Urban Drainage Modeling for Storm Water Design

Using QL2 LIDAR

CIVICMAPPER

Benjamin H. Houston
P.E., PMP, GISP

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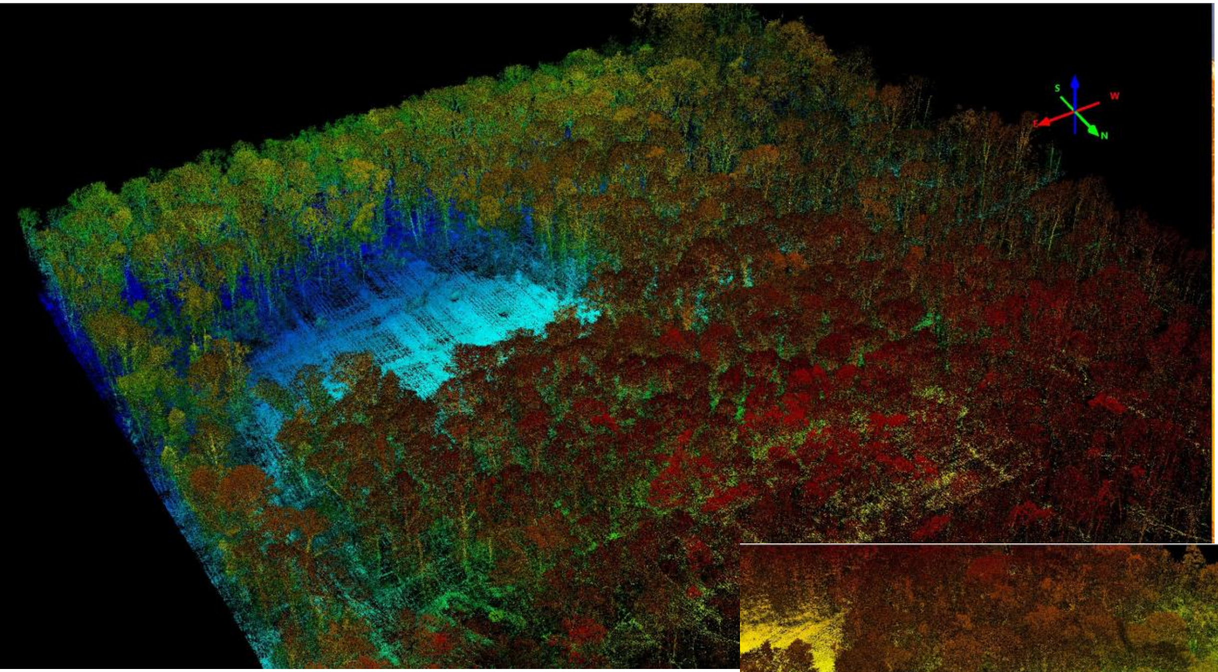
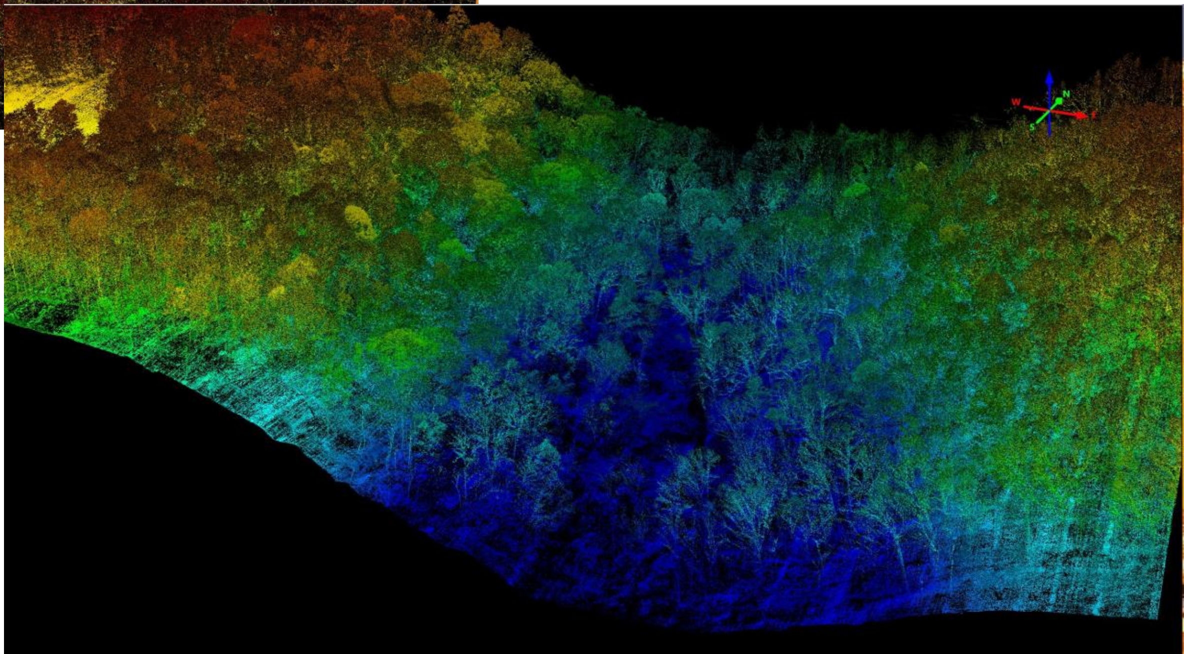
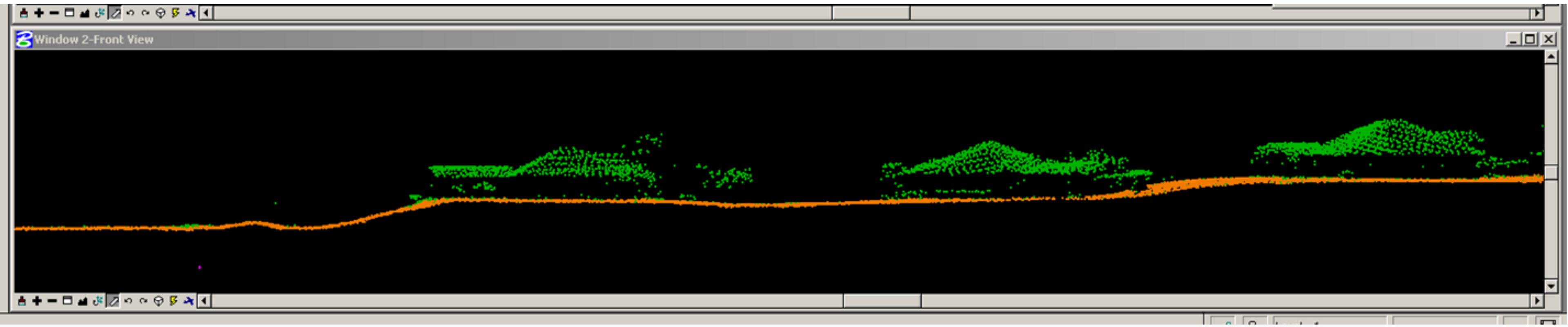
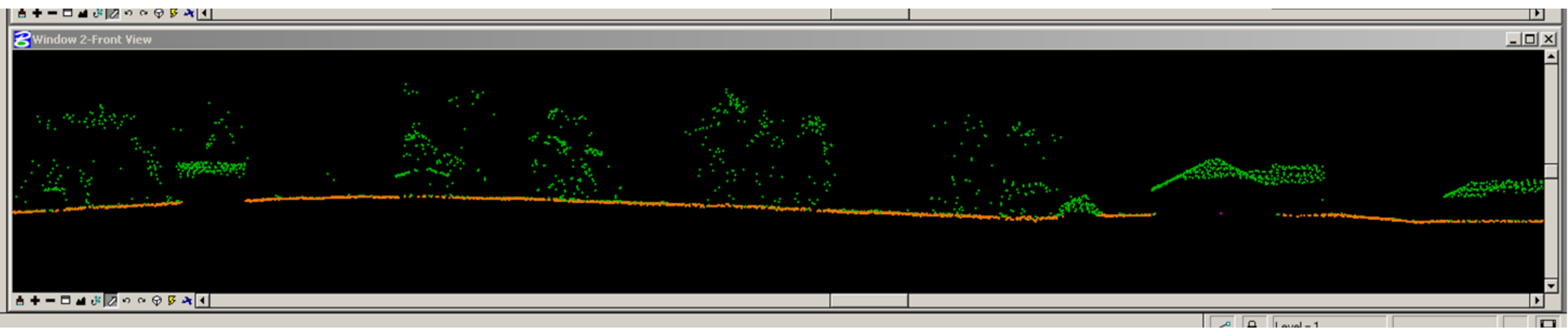
LIDAR Overview



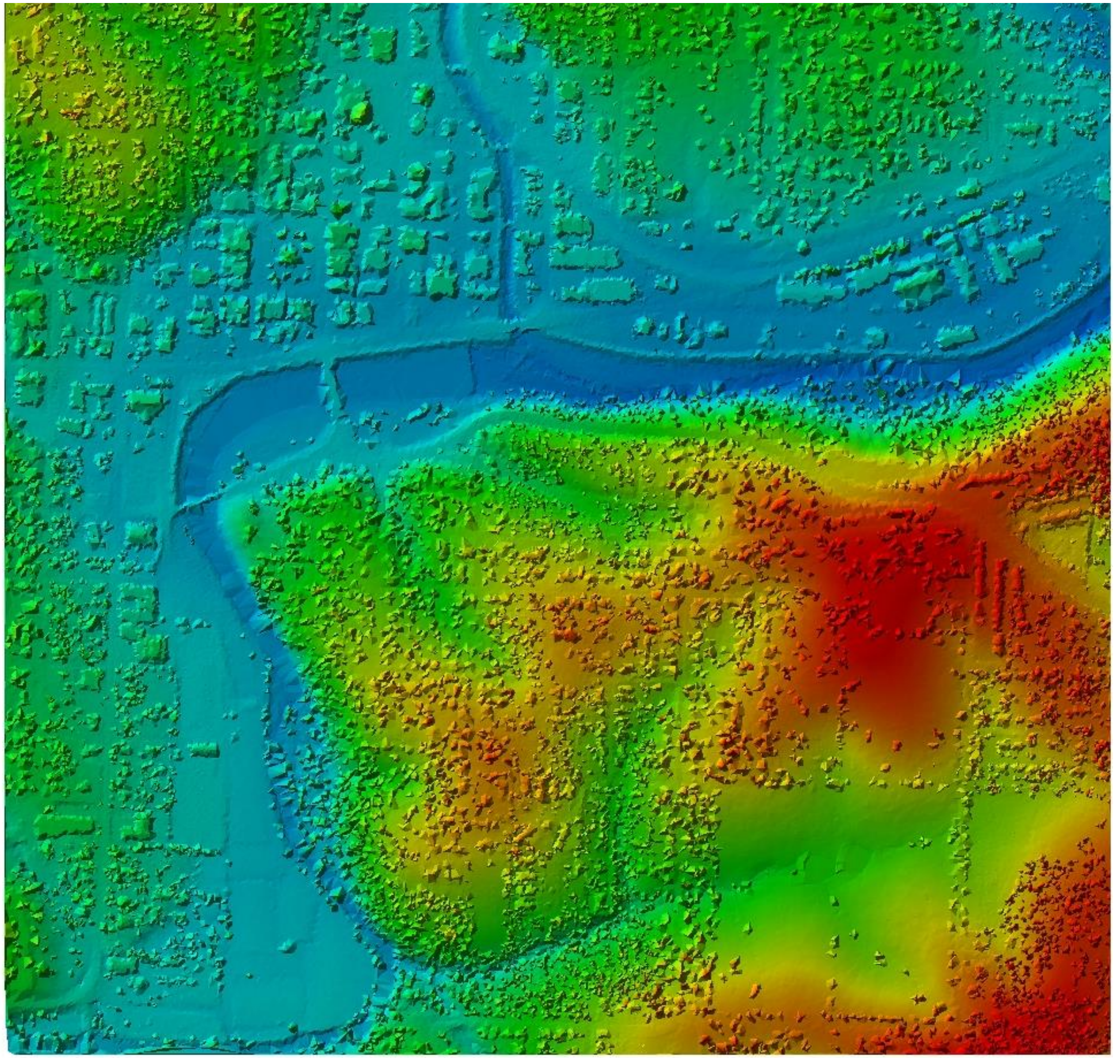


LIDAR Overview





LIDAR Overview



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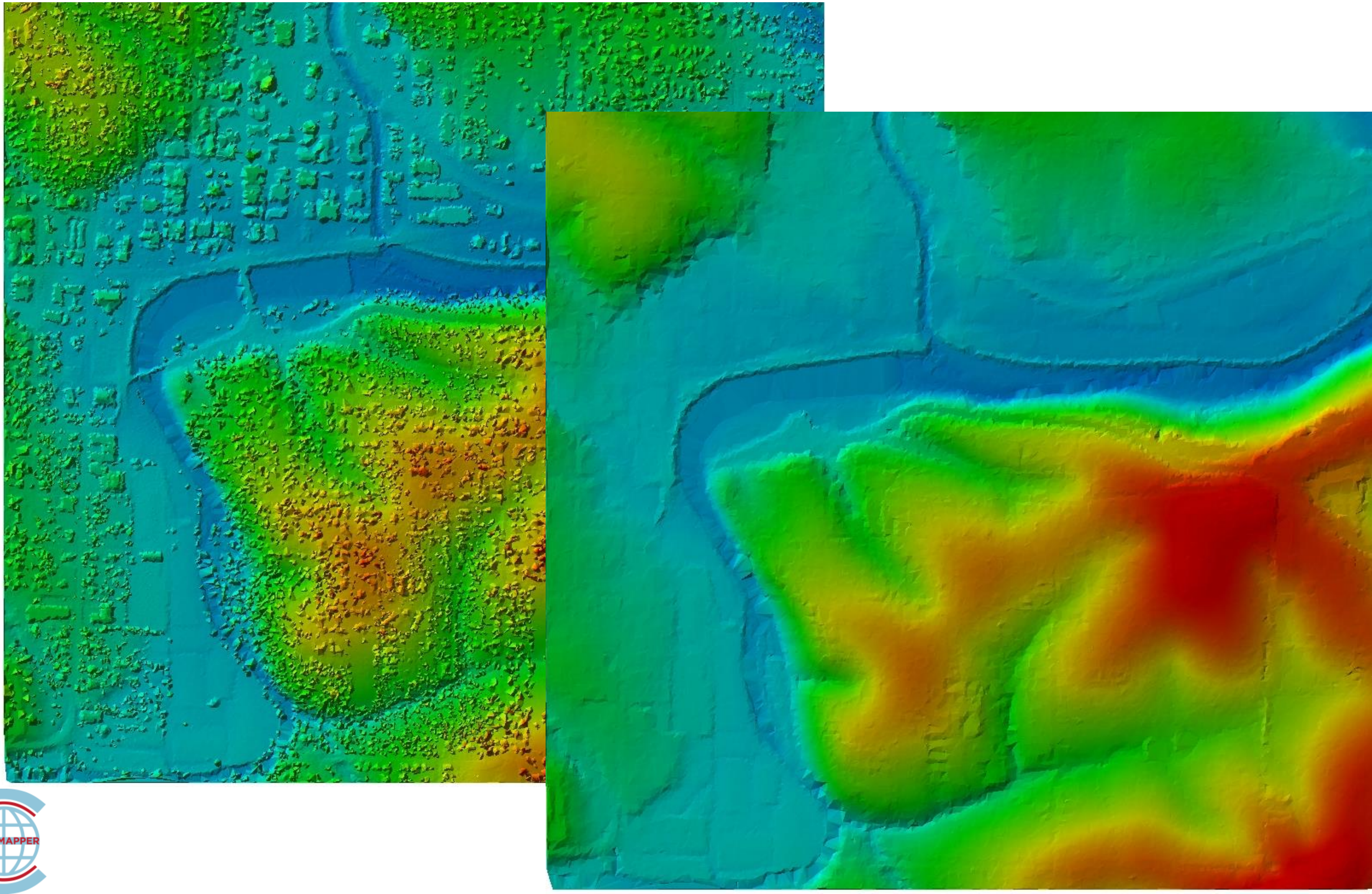

What is QL2 LiDAR?

Table 1. Aggregate nominal pulse spacing and density, Quality Level 0–Quality Level 3.

[m, meters; pls/m^2, pulses per square meter; ≤, less than or equal to; ≥, greater than or equal to]

Quality Level (QL)	Aggregate nominal pulse spacing (ANPS) (m)	Aggregate nominal pulse density (ANPD) (pls/m^2)
QL0	≤0.35	≥8.0
QL1	≤0.35	≥8.0
QL2	≤0.71	≥2.0
QL3	≤1.41	≥0.5

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What are the design implications for storm water projects?

United States National Map Accuracy Standards

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. **Horizontal accuracy.** For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. Th
shall apply in all cases to positions of well-defined points only. Well-define
are easily visible or recoverable on the ground, such as the following: mo
such as bench marks, property boundary monuments; intersections of r
corners of large buildings or structures (or center points of small buildings)
is well defined will be determined by what is plottable on the scale of the m
Thus while the intersection of two road or property lines meeting at righ
within a sensible interpretation, identification of the intersection of such lin
angle would obviously not be practicable within 1/100 inch. Similarly, fe
upon the ground within close limits are not to be considered as test poi
quoted, even though their positions may be scaled closely upon the map. In
timber lines, soil boundaries, etc.
2. **Vertical accuracy,** as applied to contour maps on all publication scales,
more than 10 percent of the elevations tested shall be in error more than
interval. In checking elevations taken from the map, the apparent vertical e
by assuming a horizontal displacement within the permissible horizontal e
scale.
3. **The accuracy of any map may be tested** by comparing the positions of p
or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of the testing.
4. **Published maps meeting these accuracy requirements** shall note this fact on their legends, as follows: "This map complies with National Map accuracy Standards."
5. **Published maps whose errors exceed those aforestated** shall omit from their legends all mention of standard accuracy.
6. **When a published map is a considerable enlargement** of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."
7. **To facilitate ready interchange and use of basic information for map construction** among all Federal mapmaking agencies, manuscript maps and published maps, wherever economically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7.5 minutes, or 3-3/4 minutes in size.

Issued June 10, 1941
Revised April 26, 1943
Revised June 17, 1947

U.S. BUREAU OF THE BUDGET

Issued June 10, 1941
Revised April 26, 1943
Revised June 17, 1947

LiDAR Standards

2003 FEMA Appendix A: Guidance for Aerial Mapping and Surveying
2004 NDEP Guidelines for Digital Elevation Data
2004 ASPRS Guidelines: Vertical Accuracy Reporting for LiDAR

2009 USGS Base Lidar Specification for ARRA funded projects
2010 Procedure Memorandum No. 61

2012 USGS LiDAR Base Specification Version 1.0 (NGP)
2012 USGS National Enhanced Elevation Data Assessment

2014 **ASPRS Accuracy Standards for Digital Geospatial Data**

ASPRS Positional Accuracy Standards for Digital Geospatial Data

(EDITION 1, VERSION 1.0. - NOVEMBER, 2014)

ASPRS Positional Accuracy Standards for Digital Geospatial Data

(EDITION 1, VERSION 1.0. - NOVEMBER, 2014)

B.2 DIGITAL ORTHOIMAGERY HORIZONTAL ACCURACY CLASSES

B.3 DIGITAL PLANIMETRIC DATA HORIZONTAL ACCURACY CLASSES

B.4 DIGITAL ELEVATION DATA VERTICAL ACCURACY CLASSES

Horizontal Standards

Table B.6 Horizontal Accuracy/Quality Examples for High Accuracy Digital Planimetric Data

ASPRS 2014				Equivalent to map scale in		
Horizontal Accuracy Class $RMSE_x$ and $RMSE_y$ (cm)	$RMSE_r$ (cm)	Horizontal Accuracy at the 95% Confidence Level (cm)	Approximate GSD of Source Imagery (cm)	ASPRS 1990 Class 1	ASPRS 1990 Class 2	Equivalent to map scale in NMAS
0.63	0.9	1.5	0.31 to 0.63	1:25	1:12.5	1:16
1.25	1.8	3.1	0.63 to 1.25	1:50	1:25	1:32
2.5	3.5	6.1	1.25 to 2.5	1:100	1:50	1:63
5.0	7.1	12.2	2.5 to 5.0	1:200	1:100	1:127
7.5	10.6	18.4	3.8 to 7.5	1:300	1:150	1:190
10.0	14.1	24.5	5.0 to 10.0	1:400	1:200	1:253
12.5	17.7	30.6	6.3 to12.5	1:500	1:250	1:317
15.0	21.2	36.7	7.5 to 15.0	1:600	1:300	1:380
17.5	24.7	42.8	8.8 to 17.5	1:700	1:350	1:444
20.0	28.3	49.0	10.0 to 20.0	1:800	1:400	1:507
22.5	31.8	55.1	11.3 to 22.5	1:900	1:450	1:570
25.0	35.4	61.2	12.5 to 25.0	1:1000	1:500	1:634
27.5	38.9	67.3	13.8 to 27.5	1:1100	1:550	1:697
30.0	42.4	73.4	15.0 to 30.0	1:1200	1:600	1:760
45.0	63.6	110.1	22.5 to 45.0	1:1800	1:900	1:1,141

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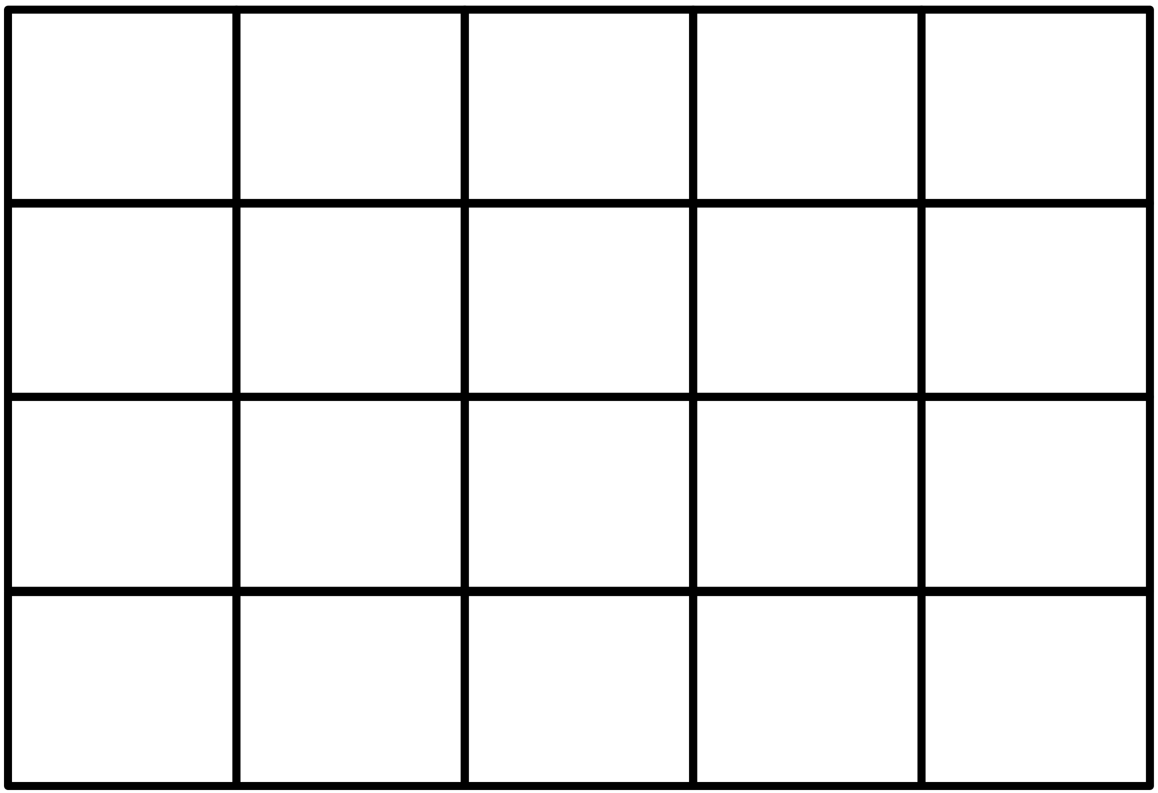
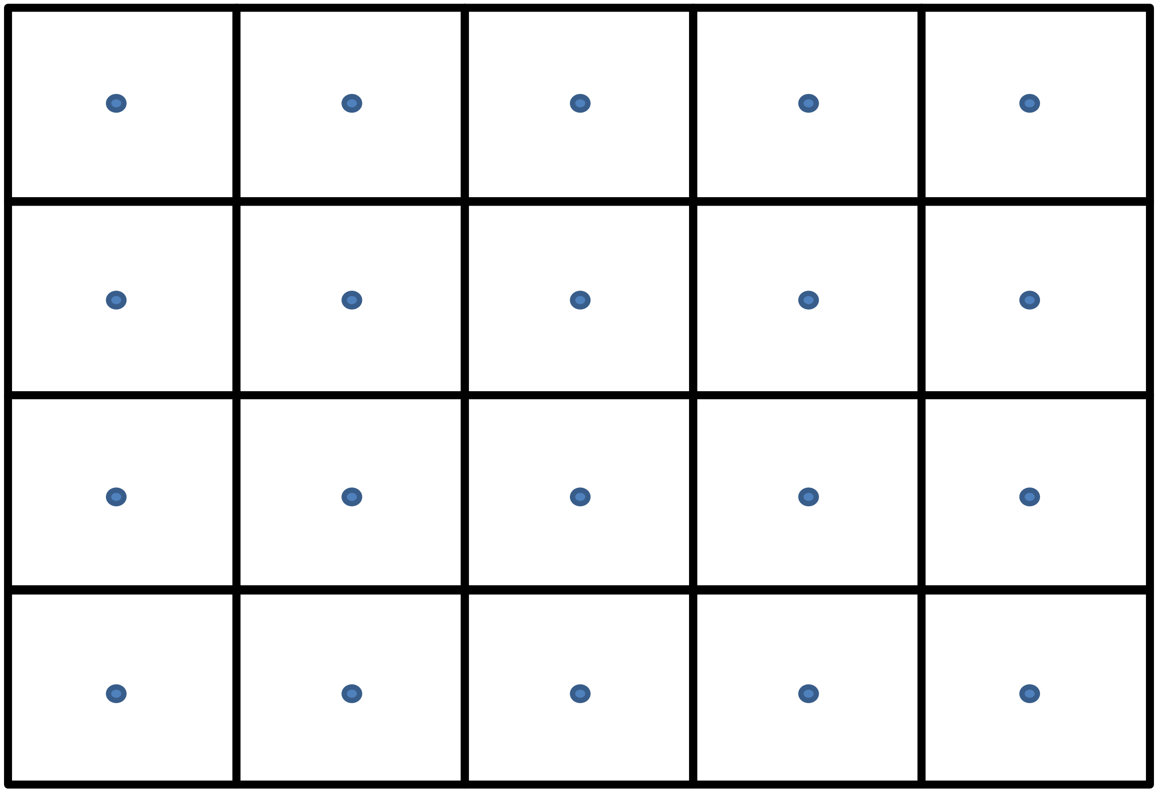
Vertical Standards

Surface Modeling



Vertical Standards

Surface Modeling



Vertical Standards

- NPS should be equal to or less than the DEM post spacing required

- 1-meter DEM for 1ft contours
- 2-meter DEM for 2ft contours
- 5-meter DEM for 5ft contours

- 0.7m NPS -> 2ppsm -> 1m DEM -> 1ft contours (QL 2)
- 1.4m NPS -> 0.5ppsm -> 2m DEM -> 2 ft contours (QL 3)

Vertical Standards

Table B.8 Vertical Accuracy of the New ASPRS 2014 Standard Compared with Legacy Standards

Vertical Accuracy Class	$RMSE_z$ Non-Vegetated (cm)	Equivalent Class 1 contour interval per ASPRS 1990 (cm)	Equivalent Class 2 contour interval per ASPRS 1990 (cm)	Equivalent contour interval per NMAS (cm)
1-cm	1.0	3.0	1.5	3.29
2.5-cm	2.5	7.5	3.8	8.22
5-cm	5.0	15.0	7.5	16.45
10-cm	10.0	30.0	15.0	32.90
15-cm	15.0	45.0	22.5	49.35
20-cm	20.0	60.0	30.0	65.80
33.3-cm	33.3	99.9	50.0	109.55
66.7-cm	66.7	200.1	100.1	219.43
100-cm	100.0	300.0	150.0	328.98
333.3-cm	333.3	999.9	500.0	1096.49

So What's the Big Deal?

- MS4 Permit Compliance
- Infrastructure design
- Flood response
- Catchment Characteristics

Infiltration islands in a parking lot in San Mateo, California, help reduce runoff. (Photo courtesy of John Kosco)
water.epa.gov

Use ***<u>LIDAR</u>*** based elevation data to:

- Show the drainage network - where runoff flows over land.
- Develop drainage catchments
- Derive metrics
- Model flow

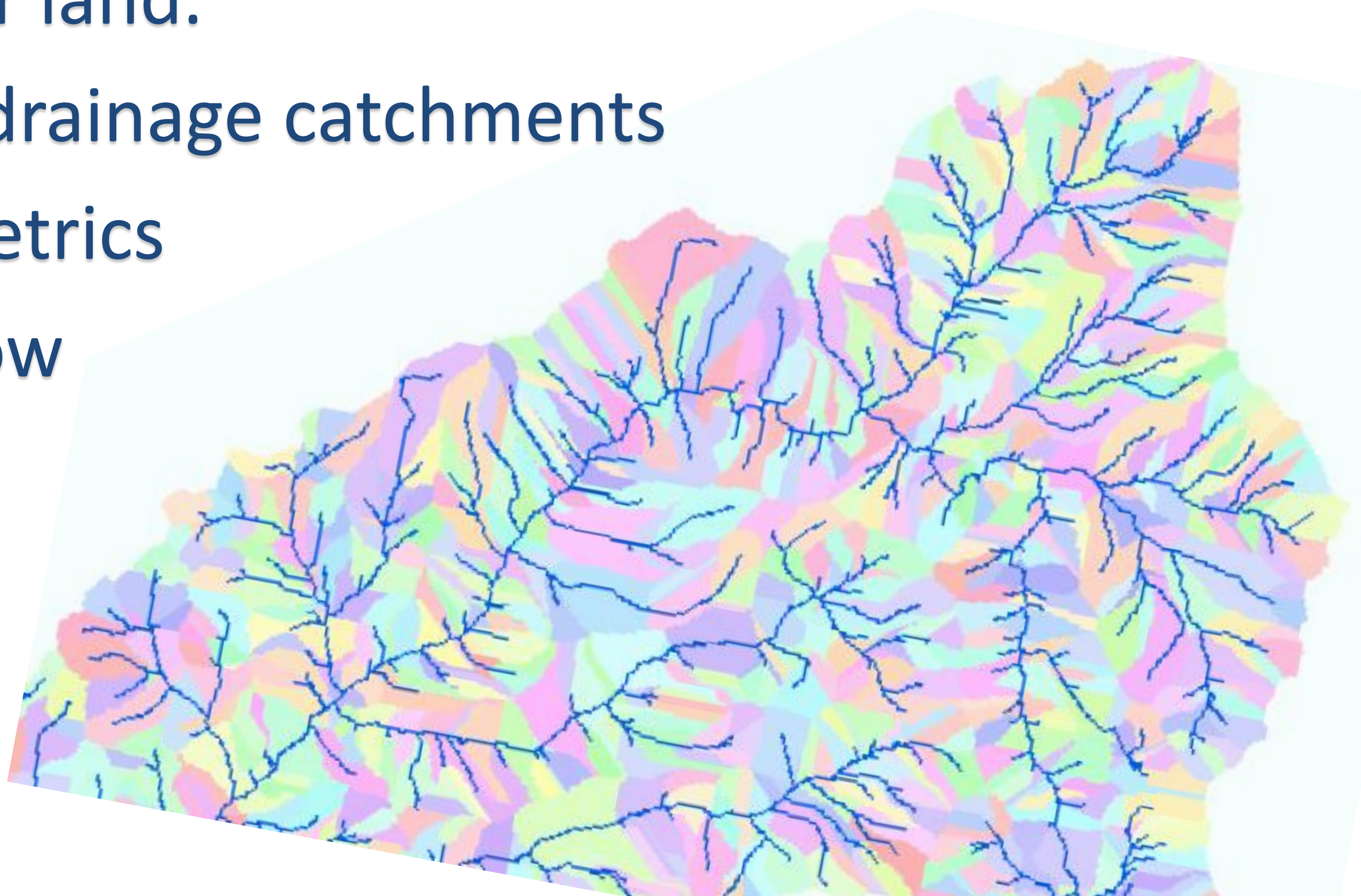
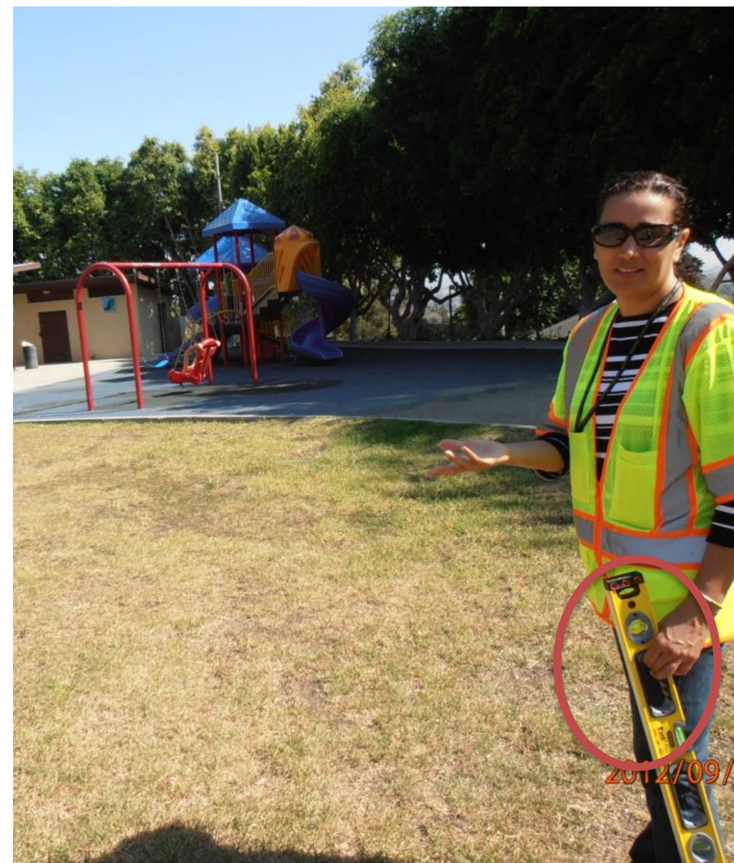


Image courtesy of hydrology.usu.edu
TauDEM 5.1 Quick Start Guide

Significant Value Proposition

- Currently a very slow, labor intensive process.
  - Estimate: **~30 Years** to complete with traditional survey approach





Current Projects

pennsylvania
DEPARTMENT OF TRANSPORTATION

Pitt

Salt Loading Assessment

750 acres

Squirrel Hill/9 Mile Run area

Compare PA Map to Allegheny County QL2

Urban drainage patterns

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Current Projects

Ulster County

Cornell University

- Culvert Capacity Study
- Peak flow at inlet for design storm
- LiDAR supported parameters
  - Area, flow path, slope, t_c
- Land Cover supported parameters
  - CN

Current Projects

Los Angeles County DPW

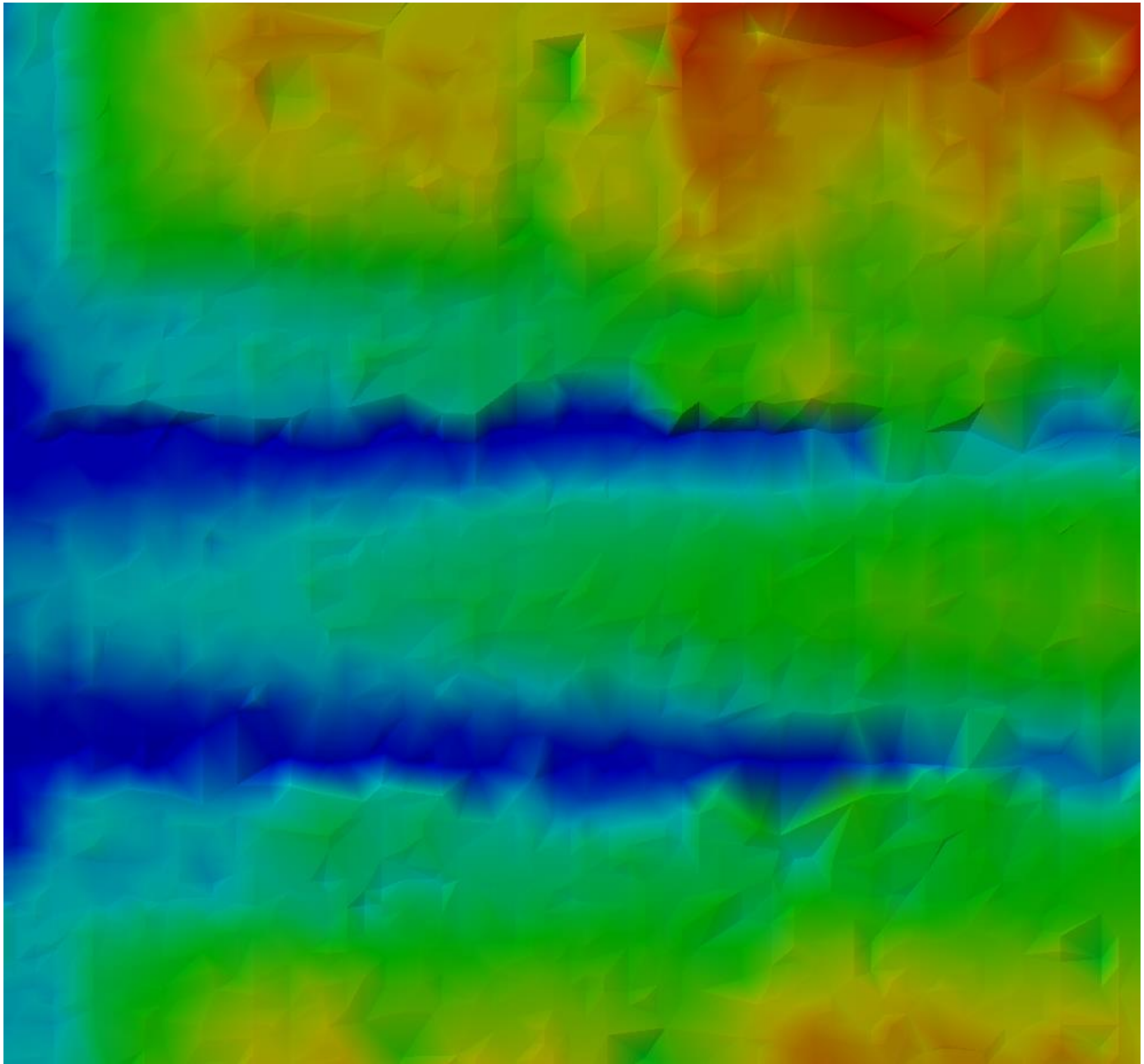
- MS4 Storm Water Program
- EPA consent decree
- Catchments for storm water modeling
- Green infrastructure design

4000 square miles

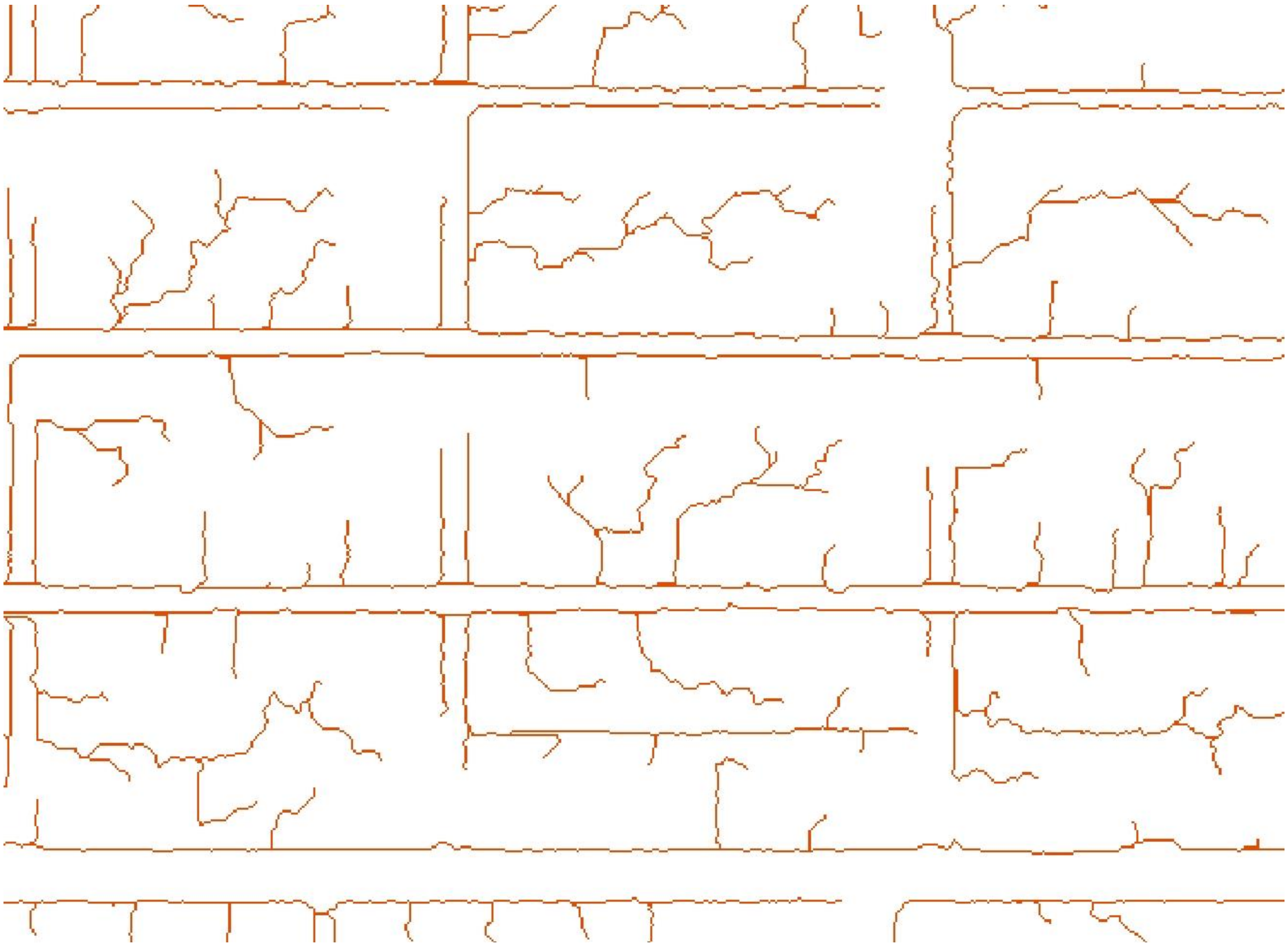
- Pilot Project- methodology development
- Program training (6months)

Point Density

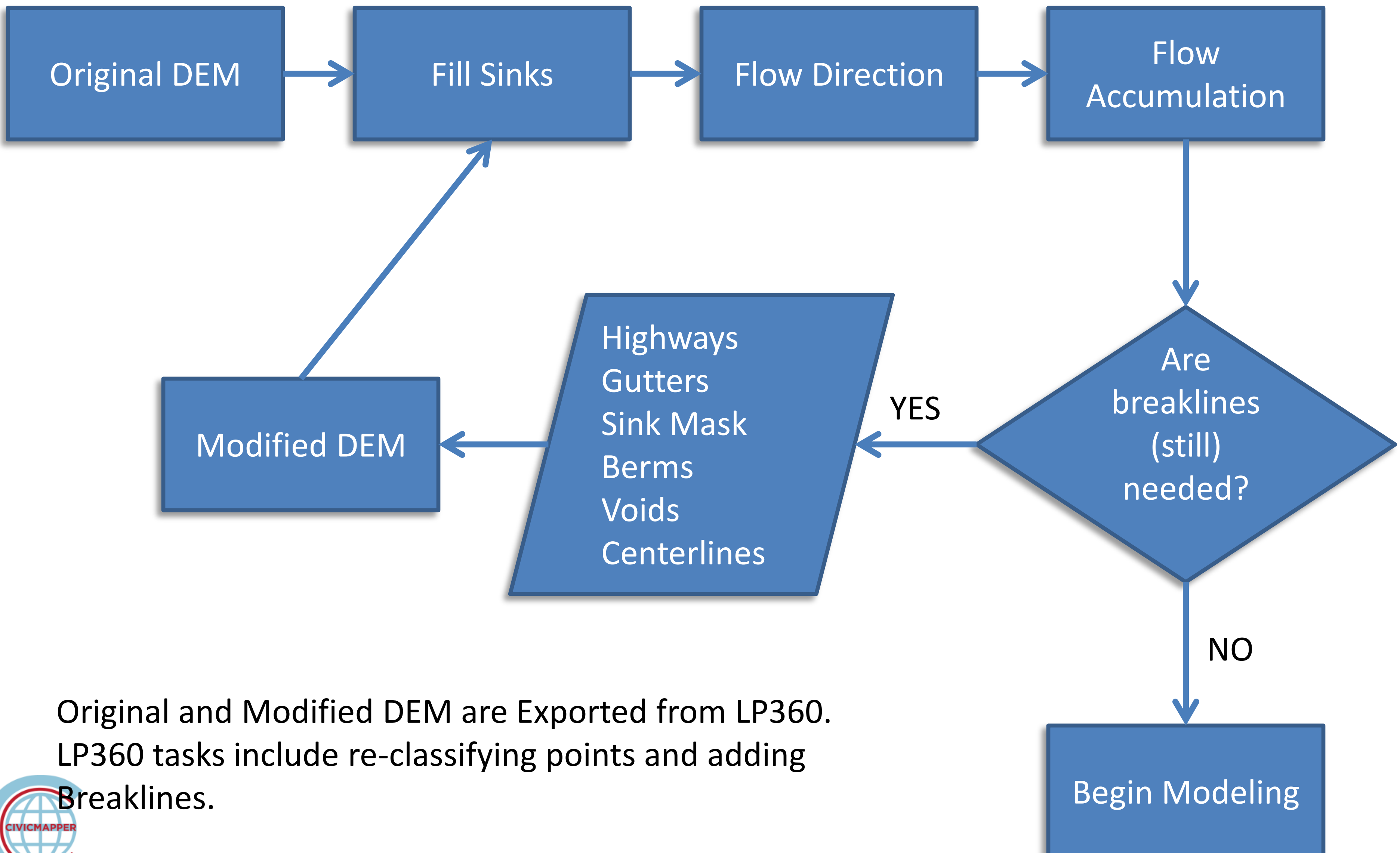
TIN Surface Model



Drainage Network Analysis

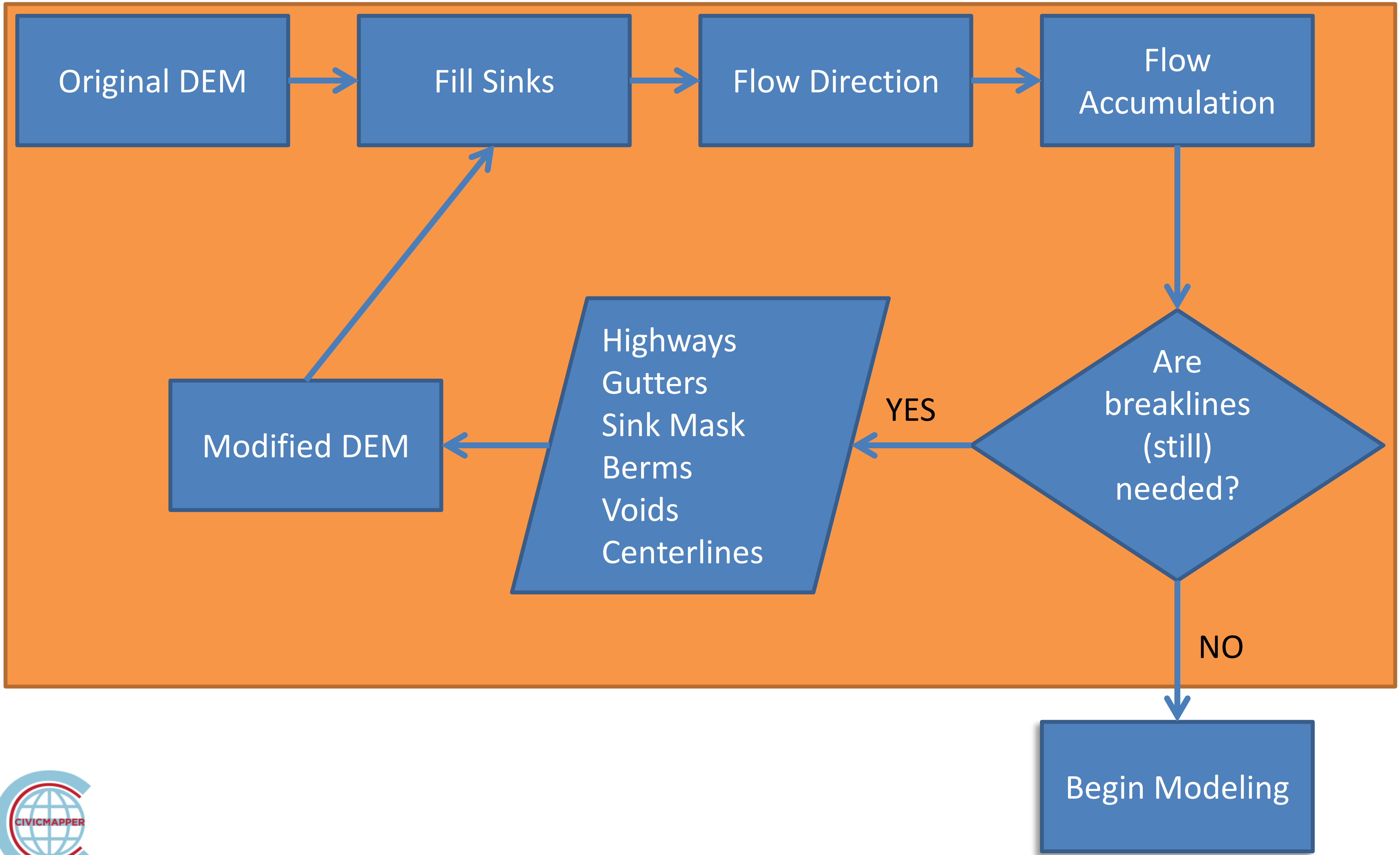


Workflow- Surface Prep

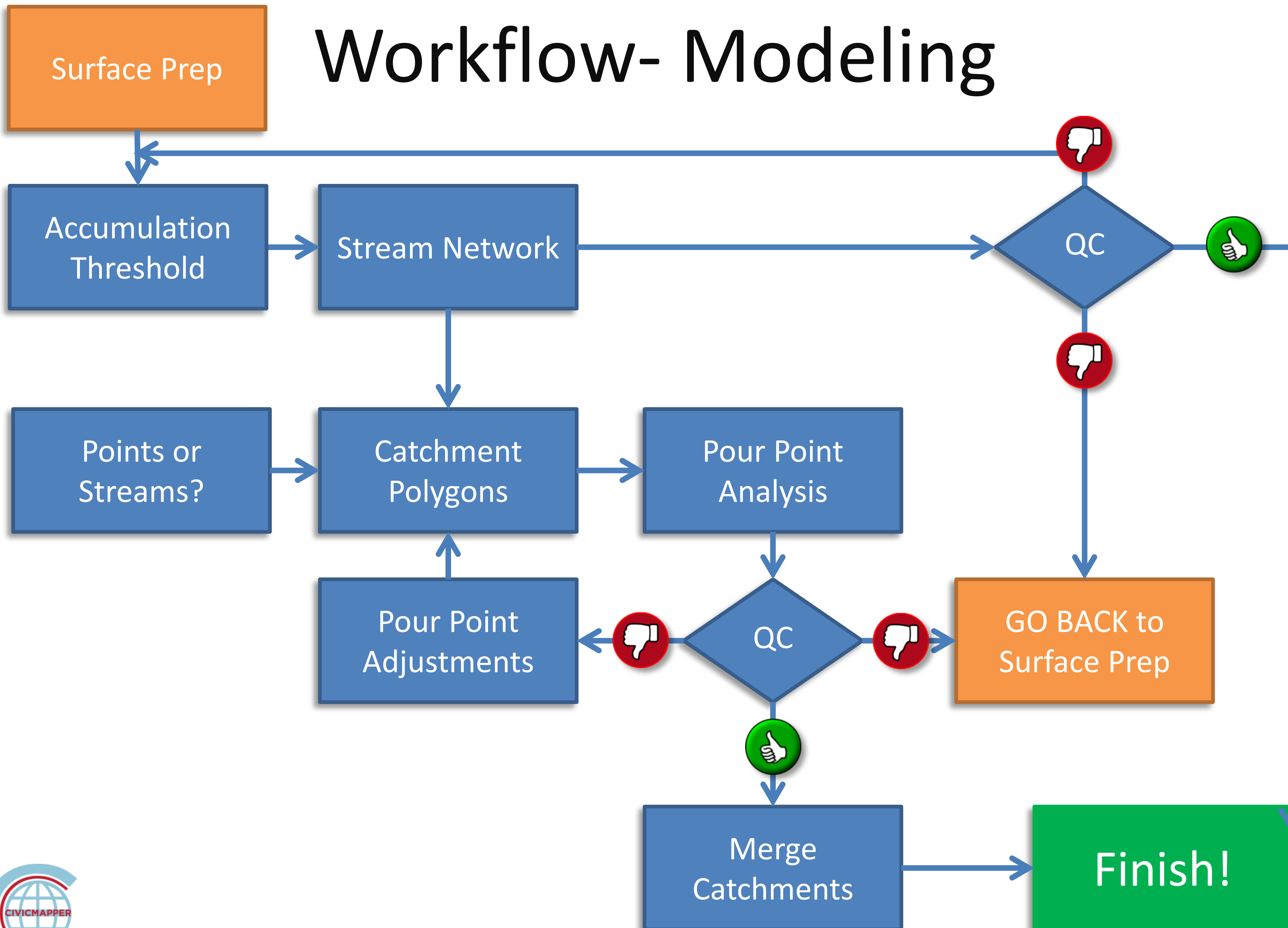


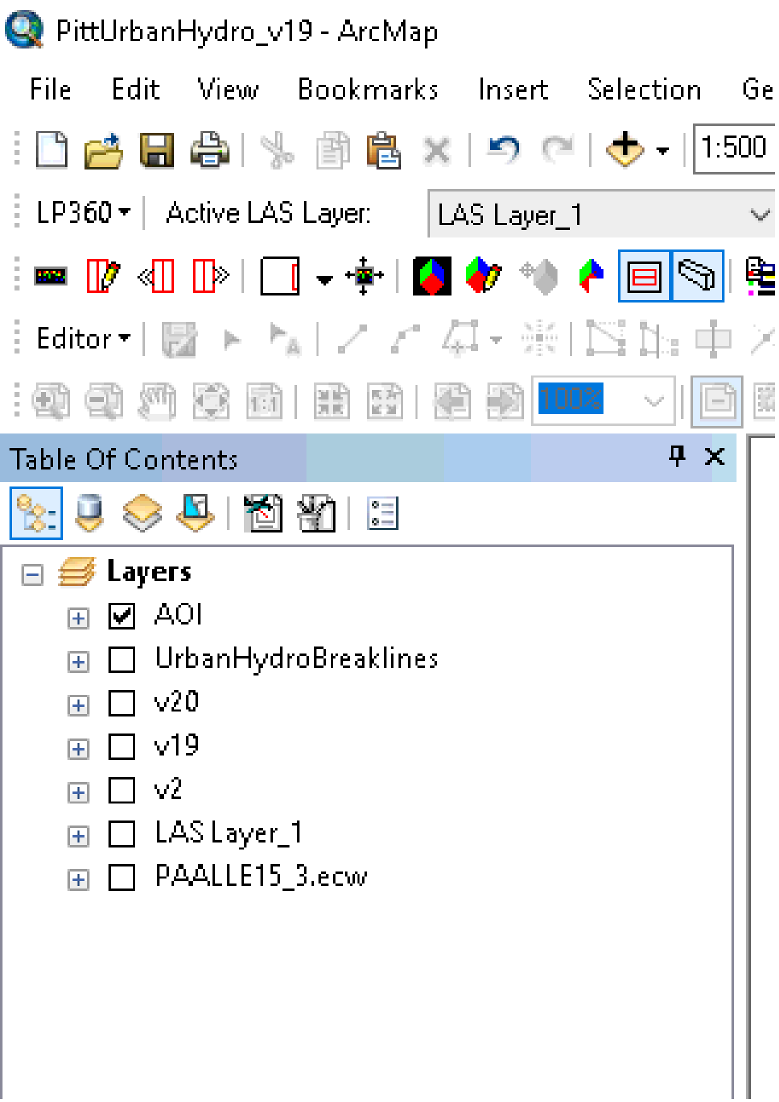
Original and Modified DEM are Exported from LP360. LP360 tasks include re-classifying points and adding Breaklines.

Workflow- Surface Prep



Workflow- Modeling

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UrbanHydroBreaklines
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v19
v2
LAS Layer_1
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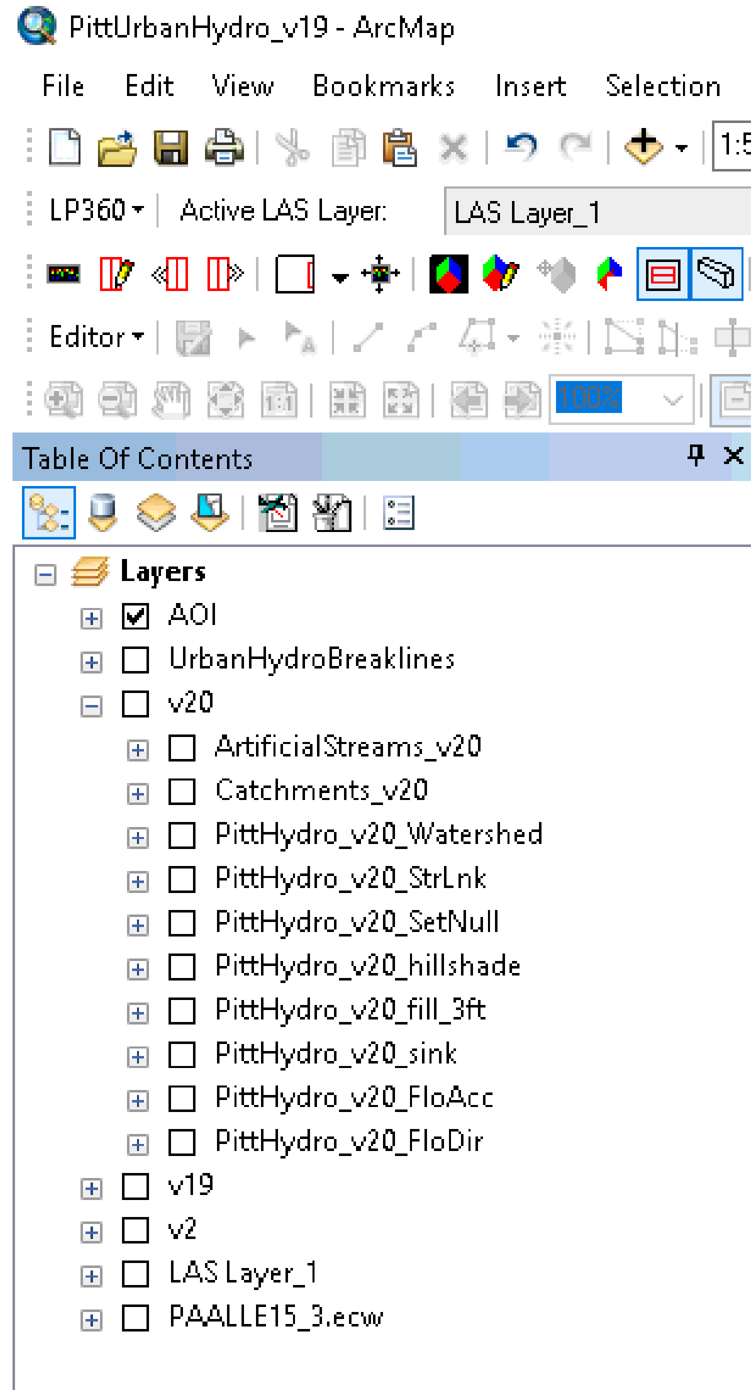
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PittHydro_v20_Watershed
PittHydro_v20_StrLnk
PittHydro_v20_SetNull
PittHydro_v20_hillshade
PittHydro_v20_fill_3ft
PittHydro_v20_sink
PittHydro_v20_FloAcc
PittHydro_v20_FloDir
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v2
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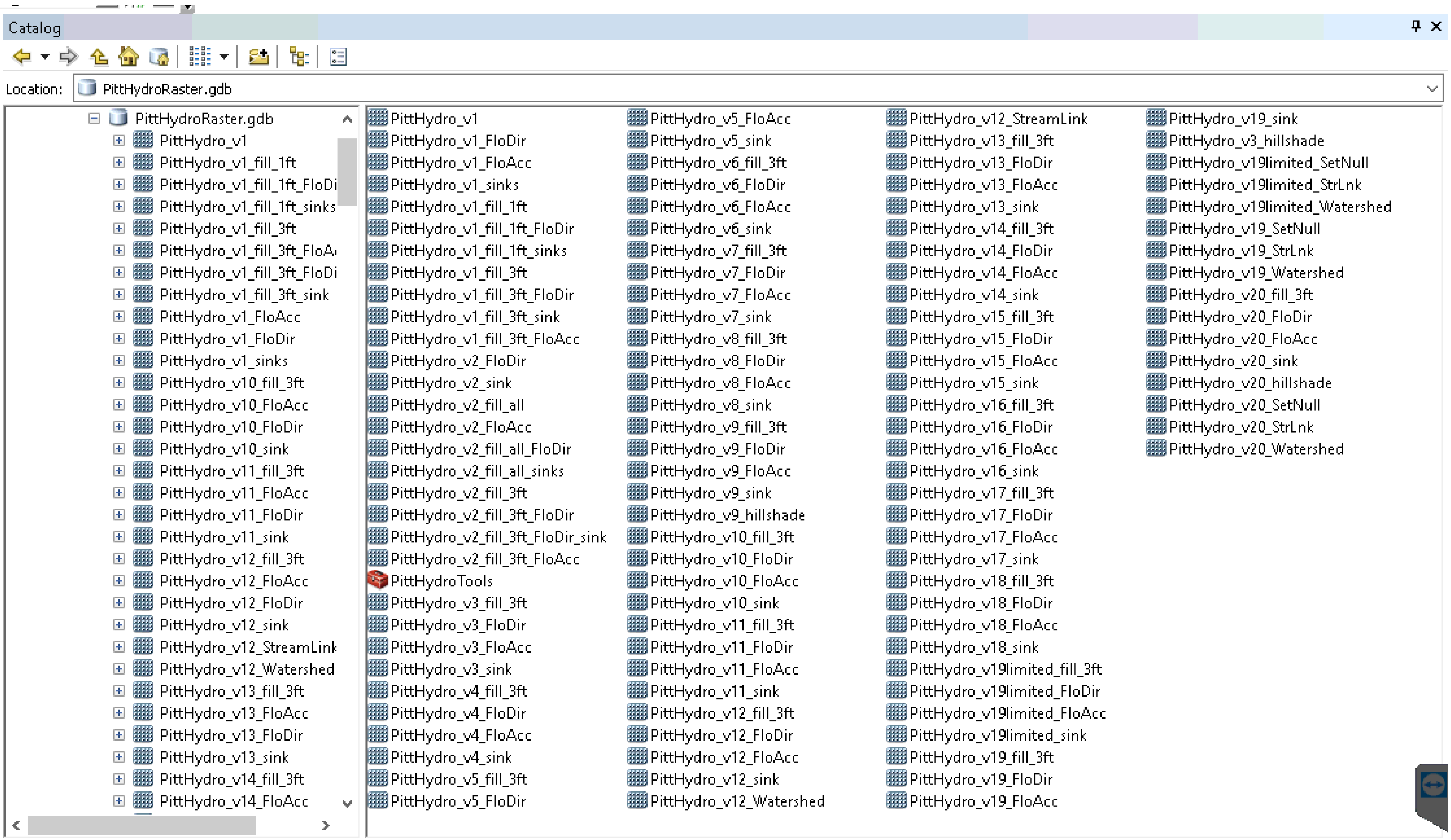

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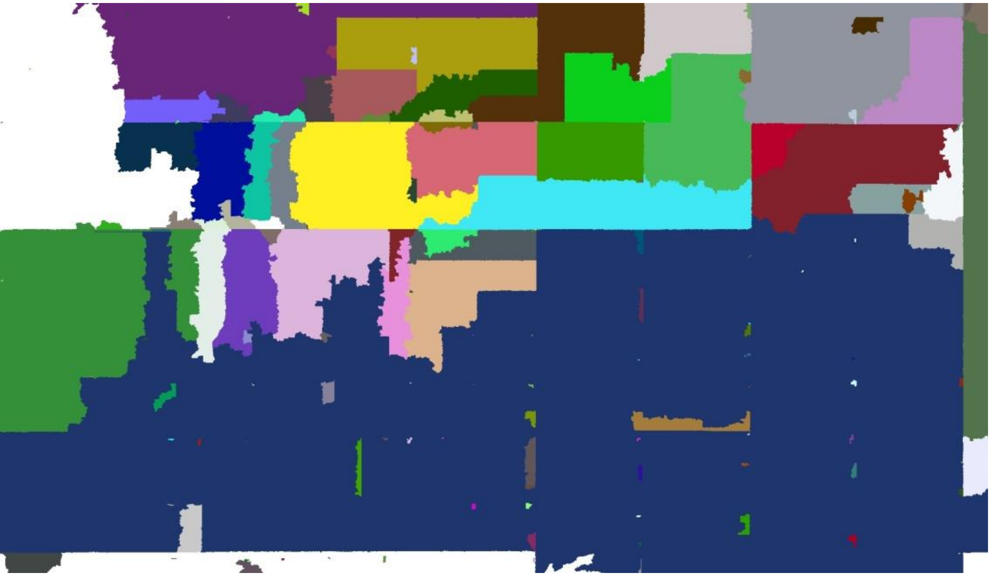
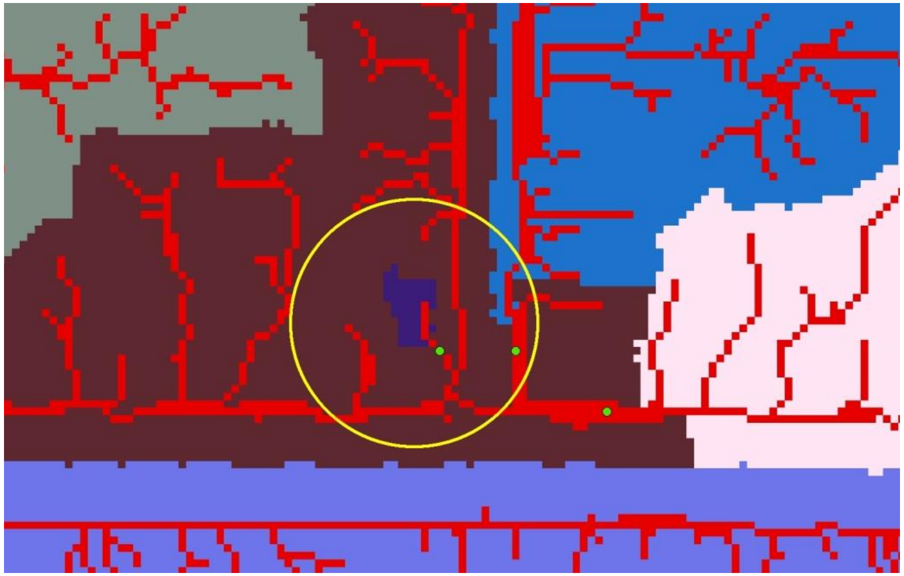
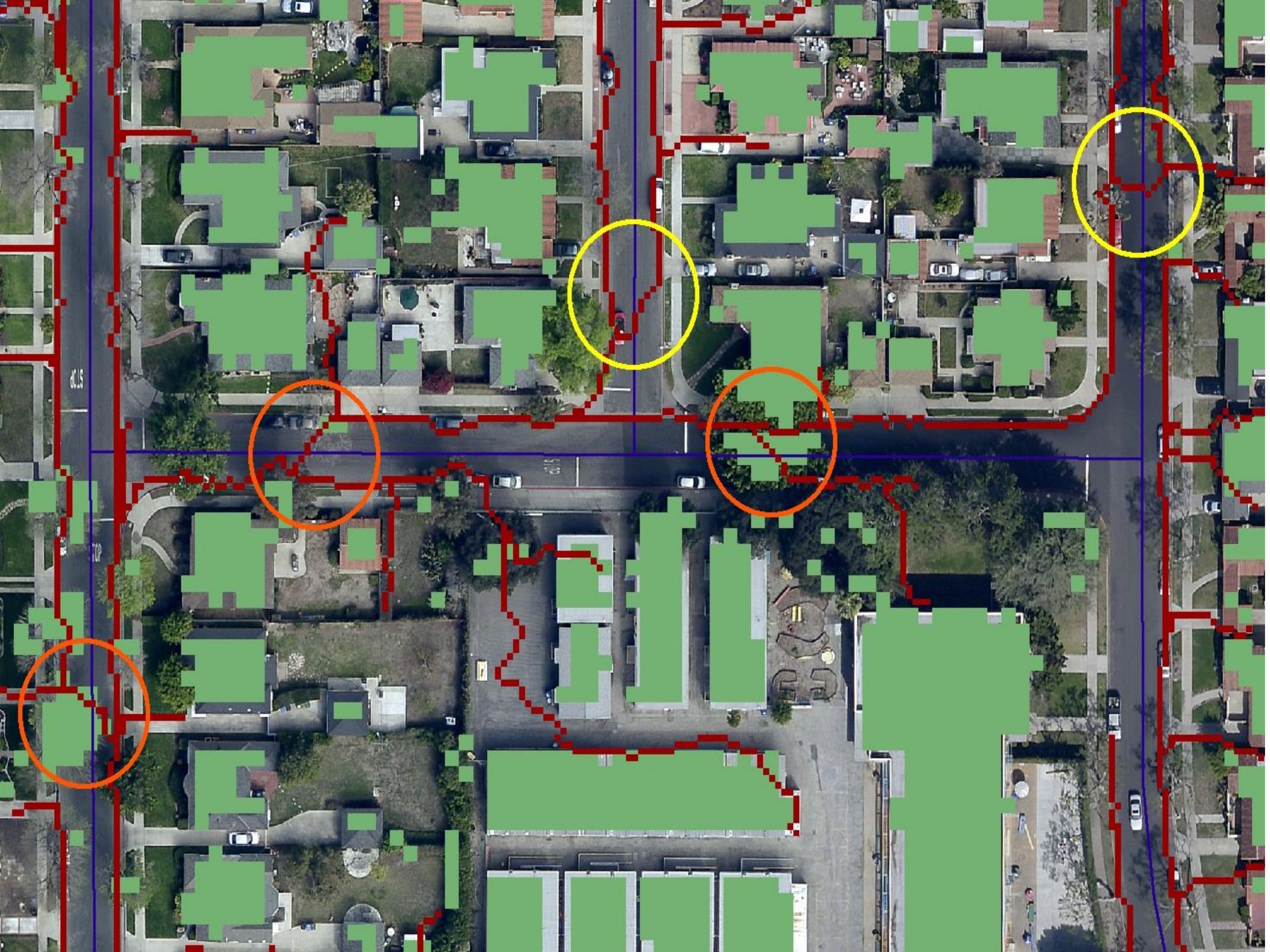
Unexpected Results

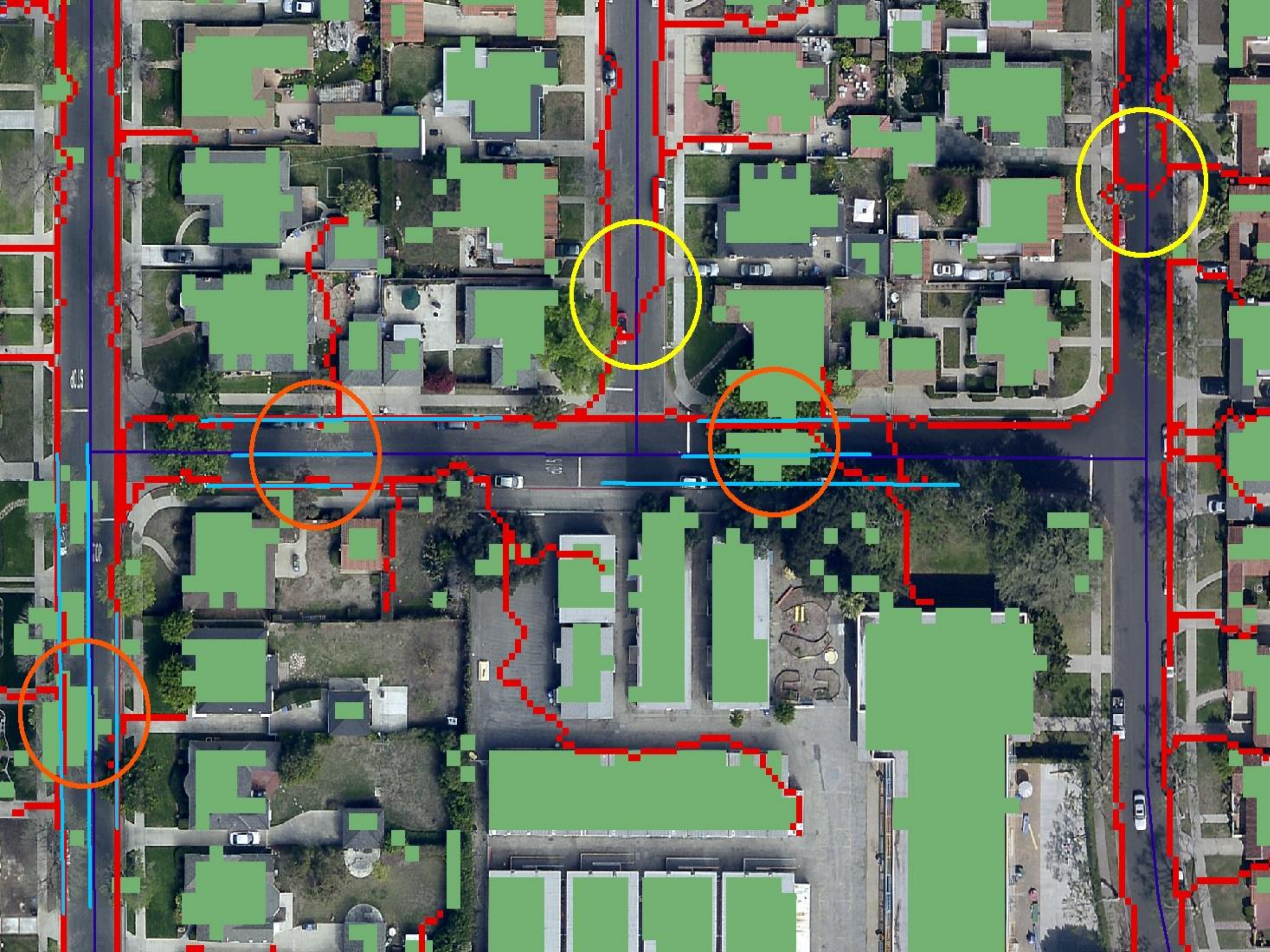


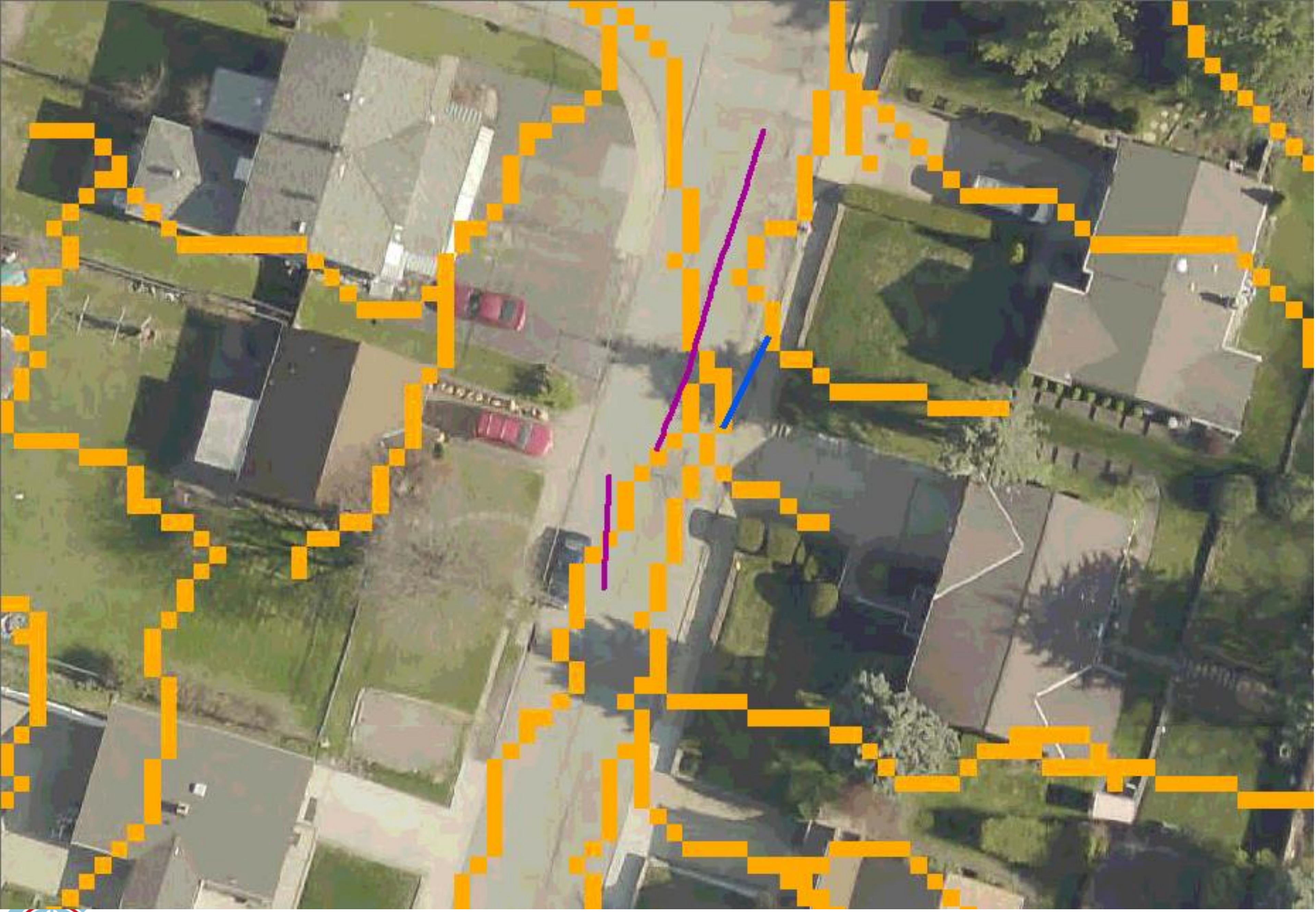
Dark Blue Watershed Too Large – surface prep issue – sinks are being over filled, need a sink mask.



Small Blue Watershed Too Small – surface is correct, point is in the wrong place, move to the right.







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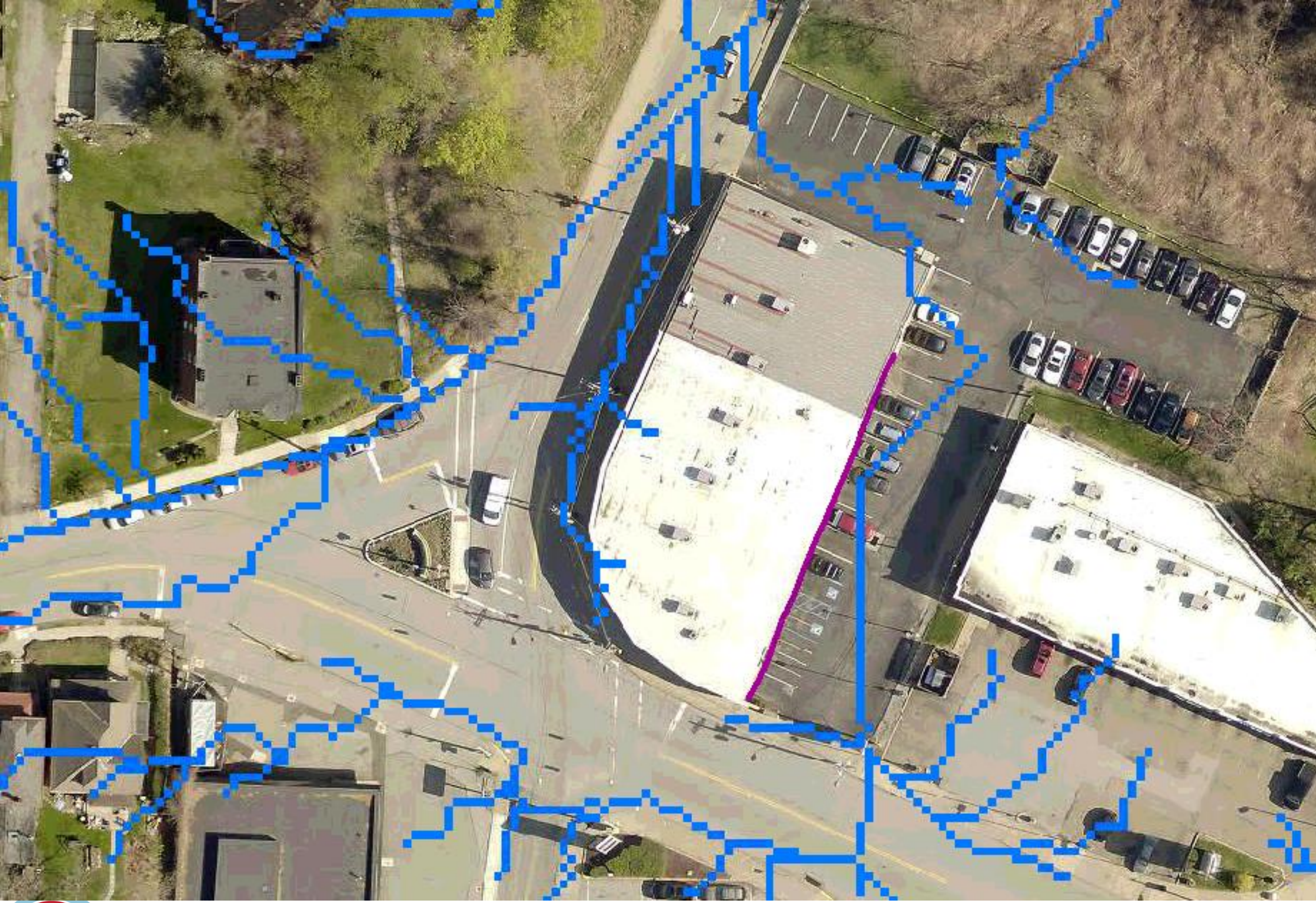

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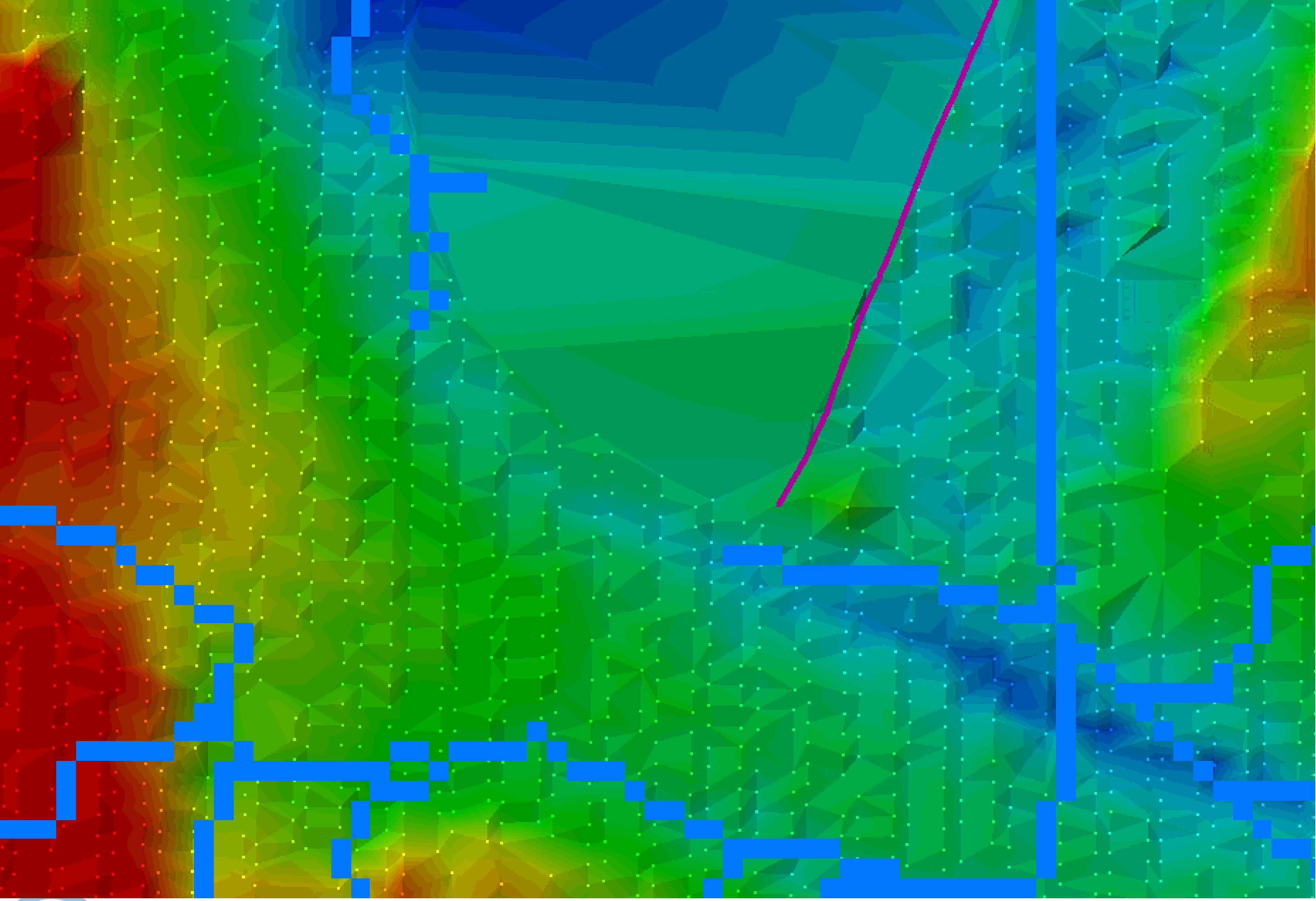

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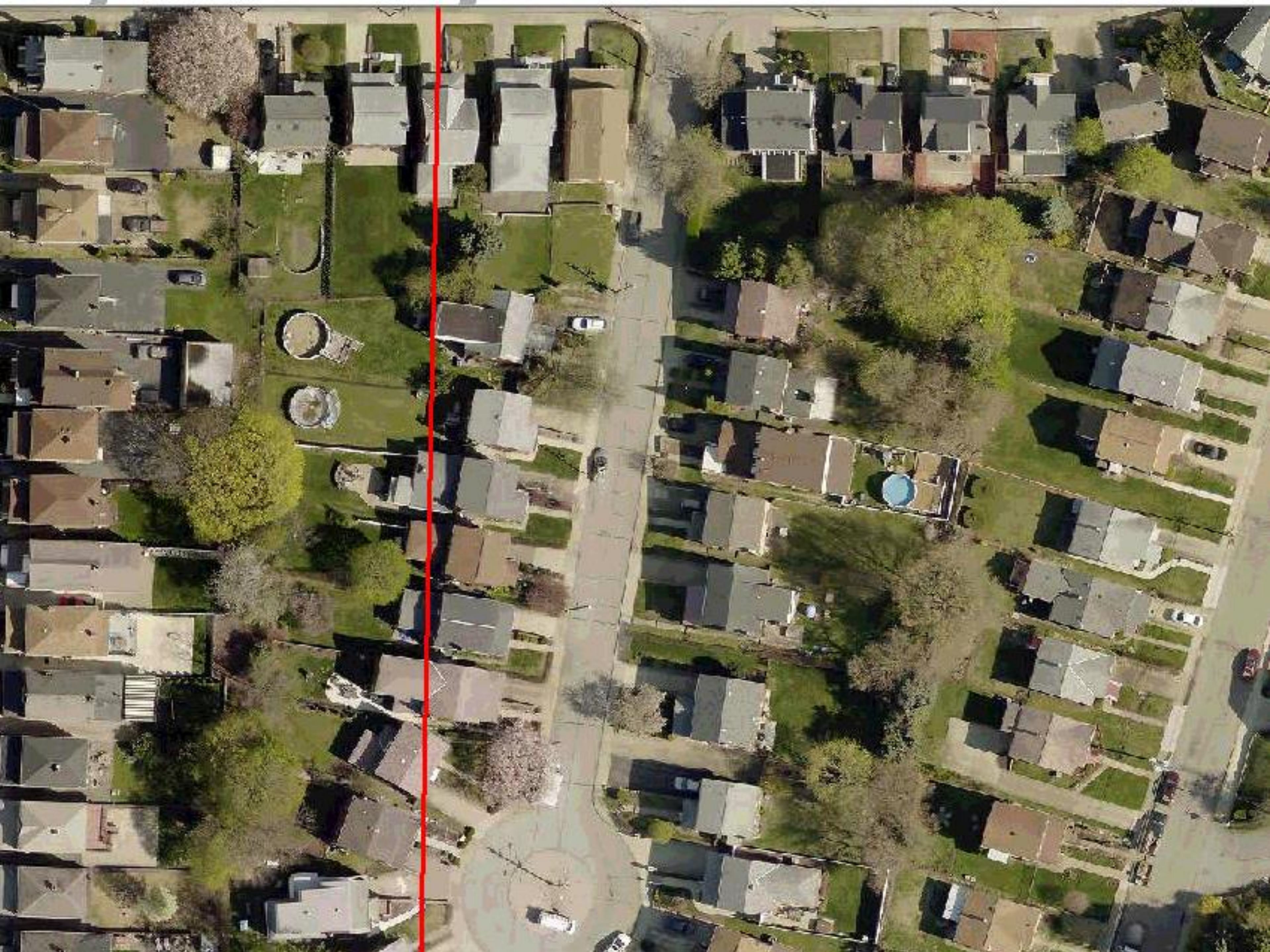
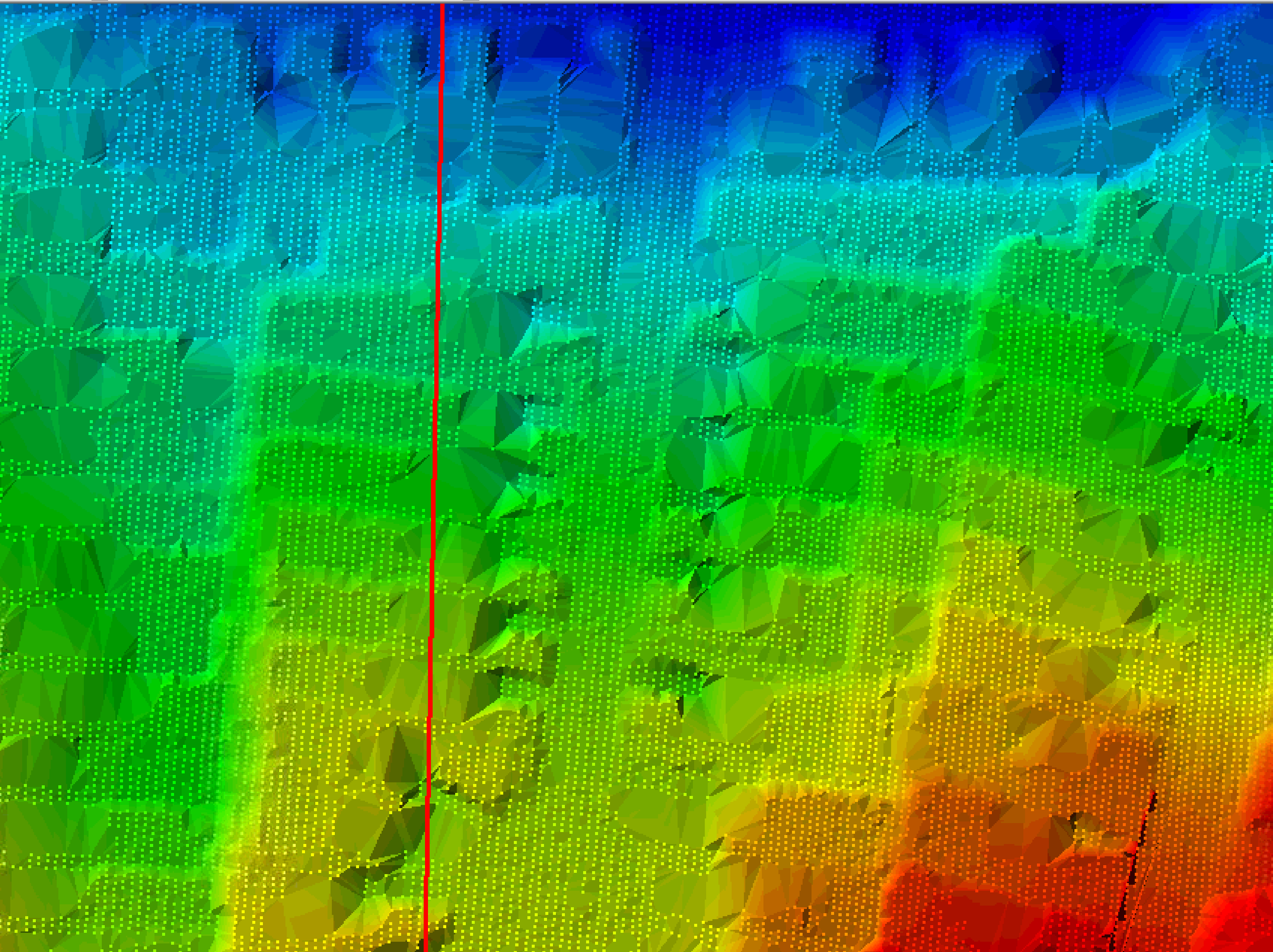
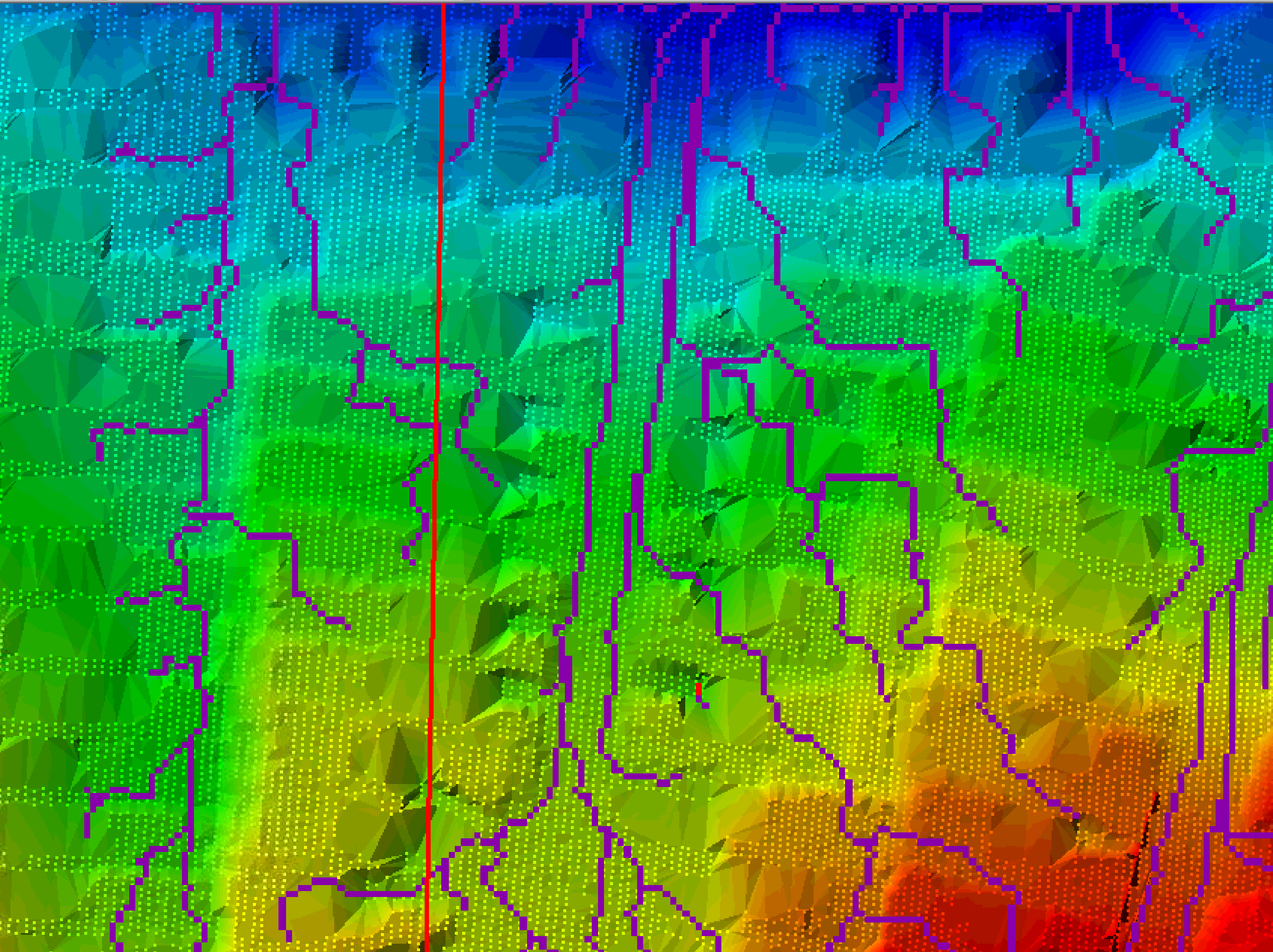
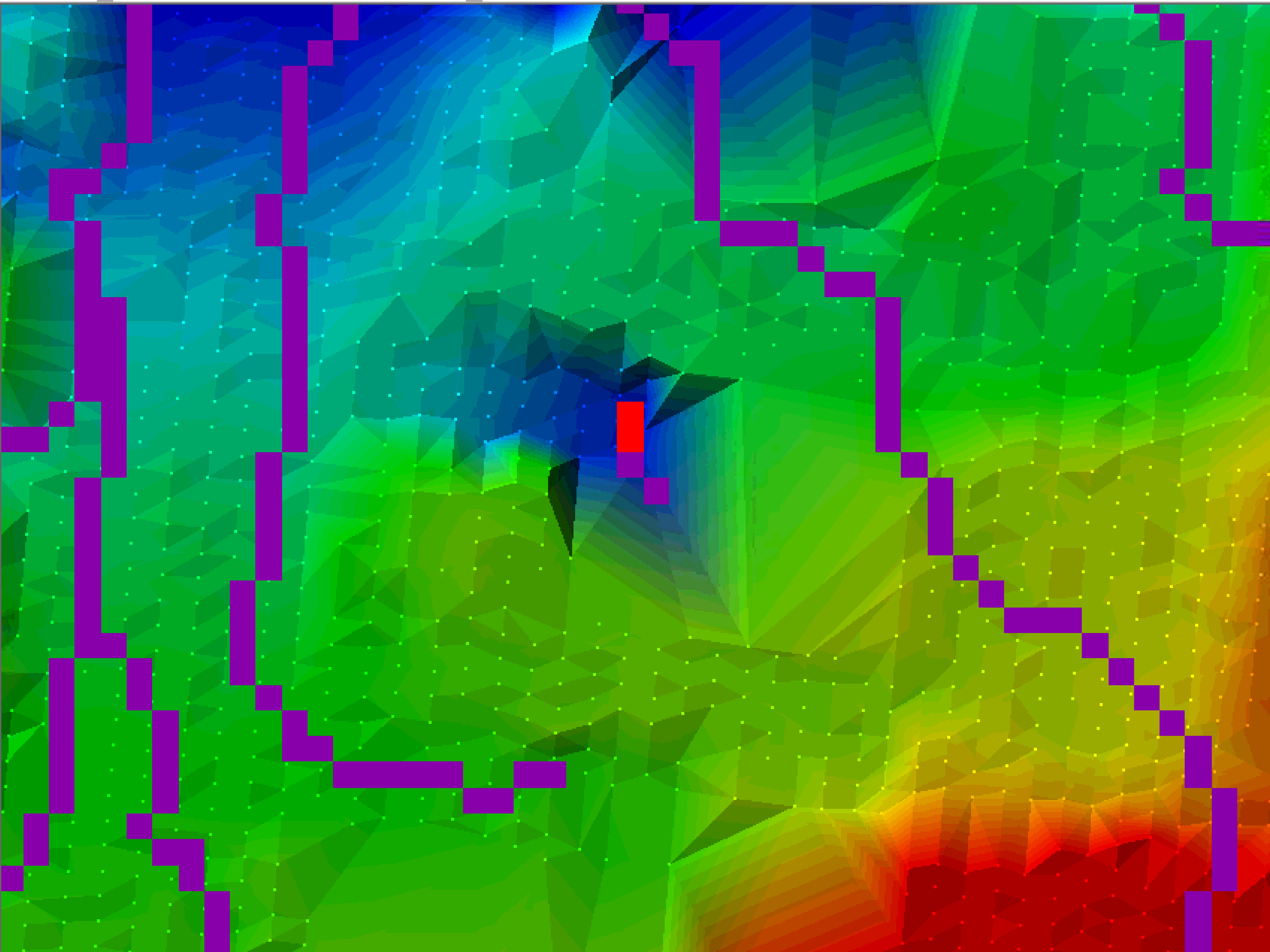
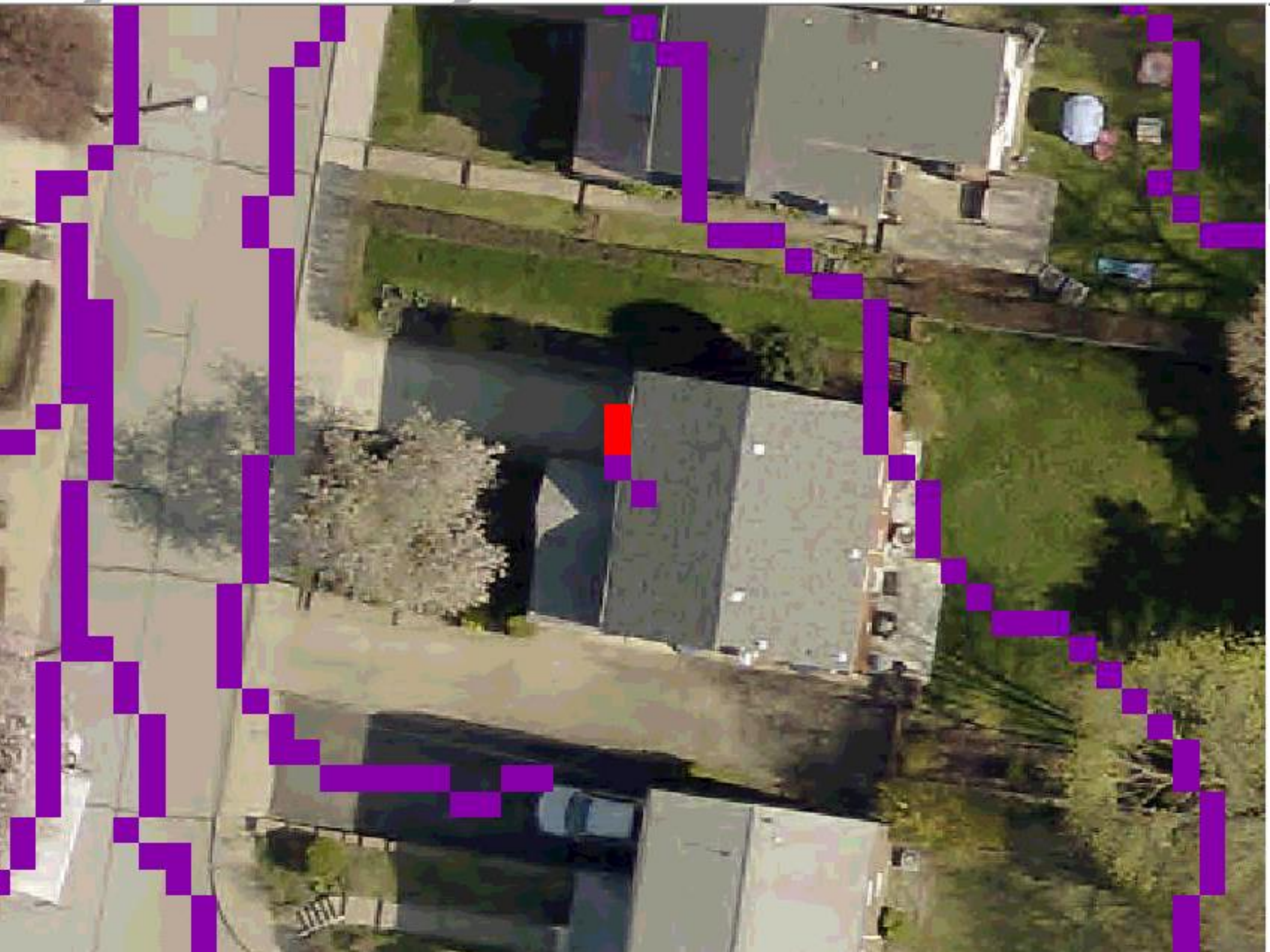
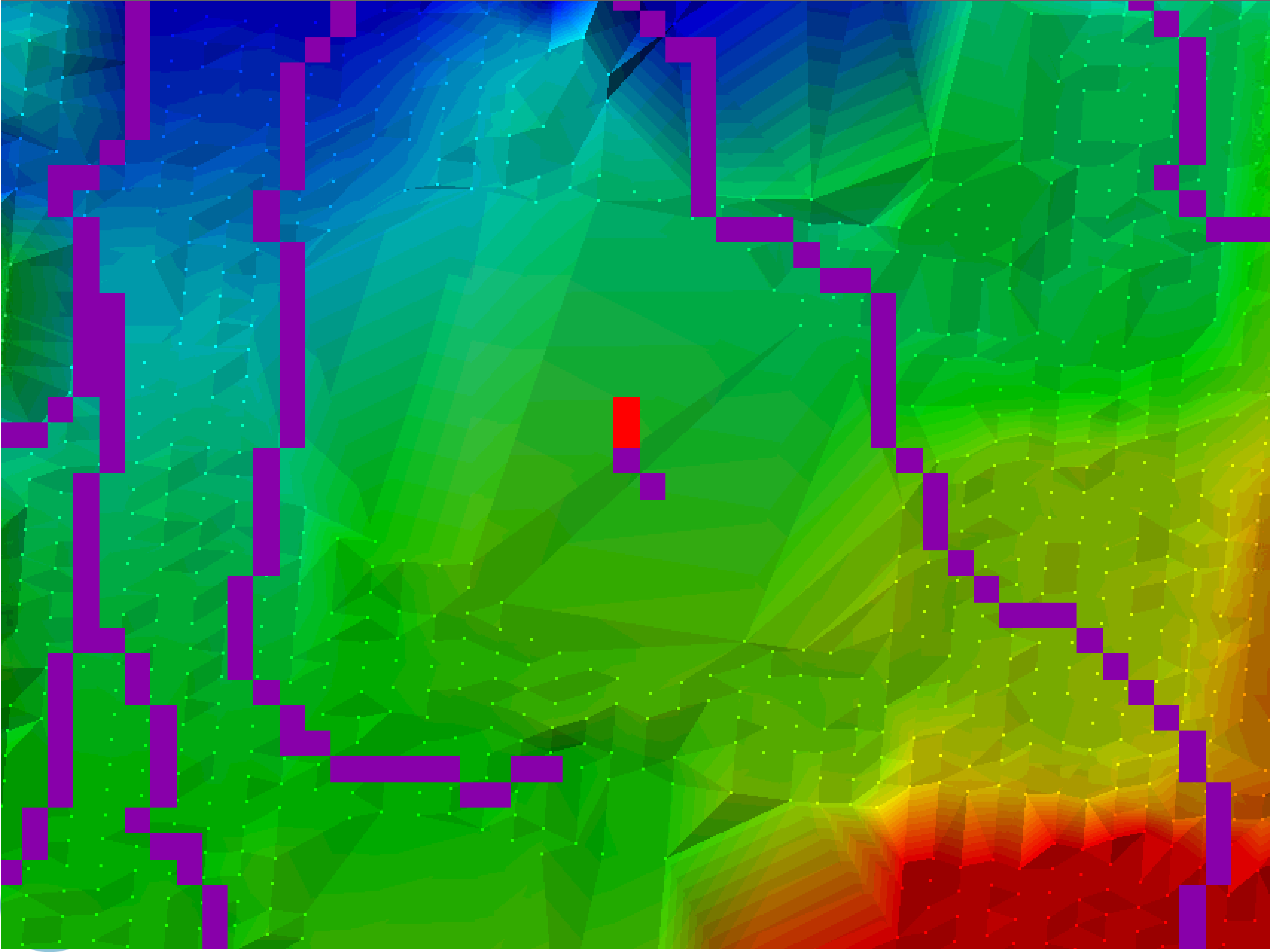


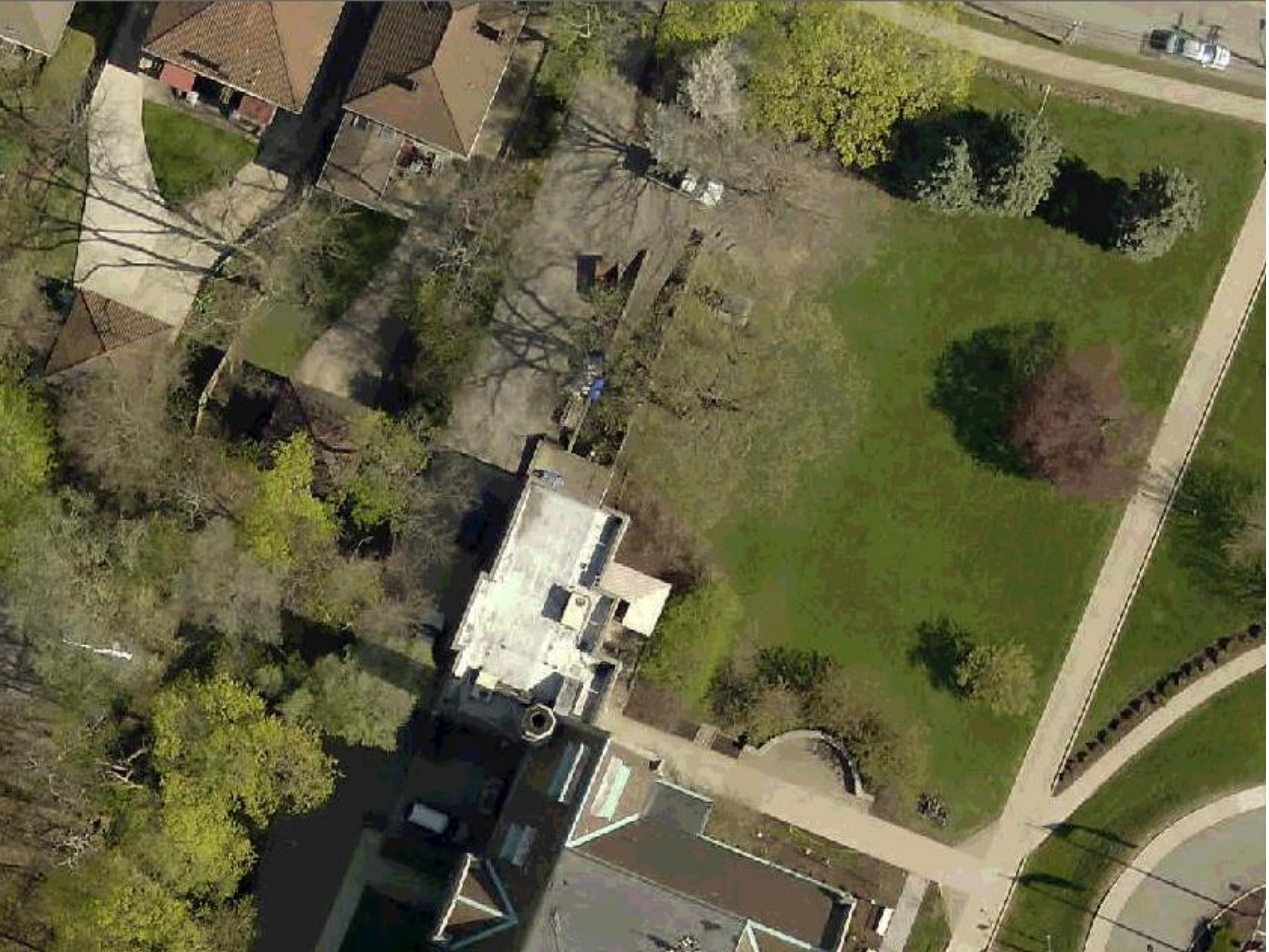


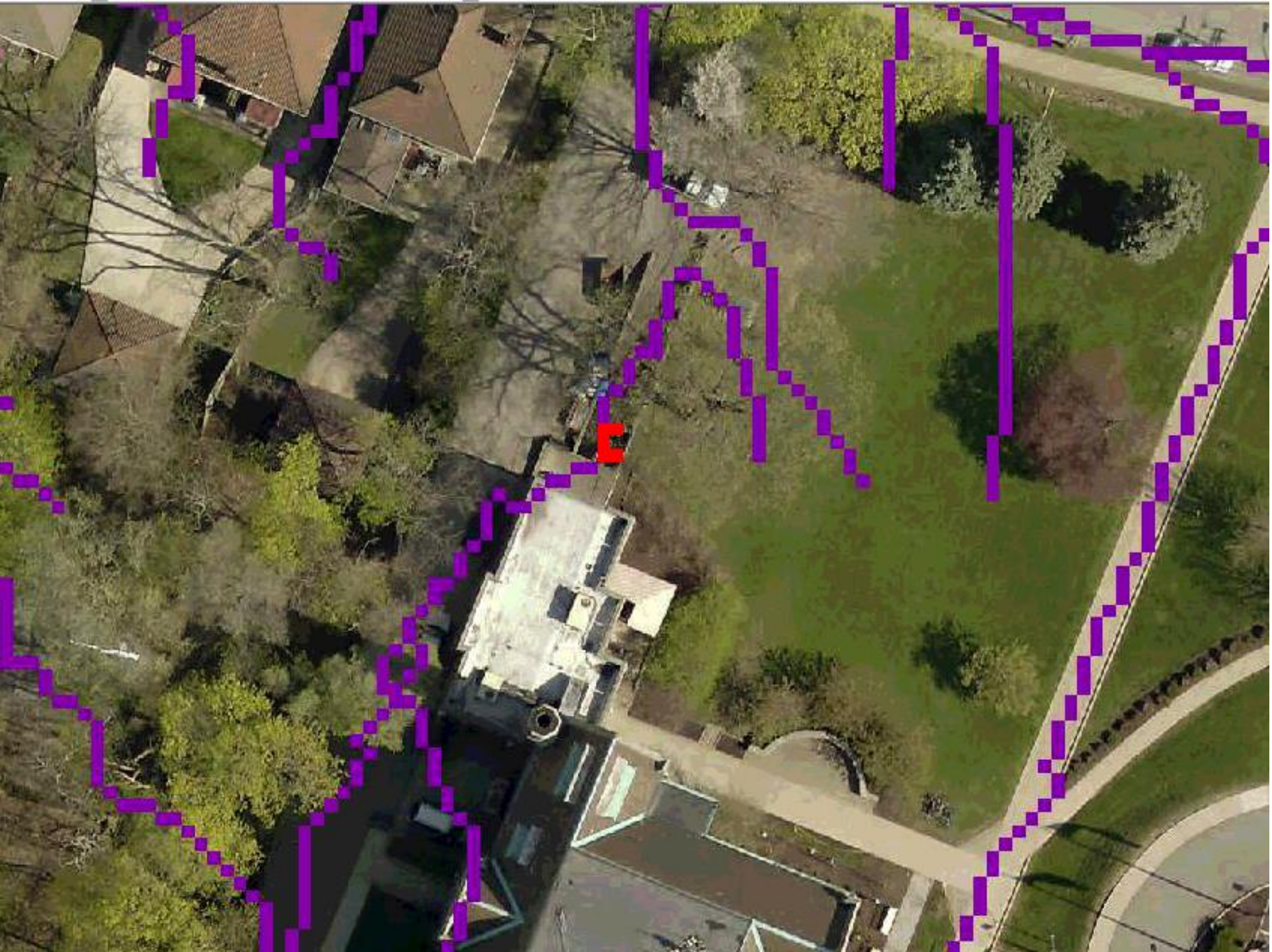


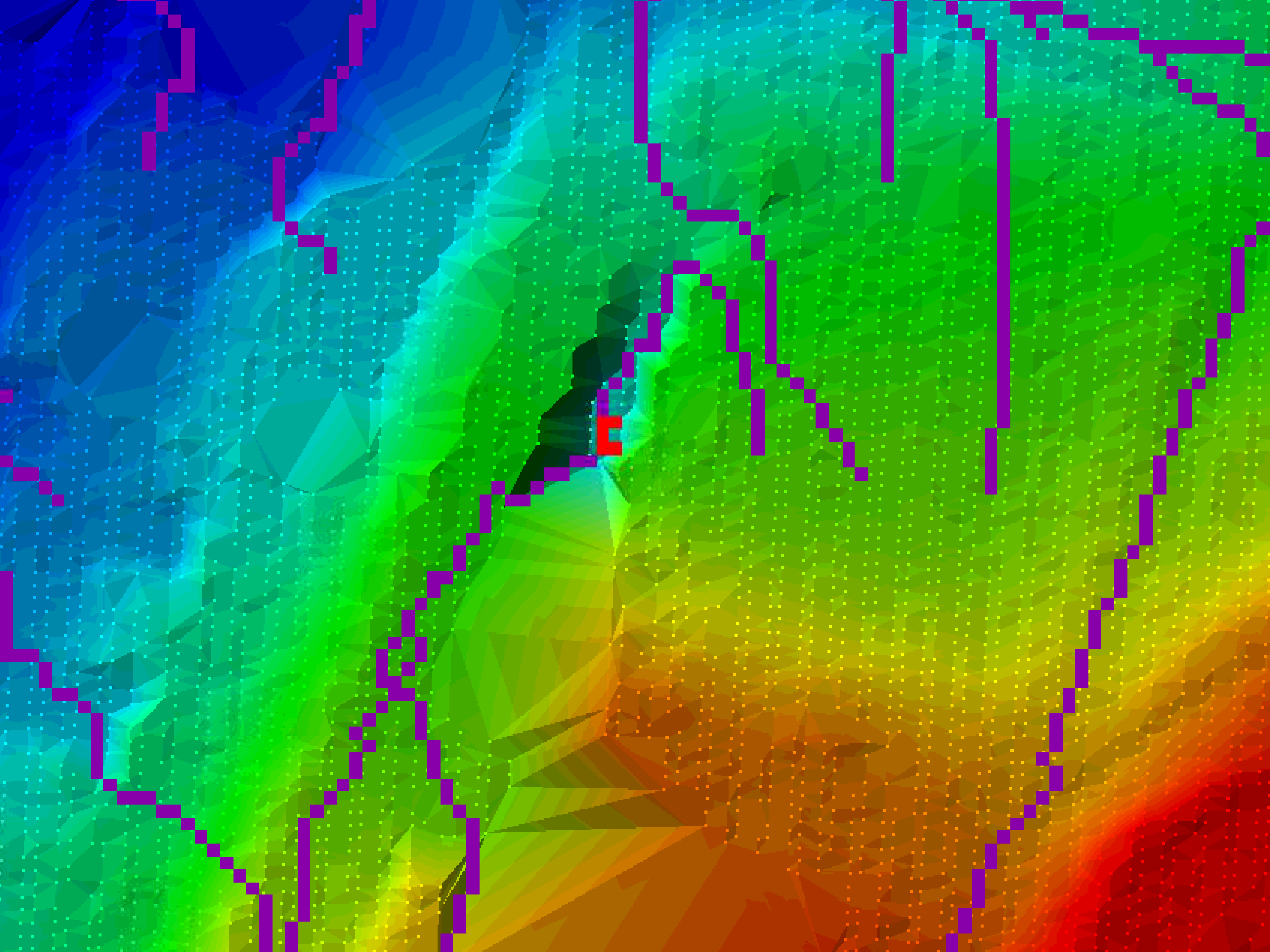


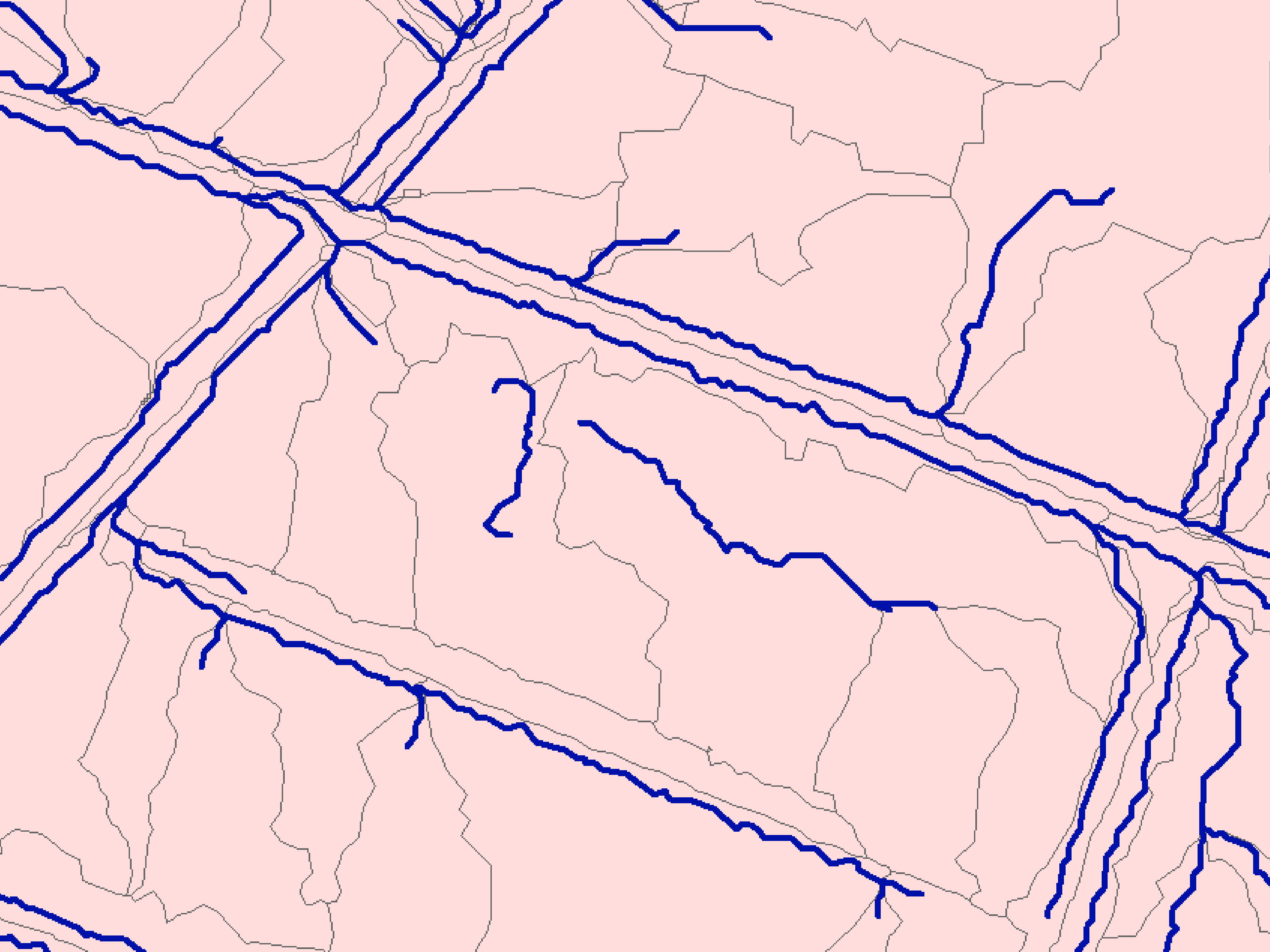


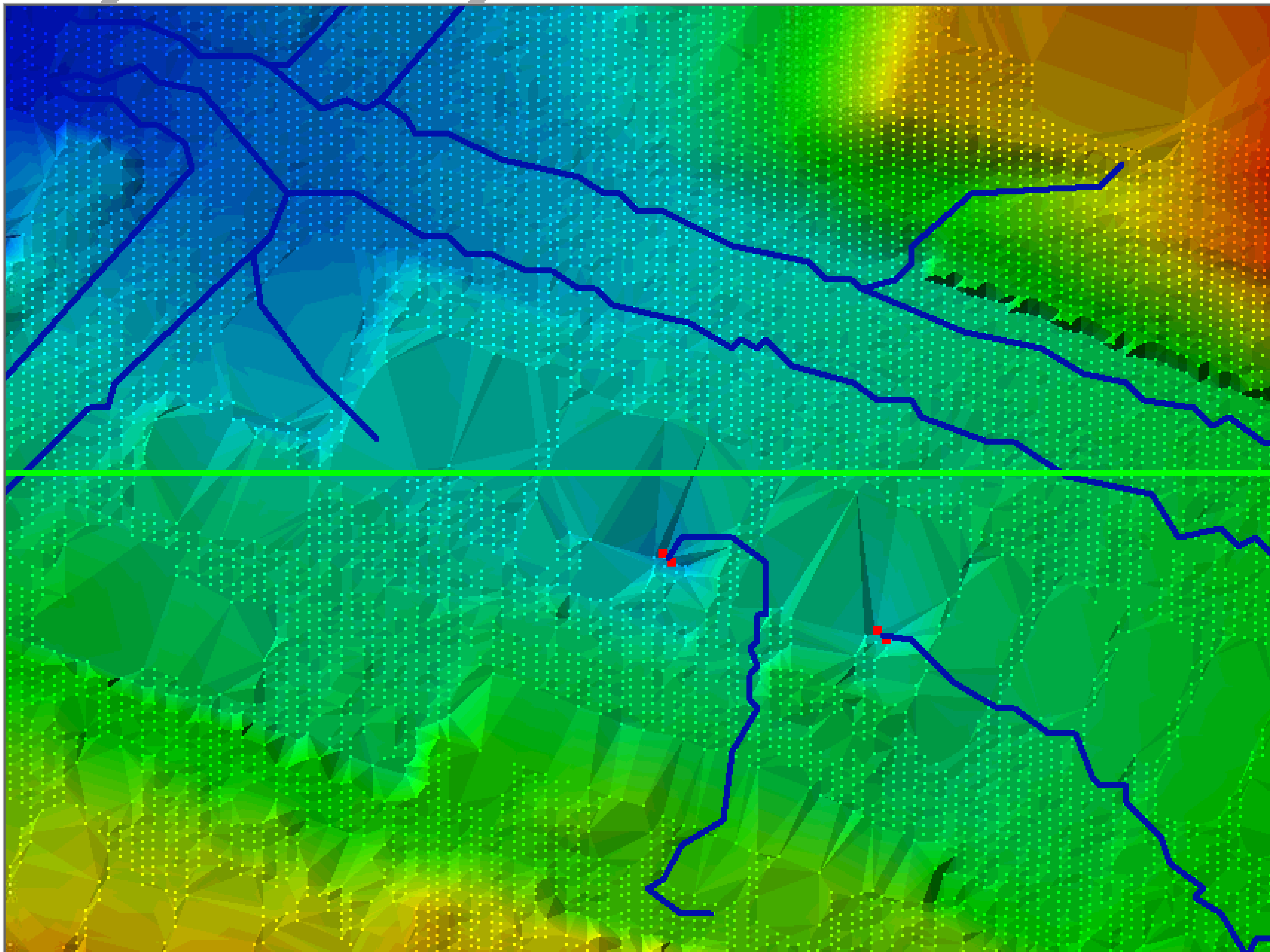


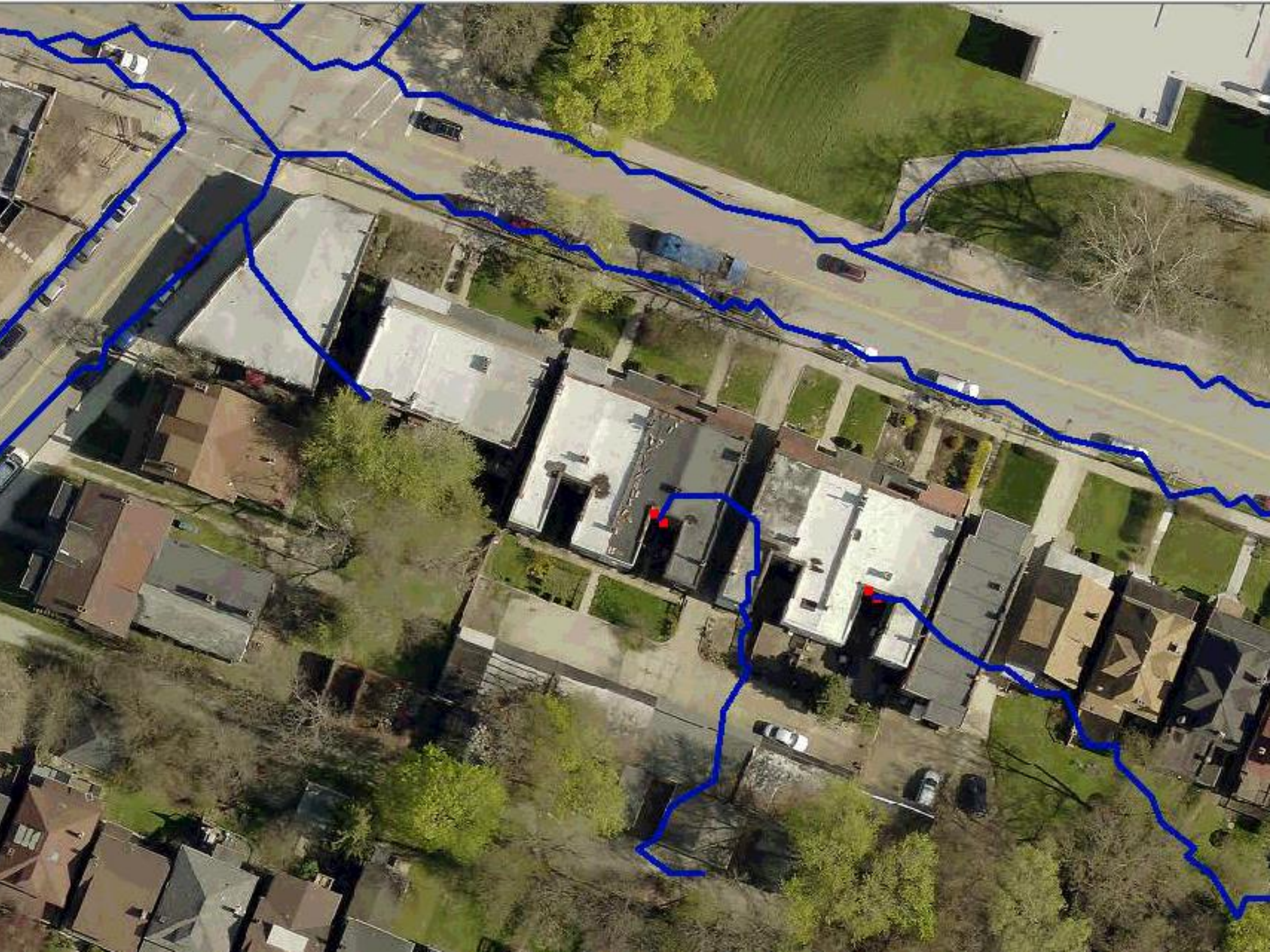


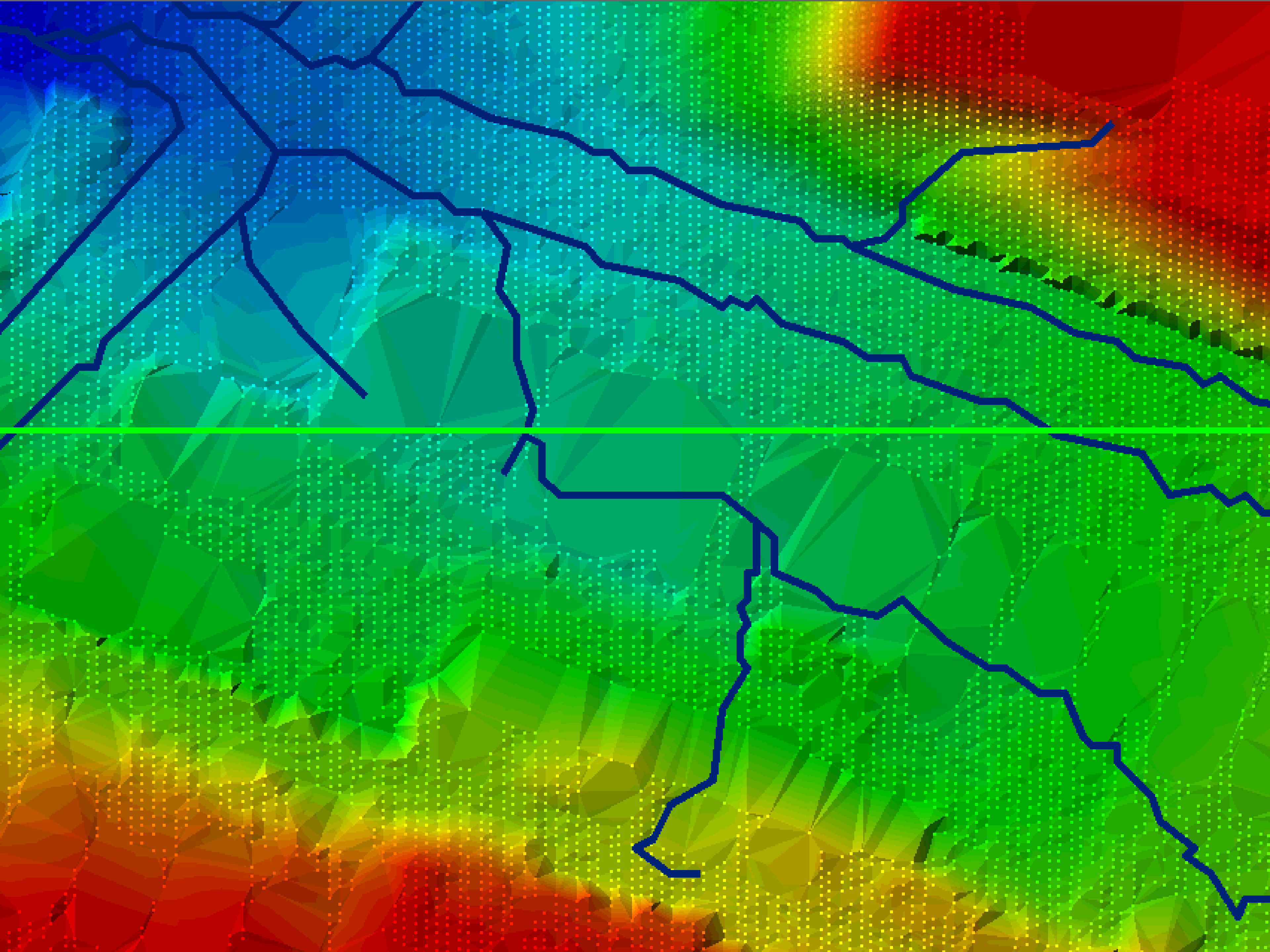




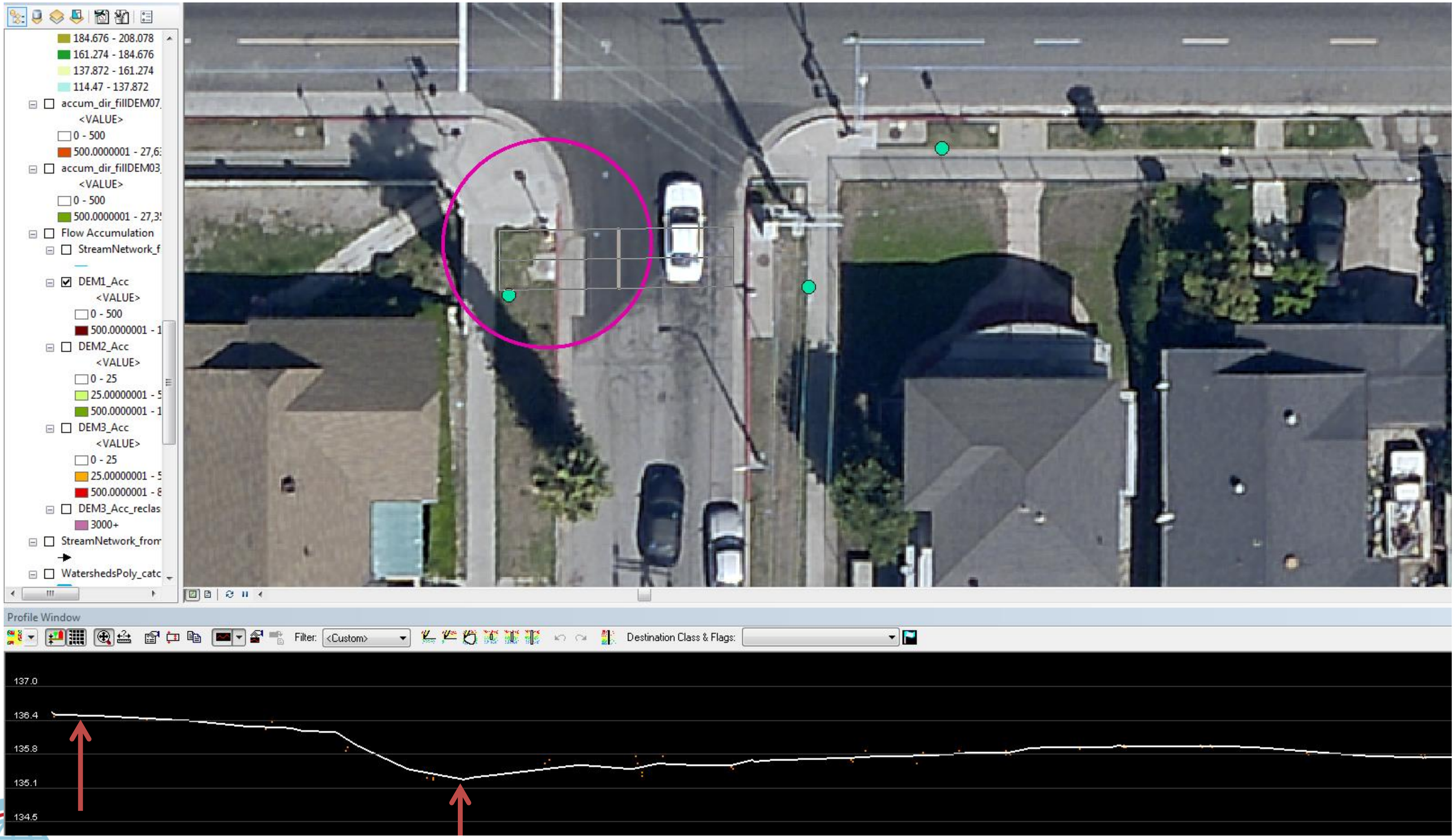








Catch Basin (Drain) Issues




LOS ANGELES REGION
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imagery acquisition consortium
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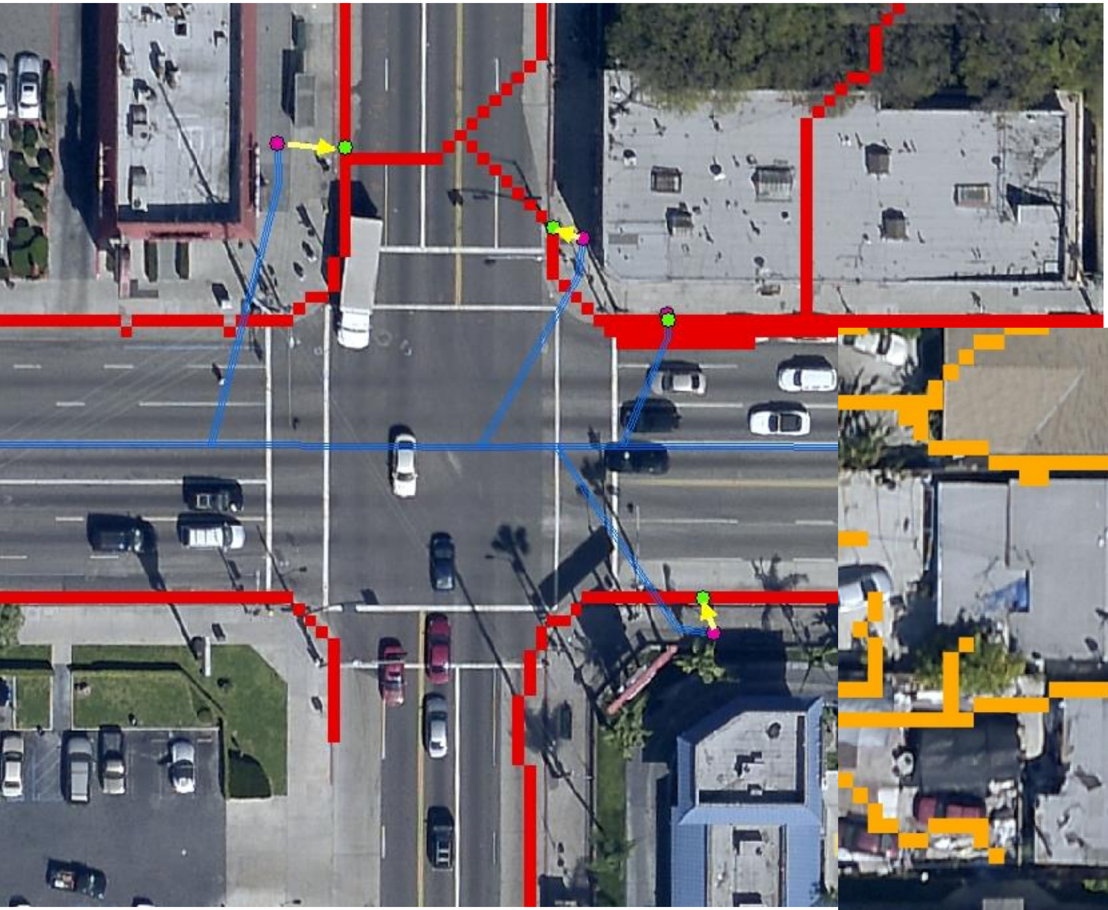
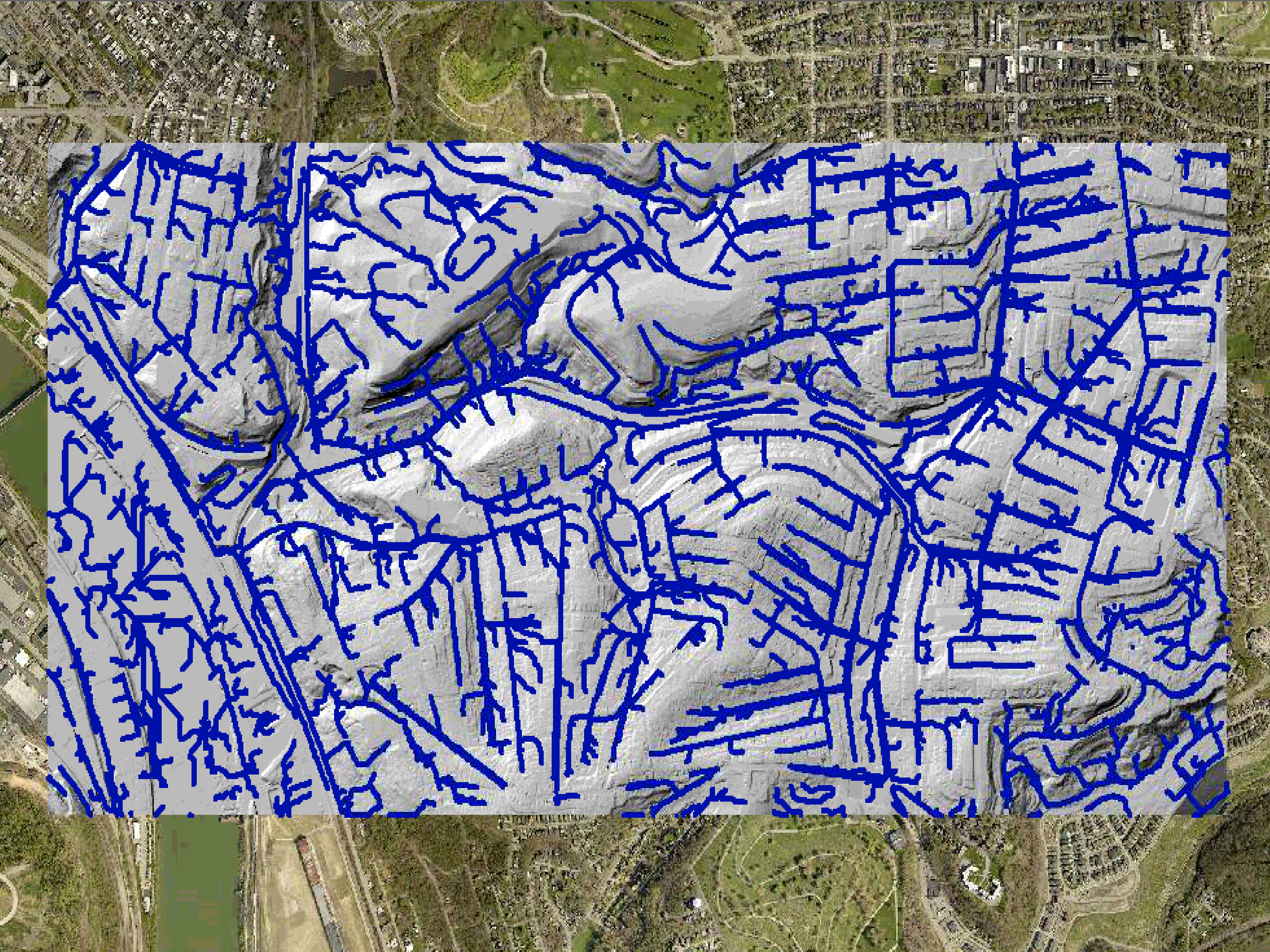
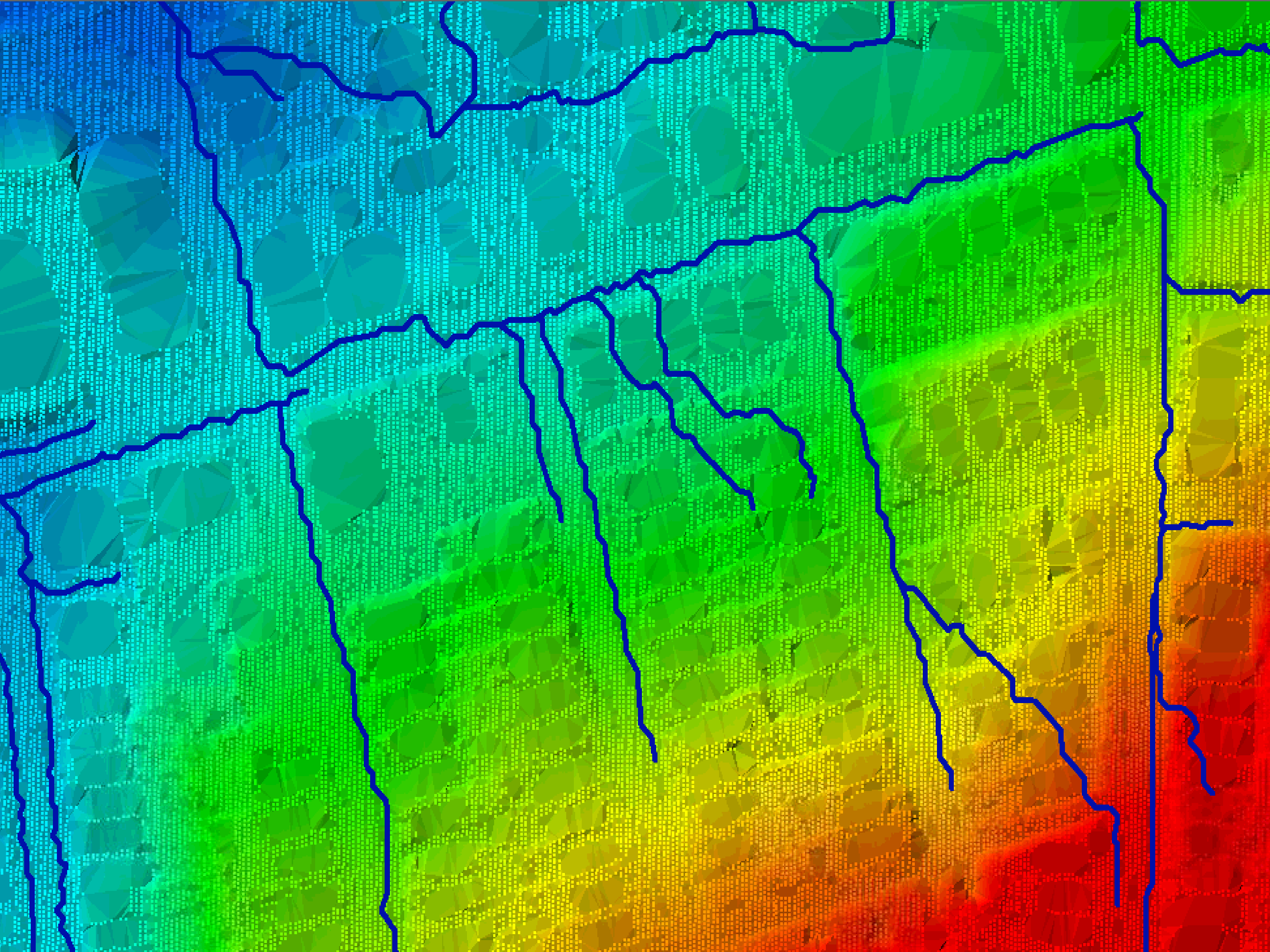
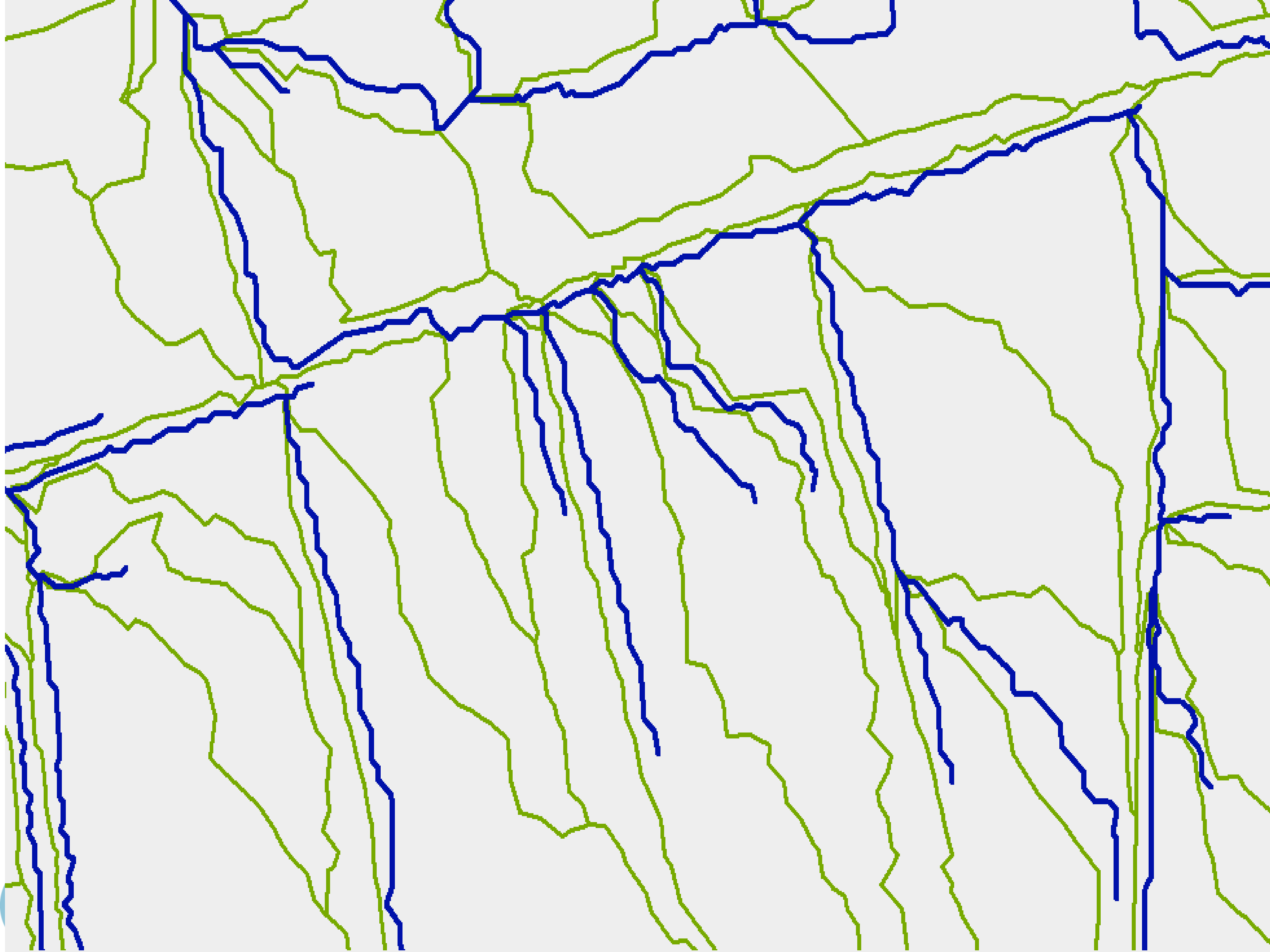
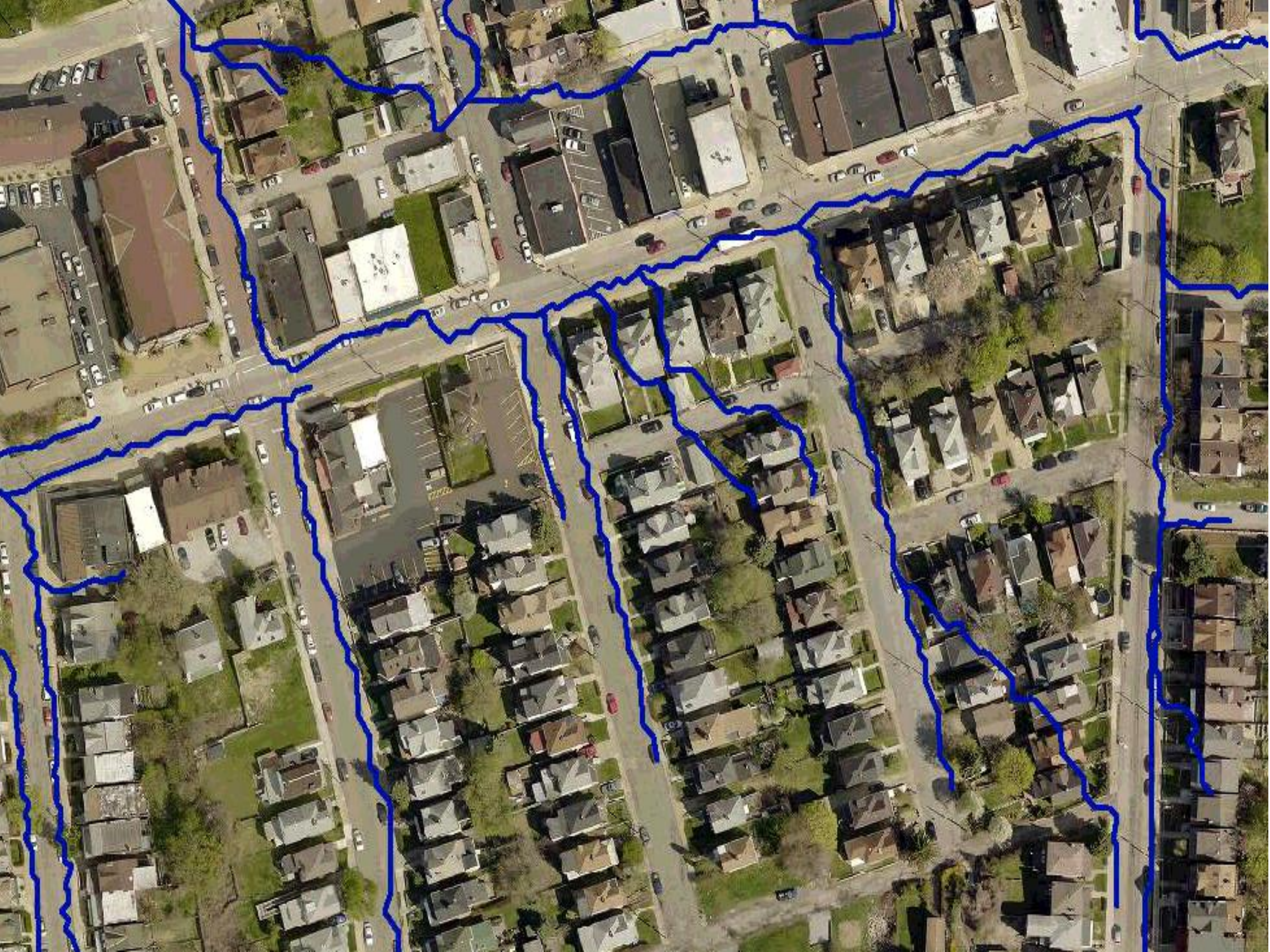
Catch Basin Points Must Be Moved





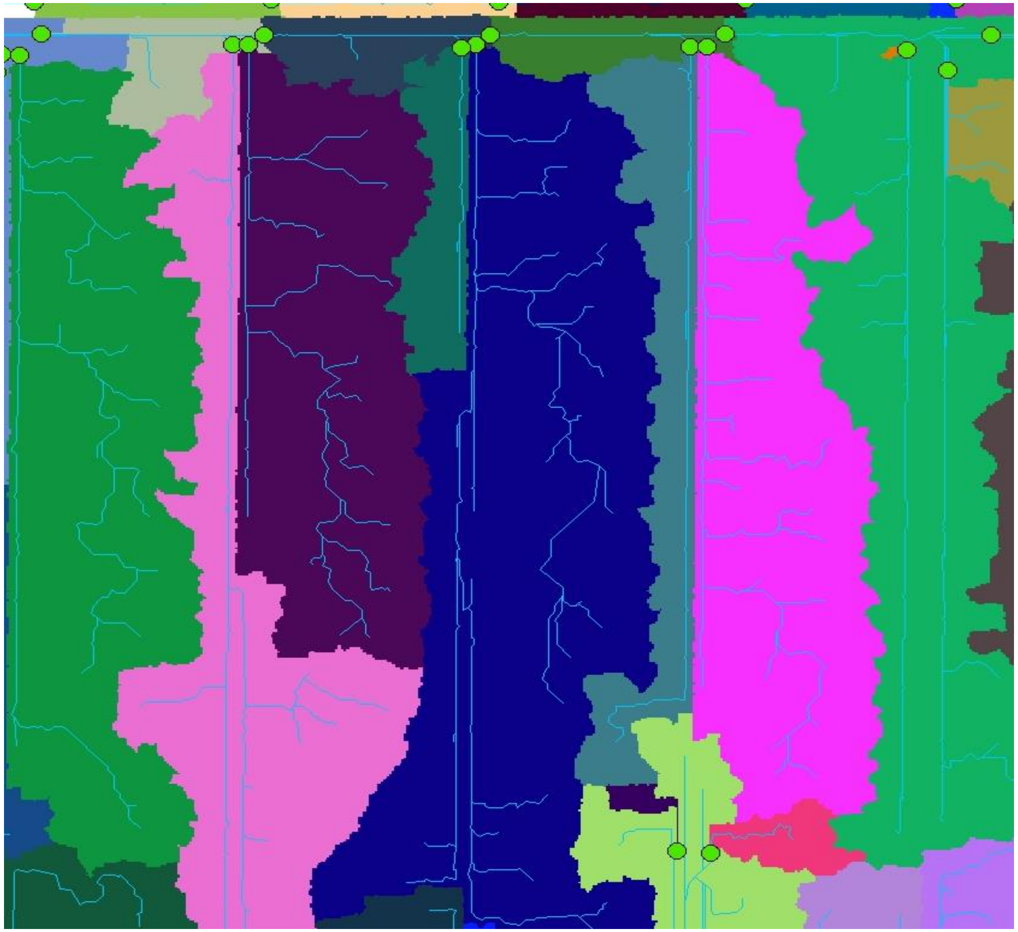






Conclusions

- Workflow is iterative
- Prepare the surface!
  - Prepare the surface
    - Prepare the surface
      - Prepare the surface



Lessons Learned

- **Stakeholder engagement**
  - Get them involved in QC
  - Expectations: goals and priorities
- **Process is iterative**
  - You don't just line it up and hit the "GO" button!
- **Not Perfect. But still FAR FAR better than field surveying method.**

Urban Drainage Modeling for Storm Water Design

Using QL2 LIDAR

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