SGW-52573 -VA
Revision 0

Gable Gap and LERF Geophysics Investigation Update, Hanford Site, Washington

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Gable Gap and LERF Geophysics Investigation Update, Hanford Site, Washington

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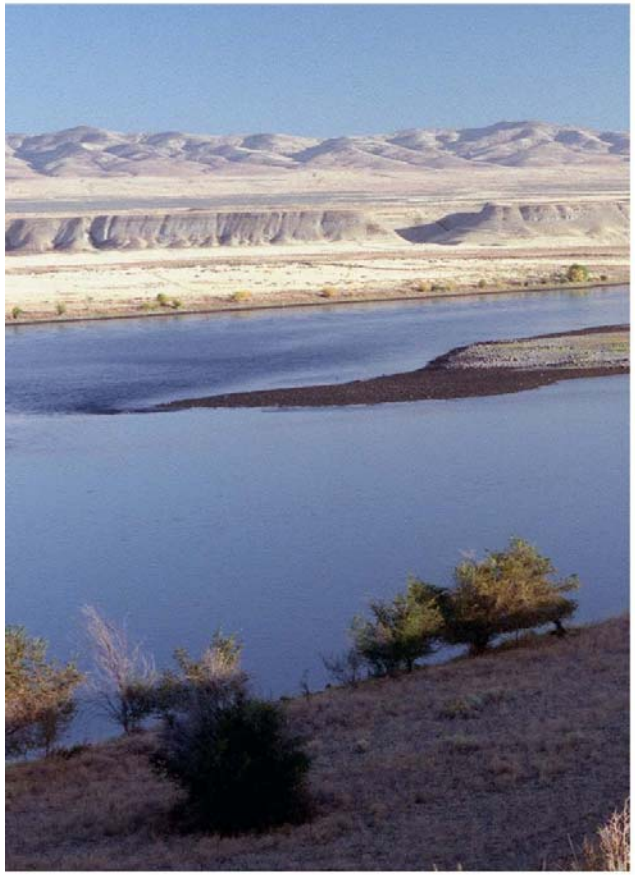


Gable Gap and LERF Geophysics Investigation Update, Hanford Site Washington

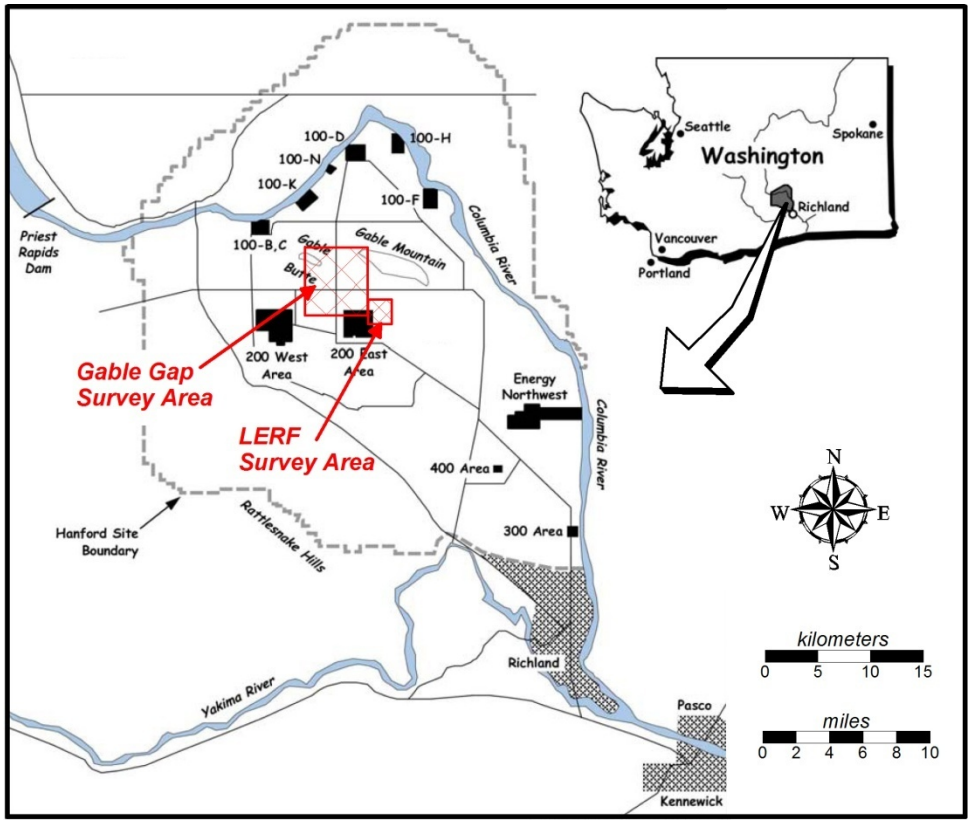
Presented to: Tribal, Oregon DOE, USDOE

Presented by: M. D. Thompson, S. F. Miller, and B. A. Williams

One Culture. One Team.

Outline

- Problem Statements and Goals
- Gable Gap Results
  - Seismic Surveys
  - Interpretations
- LERF Geophysics
  - Seismic, Resistivity and TDEM Surveys
  - Interpretations
- Basalt Surface Development
  - Conversion to Elevation
  - Seismic – Well Integration
- Final Thoughts



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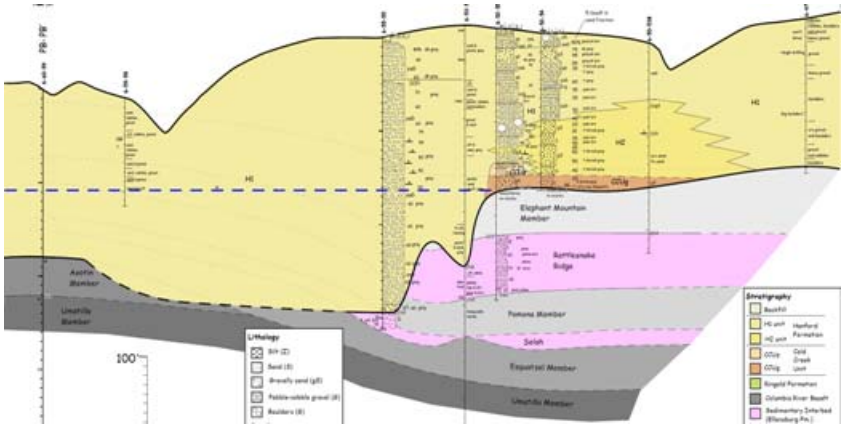
Problem Statements

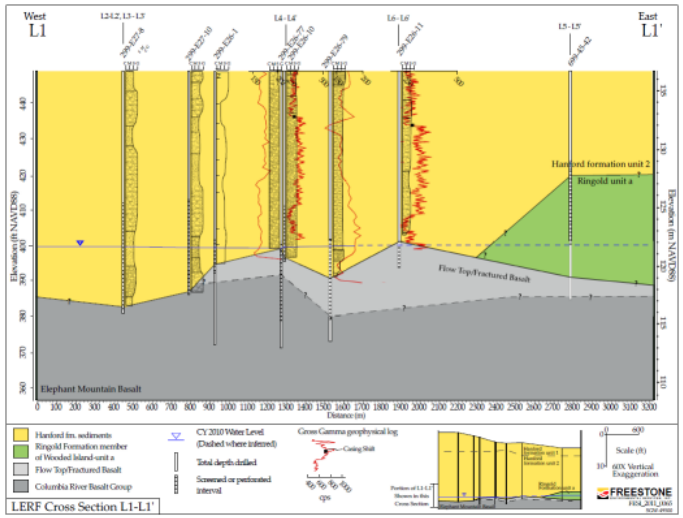
Gable Gap/200-BP-5 Groundwater OU

- Structure of the basalt surface serves as a primary control on groundwater and potentially contaminant migration northward through the Gable Gap
- The existing sparse well network is inadequate to accurately define likely groundwater migration pathways.
- Declining water levels further complicate identifying the groundwater pathways as the aquifer becomes thinner in this region.



LERF

- A replacement upgradient well is required to bring the LERF into compliance with RCRA groundwater regulations
- Declining water levels caused two of the existing wells to go dry
- Fractured flow top portion of the upper basalt is part of the unconfined aquifer.
- Need to delineate either water bearing zones within the fractured and/or weathered part of the basalt or basalt surface depressions where significant water head is present above basalt



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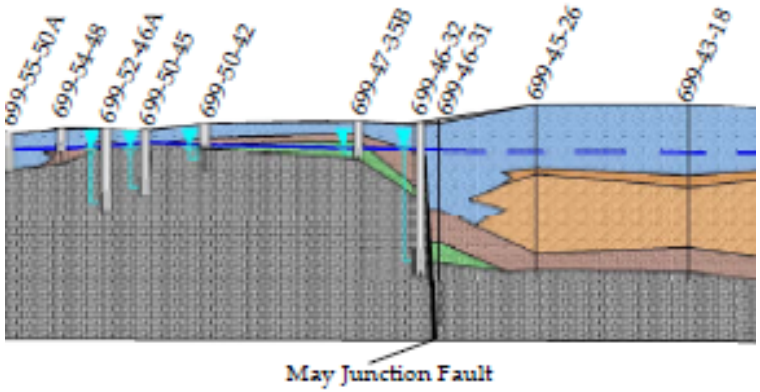
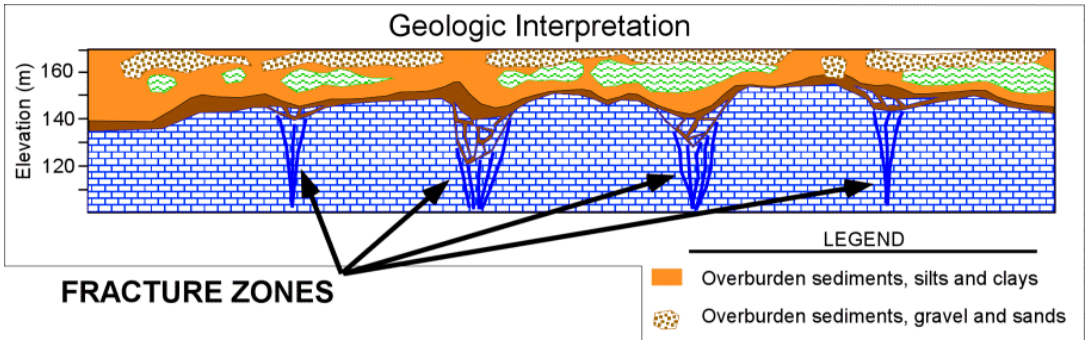
Geophysical Investigations

- Geophysical Targets
  - Map variations of top of basalt
  - Identify supra-basalt sediment interfaces



- For LERF
  - Identify potential fractured and/or weathered zones in upper basalt that are likely groundwater bearing



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Geophysical Investigations

- Gable Gap
  - Seismic Landstreamer
    - Gimbaled Geophones
    - 2 m (6.56-ft) Spacing
    - Impact Source (Elastic Wave Generator)
- LERF
  - Seismic Landstreamer
    - Standard Geophones mounted on plates
    - 1.5 m (~5 ft) Geophone Spacing
    - Impact Source (Elastic Wave Generator)
    - Seismic Reflection and Refraction
    - Shear-wave reflection attempted
  - 2D Resistivity Surveys
    - 5 m Electrode Spacing
    - Pole-Pole Geometry
  - Time Domain Electromagnetics
    - 50 m Square Coil

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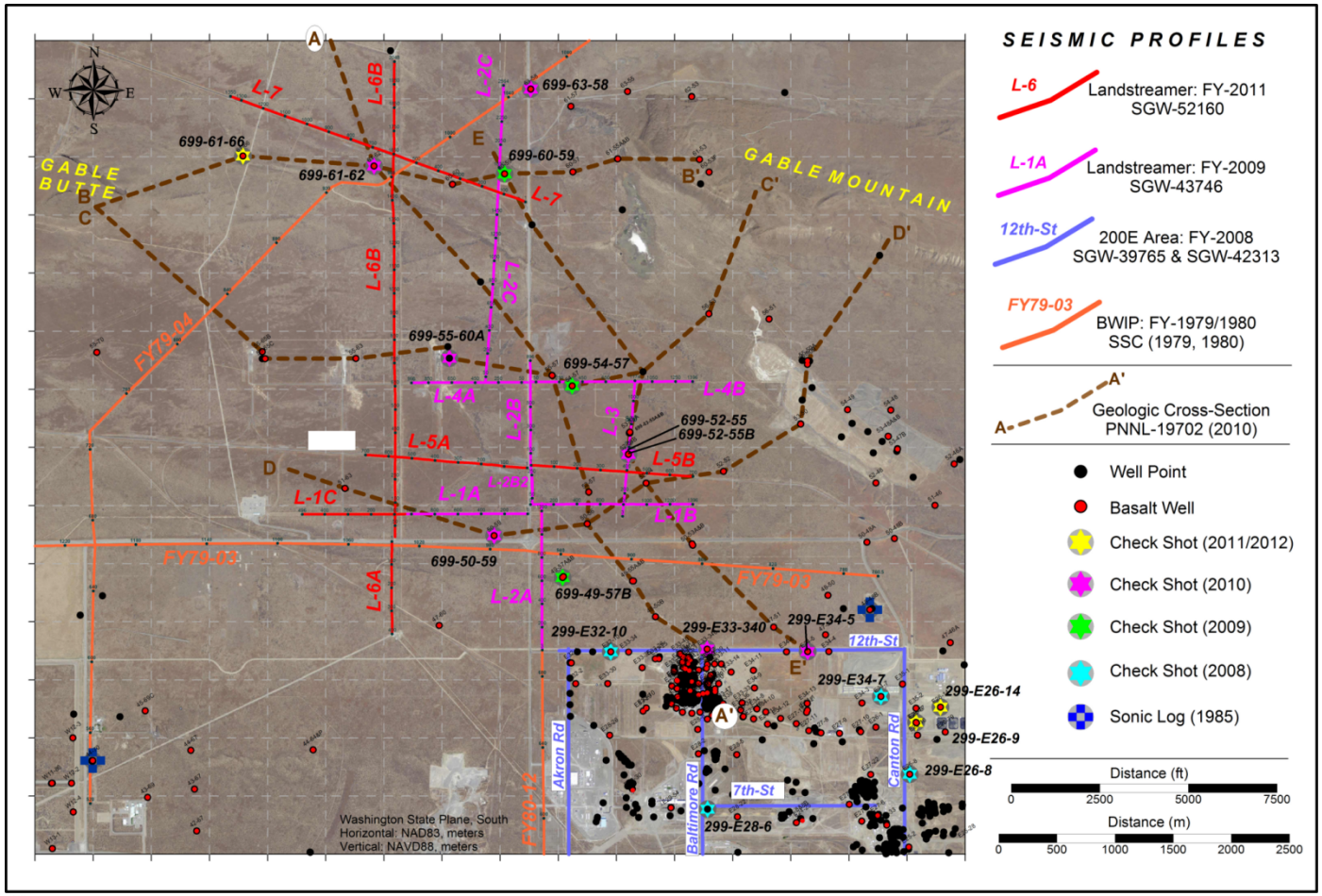
Gable Gap Seismic Surveys

Gable Gap Seismic Investigations

Data Sets

- BWIP (79/80)
- FY2008 (200E)
- FY2009
- FY2011
- Check Shot



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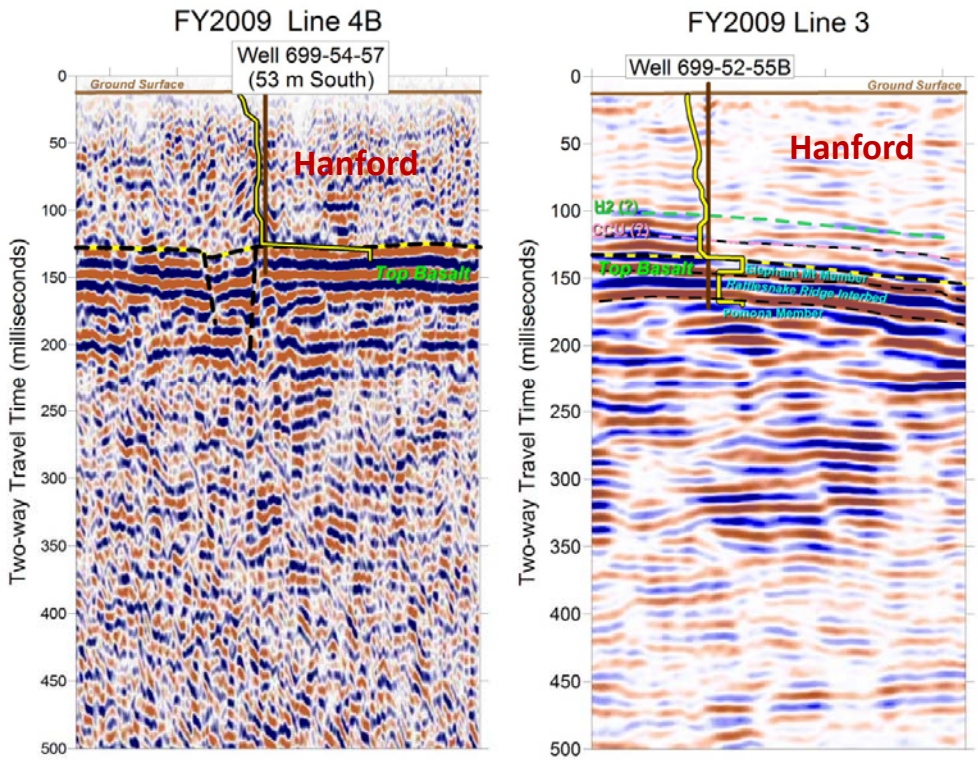
Interpretation Basis

- **Use check shot information to correlate geology with seismic features**
- **Strong reflector at sediment-basalt interface. Due to a high velocity contrast.**
- **Weaker reflectors are observed within the supra-basalt sediments. Correlate with Intra-Hanford and earlier units.**
- **Reflection events below top of basalt correlate with intra-CRBG basalt/interbed sequences**



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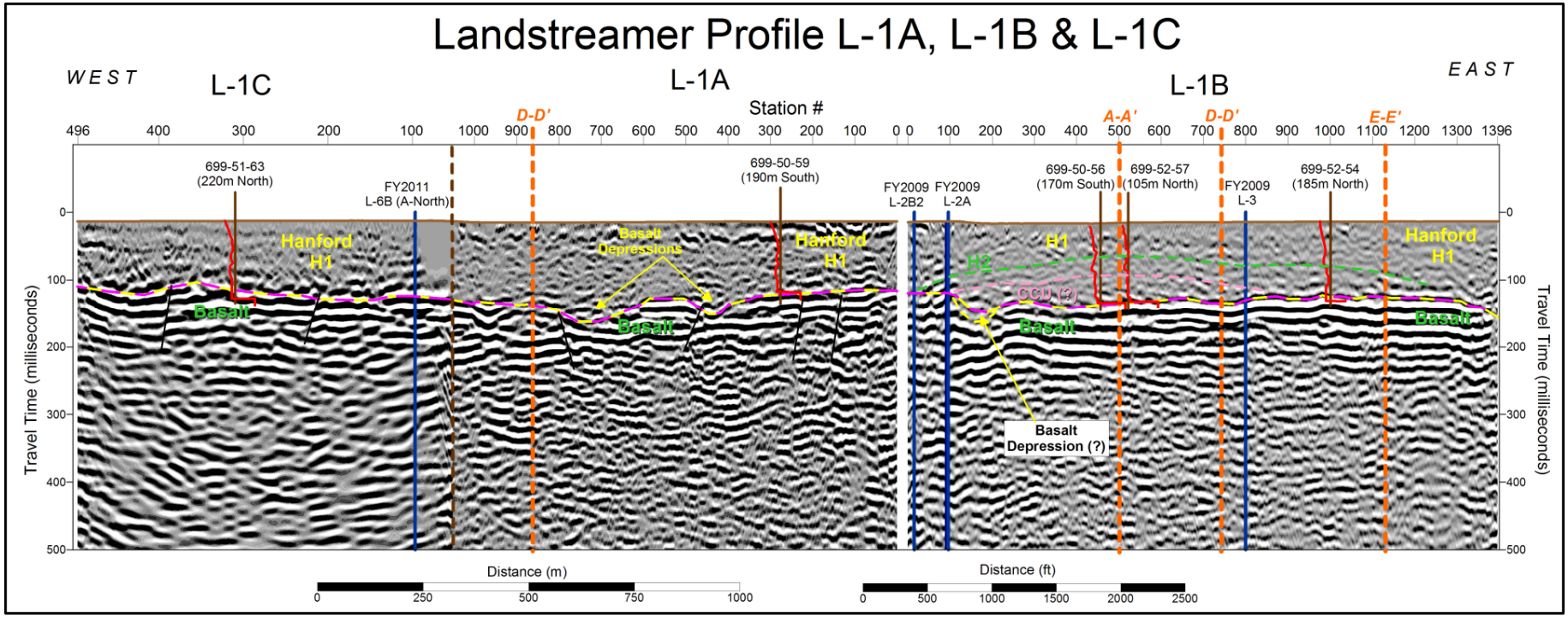
Gable Gap Profile Line 1



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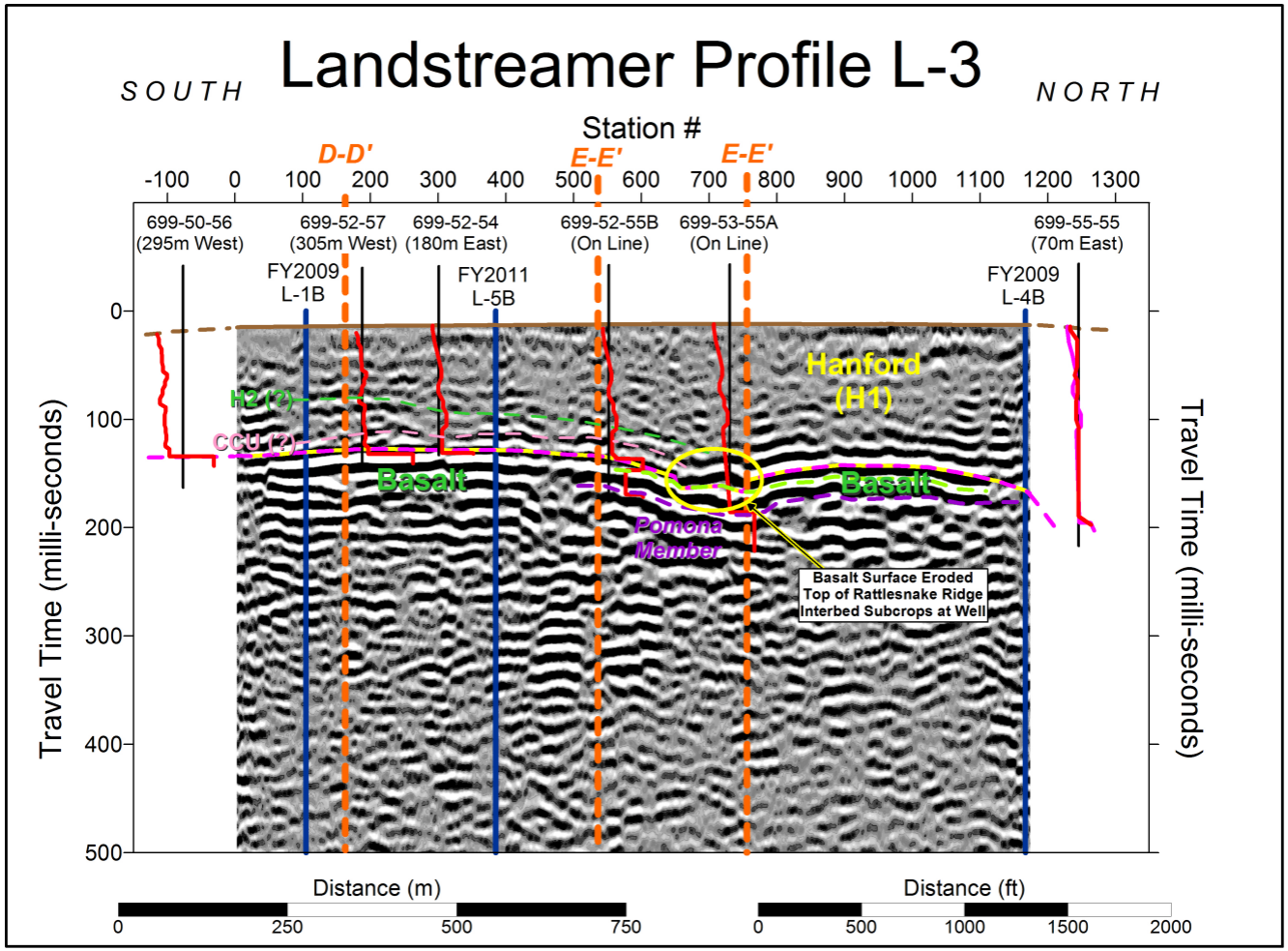
Gable Gap Profile Line 3



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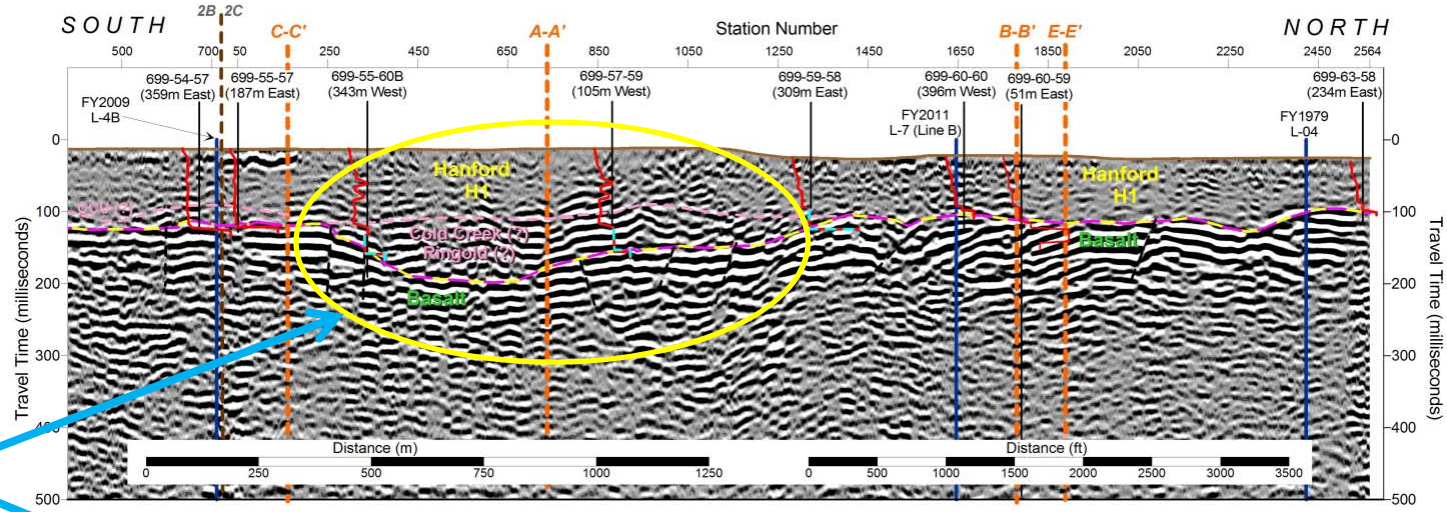
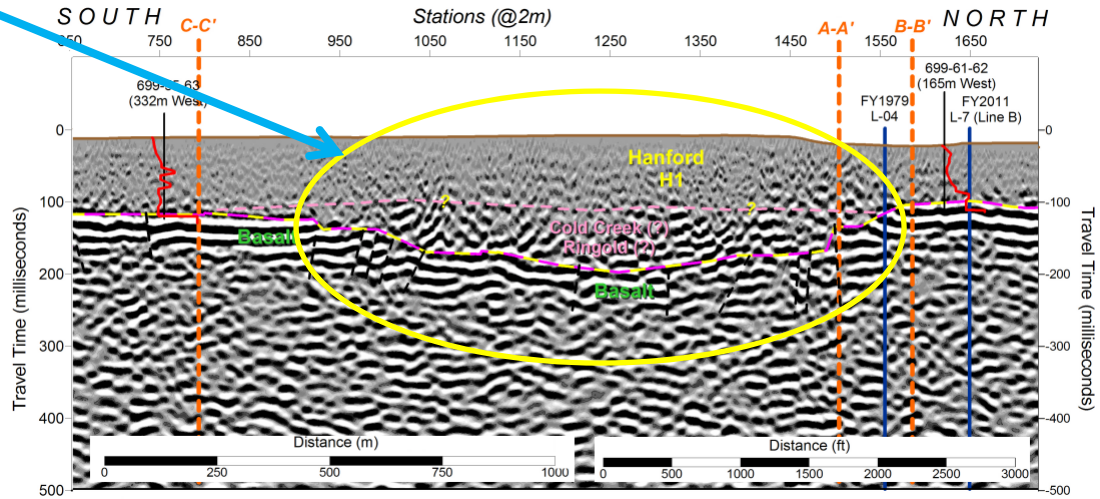
Gable Gap Profiles Line 2 & Line 6

Line 2C

Basalt Surface Depression



Line 6B



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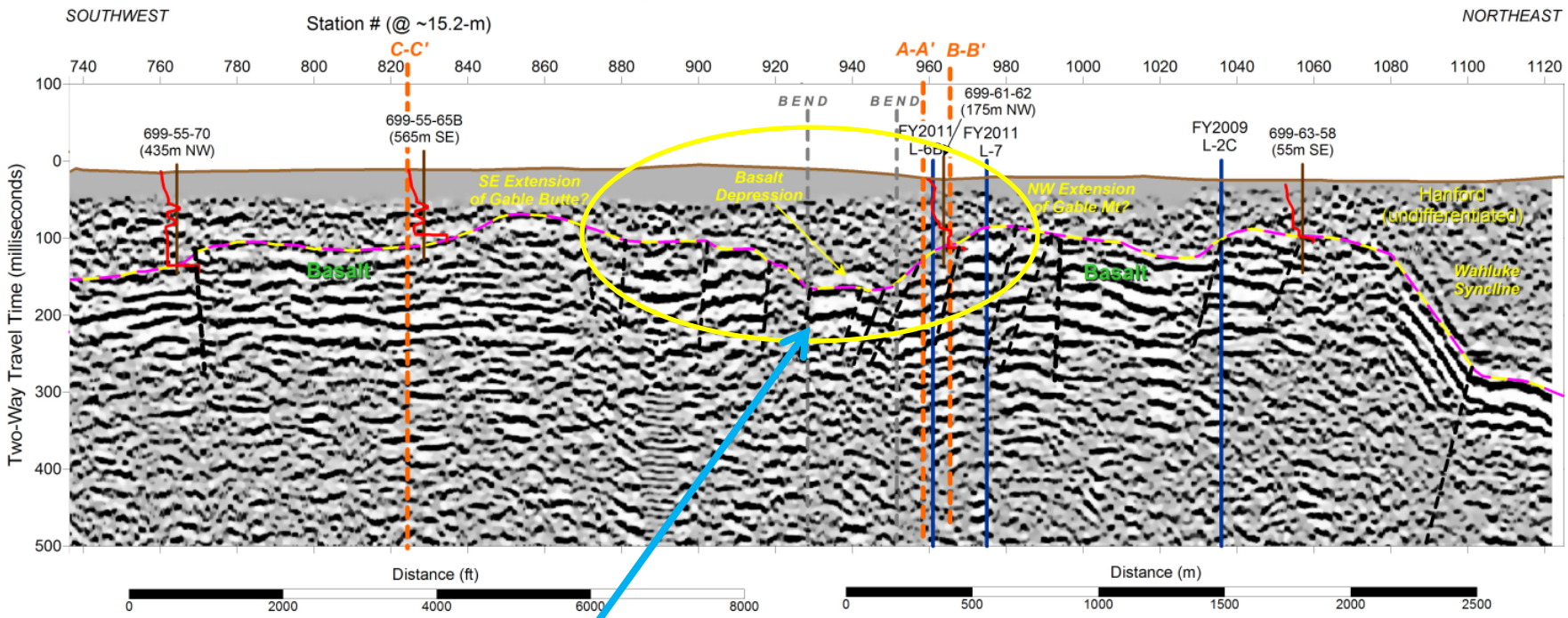
Gable Gap Profile BWIP FY79-04



Basalt Surface Depression

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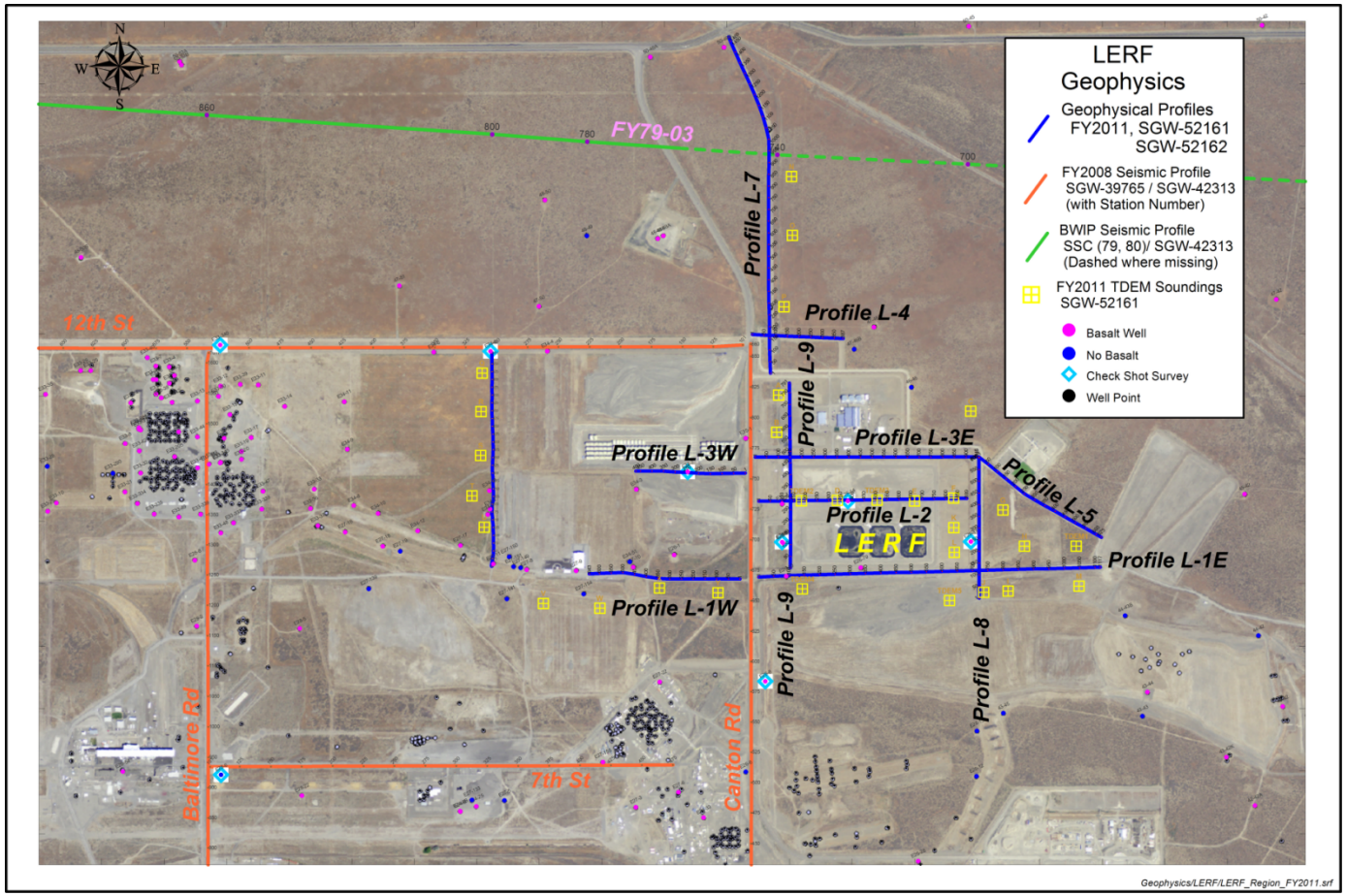
LERF Geophysical Surveys

LERF Geophysical Investigations

Data Sets

- BWIP
- FY2008 (200E)
- FY2011
- Check Shot



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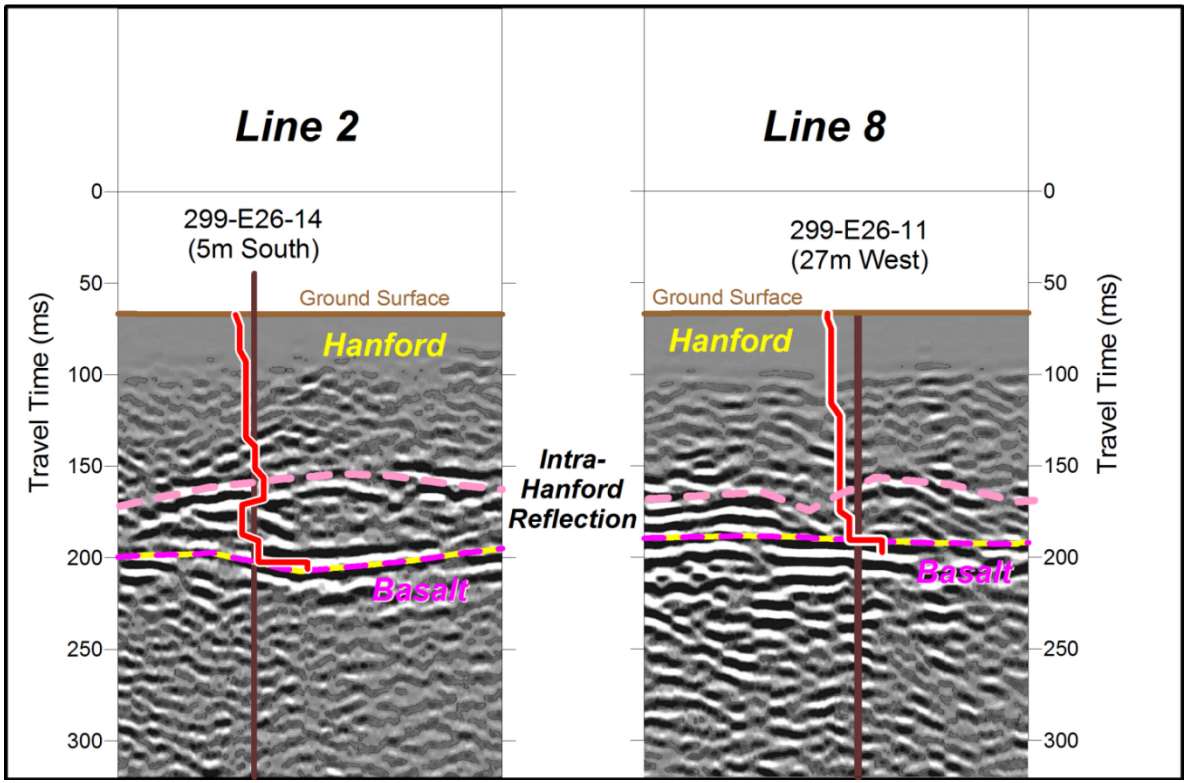

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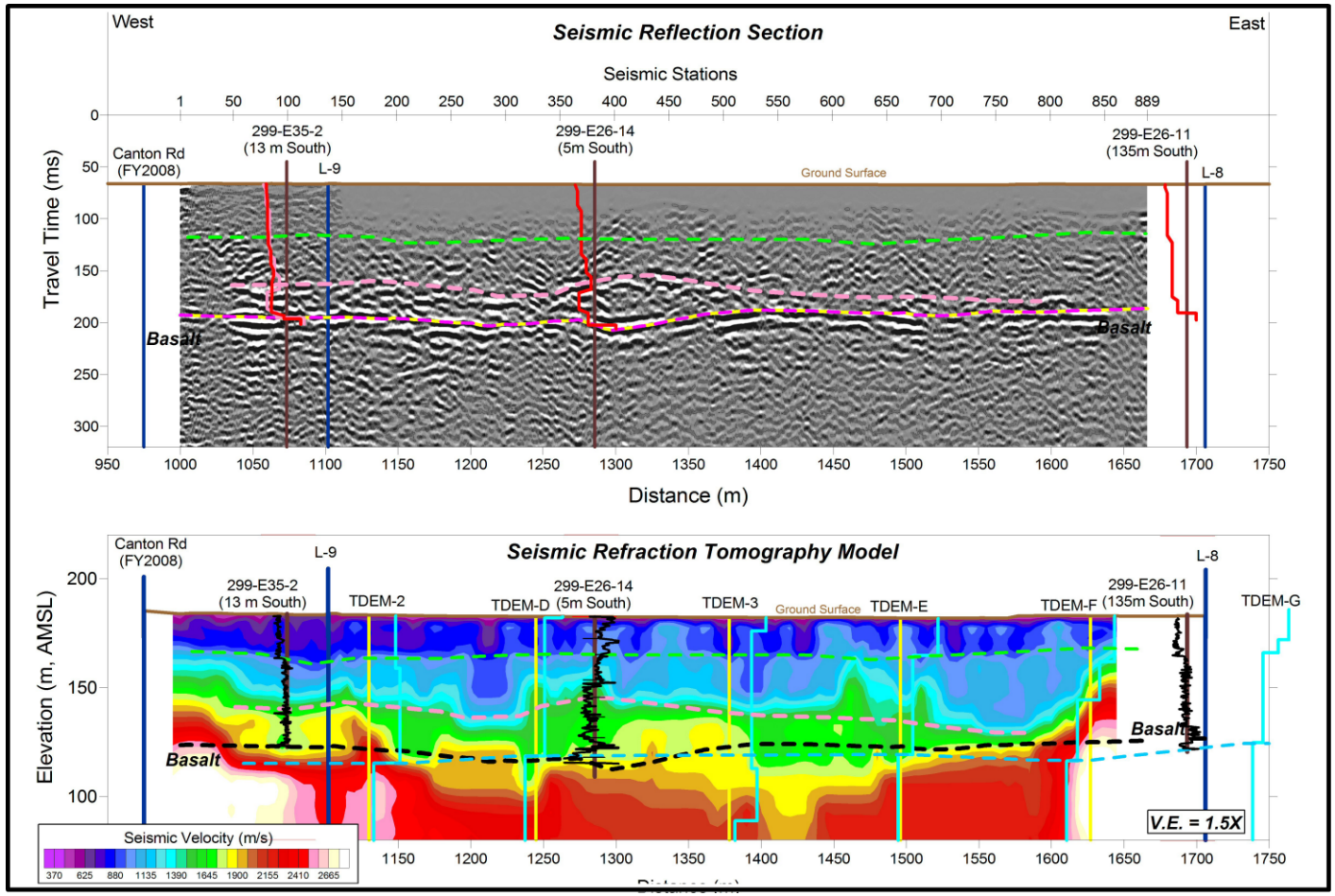
LERF Profile Line 2

Seismic Reflection Section

Seismic Refraction Model



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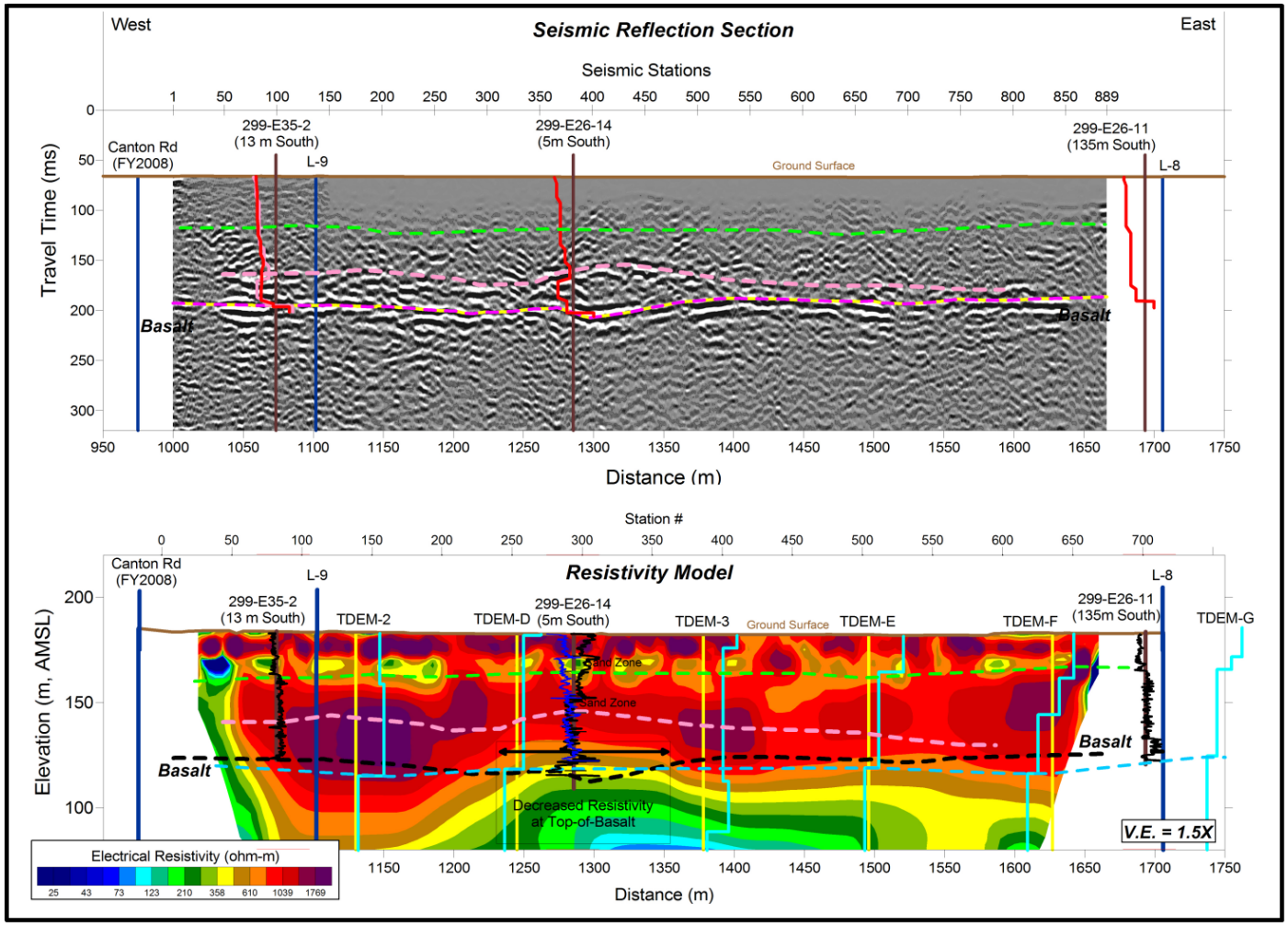
LERF Profile Line 2

Seismic Reflection Section

Resistivity Model



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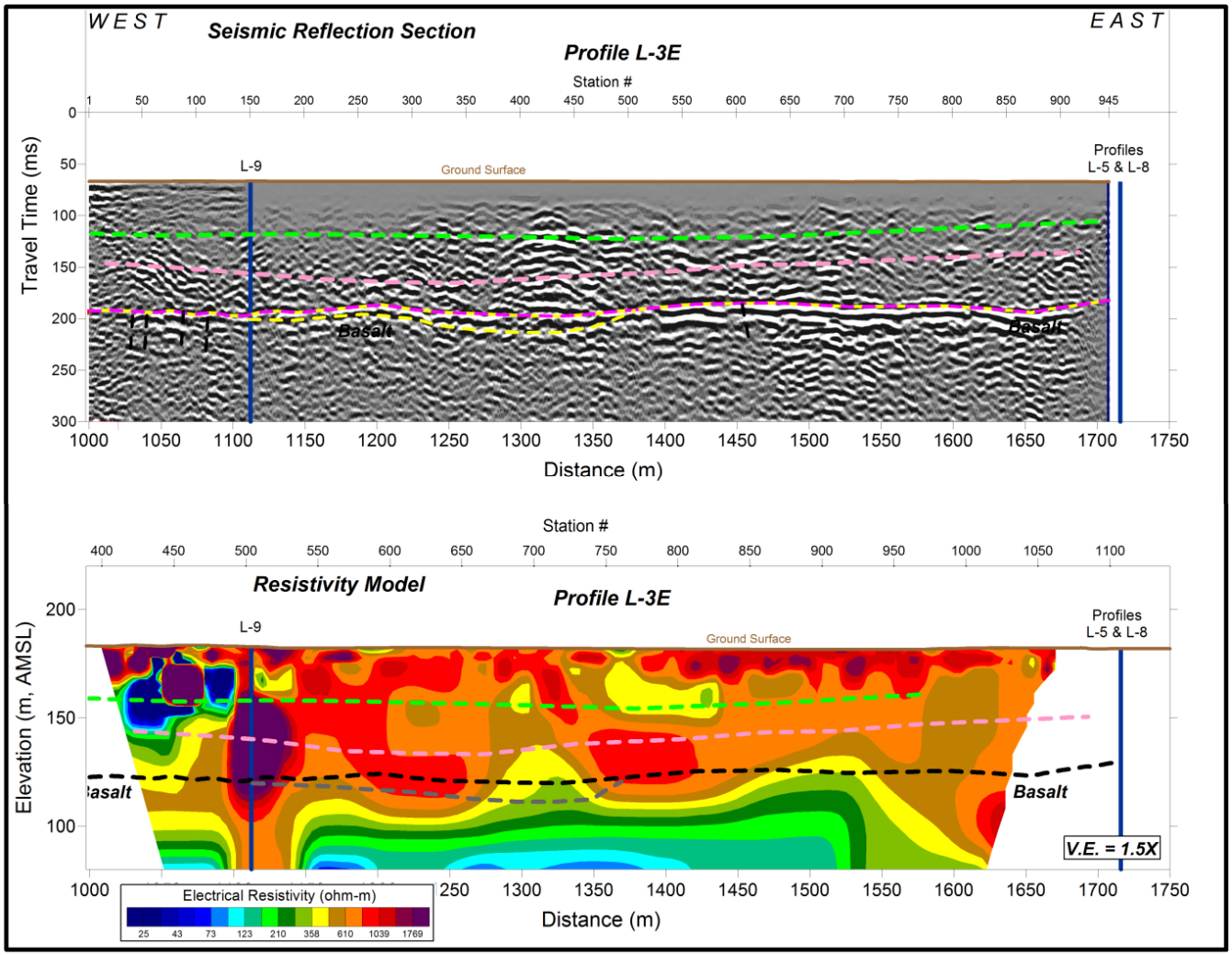
LERF Profile Line 3

Seismic Reflection Section

Resistivity Model



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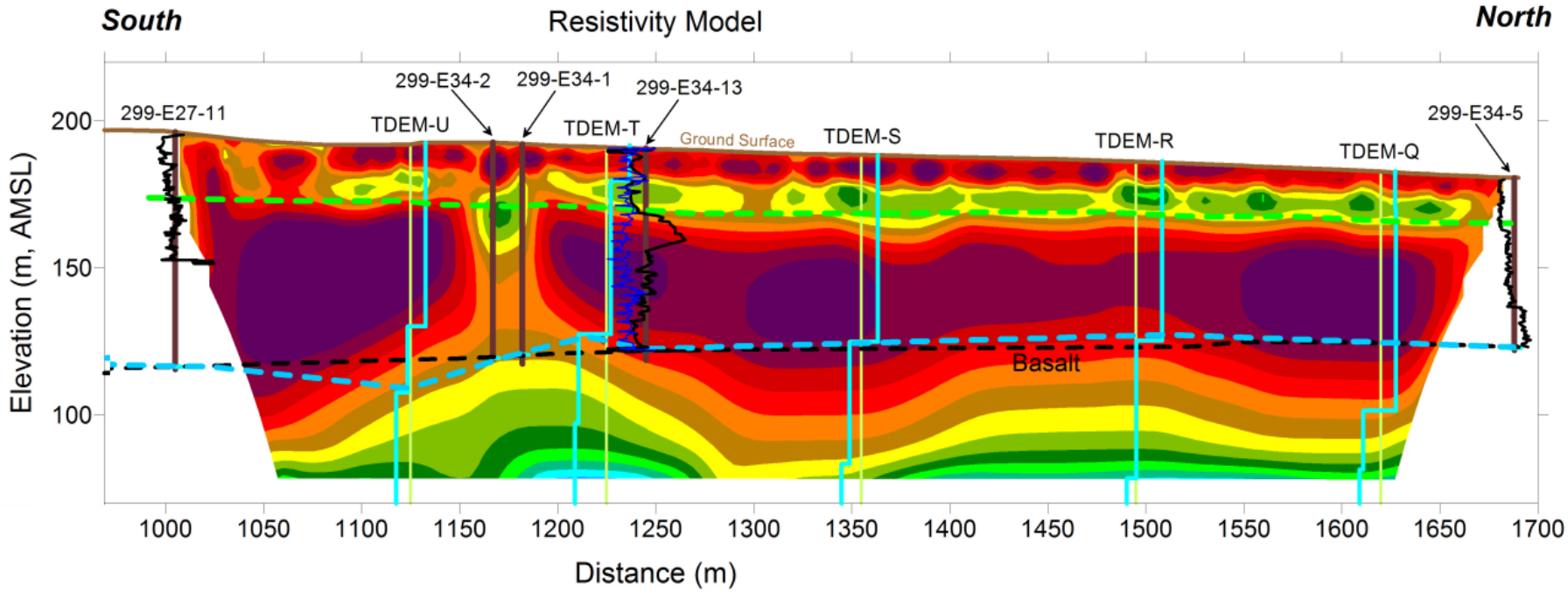
LERF Profile Line 6



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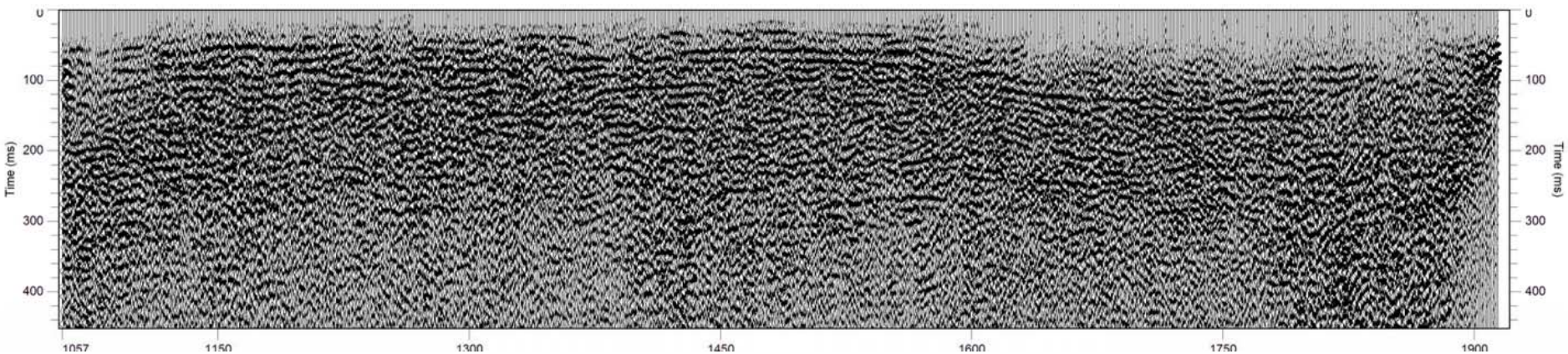
LERF Profile L-1: Shear-Wave Reflection



Results are poor, though zones of reflectivity at depth are observed.

Issues: Coarse gravels/cobbles

Poor coupling between landstreamer geophone and ground surface

Too weak of a seismic source.

Shear-wave abandoned for seismic refraction in an attempt to get strength information about the upper basalt.

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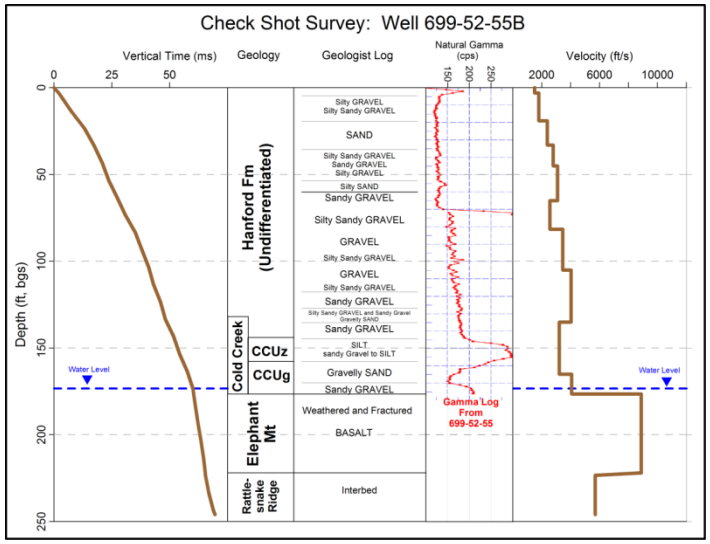
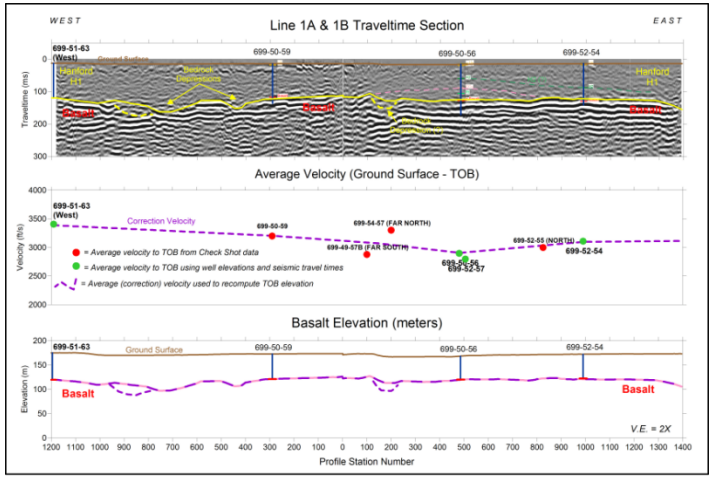
Basalt Surface Development

- Well Control
  - Geologic Tops Data
  - Geophysical and Geological Data
- Seismic Information
  - Interpreted Basalt Surface
  - Travel time and profile position
  - Check Shot: Travel Time, Depth, and Seismic Velocity
- Convert Seismic Interpretation to Elevation
  - Check Shot: Determine Average Velocity, Ground Surface to Basalt
  - Interpolate Check Shot Information Between Well Points and Along Profile
  - Develop per Profile Velocity Function to Convert from Seismic Travel Time to Depth (Elevation)





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Basalt Surface Development (cont.)

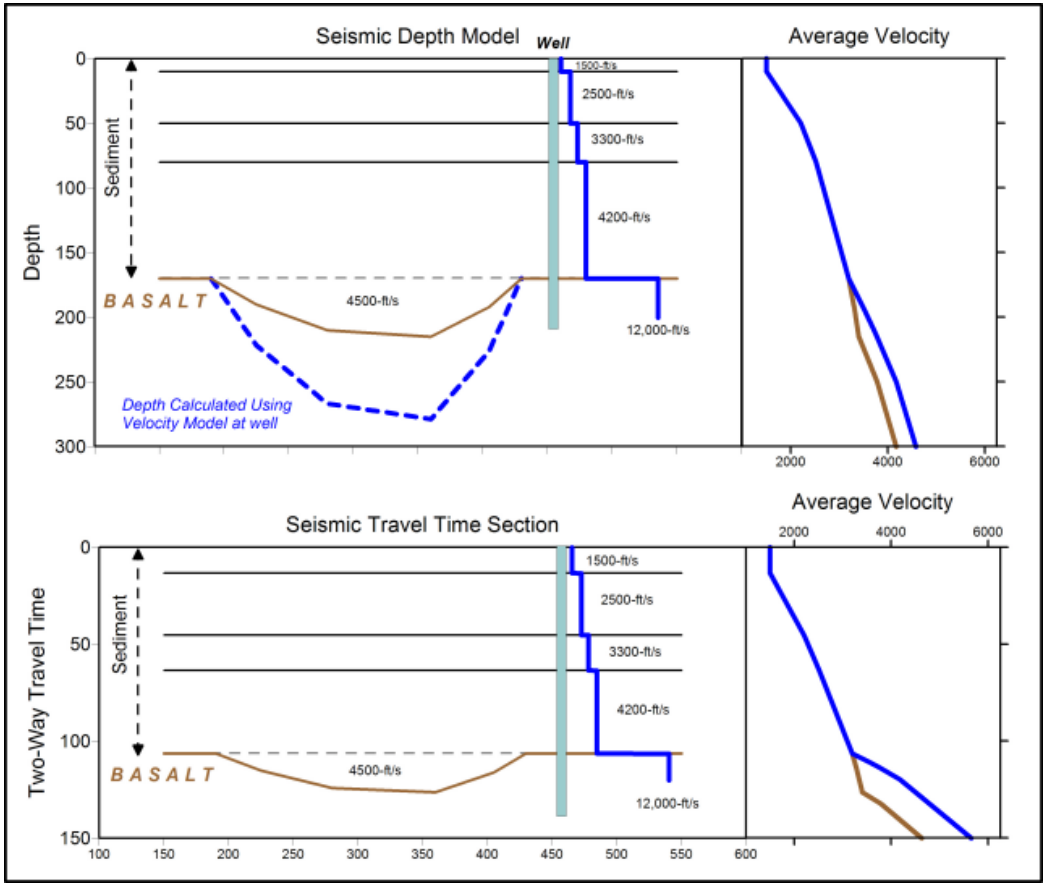
The per profile velocity function is designed to minimize over and underestimating the depth to and elevation of the basalt surface.

A Common Case

- **Depth to basalt is overestimated in observed depressions.**
- **Upper Panel:**
  - **Seismic Depth Model**
  - **Well with Check Shot**
  - **Basalt Surface Depression**
- **Lower Panel**
  - **Seismic Travel Time Model**

- **If the velocity function for the well is used for the depression, the resulting depth (blue dashed line) is greater than actual (brown line).**

- **An intermediate control point using an estimated velocity for the material within is required to more accurately determine the magnitude of the basalt surface depression**



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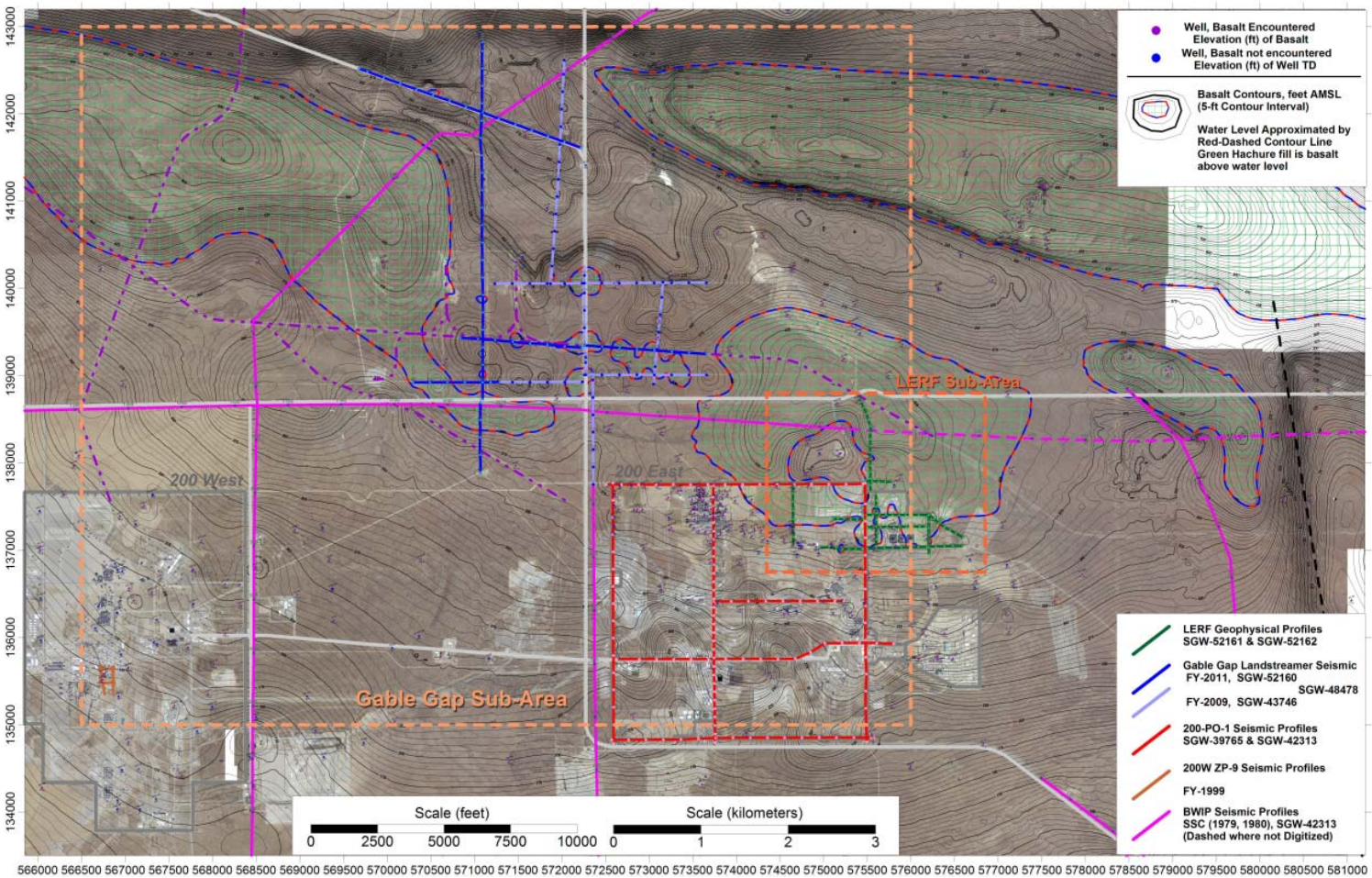
Basalt Surface (Central Plateau)



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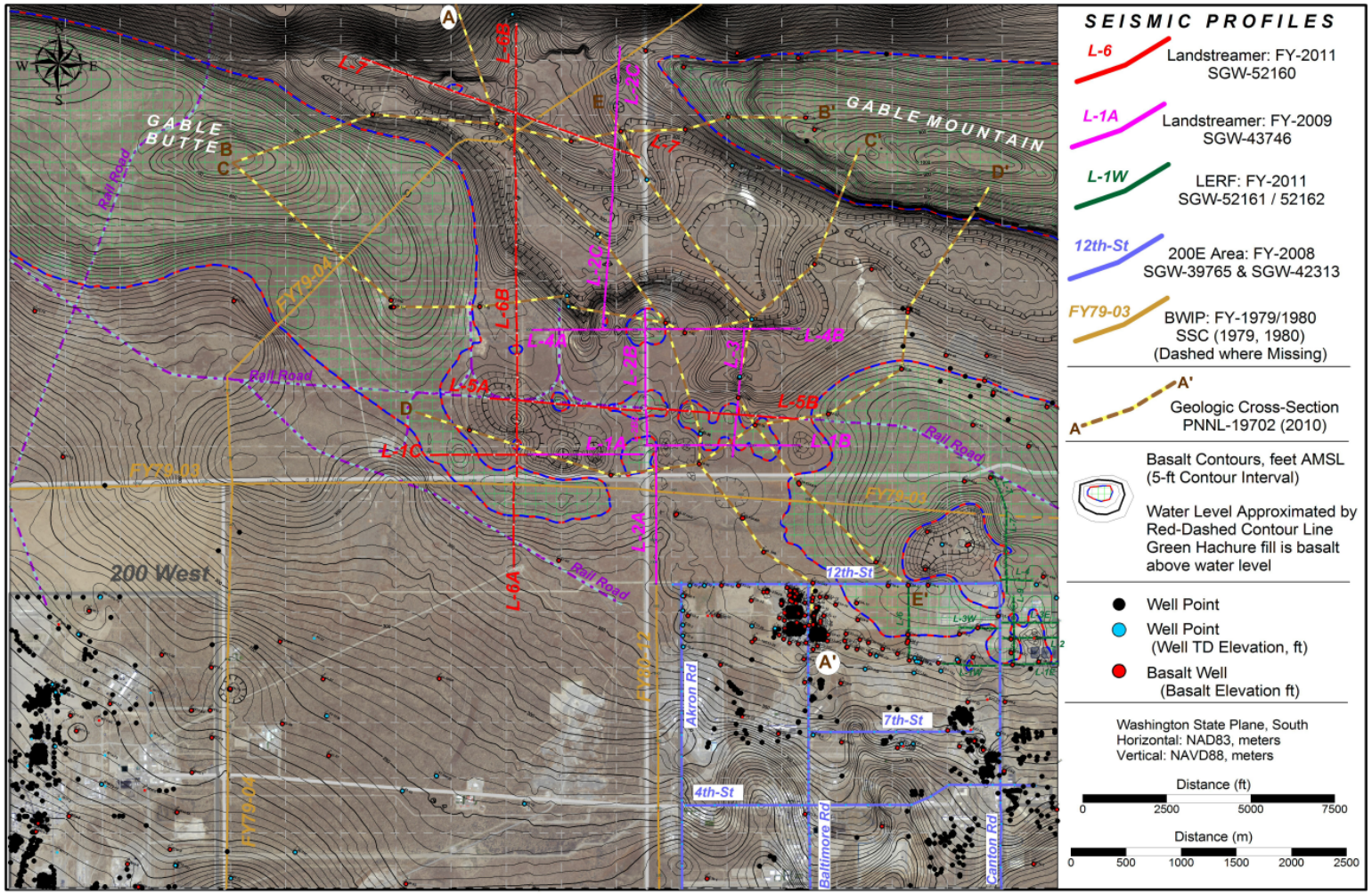
Basalt Surface (Gable Gap)



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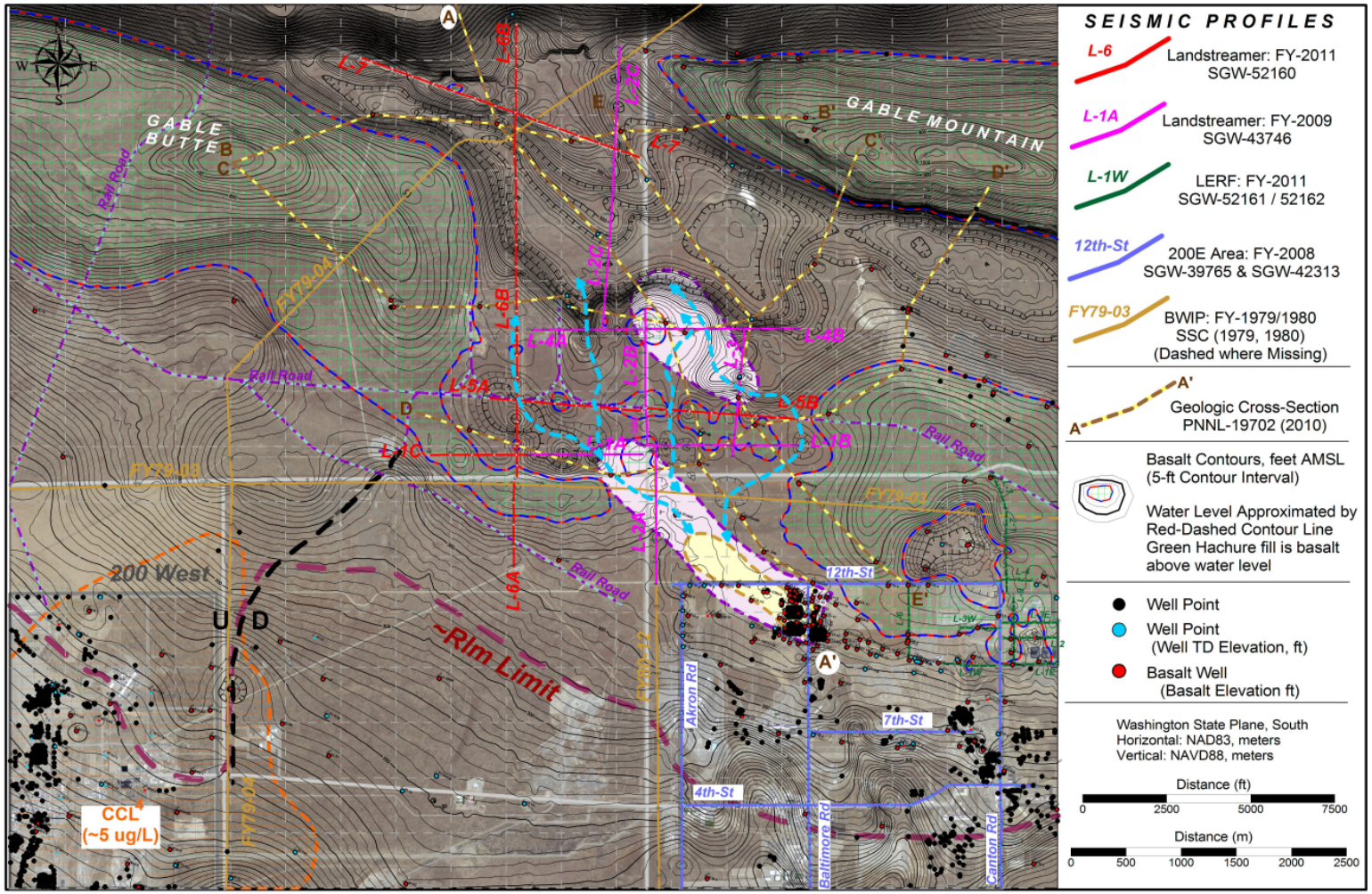
Basalt Surface (Gable Gap)



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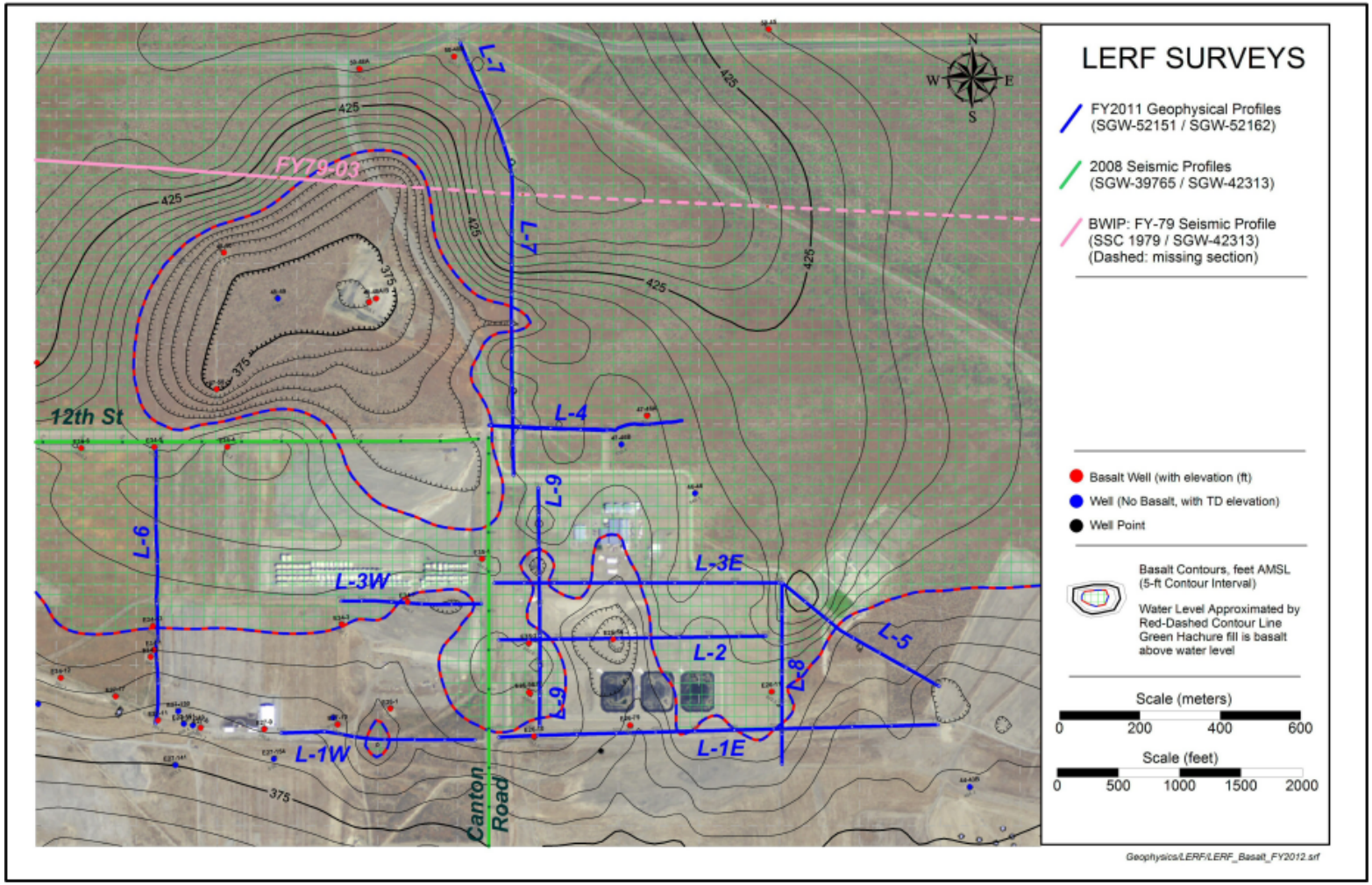
Basalt Surface (LERF)



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Summary

- **Seismic reflection data acquired within the Gable Gap and near LERF were able to:**
  - **Image top of basalt.**
  - **Identify intra-Hanford and CCU/Ringold Contacts**
  - **Intra-CBRG (interbed and basalt members) Contacts.**
- **Electrical-Resistivity data acquired near LERF**
  - **Identified likely "wet" zones near the basalt-sediment interface**
  - **Intra-Hanford changes from gravels to sands and vice-versa**
- **TDEM**
  - **Responded to a combined sediment-basalt contact and saturated zone.**

- **Top of basalt defined by the seismic reflection data**
  - **Integrated with well network to generate a refined basalt surface map for Gable Gap and Central Plateau**
  - **Detailed Low**

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Geophysical Reports

Landstreamer Seismic Surveys (Gable Gap)

SGW-43746: Landstreamer Seismic Vendor Report (FY2009 Surveys)
SGW-52160: Landstreamer Seismic Vendor Report (FY2011 Surveys)
SGW-48478, Rev.1: Integration of Landstreamer, BWIP, 200 East Seismic and Check Shot with underlying Geology. Used to aide Basalt Surface Map (PNNL-19702). Updated with information from FY2011 Surveys

LERF Surveys

SGW-52161: Seismic Surveys Vendor Report (FY2011 Surveys).
SGW-52162: Resistivity Vendor Report (FY2011 Surveys)
SGW-52467: LERF Integration Report

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Lessons Learned: Seismic

- Possible to detect interfaces between Hanford sub-units
- Landstreamer (non-planted geophones) sufficient to collect information regarding structure of basalt surface.
- Impact source is acceptable for generating seismic energy (made possible via greater recording bandwidth afforded by modern seismographs)
- Interaction with Seismic Processor required, use an iterative process for best results for final section
- Check shot information required to tie with underlying geology. Especially critical where Ringold units are more indurated as check shot information helps resolve Ringold from CRBG reflectors.
- Shear-wave reflection surveys still possible. Need more energetic source and use standard planted geophones to improve coupling with ground.

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