Multimethod Geophysical Characterization of Fault Systems for Environmental Planning

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Talk Outline

- Background
- Regional Geology
- Previous Work
- Geophysical Scope
- Results
- Questions

Background

- Historic release of petroleum hydrocarbons from leaking underground storage tank system at a former convenience store/gas station
- UST Pit reportedly straddled a mapped geologic fault zone
- EnSafe conducts initial investigation, establish preliminary conceptual site model
- Traditional boring and sampling techniques yield significant data gaps
- Conceptual site model needs refined for effective corrective action remediation

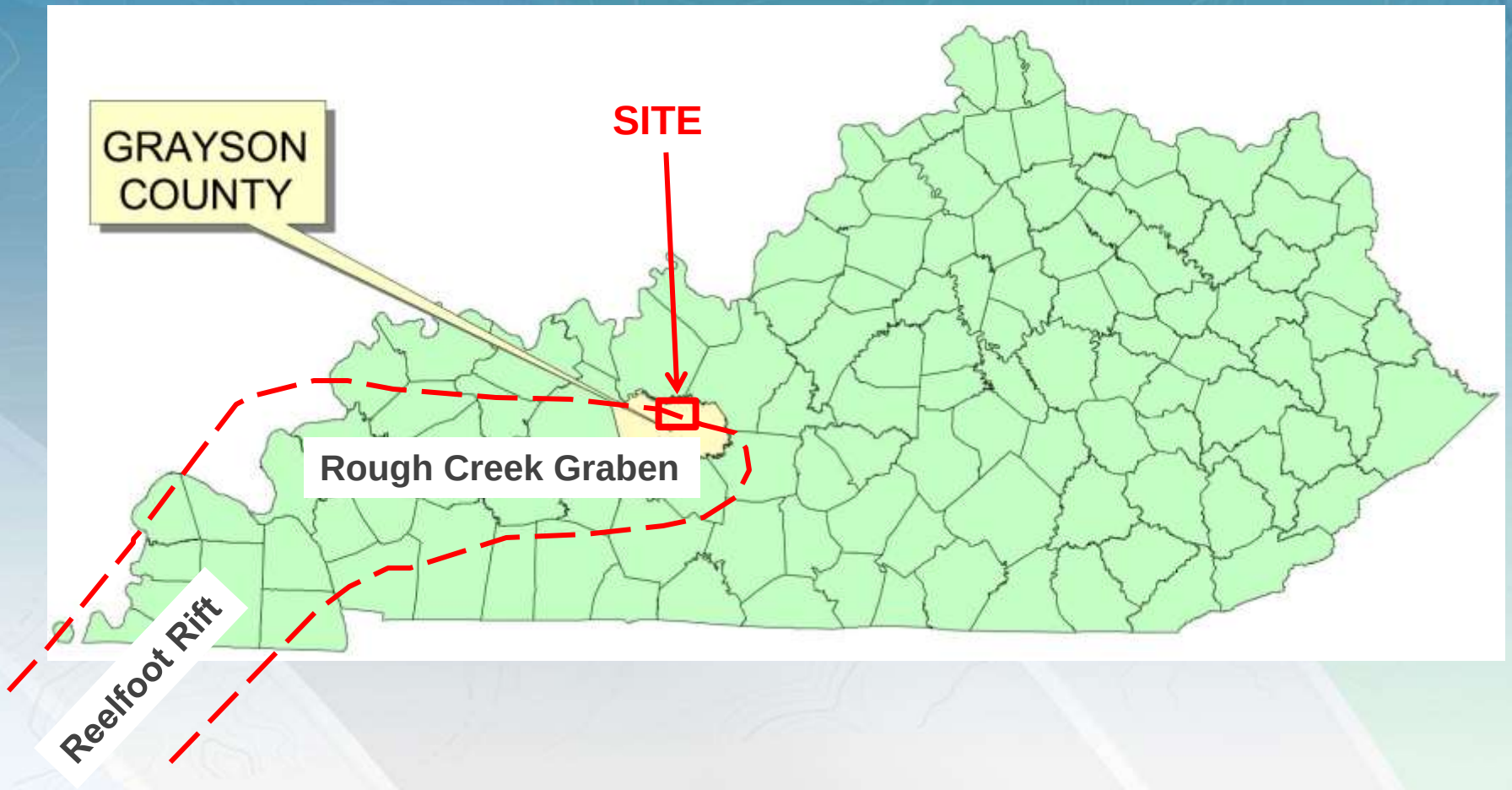
Regional Geology

- Mississippian (or Pennyroyal) Plateau Region –

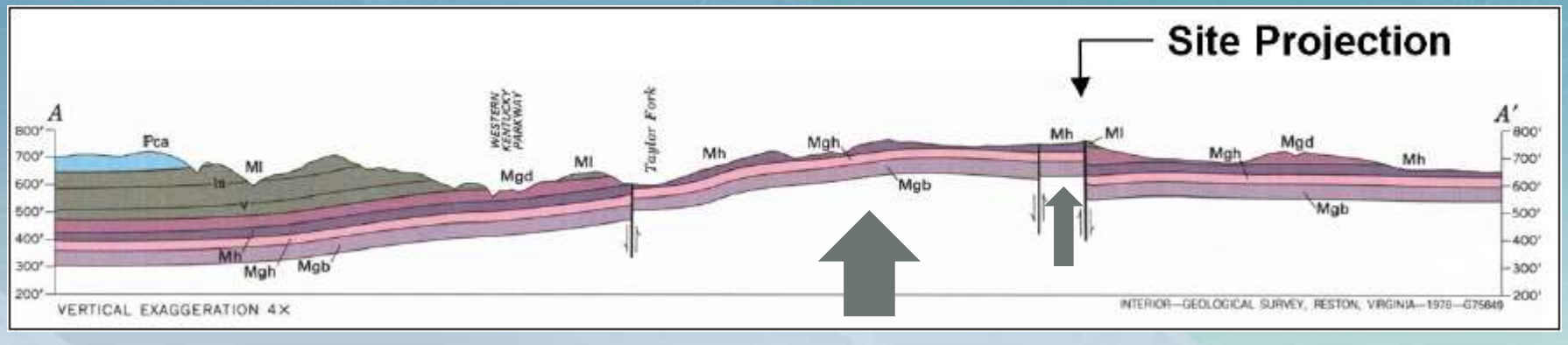
  Hilly uplands, SS ridges over LS, cut by many normal faults

- Rough Creek Fault System (northern boundary of Rough Creek Graben) – three major tectonic episodes

  1. Normal faulting during the Precambrian (Reelfoot Rift),
  2. Reverse faulting in late Paleozoic, and
  3. Normal faulting in Mesazoic.



Regional Geologic Context

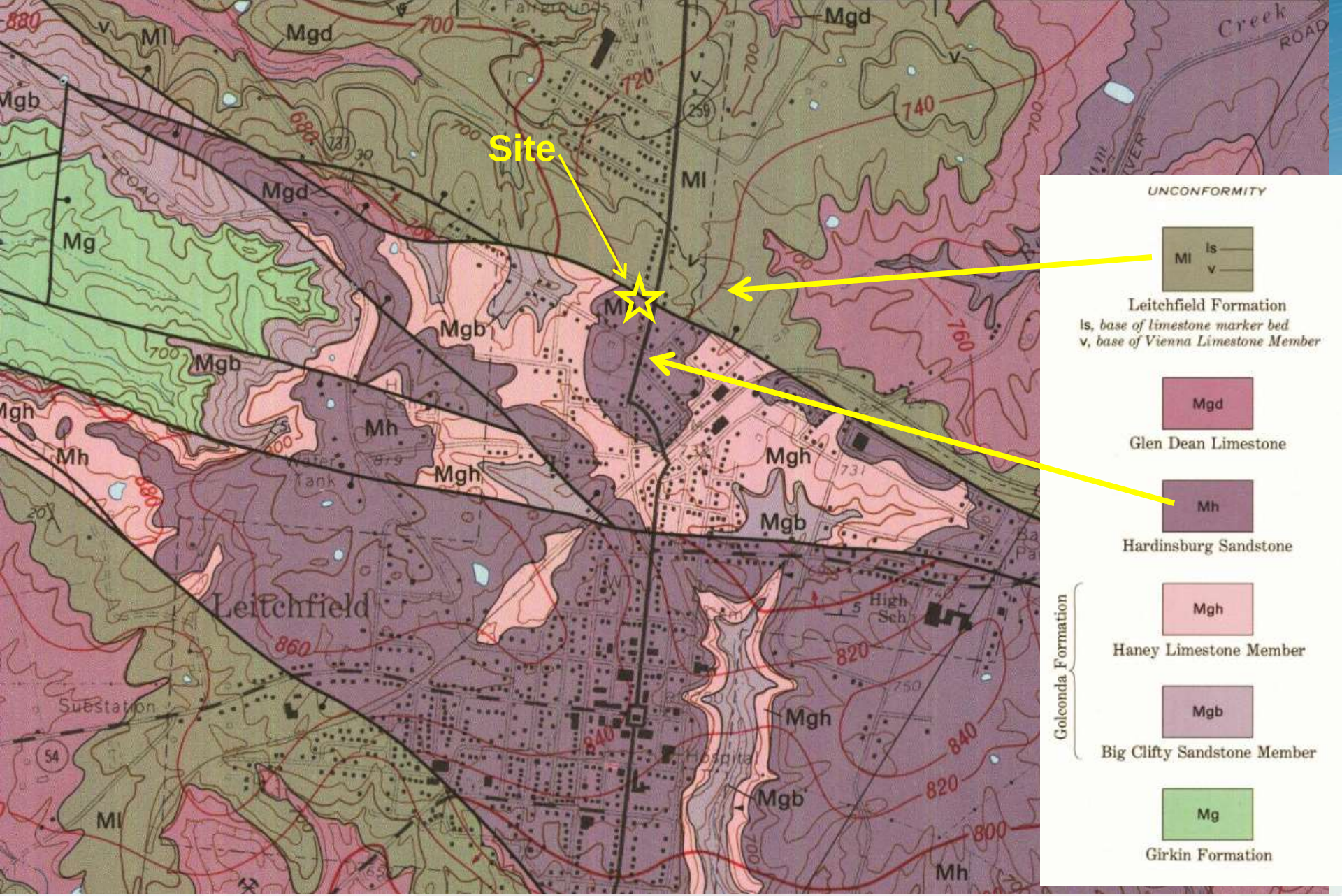


Geologic Cross-Section from Leitchfield 7.5’ Quadrangle map (from Gildersleeve, 1978).

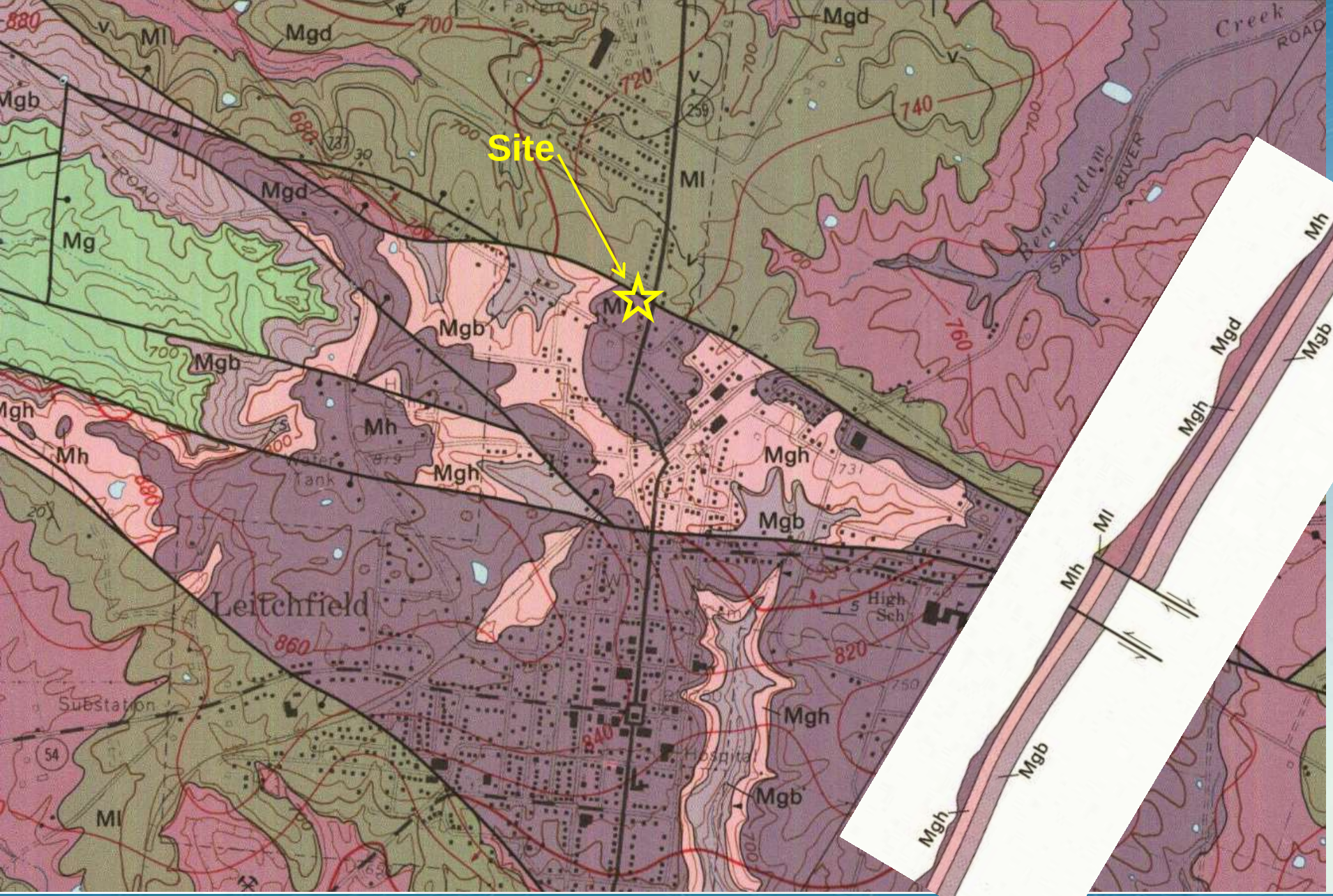
Regional Geologic Context

Regional Geology

- Uplift of graben brought Late-Mississippian to surface
- Leitchfield Formation, Ml, on north side of fault
- Hardinsburg Sandstone, Mh, on south side.
- Haney Limestone member of Golconda Formation, Mgh, contact is mapped within a few hundred feet of site so Hardinsburg may be thin.
- *Tar sands* occur in Tar Spring, Hardinsburg, and Big Clifty
- Big Clifty is locally *asphaltic* near base

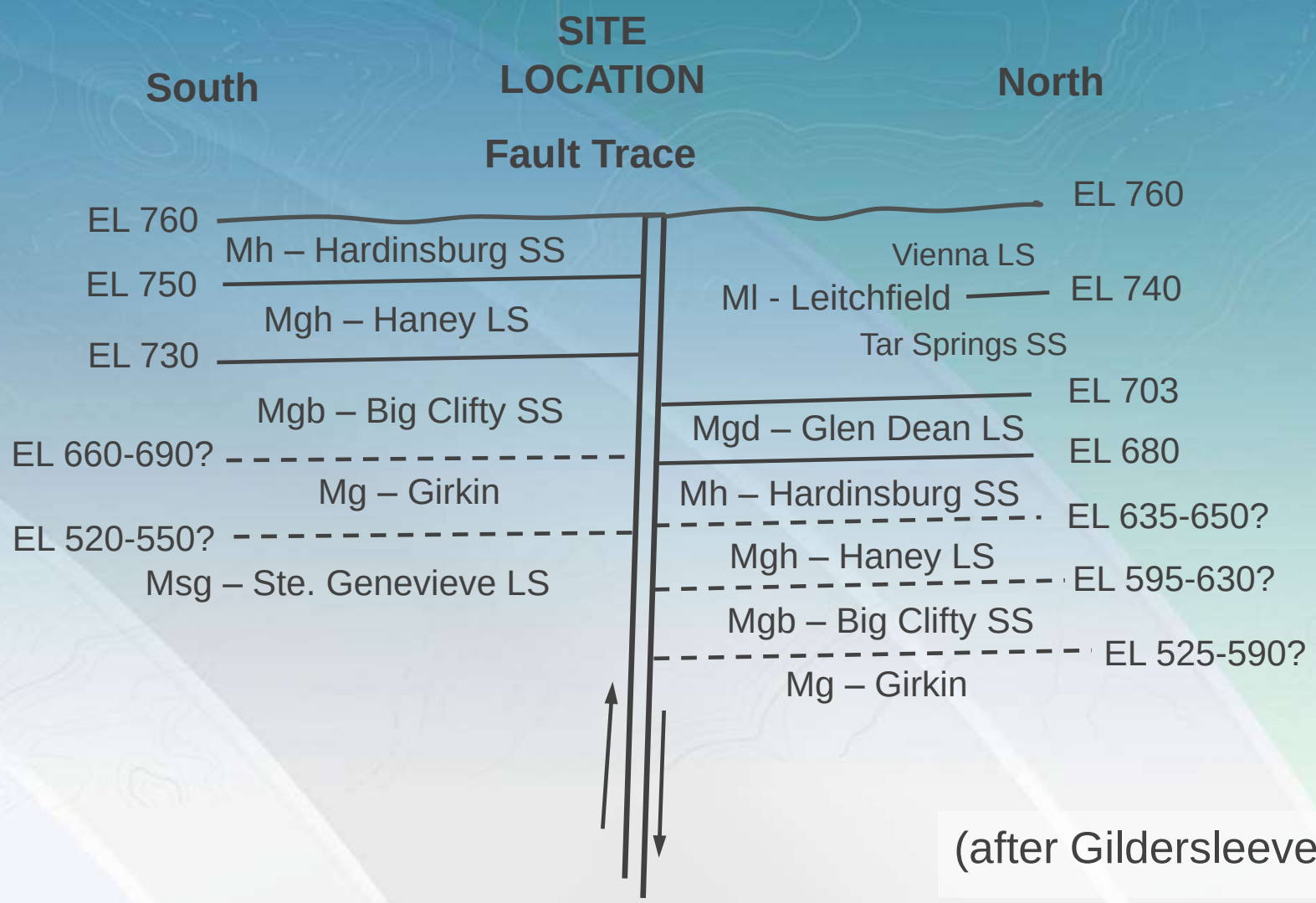


Regional Geologic Context



Regional Geologic Context

Expected Stratigraphy at the site

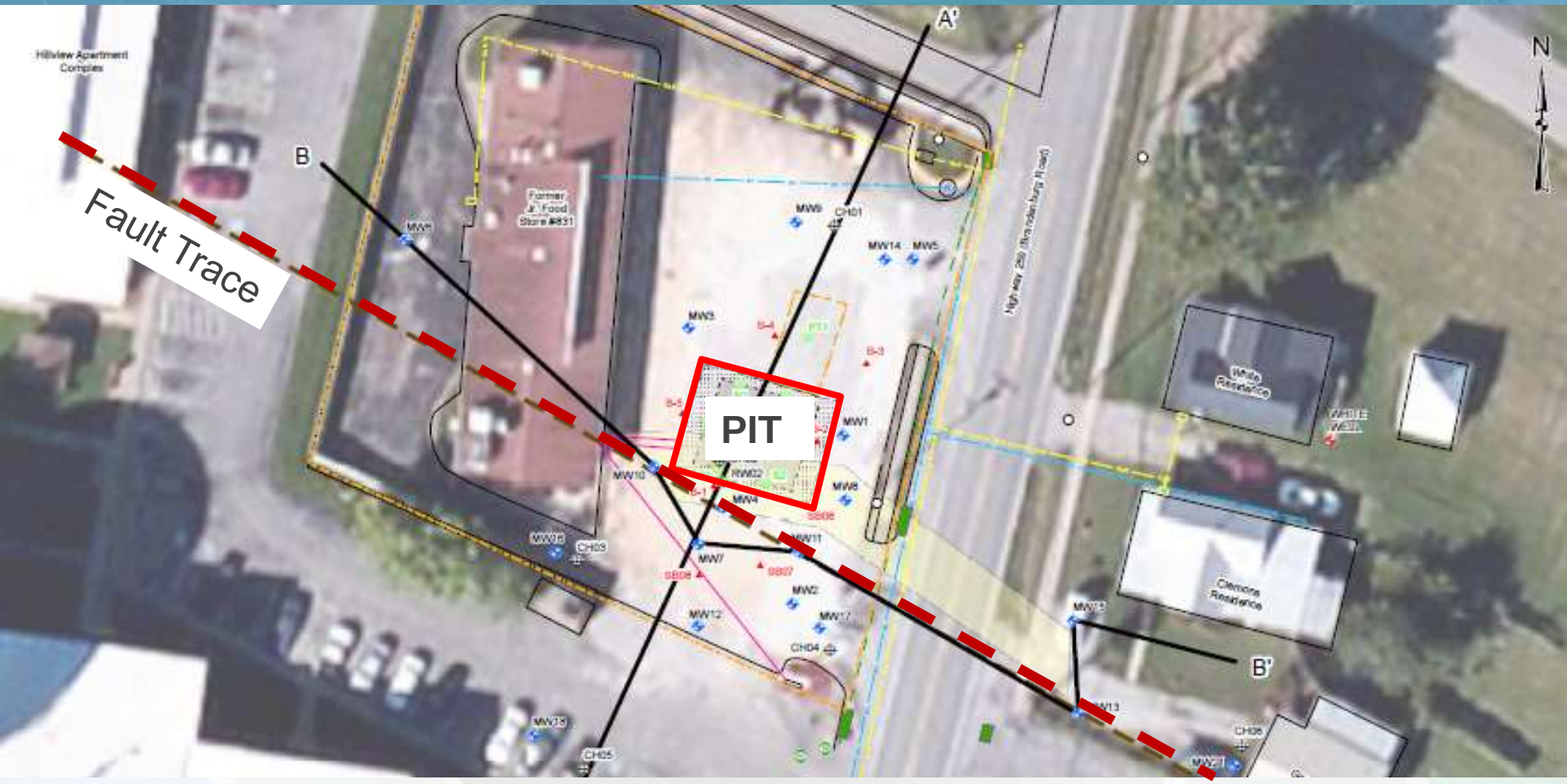


(after Gildersleeve, 1978)

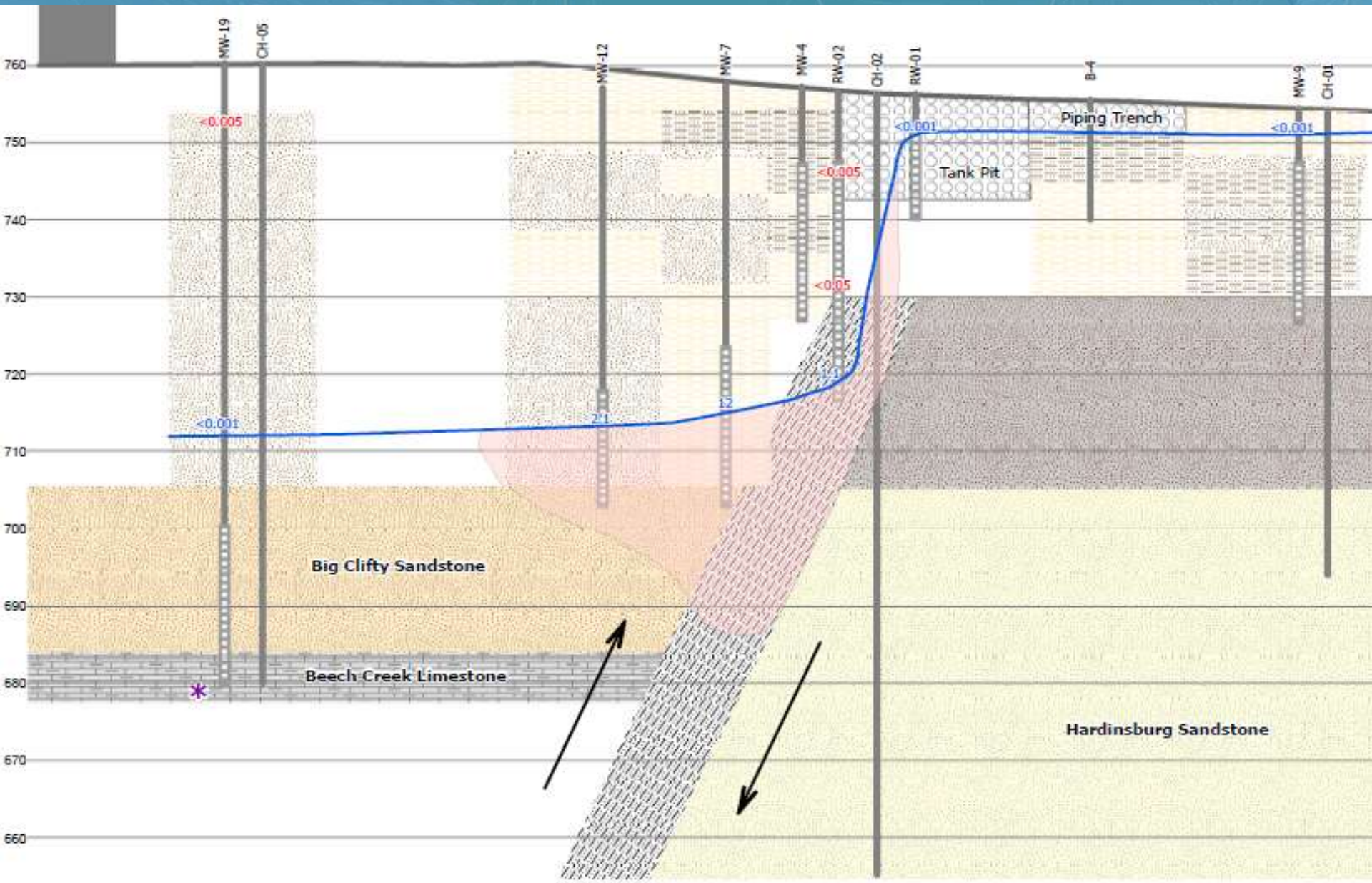
Previous Work

- EnSafe working at Site Since 2008
- Kentucky DEP-UST Branch directing efforts
- To date, 21 monitoring wells, 2 recovery wells and 6 core holes have been completed
- Preliminary interpretation of fault nature and location
- Intense bedrock fracturing and brecciation zone are present within and near the mapped fault trace

Preliminary Map



Preliminary Profile



Geophysical Scope

- Image the lateral and vertical extent of soil, bedrock, groundwater and subsurface features influencing potential groundwater impact movement.
- Desktop Study - Review completed work and published/information on the local geology and fault mapping that has occurred in the area, includes limited photo lineament and LiDAR analyses.
- Electromagnetic terrain conductivity mapping
- Two Dimensional Electrical Resistivity Imaging
- Seismic microtremor analysis shear wave profiling
- Very low frequency electromagnetics

Regional data review

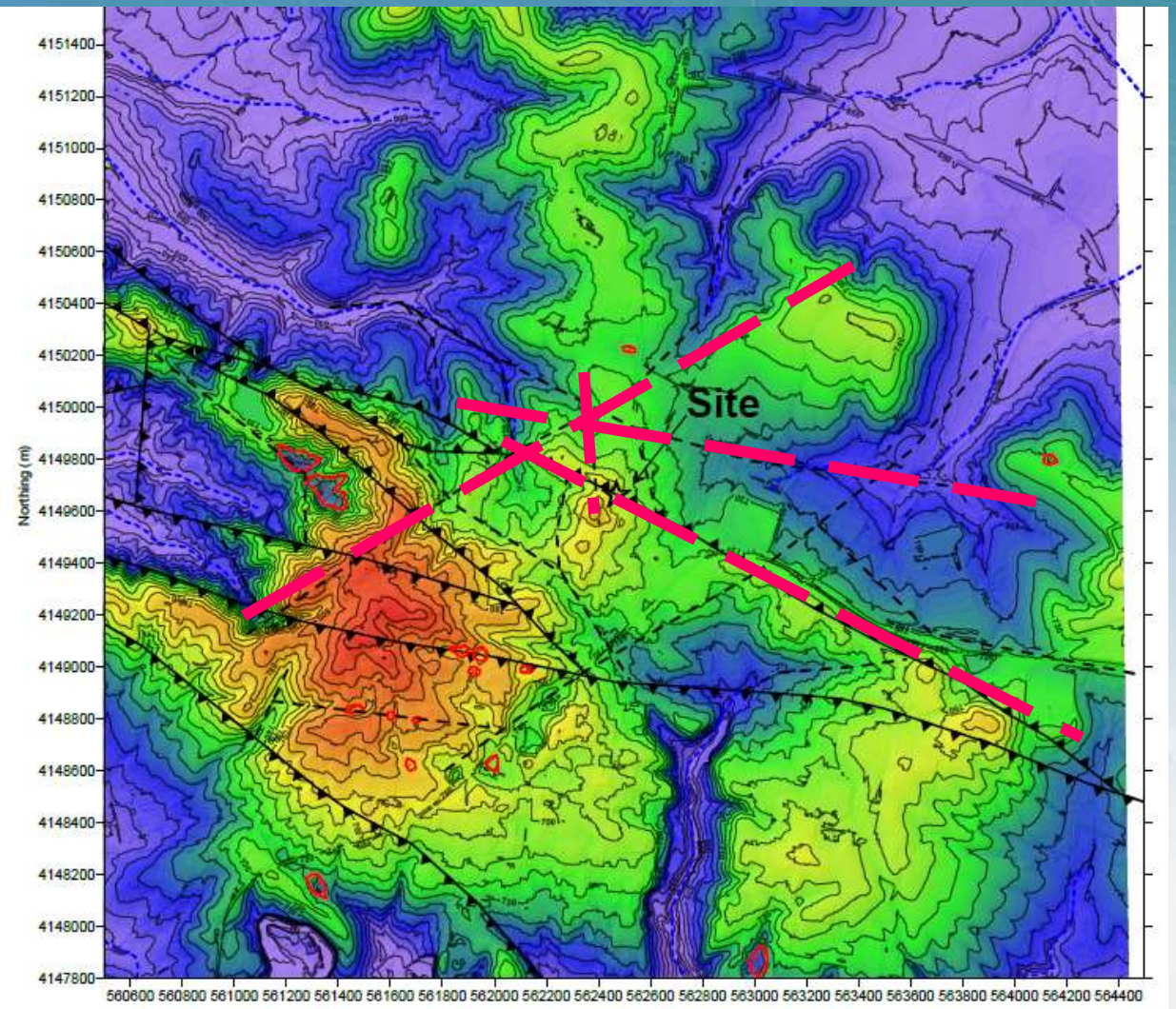
Terrain conductivity data covering site

9 resistivity profiles of varying lengths, electrode spacing

6 seismic profiles, co-located with select resistivity profiles

6 VLF profiles, co-located with select profiles

Results



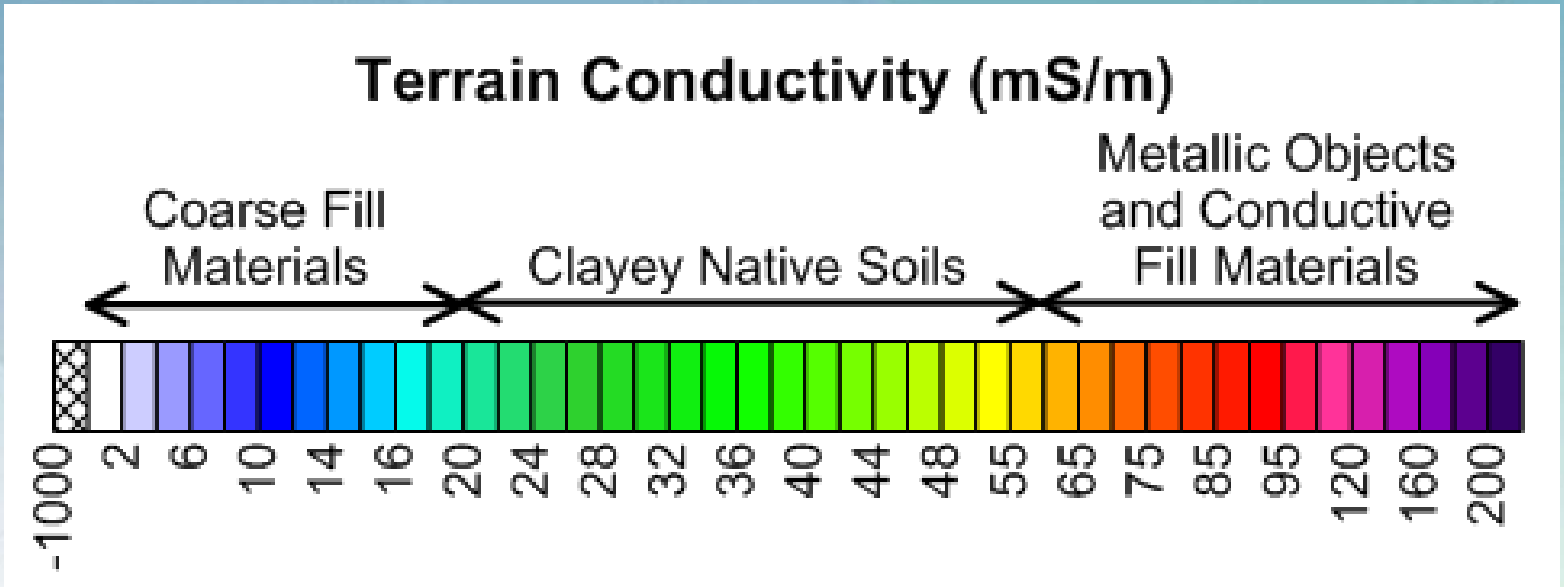
Aerial photo and LiDAR data analysis for lineaments yielded additional fault/fracture traces not indicated in the geologic quadrangle.

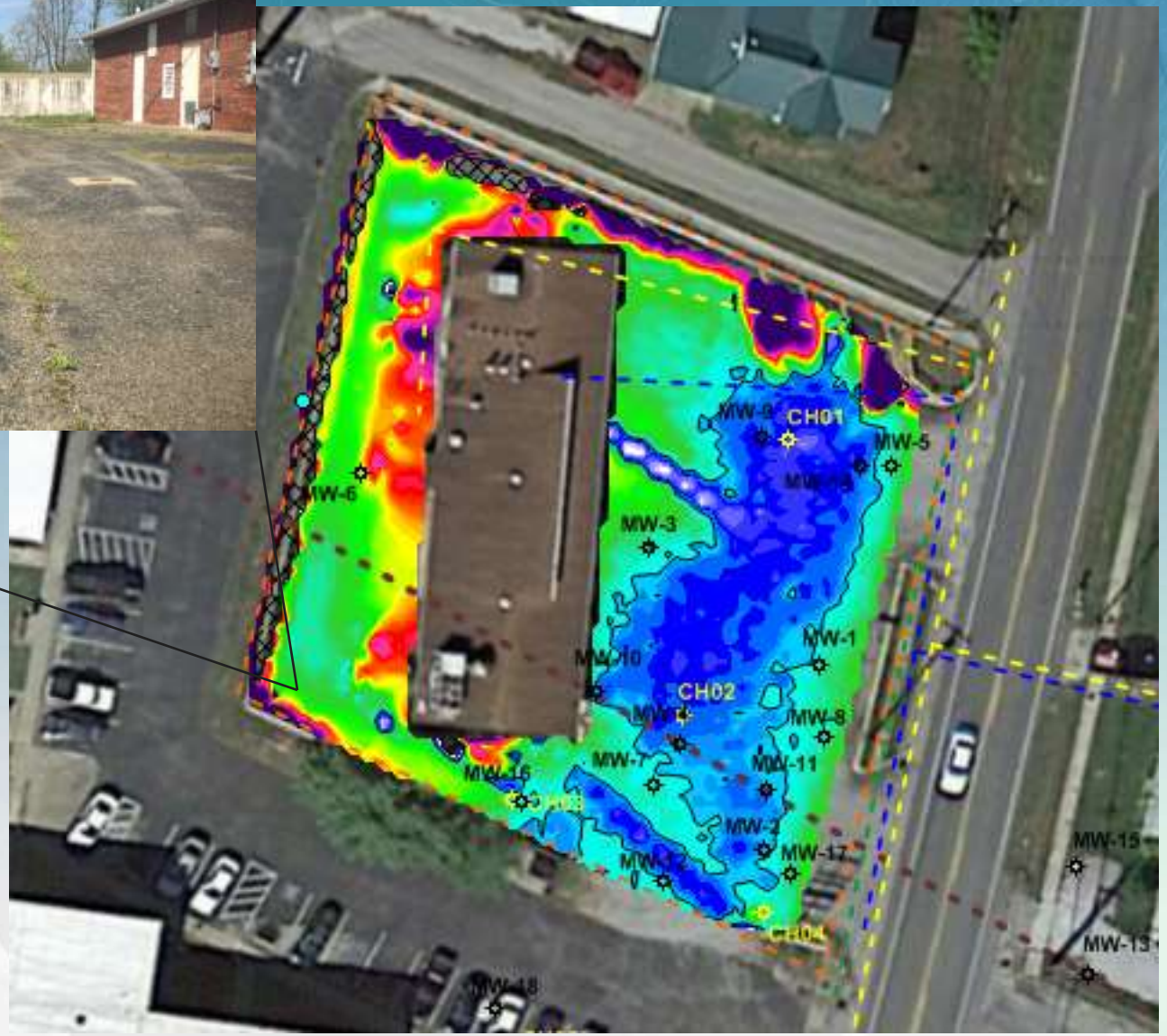
Primary Fault Orientation

Multiple orientations of minor faults, en-echelon

Conductivity mapping

Primarily for shallow preferential flow pathways such as utility trenches

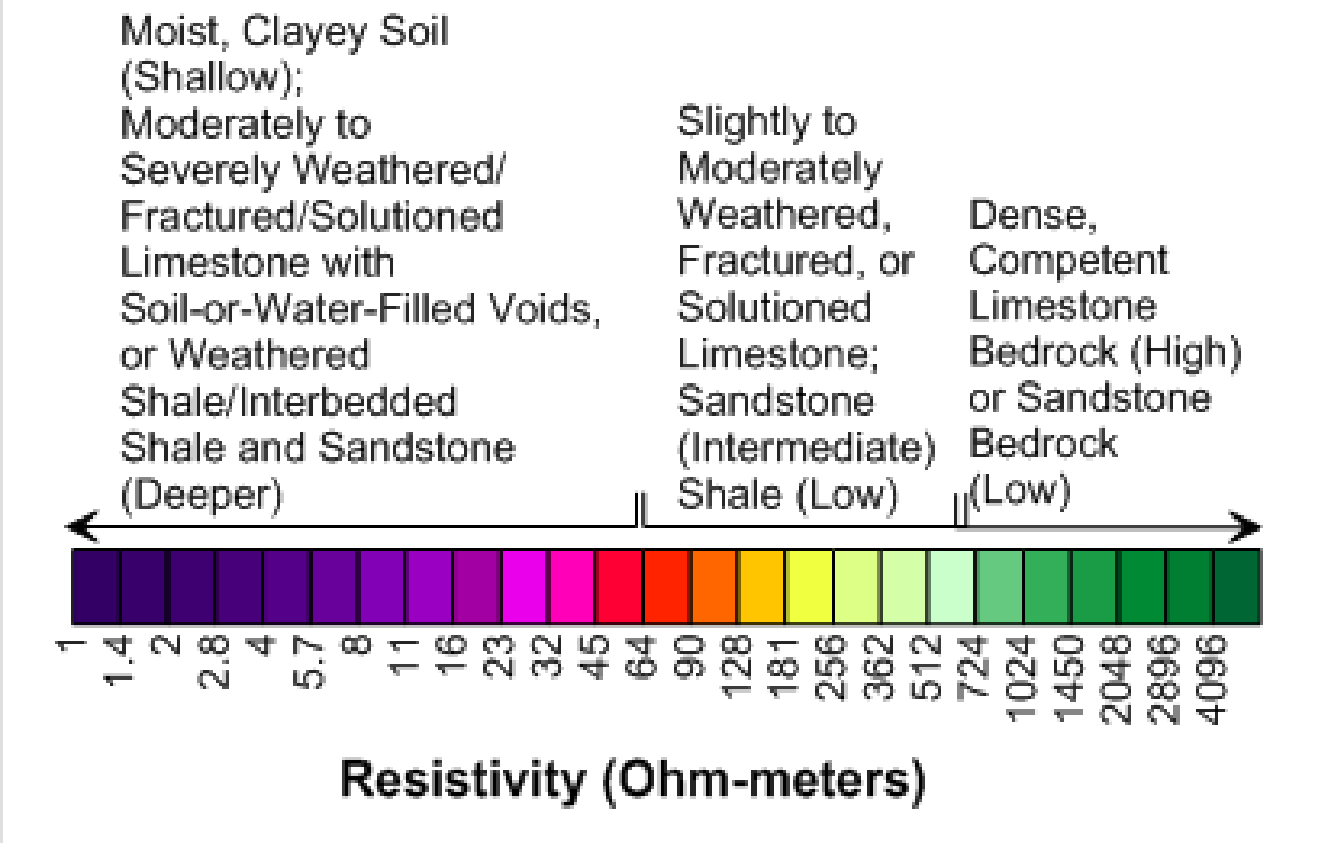



MW-9
CH01
MW-5
MW-6
MW-3
MW-1
MW-10
CH02
MW-8
MW-7
MW-11
MW-16
MW-2
MW-17
MW-12
CH04
MW-15
MW-13
MW-18

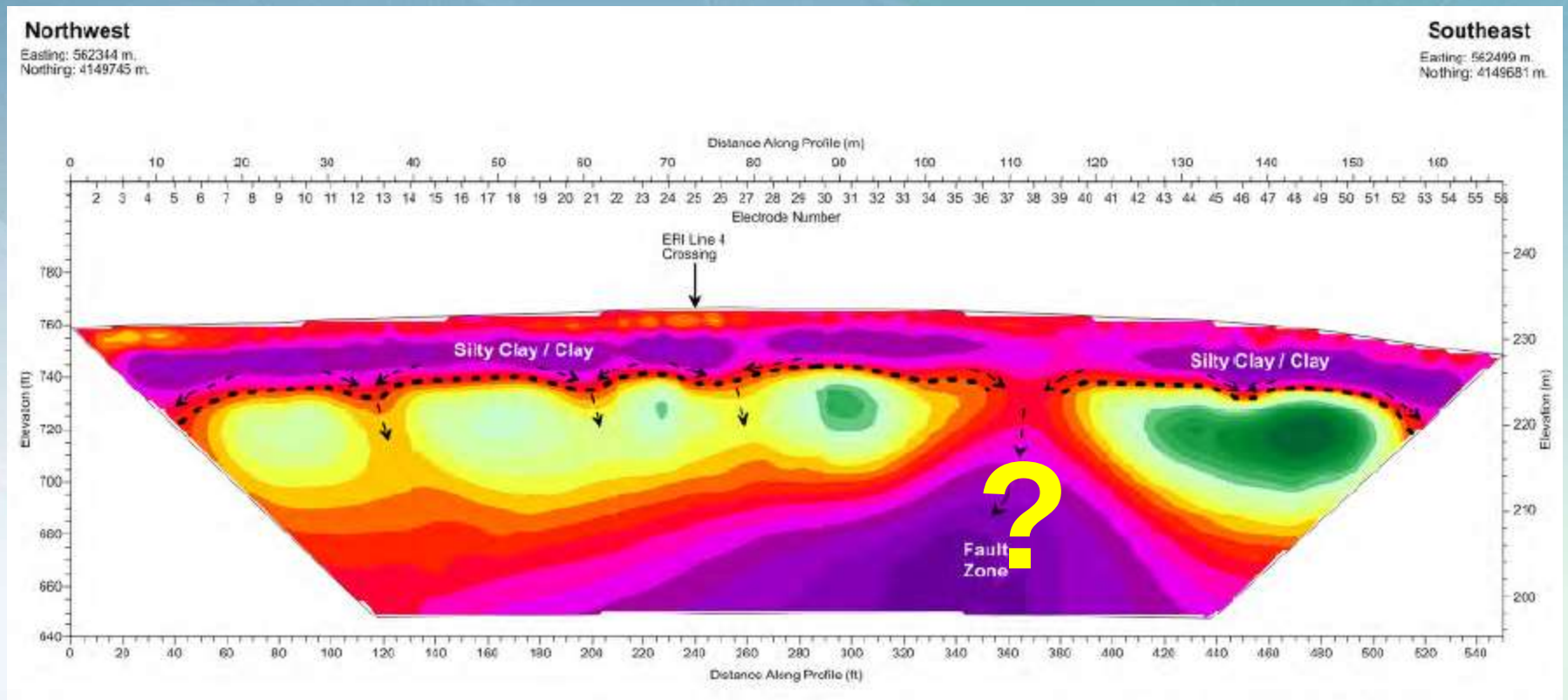

Line 1
Laura Ln
MLK VLF Station
24,800 Hz
Line 2
Line 3
Line 5
Line 6
Line 7
Line 8
Line 9
Line
259
Kelly St
Lilac Rd
Puetro Rico VLF Station
27,500 Hz
Northing (m)
Easting (m)
4149740
4149720
4149700
4149680
4149660
4149640
4149620
4149600
4149580
4149560
4149540
562340
562360
562380
562400
562420
562440
562460
562480
562500
562520
562540
562560

Resistivity profiles

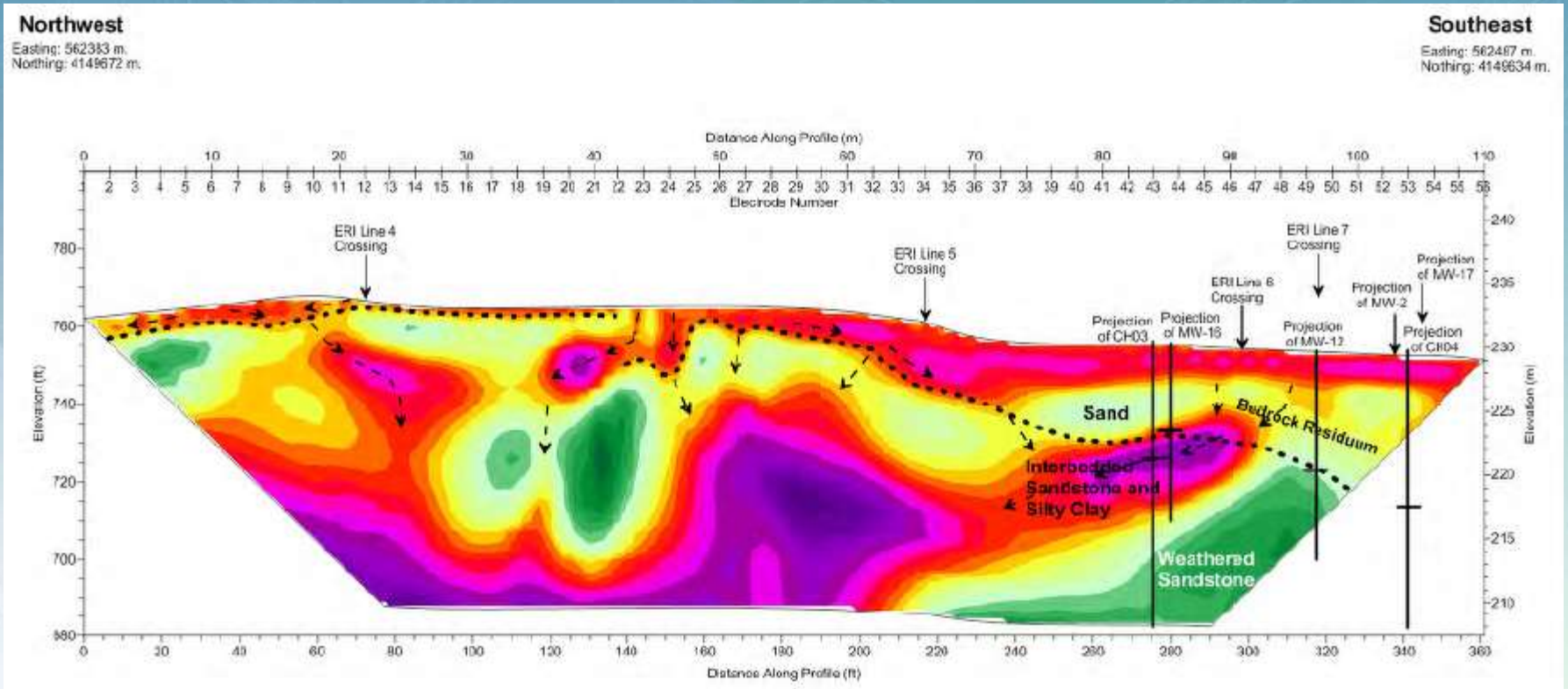
Primarily for intermediate to deep preferential flow pathways and lithology



Resistivity Line 1 – North boundary of site



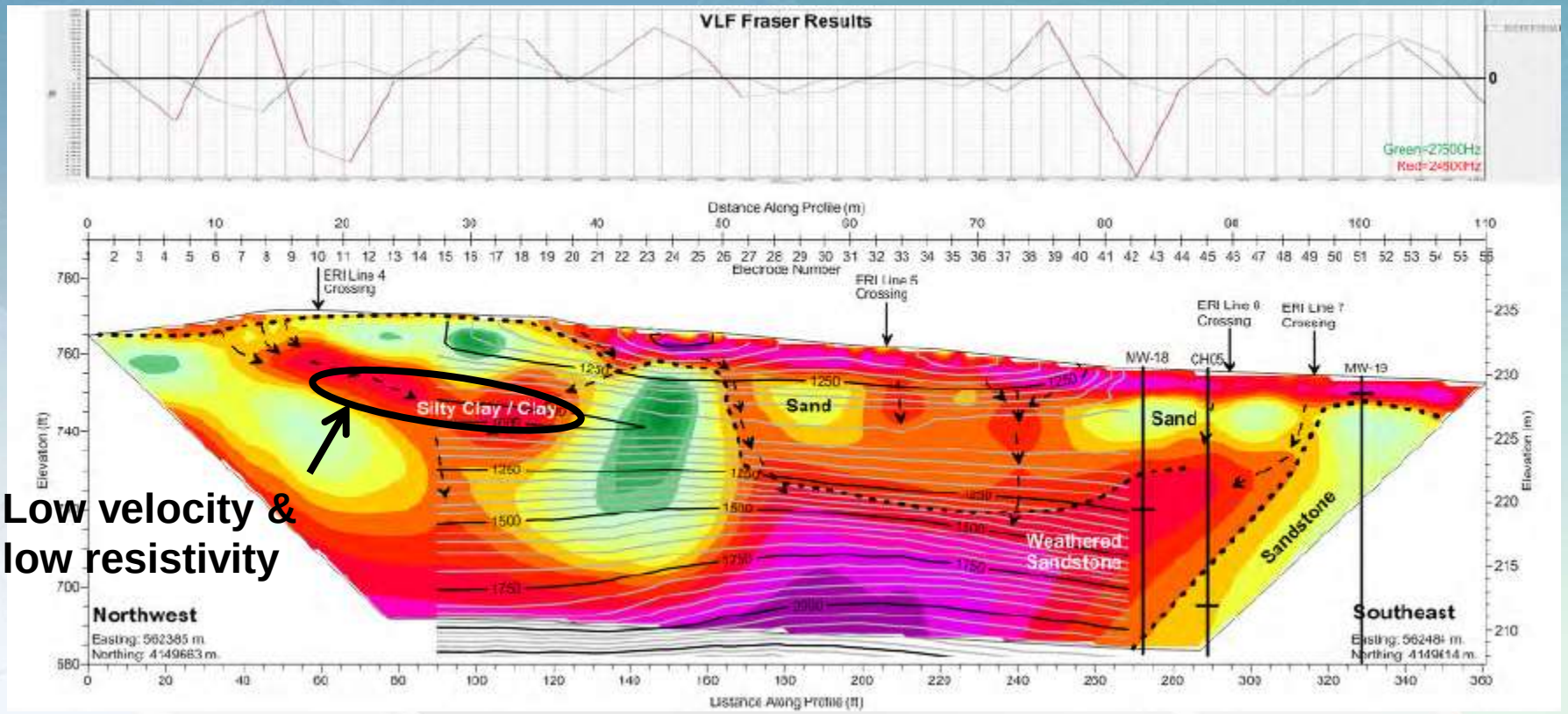
Resistivity Line 2– South side of fault



Much more complex than north side, as expected (SS vs LS)

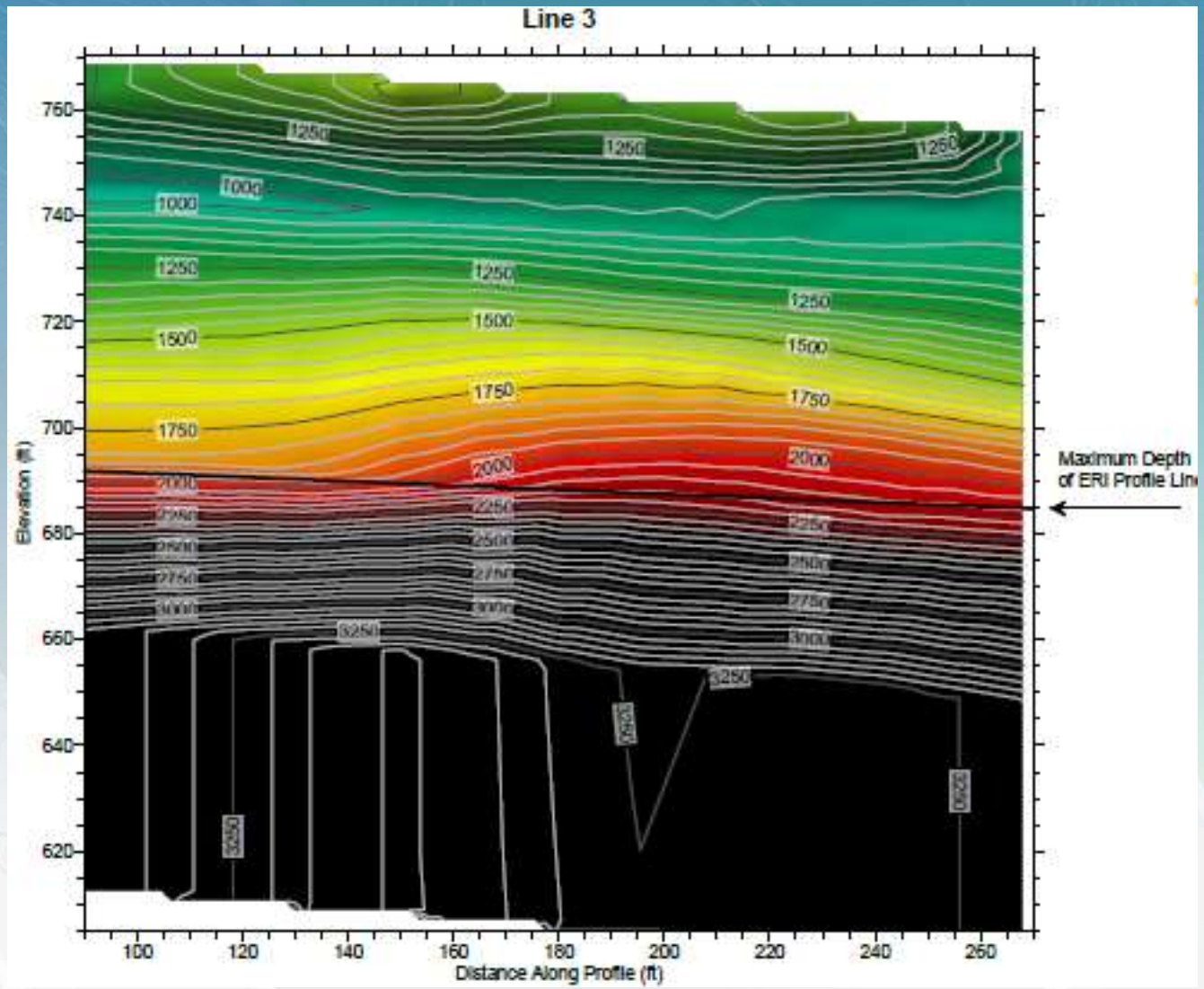
Resistivity Line 3 – South side of fault

With Seismic Vs contours and VLF Fraser profiles

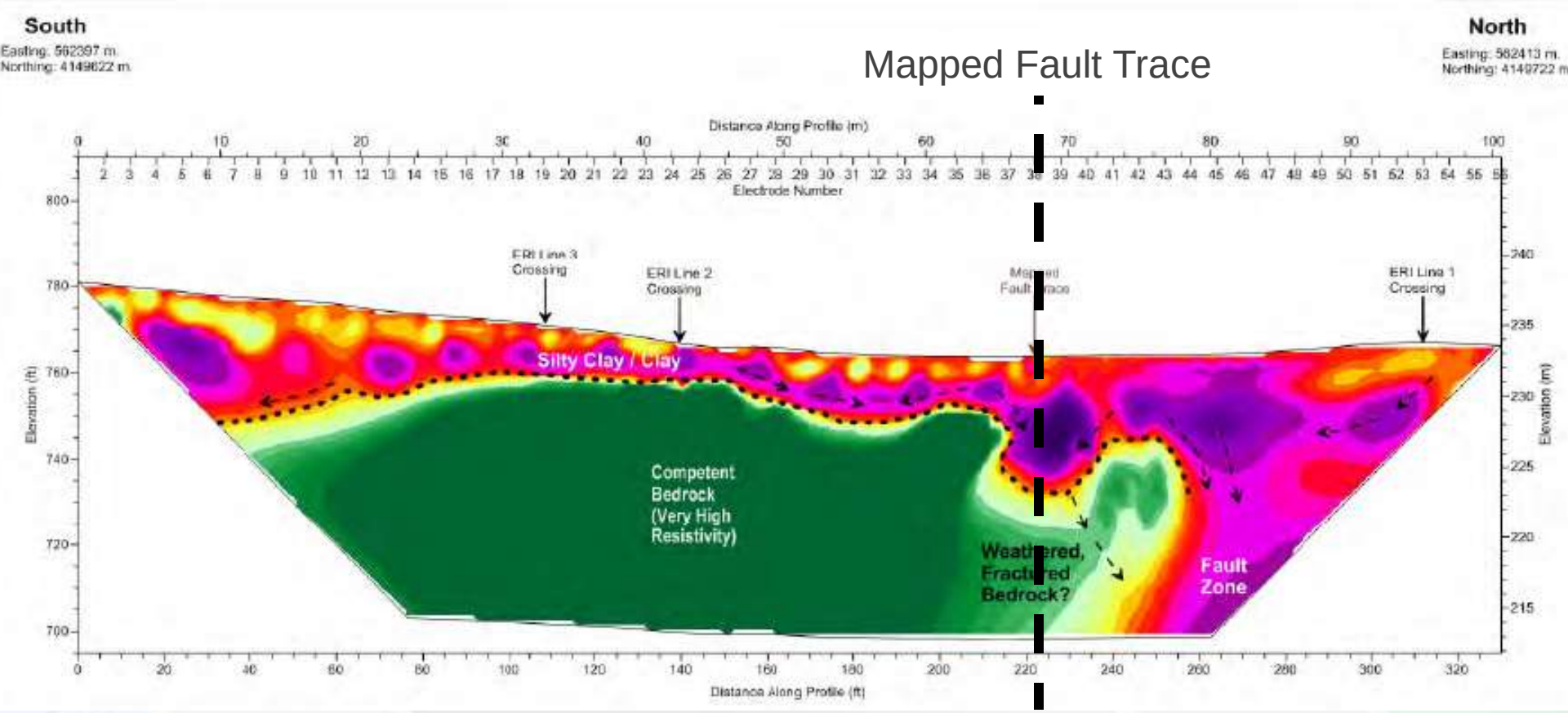


Low velocity & low resistivity

Seismic Line 3 – South side of fault

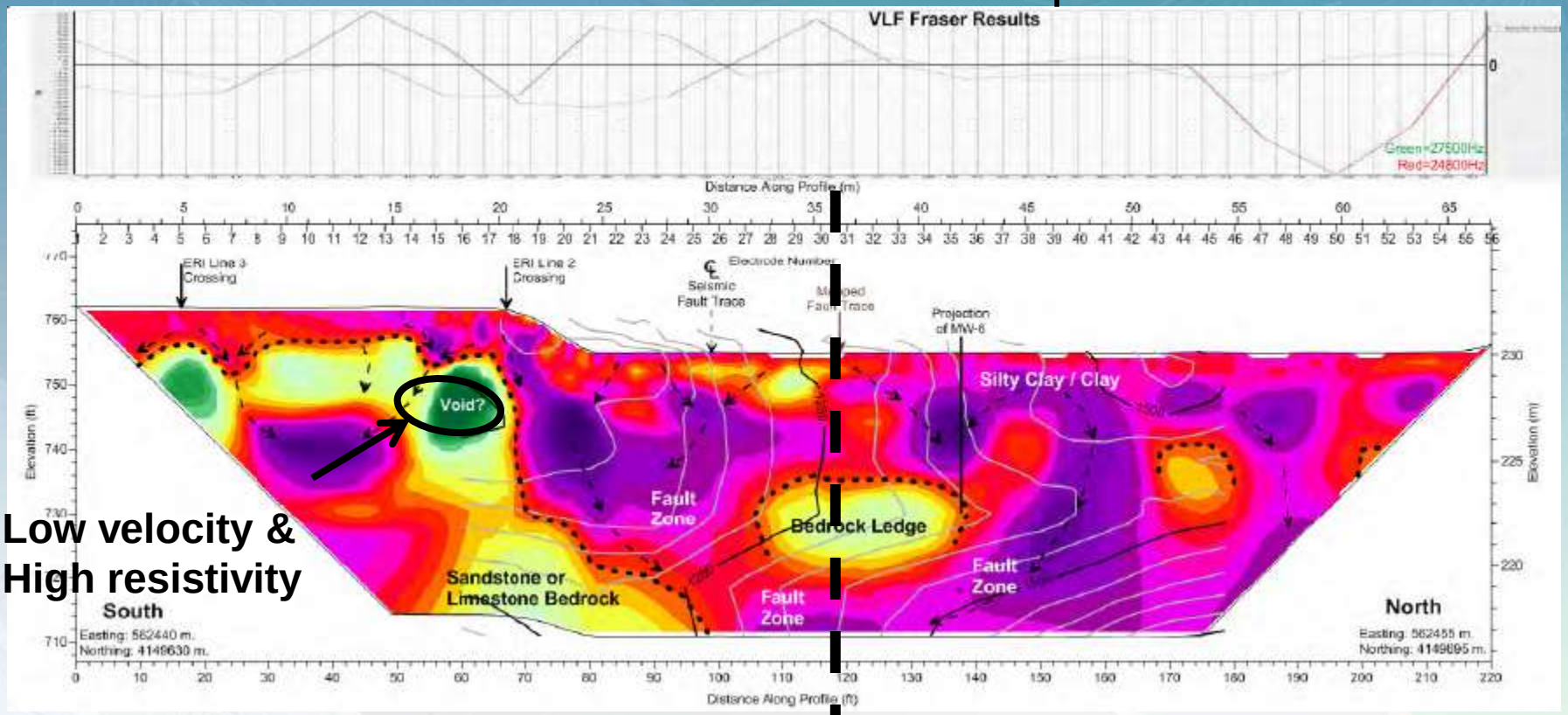


Resistivity Line 4 – Western most line



Resistivity Line 5 – West of property

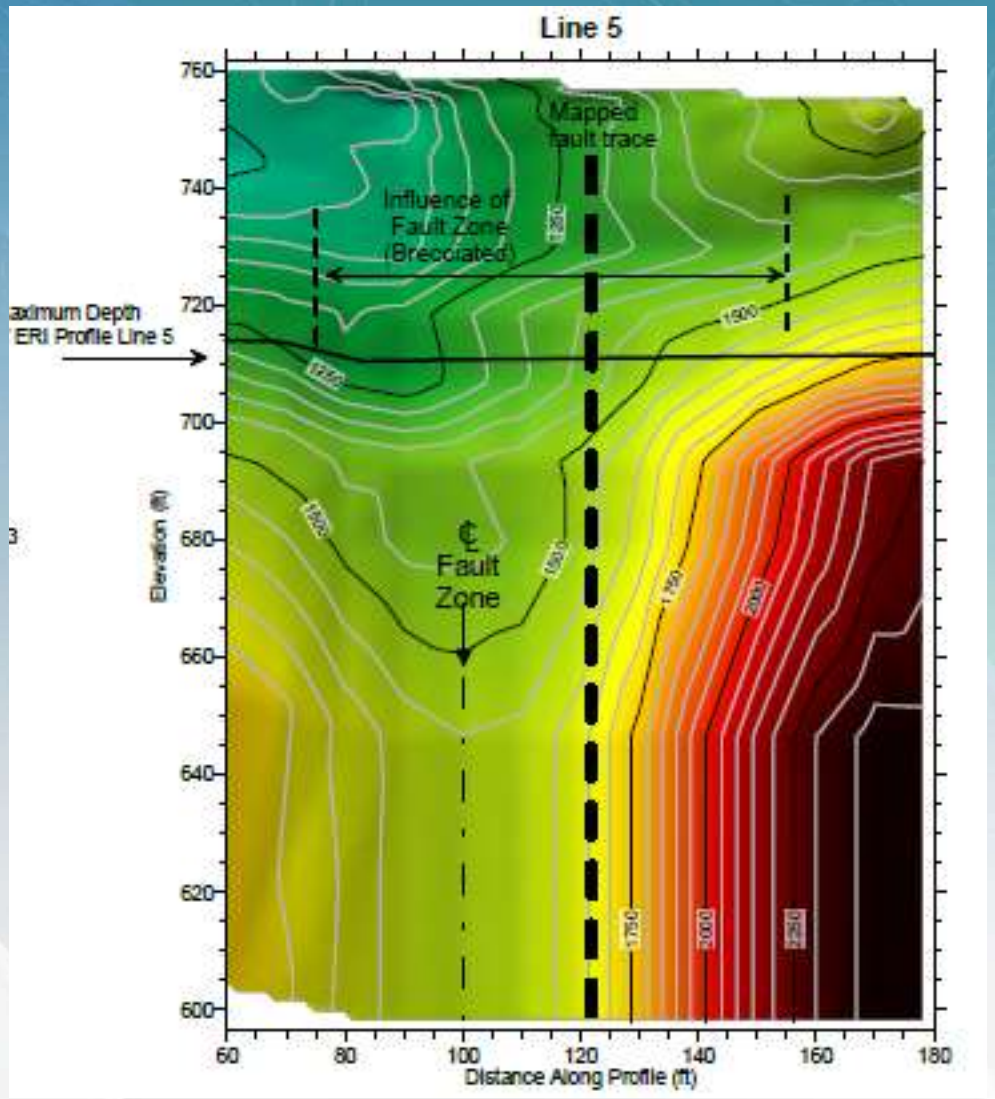
With Seismic Vs contours and VLF Fraser profiles



Low velocity & High resistivity

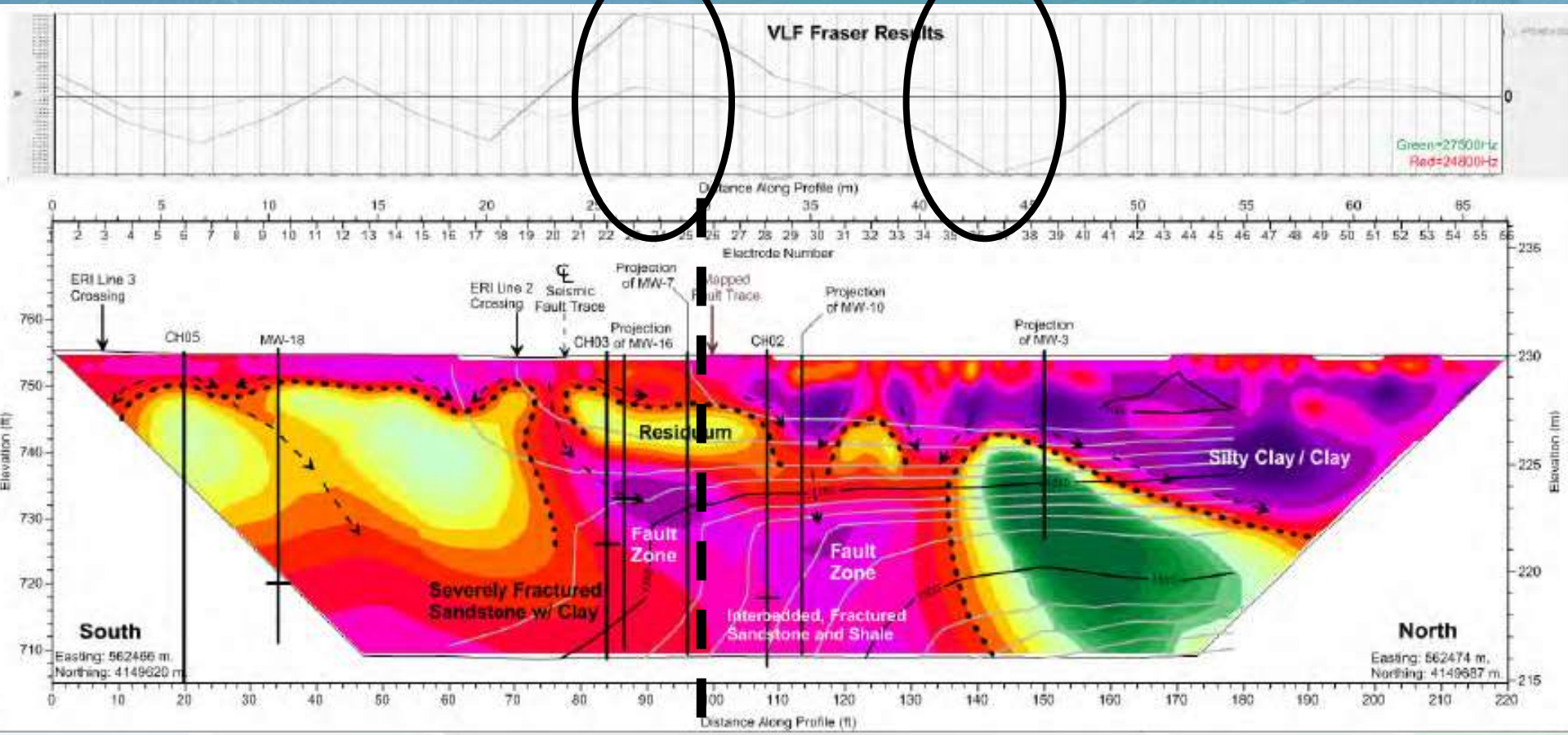
Mapped Fault Trace

Seismic Line 5 – South side of fault



Resistivity Line 6 – East of building

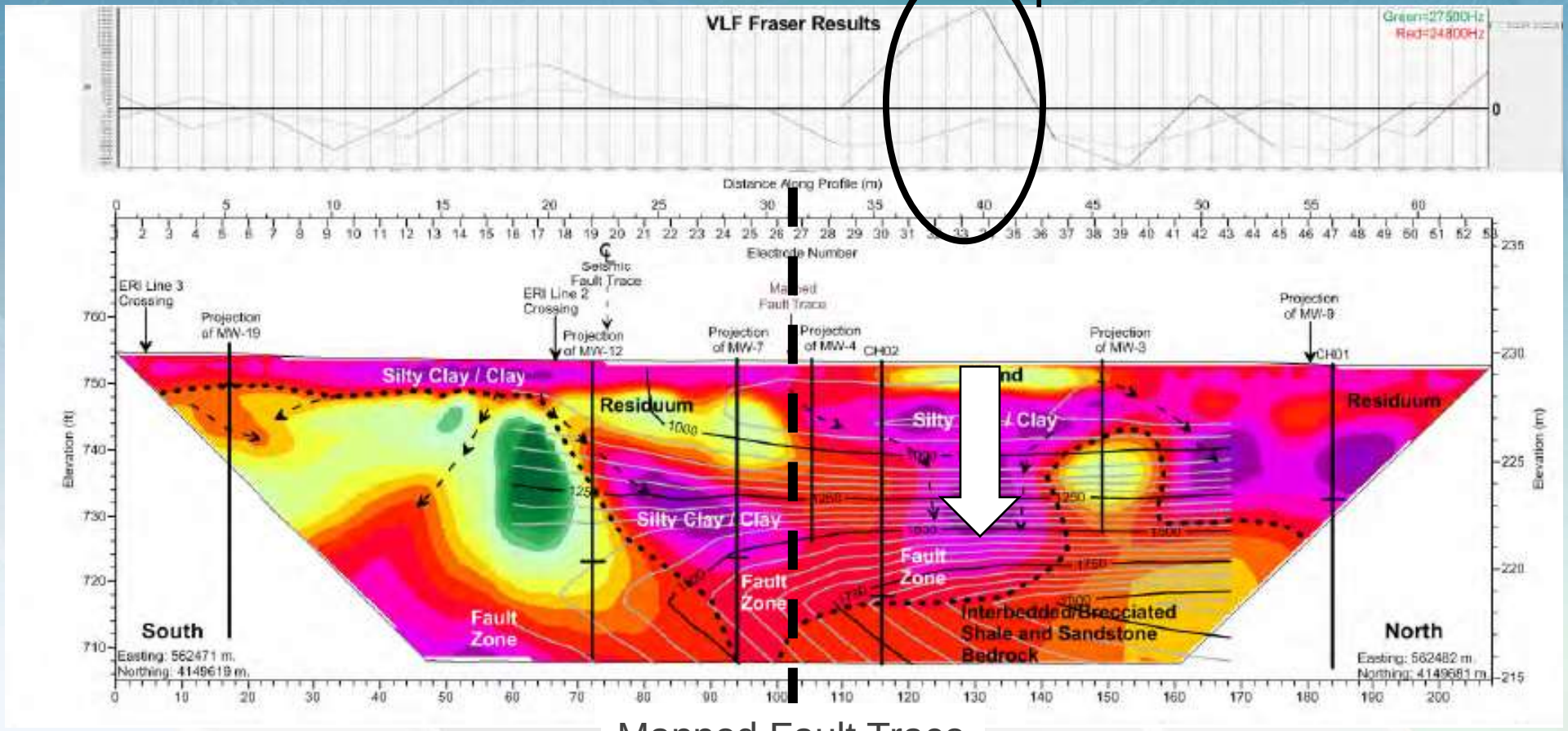
With Seismic Vs contours and VLF Fraser profiles



Mapped Fault Trace

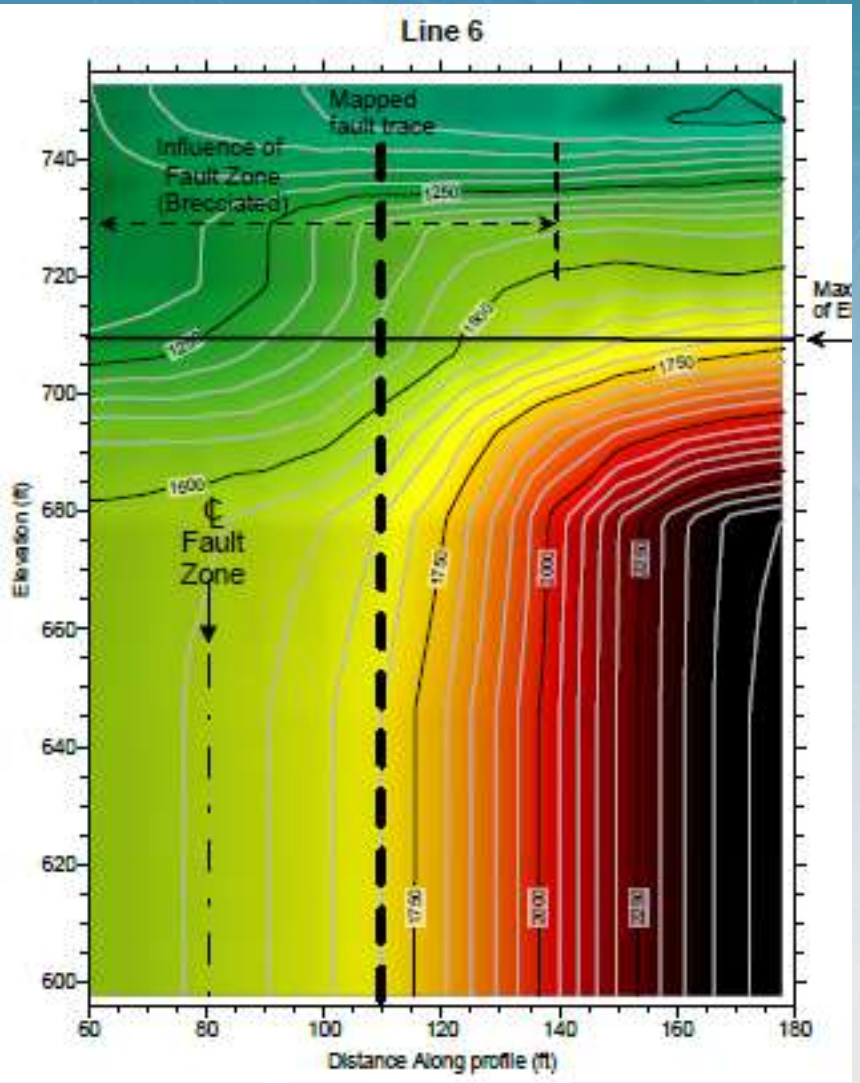
Resistivity Line 7 – Crossing Pit

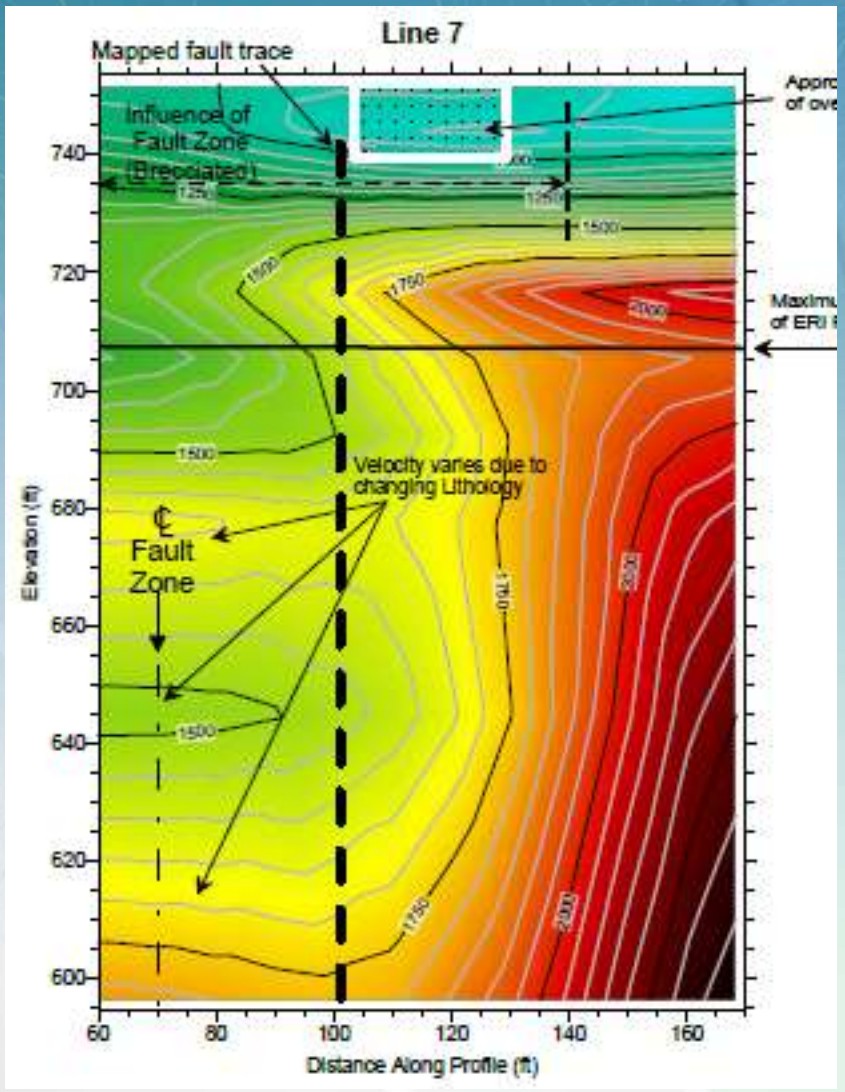
With Seismic Vs contours and VLF Fraser profiles



Mapped Fault Trace

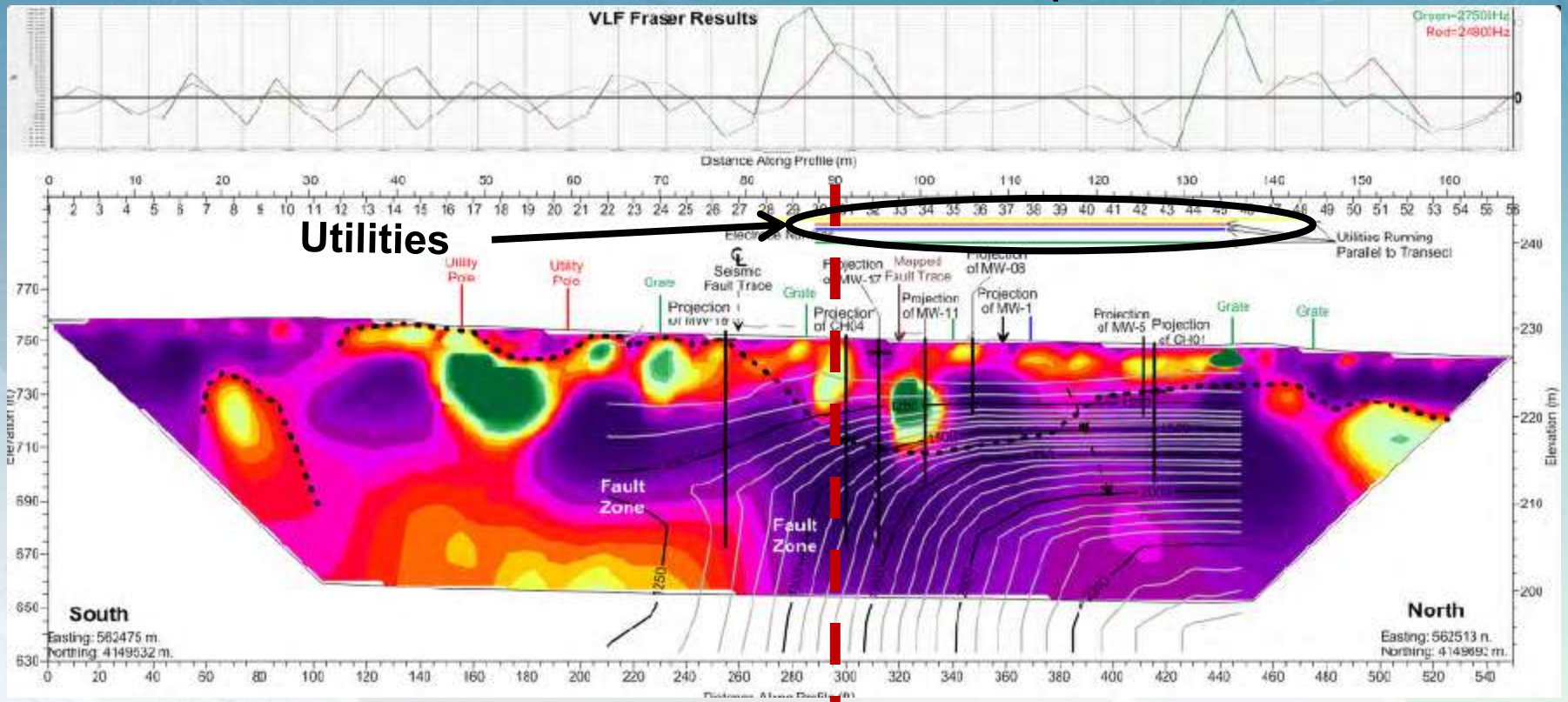
Seismic Lines 6 and 7





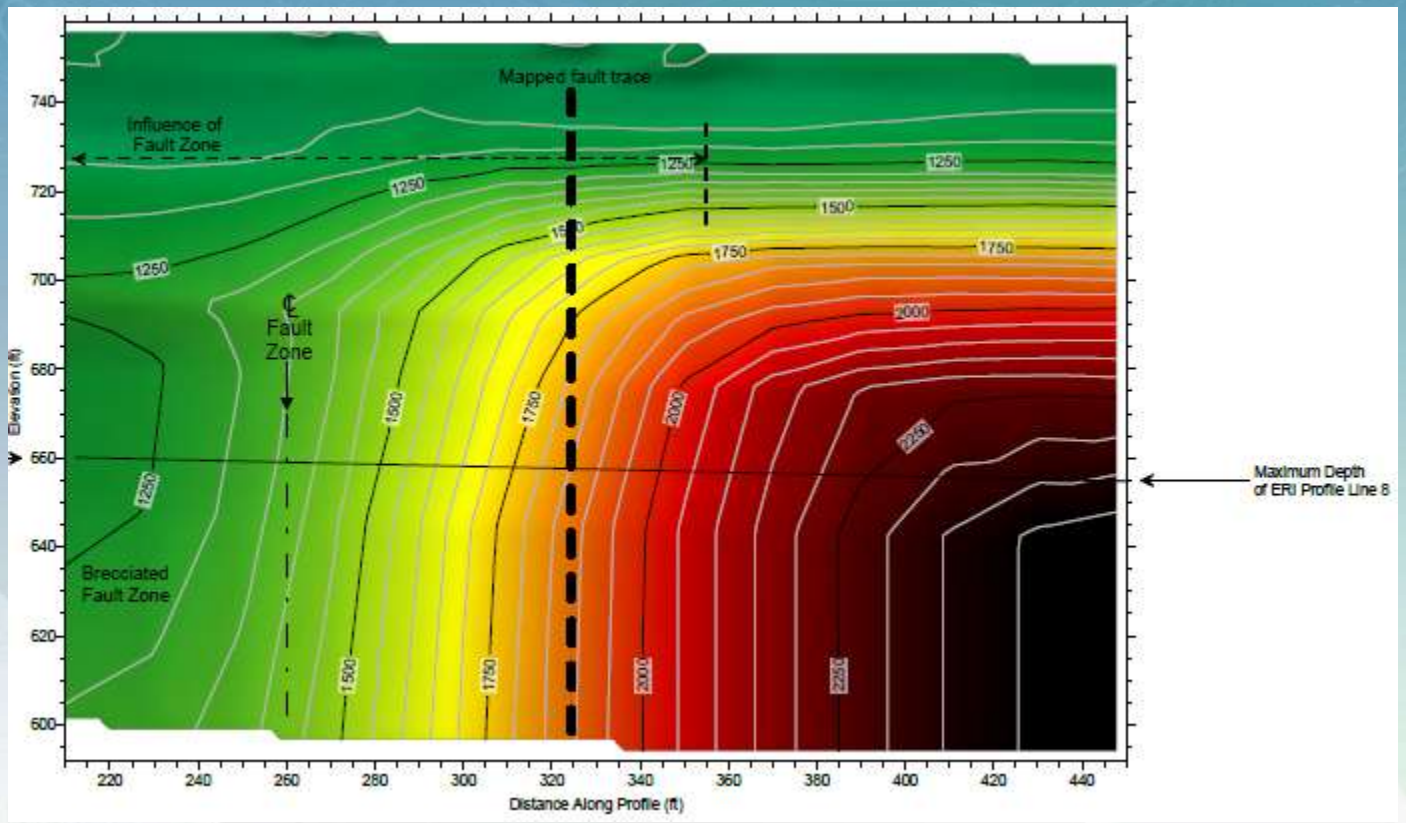
Resistivity Line 8 – East of property

With Seismic Vs contours and VLF Fraser profiles



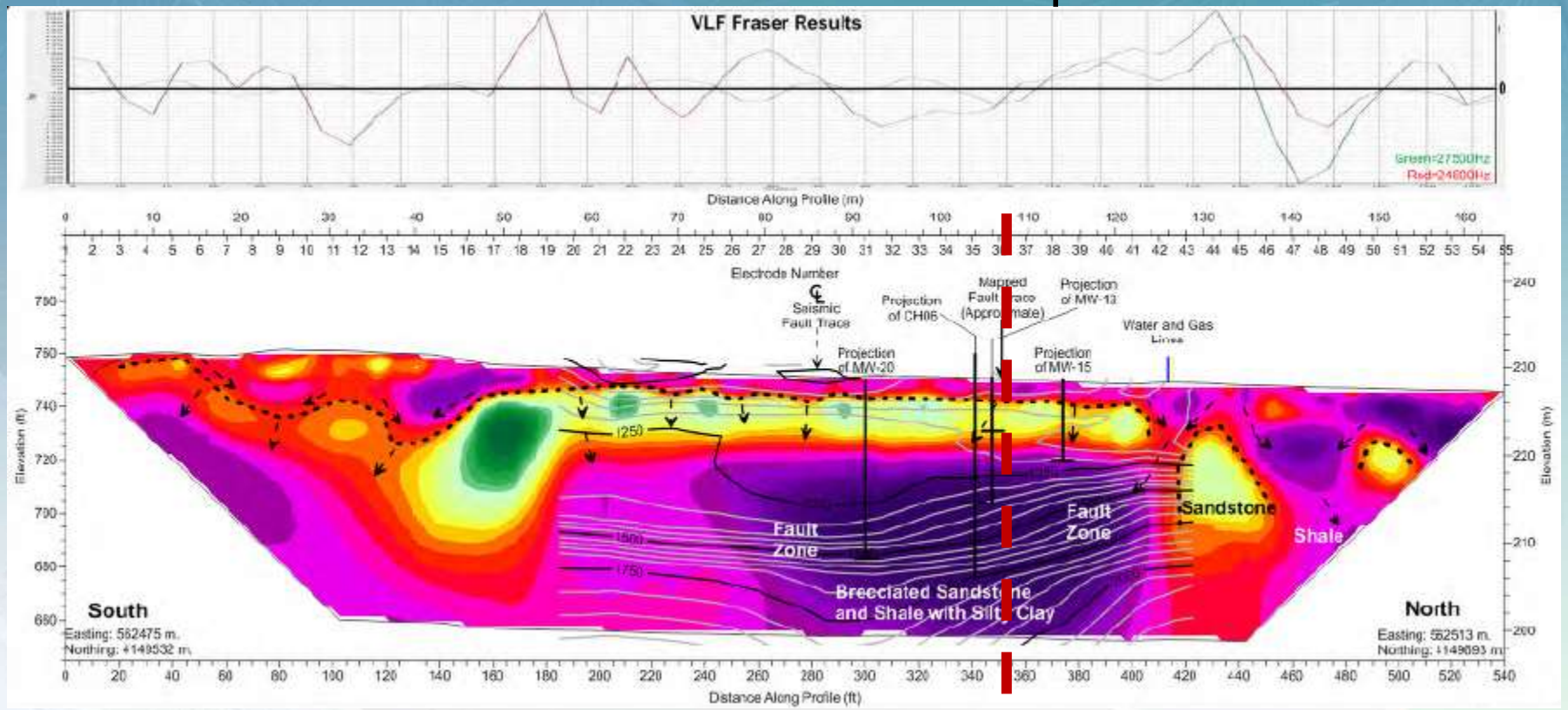
Mapped Fault Trace

Seismic Lines 8 – East of property



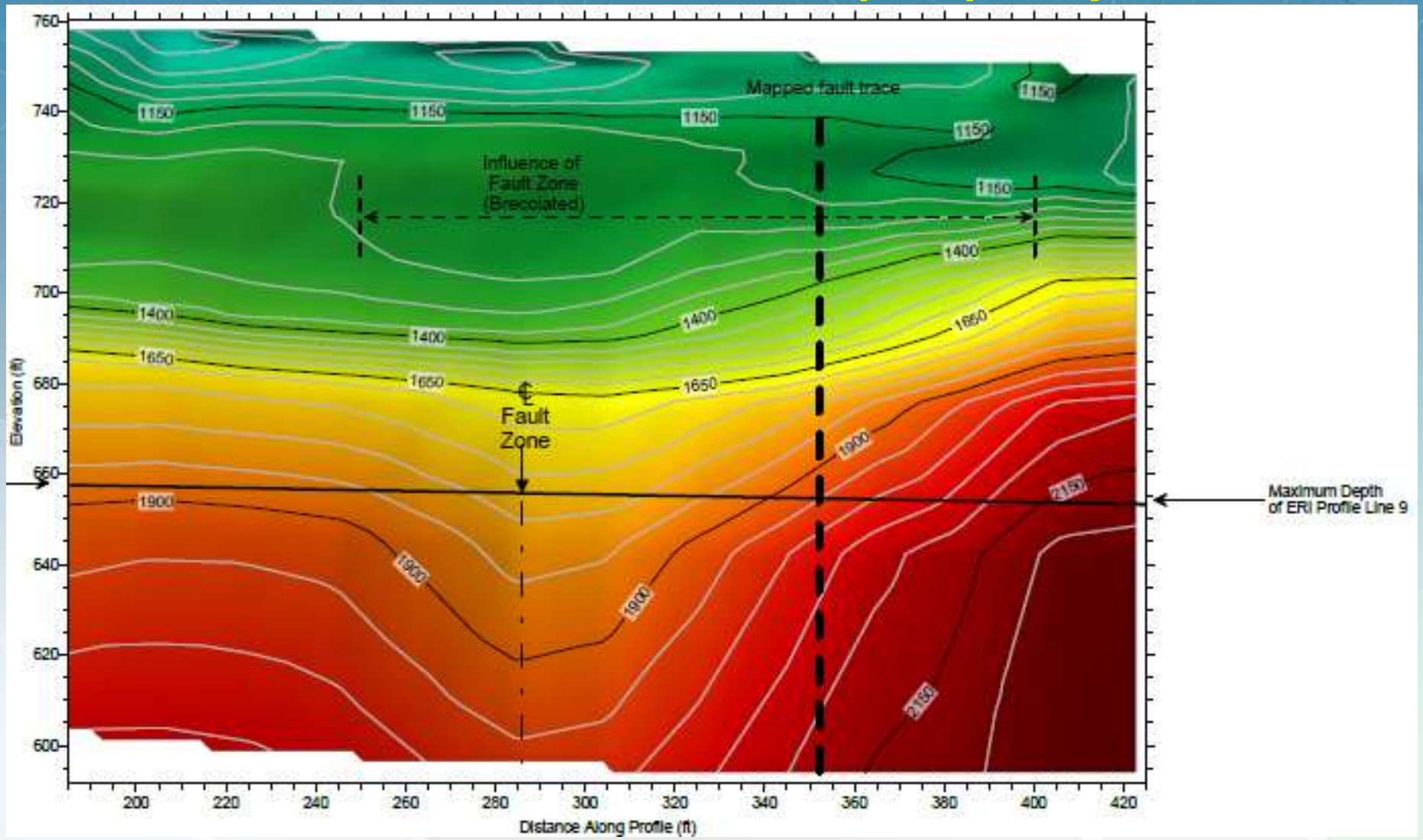
Resistivity Line 9 – East of property

With Seismic Vs contours and VLF Fraser profiles

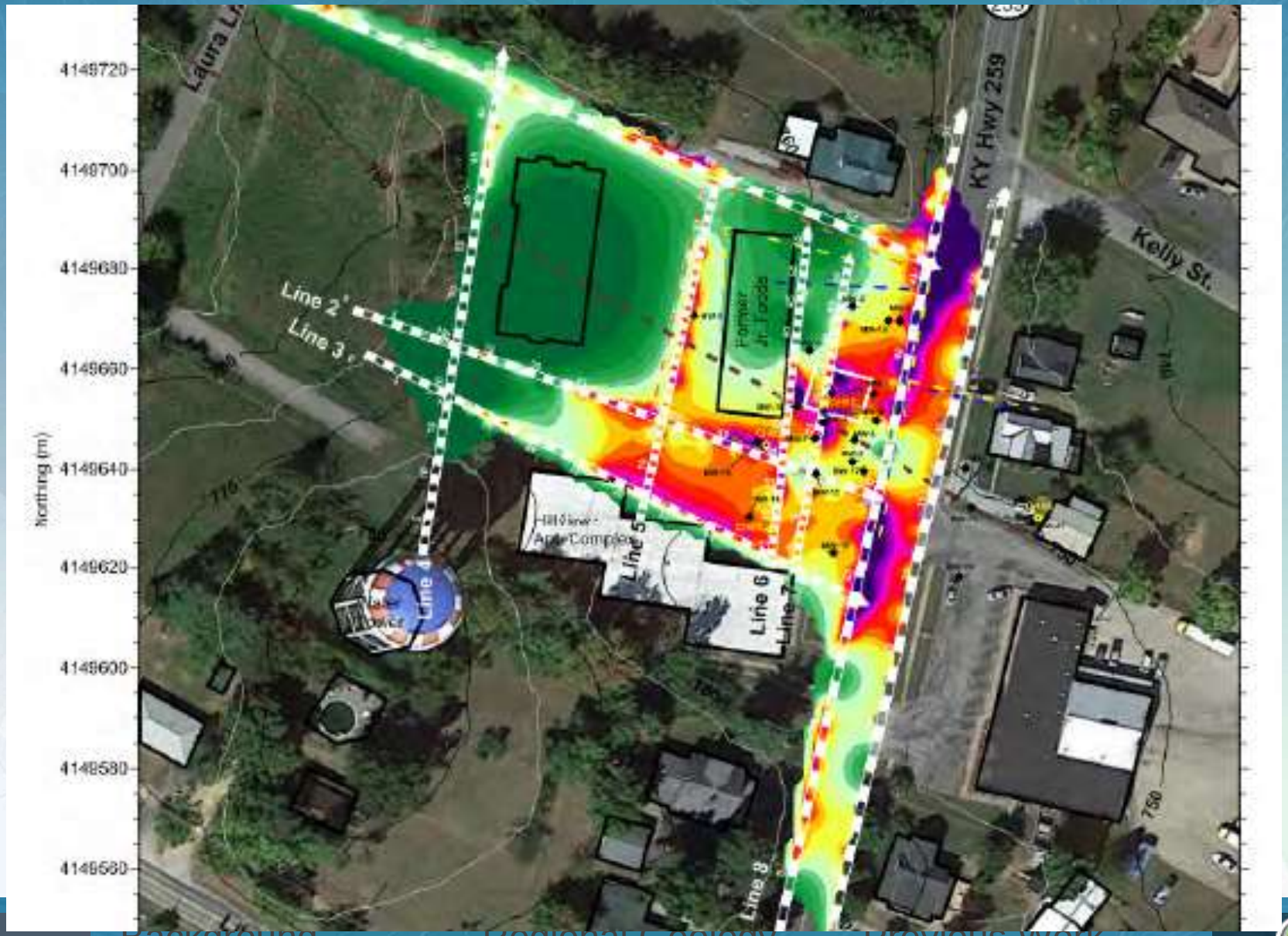


Mapped Fault Trace

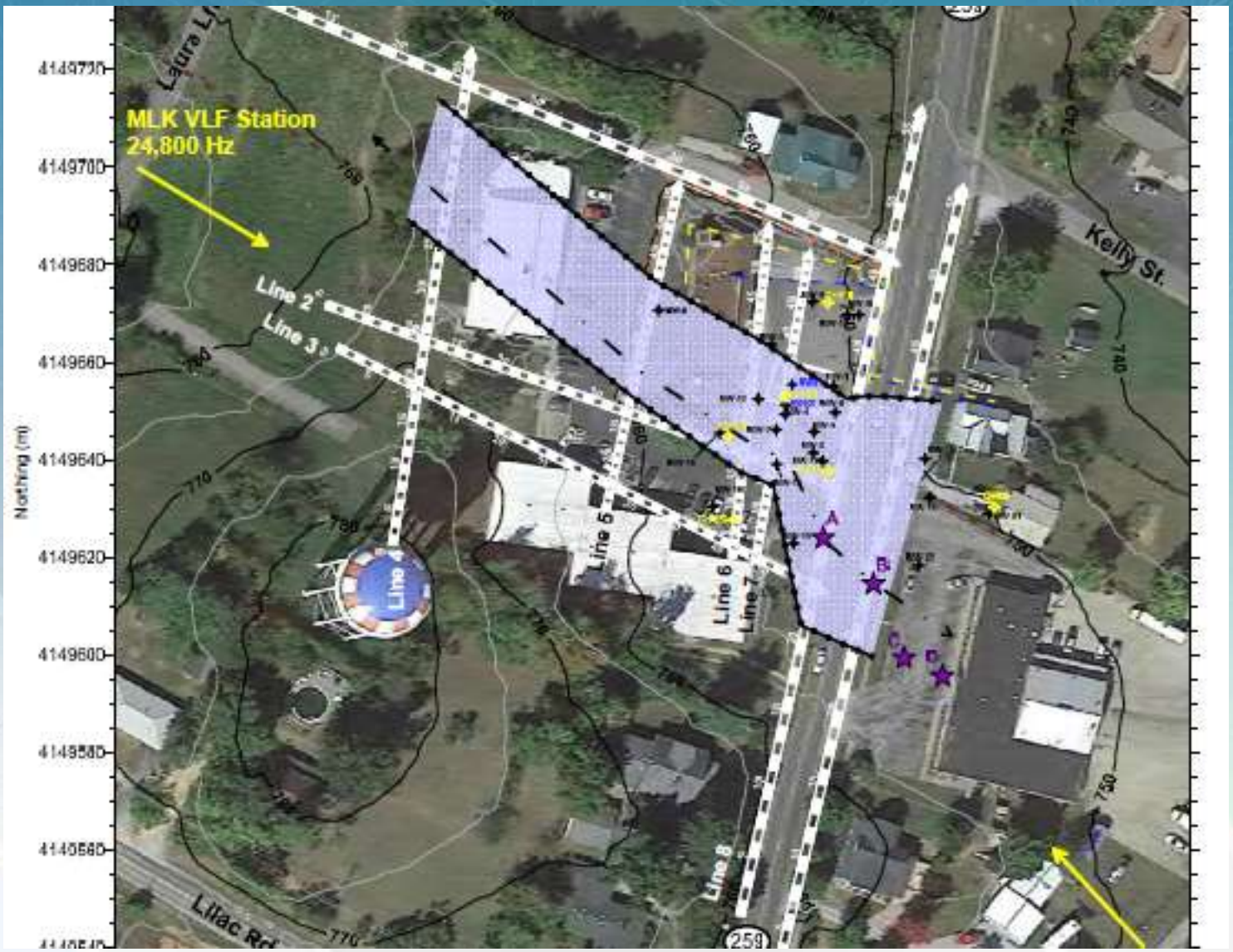
Seismic Lines 9 – East of property



Resistivity at Elev. 740 ft (~20-ft depth)



Resistivity at Elev. 740 ft (~20-ft depth)



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Miller, R. D., T. S. Anderson, J. Ivanov, J. C. Davis, R. Olea, C. Park, D. W. Steeples, M. L. Moran, and J. Xia, 2003, 3*D characterization of seismic properties at the smart weapons test range*, YPG: 73rd Annual International Meeting, SEG, Technical Program Expanded Abstracts, 22, 1195-1198.

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Questions?