Shocking Path of Least Resistance Shines Light on Subsurface by Revealing the Paths of Water and the Presence of Faults: Stacked EM Case Studies over Barite Hills Superfund Site in South Carolina

-or-

3 EM Case Studies over a superfund Site /Former Gold Mine South Carolina, USA

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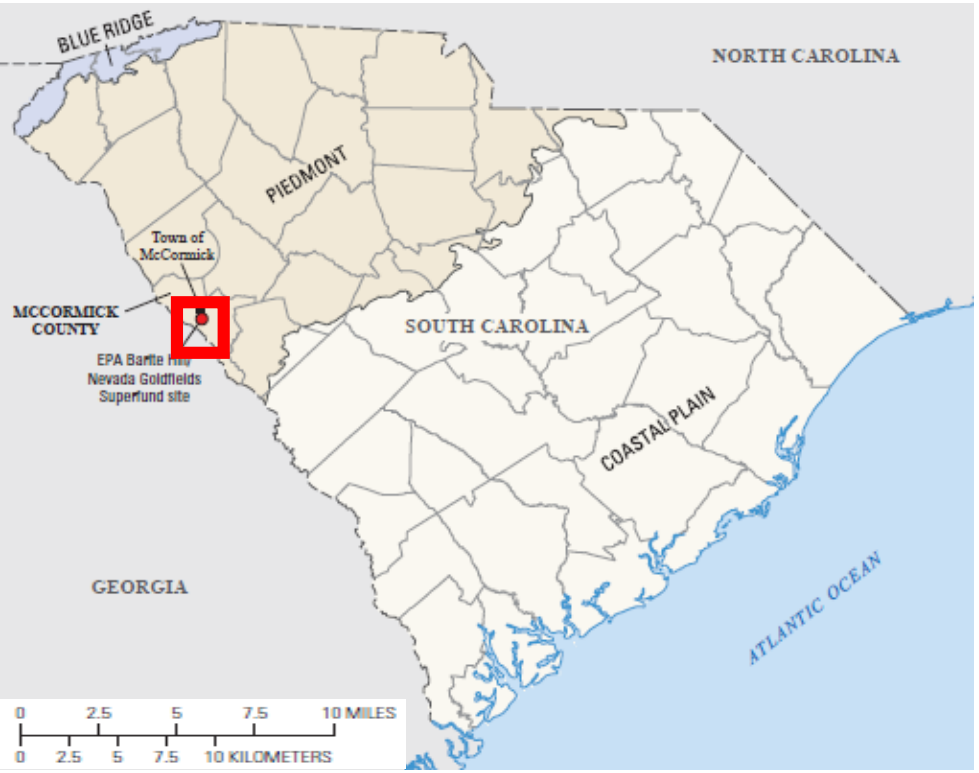
Outline

Barite Hill/ Nevada Goldfields
EPA Superfund Site, SC



1. Overview and USGS Conventional Conductivity Surveys

1. Proven Industry Technology - Flow Path Detection and Models

2. Mapped Patterns from Lightning Attribute Data
   - possible subsurface flow paths.

4. Summary

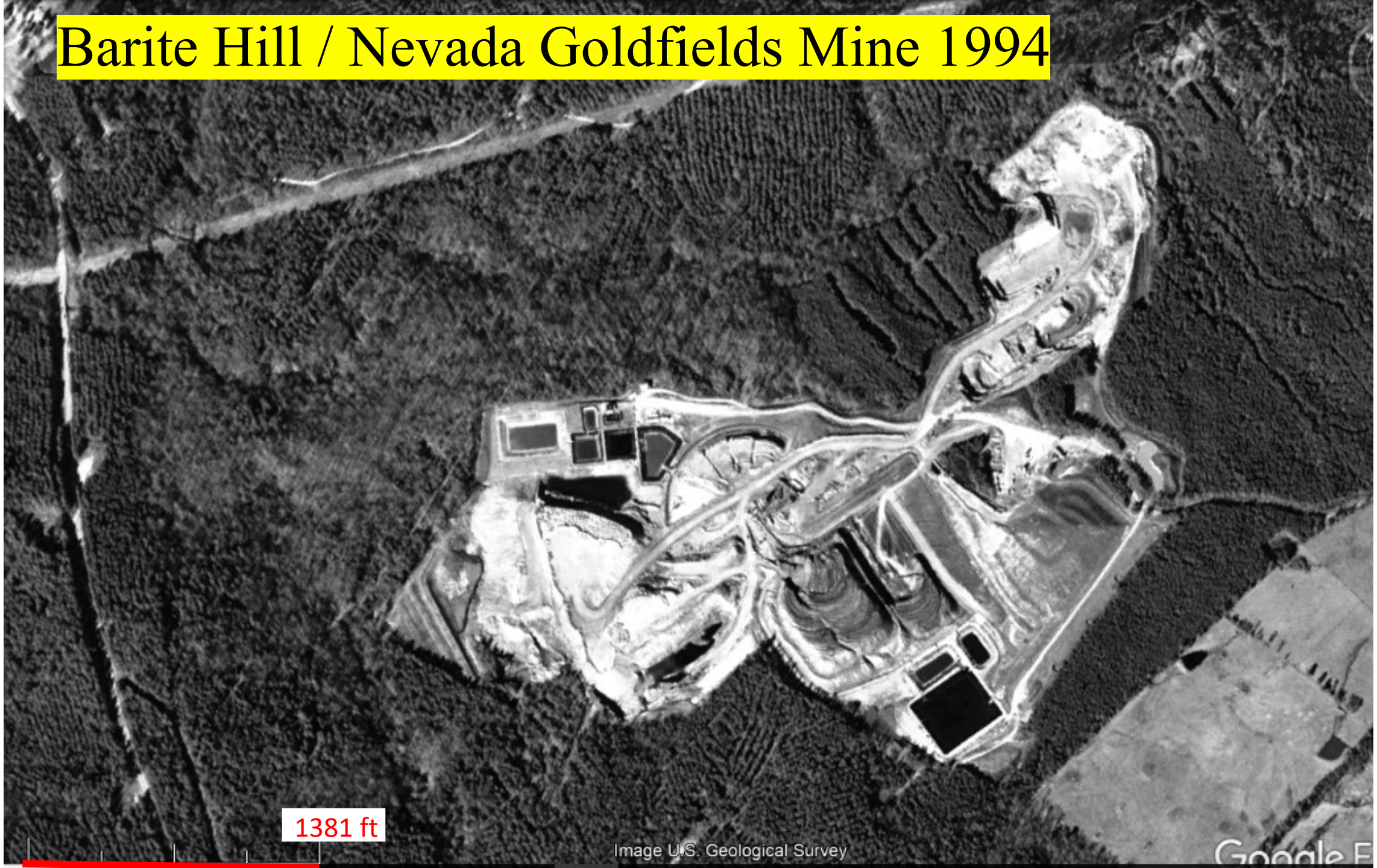
3 EM Technologies

1. Red Box – USGS 2015
   EPA Superfund Site
   Study Area

2. Yellow Box - Willowstick
   Flow Path Mapping and Modeling Patented Process by Willowstick LLC

3. Green Circle
   Dynamic Measurement's Lightning Attribute Analysis
   Remotely Sensed – Processed Archived Lightning Strike Data Patented Process by Dynamic Measurement LLC

Barite Hill / Nevada Goldfields Mine 1994



Barite Hill / Nevada Goldfields - Gold Mine 1991-1995 active 1999 –bankrupt/abandoned site / 2009 - EPA Natl. Priority List

1994 – USGS Picture

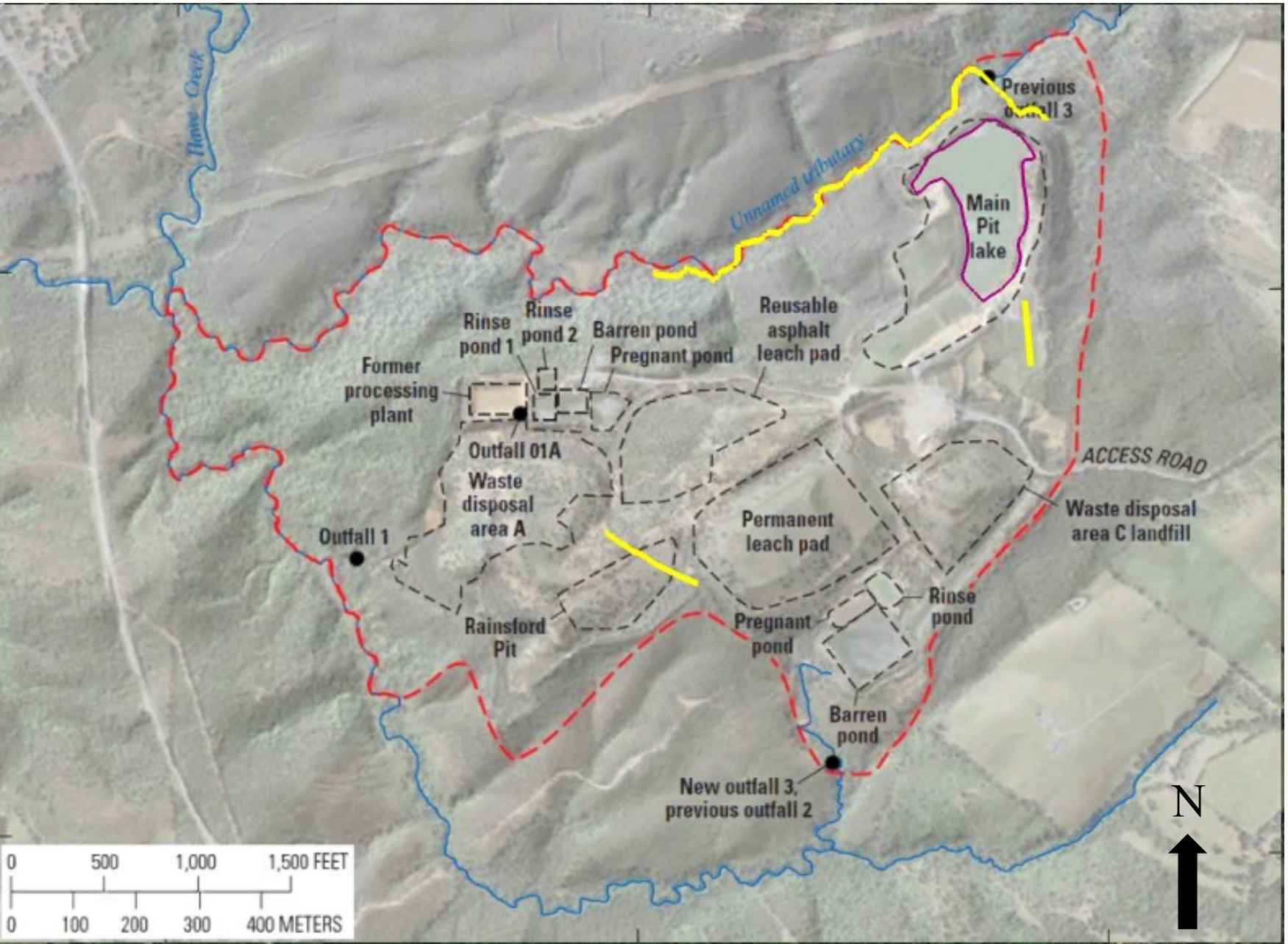
2012 – Google Earth

2016 – Google Earth

Gold & Silver and base metals infused into sub-marine volcanic deposits as part of Island Arc system – Proterozoic

Clark et al. Economic Geology (1999) 94 (8): 1329-1346.

3 Stacked EM Studies



Waterways

USGS Study Area

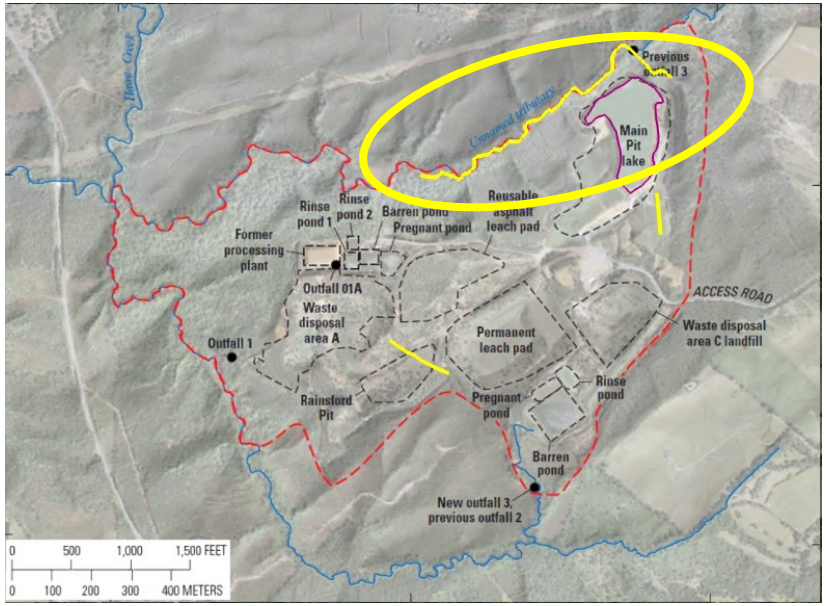
1. Conductivity Surveys

2. Willowstick Flow Path

2. Willowstick Flow Models

3. Dynamic Measurement Lightning Energy Outline

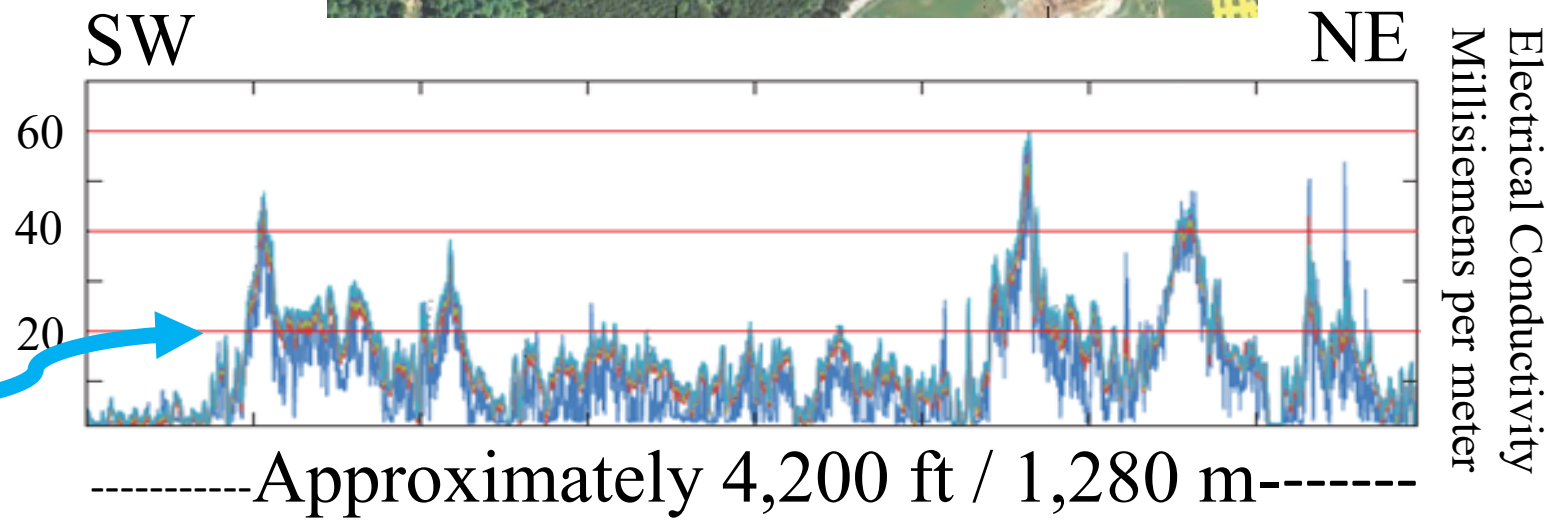
USGS Stream Resistivity Line A - A'



USGS Study Area

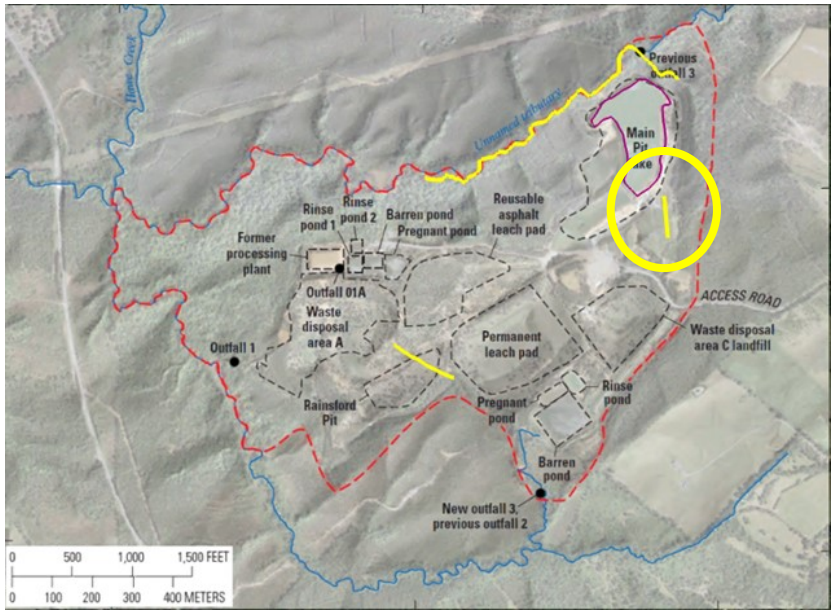
Former Operational Areas

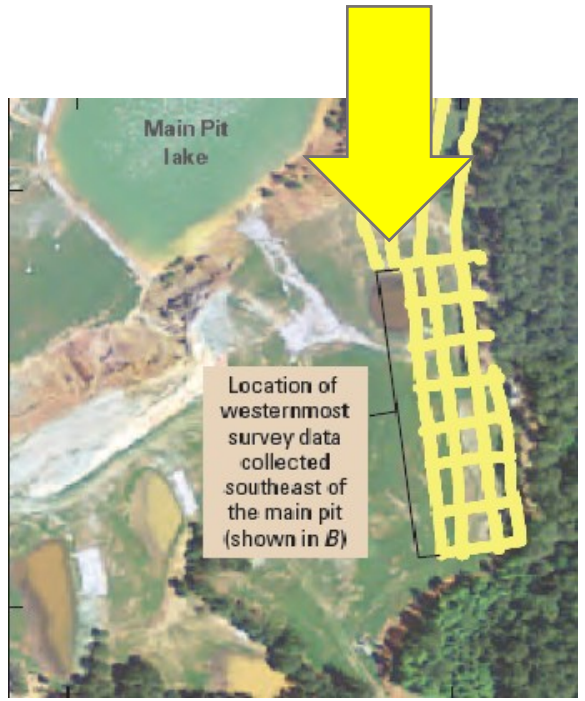
High specific conductance of stream water or thick zones of high conductivity at depth.

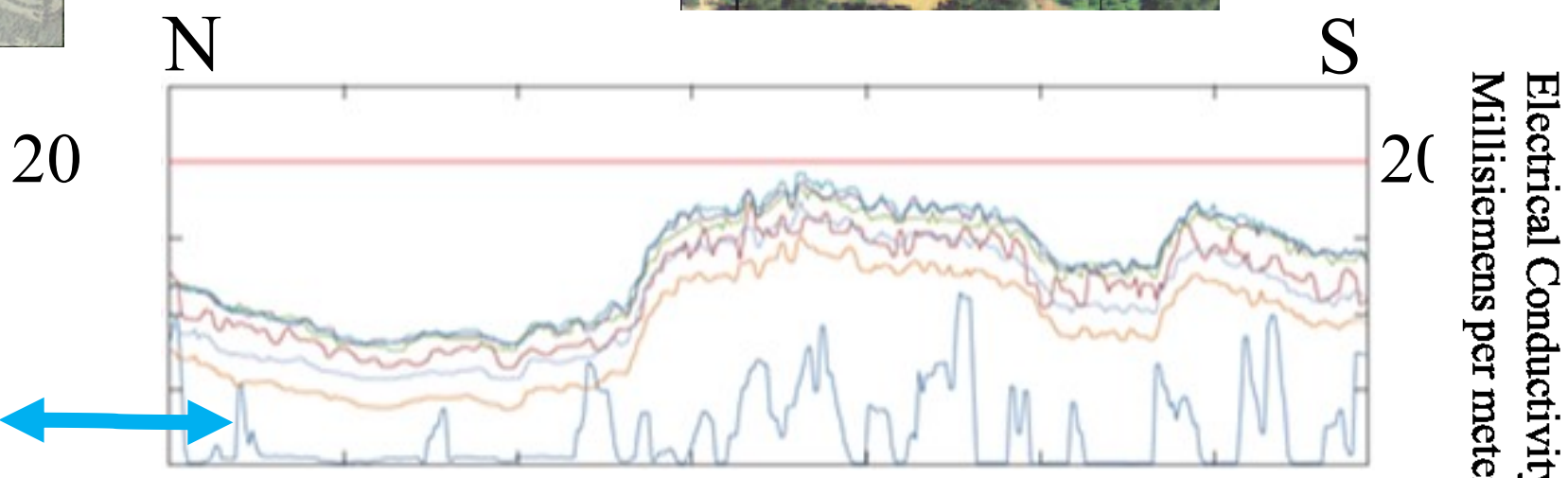


Chapman et. al 2015

Line B – B’ SE of Pit Lake







USGS Study Area

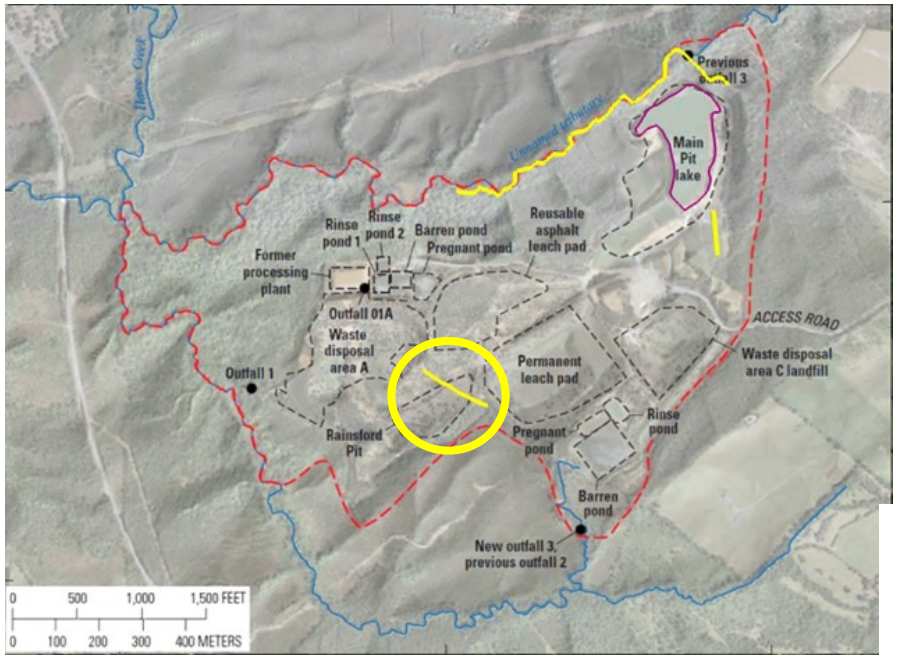
Former Operational Areas

Likely deeper bedrock recorded by low frequency 1530 Hz

-------Approximately 350 ft / 107 m ------

Chapman et. al 2015

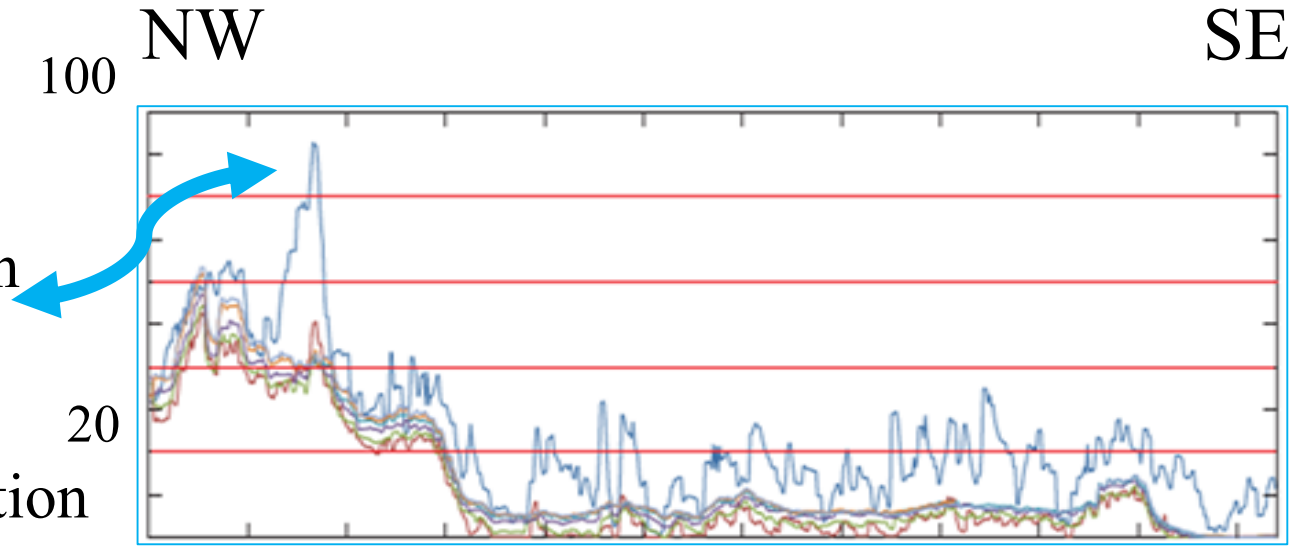
Line C – C’ Rainsford Pit Area



USGS Study Area

Former Operational Areas

Low frequency (1530 Hz) recorded high conductivity from depth - buried waste rock, native ore, groundwater with dissolved ions and metals or a combination of all of the above.

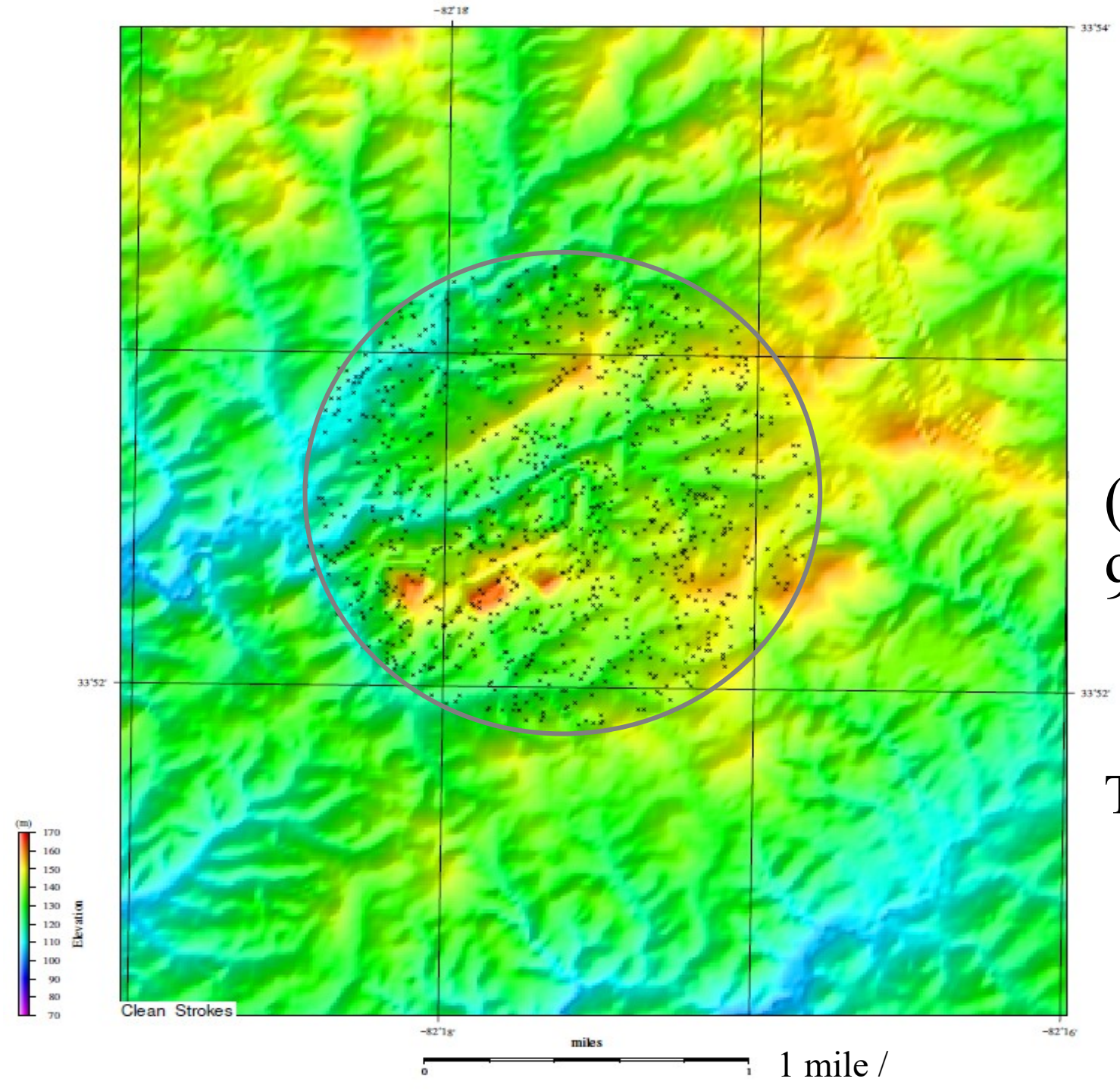


----Approximately 580 ft / 177 m----

Chapman et. al 2015

Quick Lightning Analysis Primer

- Remote non-invasive analysis – no boots on the ground and no permits required.
- Ground based sensors capture low and very low frequency radio waves and measure peak current.
- 18 years of strike data available for the continental US and Canada.
- Data is cleaned and processed through patented algorithms.



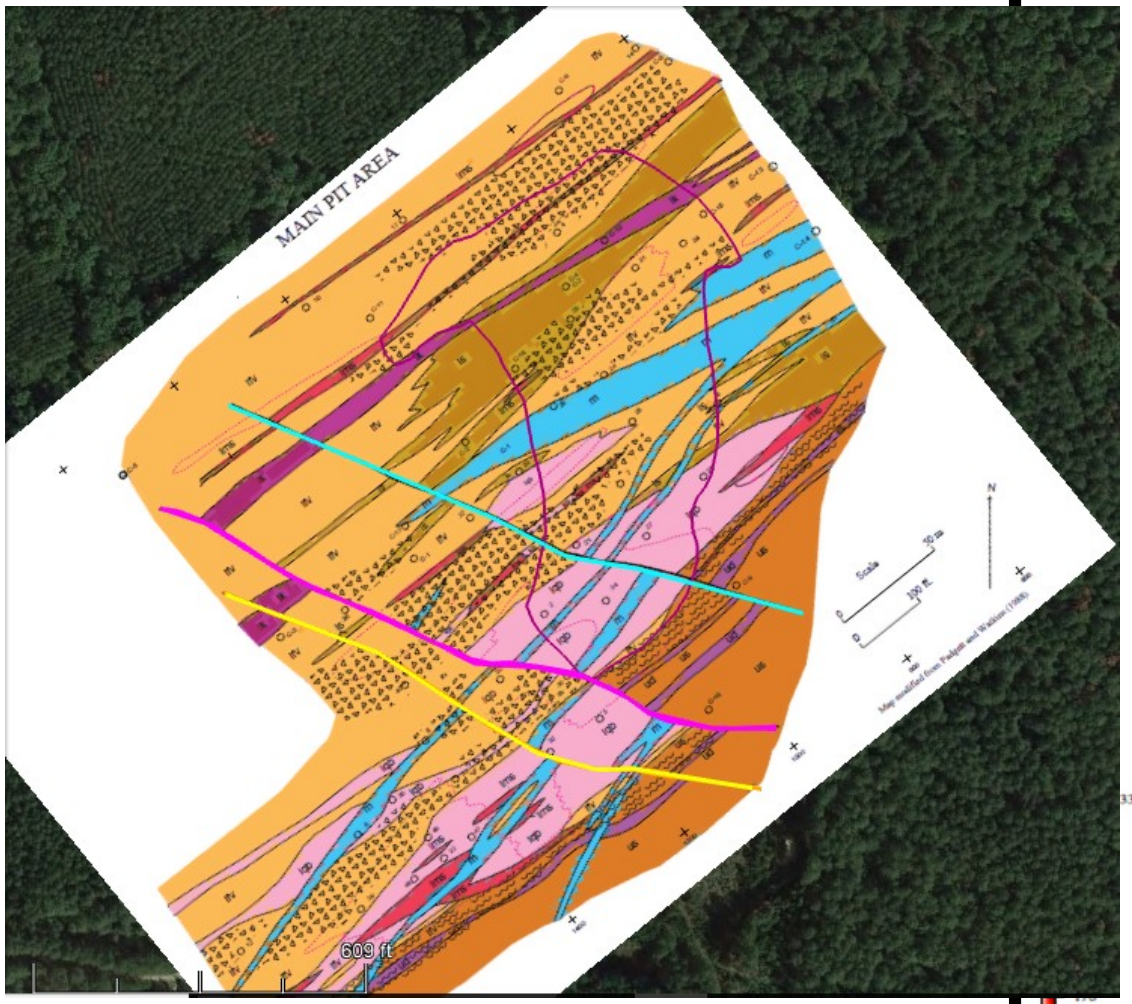
Topographic Map and Analysis Area

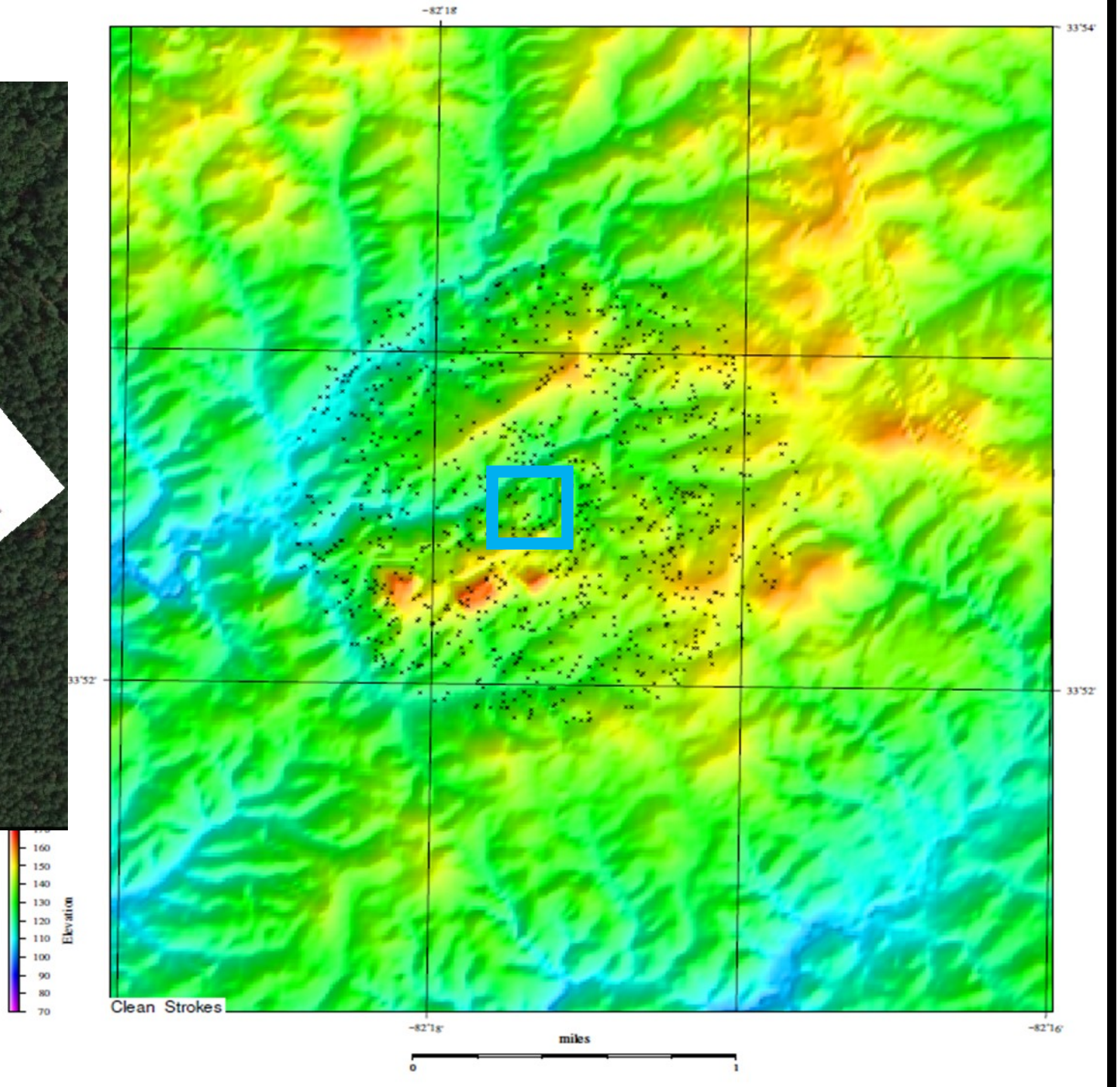
Small dots indicate lightning strike locations (a total of 1017 strikes – and 912 after data cleaning)

Study Area

Diameter: 1.59 mi/2.56km

Total Area: 1.99 sq mi/5.15 sq km

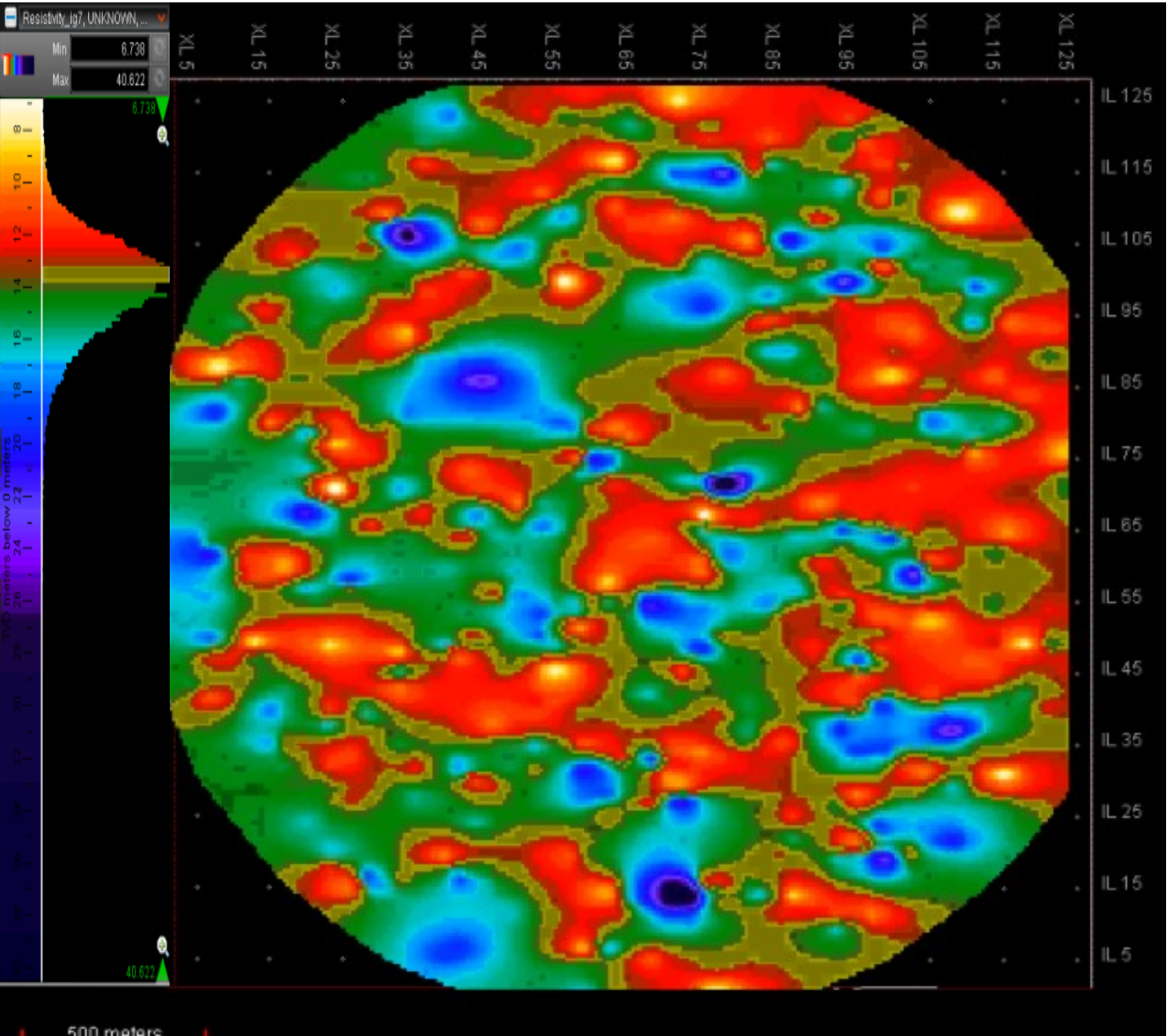

MAIN PIT AREA
609 ft


-82°18'
33°54'
33°52'
-82°16'
Elevation
160
150
140
130
120
110
100
90
80
70
Clean Strokes
miles
0
1

Lightning Attribute

"Apparent Resistivity"

Electrical resistivity and depth computed from a simple model using the Peak Current and Peak to Zero time. Color Bar Scale in ohm-meters, a relative scale.



Sub-Regional Apparent Resistivity Map

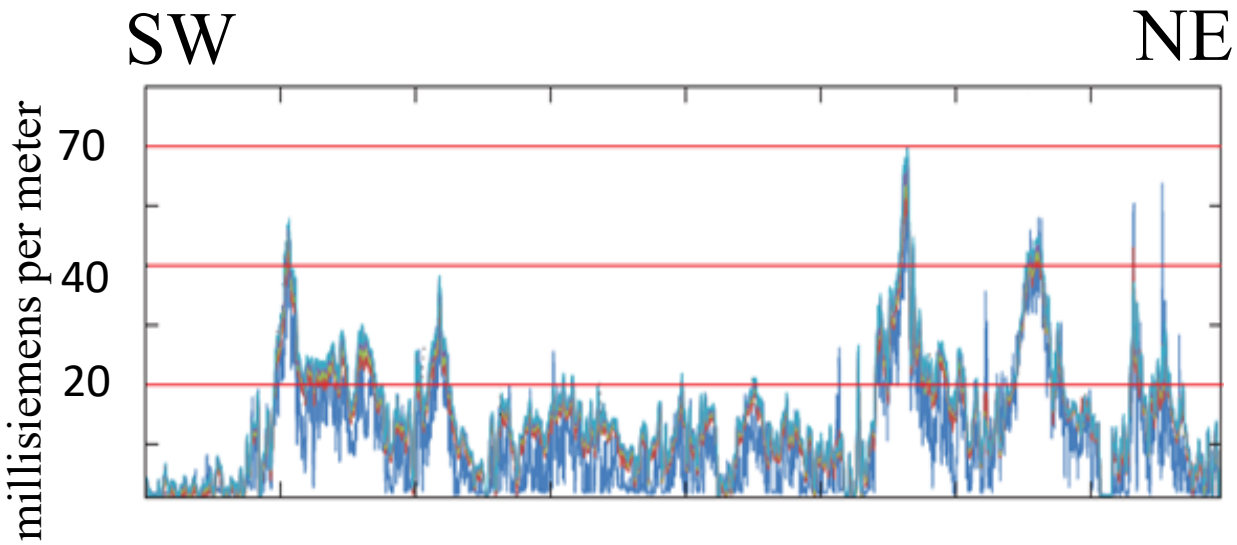
Red Areas = Low Apparent Resistivity / High Conductivity

Ore Bodies, Buried Waste Rock and/or Contaminated Regolith Groundwater (dissolved ions and metals)

Blue Areas = High Apparent Resistivity / Very Low Conductivity

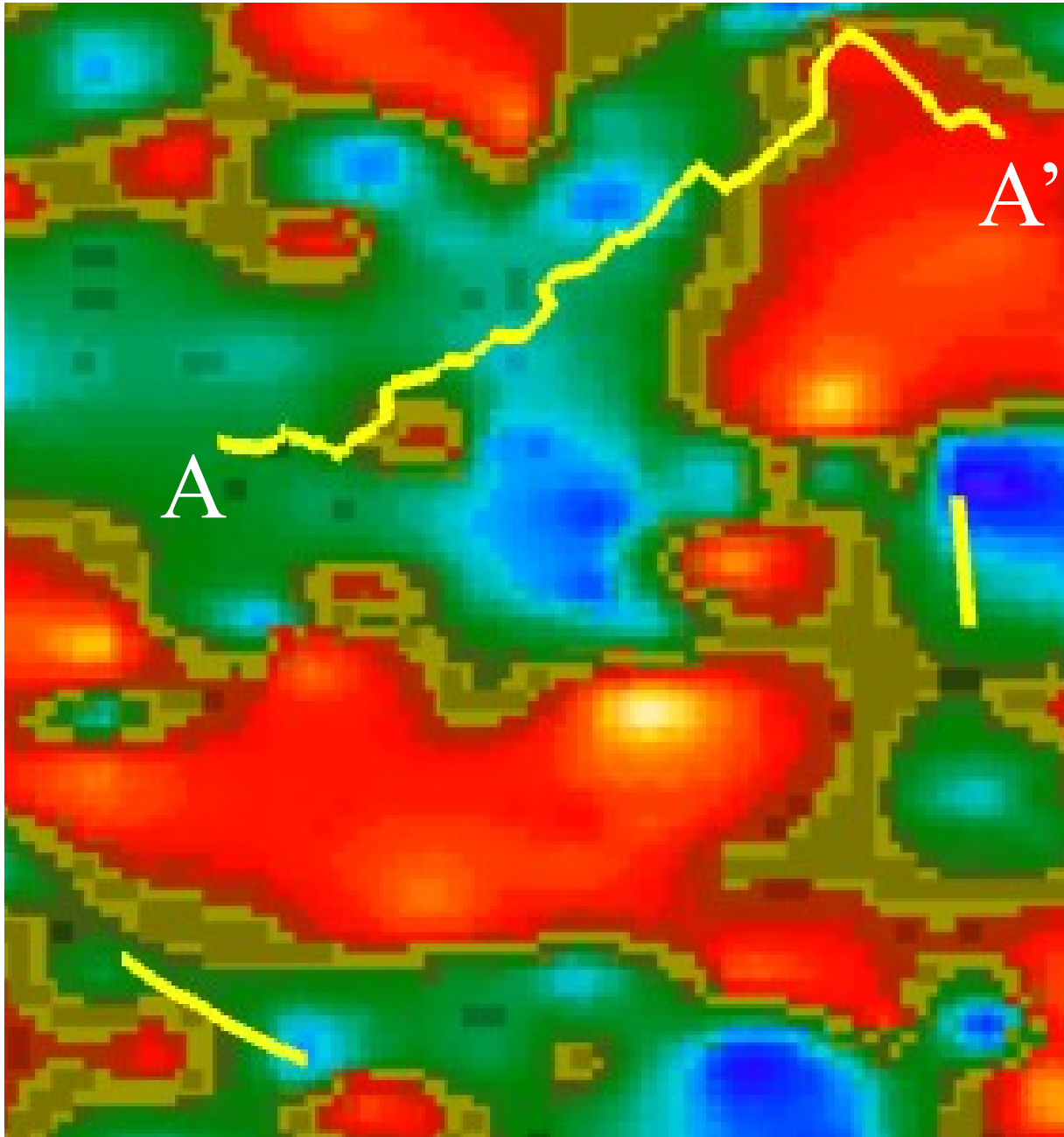
Bedrock

Apparent Resistivity Cross Section A-A’



--Approximately 4,200ft /1280 m--

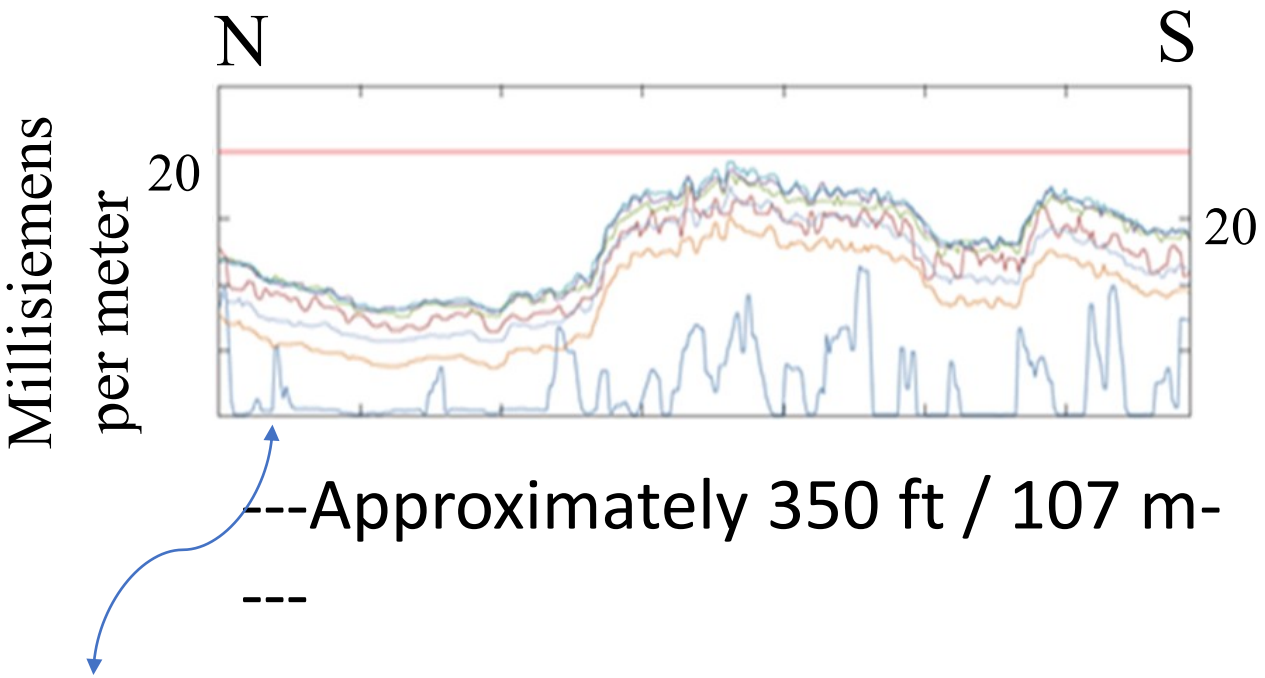
Chapman et. al. 2015



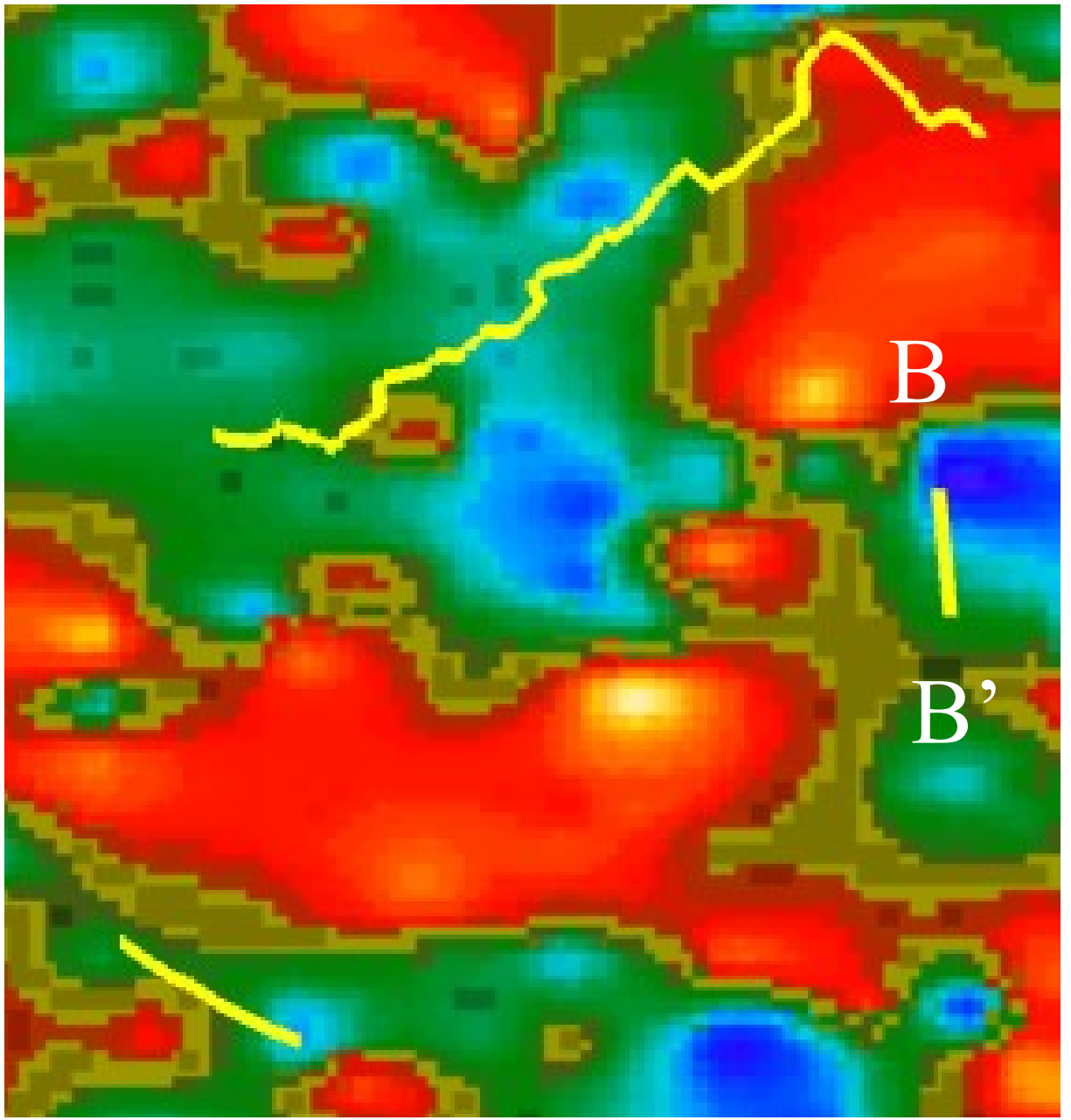
Apparent Resistivity Map

Electrical resistivity and depth computed from a simple model using Peak Current and Peak to Zero time.

Apparent Resistivity Cross Section B-B’



Lower blue line is low conductivity from (1530 Hz) and indicative of bedrock at depth.



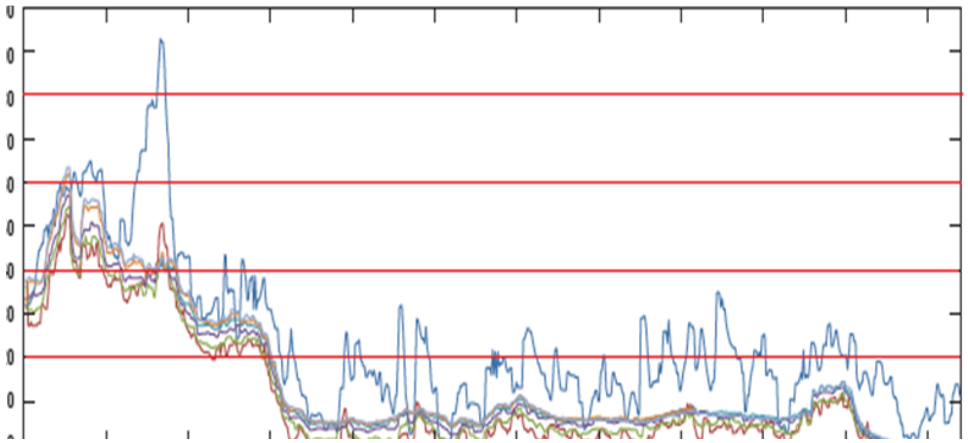
Apparent Resistivity Map

Electrical resistivity and depth computed from a simple model using Peak Current and Peak to Zero time.

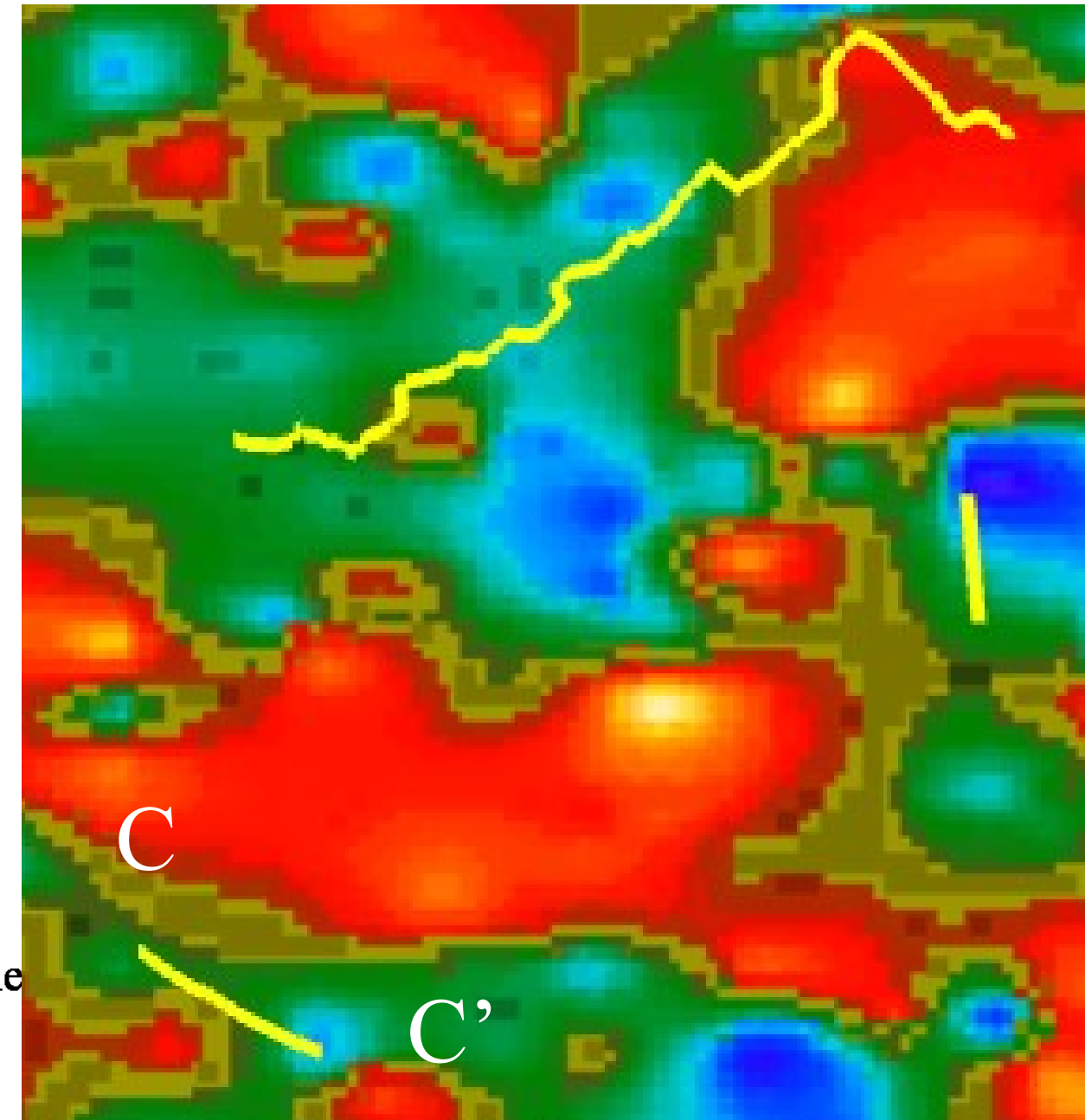
Apparent Resistivity Cross Section C-C’

NE SW

millisiemens per meter



----Approximately 580 ft / 177 m----



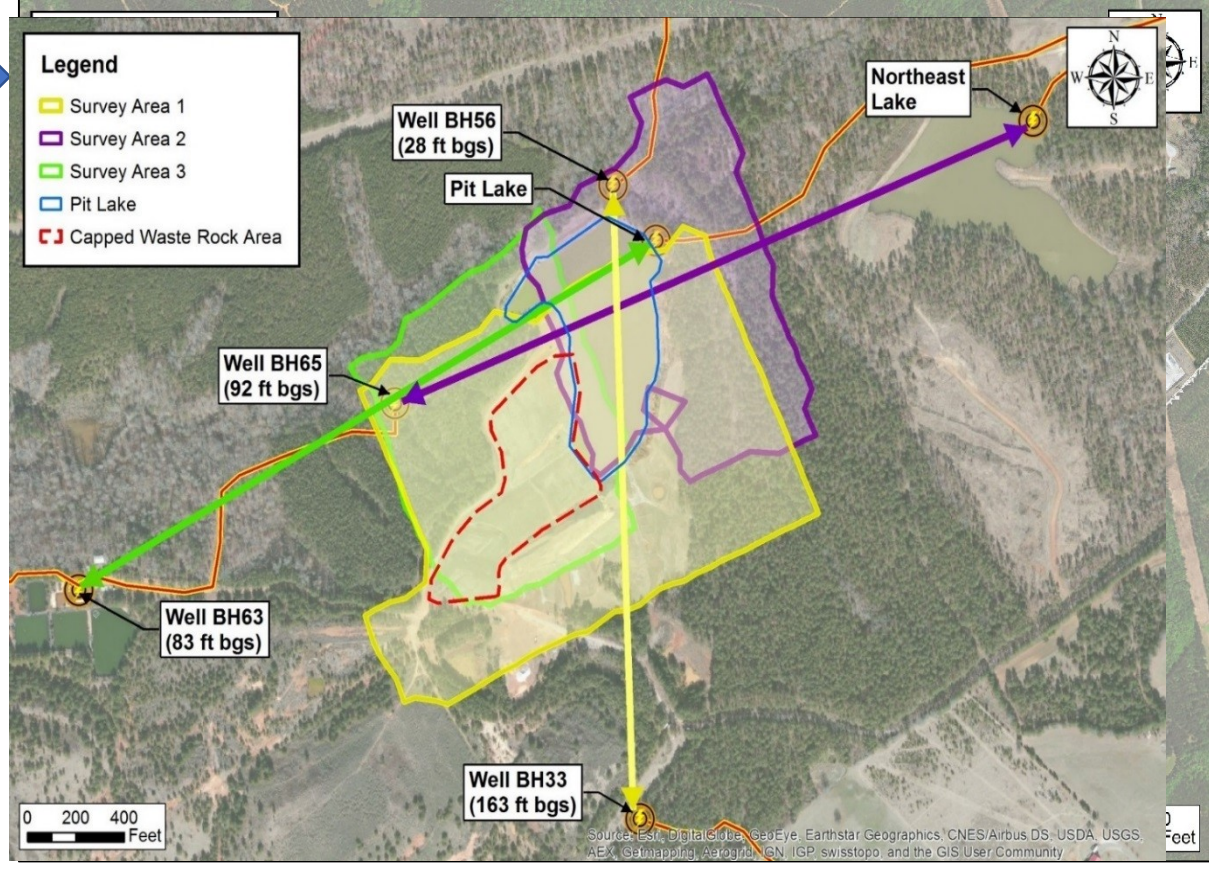
Apparent Resistivity Map

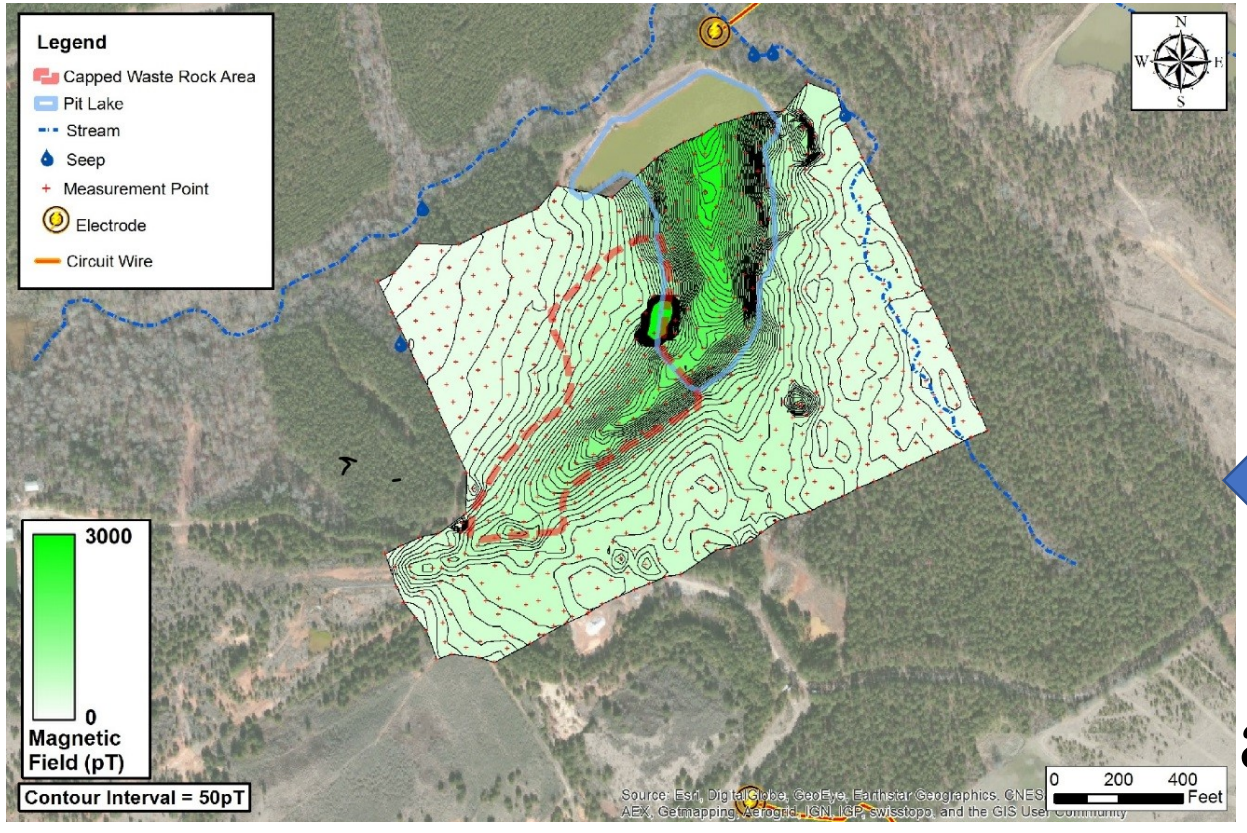
Electrical resistivity and depth computed from a simple model using Peak Current and Peak to Zero time.

Willowstick Flow Path Technology

1. Images Groundwater Paths
2. Improves Models

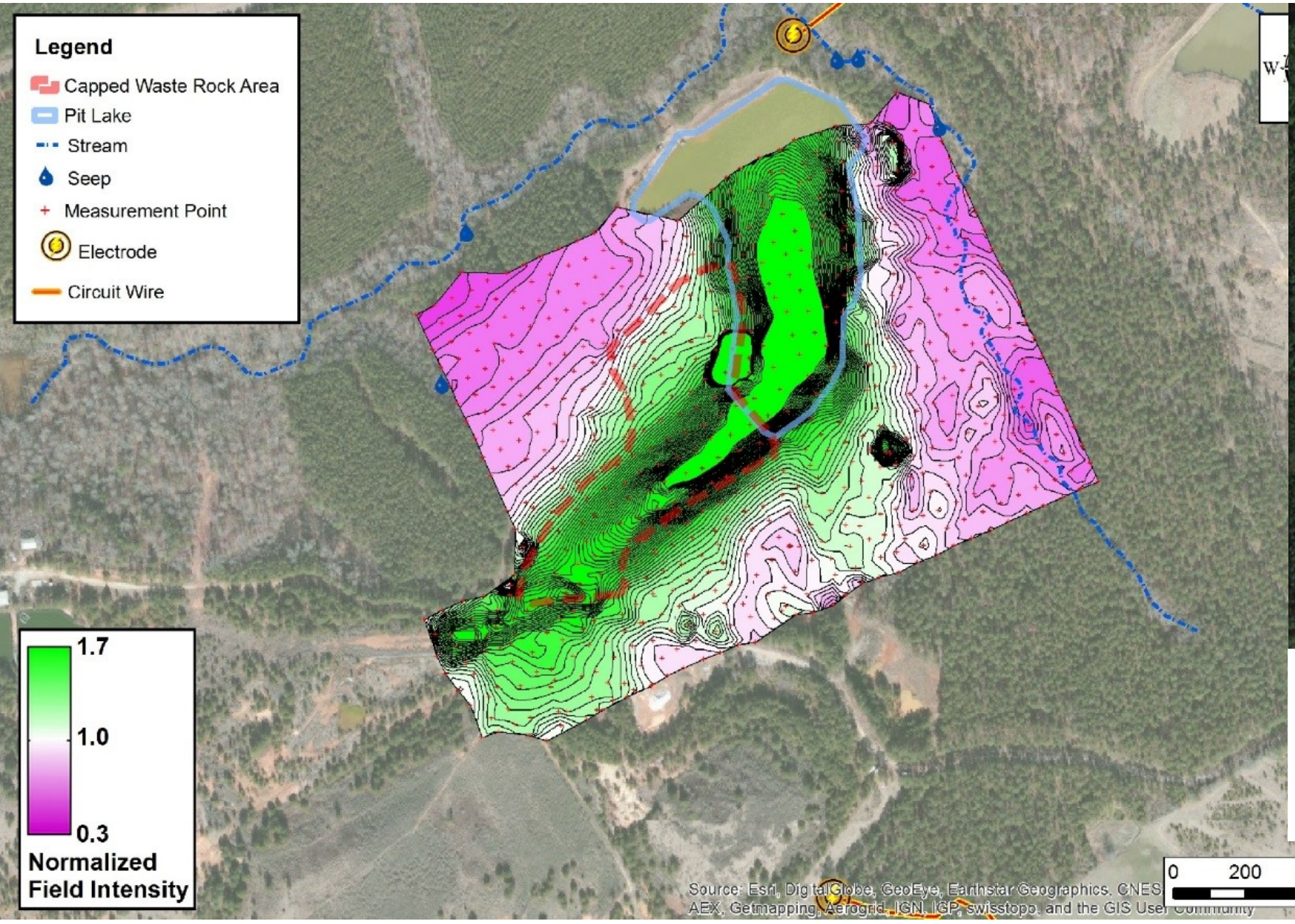
Willowstick survey configurations imaged preferred electric current flow through area from 3 surveyed grids. Area 1 is in yellow.

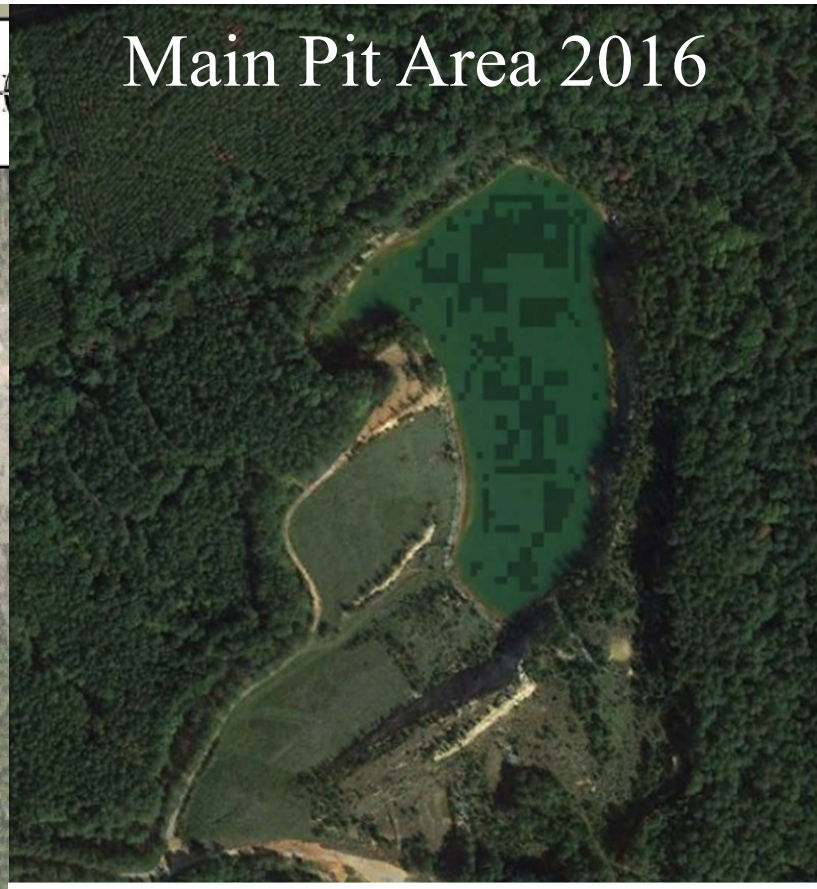




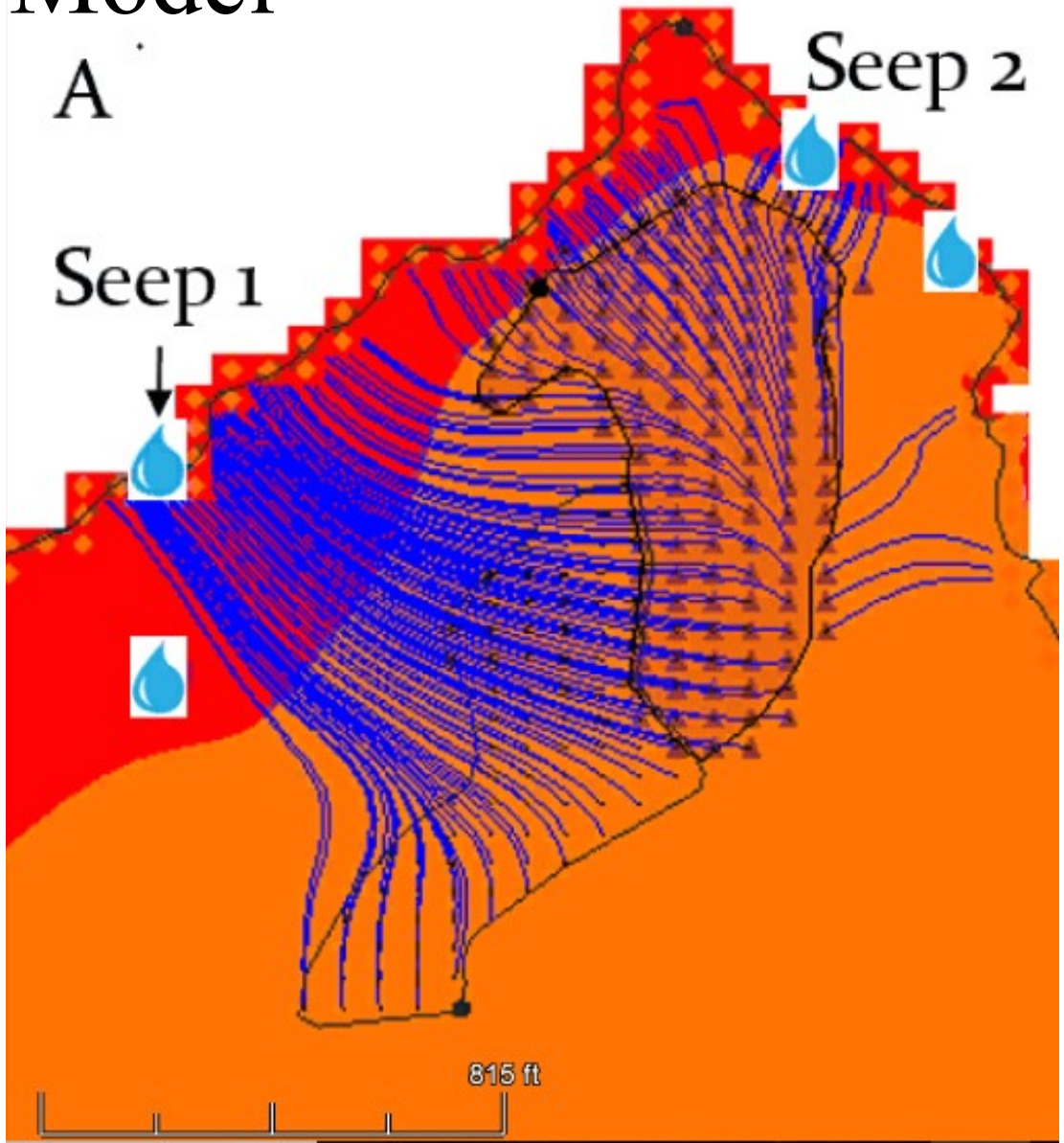
Area 1 - Contrast image of measured vs. theoretical magnetic field as a result of signature current flow.

Groundwater Flow Path

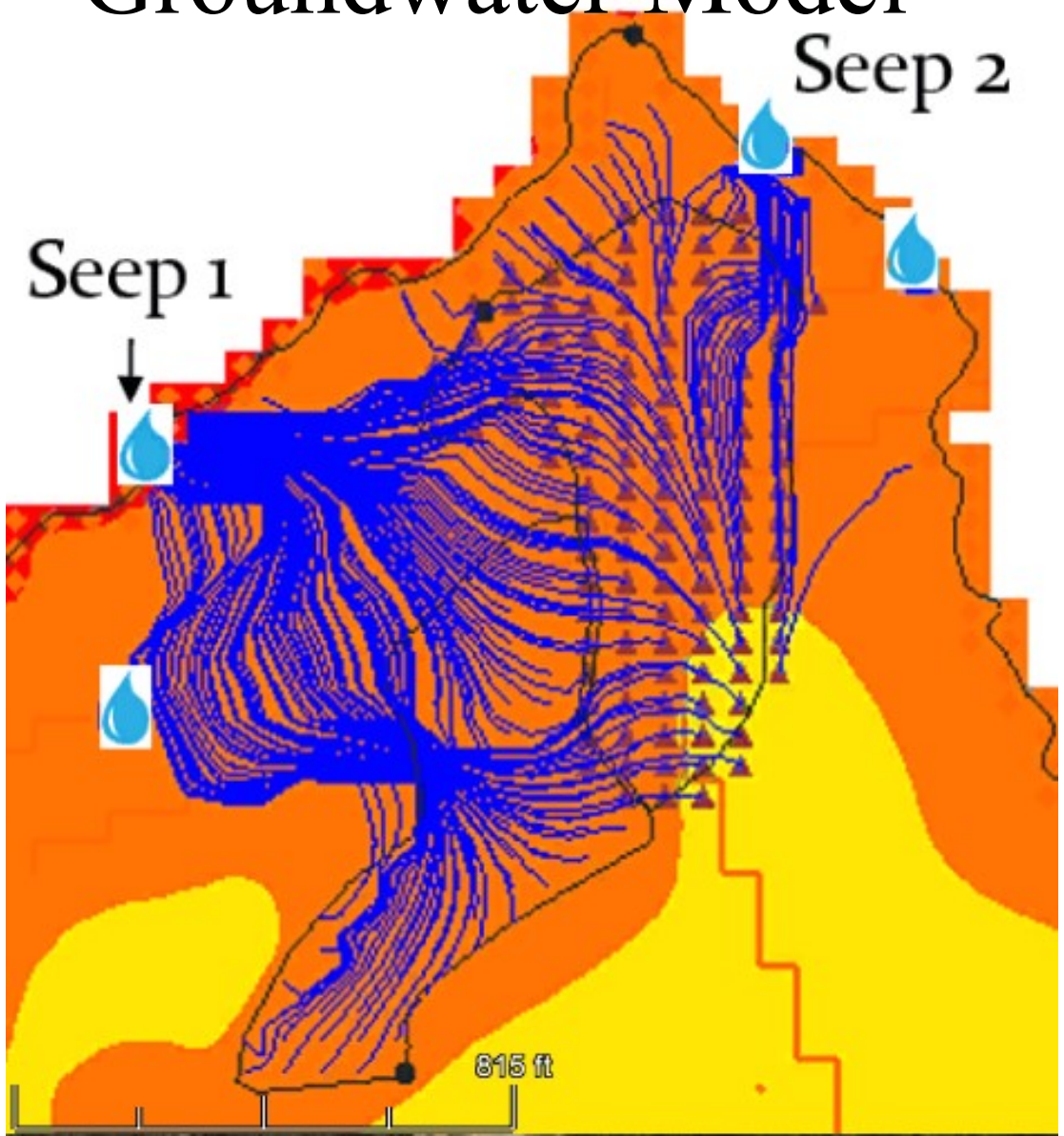




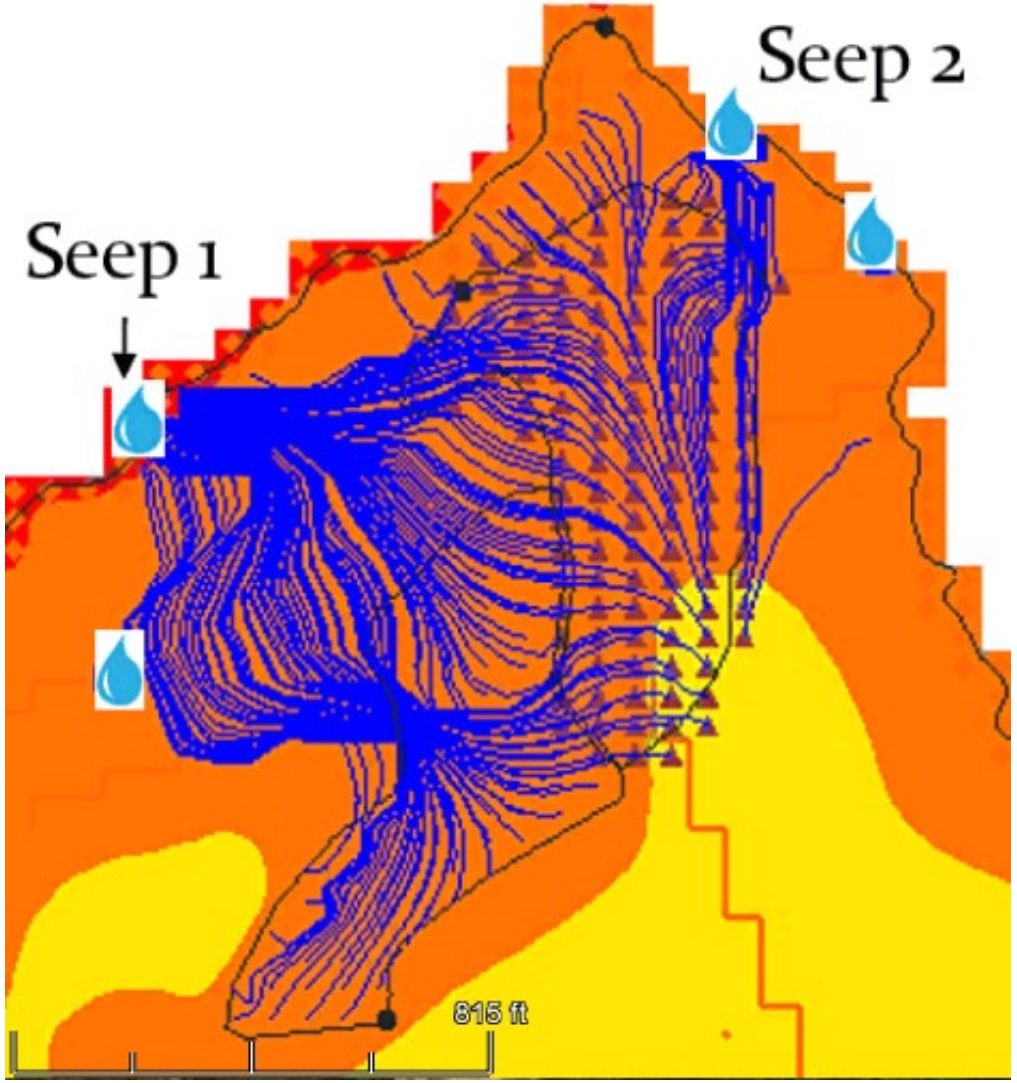
Conventional Groundwater Model



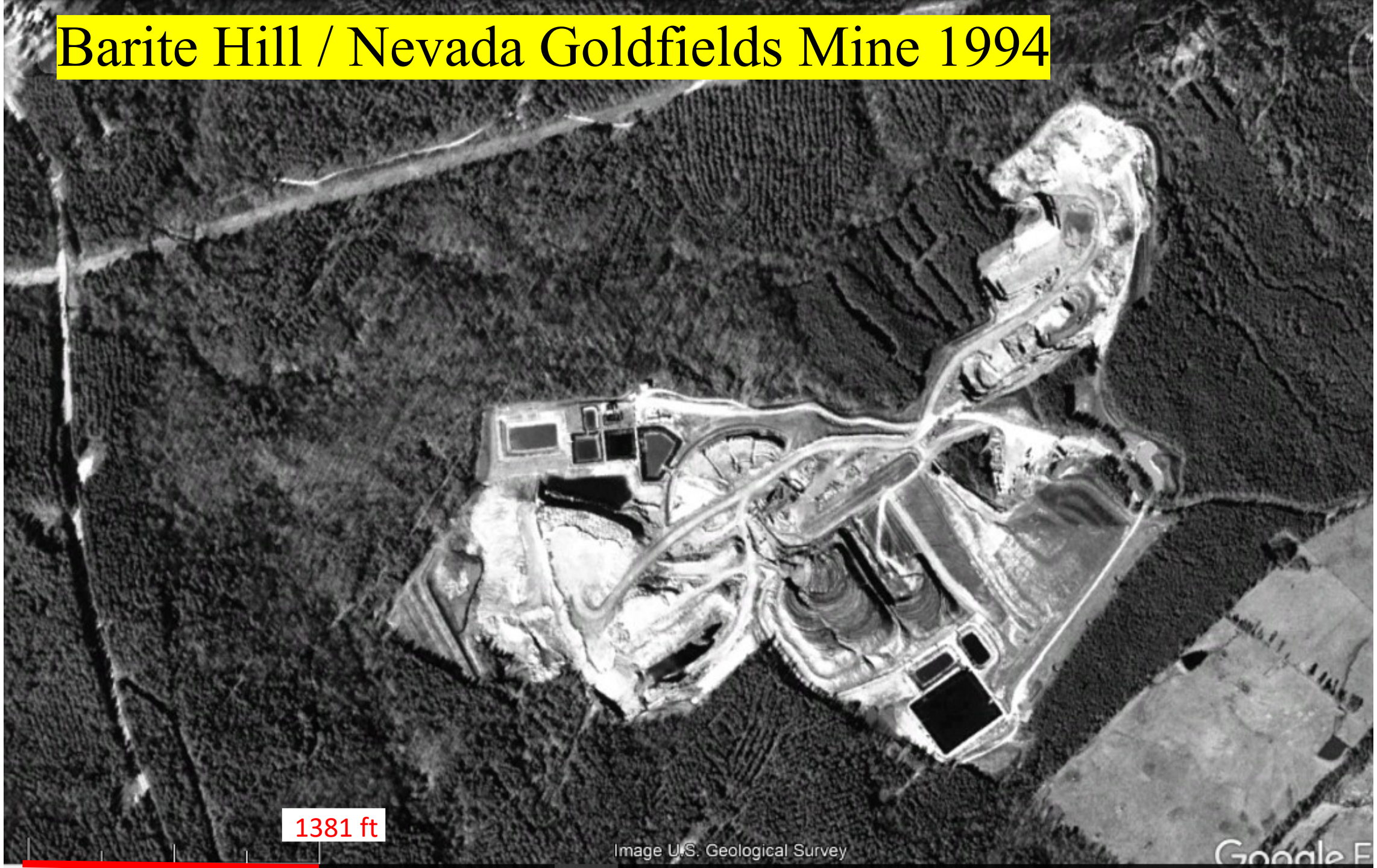
Willowstick Enhanced Groundwater Model



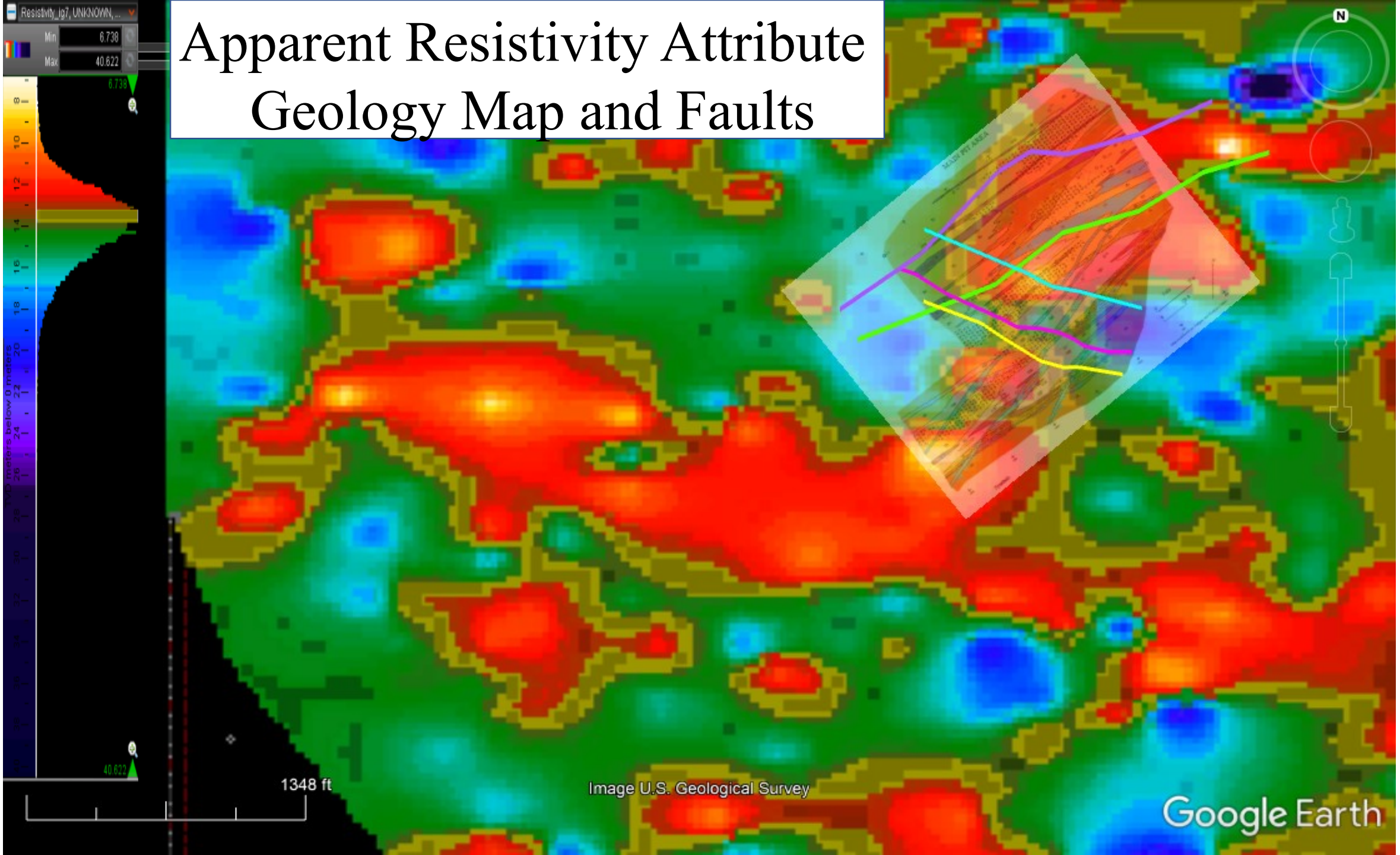
Willowstick Flow Path Enhanced Model

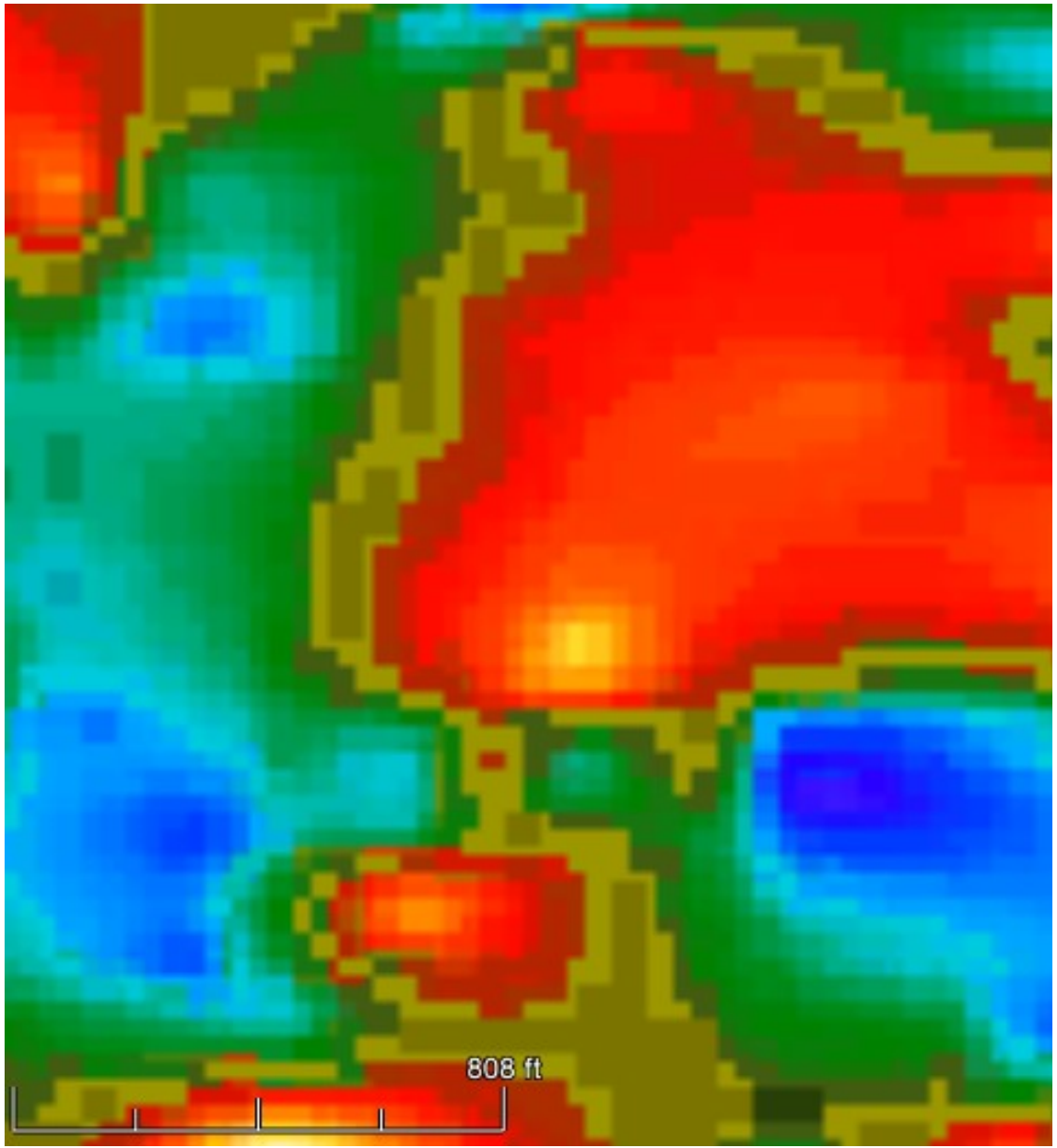


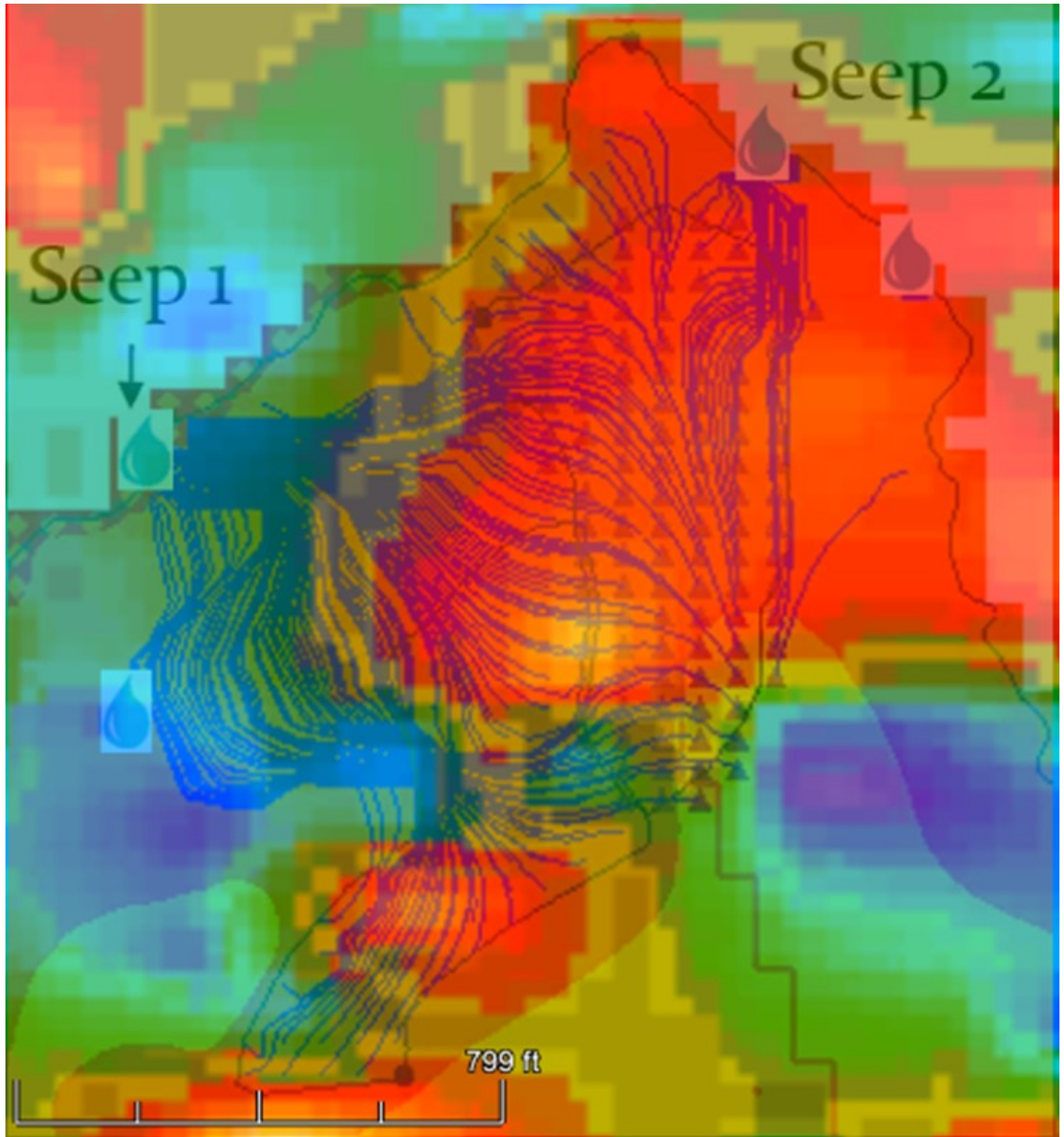
Barite Hill / Nevada Goldfields Mine 1994

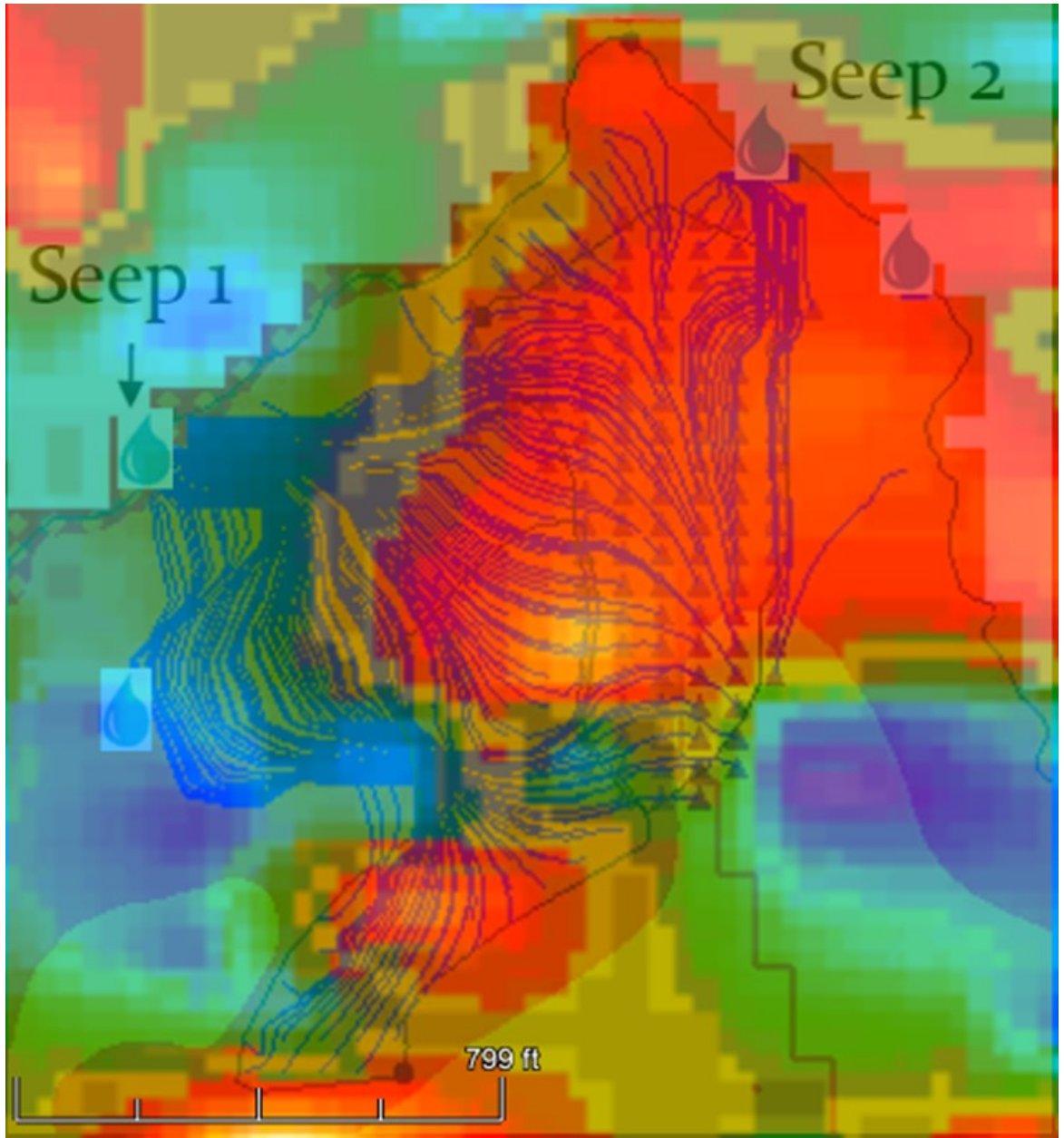


Apparent Resistivity Attribute Geology Map and Faults




808 ft


Seep 2
Seep 1
799 ft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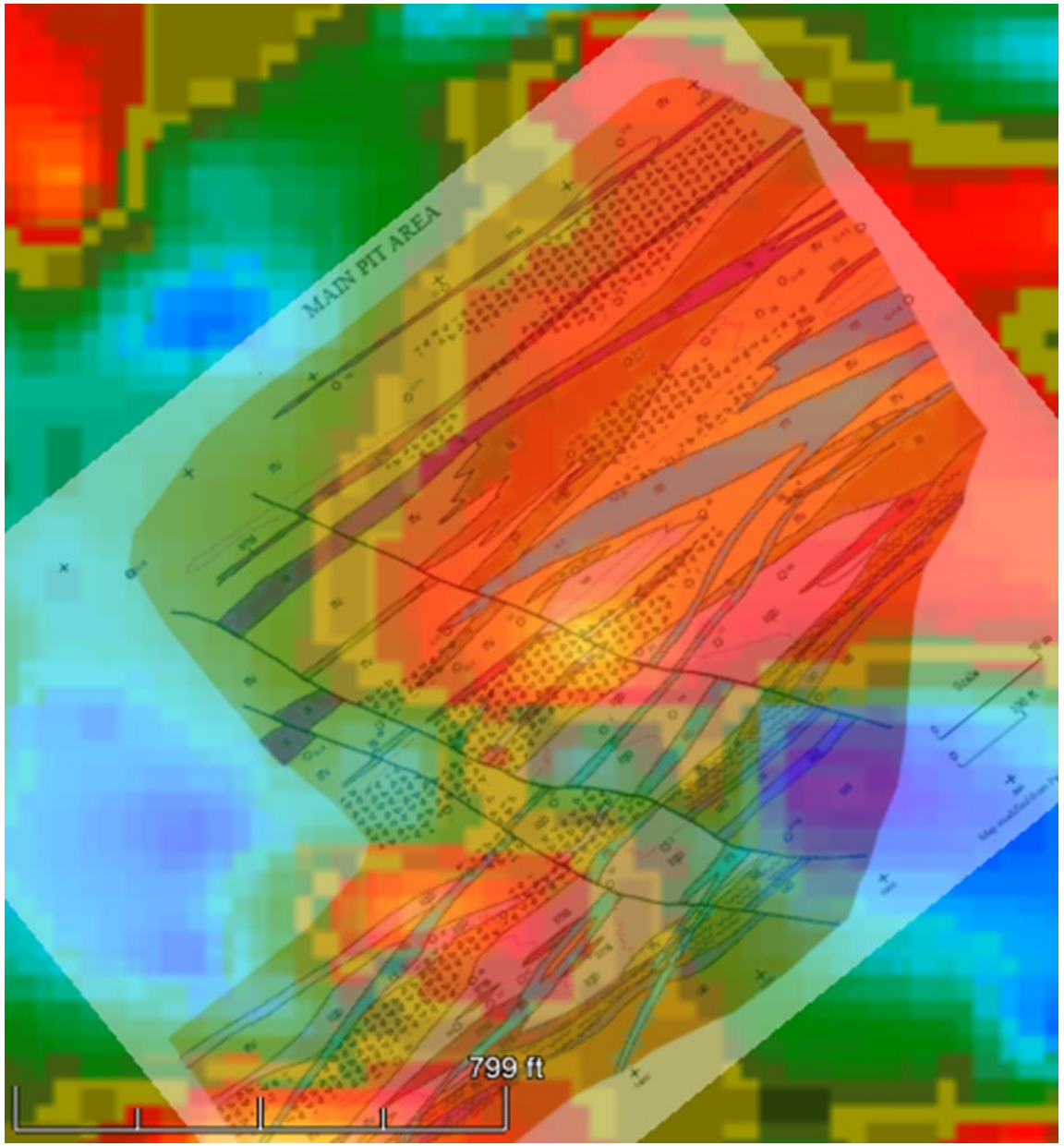
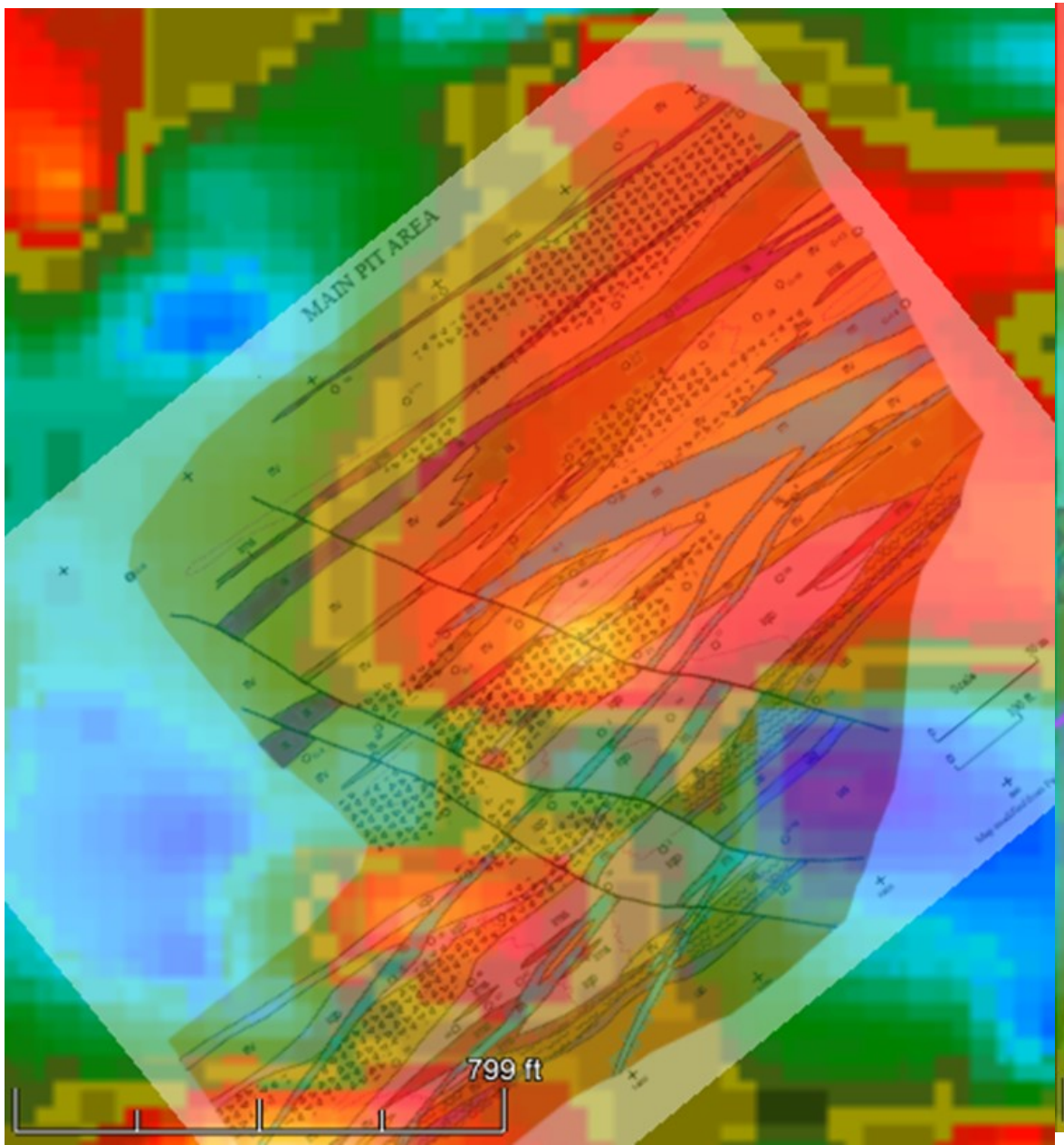
Seep 1
799 ft


MAIN PIT AREA
799 ft


MAIN PIT AREA
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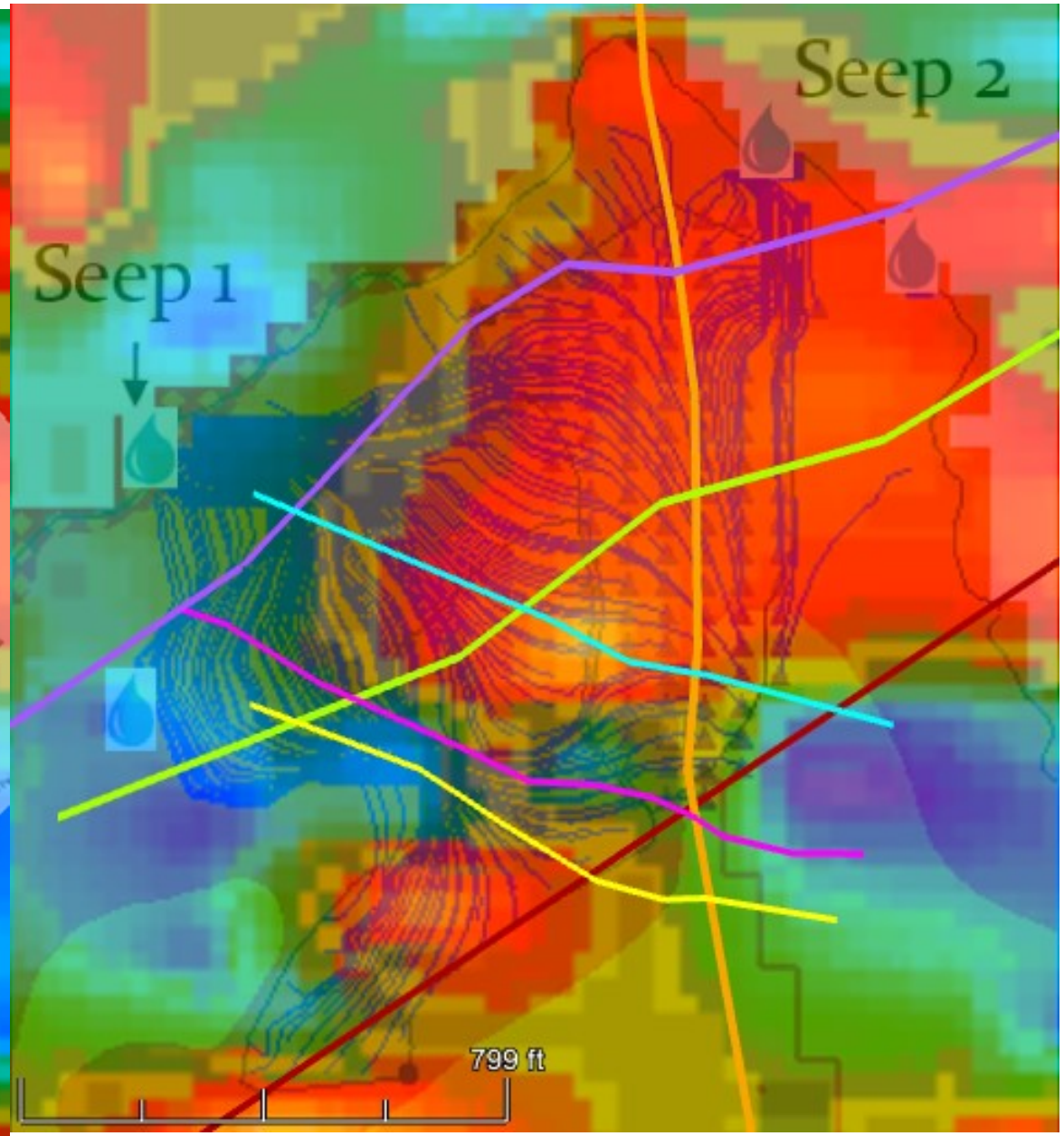
Seep 1
Seep 2
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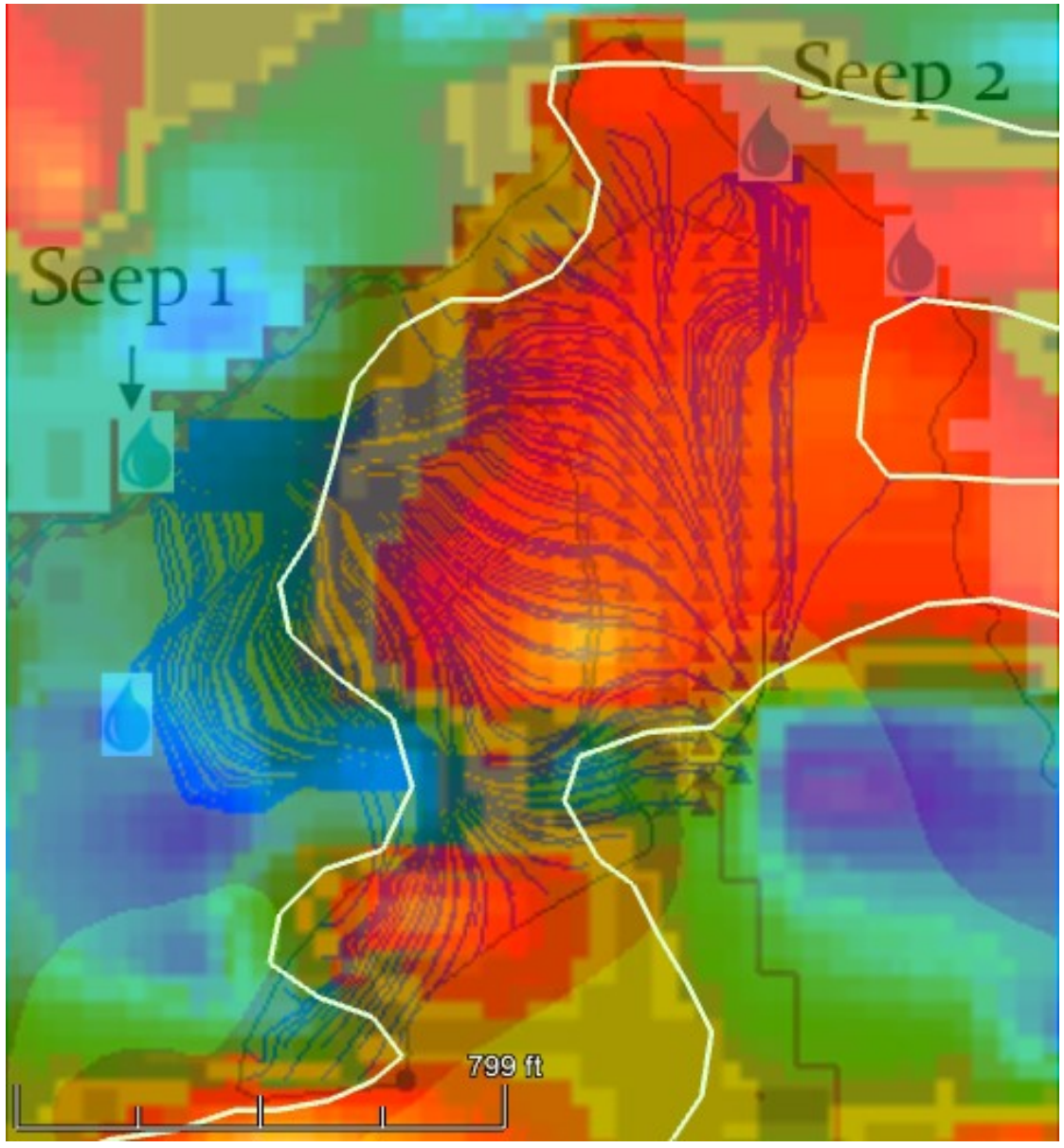
Seep 2
Seep 1
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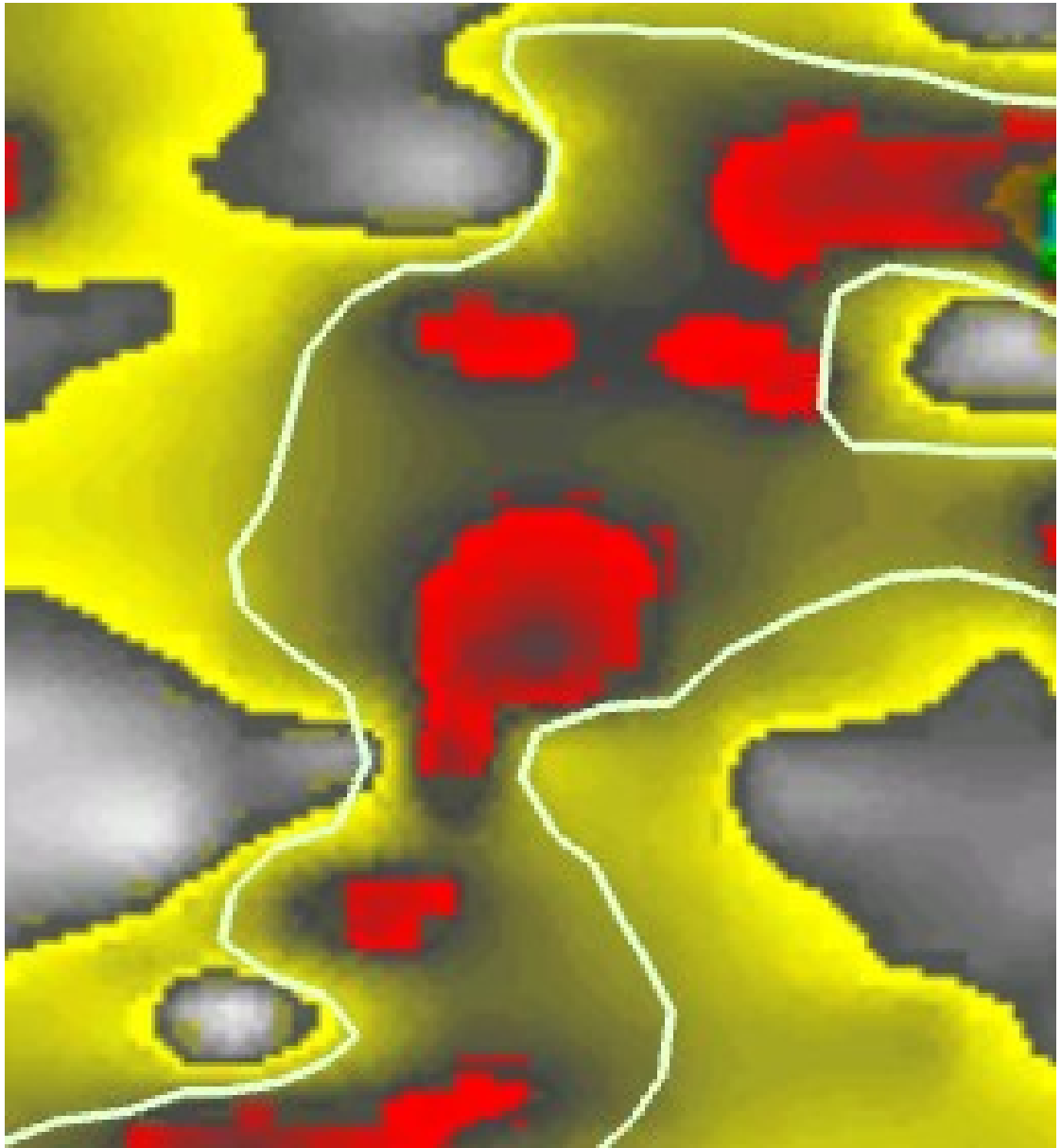

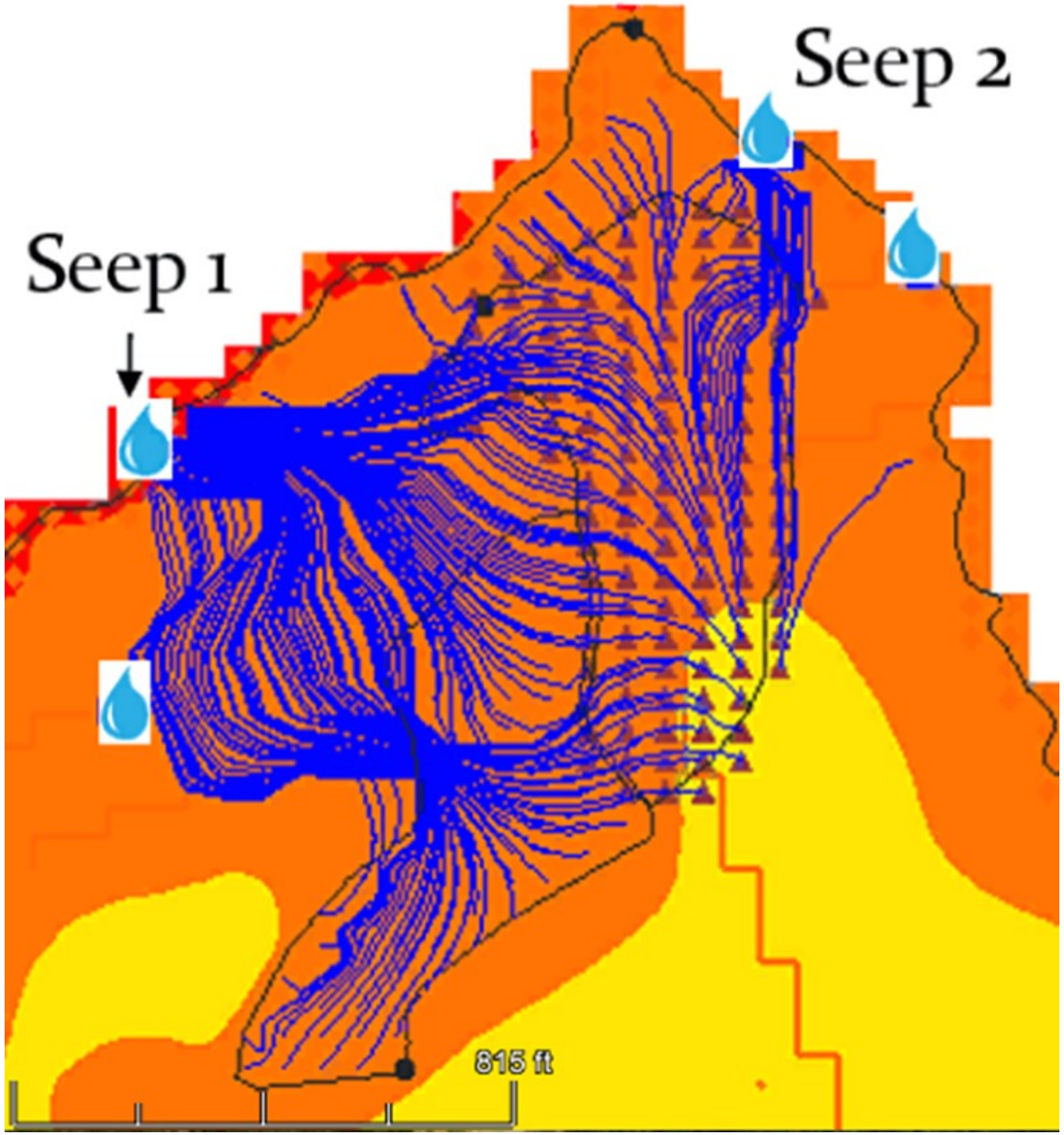
Seep 2
Seep 1
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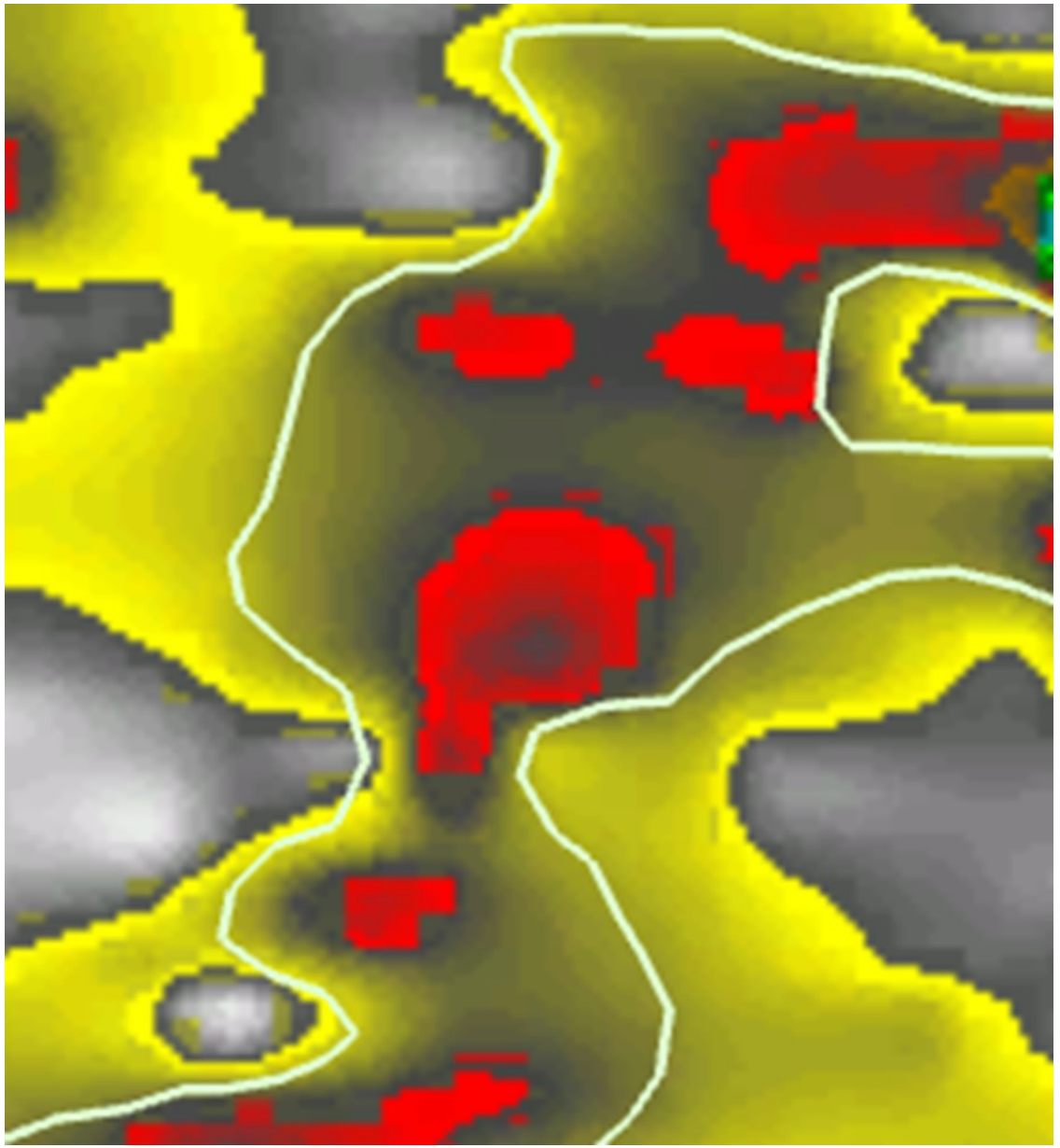

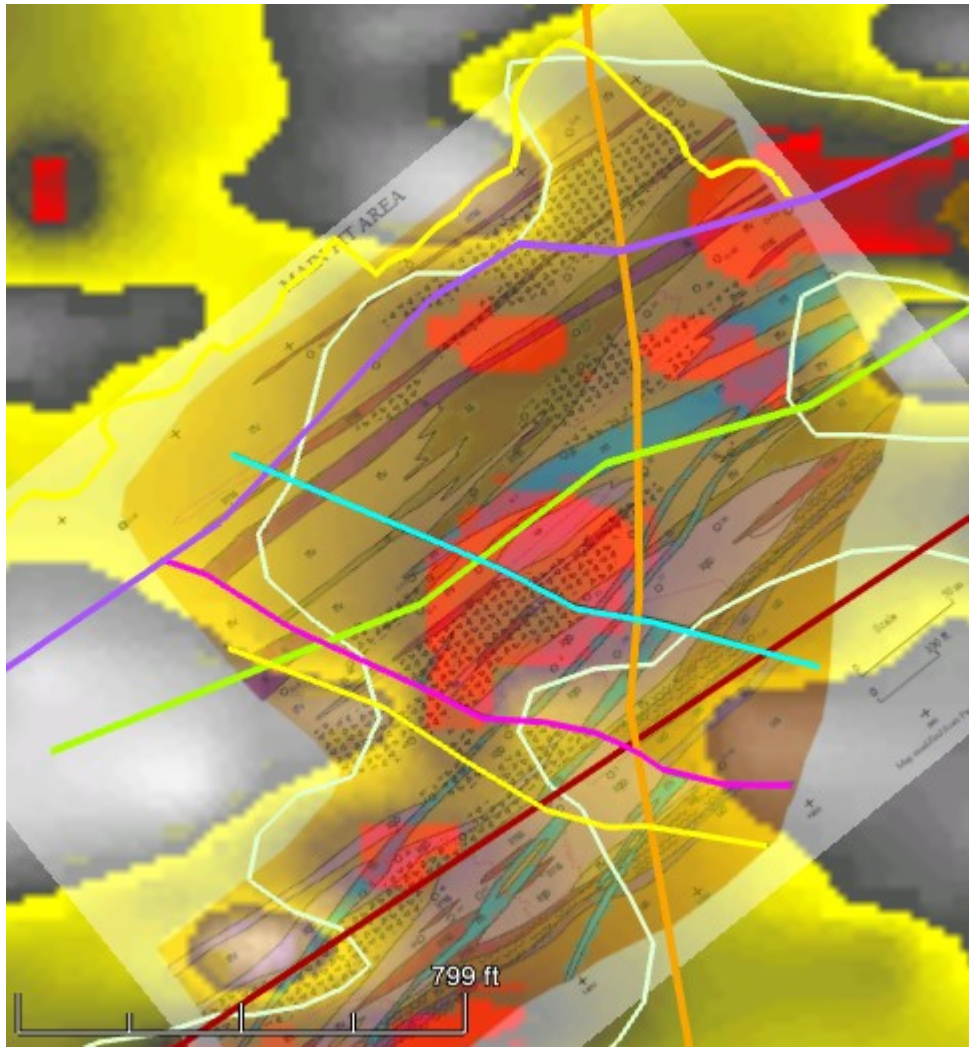
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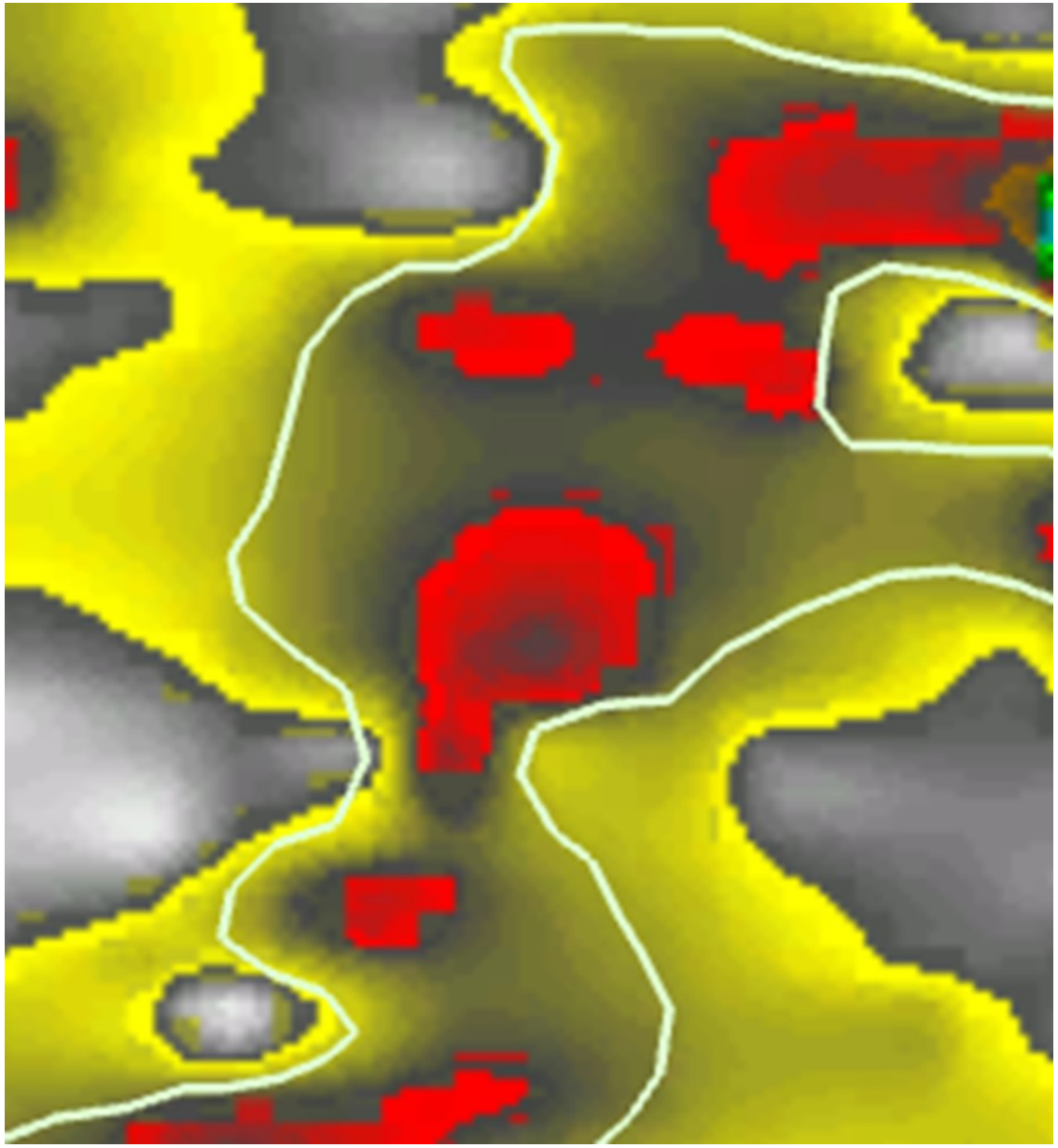


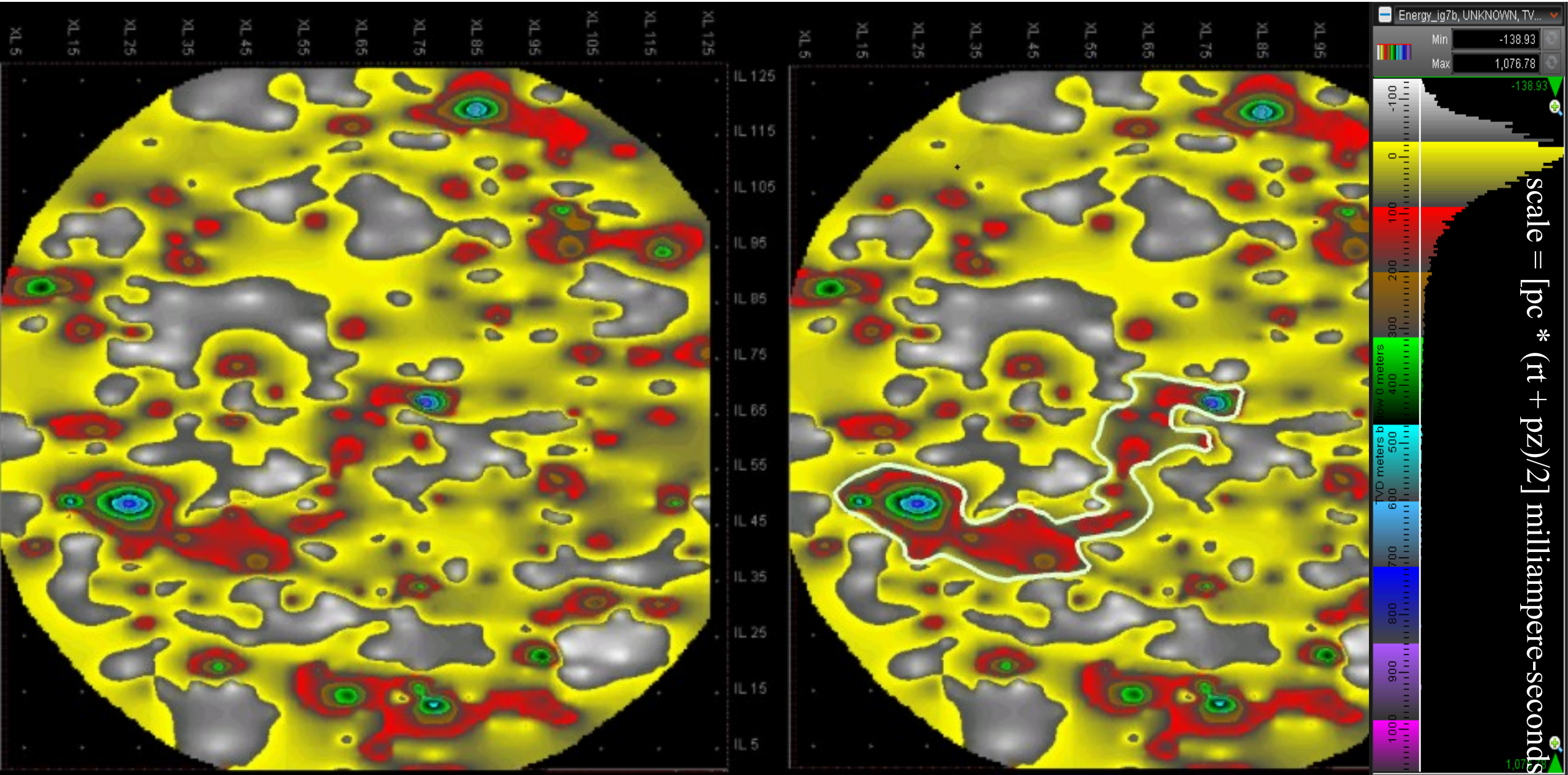
Lightning Attribute

"Energy"

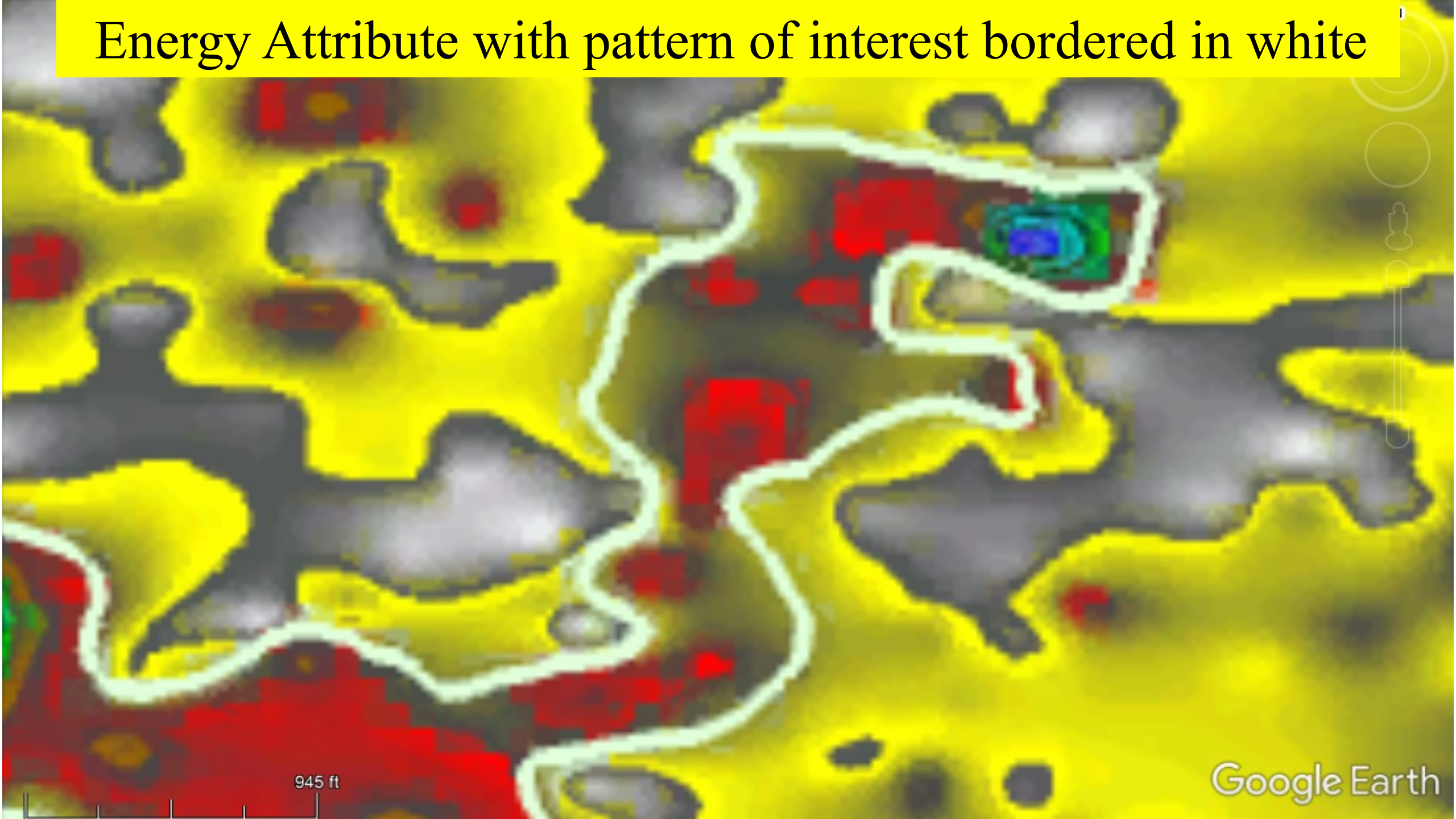
The area of a triangle with base "Total Wavelet Time" and height "Peak Current" measurements.

Color Bar Scale: ([pc * (rt + pz)/2] milliampere-seconds).

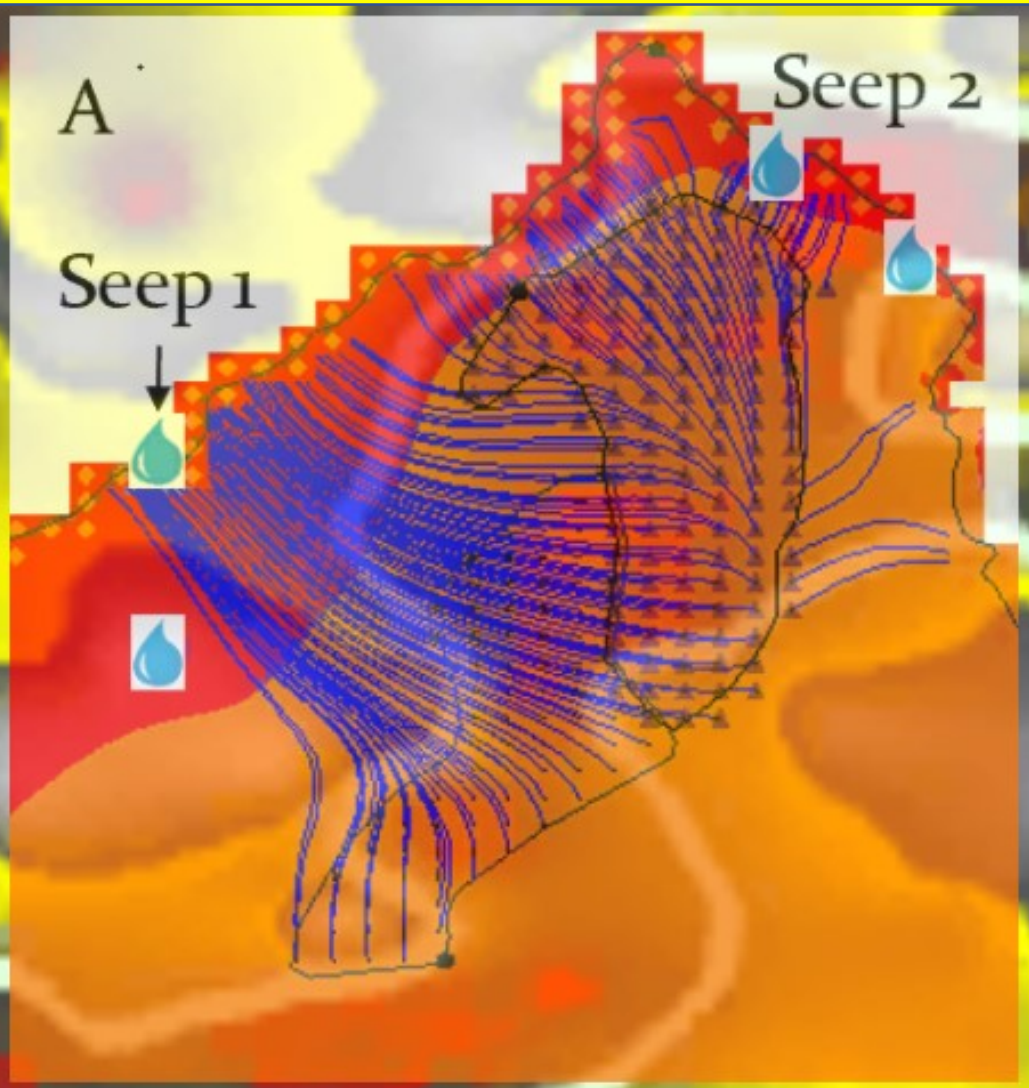
Energy Attribute Map:



Energy Attribute with pattern of interest bordered in white



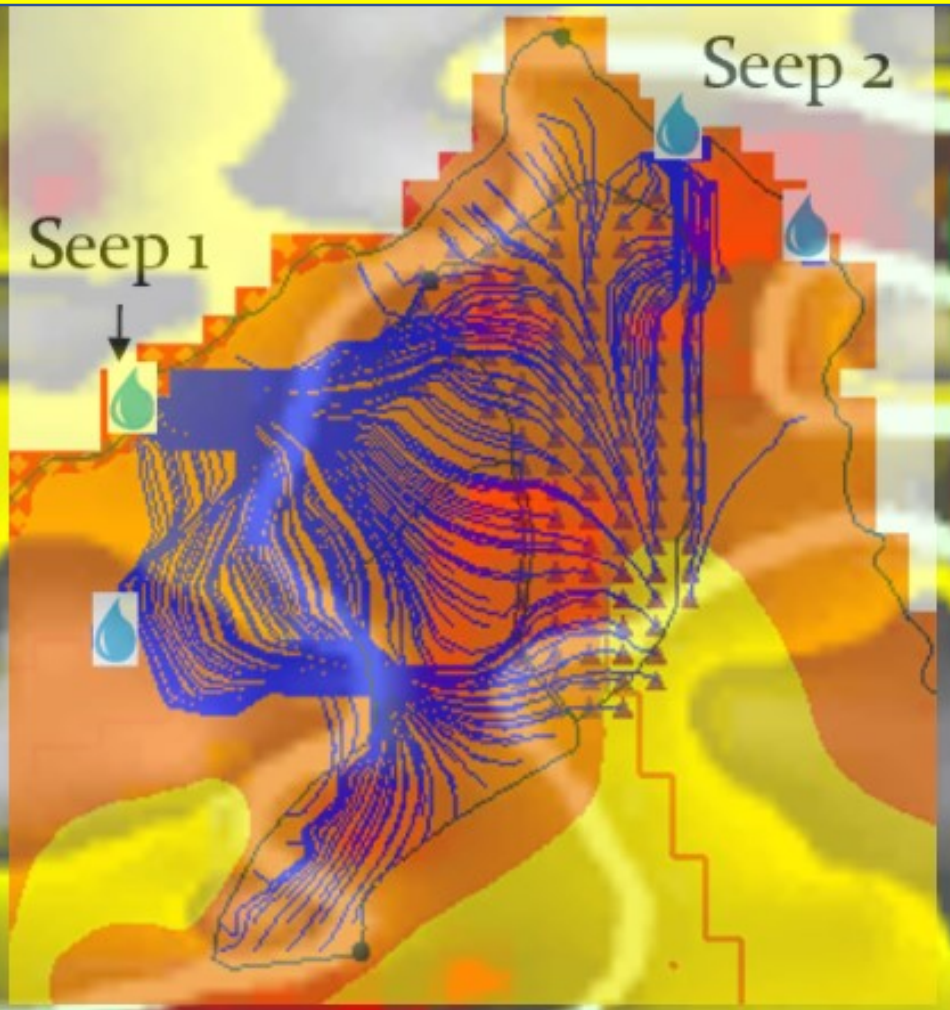
Conventional Groundwater Model



945 ft

Google Earth

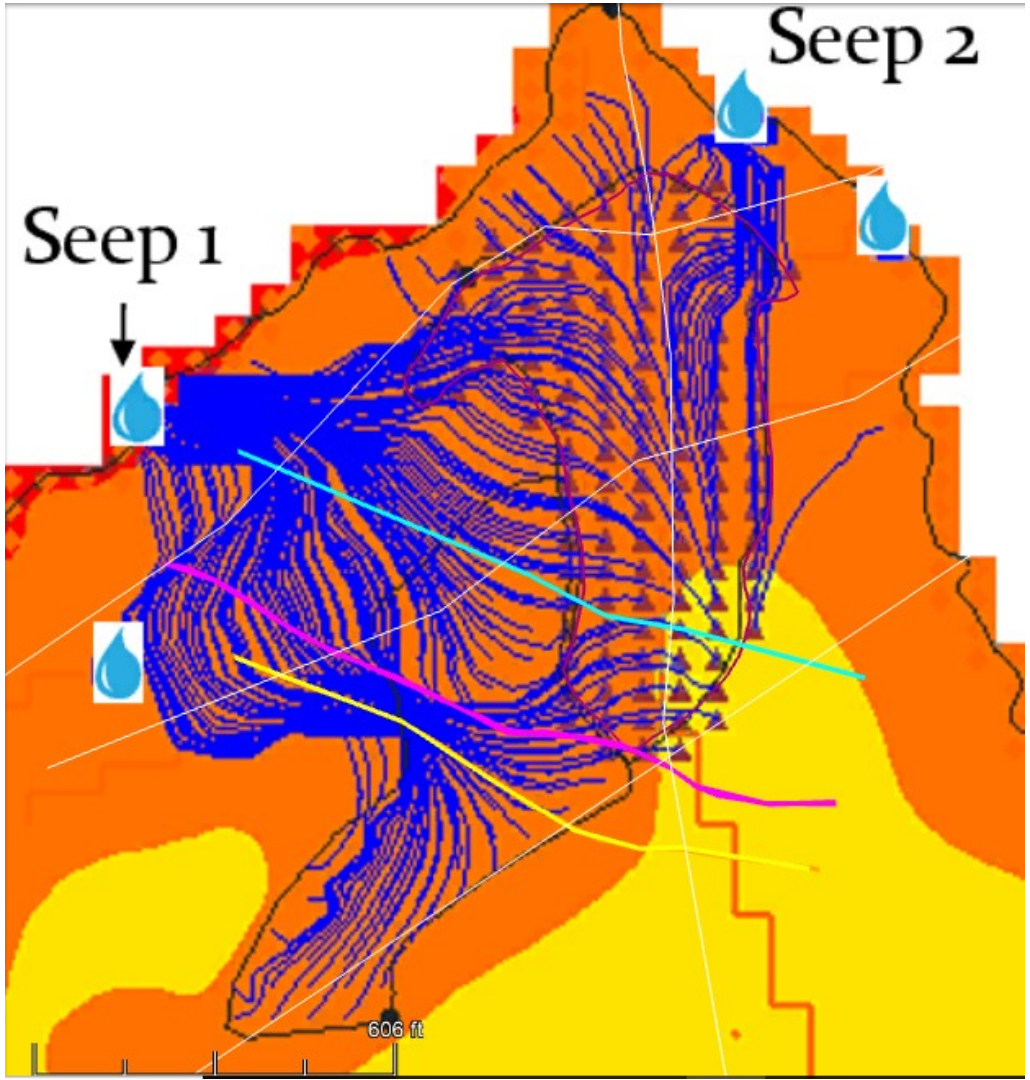
Willowstick Data Enhanced Groundwater Model

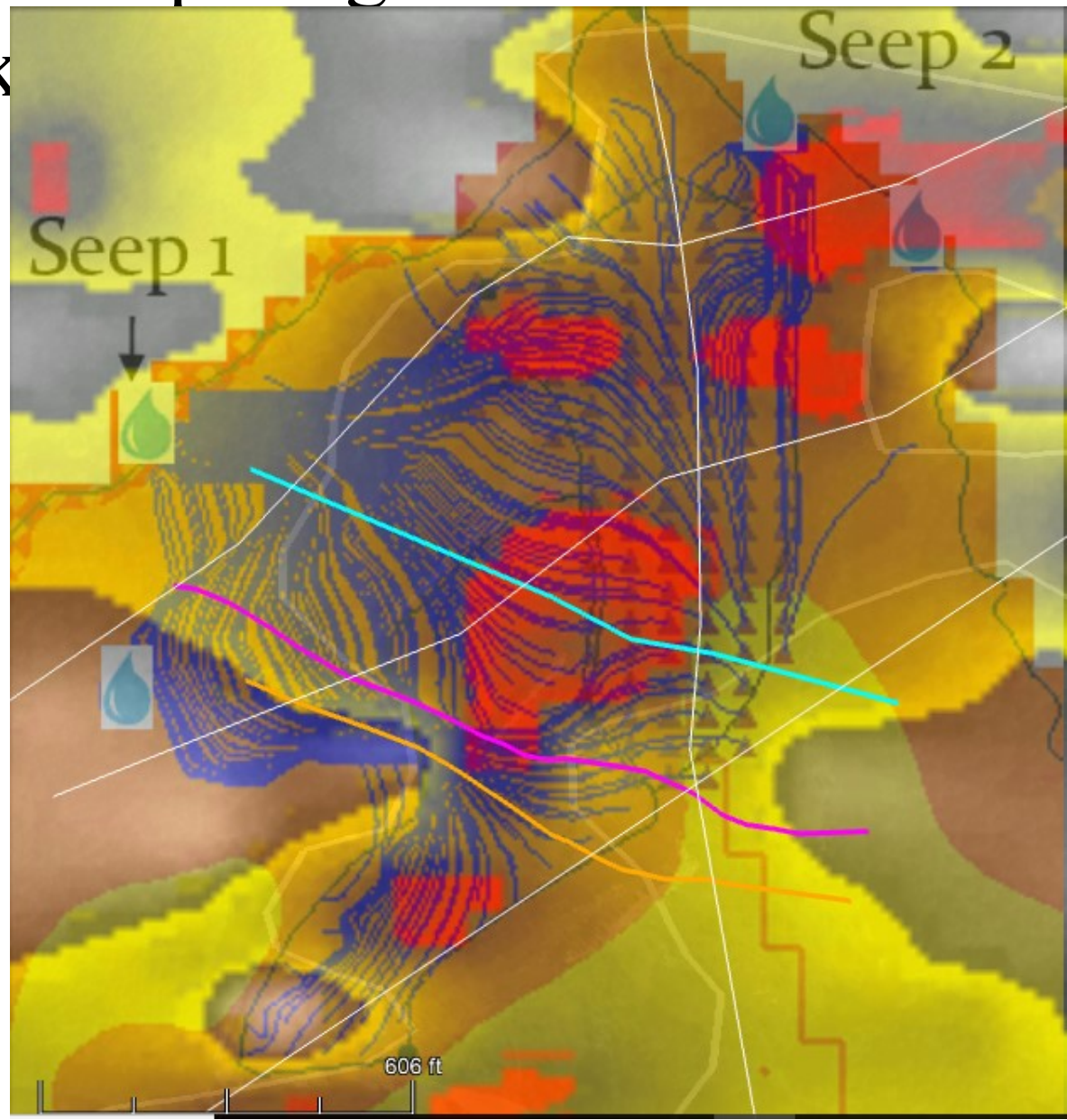


945 ft

Google Earth

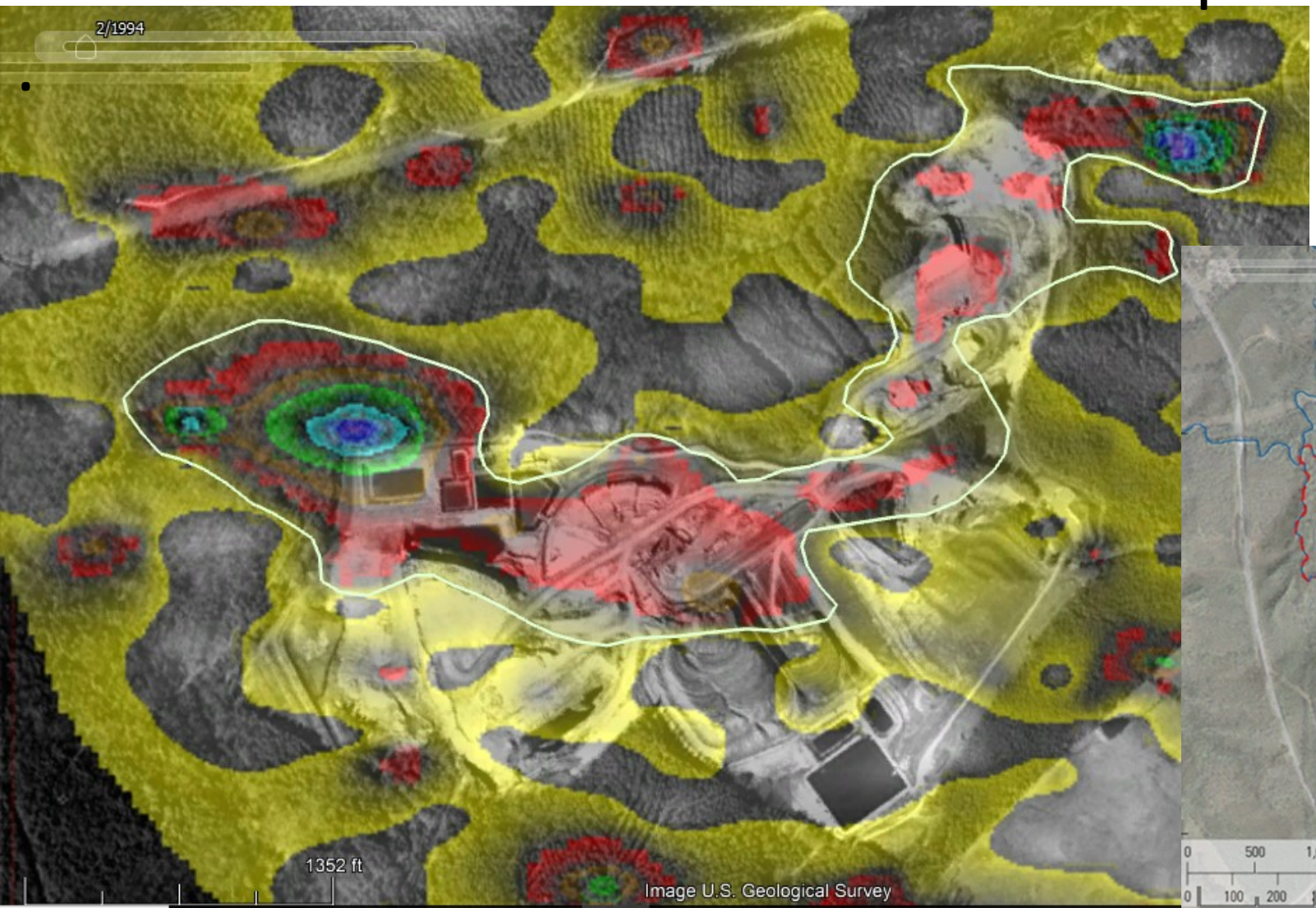
Energy Attribute data / Willowstick Enhanced Groundwater Model with Seeps / Faults - USGS blue/pink/gold Faults and Shear Zone- Willowstick

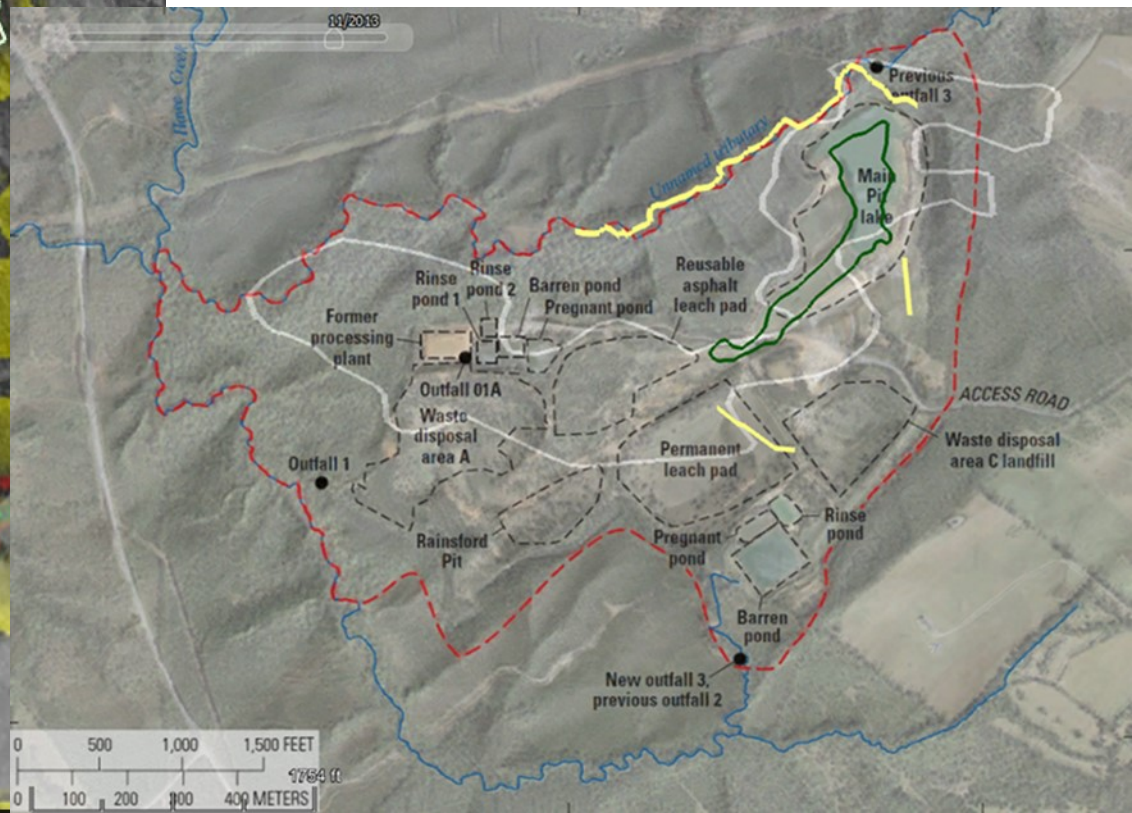


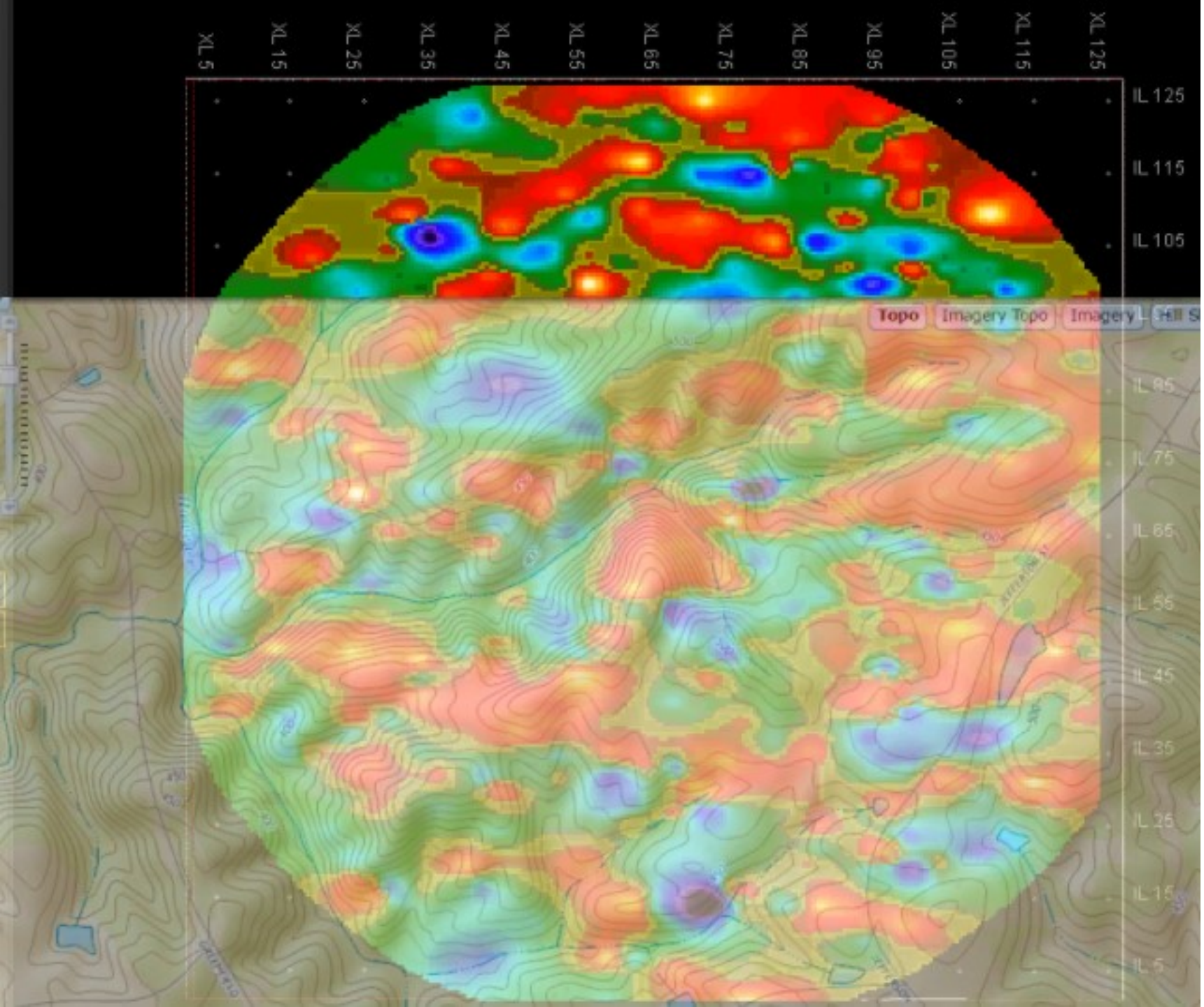


Energy Pattern - highlighted white outline - shows potentially larger and more direct contribution of contaminated ground water to Hawe Creek than earlier suspected *or* an undiscovered

- Gold Mine





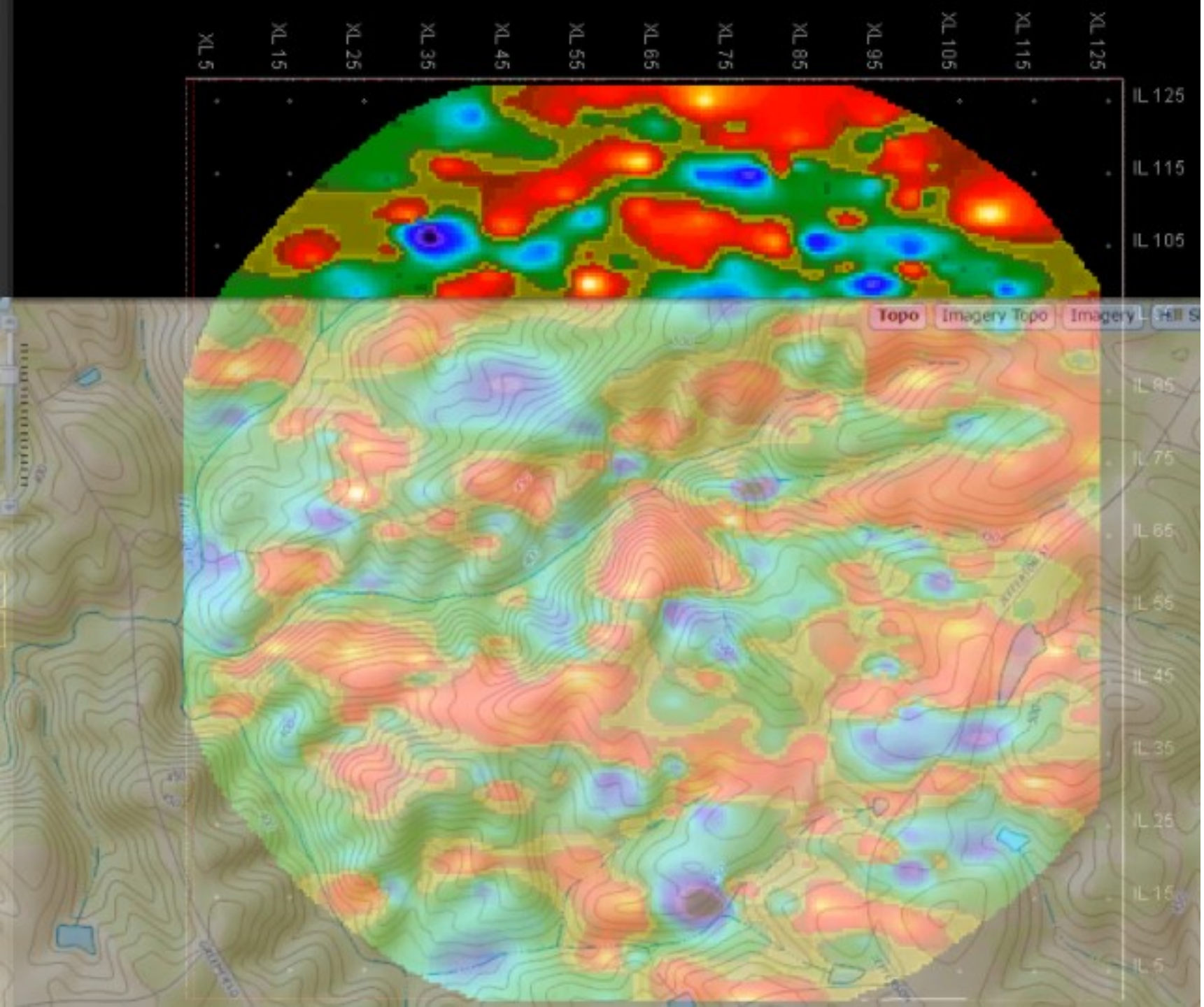


What are you looking for?

Ore bodies and contaminated ground water both have low conductivity.
Red = Low Apparent Resistivity

Conversely, fresh water has high Conductivity.
Blue = High Apparent Resistivity

Sub-regional Apparent Resistivity on a large scale – square miles



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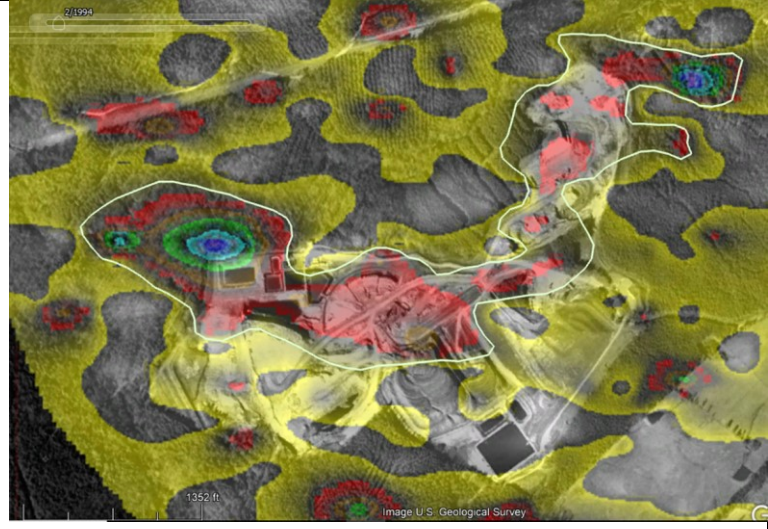
APPLICATIONS of LIGHTNING ANALYSIS

Environmental - Contamination Plumes in Groundwater
- Possible Groundwater Flow Paths

Fresh Water Aquifer / Groundwater Mapping

Mineral Exploration – Copper

Thanks for thinking with us!



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www. dynamicmeasurement.com/TAMU

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