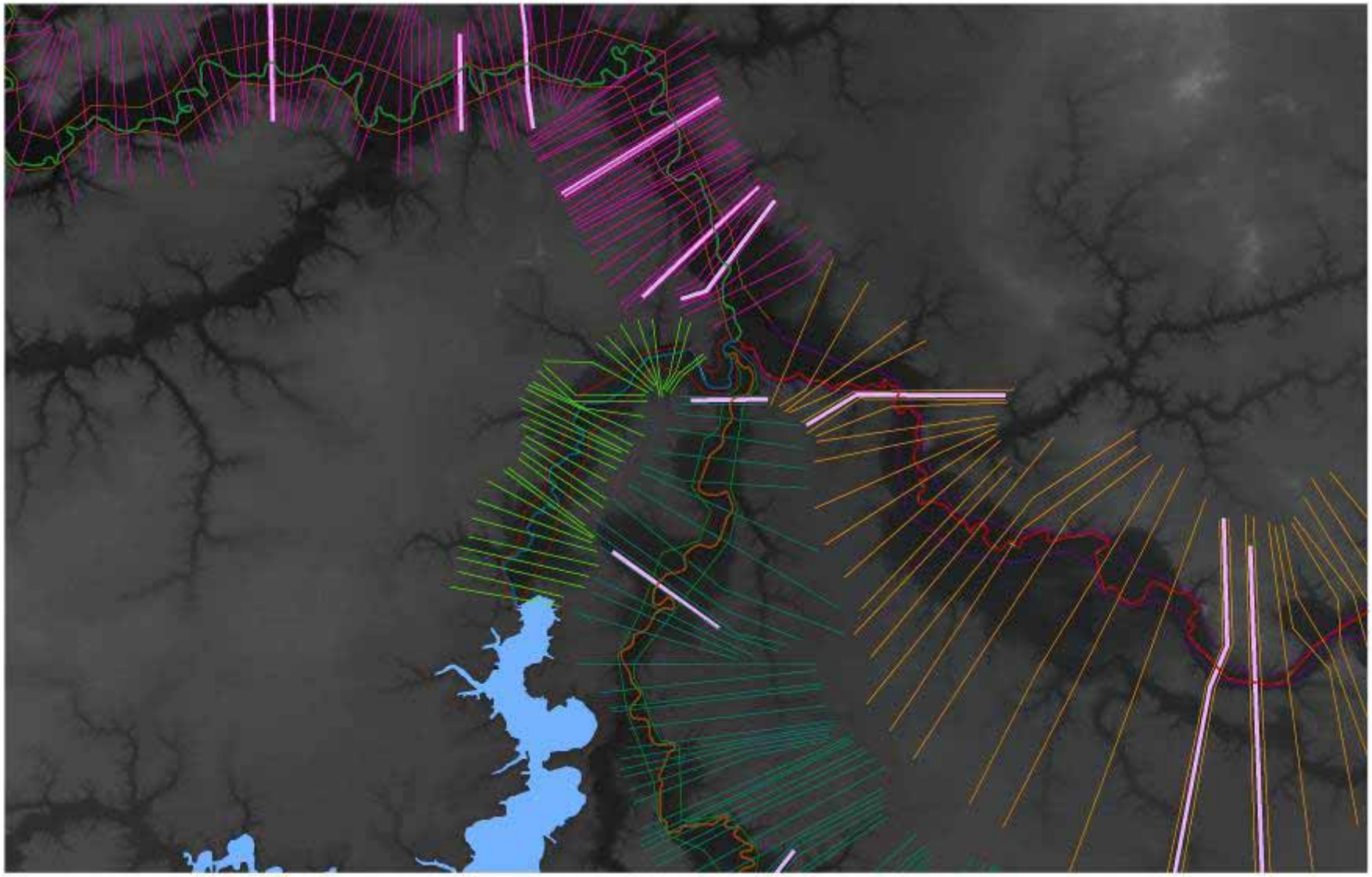
Flow Paths

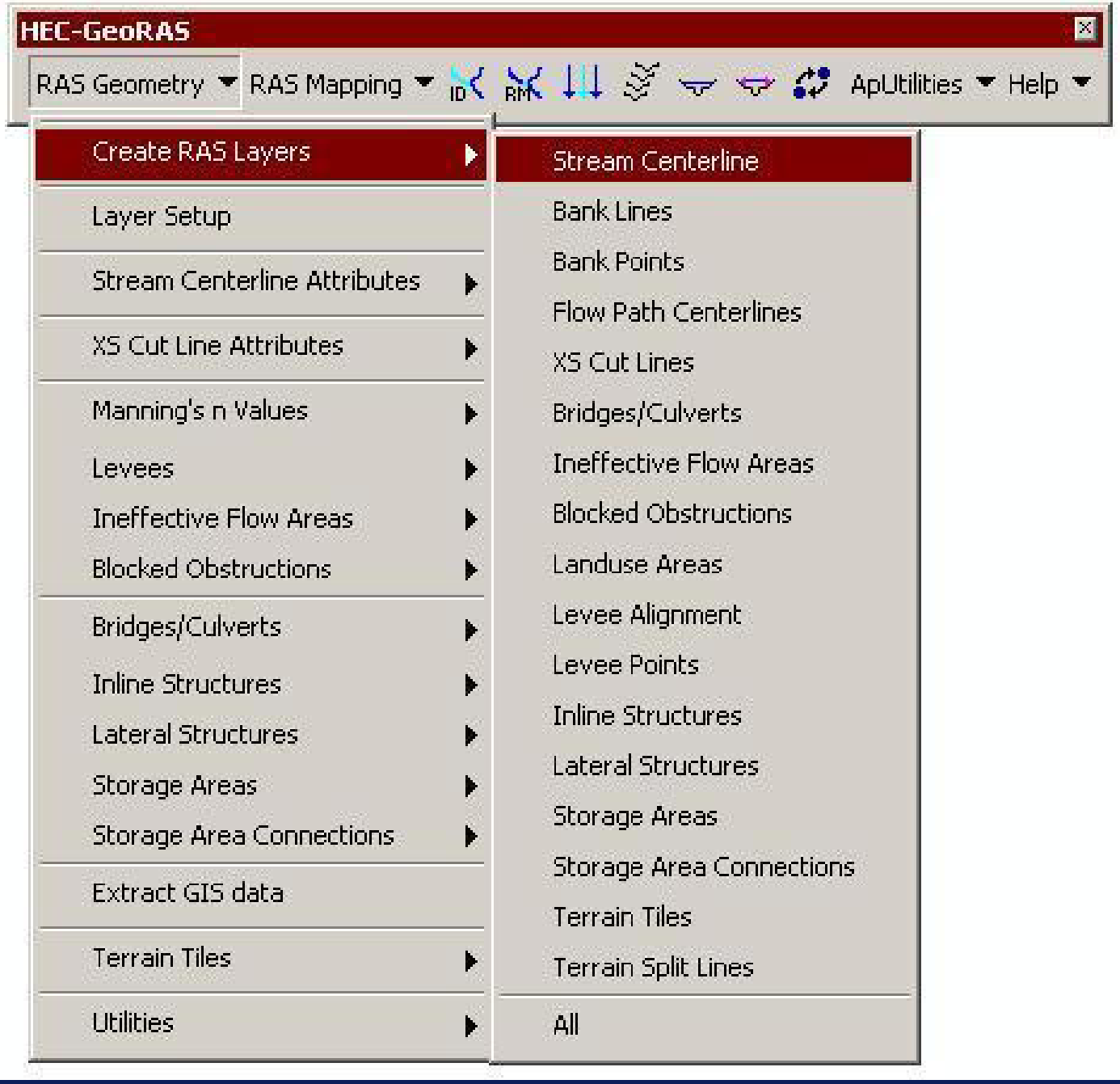


Stream Crossings

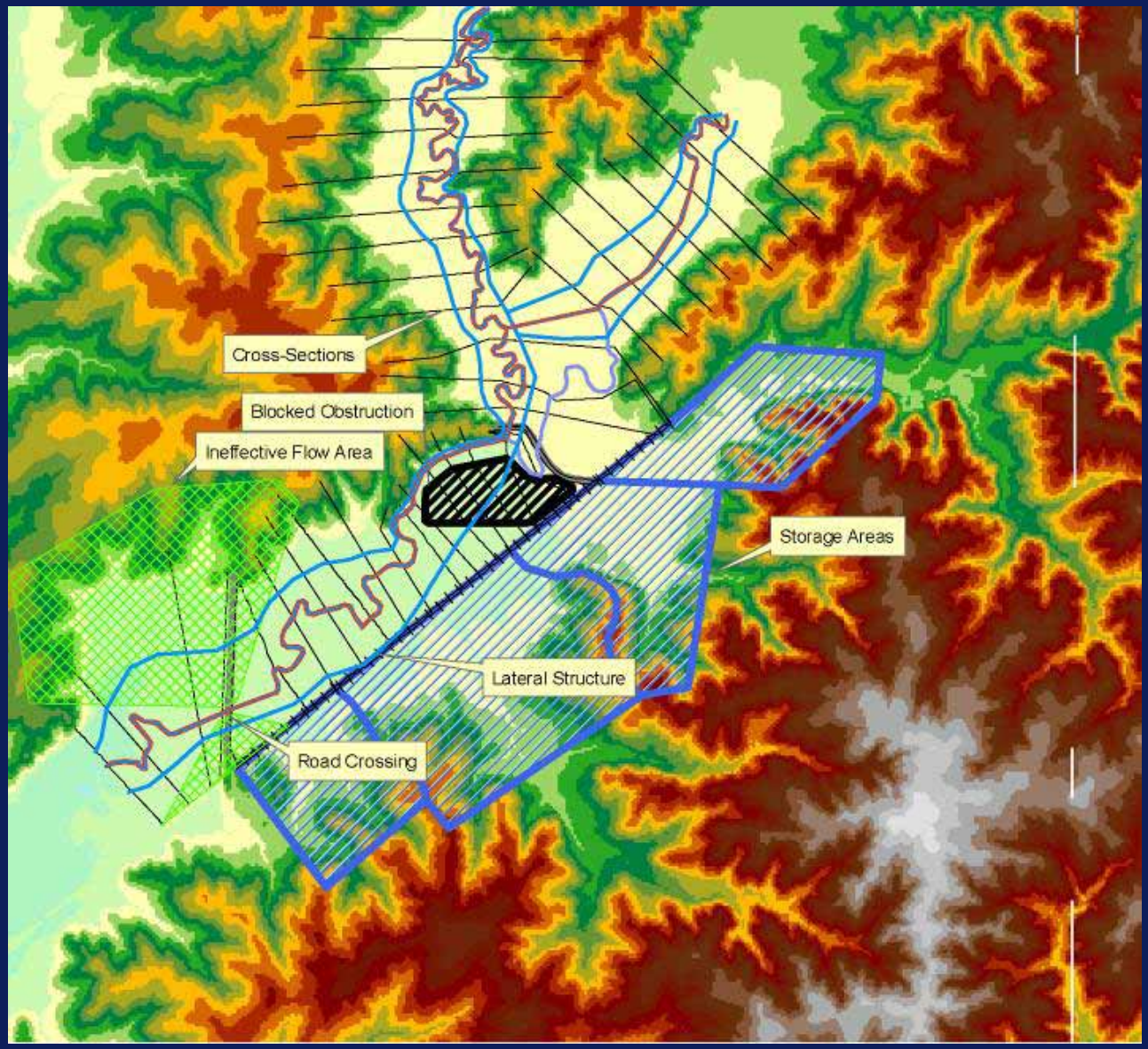


All layers are complete – ready to export to HEC-RAS

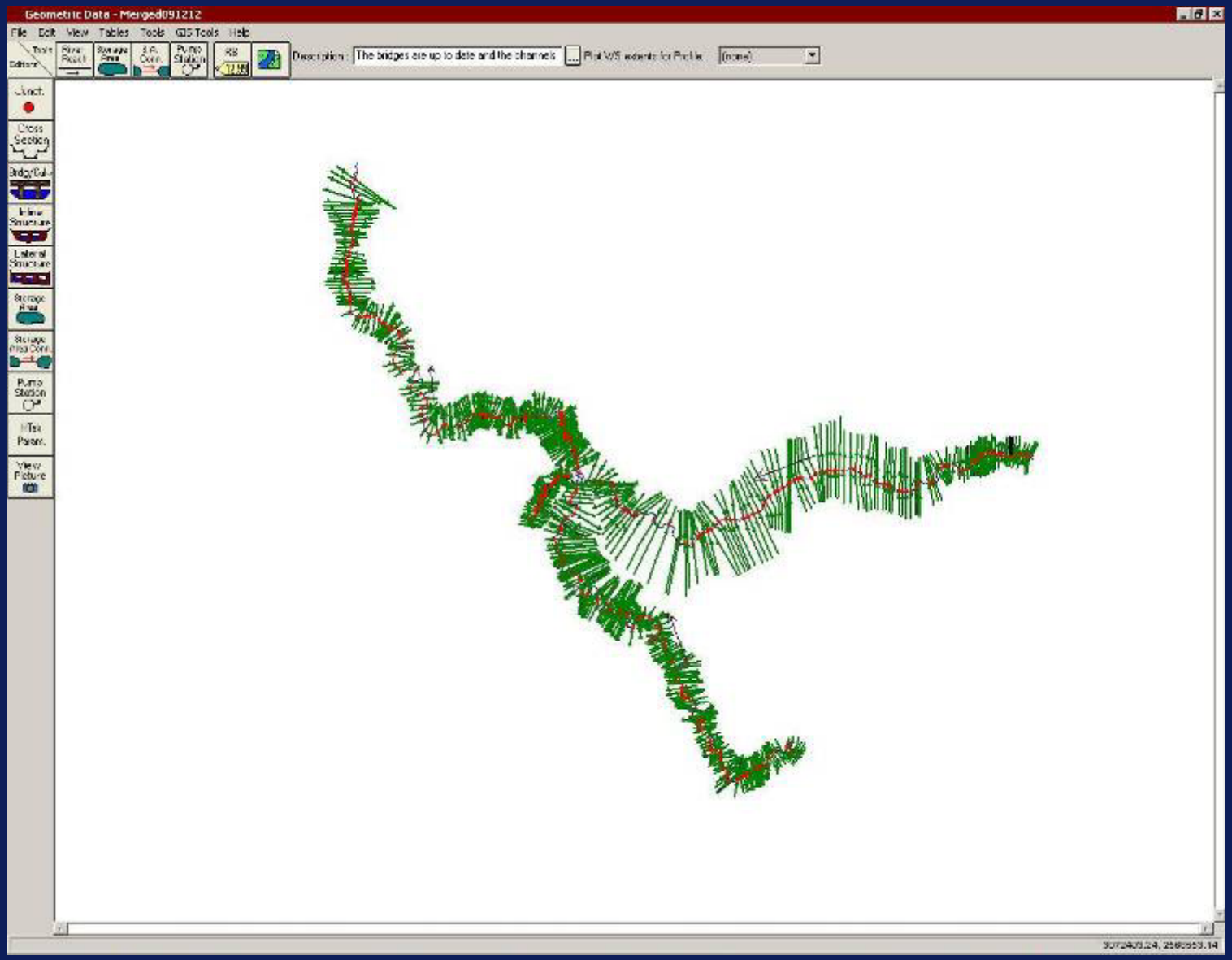



HEC-GeoRAS
RAS Geometry
RAS Mapping
ID
RM
ApUtilities
Help
Create RAS Layers
Layer Setup
Stream Centerline Attributes
XS Cut Line Attributes
Manning's n Values
Levees
Ineffective Flow Areas
Blocked Obstructions
Bridges/Culverts
Inline Structures
Lateral Structures
Storage Areas
Storage Area Connections
Extract GIS data
Terrain Tiles
Utilities
Stream Centerline
Bank Lines
Bank Points
Flow Path Centerlines
XS Cut Lines
Bridges/Culverts
Ineffective Flow Areas
Blocked Obstructions
Landuse Areas
Levee Alignment
Levee Points
Inline Structures
Lateral Structures
Storage Areas
Storage Area Connections
Terrain Tiles
Terrain Split Lines
All

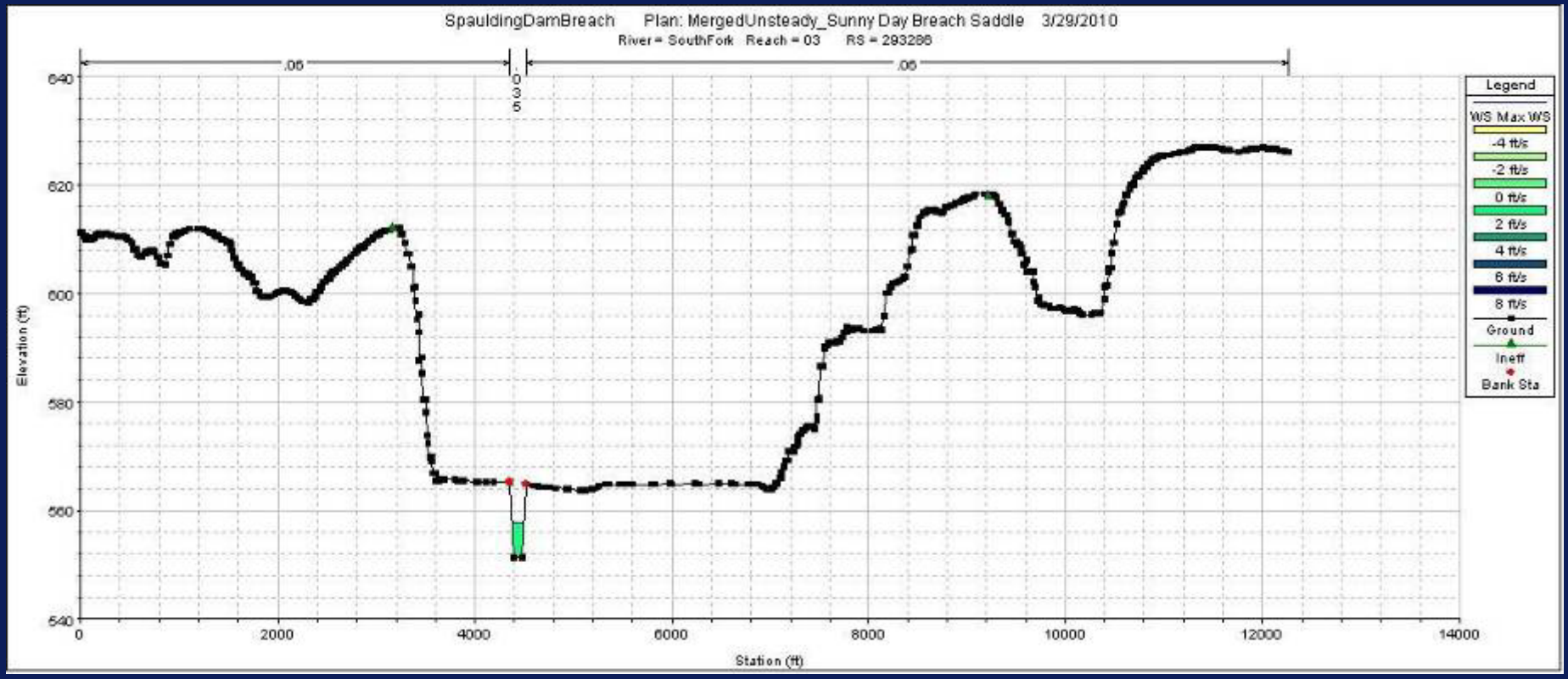
Example of Additional Layers



HEC-RAS Model - schematic

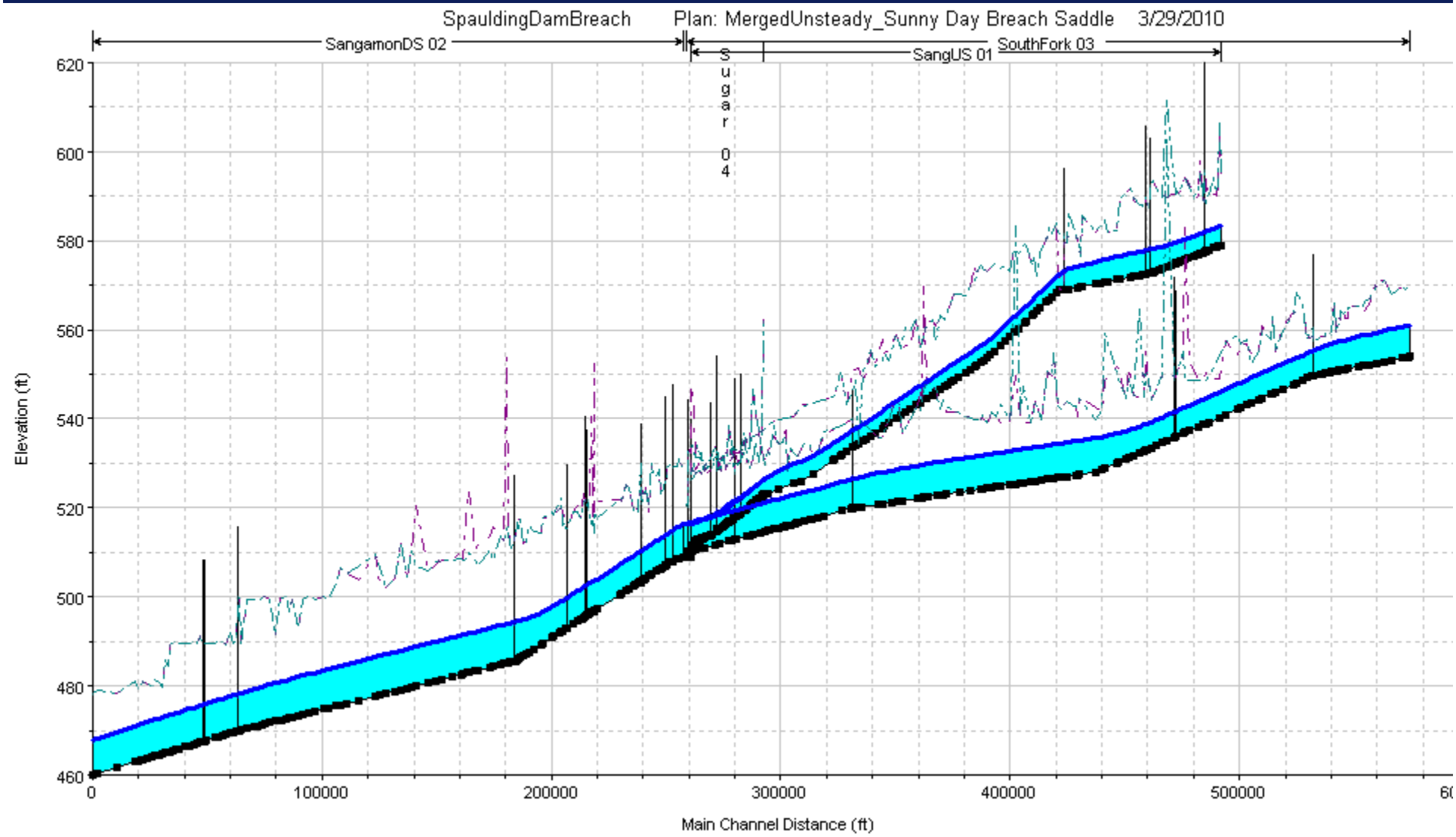


LiDAR – Light Detection and Ranging



DEM - 30 meter resolution

Dam Breach

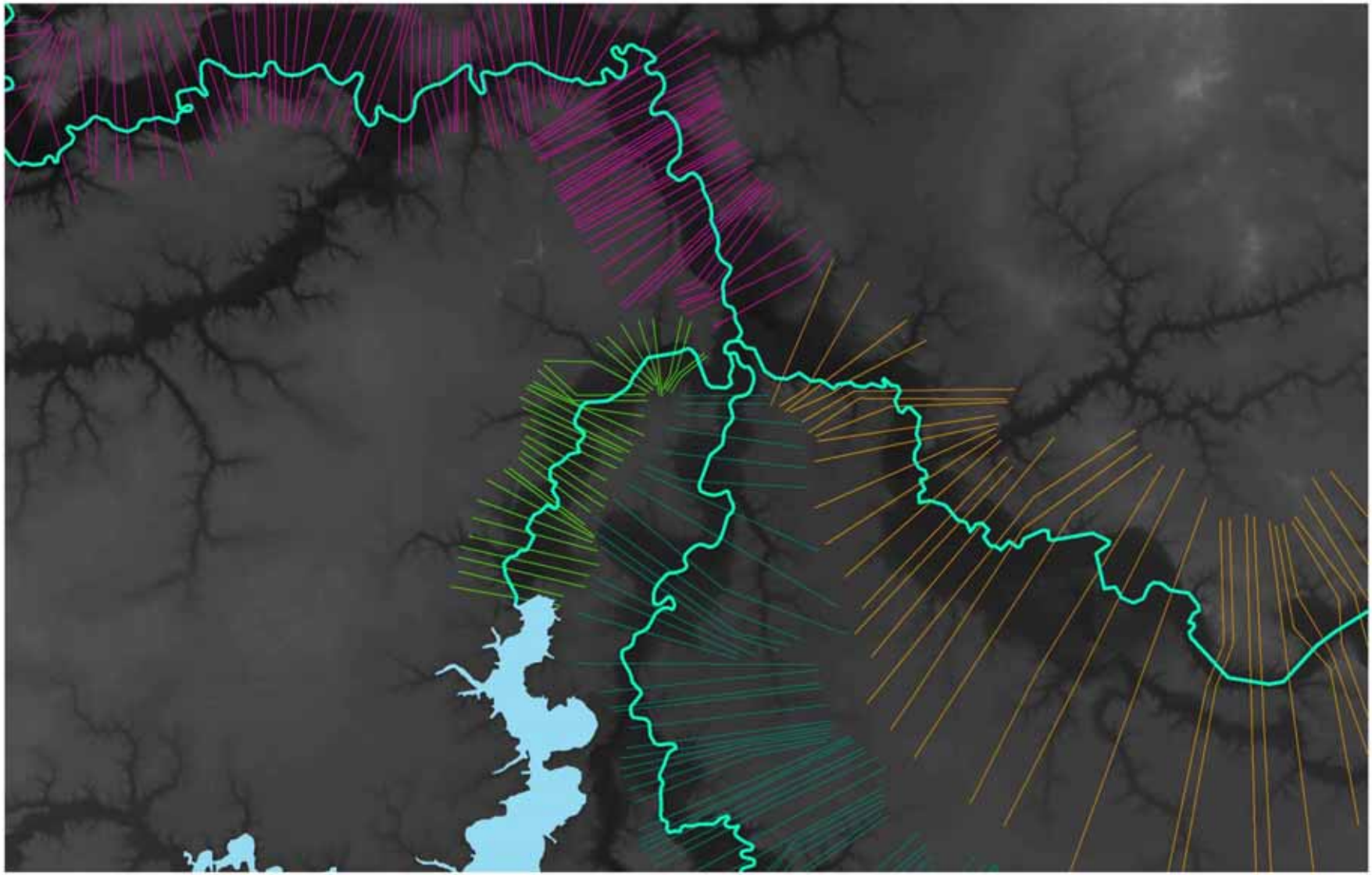

SpauldingDamBreach
Plan: MergedUnsteady_Sunny Day Breach Saddle 3/29/2010
SangamonDS 02
SangUS 01
SouthFork 03
Sugar 04
Elevation (ft)
620
600
580
560
540
520
500
480
460
0
100000
200000
300000
400000
500000
Main Channel Distance (ft)

WE NOW HAVE A MODEL AND DATA, BUT NO MAP

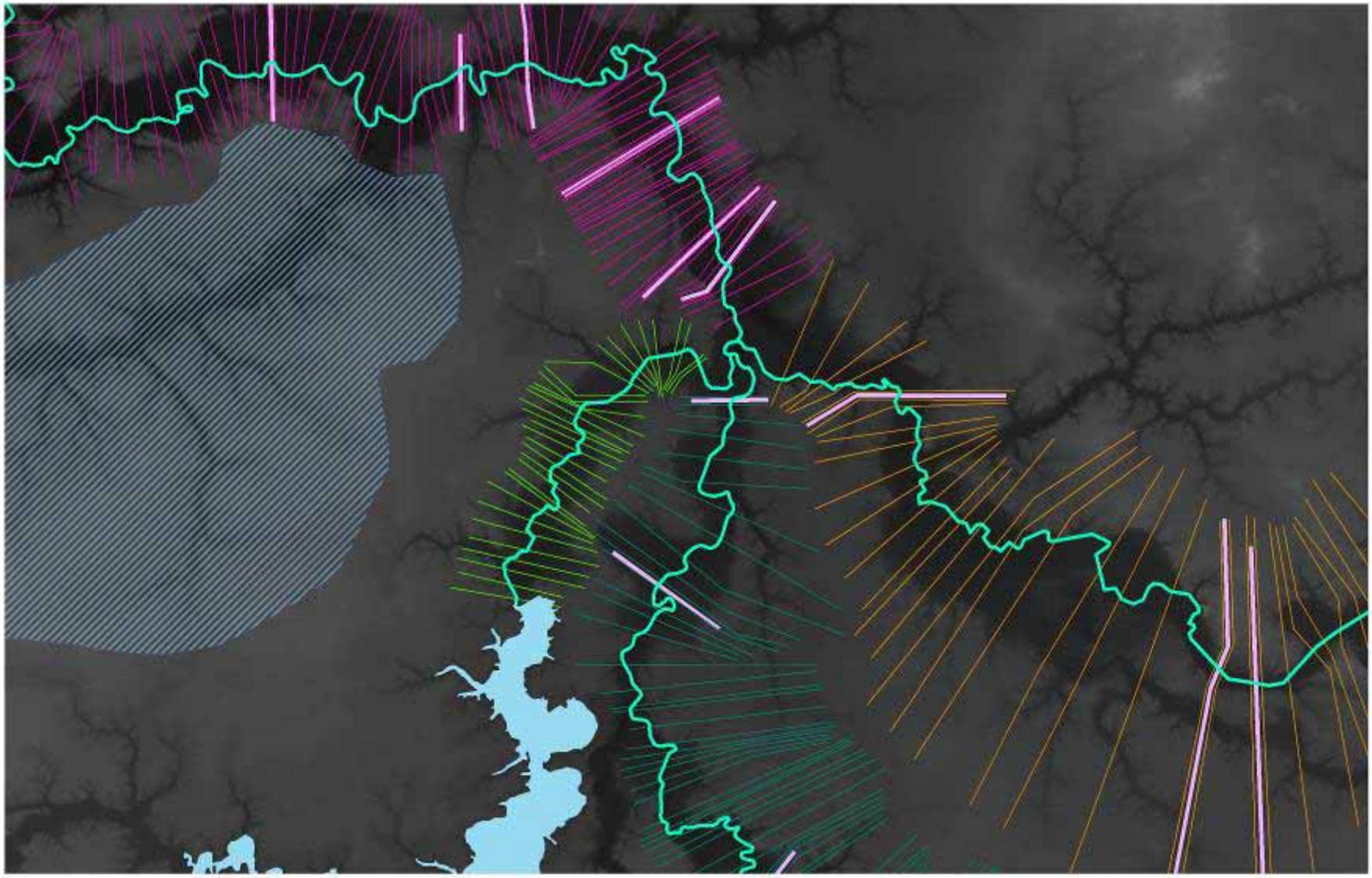
WHAT'S NEXT?

EXPORT TO GIS

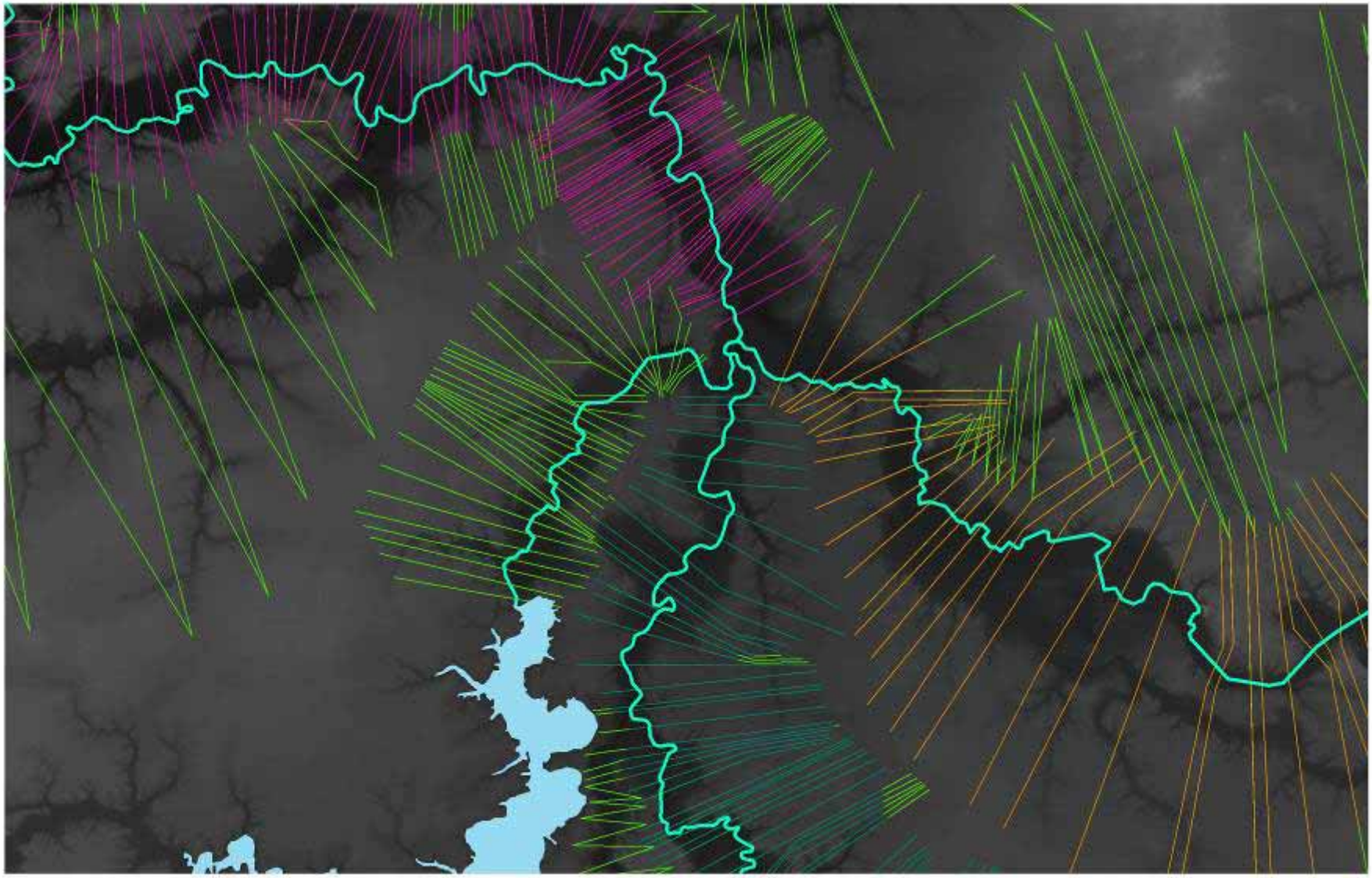
Mapping with Hydraulic Cross-sections



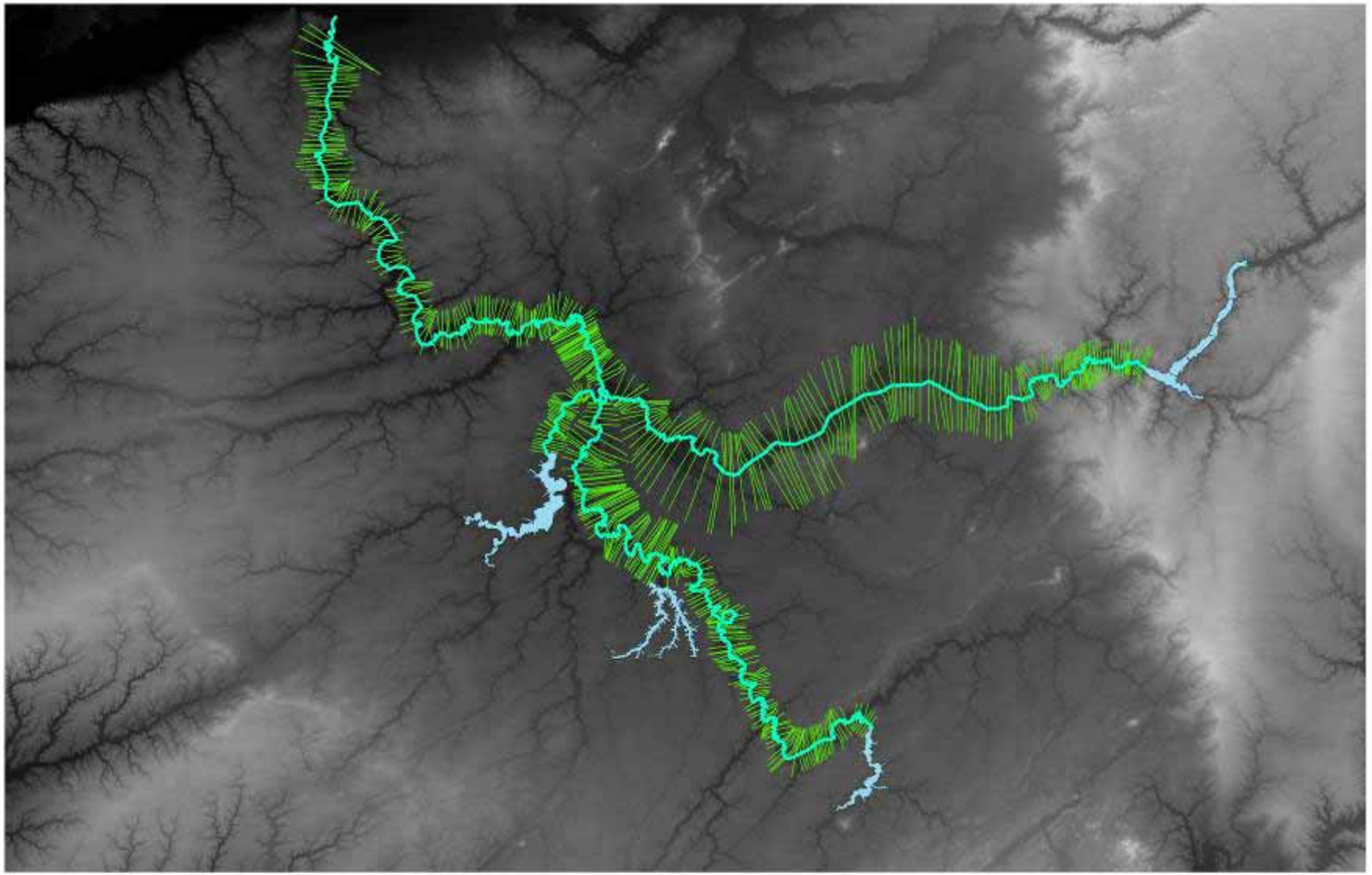
Mapping with Storage Areas



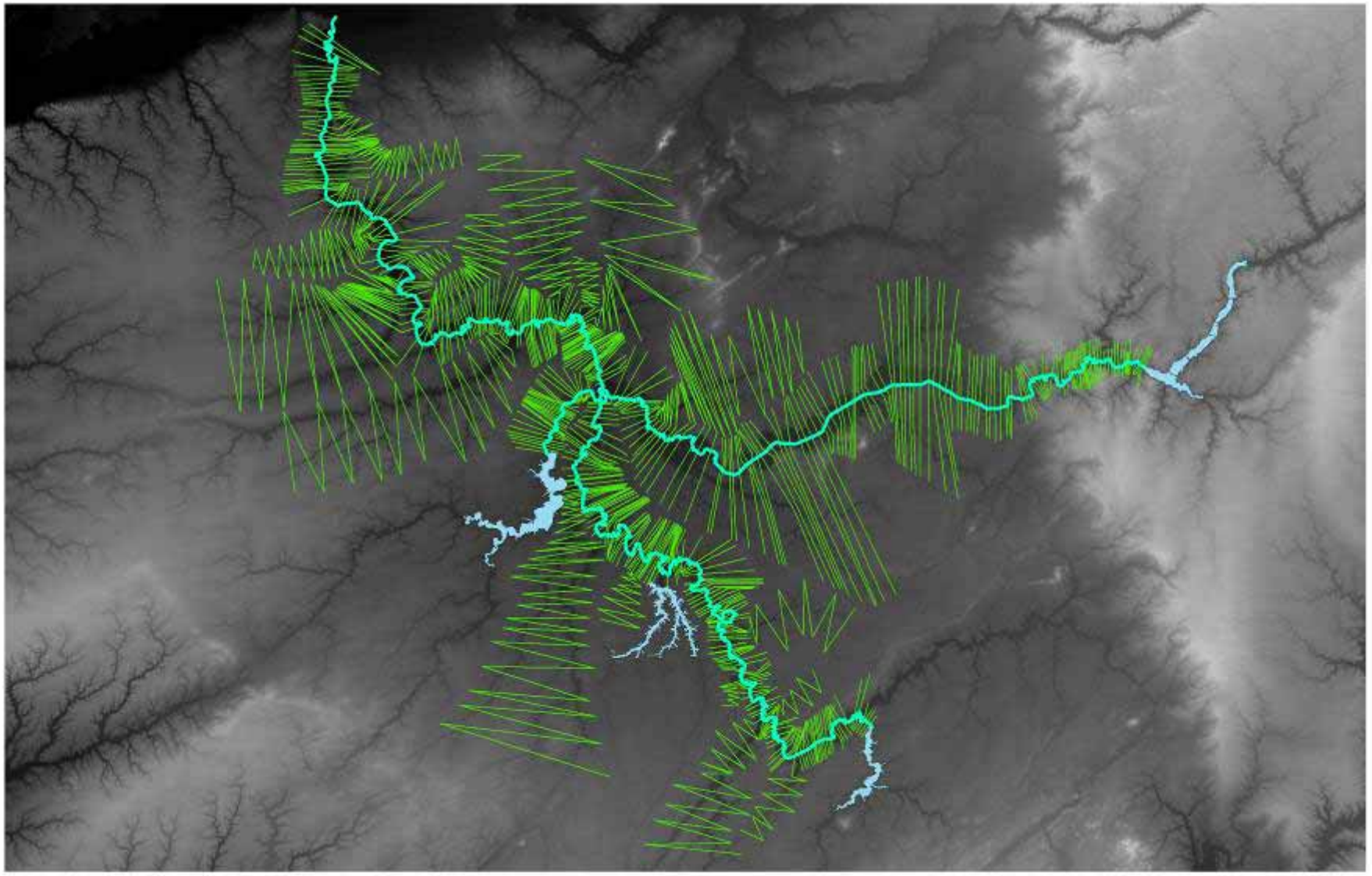
Mapping Cross-sections – good for small backwater areas



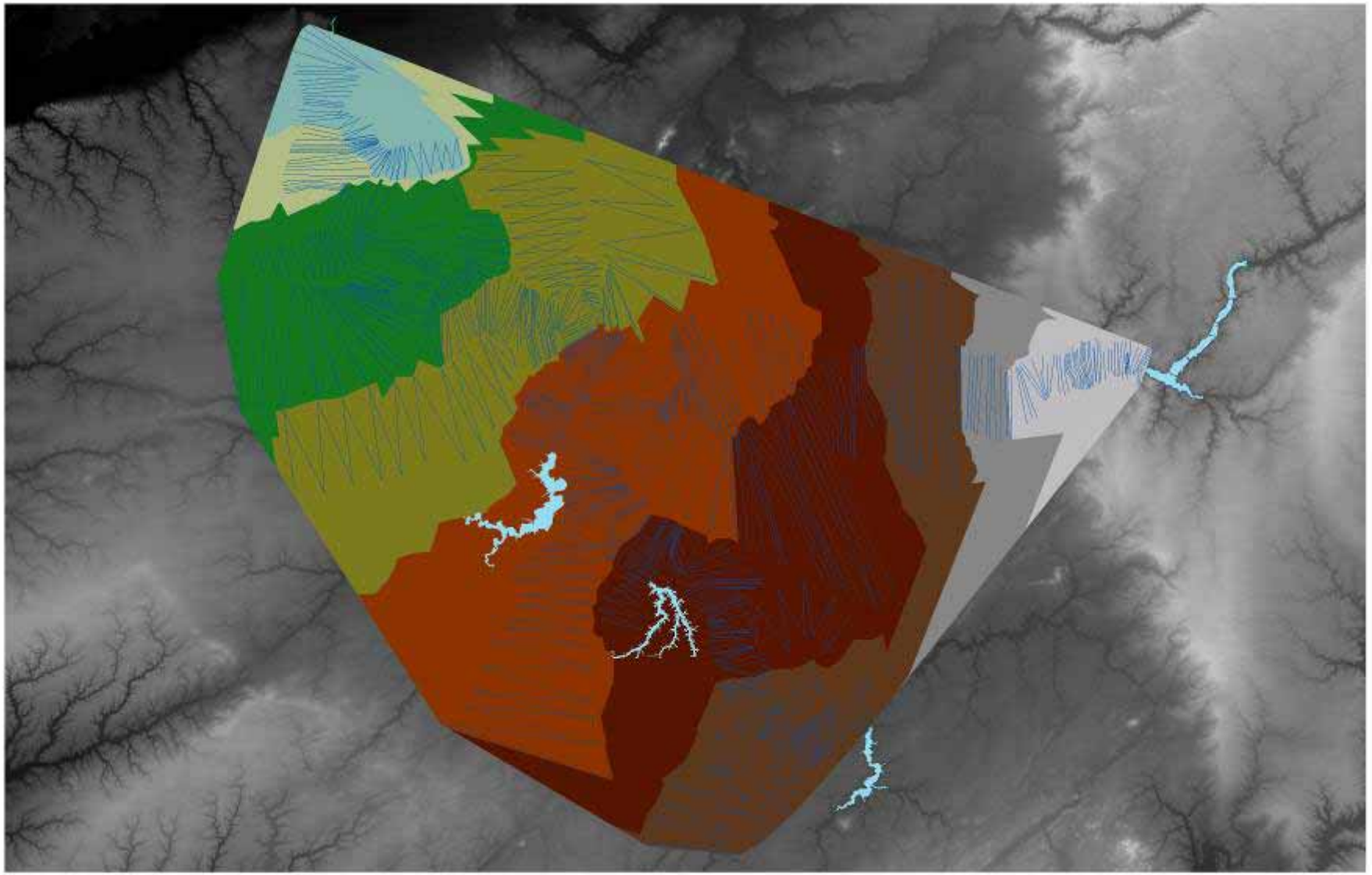
Hydraulic Cross-sections



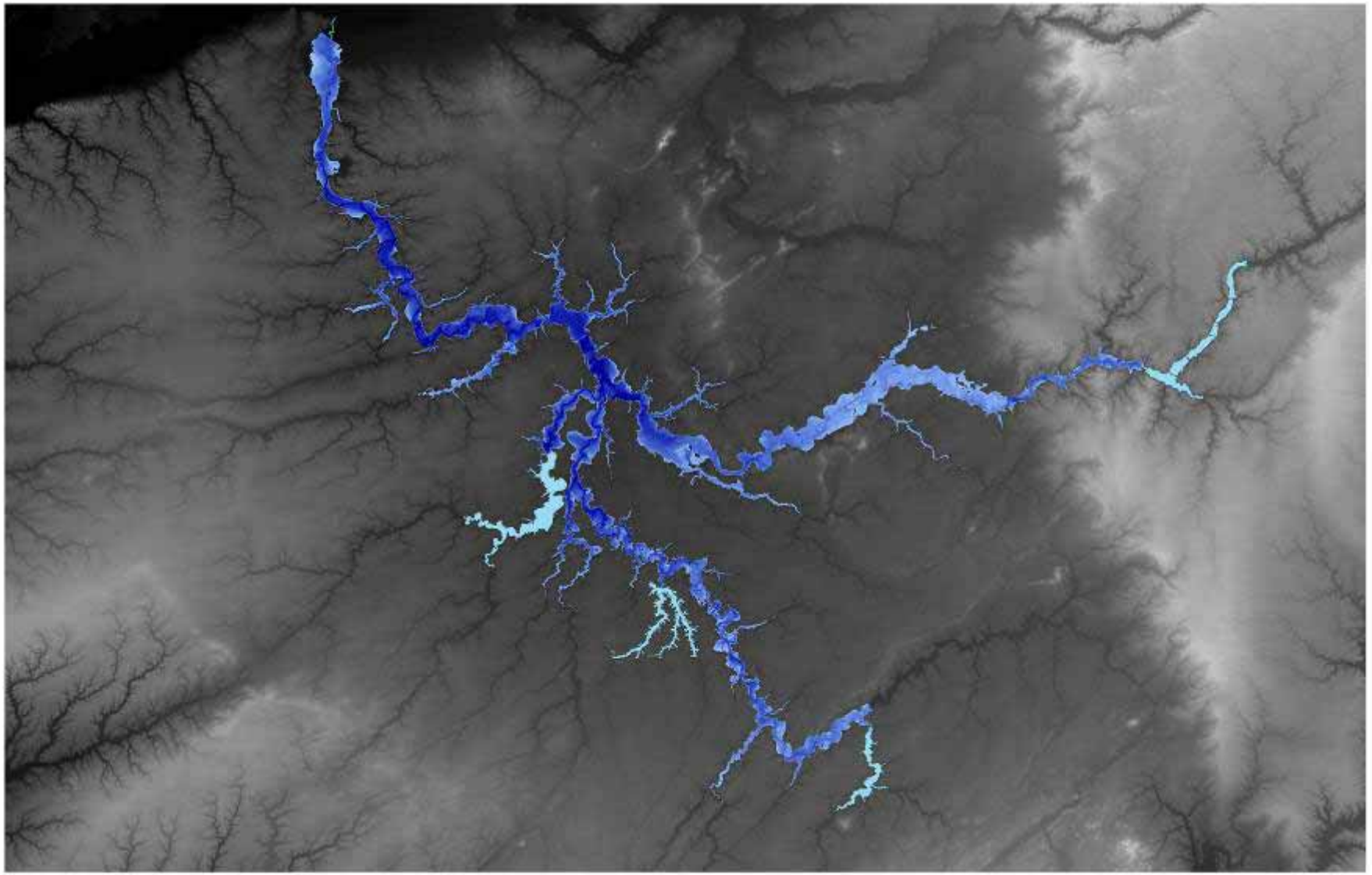
Mapping Cross-sections



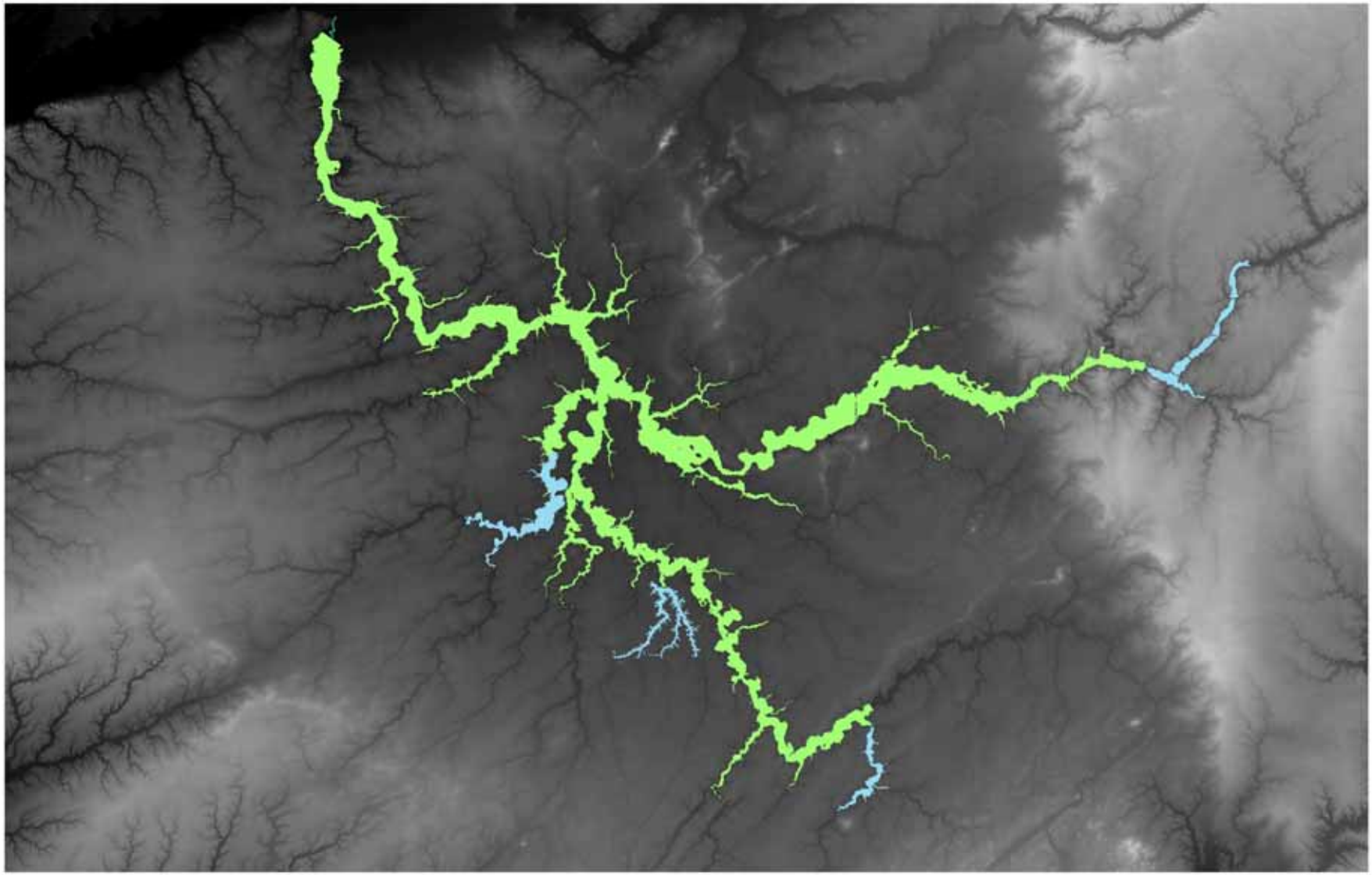
TIN – Triangulated Irregular Network



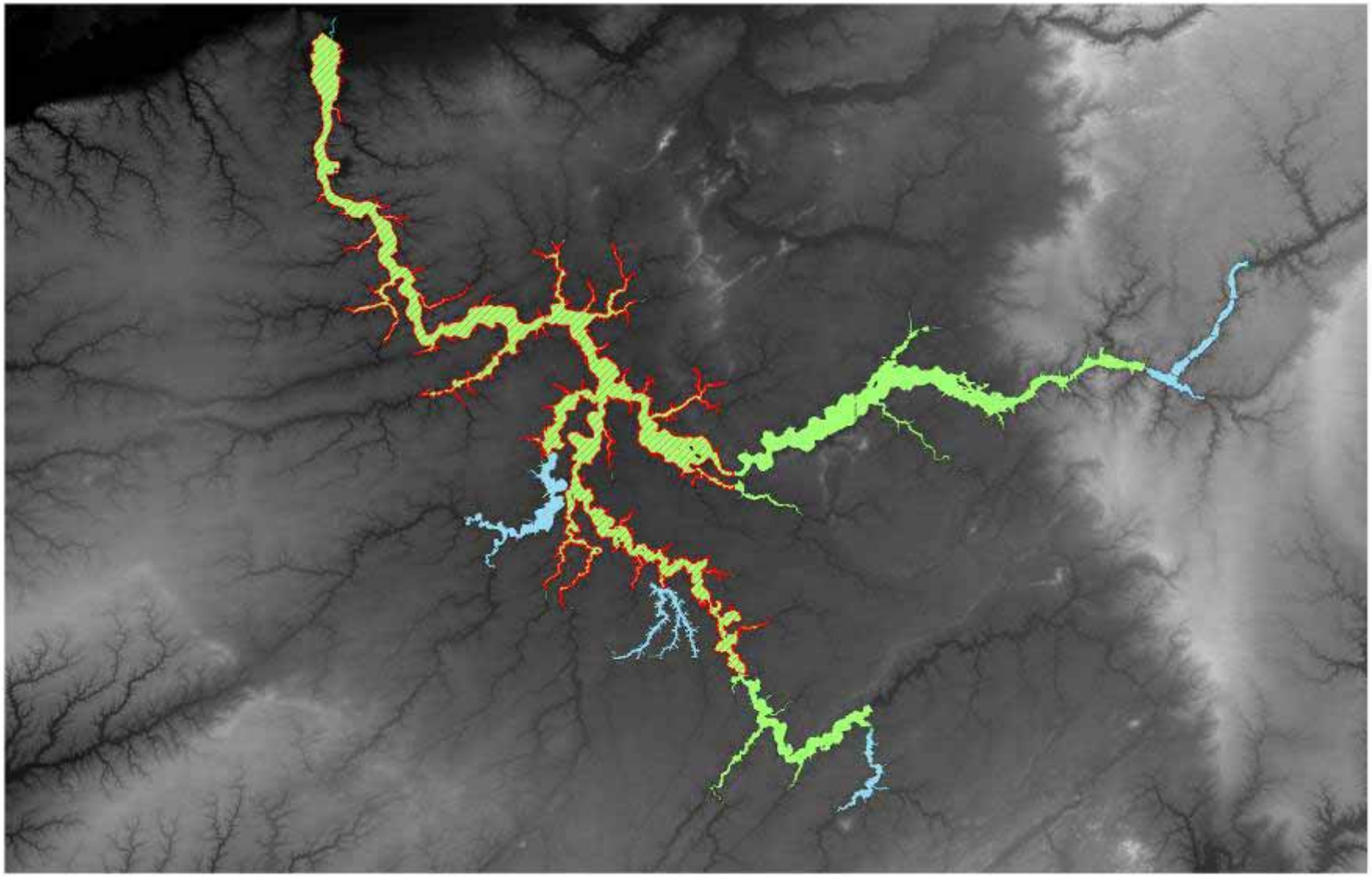
Flood Depth



Inundation Area



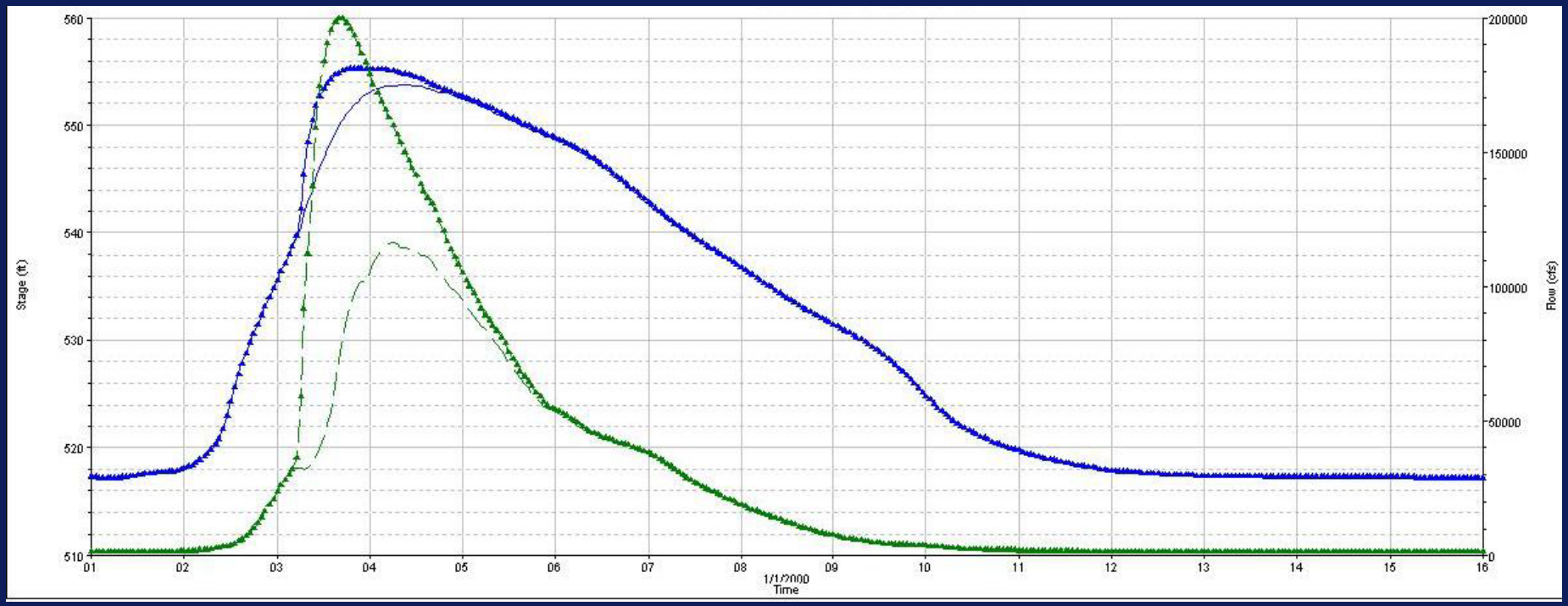
Dam Breach Impact Area



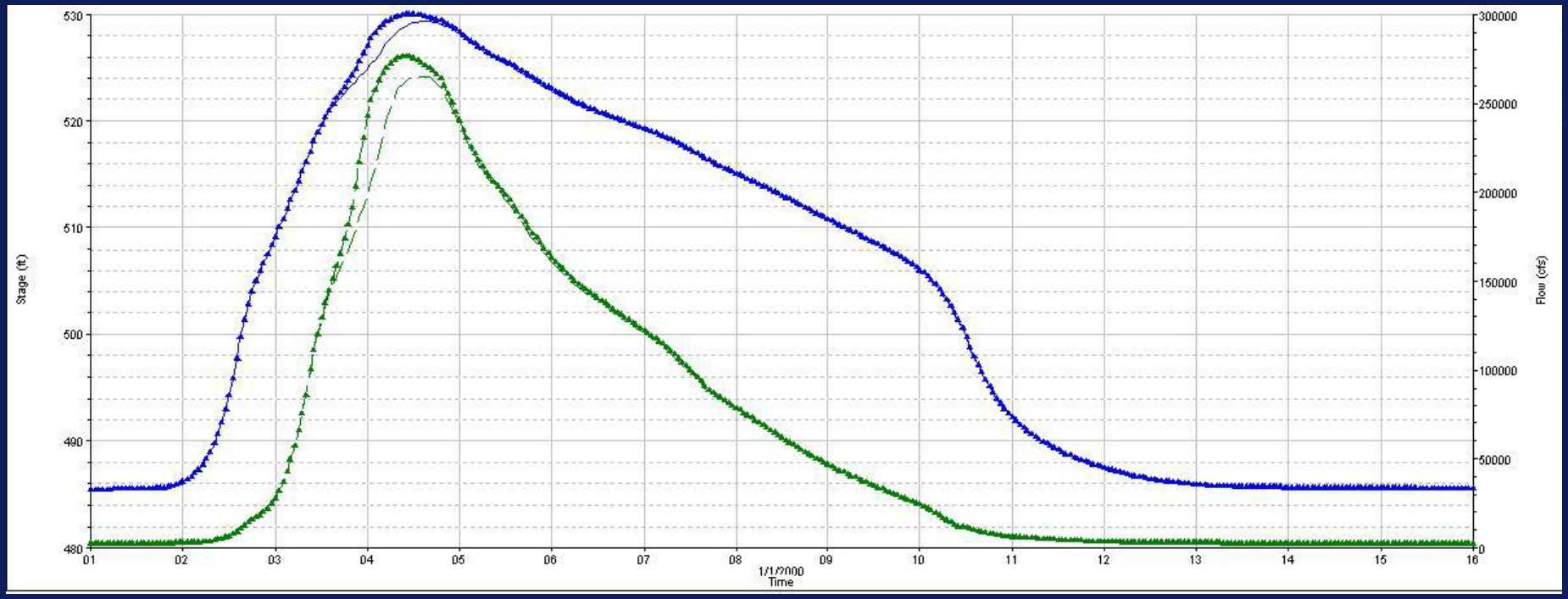
Stage/Flow hydrograph near Dam

Blue = Water Elevation

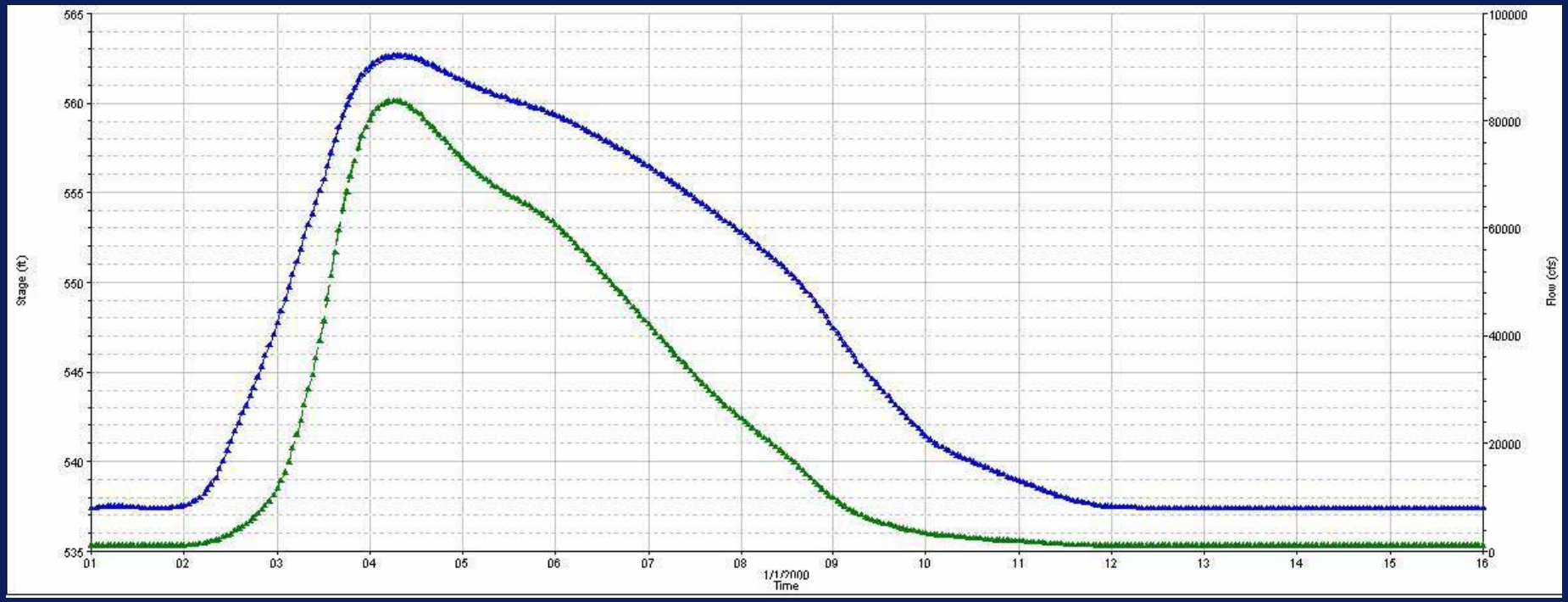
Green = Discharge



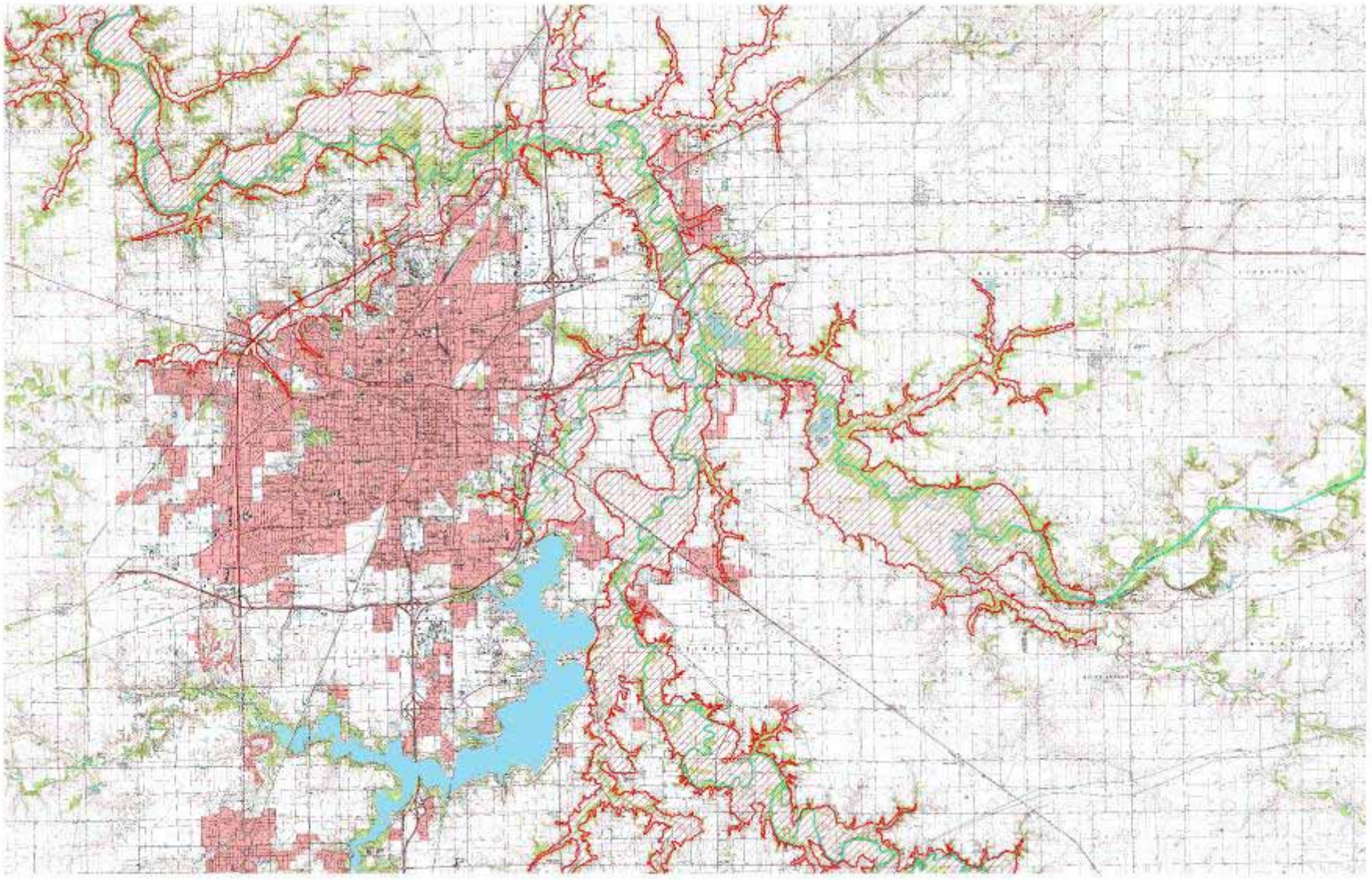
Downstream


530
520
510
500
490
480
Stage (ft)
300000
250000
200000
150000
100000
50000
0
Flow (cfs)
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
1/1/2000
Time

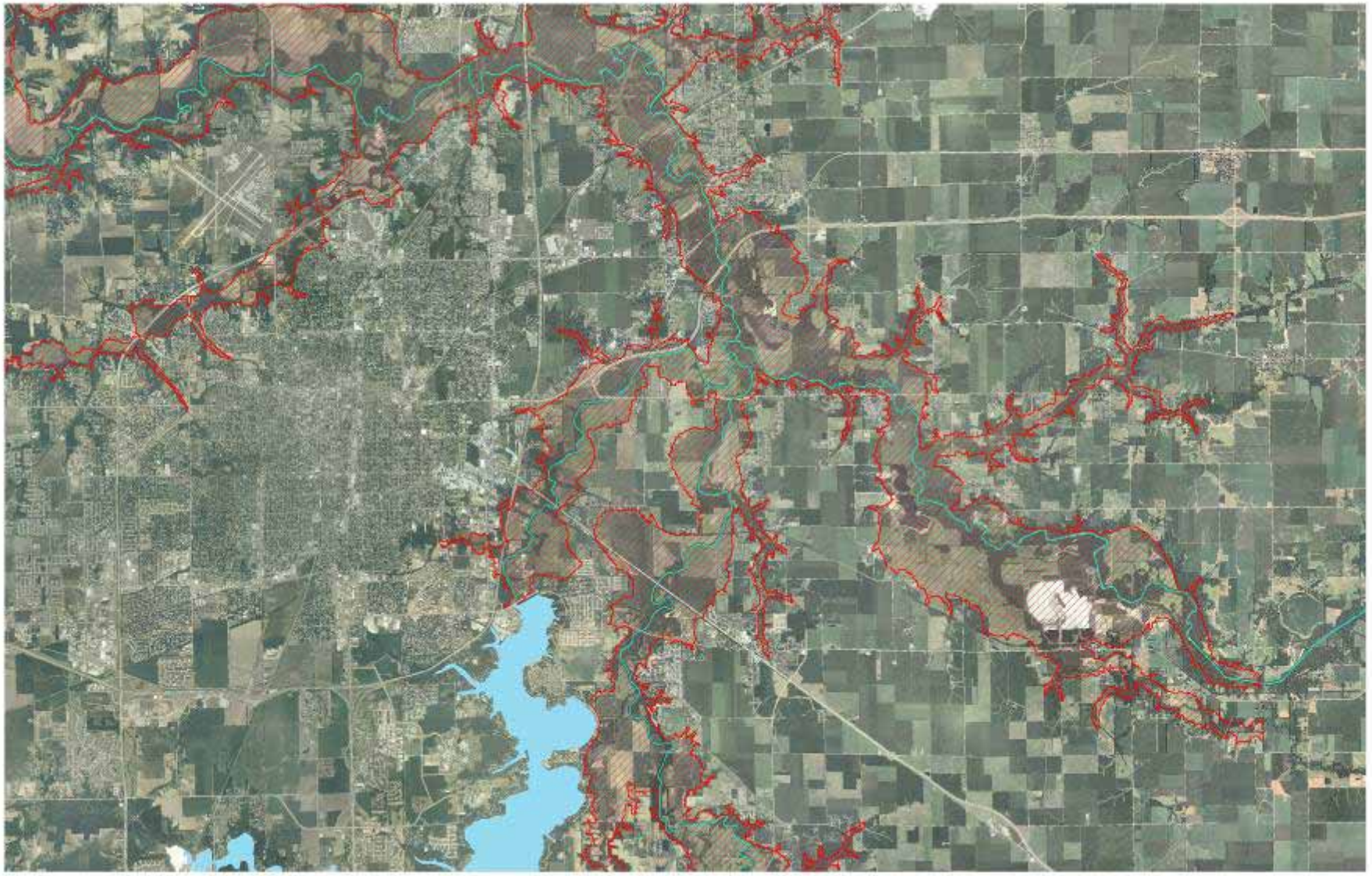
Farther Downstream



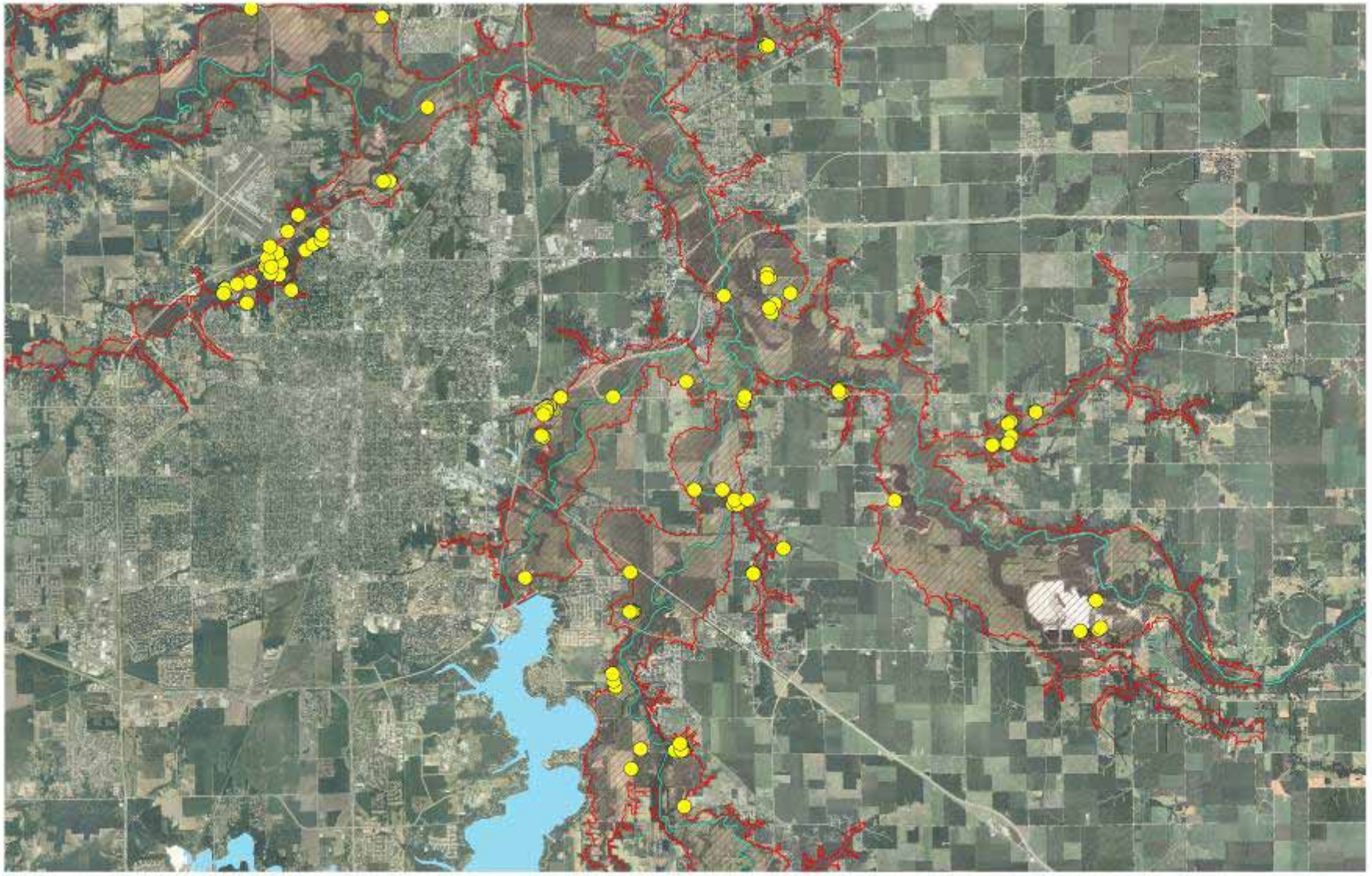
Inundation Area on USGS Quad Map



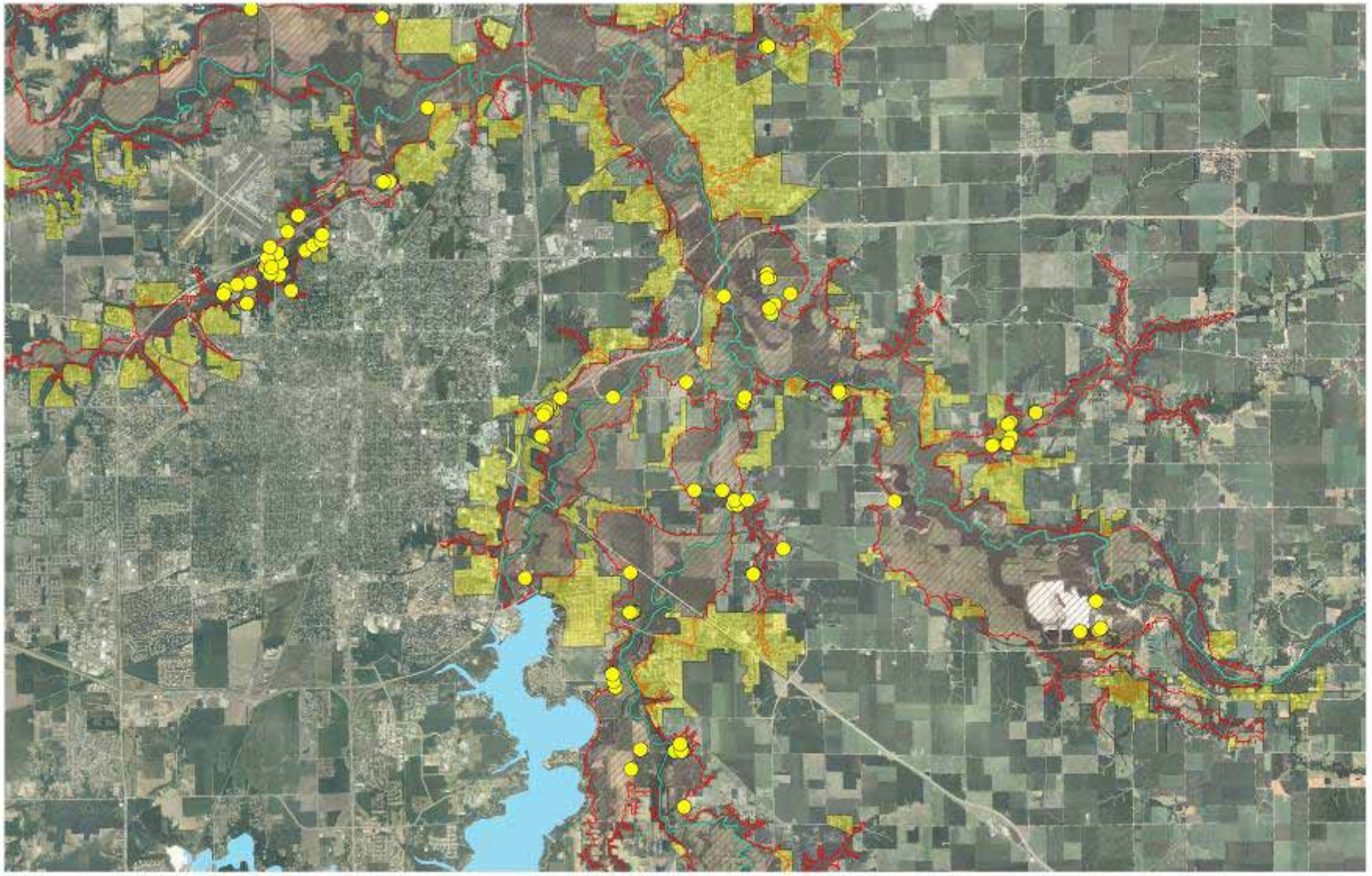
Inundation Area on Orthophoto



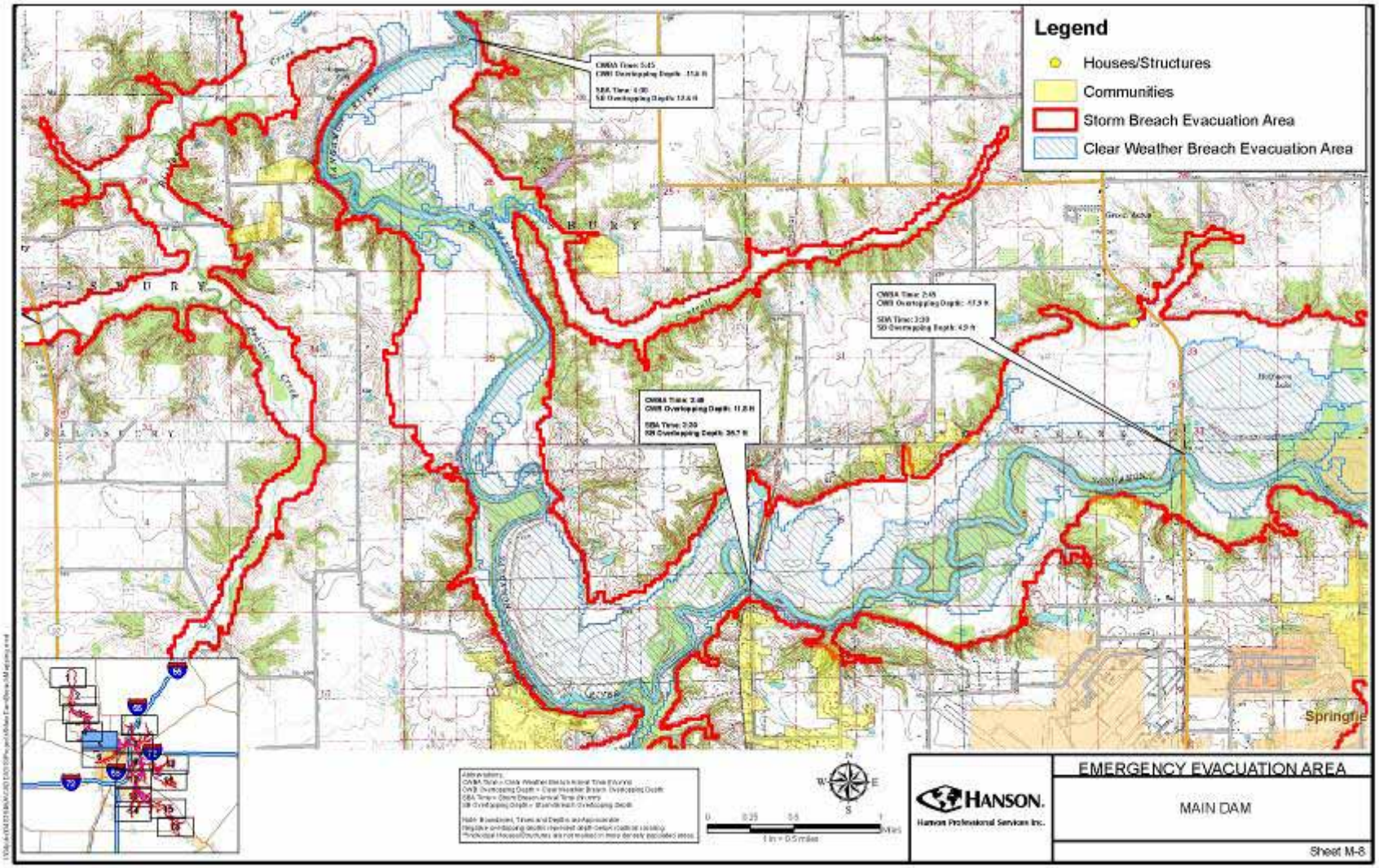
Identify Structures at Risk



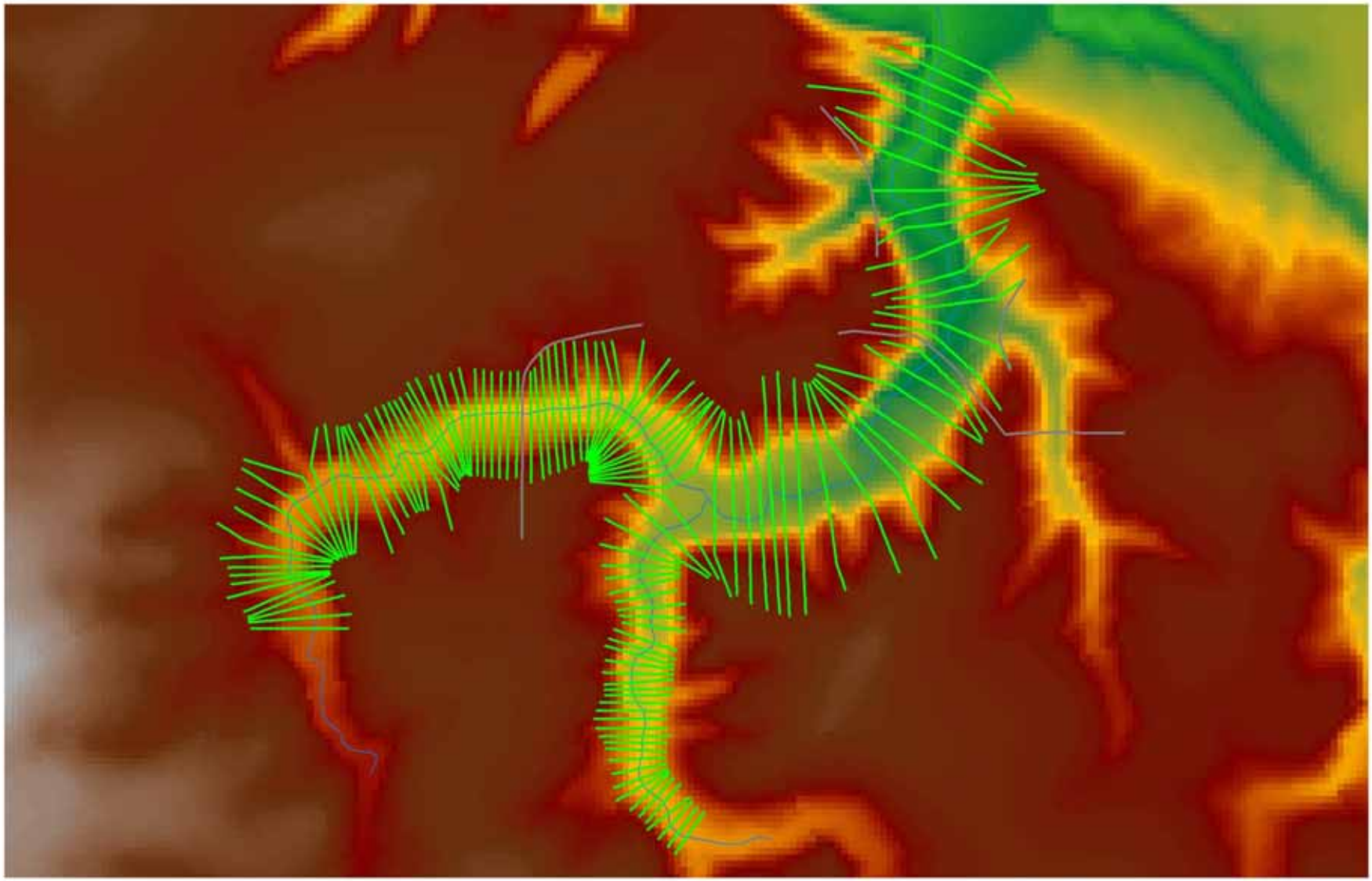
Communities at Risk



Add User Valued Information



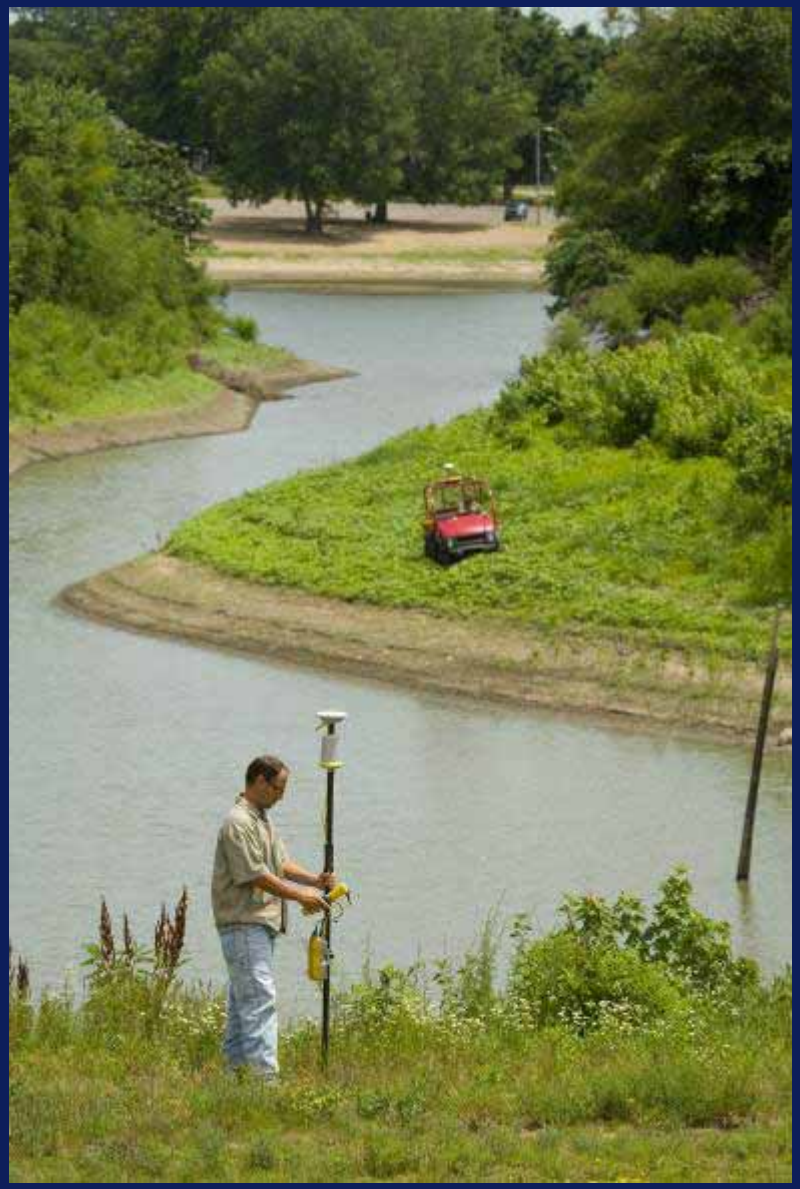
Same concept – on a smaller scale



Benefits of GIS Modeling & Mapping

Benefits of GIS Modeling & Mapping

- Minimal Survey



Benefits of GIS Modeling & Mapping

- Minimal Survey
- Data Organization

Attributes of Watershed_LC_SoilHydro_EastFINAL

OBJECTID	Shape*	FID_Waters	ID	GRIDCODE	MUKEY	musym_1	muname	hydgrpdcd	HYDRO_LC	Shape_Leng	CN
1	Polygon	84382	3608858	12	261778	3073A	Ross silt loam, 0 to 2 percent slopes, frequently flooded	B	B12	5685.264729	78
2	Polygon	91406	3622658	12	261753	131C2	Alvin fine sandy loam, 5 to 10 percent slopes, eroded	B	B12	6715.200741	78
3	Polygon	91407	3622658	12	261878	134B	Camden silt loam, 2 to 5 percent slopes	B	B12	3100.034444	78
4	Polygon	91408	3622658	12	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B12	2727.26339	78
5	Polygon	91409	3622658	12	261783	7242A	Kendall silt loam, 0 to 2 percent slopes, rarely flooded	B	B12	337.746684	78
6	Polygon	91503	3622673	17	261745	3074A	Radford silt loam, 0 to 2 percent slopes, frequently flooded	B	B17	765.407486	58
7	Polygon	91883	3623492	44	261753	131C2	Alvin fine sandy loam, 5 to 10 percent slopes, eroded	B	B44	4166.876896	60
8	Polygon	91883	3623492	44	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B44	3726.040616	60
9	Polygon	91893	3623493	17	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B17	2006.301284	58
10	Polygon	82422	3604237	12	261764	3107A	Sawmill silty clay loam, 0 to 2 percent slopes, frequently flooded	BD	BD12	1442.201732	81
11	Polygon	82423	3604237	12	261767	3284A	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded	B	B12	2512.414084	76
12	Polygon	82431	3604253	32	261780	43A	Ipava silt loam, 0 to 2 percent slopes	B	B32	381.58653	75
13	Polygon	82437	3604255	31	261780	43A	Ipava silt loam, 0 to 2 percent slopes	B	B31	1718.086312	92
14	Polygon	82785	3605113	12	261767	3284A	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded	B	B12	1301.451081	76
15	Polygon	82797	3605114	17	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B17	8047.588451	58
16	Polygon	82793	3605114	17	261781	242A	Kendall silt loam, 0 to 2 percent slopes	B	B17	5060.888085	58
17	Polygon	83185	3606059	17	261778	3073A	Ross silt loam, 0 to 2 percent slopes, frequently flooded	B	B17	2260.349012	58
18	Polygon	83187	3606060	17	261764	3107A	Sawmill silty clay loam, 0 to 2 percent slopes, frequently flooded	BD	BD17	1180.111056	68
19	Polygon	83188	3606060	17	261767	3284A	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded	B	B17	1790.153071	58
20	Polygon	83190	3606062	17	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B17	1885.169231	58
21	Polygon	83461	3606751	17	261764	3107A	Sawmill silty clay loam, 0 to 2 percent slopes, frequently flooded	BD	BD17	687.38762	68
22	Polygon	83639	3607200	12	261764	3107A	Sawmill silty clay loam, 0 to 2 percent slopes, frequently flooded	BD	BD12	737.290626	81
23	Polygon	84573	3608253	17	261878	134D	Camden silt loam, 2 to 5 percent slopes	B	B17	2675.04286	58
24	Polygon	84023	3608718	12	261767	3284A	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded	B	B12	1635.40008	76
25	Polygon	84033	3608721	12	261878	134D	Camden silt loam, 2 to 5 percent slopes	B	B12	2170.356316	76
26	Polygon	84033	3608723	31	261735	W	Water	W	W31	586.130563	100
27	Polygon	85040	3610855	12	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B12	4487.488113	76
28	Polygon	85043	3610855	12	261764	152A	Drummer silty clay loam, 0 to 2 percent slopes	BD	BD12	1795.329491	81
29	Polygon	85264	3610631	21	261878	134B	Camden silt loam, 2 to 5 percent slopes	B	B21	1310.454713	55
30	Polygon	85502	3611036	17	261878	134B	Camden silt loam, 2 to 5 percent slopes	B	B17	3870.131132	58
31	Polygon	85503	3611036	17	261790	865	Pits, gravel	W	W17	3193.047704	100
32	Polygon	85511	3611038	11	261753	131C2	Alvin fine sandy loam, 5 to 10 percent slopes, eroded	B	B11	3845.17787	78
33	Polygon	85512	3611038	11	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B11	2892.106473	78
34	Polygon	85687	3611478	21	261878	134B	Camden silt loam, 2 to 5 percent slopes	B	B21	1310.648322	55
35	Polygon	85694	3611491	31	261790	865	Pits, gravel	W	W31	948.140547	100
36	Polygon	85703	3611496	17	261773	68A	Sable silty clay loam, 0 to 2 percent slopes	BD	BD17	1174.697687	68
37	Polygon	85989	3611929	17	261753	131C2	Alvin fine sandy loam, 5 to 10 percent slopes, eroded	B	B17	1092.613068	58
38	Polygon	85990	3611929	17	261793	570D2	Martinsville sandy loam, 10 to 18 percent slopes, eroded	B	B17	1740.60022	58
39	Polygon	85905	3611931	31	261721	685D	Middletown silt loam, 2 to 5 percent slopes	B	B31	1174.000980	92
40	Polygon	85910	3611936	14	261773	68A	Sable silty clay loam, 0 to 2 percent slopes	BD	BD14	702.741288	81
41	Polygon	85910	3611936	17	261721	685B	Middletown silt loam, 2 to 5 percent slopes	B	B17	2591.188539	58
42	Polygon	85913	3611936	17	261730	684B	Broadwell silt loam, 2 to 5 percent slopes	B	B17	2864.17353	58
43	Polygon	85914	3611936	17	261773	68A	Sable silty clay loam, 0 to 2 percent slopes	BD	BD17	5047.487047	68
44	Polygon	85915	3611936	17	261773	68A	Sable silty clay loam, 0 to 2 percent slopes	BD	BD17	785.187154	68
45	Polygon	85996	3611936	17	261780	43A	Ipava silt loam, 0 to 2 percent slopes	B	B17	3802.198301	58
46	Polygon	85997	3611936	17	261748	244A	Hartsburg silty clay loam, 0 to 2 percent slopes	BD	BD17	2577.015247	68

Record: 1 Show: All Selected Records (0 out of *2030 Selected) Options

Benefits of GIS Modeling & Mapping

- Minimal Survey
- Data Organization
- Updating

Benefits of GIS Modeling & Mapping

- Minimal Survey
- Data Organization
- Updating
- Exhibits
  - Data is the exhibit

Benefits of GIS Modeling & Mapping

- Minimal Survey
- Data Organization
- Updating
- Exhibits
  - Data is the exhibit
- Graphical review

Benefits of GIS Modeling & Mapping

- Minimal Survey
- Data Organization
- Updating
- Exhibits
  - Data is the exhibit
- Graphical review
- Collaboration

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Special Thanks to

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Lead Technical Advisor

Amanda Macklin
Lead Modeler

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