APPENDIX B

Pilot Test Results
Additional Geophysical Investigations
Piñon Ridge Mill Site, Montrose County, CO

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Pilot Test Results

Additional Geophysical Investigations
Pinion Ridge Mill Site
Montrose County, CO

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Introduction

A pilot test of geophysical methods has been conducted at the Pinion Ridge Mill Site in Montrose County, Colorado. The objective of the pilot test was to assess the applicability of geophysical methods to investigate possible subsurface structure of concern to planned construction.

An earlier soil trench investigation identified a subsurface feature potentially related to Recent faulting and/or karst-like dissolution of the underlying Paleozoic rock. The soil trench revealed a small, near-surface feature that was funnel shaped and narrowing downward. This feature started approximately 2 feet below the surface, narrowing rapidly to the bottom of the trench at approximately 7 feet below the surface, with a lateral extent of approximately 15 feet.

A recent shallow seismic survey also identified a subsurface feature potentially related to karst-like dissolution of the underlying bedrock. The seismic feature was identified in a refraction profile as funnel shaped and narrowing downward in underlying rock interpreted as Paleozoic evaporites due to high seismic velocity. This feature extends approximately 600 feet north-south along the seismic line S-2 and narrows downward from approximately 50 feet below ground surface to approximately 100 feet below ground surface.

The pilot test consisted of two parts. The first part was to determine if man-packed electromagnetic ground conductivity methods were able to map a near-surface expression of the two funnel shaped features. If this ability was demonstrated, a large and relatively cost-effective survey would be feasible. The second part of the pilot test was to perform deeper soundings with direct current (DC) resistivity and transient electromagnetic (TEM) methods to determine if the Paleozoic bedrock could be detected at depth.

The field work for the geophysical pilot test was conducted during the periods 19 – 21 February and 10 – 13 March, 2008. The initial mobilization in February was curtailed due to very poor site conditions. Most of the effective work was performed during the March deployment. Labor, instrumentation, and technical expertise for the survey were provided by Sunbelt Geophysics of Socorro, New Mexico. Guidance and coordination were provided by Kleinfelder of Albuquerque.

Pilot Test Methodology

Part 1 – Near-surface ground conductivity

The soil trench was located and a data acquisition grid was placed immediately to the east. The grid started at Trench coordinate 408 ft in the south and extended to Trench coordinate 599 ft in the north. The grid extended 100 feet to the east and consisted of parallel data acquisition traverses separated by 10 feet.

The position of the seismic feature was determined from source point (SP) markers from the seismic survey. A data acquisition grid was established from SP-80 in the south to SP-20 in the north for a total length of 984 feet along seismic line S-2. The grid extended 75 feet east – west

and consisted of parallel traverses separated by 25 feet. A longer, single traverse was positioned from SP-140 to SP-1 (2296 ft) along seismic line S-2 and a perpendicular (east – west) traverse running 870 feet was positioned at SP-50.

Ground conductivity data were acquired approximately every 1.5 feet along traverse with both a Geonics EM-31 and a GSSI EMP-400 ground conductivity meter. The EM-31 samples to a depth of approximately 18 feet while the EMP-400 samples to a depth of approximately 6 feet.

Data from the EM-31 and EMP- 400 were transferred to a computer for analysis and mapping. The Oasis montaj (Geosoft Ltd.) program was used for processing and image preparation.

Part 2 – Deeper Soundings

DC resistivity and TEM soundings were acquired at two locations where recent soil borings encountered relatively thick gypsum below valley fill. GA-BH-27 with gypsum first reported at 37 feet below ground surface and GA-BH-33 with gypsum first reported at 62 feet below ground surface were selected for the deeper soundings.

DC resistivity soundings were acquired using an AGI miniSting resisitivity meter and a Wenner electrode configuration. The Wenner array was expanded to an "A" spacing of 130 feet at GA-BH-27. Local vegetation limited the maximum "A" spacing to 100 feet at GA-BH-33.

The TEM soundings were acquired with a Geonics Protem 47D system with a 10 meter square transmitter loop and the Protem high-frequency receiver loop in an off-set sounding configuration.

Results

Part 1 - Soil trench

An image of the EM-31 conductivity data acquired immediately adjacent to the soil trench is provided in Figure 1. The position of the funnel shaped feature is annotated. No subsurface expression of the soil feature is found in the ground conductivity data. The variation in measured conductivity is small across the survey, rising modestly to the east. The mild change is possibly due to the ground being cleared of vegetation near the trench.

An image of the EMP-400 conductivity data is presented in Figure 2. There is a sinuous east-west fabric to the data in the vicinity of the soil trench feature. Unfortunately, this is not unique to the position of the soil feature and similar fabric is seen elsewhere in the data. There is not a sufficient spatial abruptness or contrast in magnitude at the soil feature to reliably distinguish a distinct conductivity feature.

It is concluded that the soil feature observed in the trench does not have sufficient lateral contrast in soil properties to generate a mappable conductivity feature.

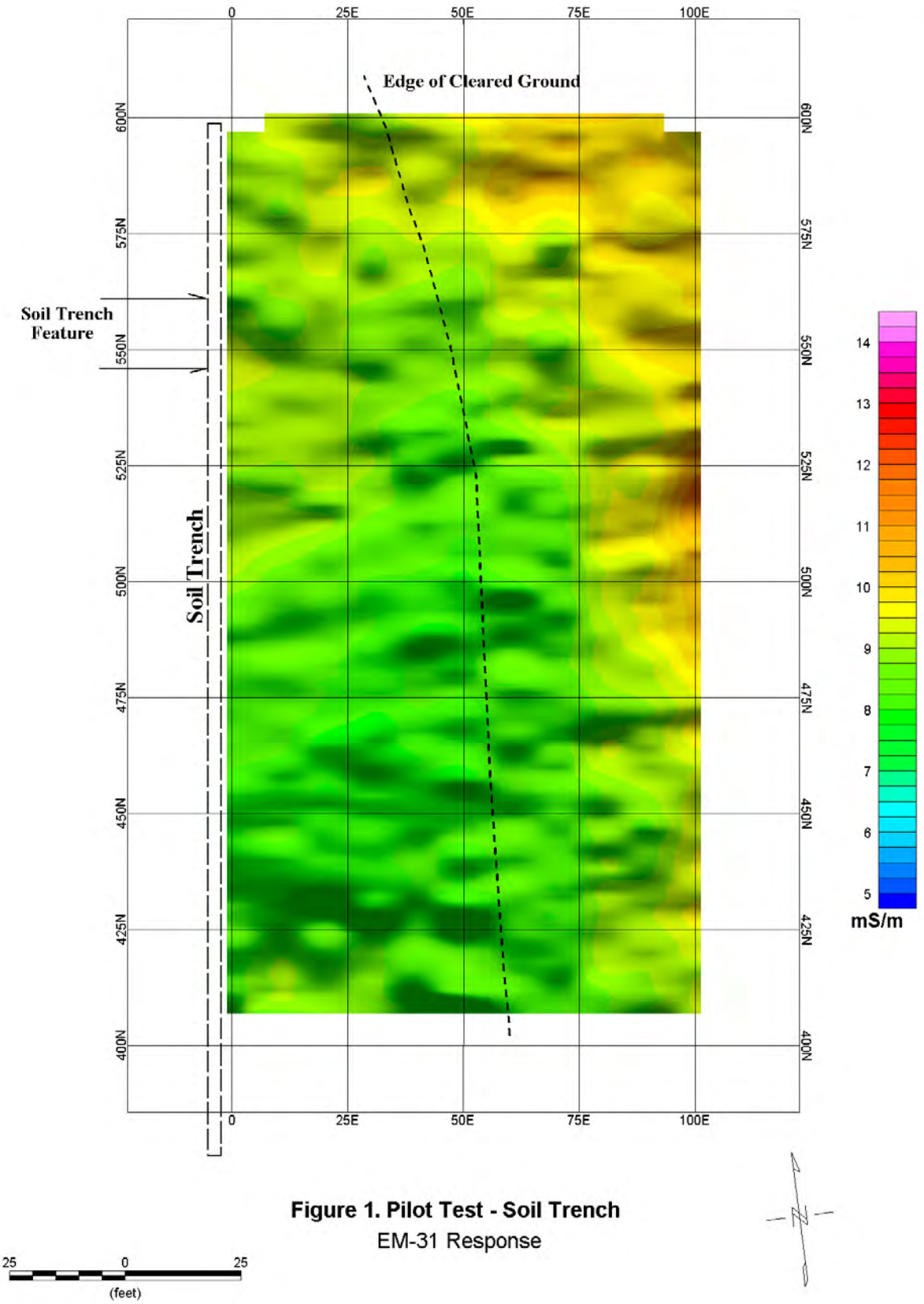


Figure 1. Pilot Test - Soil Trench

EM-31 Response

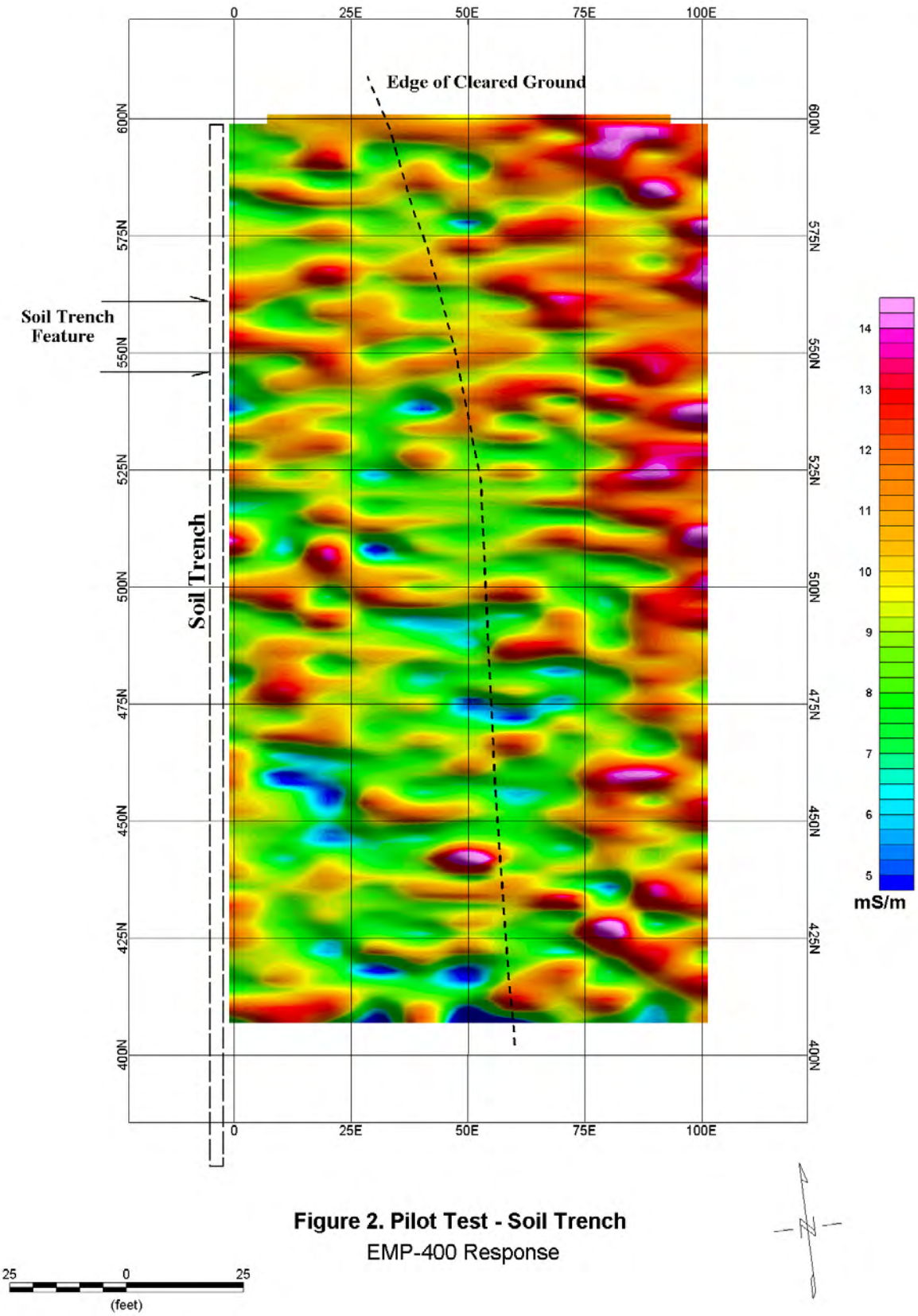


Figure 2. Pilot Test - Soil Trench

EMP-400 Response

Part 1 - Seismic Feature

An image of the EM-31 response over the seismic feature is shown in Figure 3. The approximate northern and southern edges and the approximate center of the seismic feature are indicated on the figure. The seismic source point (SP) locations are given for spatial reference. A mild but intriguing conductivity anomaly appears to be spatially correlated to the position of the seismic feature. Conductivity variations of similar magnitude are observed further to the north.

Extended EM-31 profiles were acquired along Seismic Line S-2 and perpendicular (east-west) at the approximate center of the seismic feature to test this spatially correlated conductivity anomaly. The results are shown in Figure 4. These profiles show that the structure and mild elevation in ground conductivity are not unique to the area of the seismic feature, nor continuous for a few hundred feet to the east or west. The gross elevation in measured conductivity over the seismic feature is only approximately one unit (1 mS/m) greater than "typical" structure along the extended profiles.

The results of the EMP-400 survey in the vicinity of the seismic feature are shown in Figure 5. These shallow data reveal no correlation to the position of the seismic feature.

It is concluded that the near-surface soil structure in the vicinity of the seismic feature does not have a lateral contrast in soil properties sufficient to generate useful or mappable ground conductivity signature.

Part 2. Deeper Soundings at GA – BH – 27

The resistivity sounding data from the vicinity of Borehole 27 and a numerical inversion are shown in the top portion of Figure 6. The sounding indicates a sharp increase in resistivity to approximately 3000 ohm-ft, consistent with an evaporite layer, at a depth of approximately 40 feet. This is in close agreement with the borehole log which reports gypsum at 37 feet.

The TEM data from the vicinity of Borehole 27 are presented in the bottom portion of Figure 6 as a decay curve. This curve shows a sharp increase in interpreted resistivity to approximately 2500 ohm-ft at a decay time of 0.1 mSec. This is consistent with an evaporite layer between 35 to 40 feet, in good agreement borehole log.

Part 2. Deeper Soundings at GA – BH – 33

The resistivity sounding data from the vicinity of Borehole 33 and a numerical inversion are shown in the top portion of Figure 7. These data are somewhat chaotic at shallow depths where the borehole log reports a sequence of sand-clay-silt-clay-sand-clay-claystone above the gypsum. Some of these layers are thin (~ 5 ft) and not resolved by the sounding. The resistivity data do show a strong rise, similar to the data from BH-27, starting at an "A" spacing of 60 ft. This is consistent with a gypsum layer at approximately 60 feet. The vegetation at this site limited expanding the resistivity array further as needed to resolve the top of gypsum.

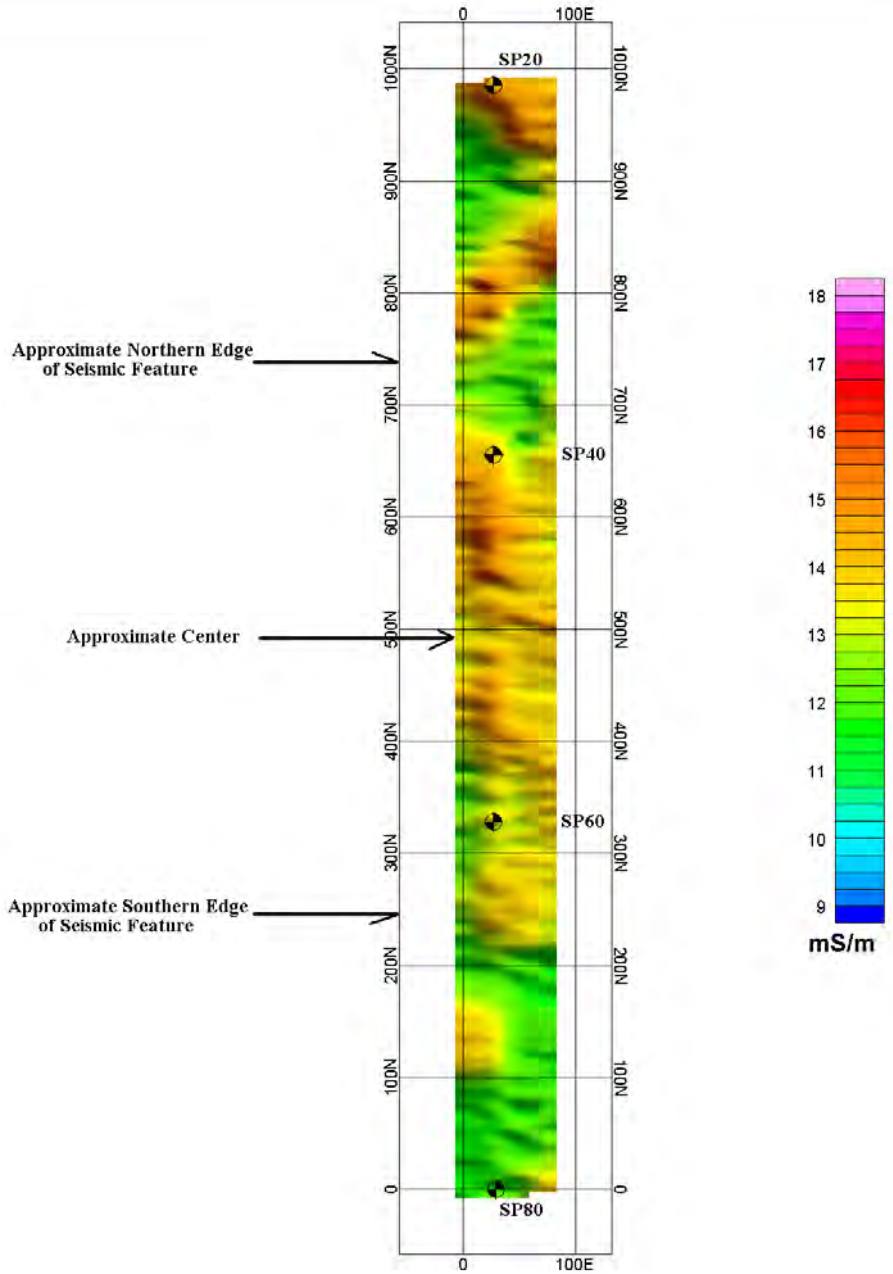
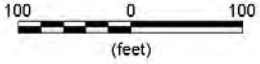
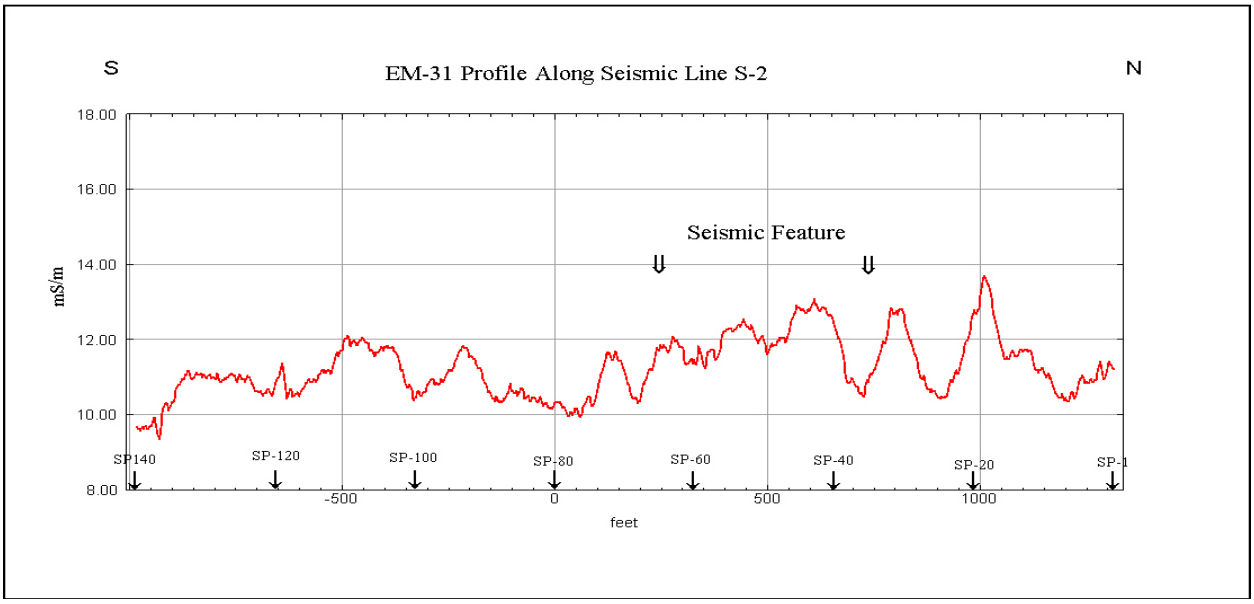


Figure 3. Pilot Test - Seismic Feature

EM-31 Response





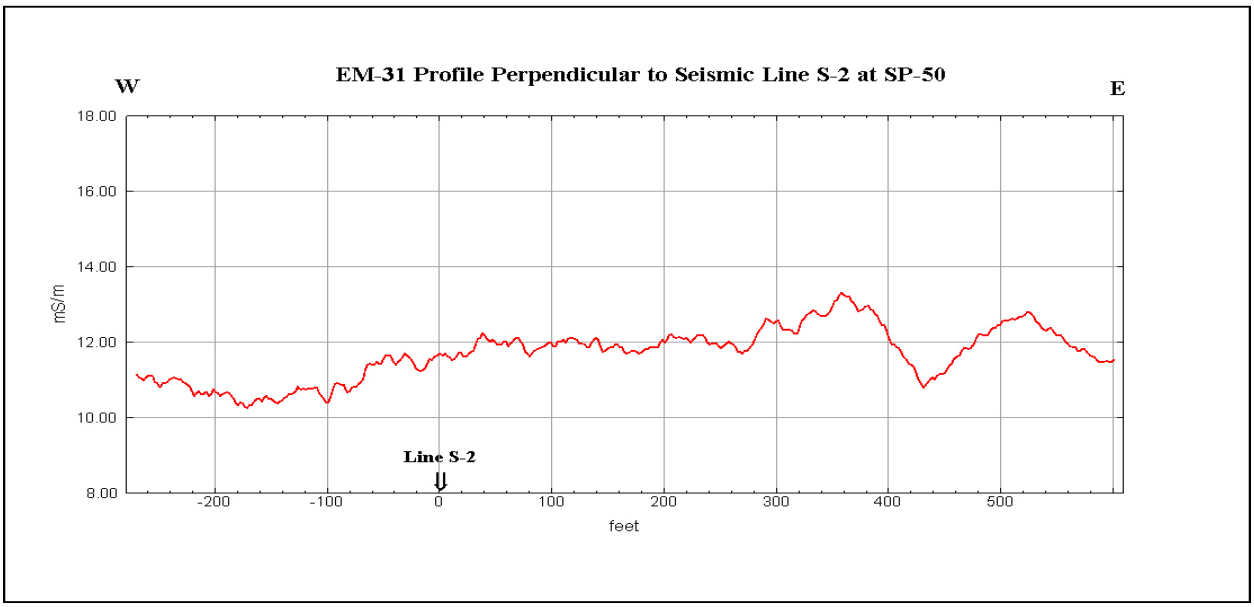


Figure 4. Extended EM-31 Profiles over Seismic Feature

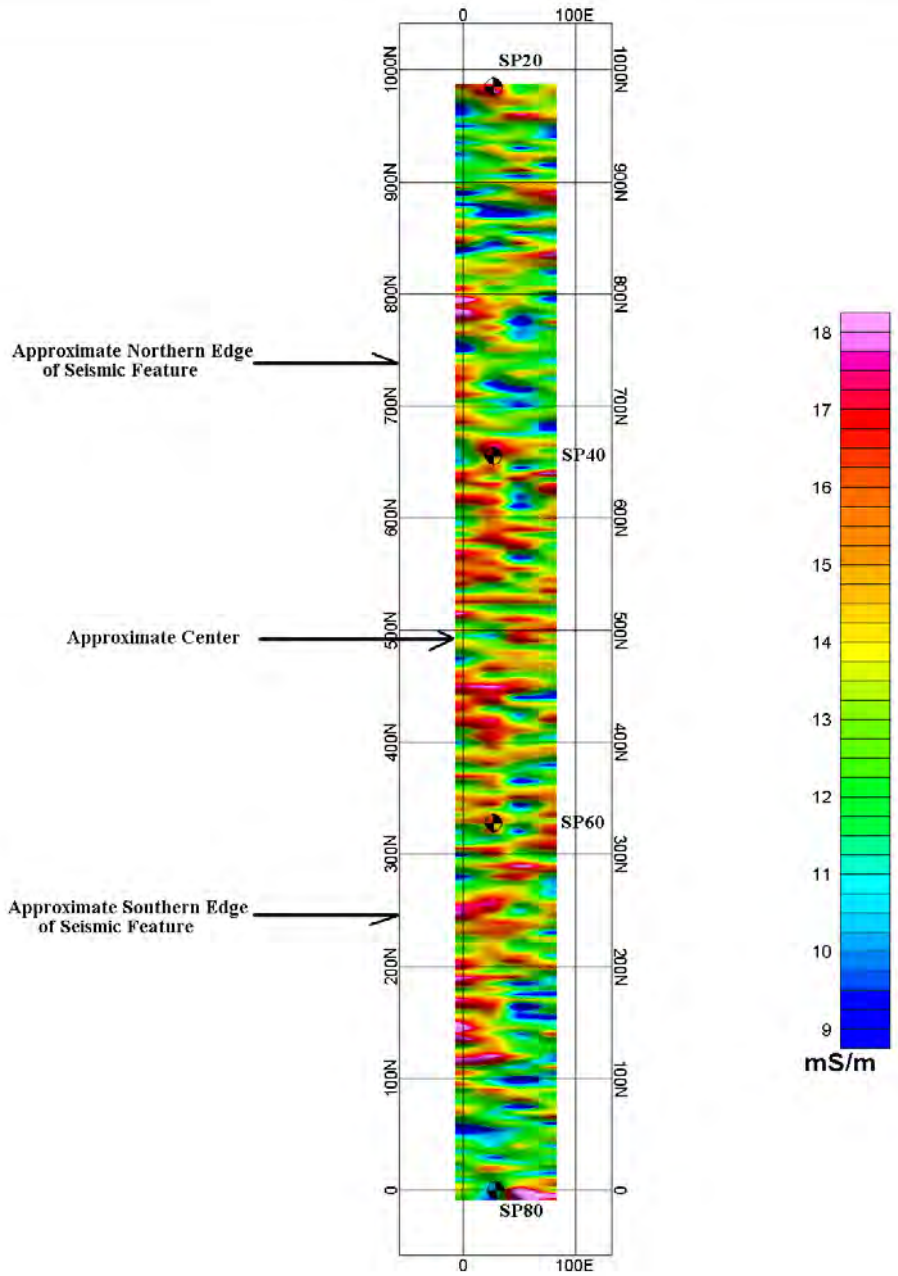
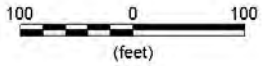


Figure 5. Pilot Test - Seismic Feature

EMP-400 Response



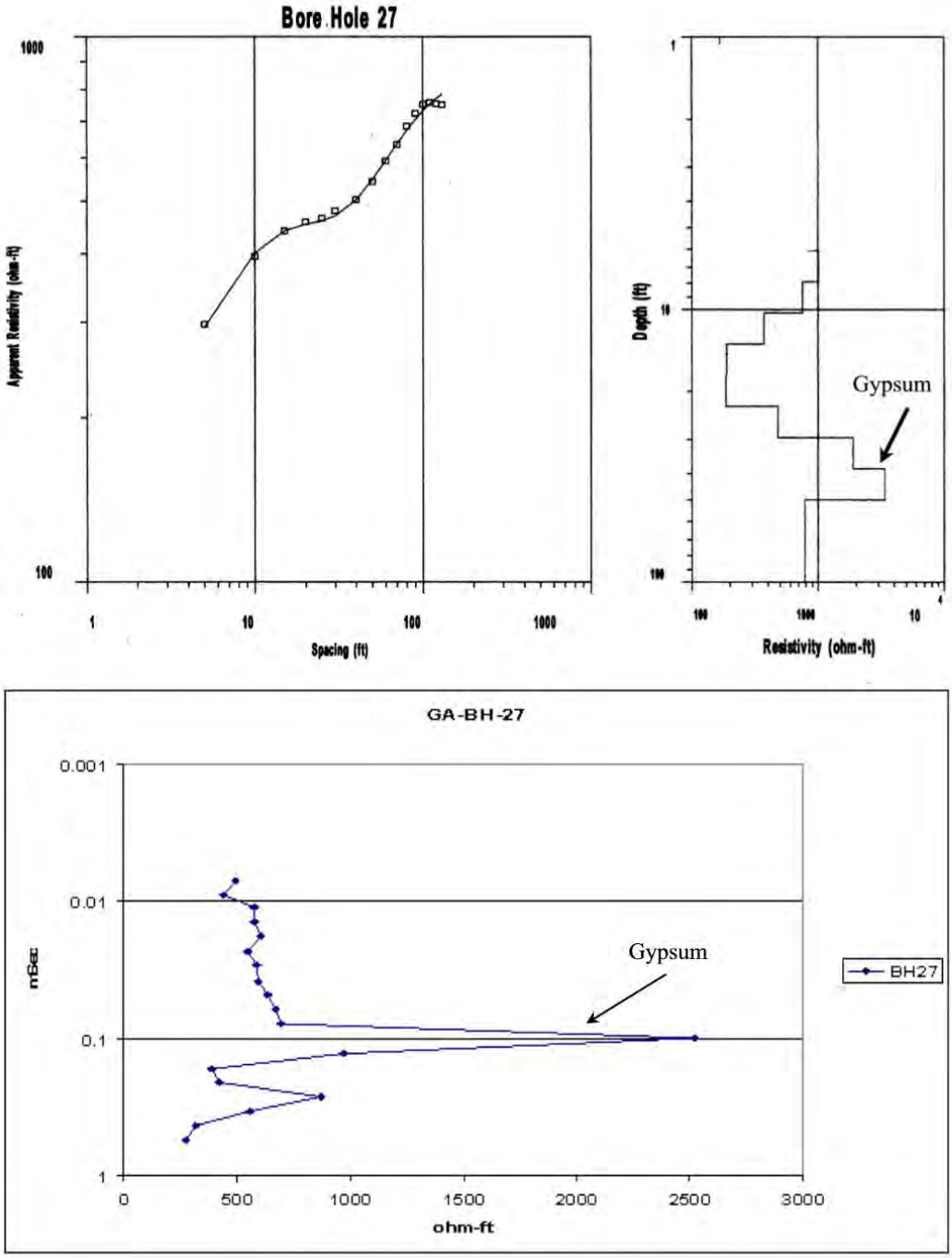


Figure 6. Bore Hole 27 Resistivity (top) an TEM (bottom)

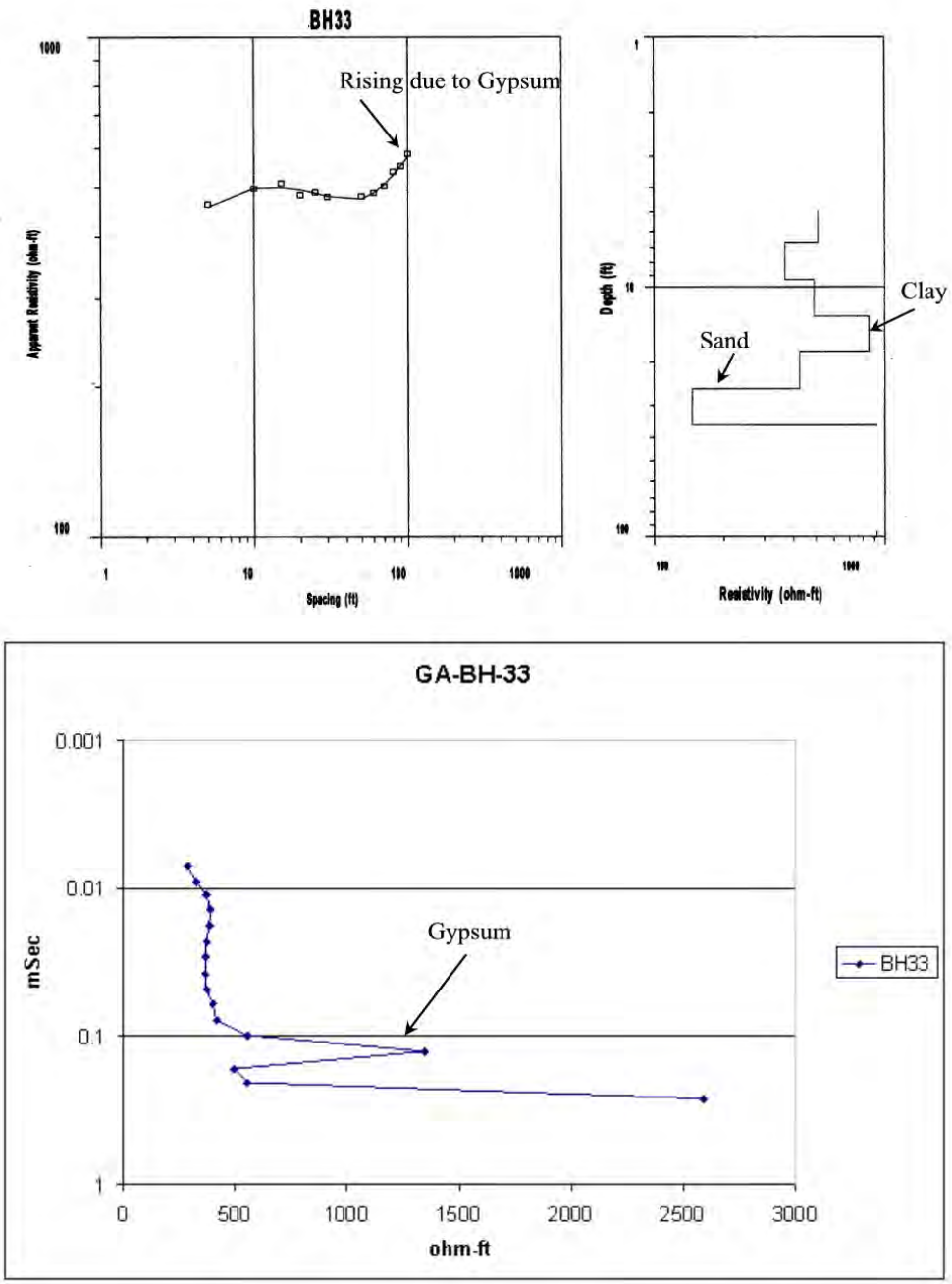


Figure 7. Bore Hole 33 Resistivity (top) and TEM (bottom)

The TEM data from the vicinity of Borehole 33 are presented in the bottom portion of Figure 7 as a decay curve. This curve shows a sharp increase in interpreted resistivity at a decay time of 0.127 mSec. This is consistent with an evaporite layer between 55 to 65 feet, in agreement borehole log that reports gypsum at 62 ft.

Conclusions

The pilot test of geophysical methods at the Pinion Ridge Mill Site was successful in providing an assessment on the applicability of geophysical methods.

- Testing the ground conductivity method demonstrated that the funnel shaped features identified in the soil trench and by the seismic survey do not have an associated near-surface expression suitable for a rapid screening survey.

- The deeper soundings by DC resistivity and TEM both demonstrated an ability to detect the Paleozoic bedrock below the valley fill.

- The DC resistivity method provided robust results near Borehole 27, less so near Borehole 33. This method is limited to those areas where the vegetation has been cleared to allow for electrode spreads on the order of 4 to 5 times the depth to bedrock.

- The TEM method proved robust for detecting the Paleozoic bedrock, although resolving the depth with high resolution would require a somewhat more involved sounding procedure than used during the pilot test. This method only requires a cleared area of approximately 35 ft by 35 ft.

The TEM and DC resistivity methods, singly or in combination, should be considered for mapping the Paleozoic bedrock in areas of critical concern. Neither method is suitable for rapid, large scale mapping.