Geophysical Surveys near Old Yuma Mine, Tucson Mountains, Arizona

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Abstract

To assist the United States Geological Survey with an on-going groundwater study around Old Yuma Mine in Tucson, Arizona, the University of Arizona GEN/GEOS 416/516 Field Studies in Geophysics class conducted geophysical surveys along two transects near the mine. Transect 1 was situated across the mine site; Transect 2 was located to the northeast in a nearby residential area. The methods used were gravity, magnetics, transient electromagnetics (TEM) and inductive electromagnetics (Geonics EM-31, and Geonics EM-34). The goal was to use these data to investigate the subsurface density, magnetic susceptibility, and electrical conductivity contrasts. A large gravity anomaly was observed on Transect 1 where it crosses both a mapped fault and the Old Yuma Mine; the anomaly is thought to represent a density contrast related to the Mine and fault. A smaller gravity anomaly was observed on Transect 2, corresponding in location along the profile to a large anomaly in the Transect 2 magnetics data. These anomalies are possibly related to the local lithology. A second magnetics anomaly was observed on Transect 1; this anomaly was also visible in the EM-31 and EM-34 data and could be due to the presence of a nearby wash. Other variations in the magnetics and EM-31/34 data consisted of narrow peaks associated with cultural interference, and the EM-31/34 data showed no large conductivity change in the shallow sediments. Interpretation of TEM data for Transect 1 was limited by the wide station spacing; much of the cross-section's resistivity contrasts were interpolated over a large distance. The TEM cross-section for Transect 2 displayed higher resistivity on the northwest side and lower resistivity on the southeast side of the transect. Since the mapped fault, if projected northwards, would pass through the middle of Transect 2, it is thought that this resistivity contrast represents the location of the fault. It is hoped that the results of these surveys will be beneficial to the USGS in further work at Old Yuma Mine.

1. Introduction

The Old Yuma Mine is an abandoned underground mine in the Tucson Mountains, just west of the Tucson metropolitan area. From 1885 to 1954 this historic location produced a wide variety of metals, including lead, copper, silver, gold, molybdenum and vanadium. The mine operated sporadically between 1916 and 1947, and was officially closed in 1954 (Mindat, 2016). The park now belongs to the National Park Service. The USGS has requested, with the National Park's permission, that a series of geophysical tests be done to determine the geological structures surrounding the mine area as well as the hydrological features.

There are a number of rocks along the two transects where the tests were carried out. Transect 1 mainly consists of volcanic rocks. The Southeast half of the line is mainly of the youngest flow of tan to light-gray aphanitic rhyolite and dacite. These lava rocks can have small phenocrysts of sanidine, plagioclase, and biotite. There is also some volcaniclastic sandstone, shale, and conglomerate at the southeast tip. The northwest half of transect 1 is dark gray aphanitic andesite volcanic rocks. These can have phenocrysts of sanidine, plagioclase, augite, and serpentine pseudomorphs. The area around transect 1 is full of many volcanic rocks. Transect 2 mainly has surficial alluvial fan deposits (Holocene and Pleistocene) consisting of sand, silt, and well-rounded boulders. This type of rock is mainly in alluvial fans. Part of the northwest part of transect 2 is surficial rocks that are found in the bottom of valleys. The Holocene alluvium is sand, silt, and gravel as well (Lipman, 2016).

The ore deposits at Old Yuma mine tended to be around intrusive igneous rocks. These were contact metamorphic deposits in the form of veins (Jenkins and Wilson 16). Some of the magmatic intrusions are called the Silver Lily Dikes. The intrusions occur throughout the area of the Tucson Mountains. Shafts were sunk along the contacts of the dikes and sedimentary rocks (Interior Nat'l Park Service, 2010).

The hydraulic gradient under the Tucson Mountain area is towards northeast in general, with a localized and relatively abrupt decrease near the Old Yuma Mine area (Figure 1.1). The purpose of this study is to better understand the underground water system in the Old Yuma Mine area, and the surveys were conducted in a manner as minimally invasive as possible.

1.1 References

Mindat.org. “Old Yuma Mine (Yuma Mine), Saguaro National Monument, Amole District, Tucson Mts, Pima Co., Arizona, USA.” Mindat.org, 2016. Web. March 23 2016. http://www.mindat.org/loc-3372.html

Lipman, P.W. “Geologic Map of the Tucson Mountains Caldera, Southern Arizona.” *National Geologic Map Database* (2016): n. pag. *Usgs*. Web. 20 April 2016. http://ngmdb.usgs.gov/Prodesc/proddesc_10186.htm

U.S. Department of the Interior National Park Service. *Saguaro National Park*, *Geologic Resource Inventory Report*. Ft. Collins: Natural Resource Program Center, 2010. Print.

Jenkins, Olaf, and Eldrid Wilson. *List of United States Geological Survey Publications Relating to Arizona*. Tucson: University of Arizona Bureau of Mines, 1920. Print. https://books.google.com/books?id=dFNEAQAAMAAJ&pg=PA60&lpg=PA60&dq=intrusive+geology+at+yuma+mine&source=bl&ots=gbJNsuRxrc&sig=gEwY9dx8dJApO3L3tb2NW4lASAQ&hl=en&sa=X&ved=0ahUKEwiiivmdgqHMAhUQ22MKHfgyDssQ6AEIKzAC#v=onepage&q=intrusive%20geology%20at%20yuma%20mine&f=false

Kimberly Beisner, USGS. Groundwater elevation contour map December 2014 through March 2015.

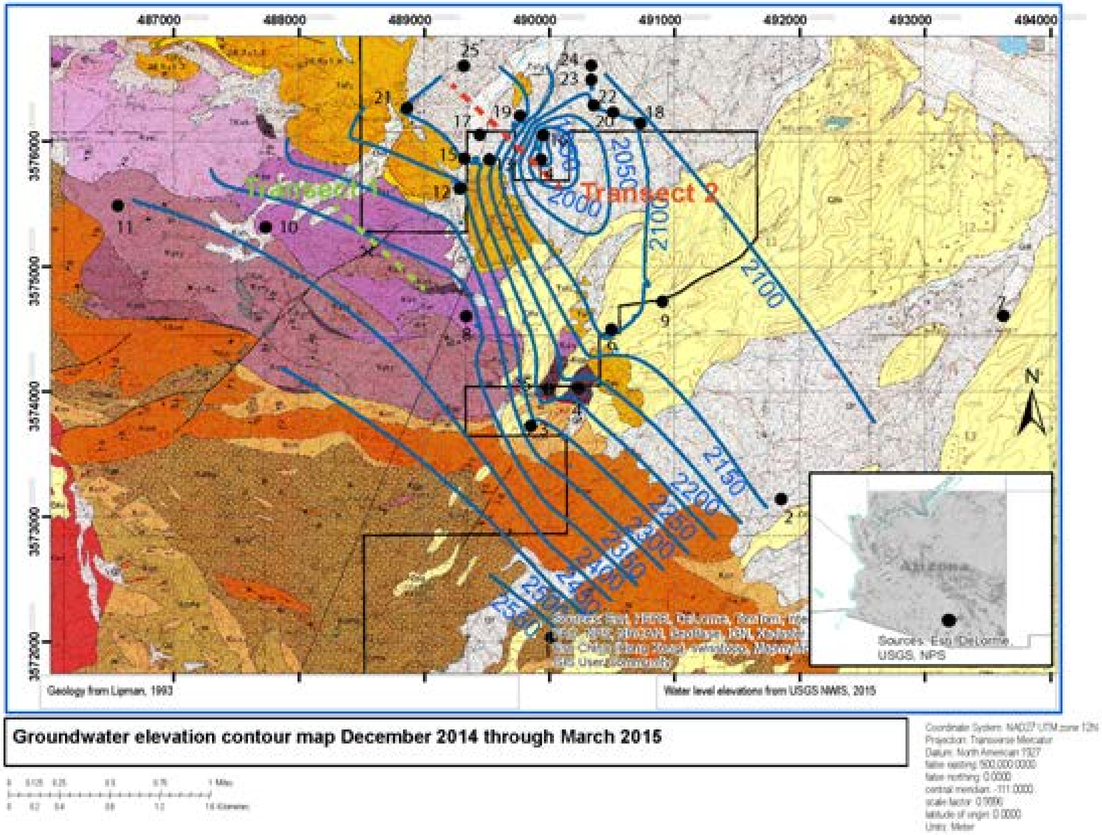


Figure 1.1 Groundwater elevation contour map in Tucson Mountain area (December 2014 through March 2015, Beisner, 2015).

2. Location Maps

2.1 Background Information

The geophysical data stations along each profile were recorded with a variety of handheld GPS units. To maintain our southeast trending lines, we used the built in compasses to maintain our proper headings. The gravity and magnetic survey stations were recorded using a Garmin Rino 520-530HCx 2-way radio and GPS unit, while the rest of the surveys were recorded with the improved Garmin GPSMAP 64S which was Wide Area Augmented System (WAAS) enabled. For locations with multiple GPS measurements, the coordinates were averaged together. The GPS coordinates were added into ArcMap using the ArcGIS WGS 1984 UTM datum.

2.2 Geographic Location

The survey area is located in the southern portion of the Amole Mining District in the Tucson Mountains west of the city of Tucson, Arizona. The two profiles, trending northwest-southeast, both located in a square bounded by UTM coordinates 488185 to 489644 easting and 3575278 to 3576563 northing. The southern profile, referred to as Transect 1, cuts through the mine property on the Saguaro National Park. Some of the survey lines had to be deviated in this area due to difficult and rocky terrain around the mine proper, as well as some old concrete structures left over from the mine. The northern profile, referred to as Transect 2, cuts through several different privately owned properties. This line was also deviated to avoid large metal fences, as well as to avoid houses in the area. Some areas were skipped again due to rough and rocky terrain towards the southeastern portion of the transect. Locations for all four geophysical methods (gravity, magnetic, TEM, and FEM) were recorded. An overview of the area is displayed in Figure 2.1.

2.3 Gravity Survey Location

There were a total of 31 gravity measurements taken across the two profiles; 12 located on Transect 1, and 19 on Transect 2. The base stations for all of these measurements were kept at the center of the transects, with the northwest considered positive and the southeast considered negative. The measured distance between the beginning and ending points of the Transect 1 gravity survey was 583.5 meters. The measured distance between the beginning and ending points of the Transect 2 gravity survey was 987.1 meters. The gravity readings were measured every 50 meters along transect in the same locations as the GPS measurements, so no interpolation was needed to calculate station location. The locations of the gravity stations are shown in Figure 2.2 for Transect 1, and Figure 2.3 for Transect 2.

2.4 Magnetic Survey Location

The magnetic surveys were taken concurrently with the gravity survey. The magnetic readings were taken every 5 meters, but the GPS coordinates were only recorded every 50 meters. The true magnetic station points were interpolated based on this information. Since these lines were the same as the gravity survey lines, the lengths were the same (583.5 m, and 987.1 m for Transects 1 and 2 respectively). The interpolated magnetic stations are shown in Figure 2.4 for Transect 1, and Figure 2.5 for Transect 2.

2.5 TEM Survey Location

The Transient Electromagnetic (TEM) surveys included large loops for data collection. The loop size used for Transect 1 was 50m x 50m and the size used for Transect 2 was 100m x 100m. A total of nine loops were recorded, five on Transect 1 and four on Transect 2. Effort was made to avoid rough terrain and sources of cultural interference, leading to the sporadic placement of TEM stations on the transects. The TEM receivers and wire loops are displayed in Figure 2.6 for Transect 1 and Figure 2.7 for Transect 2.

2.6 FEM Survey Locations

There were two different instruments used for the Frequency Electromagnetic (FEM) collection, the EM31 and EM34. The EM31 instrument took measurements every 5 meters, whereas the EM34 data was collected mostly every 10 meters. This line was adjusted twice due to terrain and structures around the mine site. The total line distance was 622 meters in length. FEM data were only collected for Transect 1, as the sediment cover and groundwater levels in the Transect 2 area were too deep to collect any meaningful data. The FEM survey lines are displayed on Figure 2.8 for the EM31 instrument, and Figure 2.9 for the EM34 instrument.

2.7 Cultural Interference and Error

Due to the 15-meter average margin of error in the Garmin Rino GPS units, the measure values were slightly off of the GPS measurements. This was improved to an average accuracy of 3 meters when the WAAS enabled unit was employed on later surveys, but the error is not significant in the gravity and magnetic profiles (Garmin, 2016). Using the geodesic measure tool in ArcMap, a line was drawn between each UTM coordinate and summed to calculate the actual transect line length. This actual value and the field value were used to calculate the relative error in the transect length. The error measured in the Transect 1 gravity and magnetic line was approximately 2.7%. The error measured in the Transect 2 gravity and magnetic line was approximately 1.3%. These errors in the context of the entire profile lines are fairly insignificant, but for sake of completeness are recorded here. Additionally, the FEM transect had an error of 0.5%. Potential sources of cultural interference are included on the relevant maps and include items such as power poles, metal fences, and other metal or utility objects.

2.8 Additional Maps

A variety of additional map themes are included in this report. These include maps with satellite imagery and hydrological contours, and may be helpful for interpretation and visualization of the presented data. Figure 2.10 shows the USGS topography map for the immediate survey area. Figure 2.11 shows the same topography map on a larger scale, showing the survey area in relation to the City of Tucson and other nearby urban areas. Figure 2.12 displays the local geology with the TEM loops for interpretation reference, while the Figure 2.13 displays the drilled wells in the area with the groundwater contours developed from them.

2.9 References

Garmin. 2016. *What is GPS?* Web. Retrieved April 19, 2016. http://www8.garmin.com/aboutGPS/.

Lipman, P.W. 1993. *Geologic map of the Tucson Mountains caldera, southern Arizona*. U.S. Geological Survey. Miscellaneous Investigations Series Map I-2205. 1:24,000.

U.S. Geological Survey. 1995. Jaynes Quadrangle. North American Datum of 1983 (NAD83). World Geodetic System of 1984 (WGS84). 1:24,000.

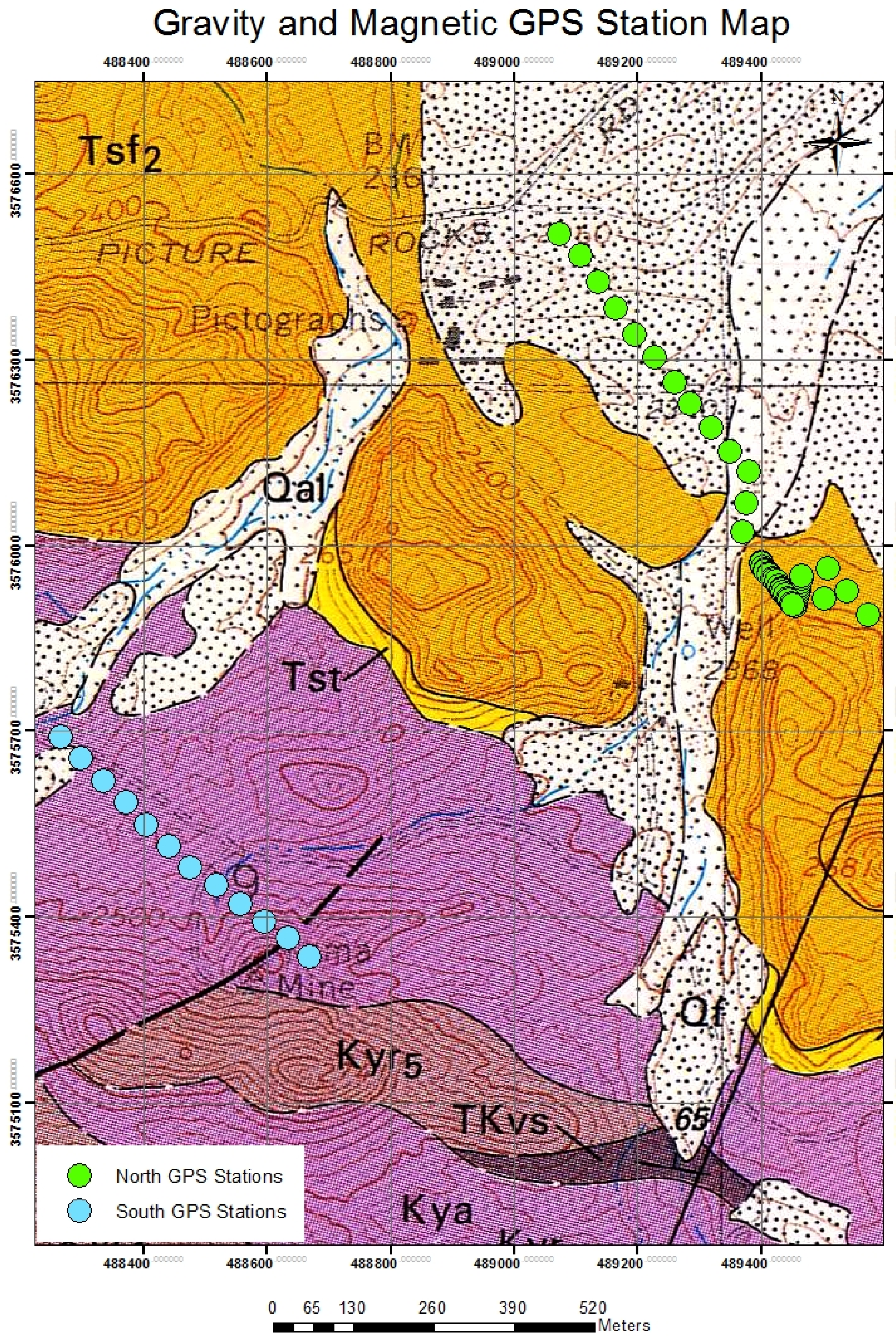


Figure 2.1: Geology map of the area (Lipman, 1993). Data points containing every measured GPS point for the gravity and magnetic stations are displayed on the map.

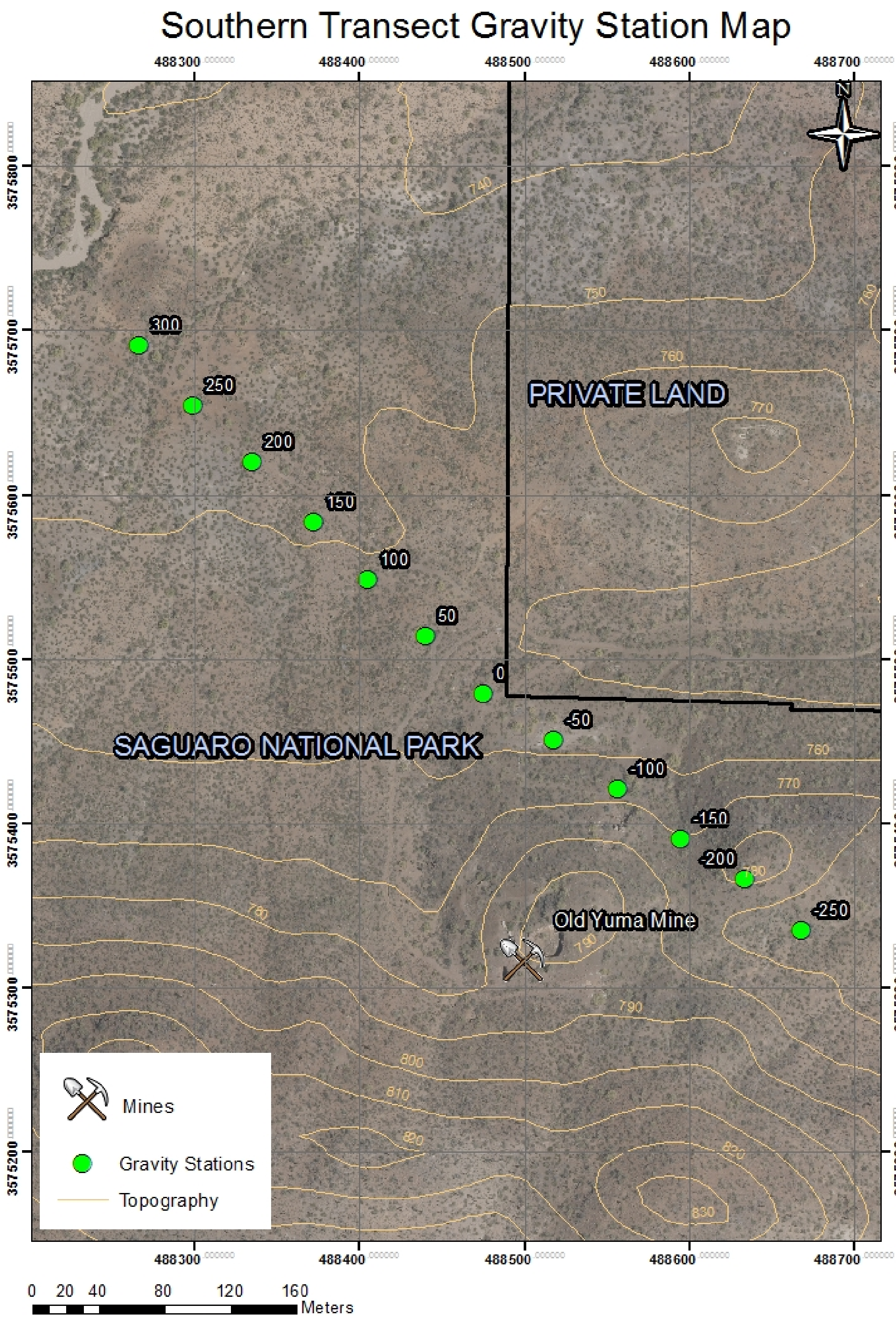


Figure 2.2. Gravity station locations with satellite imagery and topographic contours. Also displayed are private and public land boundaries. In this particular location measurements were not allowed to be taken on the adjacent private land.

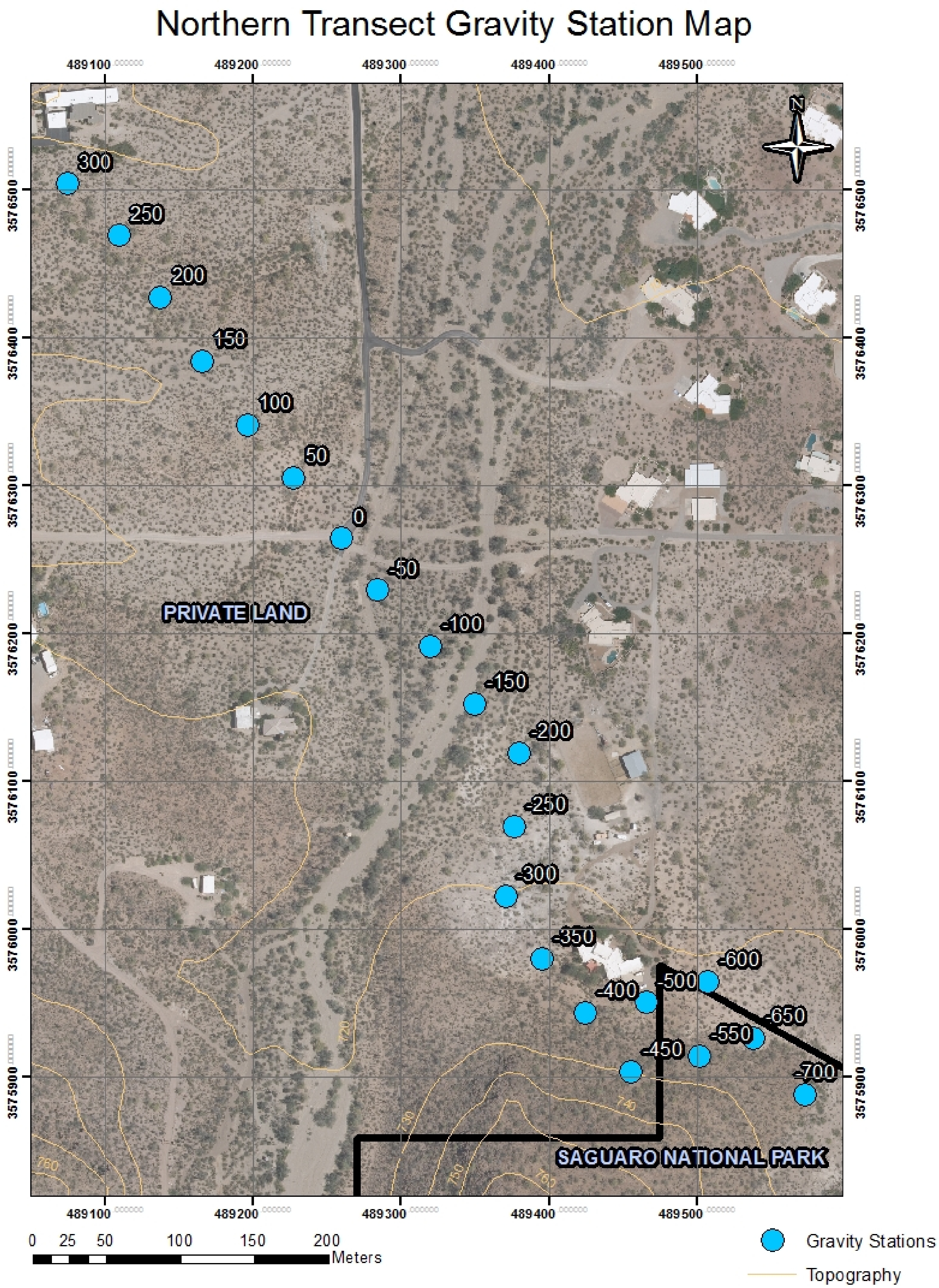


Figure 2.3. Gravity stations and topographic contours on satellite imagery. Note deviation due to house; measurements taken with permission on private land.

Southern Transect Magnetic Map

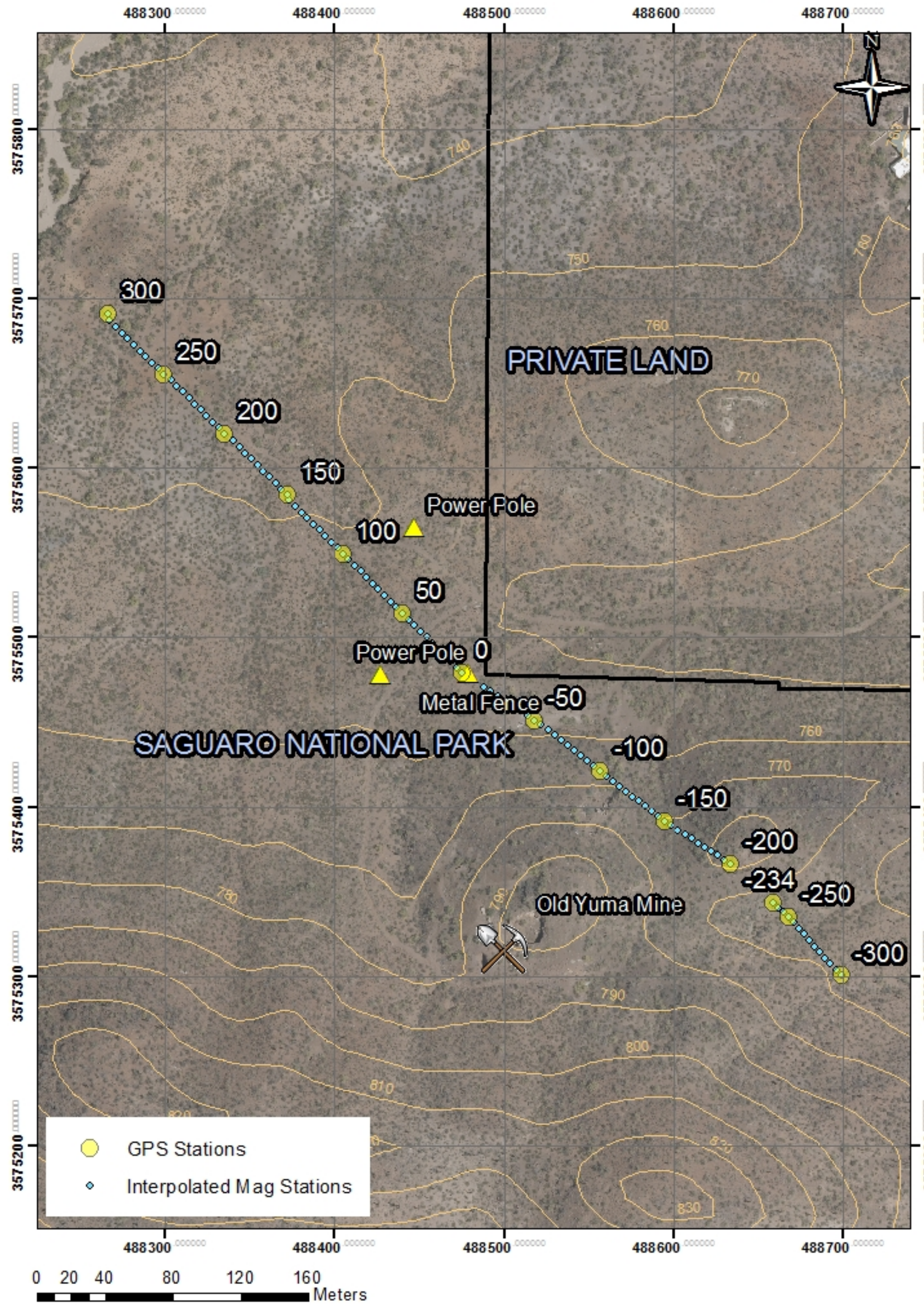


Figure 2.4. Transect 1 magnetic station map showing interpolated magnetic stations, contours, public/private land boundary, cultural interference, and GPS stations measured every 50m.

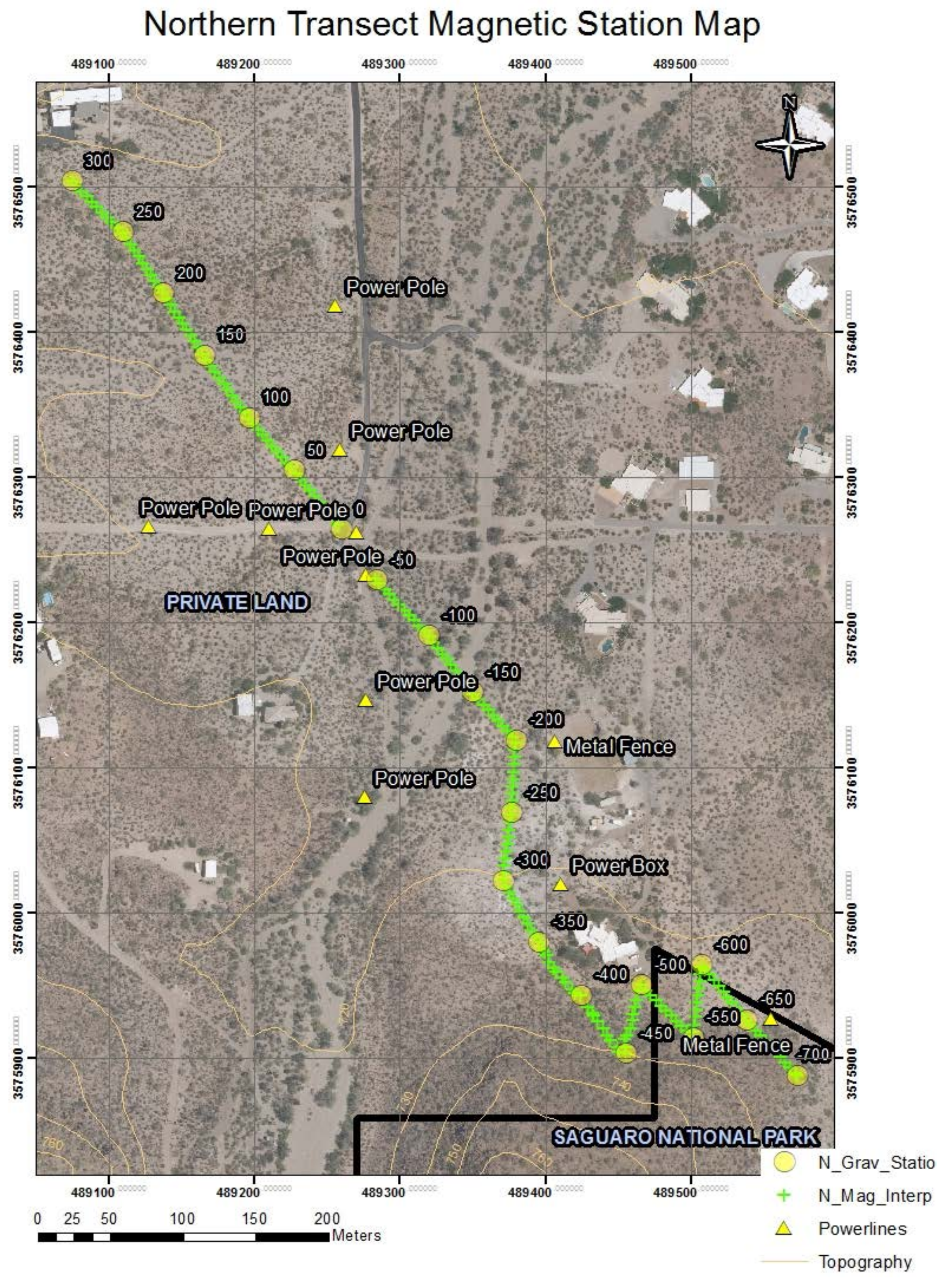


Figure 2.5. Transect 2 magnetic station map showing interpolated magnetic stations, contours, public/private land boundary, cultural interference, and GPS stations measured every 50m.

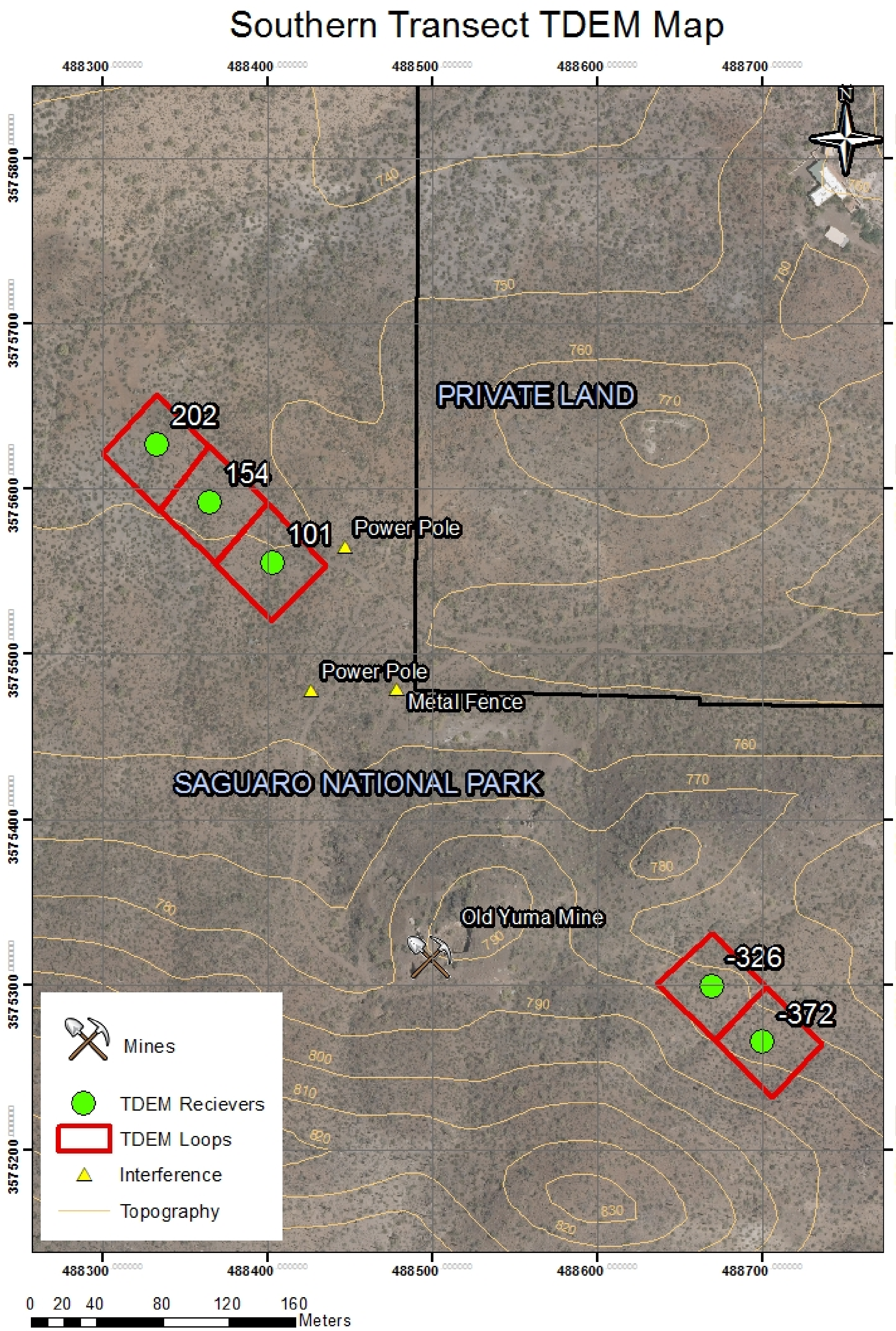


Figure 2.6. TEM receiver stations shown with loop corners on satellite imagery with topographic contours. Cultural interference areas indicated with yellow triangles.

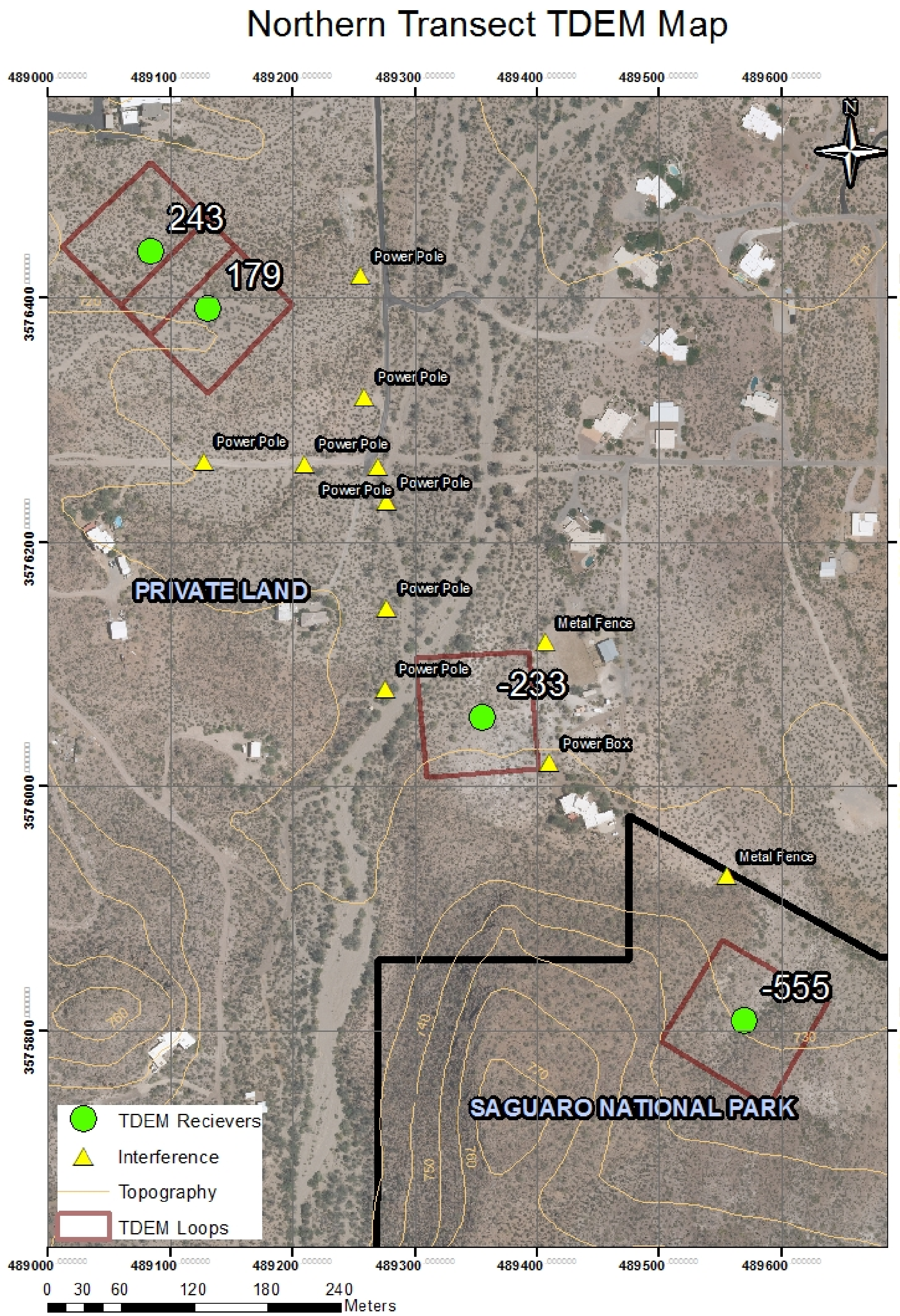


Figure 2.7. TEM receiver stations shown with loop corners on satellite imagery with topographic contours. Cultural interference indicated with yellow triangles.

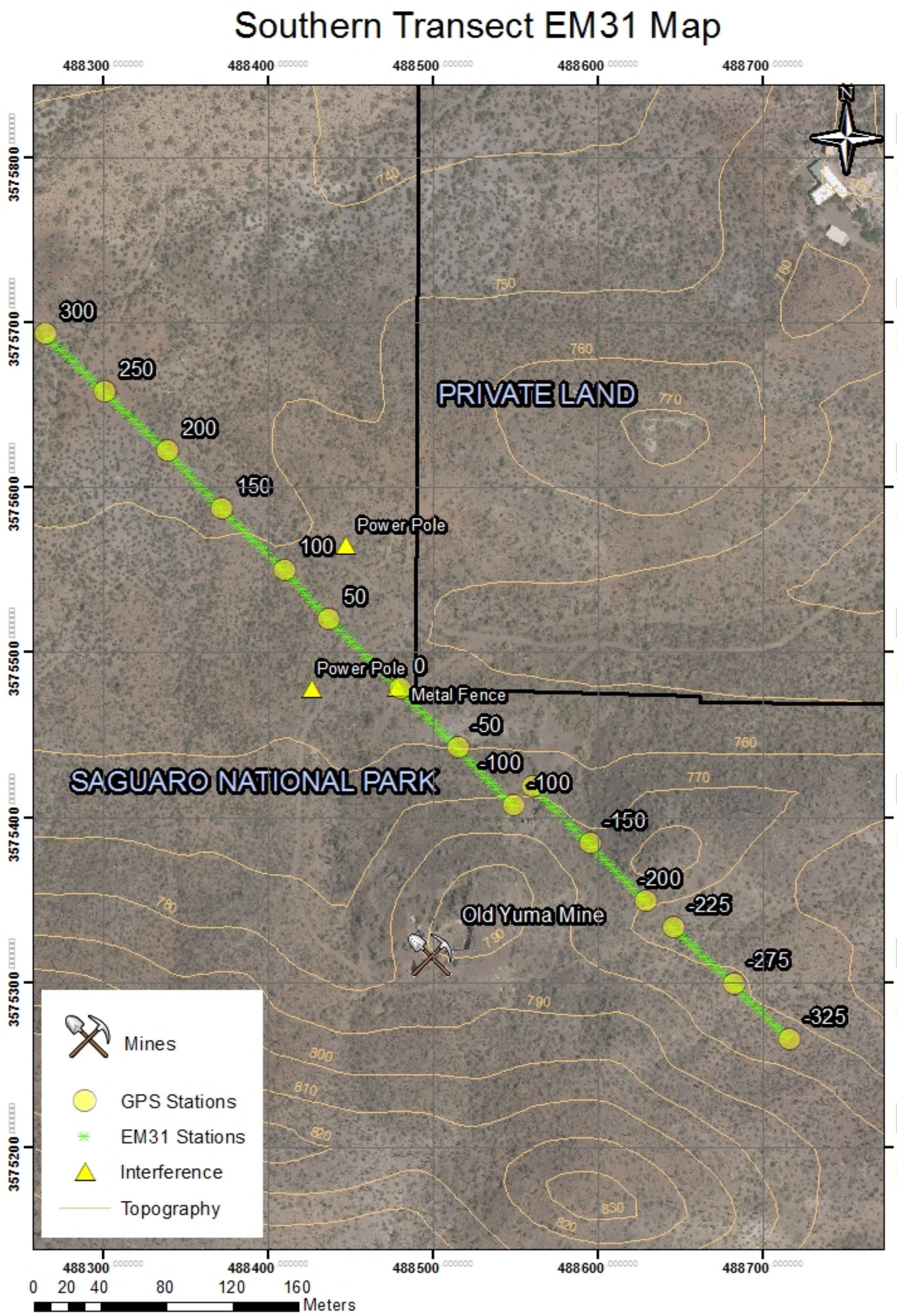


Figure 2.8 EM31 station interpolation shown. Sources of interference marked again with yellow triangles, interpolated stations shown with green asterisks. Additional information includes mine location, topographic contours, and GPS station measurements as well as land boundaries.

Southern Transect EM34 Map

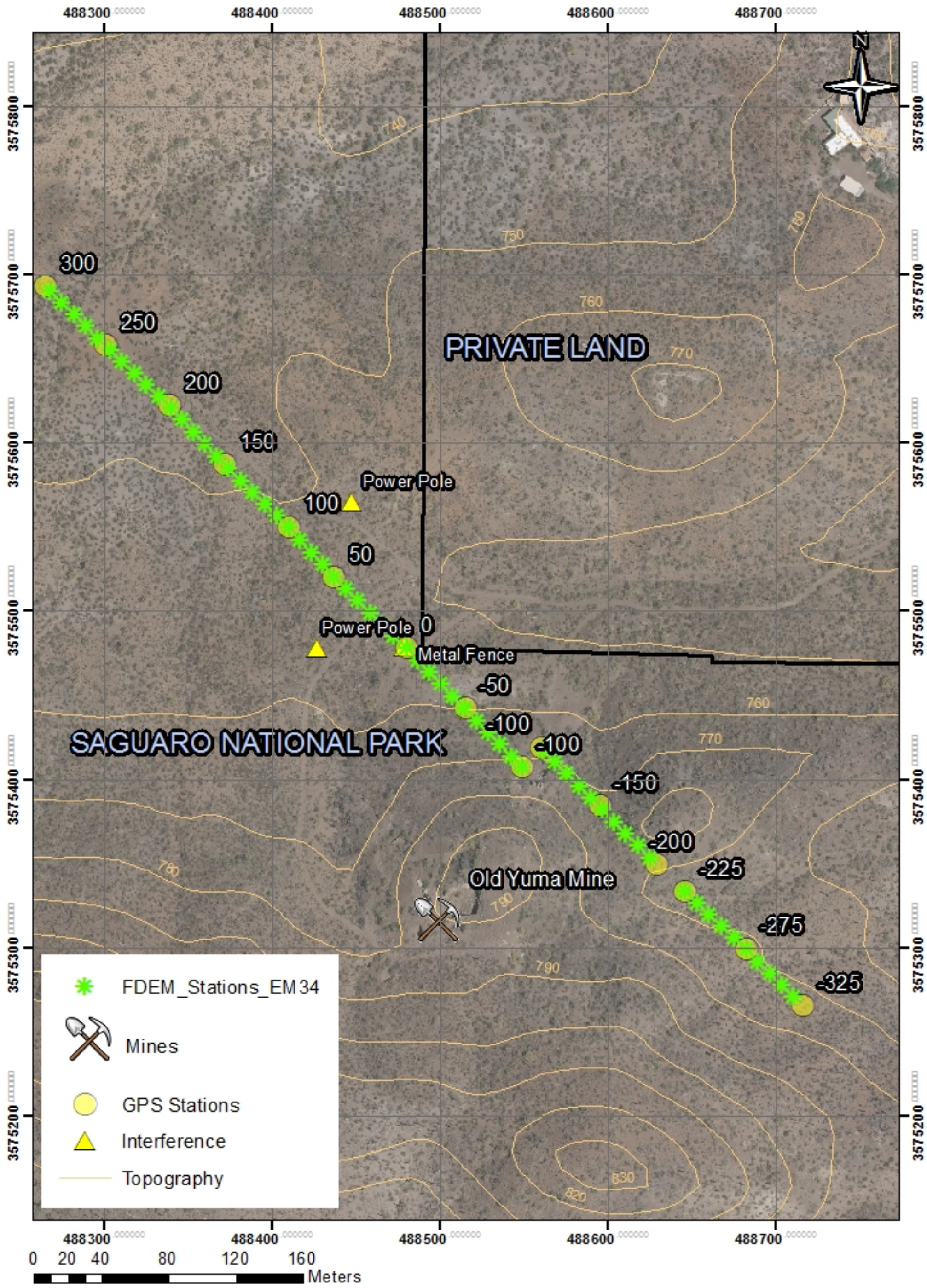


Figure 2.9 EM34 station interpolation shown. Sources of interference marked again with yellow triangles, interpolated stations shown with green asterisks. Additional information includes mine location, topographic contours, and GPS station measurements as well as land boundaries.

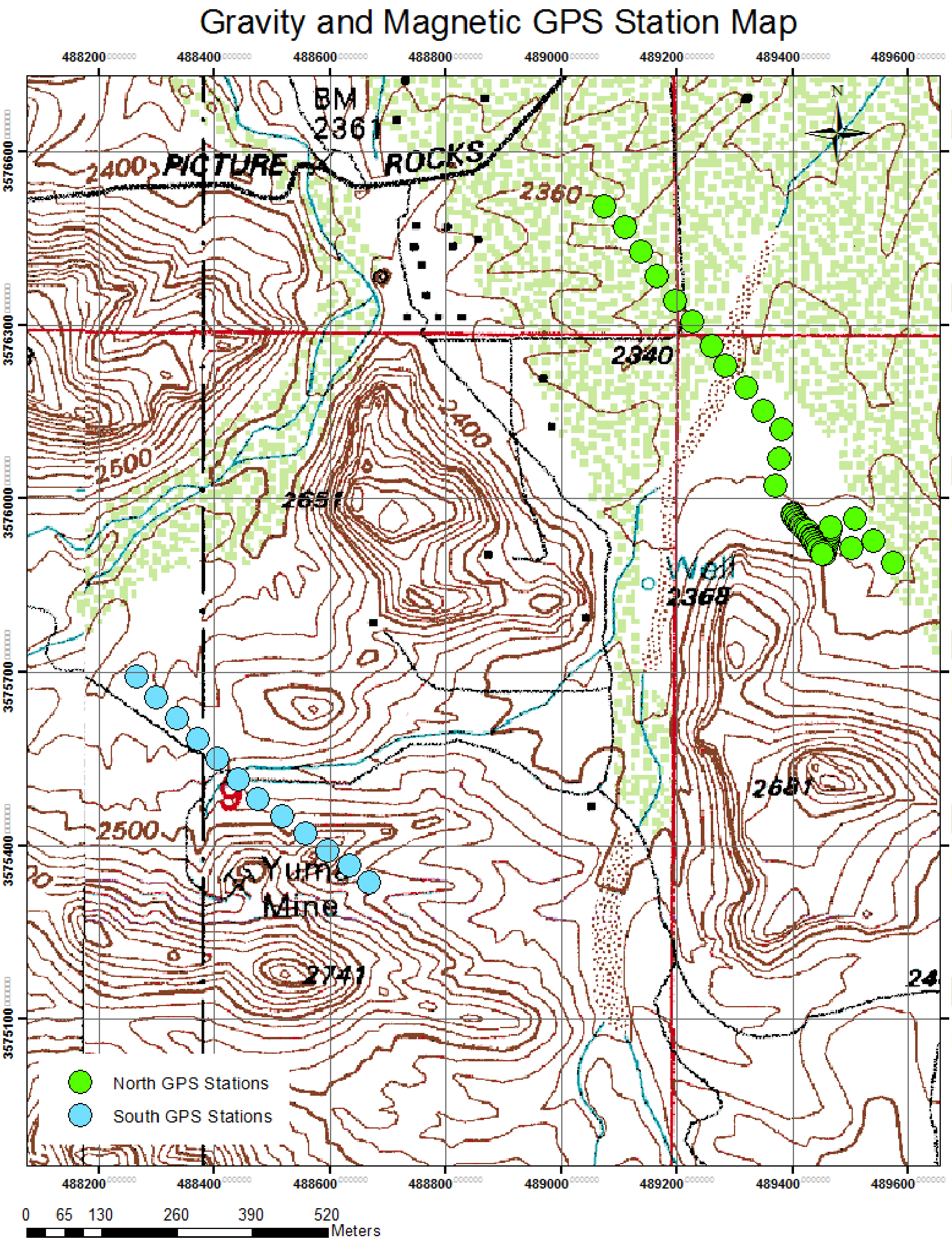


Figure 2.10. Jaynes USGS topographic map of the immediate survey area (USGS, 1995).

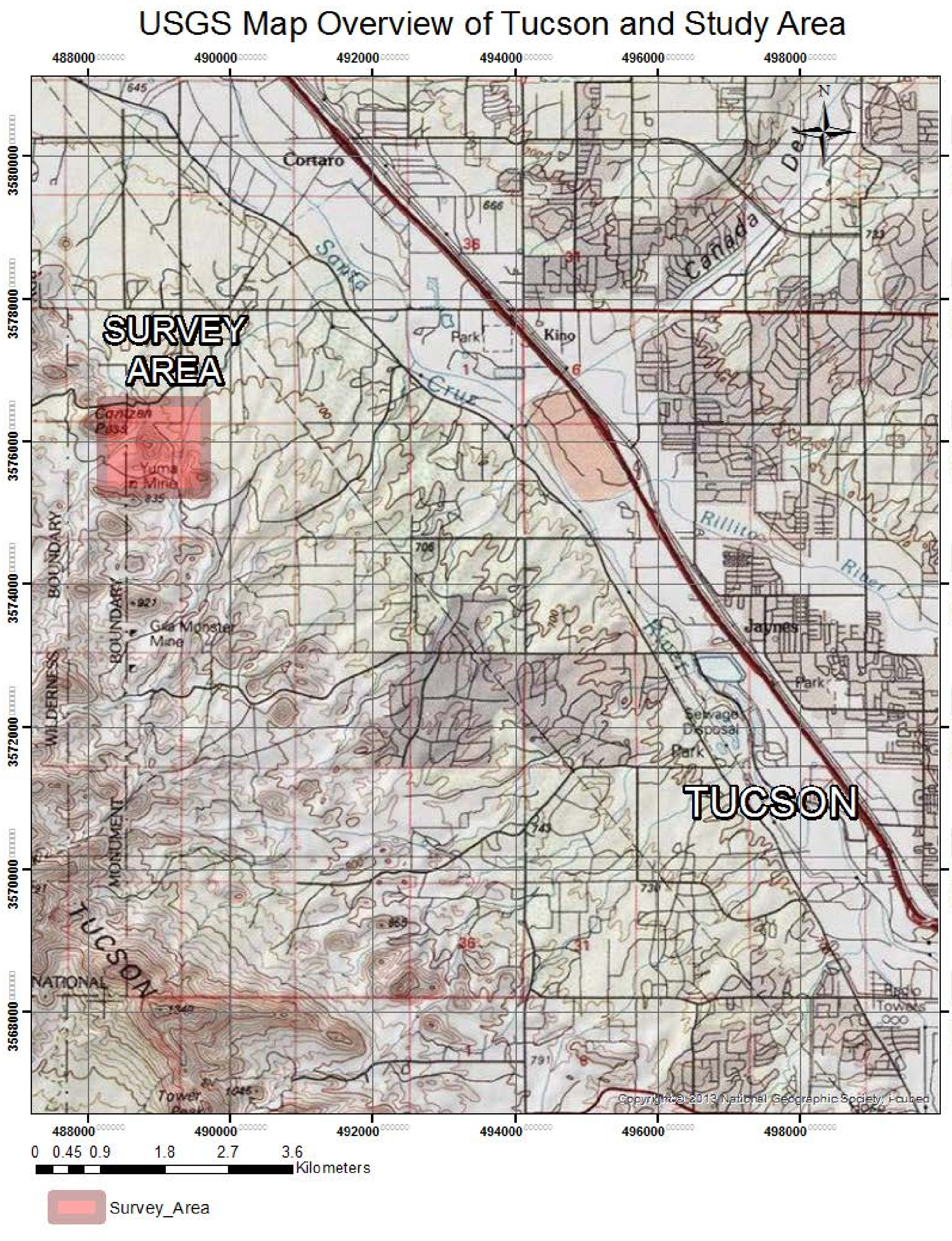


Figure 2.11. Jaynes USGS topographic map showing survey area in the northwest and the City of Tucson to the southeast (USGS, 1995). Most of Tucson proper is located to the East, off of the map.

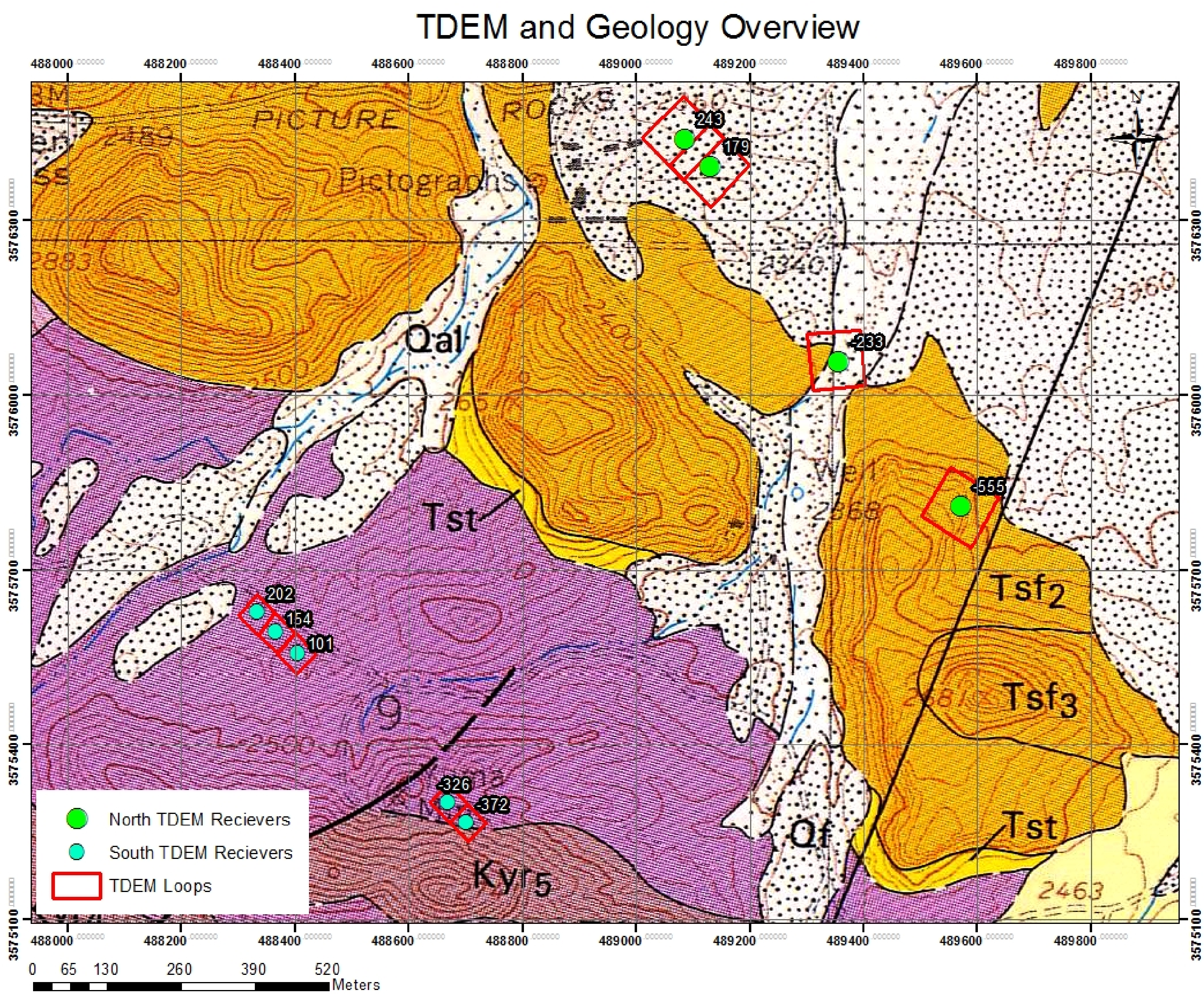


Figure 2.12. Local geology map (Lipman, 1993) overlaid with TEM receivers and TX loops.

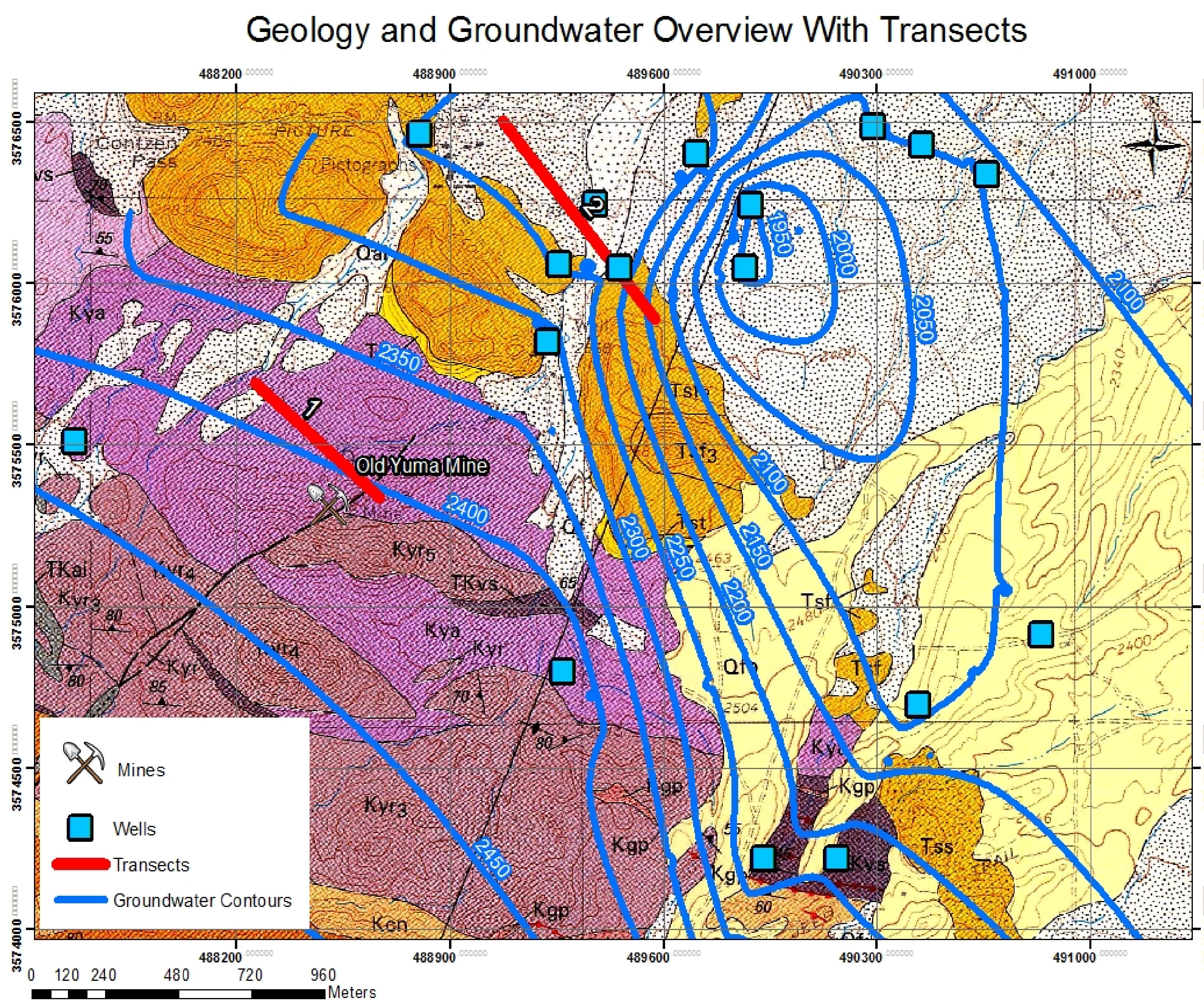


Figure 2.13. Well locations and interpolated water contours with transect lines and local geology (Lipman, 1993).

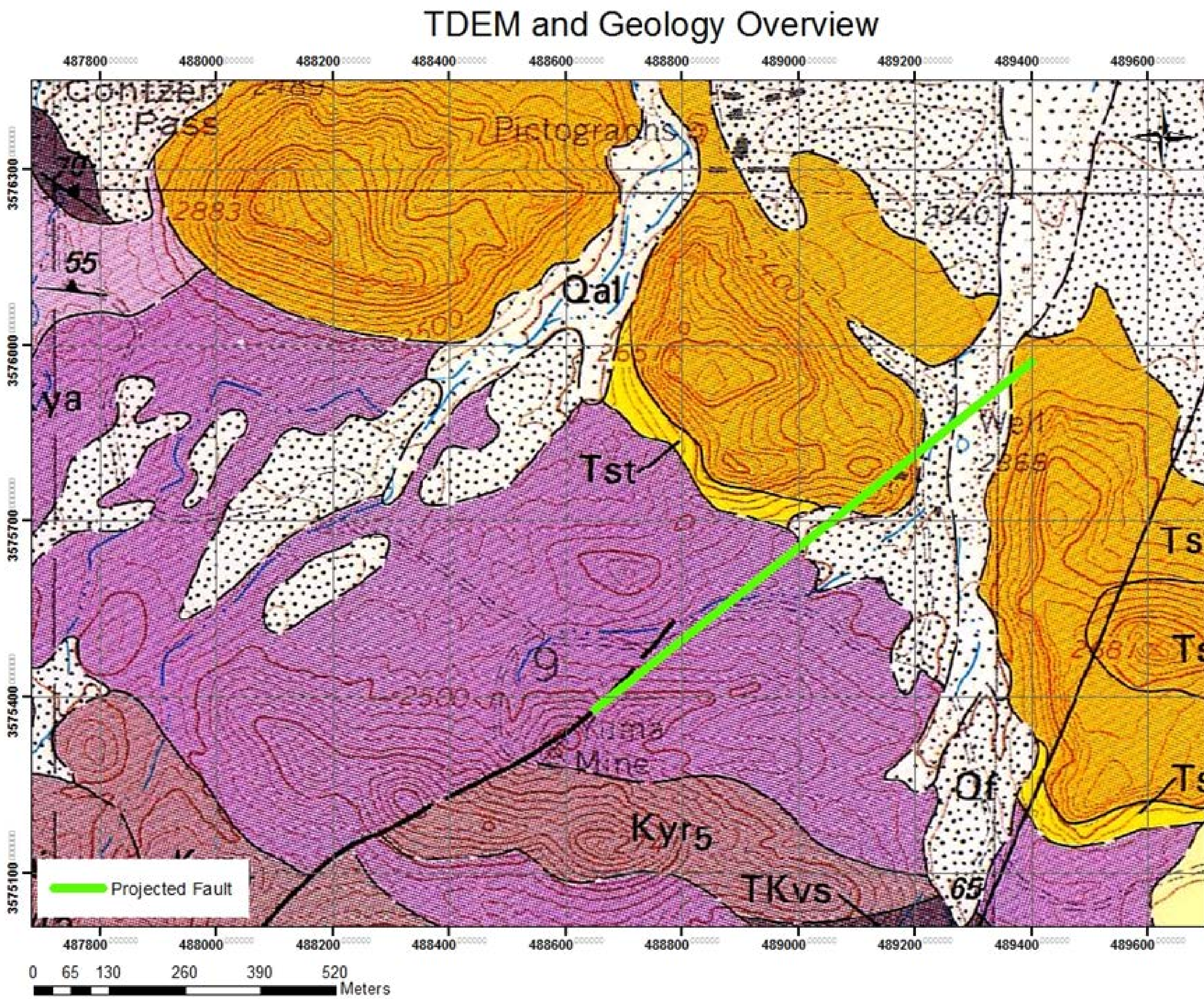


Figure 2.14. Projected fault line location based on TEM data and local geology (Lipman, 1993).

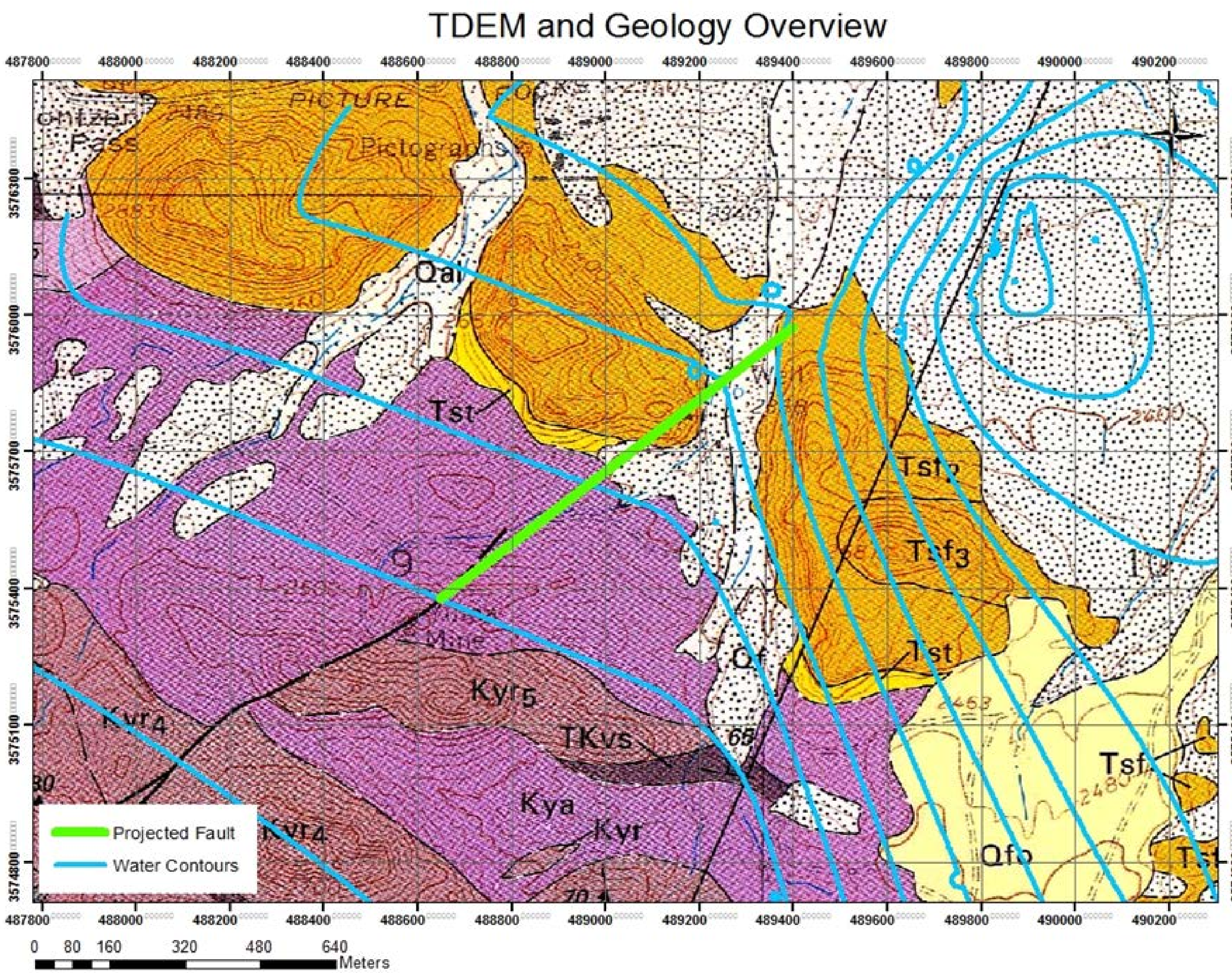


Figure 2.15. Projected fault line location based on TEM data with water contours and local geology (Lipman, 1993).

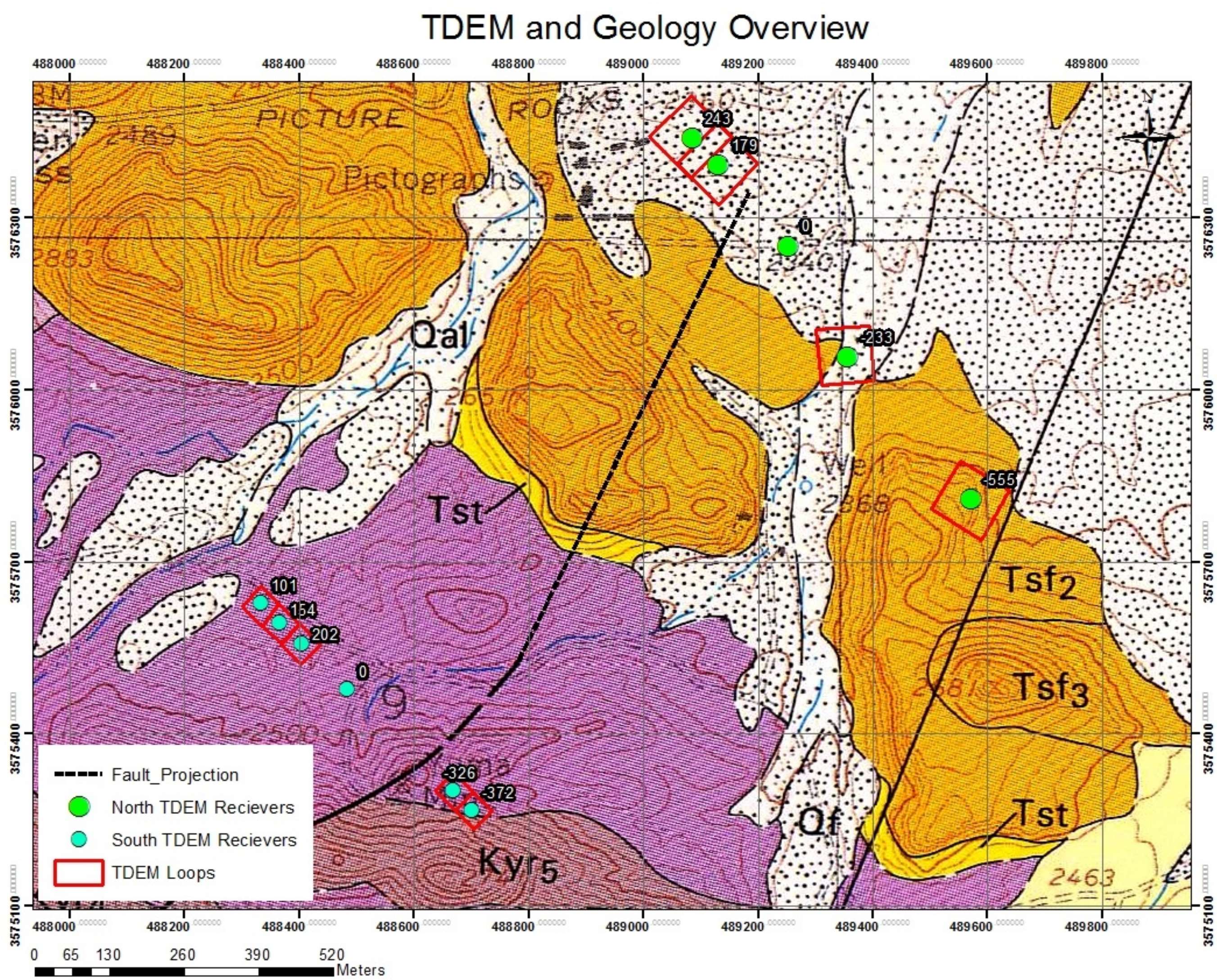


Figure 2.16. Projected fault line location based on TEM data and local geology (Lipman, 1993).

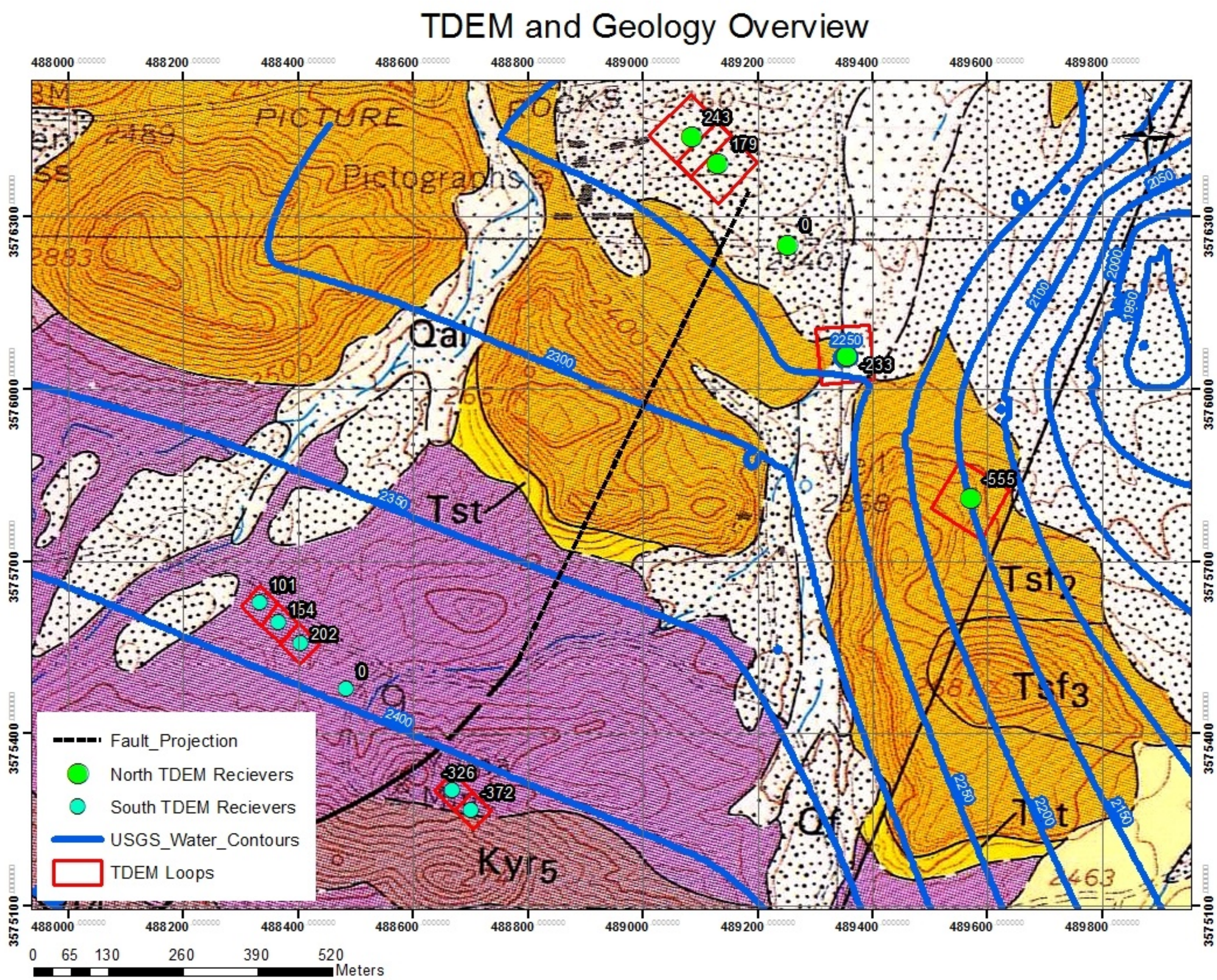


Figure 2.17. Projected fault line location based on TEM data with water contours and local geology (Lipman, 1993).

Figure 2.18. Transect line placement with local topography (Google, 2016).

3. Transient Electromagnetic (TEM) Surveys

3.1 Introduction

The transient electromagnetic (TEM) method is commonly used in geophysical exploration to map changes in the subsurface resistivity with depth. TEM relies on contrasting electrical properties below the surface that exhibit unique induced responses to an electromagnetic signal from a transmitter loop at the surface. In this project, arrays of TEM recording stations were used to investigate the depth and extent of certain lithological features, as well as the depth to water table in the two survey areas. In general, the maximum exploration depth of the TEM central-loop induction method is about 2 to 3 times the loop size. For more information about the TEM method, see the paper “Introduction to TEM” (Zonge, 2015). Data from a total of nine sites were recorded within a two-day collection period, with both 50x50 meter and 100x100 meter transmitter loop sizes. These data were then used in a series of inverse-modeling algorithms (provided by Zonge International) to build a subsurface map of electrically resistive and conductive regions beneath the transects.

3.2 Location

TEM data were collected February 13, 2016 along Transect 2 at four stations using 100x100 meter loops. These loops were laid from the southeast to the northwest along the transect, avoiding any cultural interference from buildings, power lines, and fences. Station -555 was moved south of the transect due to the presence of dense vegetation and unstable, steep terrain that forced a deviation from the line. Cultural interference from fencing and a residential home near Station -233 also caused a deviation from the transect line. Station 243 had a southeastern edge overlap with the northwestern edge of Station 179 due to proximity issues with a parking lot and other associated structures (Figure 2.6).

On February 14, 2016 data were collected using TEM with 50x50 meter loops on Transect 1 at five stations. The stations ran from the southeast to the northwest along the transect line without the need for deviations from the line that were necessary for Transect 2. Stations -372 and -326 were laid in succession and then the next three stations were placed in succession on the northwest leg of the transect due to the presence of mine workings, unstable terrain, and cultural interference of power lines and fencing (Figure 2.7).

3.3. Instrumentation and Field Procedures

Data were collected for both transects using a Zonge International GDP-3224 multi-function receiver (Figure 3.1) and TEM/3 receive antenna placed at the center of hte transmitting loops. A Zonge XMT-32 transmitter controller and NT-20 NanoTEM transmitter (Figure 3.2) were connected to copper wire loops measuring 50x50 meters (Transect 1) and 100x100 meters (Transect 2). The NT-20 creates a time-varying current in the conductive copper loop which, when shut off abruptly, produces a similar change in its induced magnetic field. This time-varying magnetic field induces an electromotive force in any surrounding conductive materials that moves downward and outward from the copper loops. This interaction produces further eddy currents and a related magnetic field that is then read by the GDP-3224 (Zonge, 2015). This secondary magnetic field can be used to calculate the resistivity of the subsurface.

For our study, the NT-20 transmitter used frequencies at 16 and 32 Hz using 50x50 meter loops for Transect 1, and frequencies of 8, 16, and 32 Hz using 100x100 meter loops for Transect 2. The loops were placed at a minimum of 50 meters away from any cultural interferences to minimize data anomalies. The magnetic field was transmitted using a current of 6.0 amps for Transect 1 and 3.5 amps for Transect 2.

Figure 3.1. Zonge GDP-3224 multi-function receiver attached to the TEM/3 receiving antenna (not shown).

Figure 3.2. Zonge XMT-32 transmitter controller and NT-20 NanoTEM transmitter attached to copper loops (red wires).

3.4. Data Processing

The data were first separated into blocks associated with a header block that indicated each individual station and the settings for that station, thus creating raw data files. Removing sections where data were not collected or where there was an error in the system itself, individual raw data files were created for each Transect at each pulse-repetition frequency used: 16 and 32 Hertz for Transect 1 and 8, 16, and 32 Hertz for Transect 2.

Using the software provided by Zonge International, TEM processing software, and the raw data sets, each Hertz raw file was opened individually in TEMAVG. It is at this point where we attributed GPS coordinates and elevation data to the specific stations by inserting a STN file that contained GPS UTM easting coordinates, and elevation correlated to specific station numbers. It was also at this point where we adjusted the delay time to 15 microseconds. This step is used to remove any primary field data that might have remained following the turn-off of the transmitter. Viewing the curve for both data sets (Figure 3.3), this section shows that for each pulse-repetition frequency, we recorded 3 sets of TEM data for each station. This is displayed in an averaged curve that gives relative resistivity of the area at the point in time that the data were collected. Viewing the data in TEMAVG, data sets that did not give consistent downward transient voltage trends were removed from the averaging of the data sets, with a focus on removing any data that might have been in error or in the noise. Once these data sets were edited, the data were then processed with a data trimming program, TEMTRIM. This is used to remove any data sets that had been marked for removal. Trimming was followed by inverting the data set with STEMINV, another Zonge based program, that is used to plot the data in a subsurface pattern with resistivity versus depth. Following this the data were graphed using the MODSECT program, which displays resistivity versus distance and depth over the mapped area.

Note that the Zonge programs, having a linear placement of points, initially placed the data points equally along the profile, but after consultation with Mykle Raymond from Zonge International, a renaming of the station points was done, inverting points 1 and 2 for Transect 2 and points 1, 2, and 3 for Transect 1. This allowed us to have a consistent line of resistivity data along each individual transect.

3.5. Interpretation

In Figure 3.4, the resistivity plot for 16 Hertz along Transect 1, we see that there is a distinct area of high resistivity at approximately 700m - 800m elevation. The placement of this area corresponds to the presence of andesite as shown on the Lipman 1993 geologic map (Figure 2.12). Noting the trend for Stations -326 and -372 on the mapped area, we actually see zones of conductive material that correspond to the presence of the Old Yuma Mine. This is also possibly the depth of the water table in this zone (Figure 2.13). Looking at points located at Stations 202, 154, and 101, we see low resistivity at depth, but also at higher elevations.

Viewing the Modsect plot for the 32 Hertz (Figure 3.5), we see a high concentration of resistivity ranging across the area, with the highest resistivity in the area to the center of the mapped area. This placement corresponds with the known location of the mine itself. On the far east and west of the mapped zone we see increased resistivity as well, with the points located to the east, specifically below Station -372, located above an observed flow area. The increased resistivities found below Station 101 are possibly related to this station being close to an existing powerline. The increased resistivities below Station 202 may be due to this station being the farthest from any known structures and possibly shows the most likely placement of an area of low conductivity surrounded by subsurface ground water.

The 8 Hertz data for the Transect 2, located in a valley area to the east of the mine, has relatively low resistivity in the eastern portion of the mapped zone and a small zone of increased resistivity beneath Station -555, which was located on a surface flow (Figure 3.6). On the western portion of the area, specifically beneath Station 243, we see significantly higher resistivity. Since the 8 Hertz frequency has a greater depth of investigation, compared to the higher pulse-repetition frequencies, it is likely that the presence of this anomaly is due to the placement of subsurface water around a zone of highly resistive material. This field area was surrounded by cultural interference, specifically two roads on the east and south and a series of buildings to the west. However, all of these station locations were a minimum of 25 meters away from any structures.

In the 16 Hertz data we see generally low resistivity across the area with only small changes again located to the far east and far west and a significantly lower amount of resistivity in the center of the area (Figure 3.7). Similarly, to the 8 Hertz data, the far west resistivity increase can be associated with the presence of the subsurface water and increases in the far east may be due to being located above a surface expressed flow area.

Transect 2 data for 32 Hertz also had a medium to low amount of subsurface resistivity, with zones of higher resistivity located to the east and to the west of the area. The lowest resistivity was in the center, located beneath Station 179, and ranging east to Station -233 (Figure 3.8).

3.6 Conclusions

In the area of Transect 1, it was difficult to extract reliable information about the subsurface in the area closest to the mine because of the prohibited area around the mine and steep terrain conditions, resulting in gaps in the measurements. In addition, all of the area around the Mine site had extensive scrap metal on the surface, which interfered with many of the measurements. The TEM data collected along Transect 2, in the vicinity of the residential area, provides strong evidence for the existence of a fault below Transect 2. This interpreted fault is consistent with a continuation of the normal fault that is known to exist to the southwest near the Old Yuma mine.

3.7 References

- Zonge, 2015. *Geophysical Methods: Transient Electromagnetic or Time-Domain EM (TEM)*. Web. Retrieved April 14, 2016. http://zonge.com/geophysical-methods/electrical-em/tem/

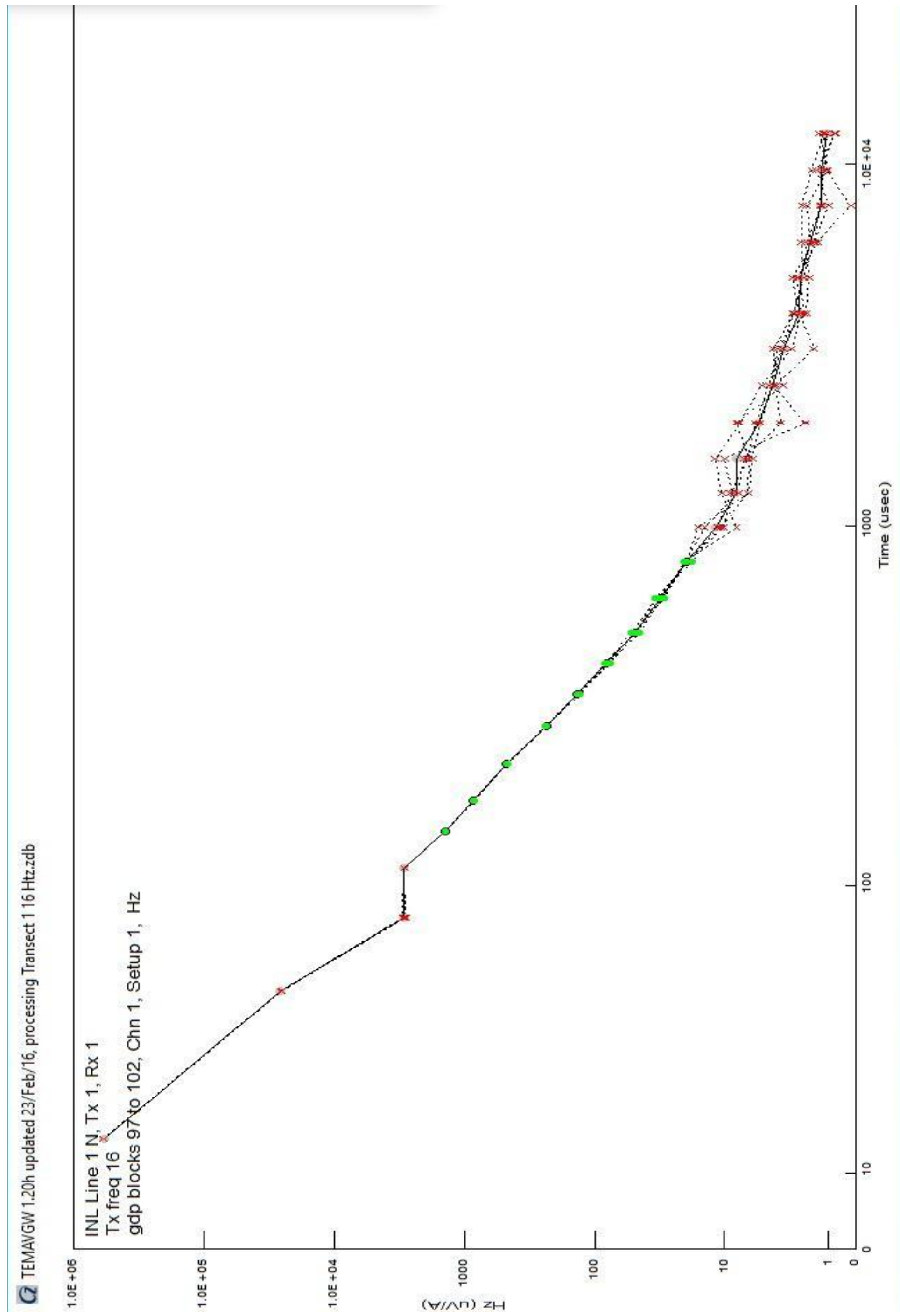


Figure 3.3: Example of single station of TEM resistivity with multiple runs.

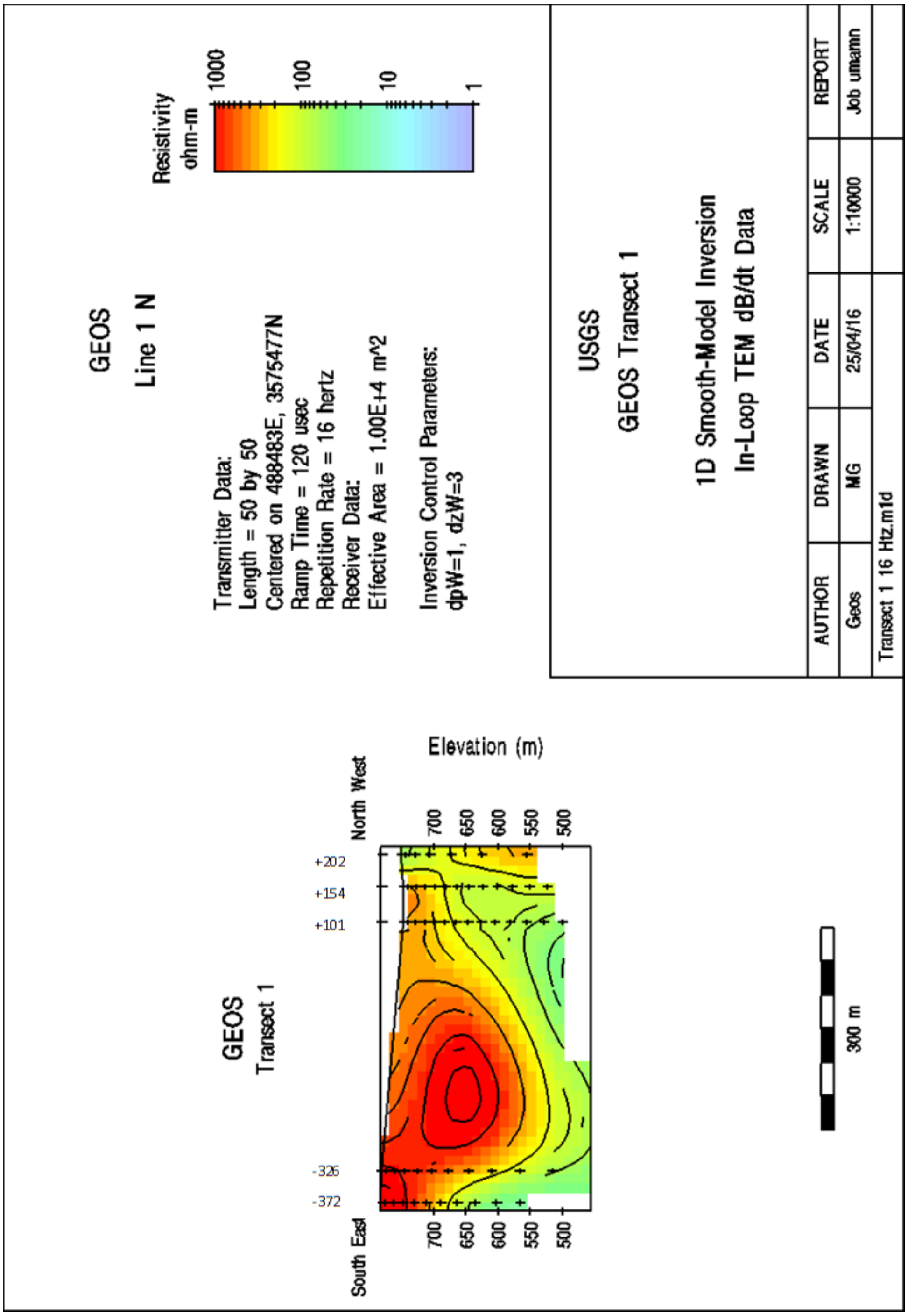


Figure 3.4: Transect 1 at 16 Hertz.

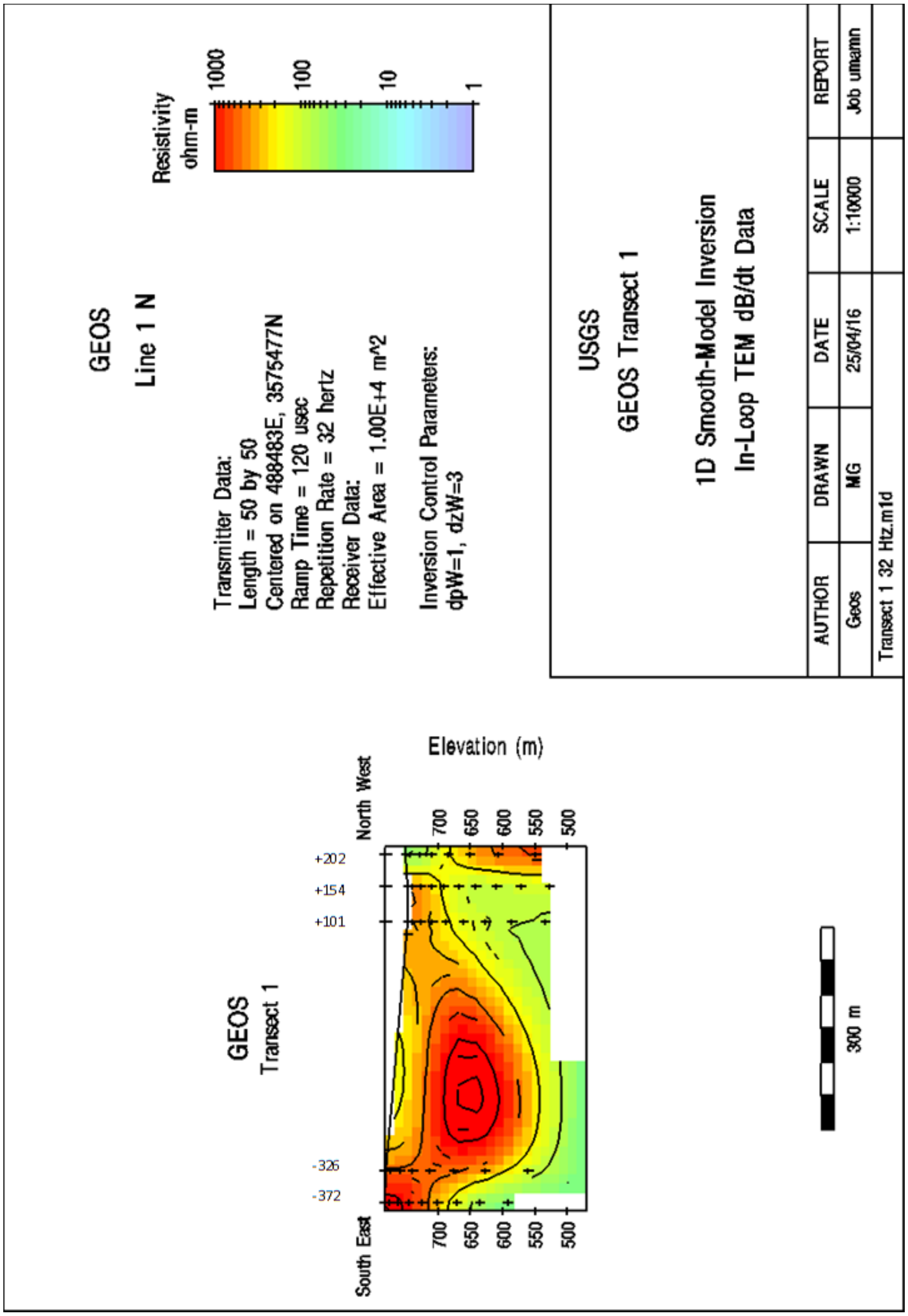


Figure 3.5: Transect 1 at 32 Hertz.

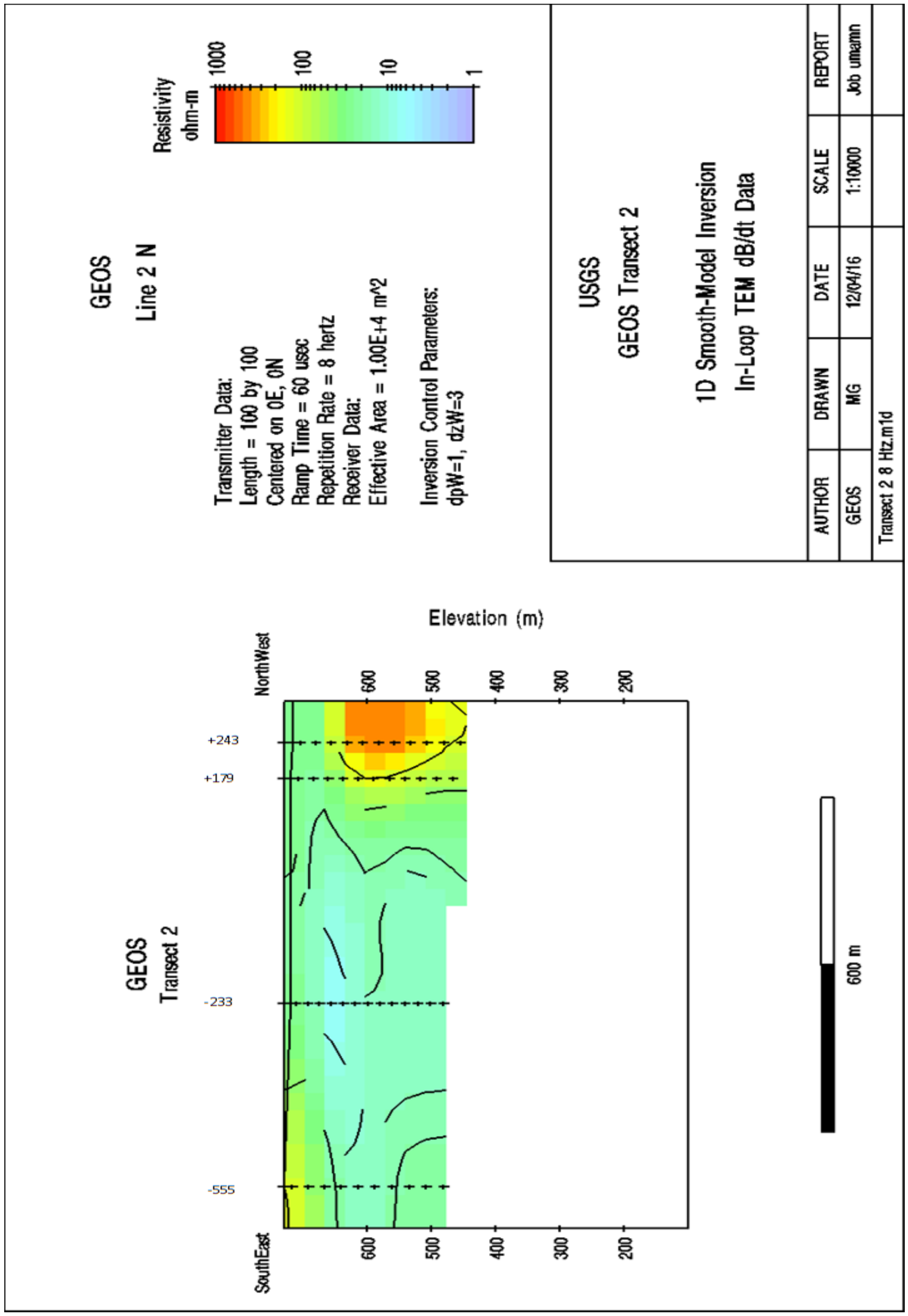


Figure 3.6: Transect 2 at 8 Hertz.

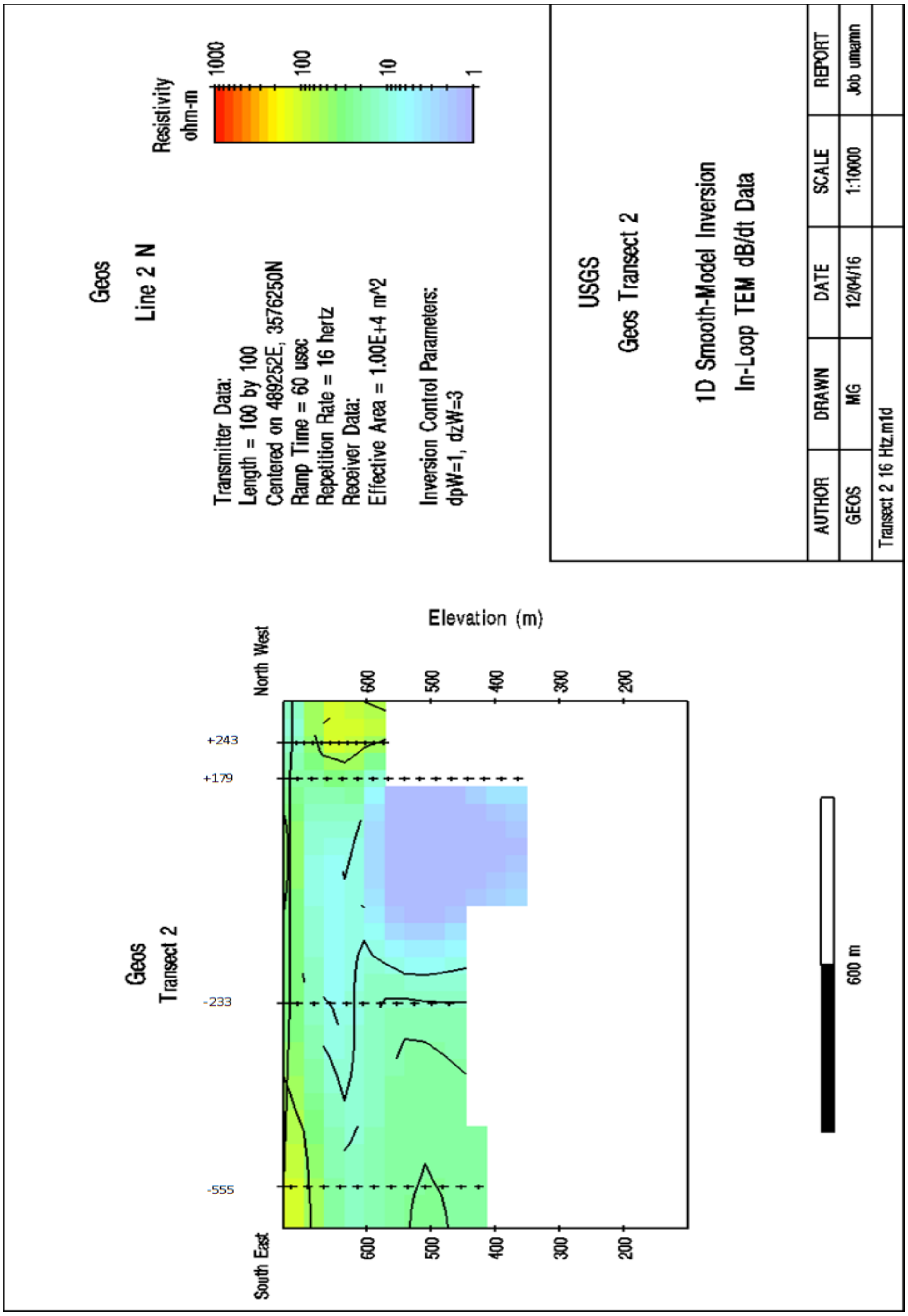


Figure 3.7: Transect 2 at 16 Hertz.

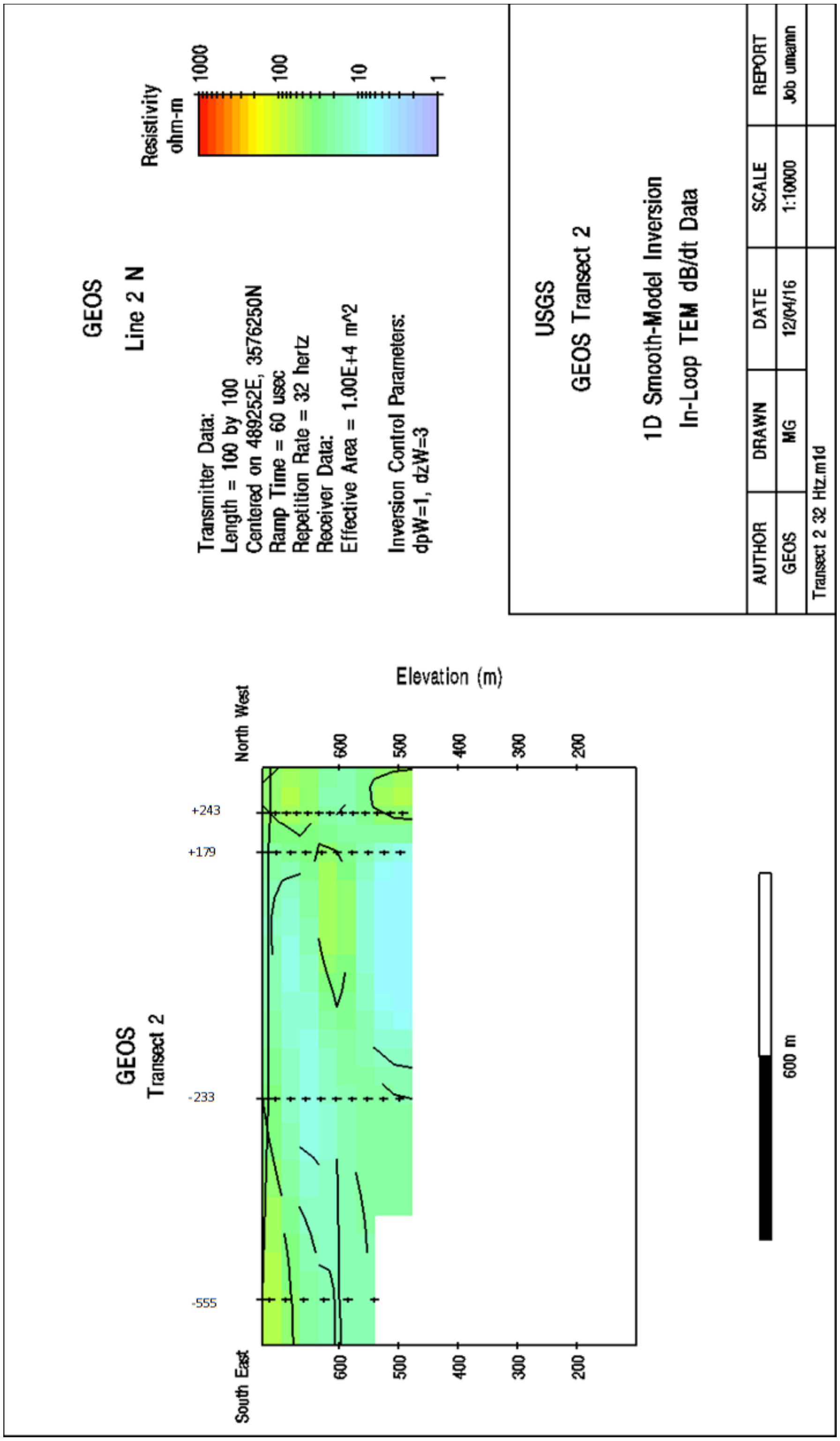


Figure 3.8: Transect 2 at 32 Hertz.

4. Gravity Surveys

4.1 Introduction, Instrumentation and Data Collection

Gravity data were collected using a LaCoste and Romberg D-127 meter. Gravity measurements go through a series of corrections based on the location of the collected data. There is the instrumental drift, tidal effect, free air and Bouguer correction to be made for each set of gravity data. Instrumental drift is when the inner workings of the gravity meter (primarily the spring) changes due to temperature and being moved from one station to another. Over even a short period of time this can be significant. In order to accommodate for this drift, a field base station was regularly reoccupied. These data were then tied to an absolutely gravity base station located at the University of Arizona in the basement of the Harshbarger building (1133 E North James E Rogers Dr, Tucson AZ 85721). Tidal effect changes throughout the day were also removed. Elevation changes were accounted for using an Excel spread sheet and subtracted from the collected gravity measurement. These elevation changes were accounted for in the free-air and Bouguer correction. The Bouguer equation accommodates for the change in the rock density between a station and the datum. The free-air correction is the change in elevation.

4.2 Locations

The relative gravity measurements were taken approximately every 50 meters along each transect. Transect 1 was measured on January 30, 2016. Gravity measurements were initially taken at a base station (station 0), then in 50 meter increments to the northwest (NW) up to 300 meters. After finishing all measurements on the NW, gravity measurements were taken at base station again, and then in 50 meters increments to the southeast (SE) up to 250 meters. After getting all data from SE line, the base station was reoccupied for a final reading (see location map Figure 2.2).

Transect 2 gravity data was collected on January 31, 2016. The first measurement was taken at station 0 (base station), and then in 50 meters increments to the NW. The base station of transect 2 was reoccupied before and after the measurements were taken in 50 meters increments to the SE. Transect 2 was deviated from a straight line projection due to the presence of a residential home and associated structures. The deviation occurred after 200 meters to the SE and returned to the original projection at 397 meters SE (see location map Figure 2.3).

The relative gravity was tied in to the absolute gravity station at Harshbarger building at the beginning and the end of the day for both transects.

4.3 Data Processing

All measured gravity data are relative gravity. By knowing the absolute gravity at the tie-in station located at Harshbarger, all data were converted to absolute gravity.

The gravity measurements were then corrected for tidal effects, using data processing Excel spreadsheets provided by USGS. The earth tide caused changes of -0.35 to 0.60 $\mu m/s^2$ for transect 1, and -0.60 to 0.48 $\mu m/s^2$ for transect 2, both within acceptable range and were corrected for each station.

For transect 1, instrumental drift was negligible, since the difference between multiple readings taken at the base station is minimal throughout the day (Appendix B). All measurements were taken in relatively close vicinity to each other, so a latitude correction was not necessary for both transects.

Then measurements of both transects were corrected for free air and Bouguer effects, which were performed using the following equation:

$$G_s = G_{OBS} + (3.086 - 0.000421\Delta p_b)\ \Delta h,$$

in which G_s is the simple Bouguer corrected gravity value, measured in $\mu m/s^2$; G_{OBS} is observed gravity value in $\mu m/s^2$; Δp_b;is the near-surface density of the rock in kg/m^3; Δh is the elevation difference between the measured station and the base station in meters. We used 2670 kg/m^3 for rock density.

For transect 2, a tare (an instantaneous variation in reading) occurred at 13:57 at station -370 (Appendix B). Therefore, all stations measured after 13:57 need to be corrected for this tare (from -370 to -497). The size of the tare was identified by calculating the difference between base readings before and after the event.

4.4. Results

For transect 1, gravity readings are fairly stable for the flat area (NW of the base station), and show more noise on the hill (SE of the base station). Near station -200 meters, there is one major anomaly. This indicates a change in rock density in that area, probably close to the surface. The anomaly is located near the fault and the mine shaft (see location maps in Figures 2.1 and 2.2).

For transect 2, gravity readings are stable except for the SE end area (from station -370 m to -500). The anomalies in this area may have geological significant, because the magnetic survey also found anomalies in the same area. The minor decrease in gravity readings between station 50 and 200 coincide with the projected fault concluded by TEM data (Chapter 3).

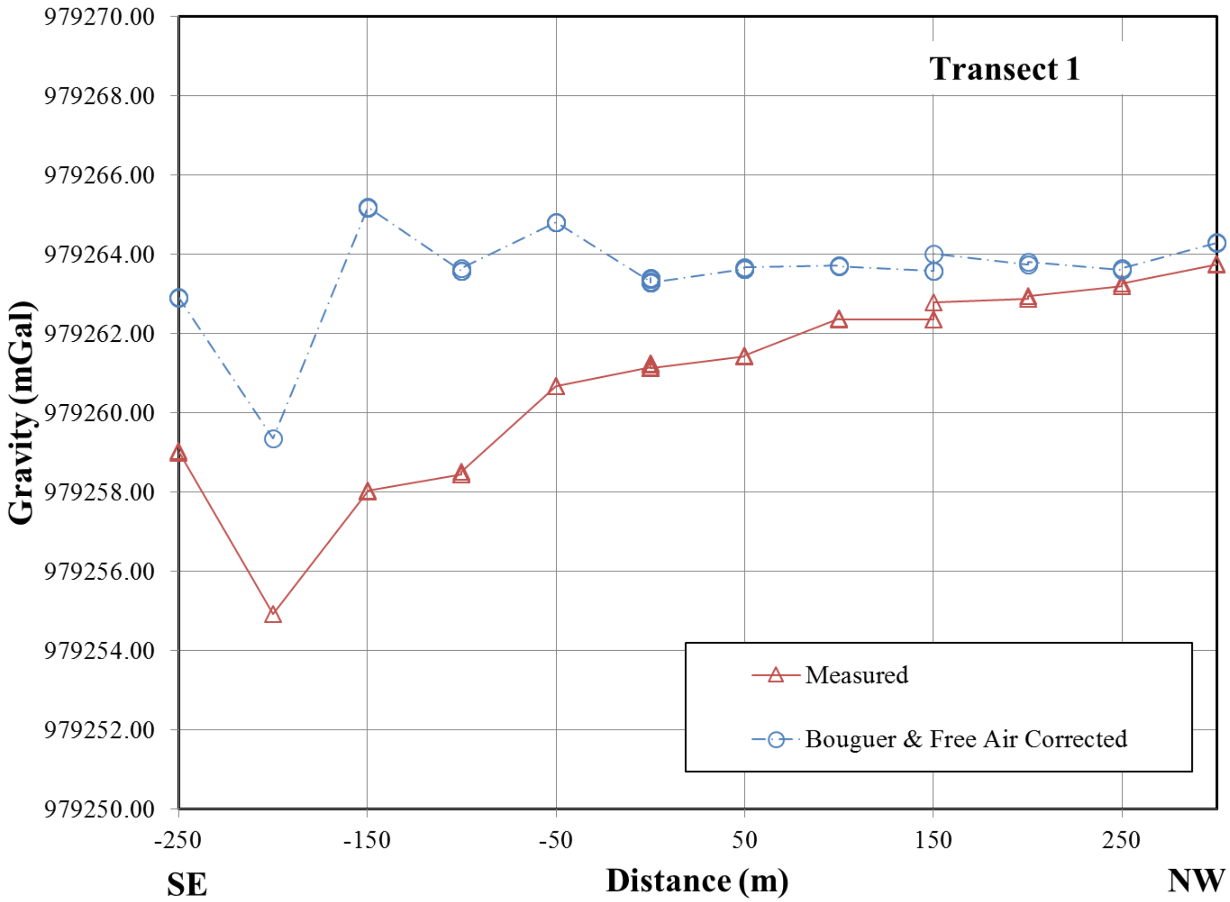


Figure 4.1 Measured gravity before and after Bouguer and free-air correction for transect 1.

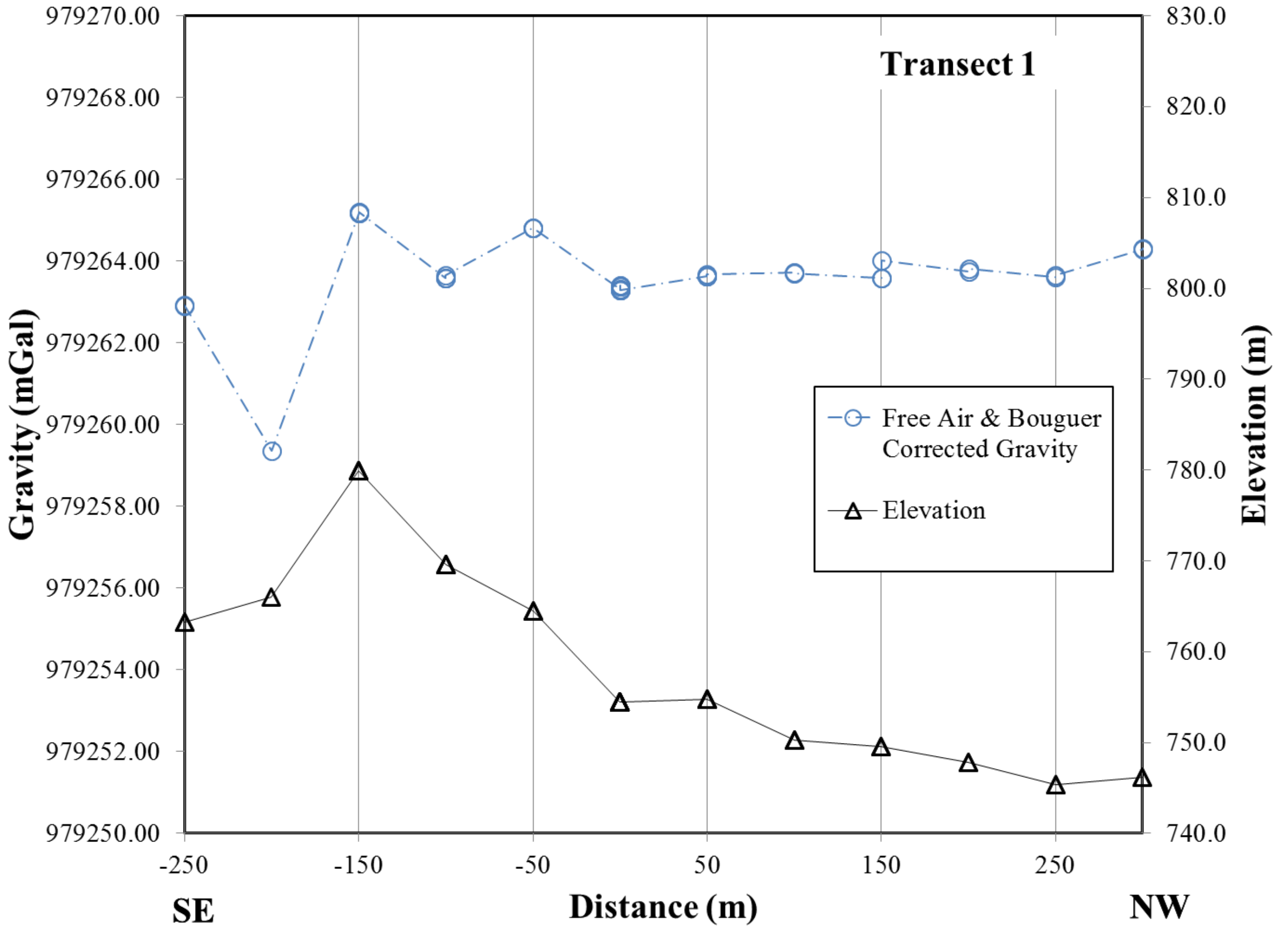


Figure 4.2 Gravity and elevation over distance for transect 1.

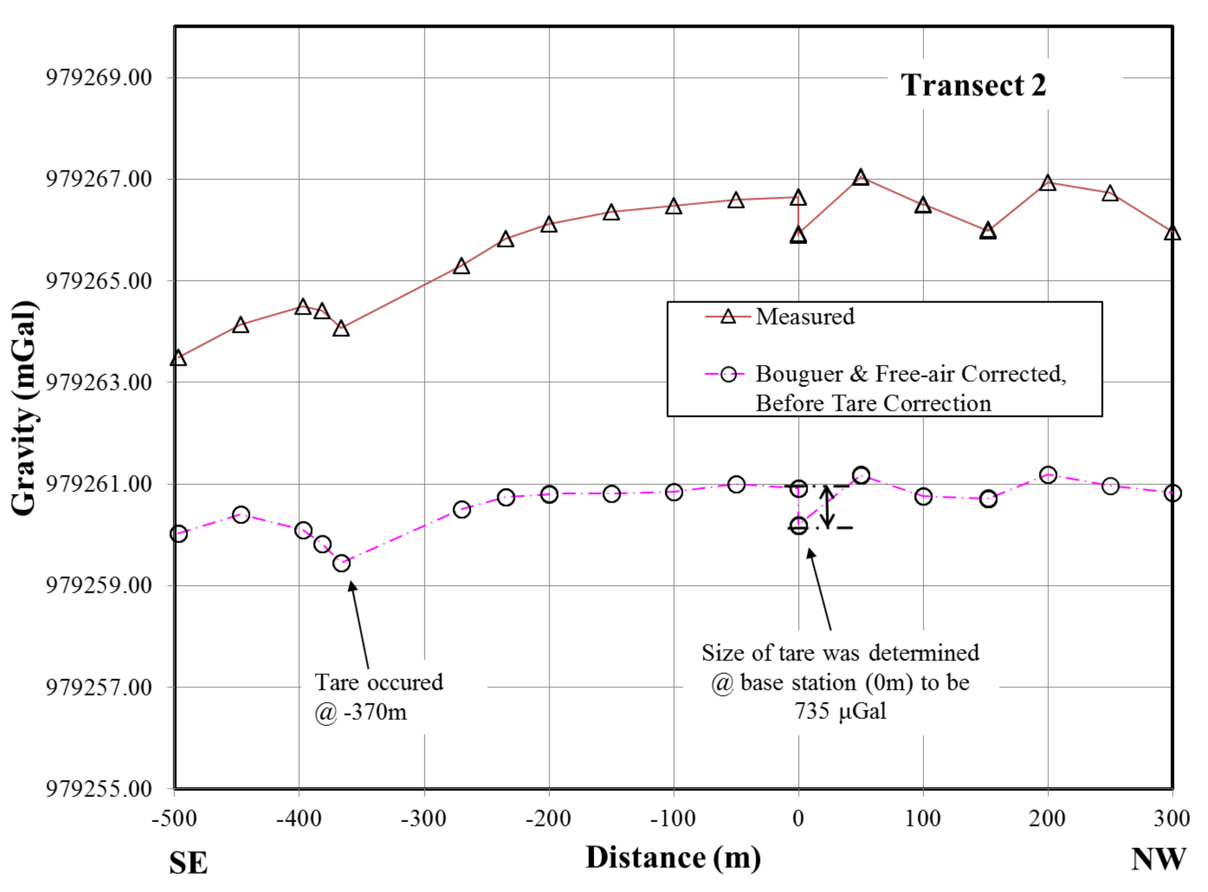


Figure 4.3 Measured gravity before and after Bouguer and free air correction for transect 2, with indication for the occurrence and size of tare (not corrected in the figure).

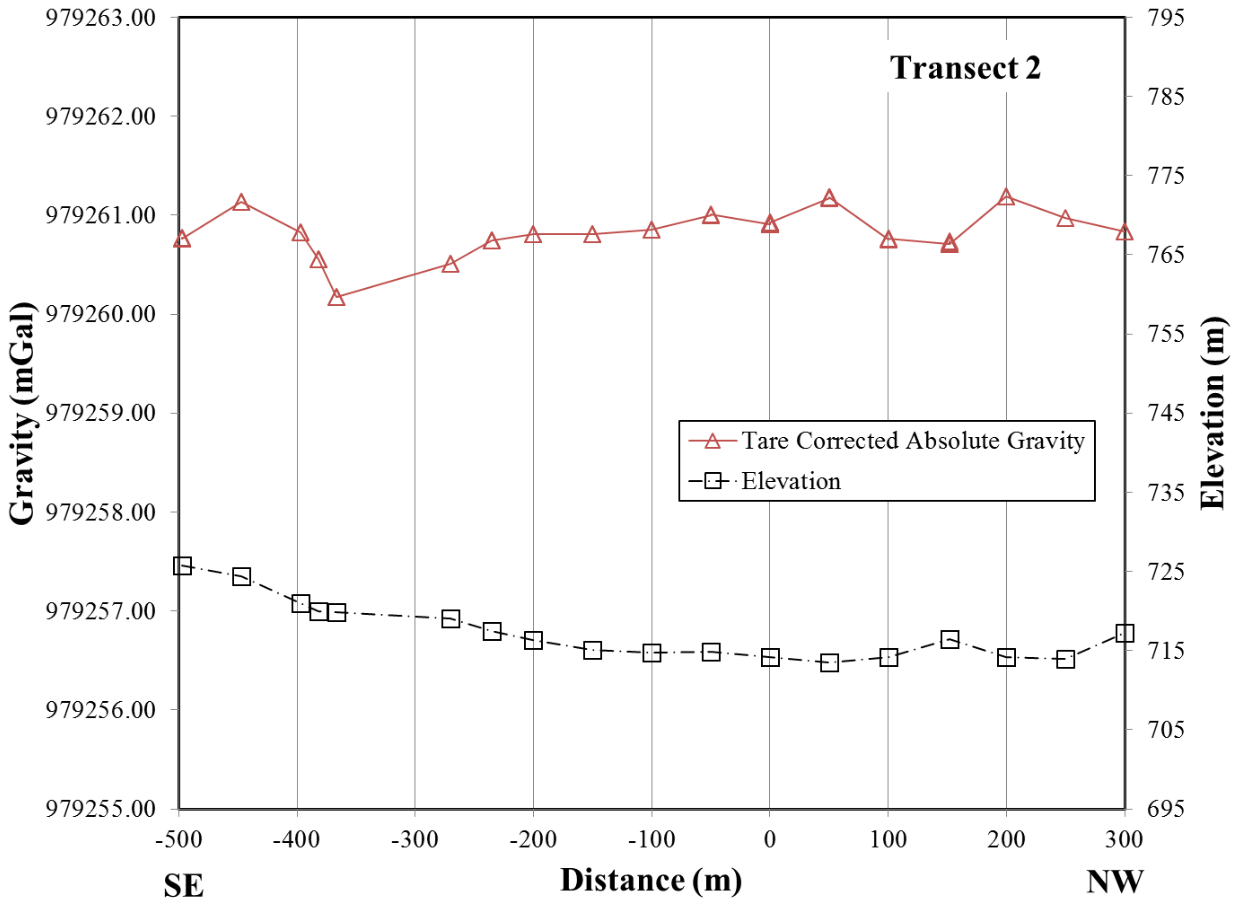


Figure 4.4 Gravity and elevation over distance for transect 2.

4.5 References

Lowrie, William. Fundamentals of geophysics. Cambridge university press, 2007.

U.S. Army Corps of Engineers. 1995. Geophysical Exploration for Engineering and Environmental Investigations. USACE EM 1110-1-1802

5. Magnetic Surveys

5.1 Introduction

The magnetic survey is a tool in exploration geophysics that can provide valuable insights during the mapping of oil, water, mineral resources, and other subsurface structures in Earth's shallow interior. This method involves the measurement of Earth's magnetic-field intensity at a series of densely spaced surface points, with the goal of detecting spatial variations in the magnetic susceptibility of Earth materials. Sufficient processing and interpretation of these data are completed using a fundamental understanding of the observable magnetic field, and the results can be used to make inferences about what exists below an area in question.

The magnetic field measured at the surface of the Earth can be attributed to three main sources. The first is the main field, which is generated by dynamic liquid materials in the Earth's deep interior (Likkason, 2014). The main field is by far the largest contributor to magnetic field measurements and generally only varies over long time scales (on the order of 100,000 years (Likkason, 2014)). The second component is generated from the interaction between Earth's upper atmosphere and the Sun's electromagnetic radiation. Diurnal variations in this field are generally regular and are strongly correlated with the Sun's activity and position relative to the Earth (Cnossen et al., 2012). Because these changes are detectible over much shorter time-scales, the measured data must be treated with the drift corrections described in the data processing section below. The third major contributor to field-intensity measurements is related to the material properties of the Earth and is thus the basis for using this method for exploration. The presence of magnetically susceptible materials in the near surface causes variations in the ambient field. When a magnetically susceptible material is subjected to a changing magnetic field, the material itself generates an induced magnetic field that can cause both positive and negative interference in the field around it. The magnitude of these variations is determined by several factors, including the magnetic susceptibility of the material, its orientation and distribution, and in the case of iron-bearing materials, the timing of its freezing below the Curie temperature during formation (Likkason, 2014). For similar reasons, metal objects on the surface of the Earth can also cause cultural interference that heavily affects survey measurements. These things must also be accounted for in handling the data. Once all corrections and considerations have been applied to the data, a profile of the magnetic field can be generated, and the locations of the anomalous bodies can be plotted (U.S. Army Corps of Engineers, 1995, 6-1).

5.2 Field location

Magnetic surveys were conducted on January 30 and 31, 2016. The magnetic data were gathered along two transects in the Tucson Mountains near Old Yuma Mine (Figure 5.1). Transect 1, collected on January 30, stretched through a hilly region near the mine shaft entrance. Nearby cultural interference included wire fences, telephone lines, telephone poles, and large amounts of metal trash. Transect 2, collected on January 31, was in a more level area farther north. Cultural interference along the second transect included telephone lines, wire fences, several washes, a horse paddock, and a house. A base station was designated in the center of each transect, and magnetics stations were laid out every 5 m to both the northwest and the southeast of the base station. Magnetics stations were identified by distance from the base station along the transect. A total of 112 stations along Transect 1 and 193 stations along Transect 2 were surveyed.

5.3 Data collection

An Overhauser GSM-19 Magnetometer was used to take two magnetic field readings at each station. The time of each reading was also recorded. Reading values and times were entered manually into field notebooks. A Garmin GPS unit was used to record the UTM coordinates of every tenth station (50 m intervals). All station locations, magnetic readings, and times are provided in Appendix C.

The northwest section of Transect 1 was collected first, to a total distance of 300 m from the base station. Repeat measurements were taken at the 50 m NW station before beginning the section and after completing the section. The southeast section of Transect 1 was collected next, also to a total distance of 300 m from base station. The first 15 m were skipped due to the presence of wire fences. Repeat measurements were taken at the 50 m NW station before beginning the southeast section, after completing the first 200 m of the southeast section, and after completing the entire southeast section. These repeat measurements were used to correct each section individually for drift.

The northwest section of Transect 2 was collected next, to a total distance of 300 m from base station. Initially, the base station (designated 0 m) was chosen to take repeat measurements for use in drift correction after every 100 m of data collection. However, significant variation in these repeat measurements was noticed and was thought to be caused by the power lines near the base station. All further repeat measurements for Transect 2 were taken at the 100 m NW station to avoid power line interference. The southeast section of Transect 2 was collected last. The first 45 m of the section were skipped due to the presence of multiple power lines and a large wash. At 200 m from base station, the southeast section of the transect passed through a house and garage complex. To avoid disturbing the residents, the magnetics measurements were deviated to the south and collected parallel to the original transect for approximately 400 m before rejoining the original transect. This deviation is visible as a loop off of the transect in Figure 5.1. Measurements were taken to a total distance of 700 m; after projecting the deviated stations back onto the original transect (as described in the data processing section below), the total distance from base station of the southeast section of Transect 2 was 497 m.

5.4 Data processing

Magnetic field readings, times, and locations were entered into Excel. The readings were then corrected for the effect of drift using repeat measurements along each transect. For Transect 1, repeat measurements at the 50-meter mark on the northwest section of the transect were used; for Transect 2, repeat measurements at the 0-meter mark were used for the initial 100 meters of readings and at the 100-meter mark on the northwest section of the transect for all other readings. The reading times recorded in the field were converted into decimal hours past noon or midnight, to permit calculation of time difference between readings (example: 1:37 pm → 1.617 hours past noon). The time of the initial reading and the magnetic field value of the initial reading were subtracted from the time and magnetic field value of the repeat reading(s), providing the total time and total drift. The time of the initial reading was subtracted from the time of each station reading and then divided by the total time in order to give the fraction of total time at which each reading was taken. This fraction was multiplied by the total drift amount in order to calculate the necessary drift correction for that particular station reading. Each drift correction was subtracted from each magnetic field value along the two transects in order to calculate the drift-corrected values (Figures 5.2 and 5.3). Drift corrections and corrected magnetic readings for all stations are provided in Appendix C.

Least squares procedures were used to interpolate UTM coordinates for the 5m-spaced stations from the GPS measurements taken every 50 meters and to project the deviated stations of the southeast section of Transect 2 onto the original transect bearing. The corrected magnetic field readings were plotted vs. the projected station distances from base station to create magnetic profiles for Transect 1 (Figure 5.4) and Transect 2 (Figure 5.5).

5.5 Interpretation

Many of the anomalies observed in the two profiles are narrow and associated with cultural interference such as metal fences and poles. However, at the southeast end of Transect 2 (about -450 to -500 m), a broader anomaly occurs, corresponding in location along the profile to a small anomaly in the Transect 2 gravity data. Since no metal objects were noted and the terrain is relatively level in this area, this anomaly is thought to be caused by a variation in the local lithology. A second magnetics anomaly was observed at the northwest end of Transect 1 (about 275 to 300 m); this anomaly was also visible in the EM-31 and EM-34 data and could be due to the presence of a nearby wash.

5.6 References

Cnossen, I., M. Wiltberger, and J. E. Ouellette. 2012. The effects of seasonal and diurnal variations in the Earth's magnetic dipole orientation on solar wind–magnetosphere-ionosphere coupling. *J. Geophys. Res.*, 117, A11211. doi:10.1029/2012JA017825.

Likkason, Othniel K. 2014. "Exploring and using the magnetic methods". *Advanced Geoscience Remote Sensing*, Maged Marghany (Ed.). InTech. DOI: 10.5772/57163.

U.S. Army Corps of Engineers. 1995. *Geophysical Exploration for Engineering and Environmental Investigations*. USACE EM 1110-1-1802

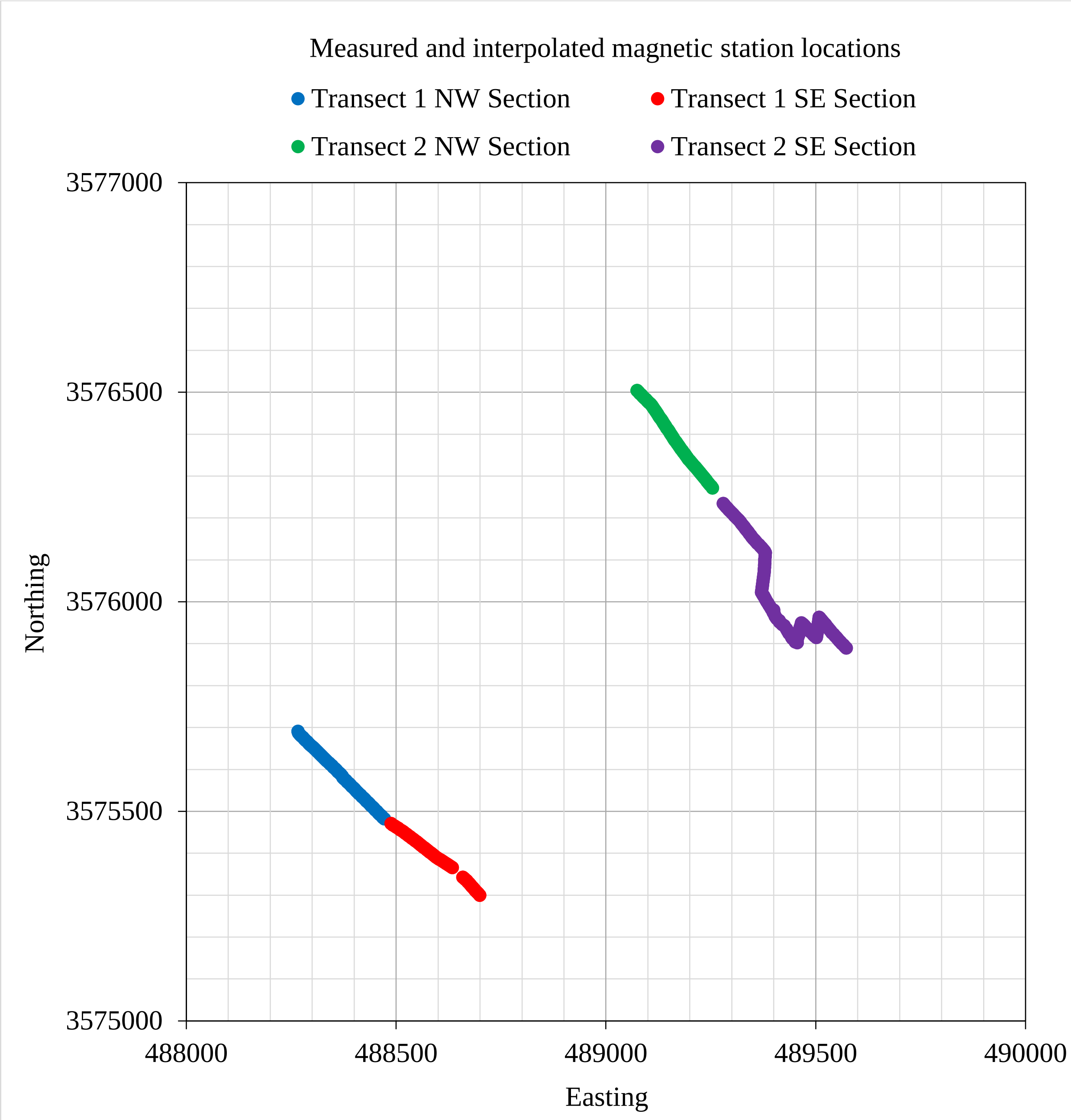


Figure 5.1. Location map for magnetic field measurements. Survey coordinates were recorded at every 50 m mark along each transect and were later interpolated to every 5 m.

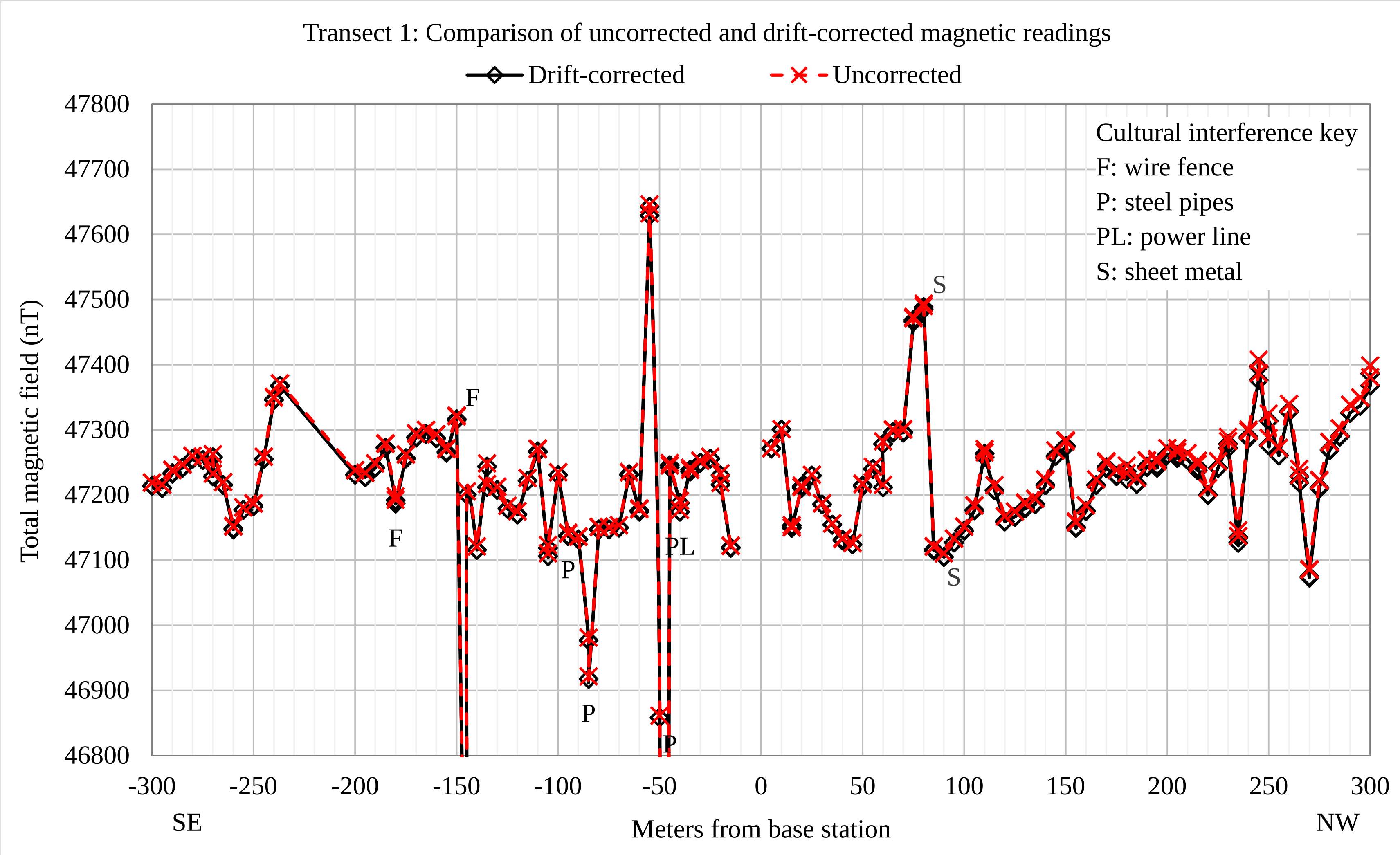


Figure 5.2. Magnetic profile for Transect 1, demonstrating the magnitude of the applied drift correction. Readings were taken at every 5 m mark with an Overhauser GSM-19 Magnetometer. The locations of large metal objects were noted in the field and are marked on the profile as cultural interference.

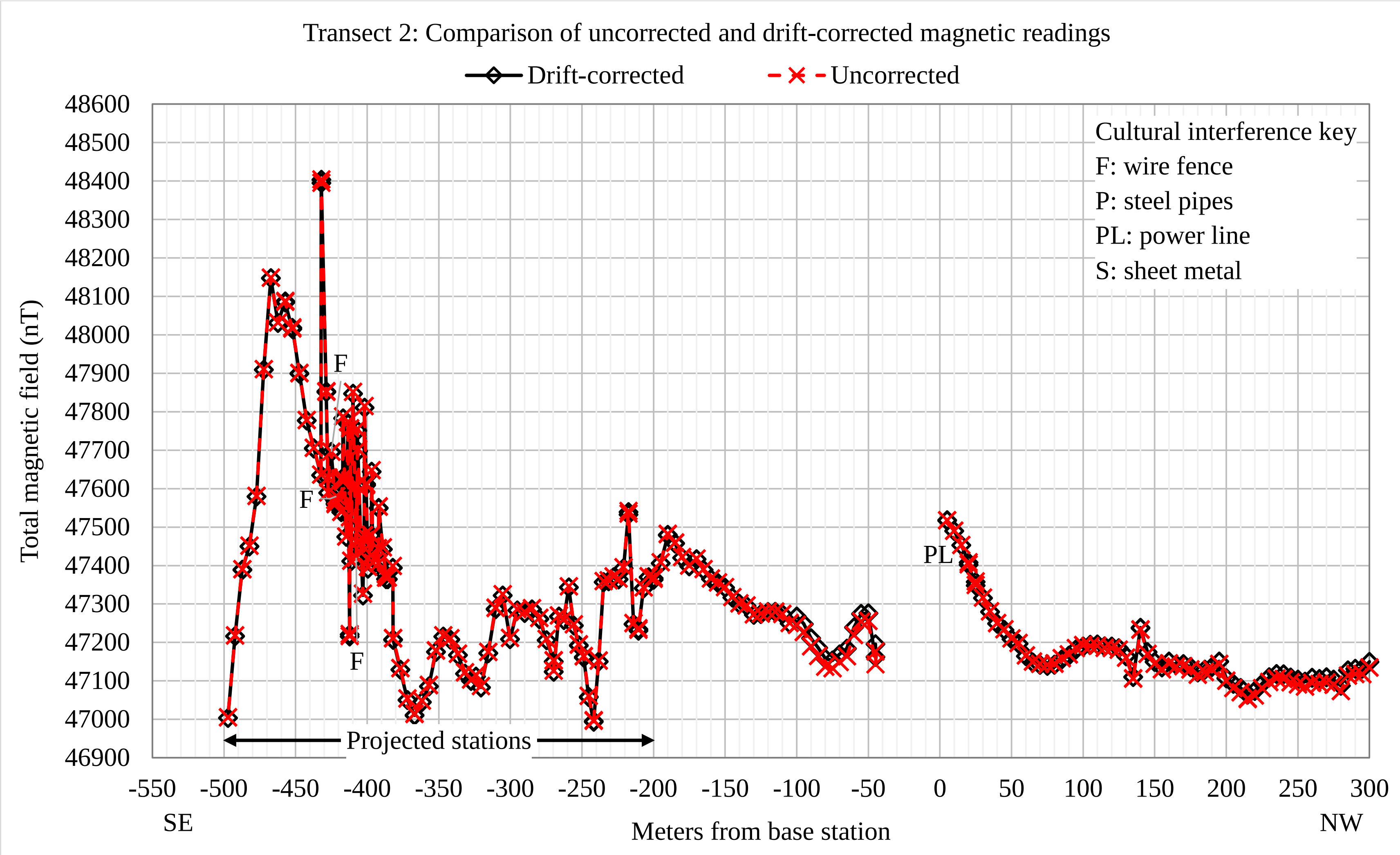


Figure 5.3. Magnetic profile for Transect 2, demonstrating the magnitude of the applied drift correction. Readings were taken at every 5 m mark with an Overhauser GSM-19 Magnetometer. The locations of large metal objects were noted in the field and are marked on the profile as cultural interference. The noise between -380 m and -440 m is due to overlapping station locations that were measured off of the transect and then projected back onto the transect.

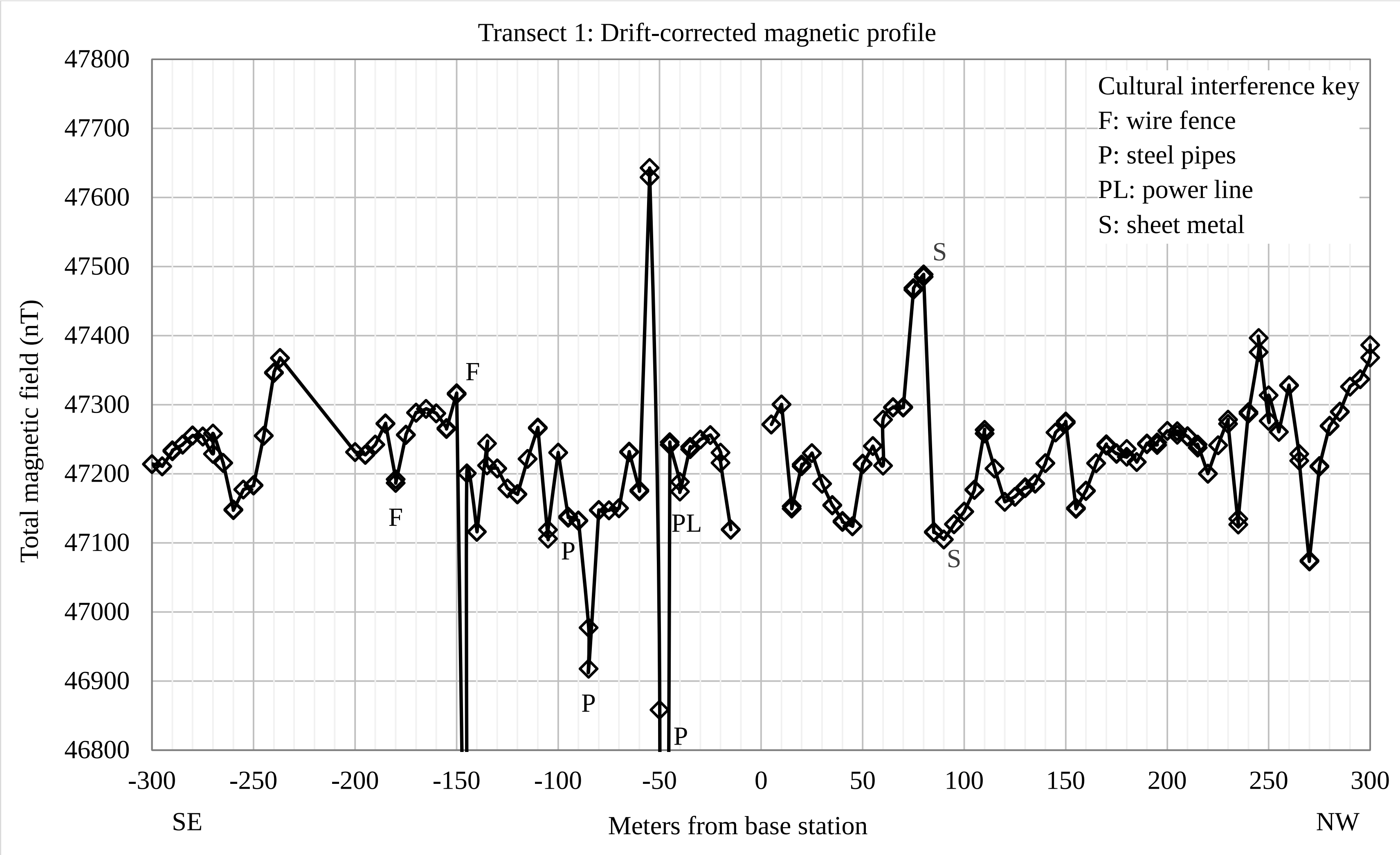


Figure 5.4. Magnetic profile of Transect 1, corrected for drift using repeat measurements at the +50 m (NW) station. Readings were taken at every 5 m mark with an Overhauser GSM-19 Magnetometer. The locations of large metal objects were noted in the field and are marked on the profile as cultural interference.

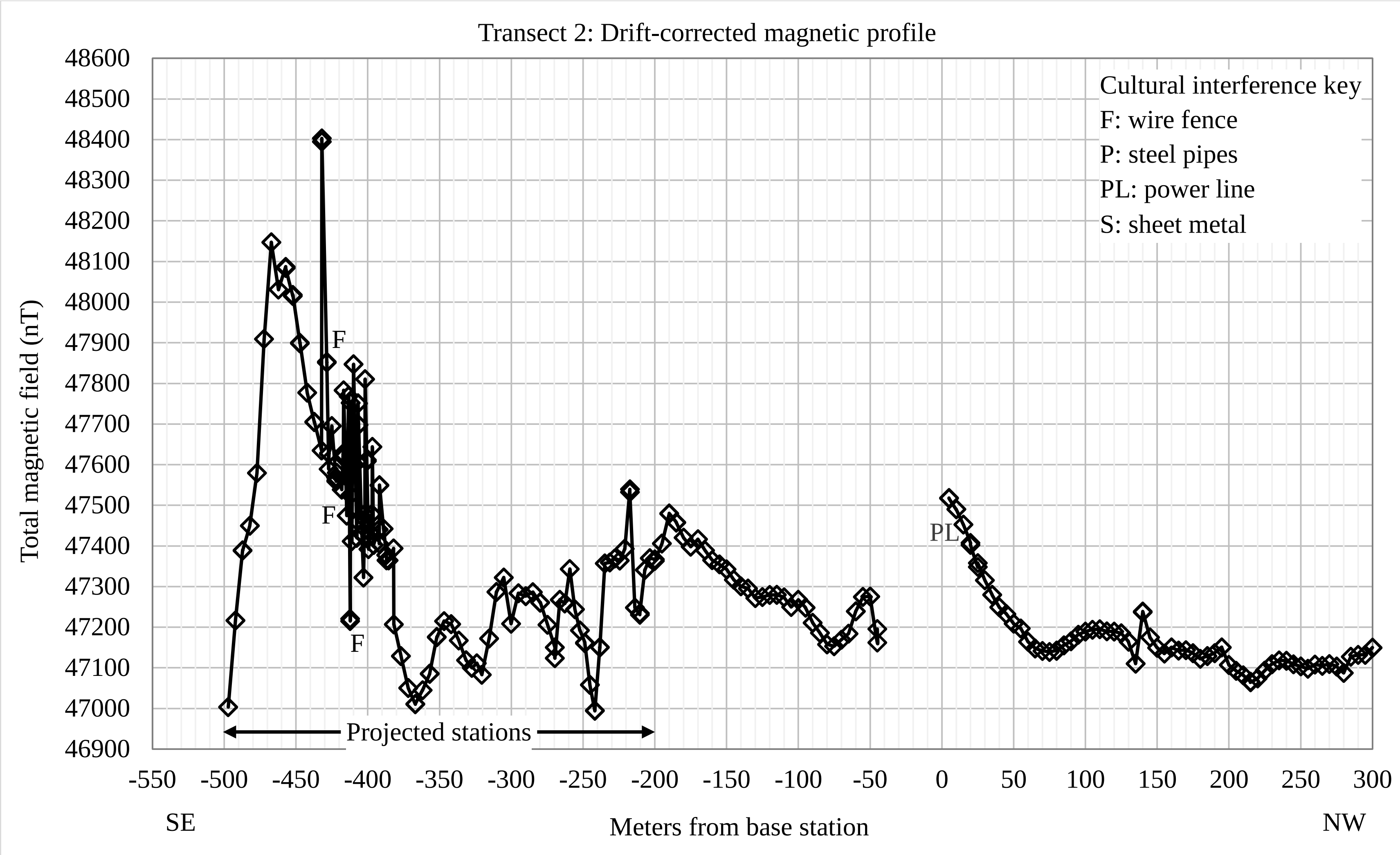


Figure 5.5. Magnetic profile of Transect 2, corrected for drift using repeat measurements at the 0 m and the +100 m (NW) stations. Readings were taken at every 5 m mark with an Overhauser GSM-19 Magnetometer. The locations of large metal objects were noted in the field and are marked on the profile as cultural interference. The noise between -380 m and -440 m is due to overlapping station locations that were measured off of the transect and then projected back onto the transect.

6. EM-31 Conductivity and In-Phase Surveys

6.1 Introduction

The Geonics EM31 maps geological variations, groundwater contaminants or other subsurface feature associated with changes in the ground conductivity using an electromagnetic induction technique. The effective depth of exploration is up to about six meters, making it ideal for many geotechnical and groundwater contaminant surveys, [*www.expins.com*]. An EM-31 MK-1 and MK-2 were used only for the southern transect, Figure 2.8. This survey stretched 300m to the northwest, and 315m to the southeast, from the base station at 0m. Due to the data-logger battery in the MK-2 dying after the first 70 m northwest, the data relies most heavily on the MK-1 (with an analog readout). There was a power line overhead at about 50 m (northwest) on transect 1, along with scrap metal visibly lying about on the ground, which has been noted on the plots and taken into account when interpreting the data. At each 5m location, four measurements of in-line horizontal and in-line vertical as well as cross-line horizontal & cross-line vertical measurements were made. The horizontal and vertical operating modes are defined by the orientation of the coils relative to the ground surface. When the plane of the coils lies parallel to the ground surface, the Magnetic Dipole orientation is said to be vertical, hence the term Vertical Magnetic Dipole. Conversely, coils that are at right angle to the ground surface represent the Horizontal Magnetic Dipole orientation [*Reynolds International*]. The horizontal and vertical terms refer to the coil orientation relative to the ground. Vertical dipole (horizontal coil) also has a better penetration depth [*EM 31 Forum*].

6.2 Pre-survey equipment test

Prior to the day of the survey, a site was set-up where, in a conrtolled test-environment, the equipment could be thoroughly tested to check for functionality and to compare output between the MK-1 and the MK-2. For the practice runs, two 100-meter tapes were laid out (approximately 50 m in opposite directions from one another). A reading was taken every meter in both directions. Both MK-1 and MK-2 worked well, with the exception of the in-phase reading for MK-2 (the digital readout). The problem with the in-phase reading for the MK-2 was not worked out until the day of the survey.

After the profile was collected, it was plotted and comparison was made as shown in Figure 6.1. There was a difference in readings between the two instruments of about 3.3 mS/meter. As discussed in the following sections, this offset was taken into account when processing the data for the Old Yuma Mine survey.

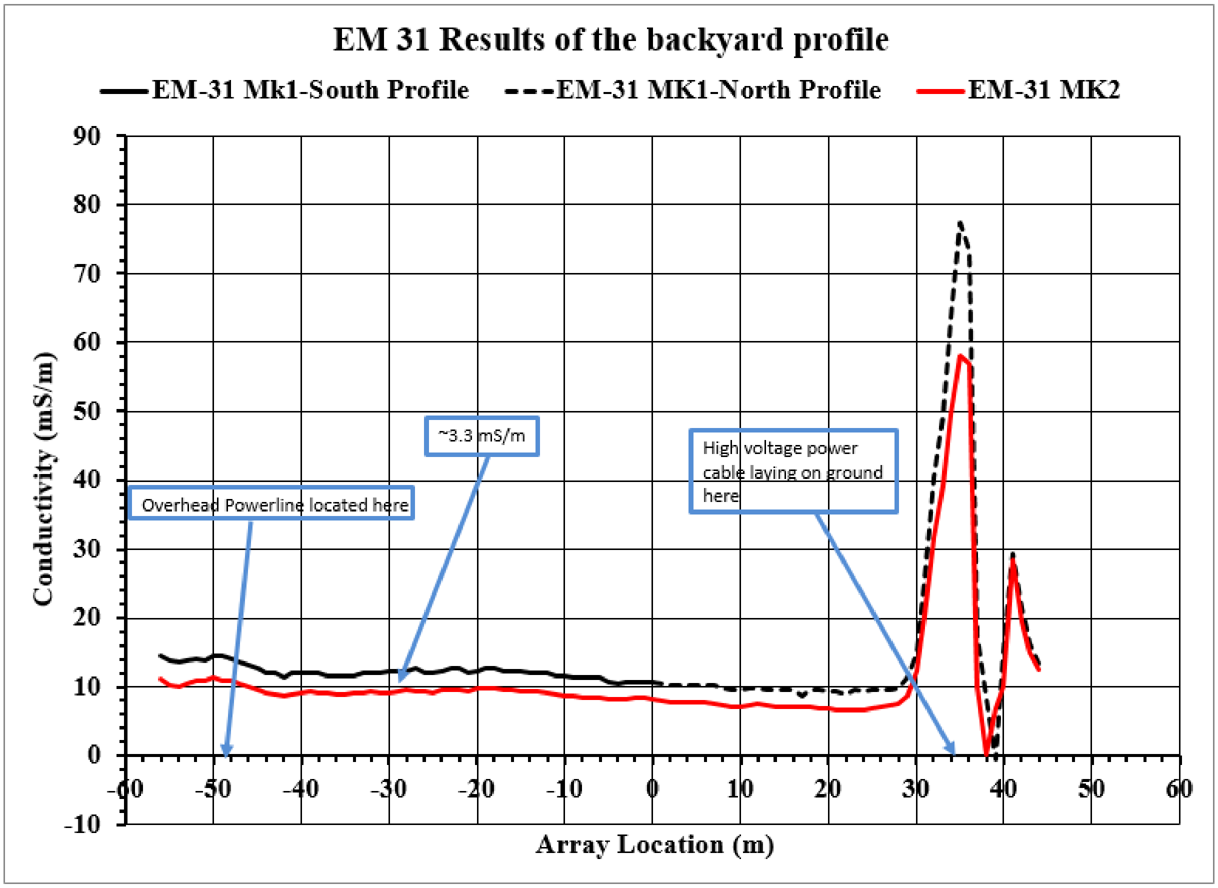


Figure 6.1: EM 31: MK-1 & MK-2 data plot from a test-site, conducted to check the equipment's functionality and to compare the output between the two models of EM-31. Only the in-line, horizontal coil test was performed at the test site. Neither the cross-line, nor the vertical surveys were performed.

6.3 Instruments and Field Methods.

EM-31 models MK-1 and MK-2 were calibrated on an area relatively clear of cultural interference (metal debris, power lines etc.) prior of their deployment for actual measurement on transect 1. A base station was set up near a corner fence at the Old Yuma Mine during the beginning of the field measurements. Starting from this base station, both conductivity and in-phase data were collected every 5m increment along measuring tape laid at NW-SE transverse of the transect line. Since the MK-2 failed during operation, measurements were resumed using the MK-1, starting from 50m location, and 5 measurements were repeated from the previous measurement.

Even though most of the measurements went smoothly, due to steep terrain and dense vegetation, some locations were inaccessible or difficult to reach. Great caution was also taken to avoid any interference with the EM-34 instrument. During data acquisition, the equipment was turned off until EM-34 crew went far enough away from the EM-31 so that there was no change in the reading when the other transmitter was turned on and off.

6.4 Data Processing

The conductivity [mS/m] and the in-phase, which is the ratio of the secondary to primary magnetic field in parts per thousand [ppt], data were manually entered into an Excel spreadsheet. Separate plots, only up to 150m NW from the base, were used to analyze and compare the different data sets for the MK-1 and MK-2 as seen in Figures 6.2a and 6.3a. From the repeated 5 data points on the NW section, a scaled correction was done to the MK-2 data (same technique as in Figure 6.1) in order to make it usable and fit with MK-1 data. The corrected conductivity data are much more coherent with the MK-1 data than their in-phase counterparts (Figure 6.2b and 6.3b).

Complete transect conductivity and in-phase as well as separated plots of in-line (conductivity & in-phase) and cross-line (conductivity & in-phase) were made to better understand and analyze any geologic related anomalies in the area.

6.5 Data Interpretation

Around the base station 0m to 40m NW, the EM-31 data show high interference from metallic waste and proximity to a power line. Around -153m in the SE direction the data are apparently affected by nearby barbed wire-fences. Effect from the power line is highly noticeable on the in-phase plots affecting a segment from SE 10m to NW 40m, Figures 6.4b, 6.5b and 6.6b.

Two anomalies are identified along the transect line, one around SE -195m to - 225m and the other around NW 260m – 295m, Figures 6.4a, 6.5a and 6.6a. Though there is a fenced portal near the buried mine shaft around SE -195m to - 225m, the anomalies on the SE section are mostly one-point peak anomalies and are interpreted to be caused by cultural interference. The NW section in general shows an increasing conductivity trend starting around 85m (Figures 6.5a & 6.6a) and there is an abrupt anomaly between the segment of 260m – 295m, Figures 6.4a & 6.5a. This NW part of the transect is topographically flatter and seems to have thicker alluvial deposits. The general increasing trend therefore possibly may be associated with water saturation characteristics of alluvium and the anomalous area was also close to a small wash. Similarly, the in-phase plots for both in-line and cross-line surveys also depict the same anomalies, especially when the EM-31 equipment was in the horizontal position.

Figure 6.2a

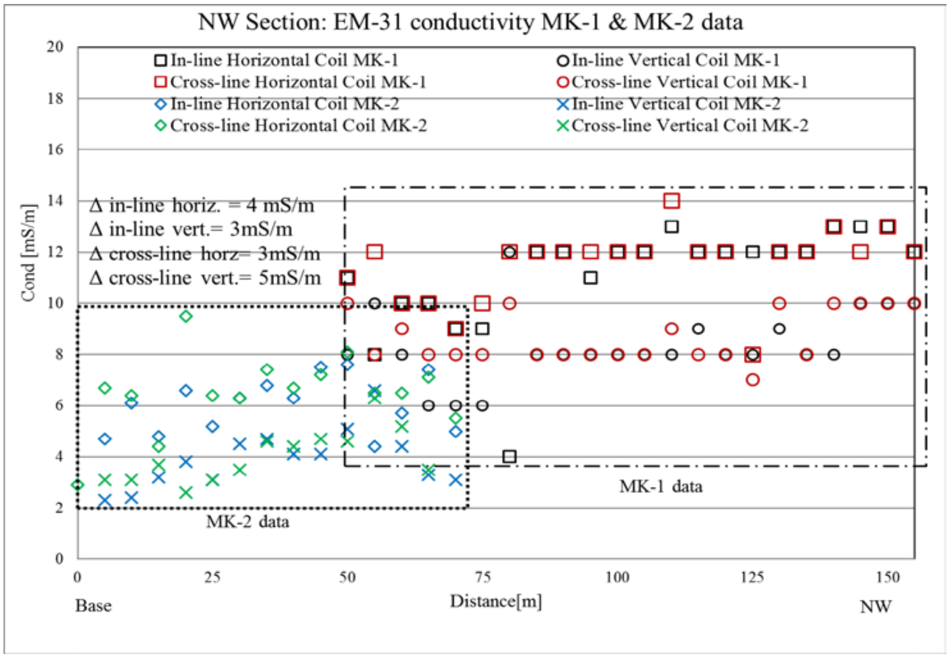


Figure 6.2b

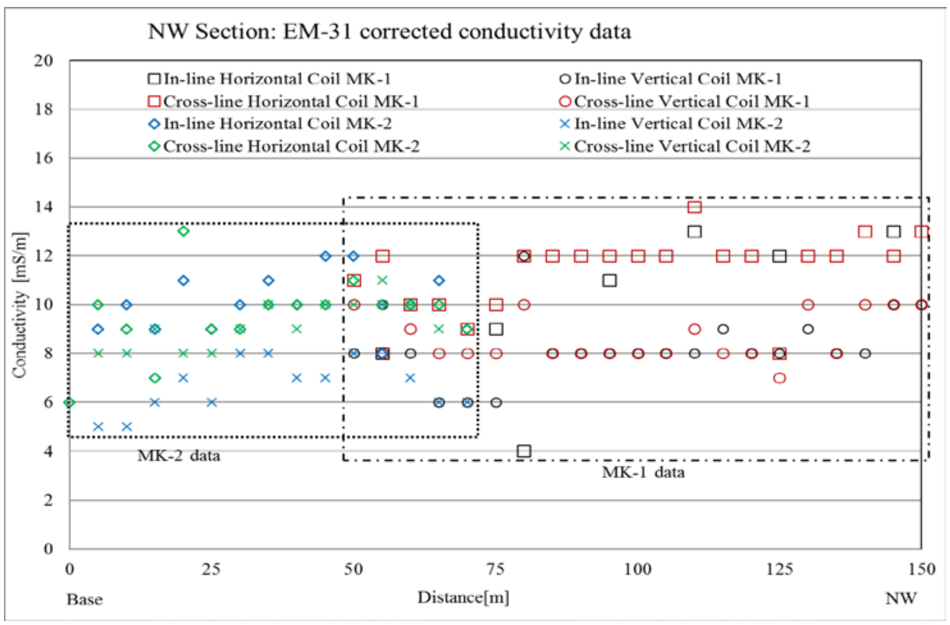


Figure 6.2: EM-31 MK-1 and MK-2 data of conductivity [mS/m] only in the NW 150m section of transect #1 for clarity purpose. MK-2 was failed to operate around 70m NW of the base. Data acquisition was resumed using MK-1 starting at 50m NW of base with 5-points repeated measurements. From the repeated data points, a scaled correction was done to the MK-2 data in order to make it usable and fit with MK-1 data. Figure 6.2b shows the corrected and fitted data of MK-2 with MK-1 for the NW section of transect #1. (In-line with transect line are in Black symbols for MK-1, Blue for MK-2 and for Cross-line data are Red symbols for MK-1, Green for MK-2).

Figure 6.3a

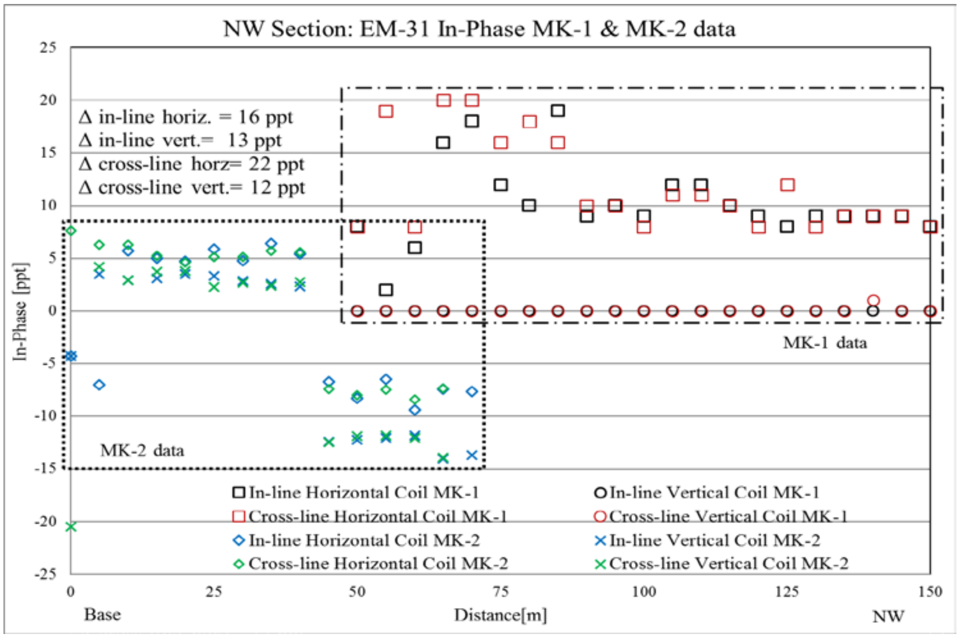


Figure 6.3b

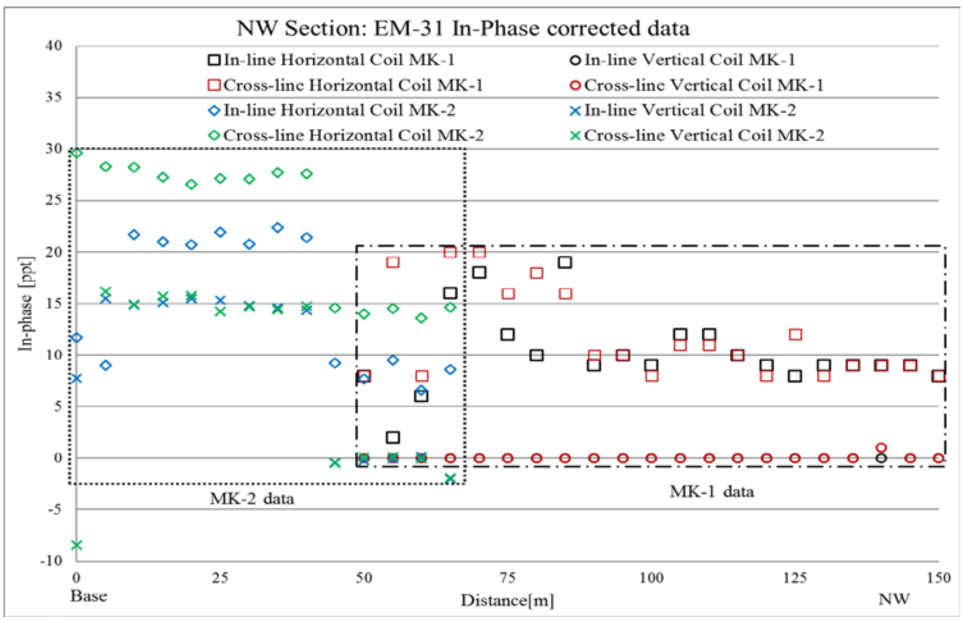


Figure 6.3: EM-31 MK-1 and MK-2 In-Phase [ppt] only in the NW 150m section of transect #1 for clarity purpose. MK-2 was failed to operate around 70m NW of the base. Data acquisition was resumed using MK-1 starting at 50m NW of base with 5-points repeated measurements. From the repeated data points, a scaled correction was done to the MK-2 in-phase data in order to make it usable and fit with MK-1 data. Figure 6.3b shows the corrected data of MK-2 with MK-1 for the NW section of transect #1. (In-line with transect line are in Black symbols for MK-1, Blue for MK-2 and for Cross-line data are Red symbols for MK-1, Green for MK-2).

Figure 6.4a

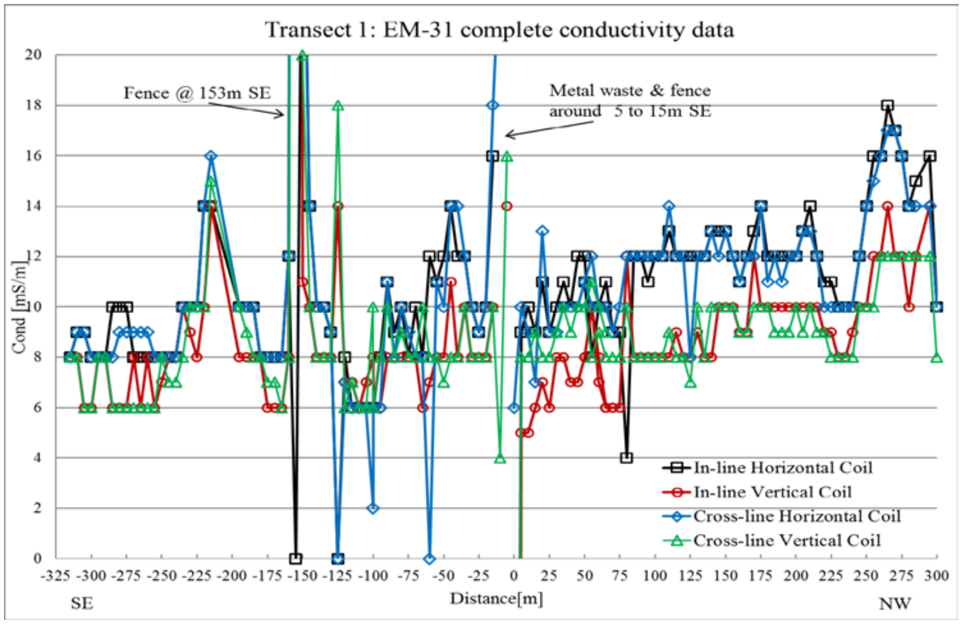


Figure 6.4b

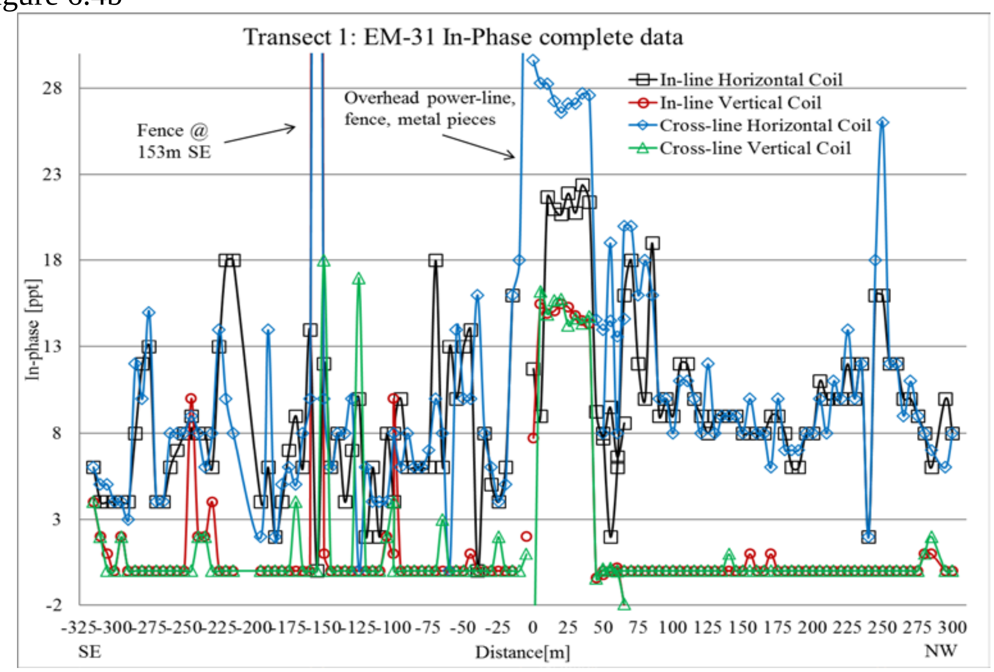


Figure 6.4: Complete EM-31 conductivity data [mS/m] and In-phase ratio (ppt) with in-line and cross-line to the SE-NW transect #1 line. In both Figures 6.4a & 6.4b, the EM-31 show interference with metallic fence around 155m SE direction. The high interference between SE 15m to NW 85m section shown in Figure 6.4b may be possibly due to the overhead power-line, nearby metal wastes and proximity to the fences near the mine. Possible anomalies are identified around NW 260m – 295m and around SE 195m – 225m.

Figure 6.5a

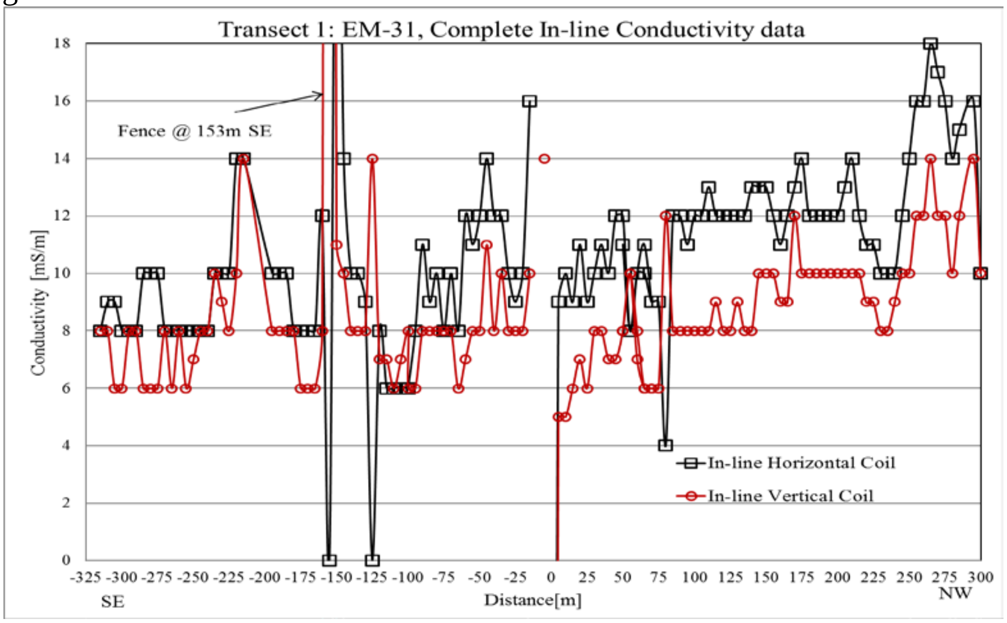


Figure 6.5b

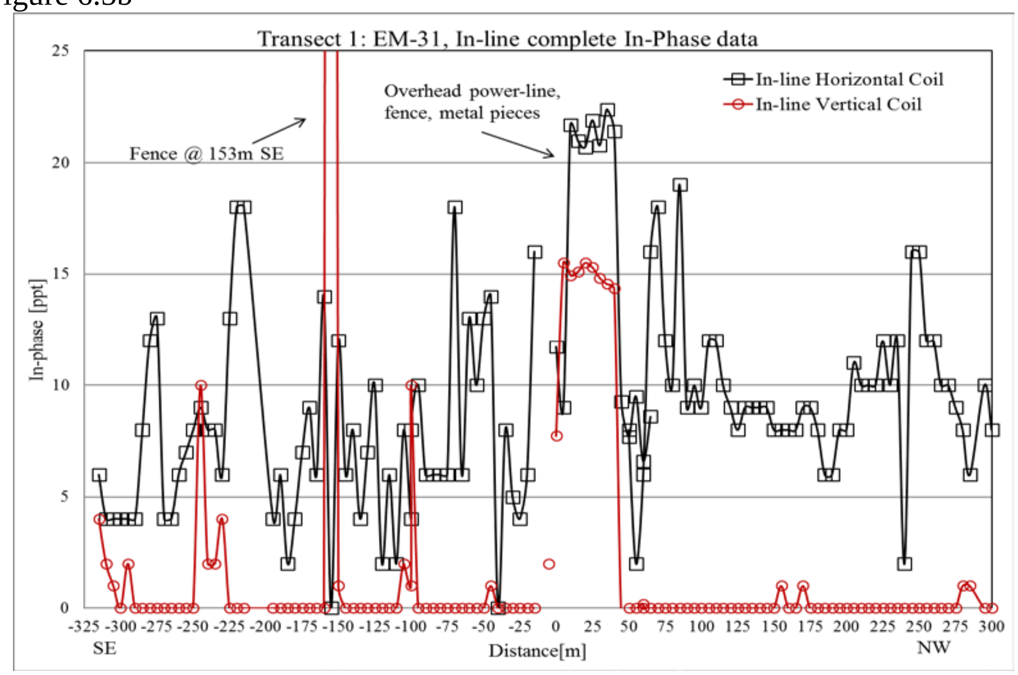


Figure 6.5: In-line with the transect conductivity and in-phase plots. Figure 6.5a: In-line conductivity data: shows anomalies around NW 260m – 295m and SE 195m – 225m. Anomalies on the SE section are one-point peak anomaly and assumed to be of cultural interference. The anomalies on the NW section are near a wash and possibly could be due to relatively water saturated alluvium deposit. Figure 6.5b in-phase data, though less apparent, the anomalies are the same as the conductivity data and are better identified when the EM-31 is in horizontal position. The high metallic & power line interference near SE 15m to NW 85m section also are better reflected with the horizontal coil orientation.

Figure 6.6a

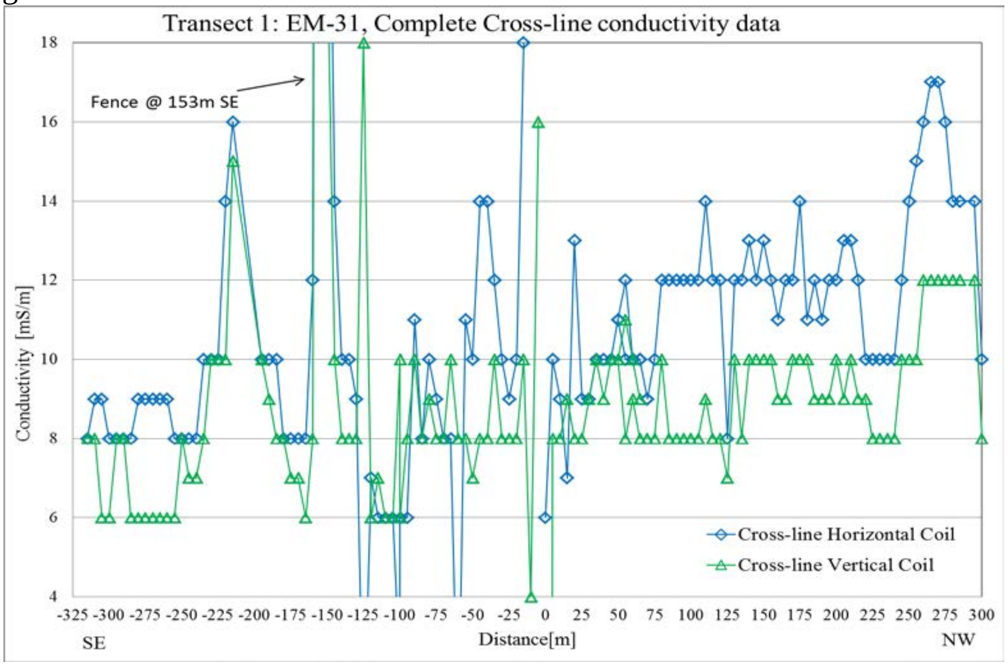


Figure 6.6b

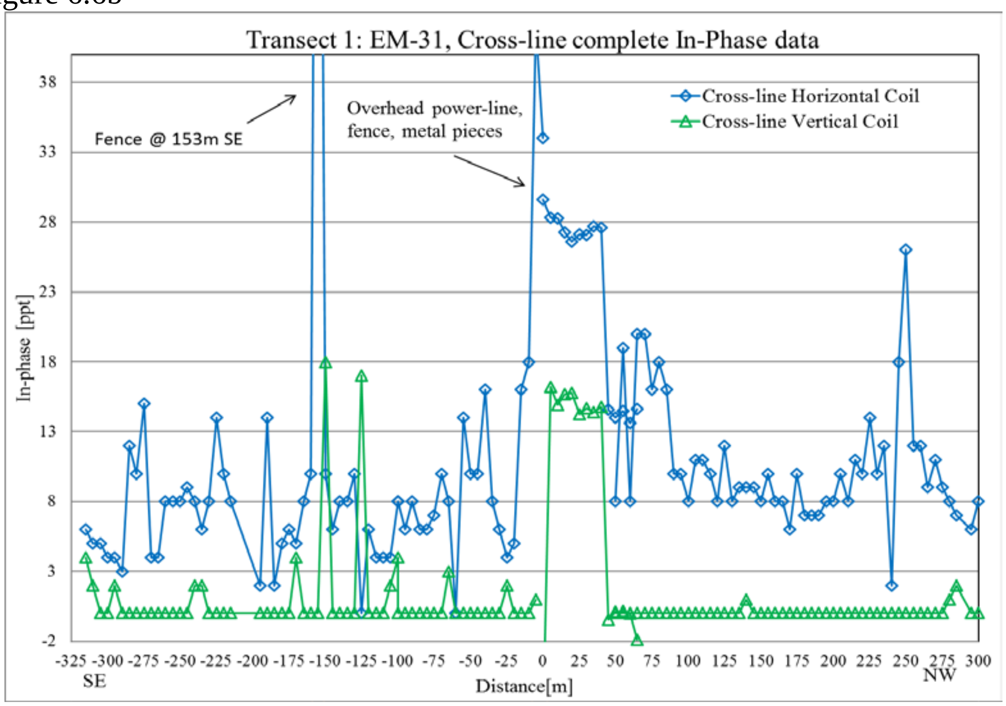


Figure 6.6: Cross-line to the SE-NW transect line. Figure 6.6a: conductivity data express the same anomalies with the in-line data plot. The metallic interferences around the SE 15m to NW 5m and with fence near -155m are better expressed on the cross-line conductivities. Figure 6.6b: Cross-line In-phase data becomes more sensitive when the EM-31 meter is in horizontal position. All the anomalies and metallic interferences are the same with the in-line plot.

6.5 References

Geonics EM-31 manual: http://geonics.com

Exploration Instruments: http://www.expins.com/item/geonics-em-31

EM31 Users Online Forum: http://www.forum.detectation.com/viewtopic.php?f=2&t=737

Reynolds International, technical summary of EM31 electro-magnetic ground conductivity mapping: http://www.reynolds-international.co.uk/uploads/files/04tssem31.pdf

7. EM34 Conductivity Surveys

7.1. Introduction, Instrumentation, and Data Collection

Electromagnetic (EM) surveys can be used to determine the apparent conductivity of the earth. The instrument used for this survey is the Geonics EM34-3. It can use 3 inter-coil spacings to explore variable depths down to 60 meters. In the vertical dipole, aka the horizontal coplanar (coil) mode, the EM34 is sensitive to vertical geological anomalies. Measurements were conducted at 10 m spacing, in both the vertical and horizontal dipole modes for transect 1 (Old Yuma Mine location) on 2/27/2016.

7.2. Locations

The EM measurements were taken only for transect 1, approximately every 10 meters to the SE first along the transect line, then every 10 meters to the NW, after reoccupying the base station. Near the base station, a few measurements were taken every 5 meter to the SE, but soon switched to every 10 meters. The line was translated a few meters at station -100m due to geological obstacles (see location map Figure 2.9). Significant cultural noise includes a power line overhead at about 50 m (northwest) on transect 1, a fence at the base station, and fence and scrap metal 150 meters to the SE.

7.3. Results

EM34 conductivity survey were only performed for transect 1. For this survey, the EM34 was more sensitive to cultural noise with the vertical dipole. The anomalies are interpreted be due to cultural noise. Other readings are fairly stable except for the slight increase between station 250 and station 300. This matches with the presence of a roughly 5m-wide wash through those stations (Appendix E). There is a small and stable decrease in ground conductivity from the NW to the SE, towards the old mine shaft.

7.4 Reference

EM34-3 User Manual.

Lowrie, William. Fundamentals of geophysics. Cambridge university press, 2007.

U.S. Army Corps of Engineers. 1995. Geophysical Exploration for Engineering and Environmental Investigations. USACE EM 1110-1- 1802

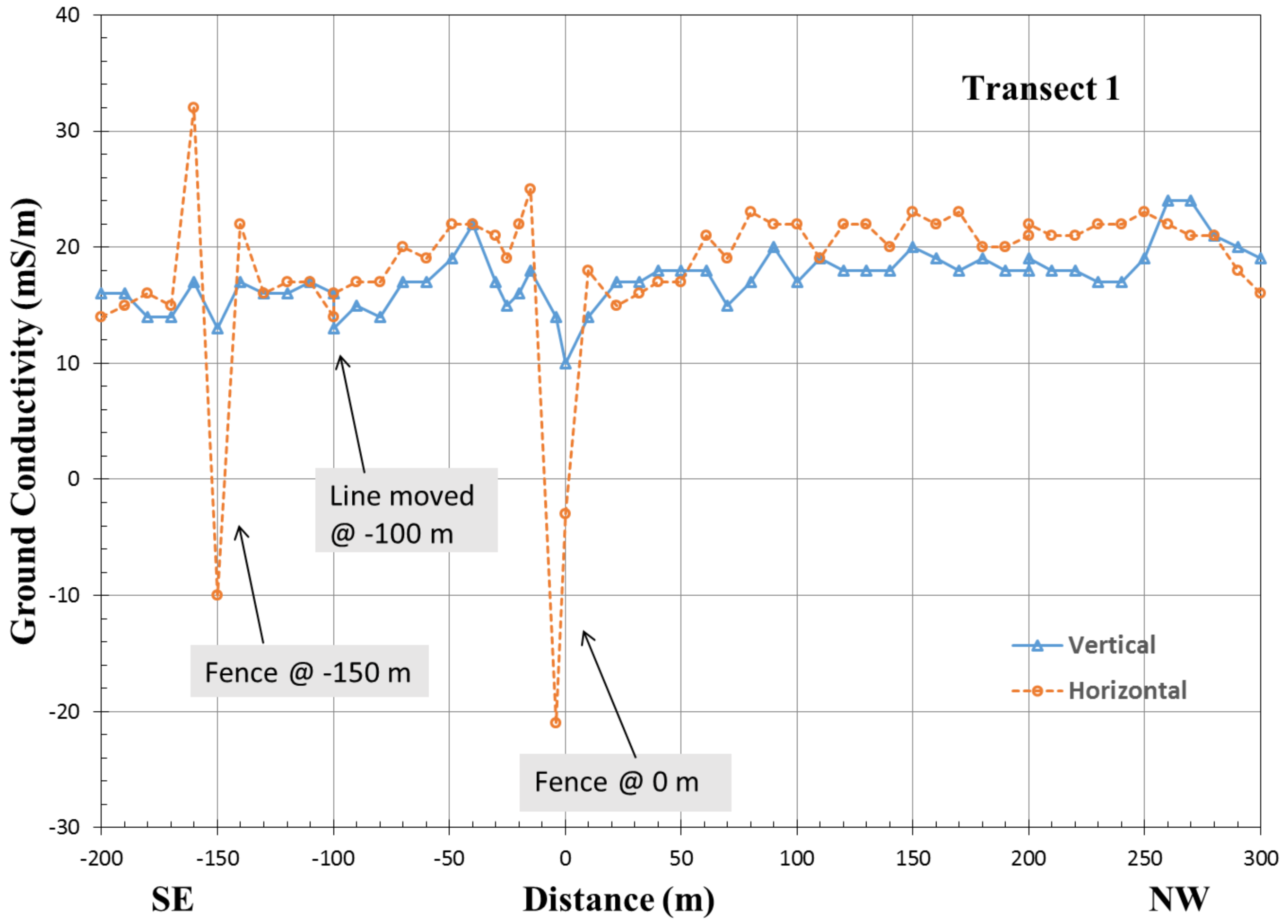


Figure 7.1. EM34 measured ground conductivity (mS/m) over distance for transect 1.

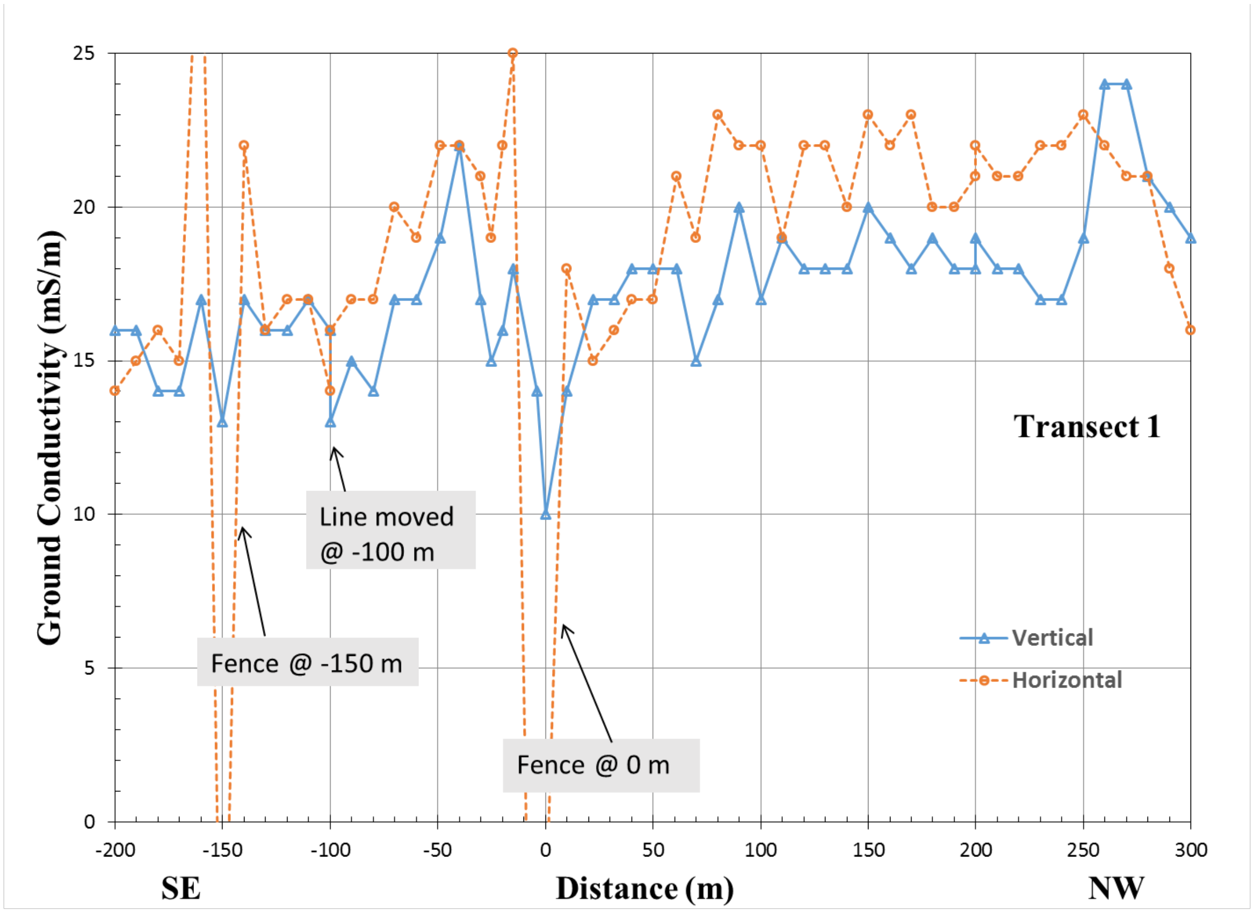


Figure 7.2. Zoomed-in EM34 measured ground conductivity (mS/m) over distance for transect 1.

8. Conclusions

Geophysical investigations at the Old Yuma Mine site in the Tucson Mountains and a down-slope residential area have yielded several data sets that may help provide insights into the subsurface geology and water resources related to the area.

In the area of Transect 1, it was difficult to extract reliable information about the subsurface in the area closest to the mine because of the prohibited area around the mine and steep terrain conditions, resulting in gaps in the measurements. In addition, all of the area around the Mine site had extensive scrap metal on the surface, which interfered with many of the measurements.

The near-surface conductivity (EM31 and EM34) measurements provide no significant evidence for the existence of washed-out mine materials away from the mine.

The TEM data collected along Transect 2, in the vicinity of the residential site, provides strong evidence for the existence of a fault below Transect 2. This interpreted fault is consistent with a continuation of the normal fault that is known to exist to the southwest, near the Old Yuma mine.

The following is a detailed outline of the major results from each of the survey methods used.

The corrected gravity data along Transect 1 exhibit little variation until an anomaly near the -200m mark at the southeast end. The anomaly is a single-point decrease in gravity response, possibly indicating a region of lower density or a void in the subsurface. Since the entire transect runs through the same rock unit of aphanitic andesite, the anomaly is not likely to be caused by a lithological density contrast in the continuous stratigraphy. Instead, it can possibly be associated with the normal fault that is known to crosscut our survey line near that point. Still, this argument is not strongly rooted in the data. The gravity response curve is atypical of what is expected across a normal fault, and the anomaly is only apparent at a single point, just before the end of the survey line. It was also proposed that part of the anomaly could be explained by the removal of material during excavation of the ore deposits that exist close to the fault structure. This was dismissed because the anomaly does not coincide well enough with the locations of the nearby entrance shafts and known mine structure. The corrected data from Transect 2 were recorded along relatively flat terrain and contain only one small, but note-worthy variation in the gravity between southeast markers at -400m and -500m. This anomaly also correlates with the broad magnetic anomaly discussed below.

Most of the magnetic survey anomalies are narrow and have been identified as cultural interference related to metal objects such as fences, poles, and litter at the surface. Only along Transect 2 has a broad anomaly been identified, and it was recorded at the southern end between the -425m and -500 m markers. Because of the relatively low relief and absence of sources for cultural interference in the area, it is thought to be caused by a variation in the local lithology. The geological map published by Lipman (1993) does not necessarily support a change in lithology, but the area is notably covered in sediments that make a clear regional interpretation difficult. Lipman's map indicates that the area associated with the anomaly lies entirely within the Safford Dacite lava flows, but very few outcrops were present where the anomalous measurements were taken.

Inductive electromagnetic data were collected with Geonics EM-31 and EM-34 instruments along Transect 1 only. Cultural interference in both techniques is pronounced, as shown by very high, narrow spikes in the data. The EM-31 conductivity data show single-point peak anomalies around southeast markers -175m and -225m. These are assumed to be from cultural interference. A subtle, broad anomaly can be seen to the northwest between 250m and 300m that may be associated with higher moisture content in a nearby wash. These variations in conductivity are too small to be associated with significant geologic features or materials washed out from the mine site. The EM-34 data likewise contain little variation besides a few narrow peaks caused by metal fences. The second possibly significant result displays a region of slightly higher conductivity at the northwest end of the EM-34 data profile. There is no lithology or terrain change in the area and the TEM data shows no unusually high or low resistivity regions at this location. Again, a roughly 5m-wide wash exists at this location that might have an effect on the conductivity measured at these stations. Overall, the conductivity anomalies over the shallow sediments are very small variations (on the scale of a few mS/m) and they indicate little justification for further investigation.

The most detailed information to be drawn from this study comes from the transient electromagnetic (TEM) data. The modeled cross-section for Transect 1 shows a region of near-surface, high resistivity at the southeast end and in the center of the transect. Because of the lack of station coverage near the mine (between stations 3 and 4 in Transect 1), it is not practical to draw significant conclusions from this part of the cross-section. However, the region of higher resistivity where the stations do exist (below 4 and 5) can be interpreted as a zone of low water saturation or impermeable rock. According to Archie's Equation, soil and rock resistivity is inversely related to porosity and water saturation. At the opposite (northwest) end near stations 1 through 3, lower resistivity material can be seen near the surface that is likely explained by a somewhat thicker sedimentary cover in the vicinity of station 1. Below this same station, there is a significant increase in resistivity beginning at an elevation of about 650m and continuing with depth to an elevation below 550m. Because of the previously mentioned TEM station gap, the fault interpreted by Lipman (1993) is not directly apparent in the Transect 1 TEM models near the mine.

From the 8-Hz data collected along Transect 2, the resulting TEM model displays a highly resistive zone at the end of the northwestern section starting at an elevation of about 650m. A more conductive and thicker section is present at this elevation on the southeastern portion of the cross-section. This lateral contrast in the profile leads us to interpret a fault boundary somewhere between stations 2 and 3 (Figure 8.1) with up-thrown igneous rocks on the northwest and down-thrown igneous rocks, covered by alluvium on the southeast. The northwestern resistive zone is representative of the resistive lithological feature discussed earlier, and the eastern section represents a thick, conductive layer of alluvium on the down-thrown side. Overall the TEM cross-section of Transect 2 is relatively homogenous and displays lower resistivity than Transect 1, indicating that the subsurface of Transect 2 has higher porosity and more water saturation.

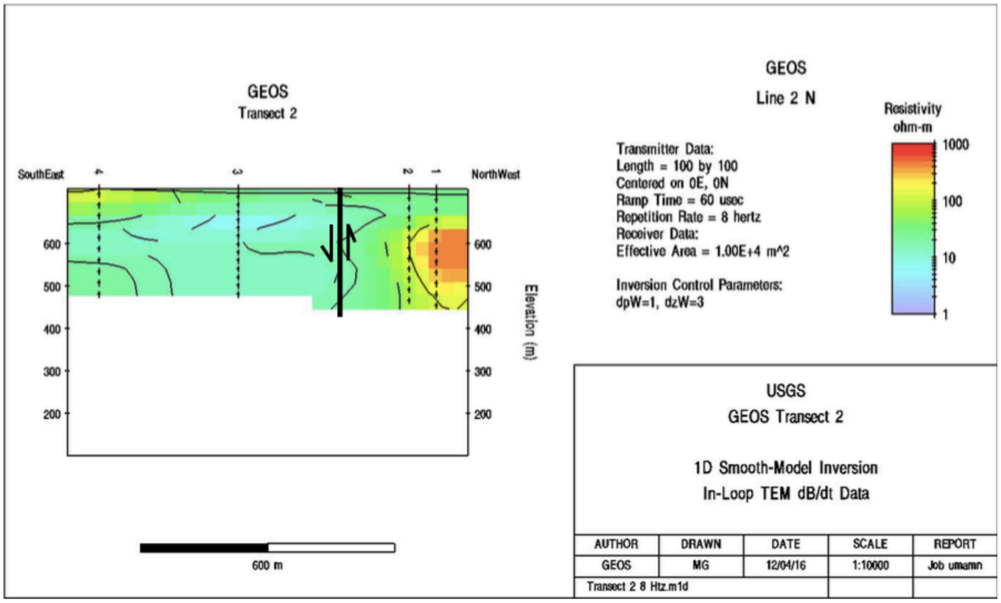


Figure 8.1. The 8-Hz. TEM modeled cross-section from Transect 2, with an approximate location for the normal fault detected between stations 2 and 3. This fault may be a subsurface continuation of the fault interpreted near the mine by Lippman (1993).

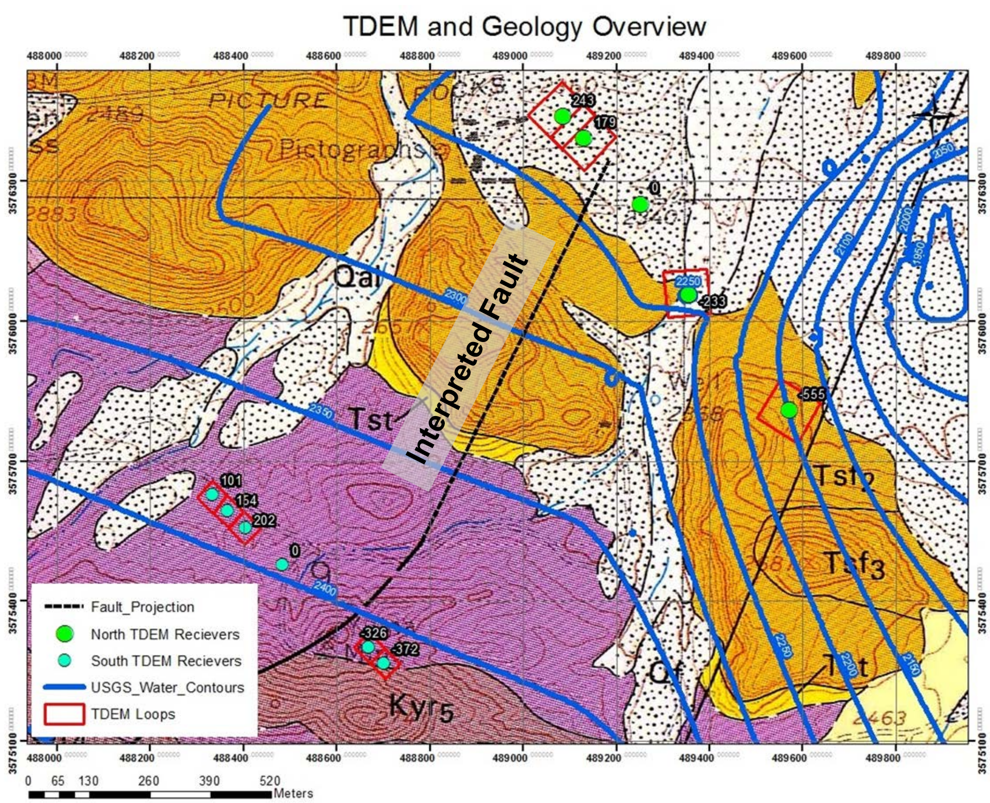


Figure 8.2. Projected fault line location based on TEM data with water contours and local geology (Lipman, 1993).

9. Acknowledgements

The University of Arizona Geophysics Field Camp class, GEN/GEOS 416/516, would like to thank the United States Geological Survey (USGS) for providing funding and support for this project. Specifically, we would like to thank Kimberly Beisner of the USGS for organizing and coordinating the project. Without these sources of funding and support, the class would not have been possible this year.

Jamie P. Macy, USGS Hydrologist, Arizona Water Science Center, Flagstaff Programs, provided the TEM equipment and assisted with the collection of TEM data for both transects. He instructed us in the operation of the equipment and the basic data processing with Zonge software. His experience with these methods was invaluable for the completion of the project.

Zonge International provided updated data processing, modelling, and model display software to the class. Scott Urquhart and Anna Szidarovszky provided an excellent introduction to instrumentation capabilities and their processing software. Mykle Raymond also answered questions about data processing that came up during our data processing. Zonge International has played a vital role in our Geophysics Field Camp for the past 30 years. We sincerely appreciate that they have continued to provide our students with the opportunity to use state-of-the-art electrical geophysics methods.

Elizabeth 'Libby' Kahler from the USGS Water Science Center came to the field with us and showed us how to use the L&R D-meter and helped us with the gravity data calculations. Donald Pool of the USGS Water Science Center provided us with his spreadsheet for our gravity calculations. James Callegary from the USGS Water Science Center loaned us the Geonics EM31-Mk2 and EM34 instruments.

The class would like to thank personnel from Saguaro National Park for allowing us to have access to the site. Various private landowners also gave us permission to use our equipment across their properties.

The Pima County GIS department provided a variety of GIS tools and data that were heavily utilized in this project. Additionally, Dr. Craig Wissler of the University of Arizona provided support in solving problems with ArcMap, the GIS program heavily utilized for the project.

Gayle Heath, Phillip McFarland, and Rick Bennett provided a variety of instructional support and advice for some of the methods utilized in the survey, helping some in the class to interpret and process the data collected in the field.

Appendix A. TEM sounding curves and smooth-model inversions.

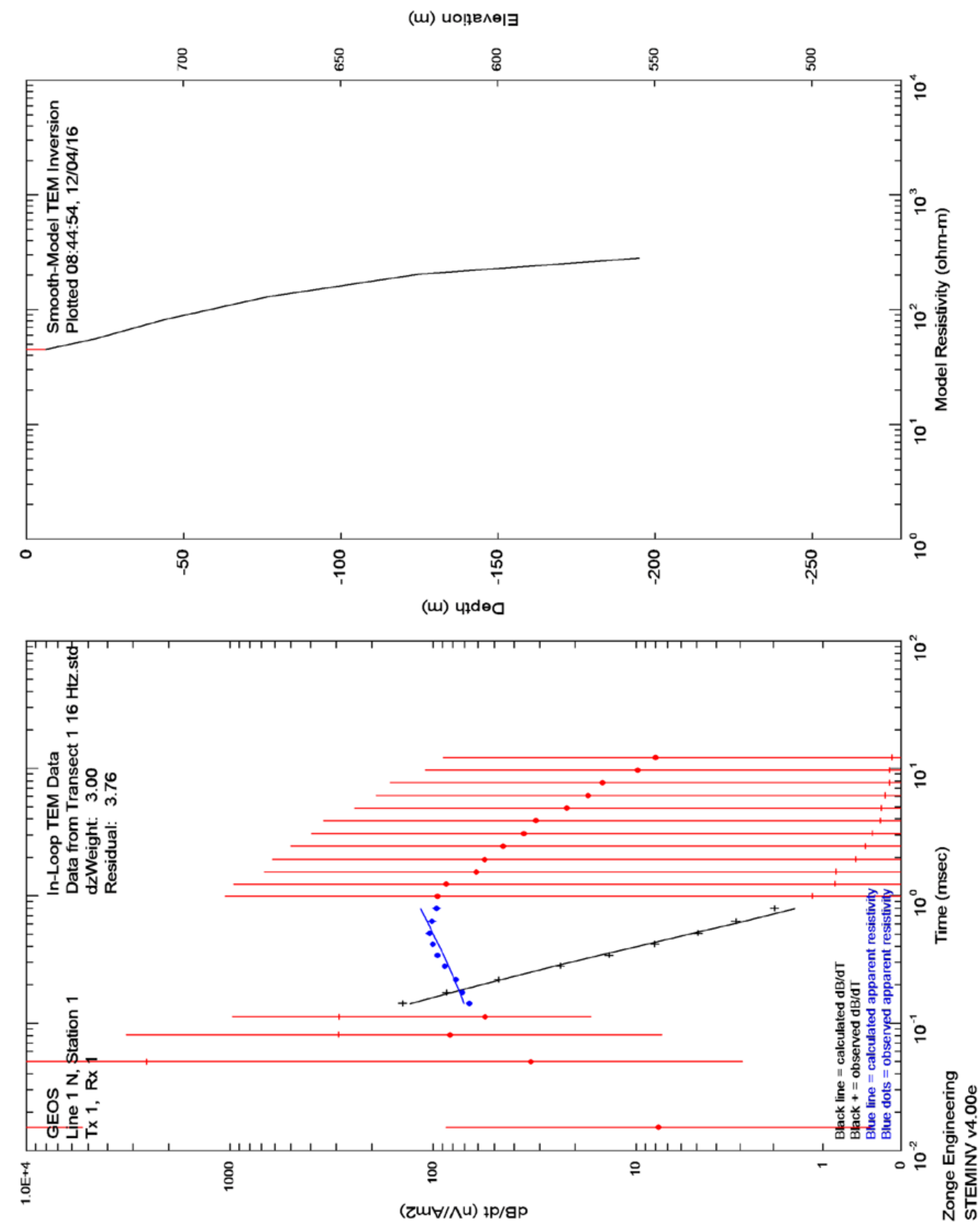
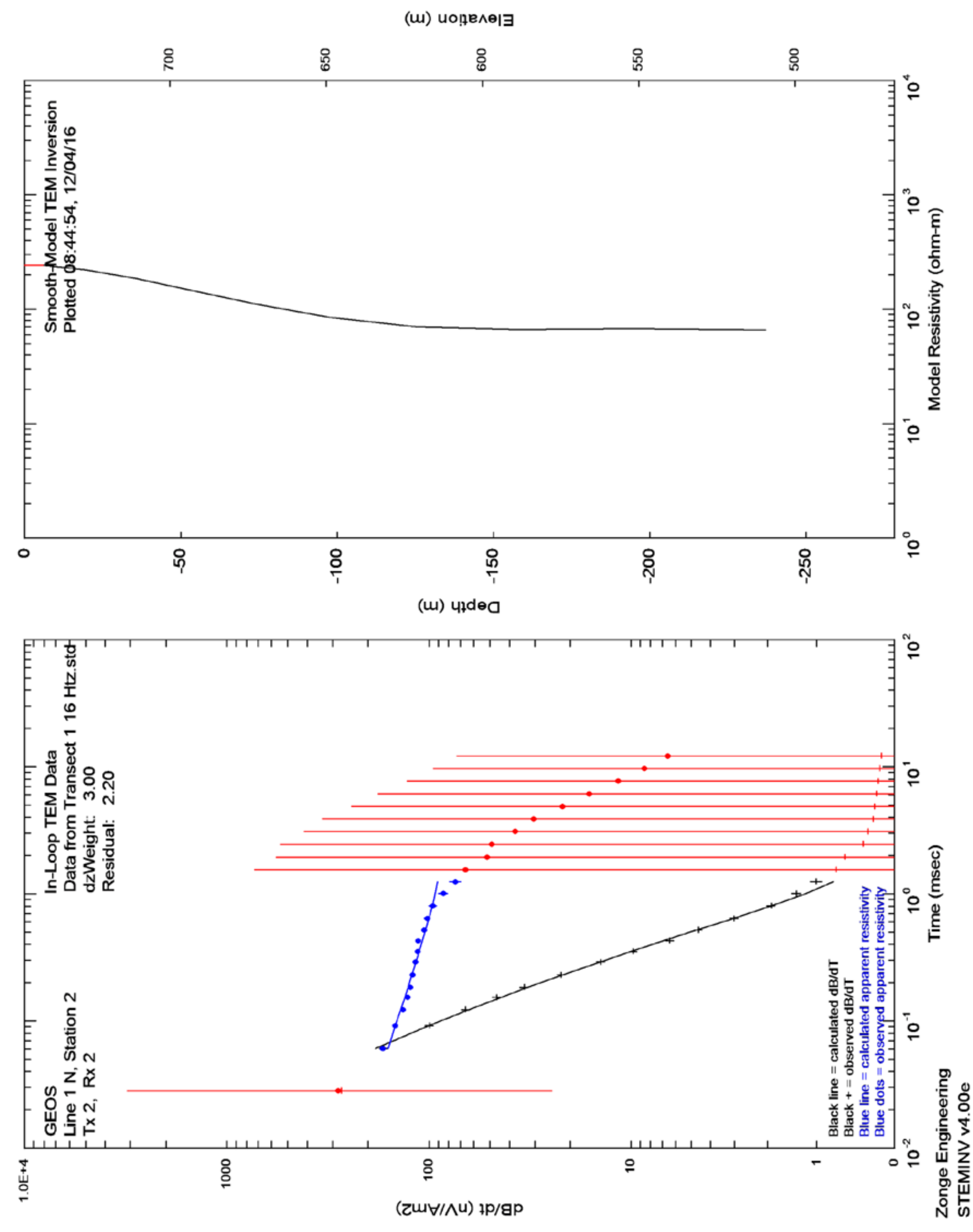


Figure A.1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In-Loop TEM Data
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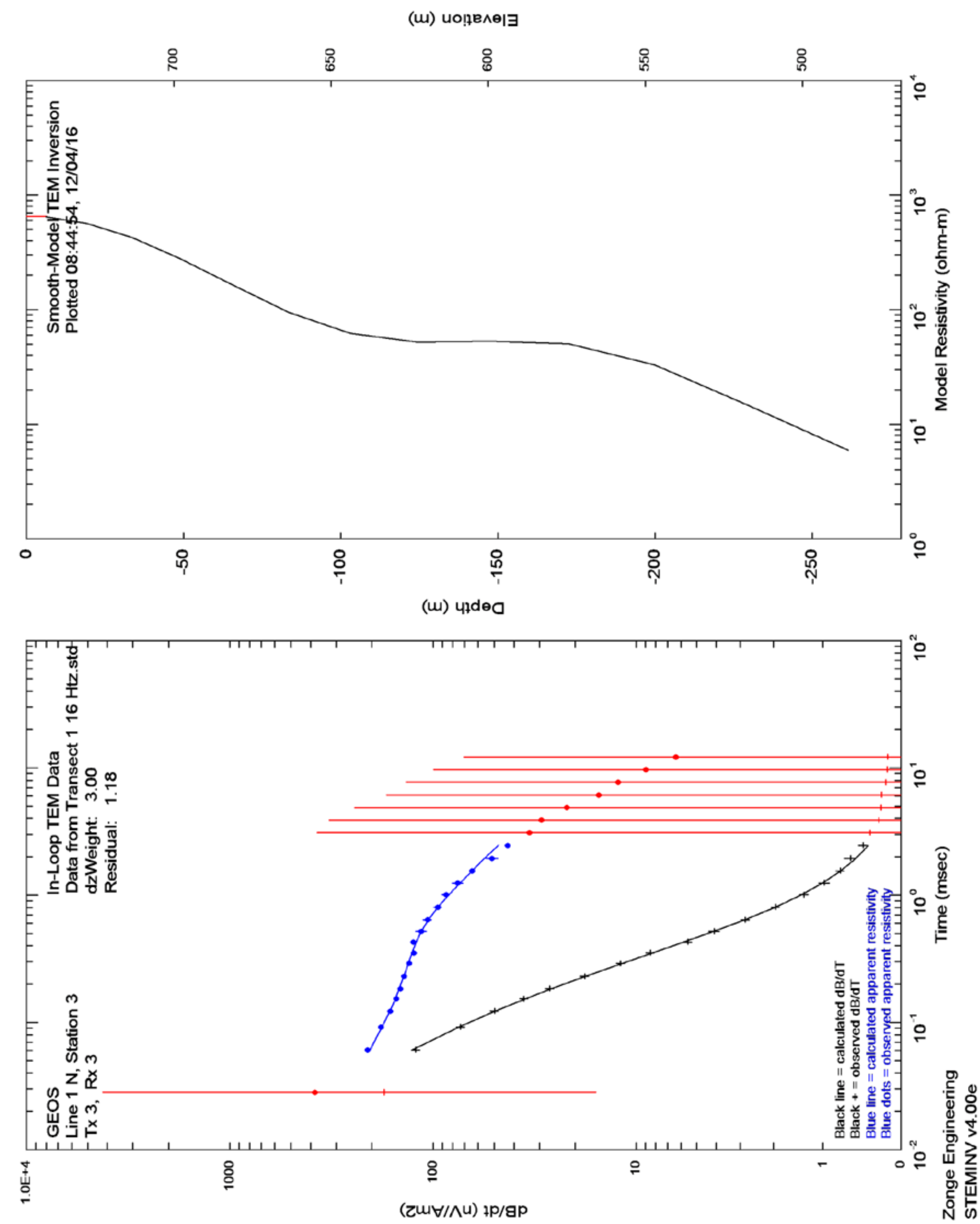
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:44:54, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.2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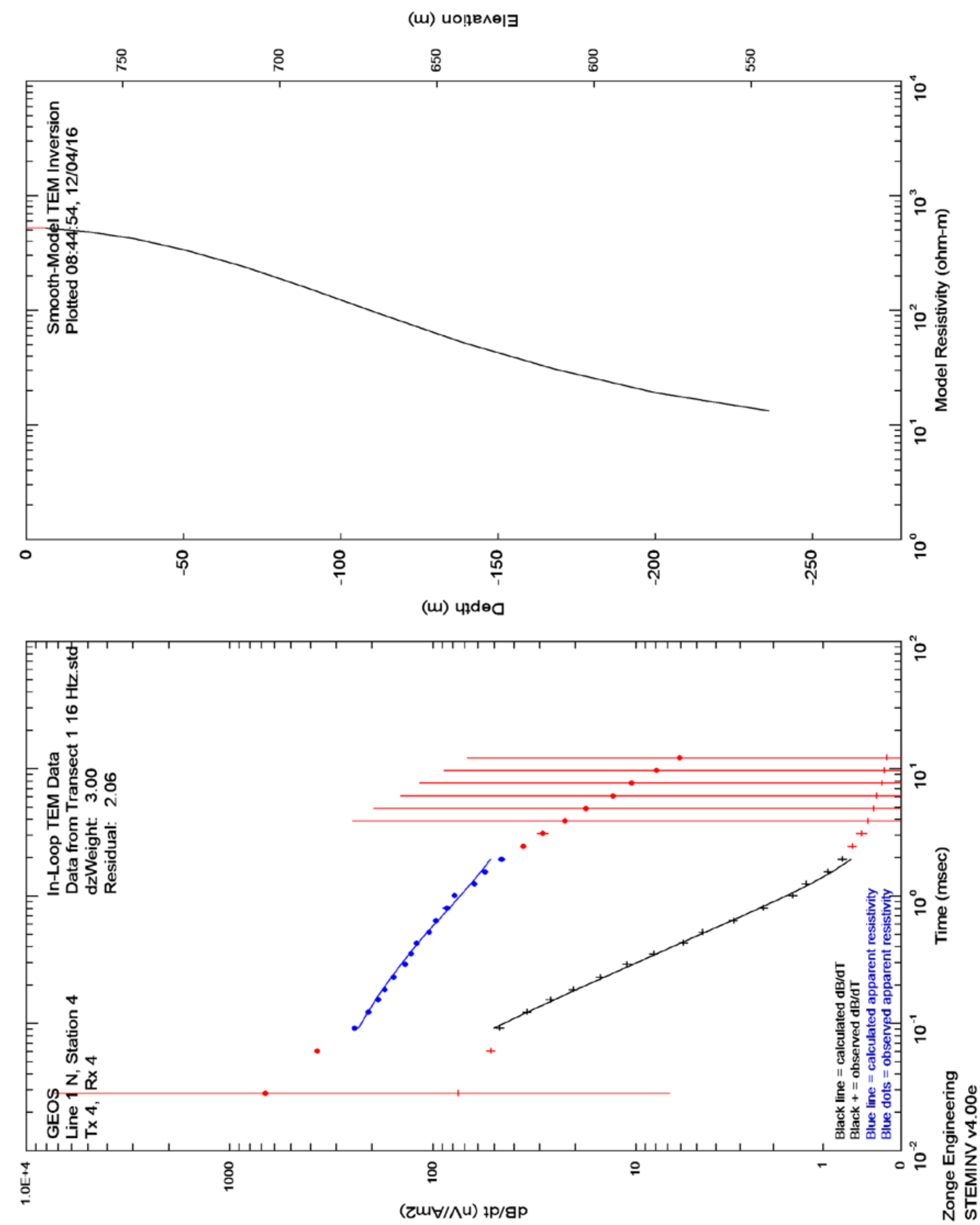
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:44:54, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.3



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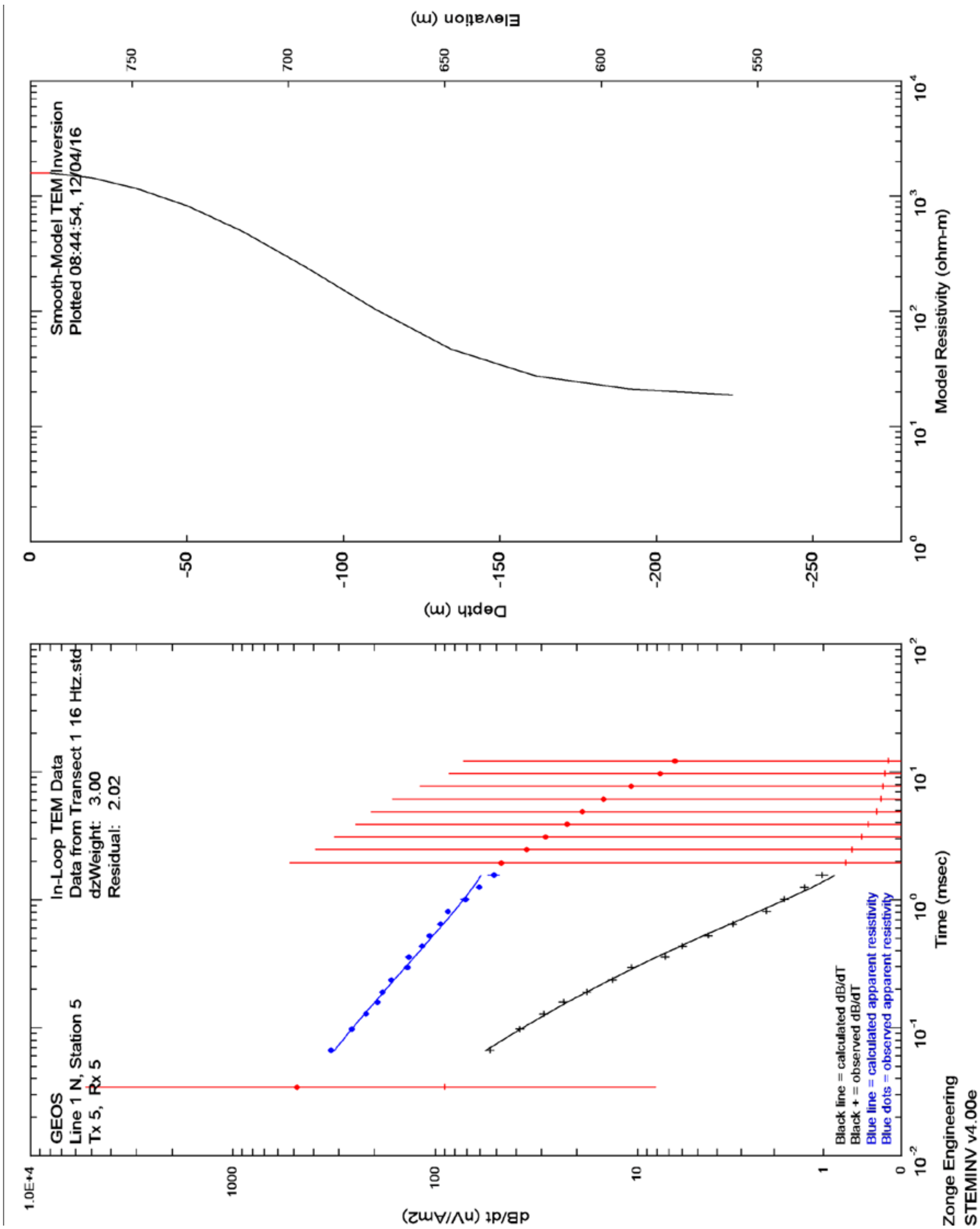
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:44:54, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.4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Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
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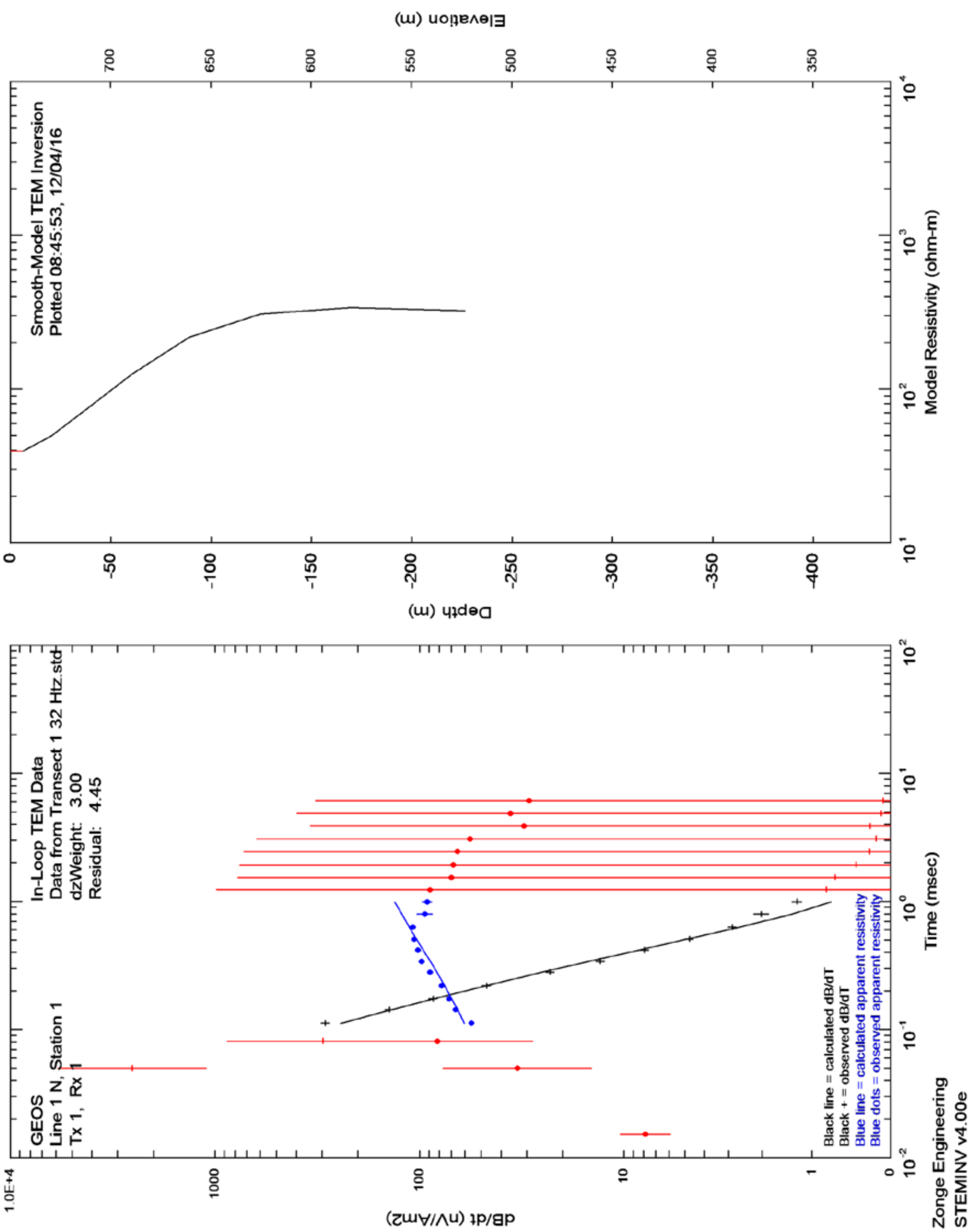
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.5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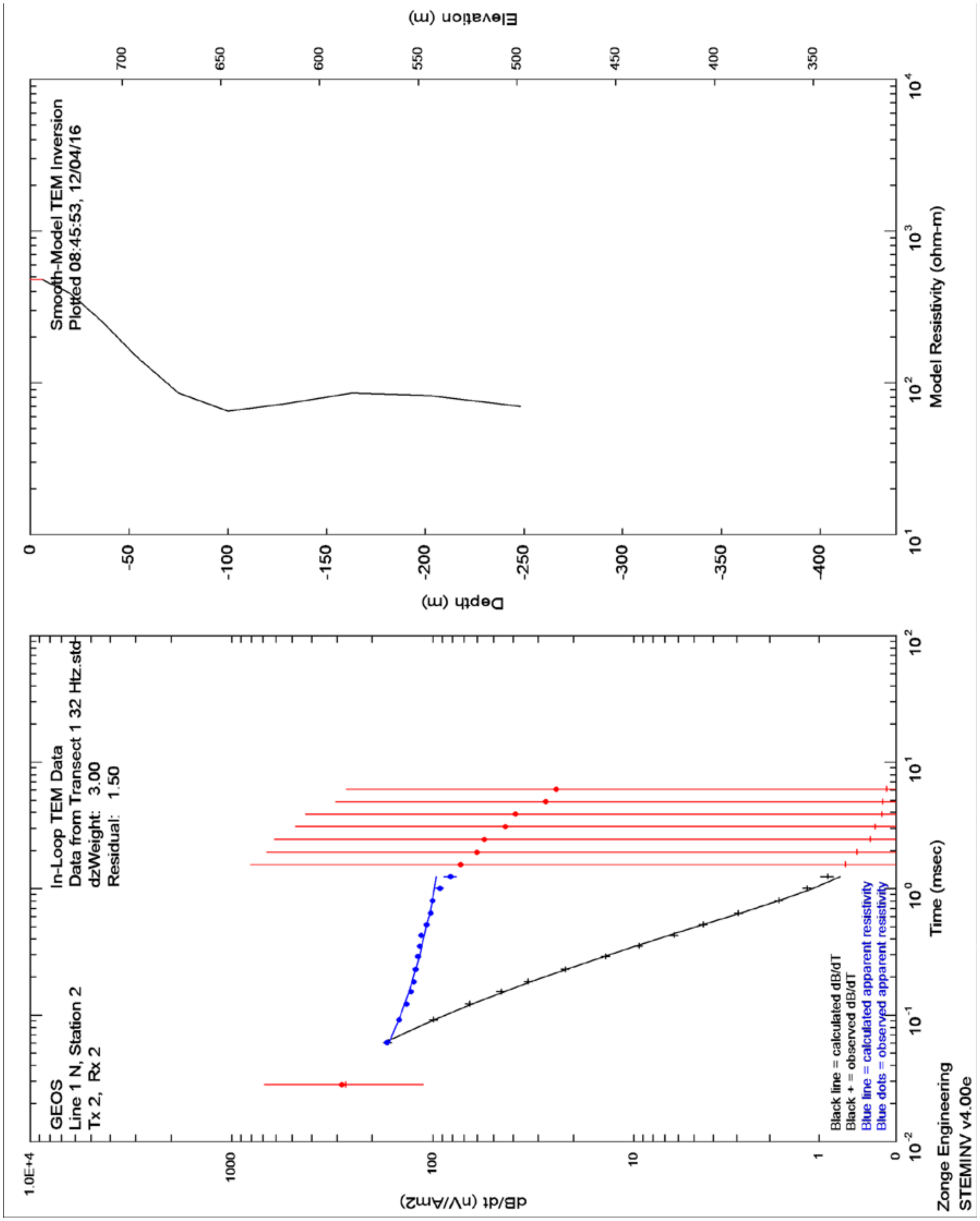
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:45:53, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.6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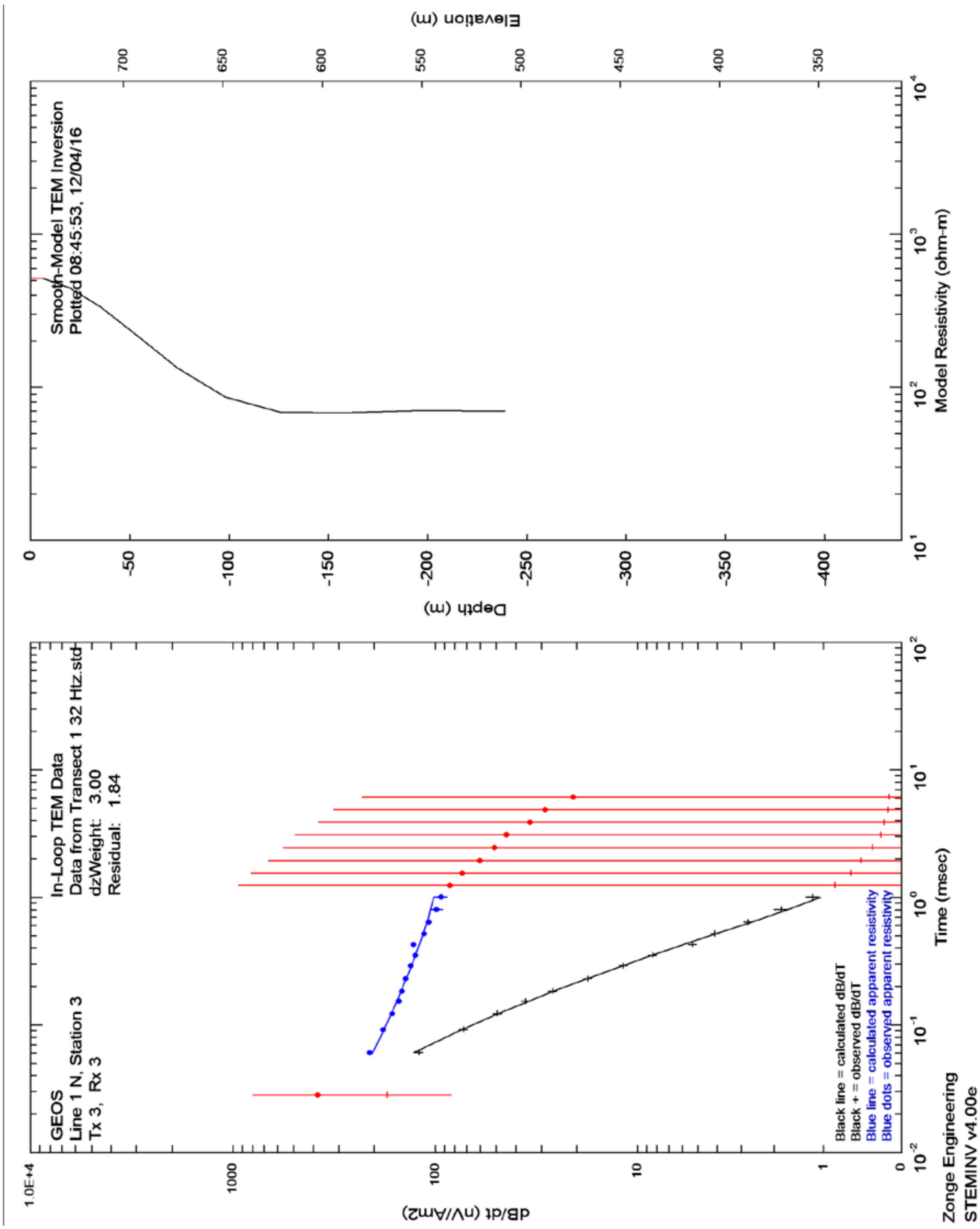
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:45:53, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.7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Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
Time (msec)
dB/dt (nV/Am2)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
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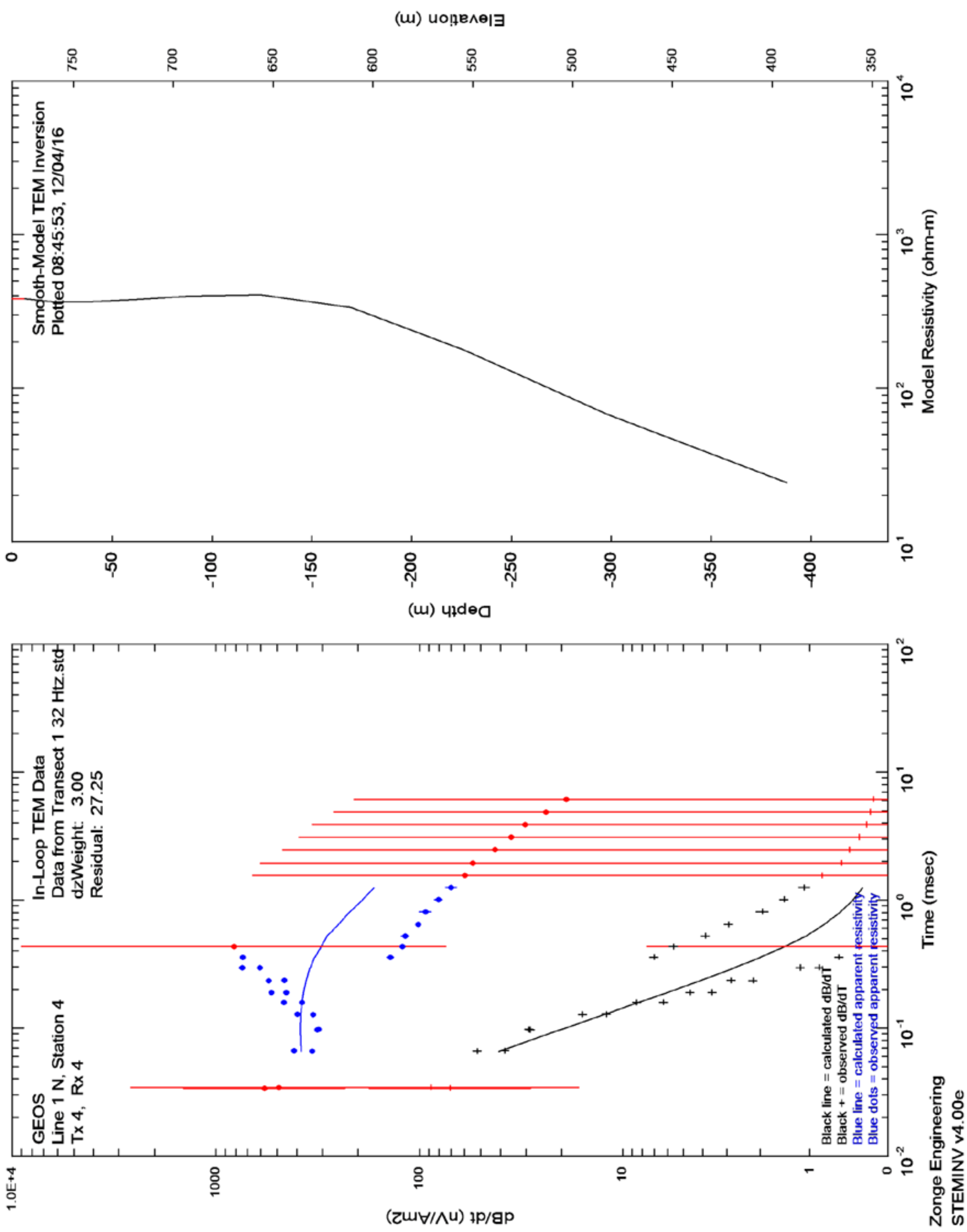
Model Resistivity (ohm-m)
Depth (m)
Elevation (m)

Figure A.8



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Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
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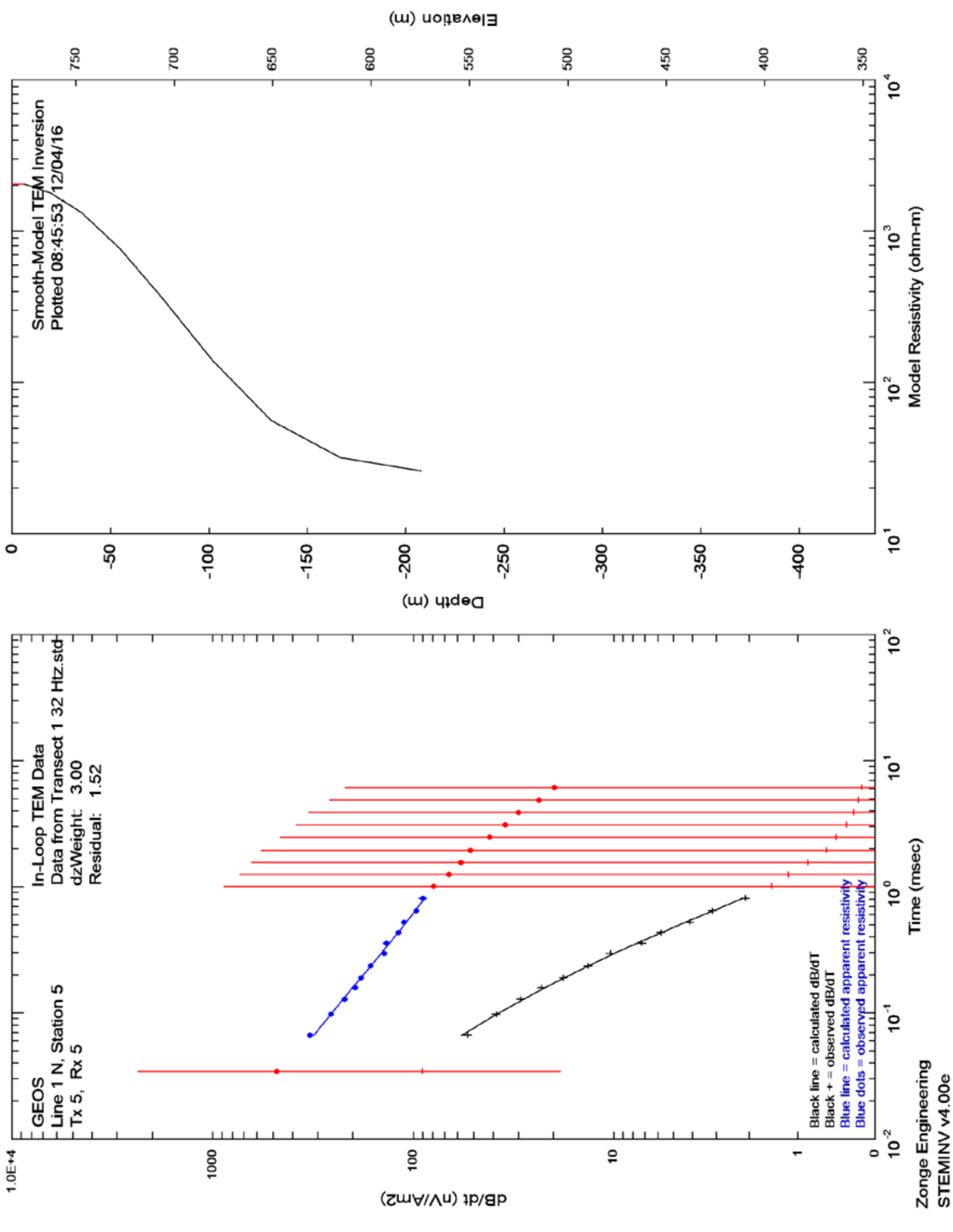
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.9



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Residual: 1.52
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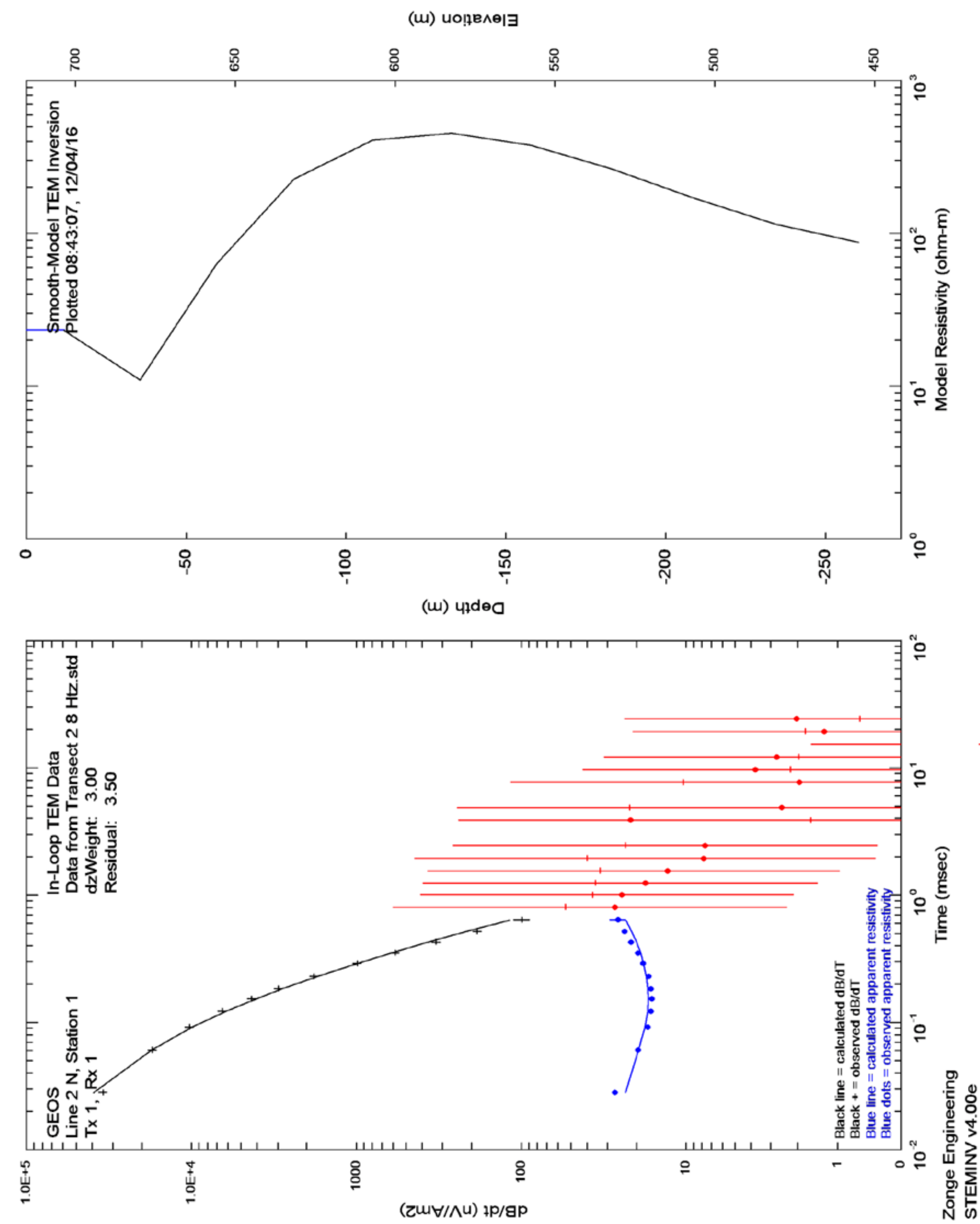
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
Time (msec)
dB/dt (nV/Am2)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:45:53 12/04/16
Model Resistivity (ohm-m)
Depth (m)
Elevation (m)

Figure A.10



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Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
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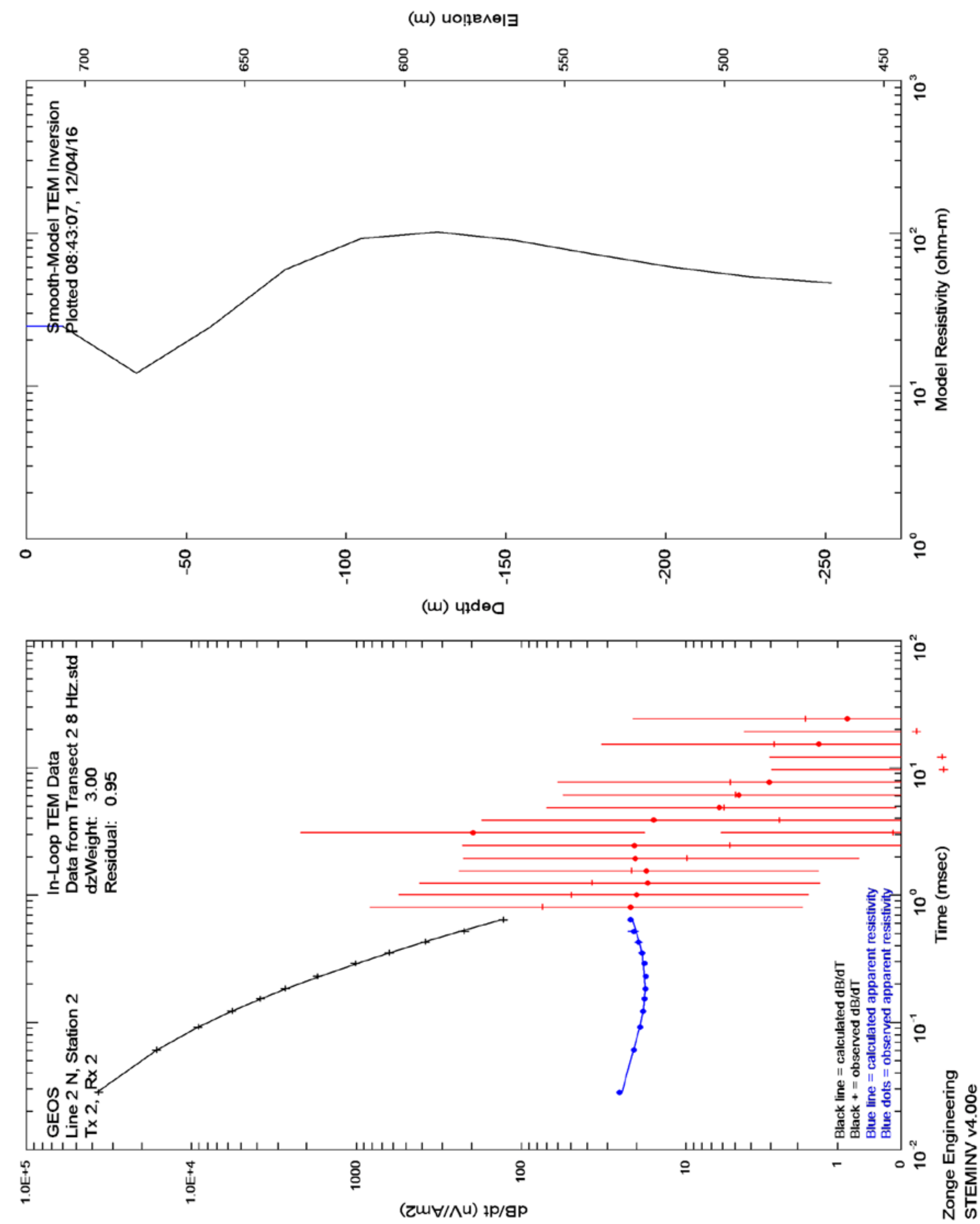
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.11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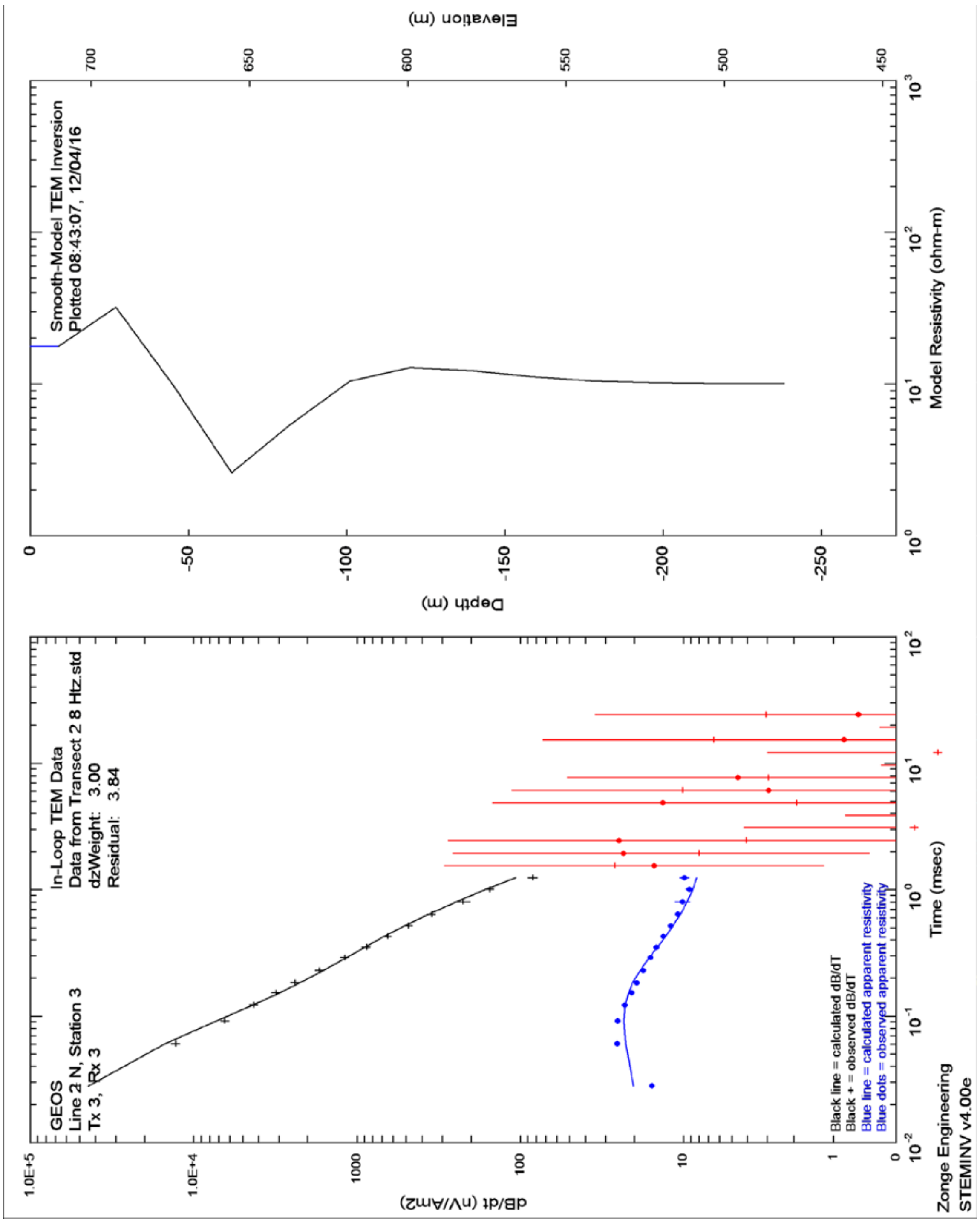
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:43:07, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.12



GEOS
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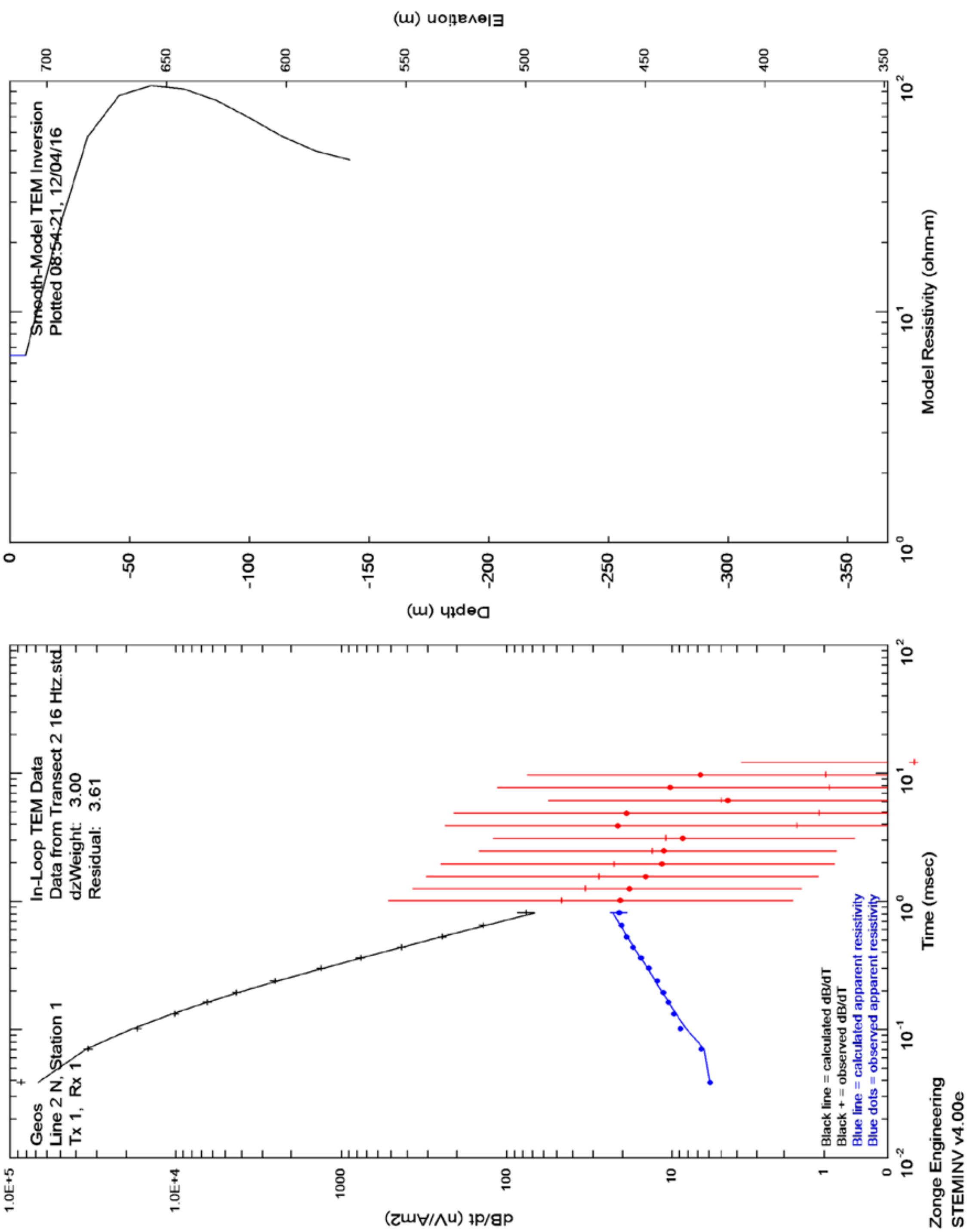
Tx 3, Rx 3
In-Loop TEM Data
Data from Transect 2 8 Htz.std
dzWeight: 3.00
Residual: 3.84
Smooth-Model TEM Inversion
Plotted 08:43:07, 12/04/16
Black line = calculated dB/dT
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
Time (msec)
Model Resistivity (ohm-m)
dB/dt (nV/Am2)
Depth (m)
Elevation (m)
Zonge Engineering
STEMINV v4.00e

Figure A.13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Tx 1, Rx 1
In-Loop TEM Data
Data from Transect 2 16 Htz.std
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Residual: 3.61
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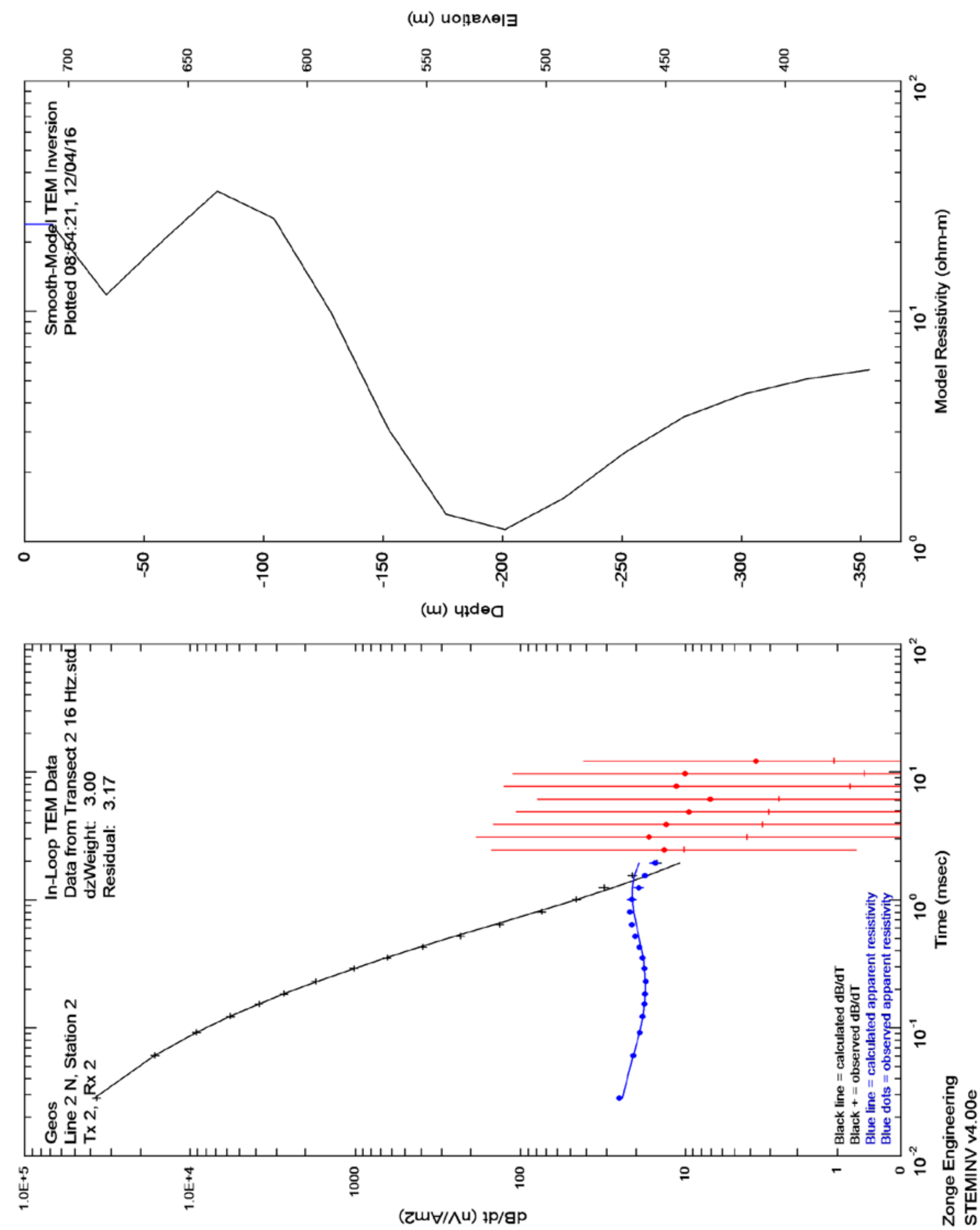
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:54:21, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.14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Tx 2, Rx 2
In-Loop TEM Data
Data from Transect 2 16 Htz.std
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Residual: 3.17
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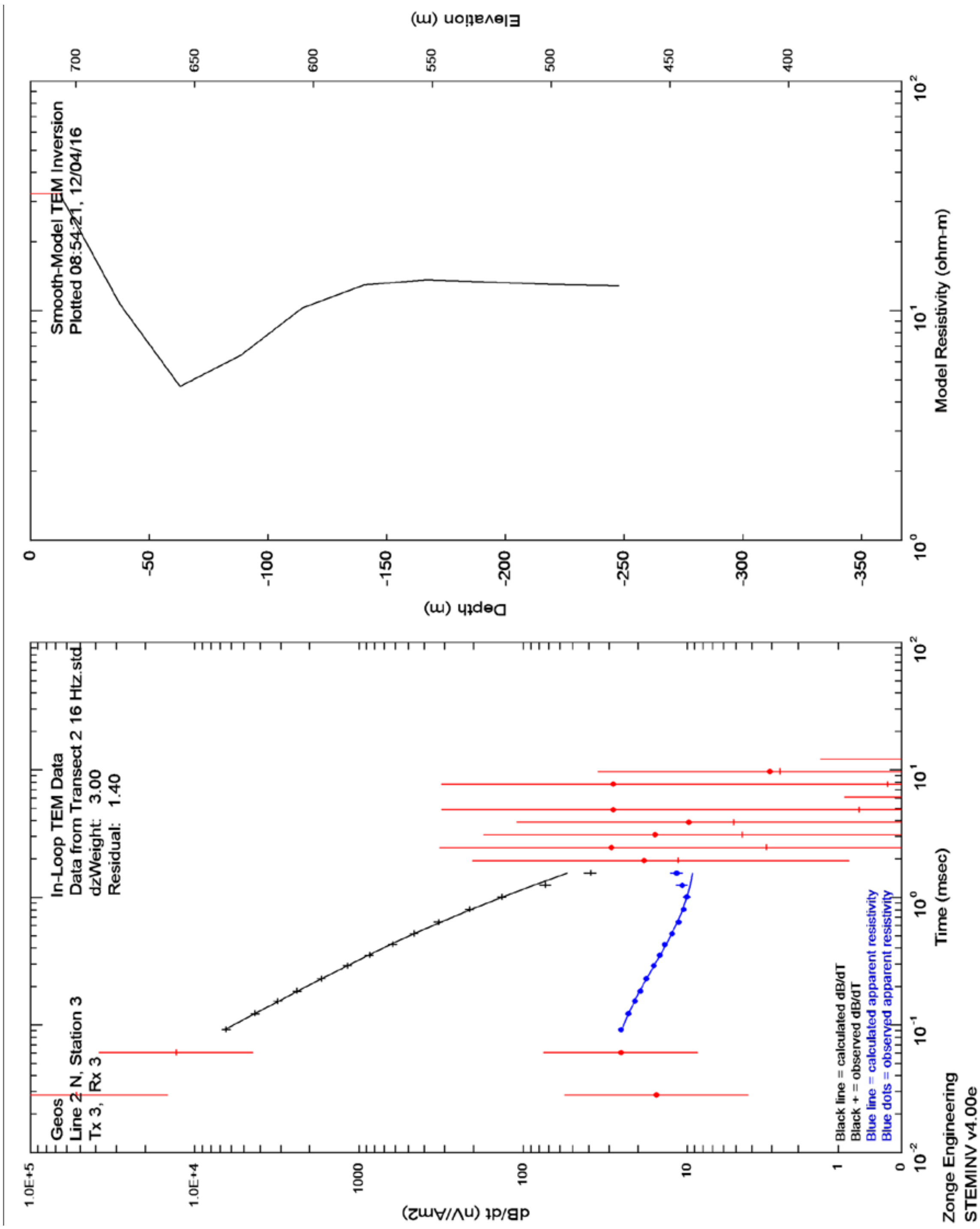
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:54:21, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.15



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In-Loop TEM Data
Data from Transect 2 16 Htz.std
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Residual: 1.40
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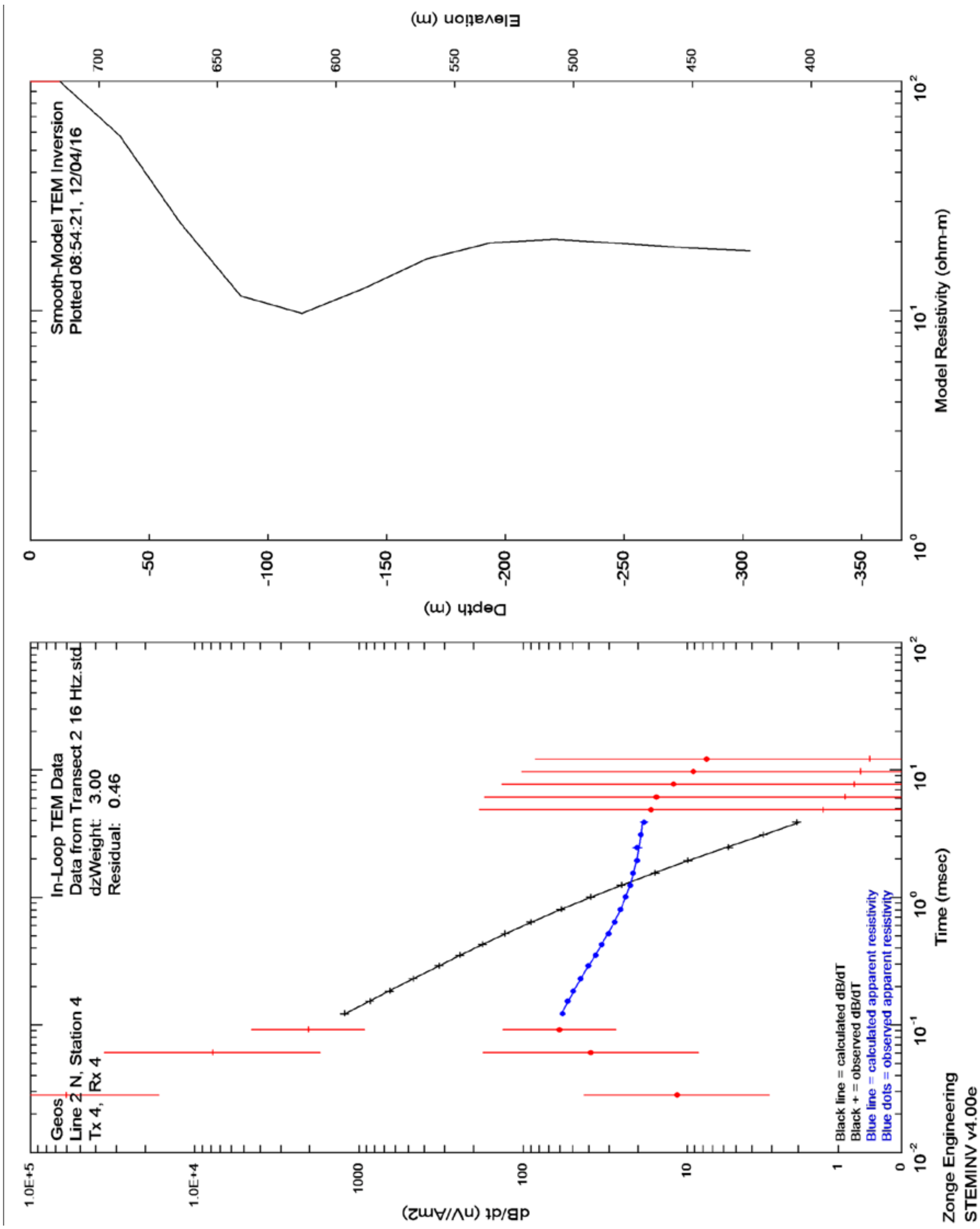
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
Time (msec)
dB/dt (nV/Am2)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:54:21, 12/04/16
Model Resistivity (ohm-m)
Depth (m)
Elevation (m)

Figure A.16


Geos
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Tx 4, Rx 4
In-Loop TEM Data
Data from Transect 2 16 Hz.std
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Residual: 0.46
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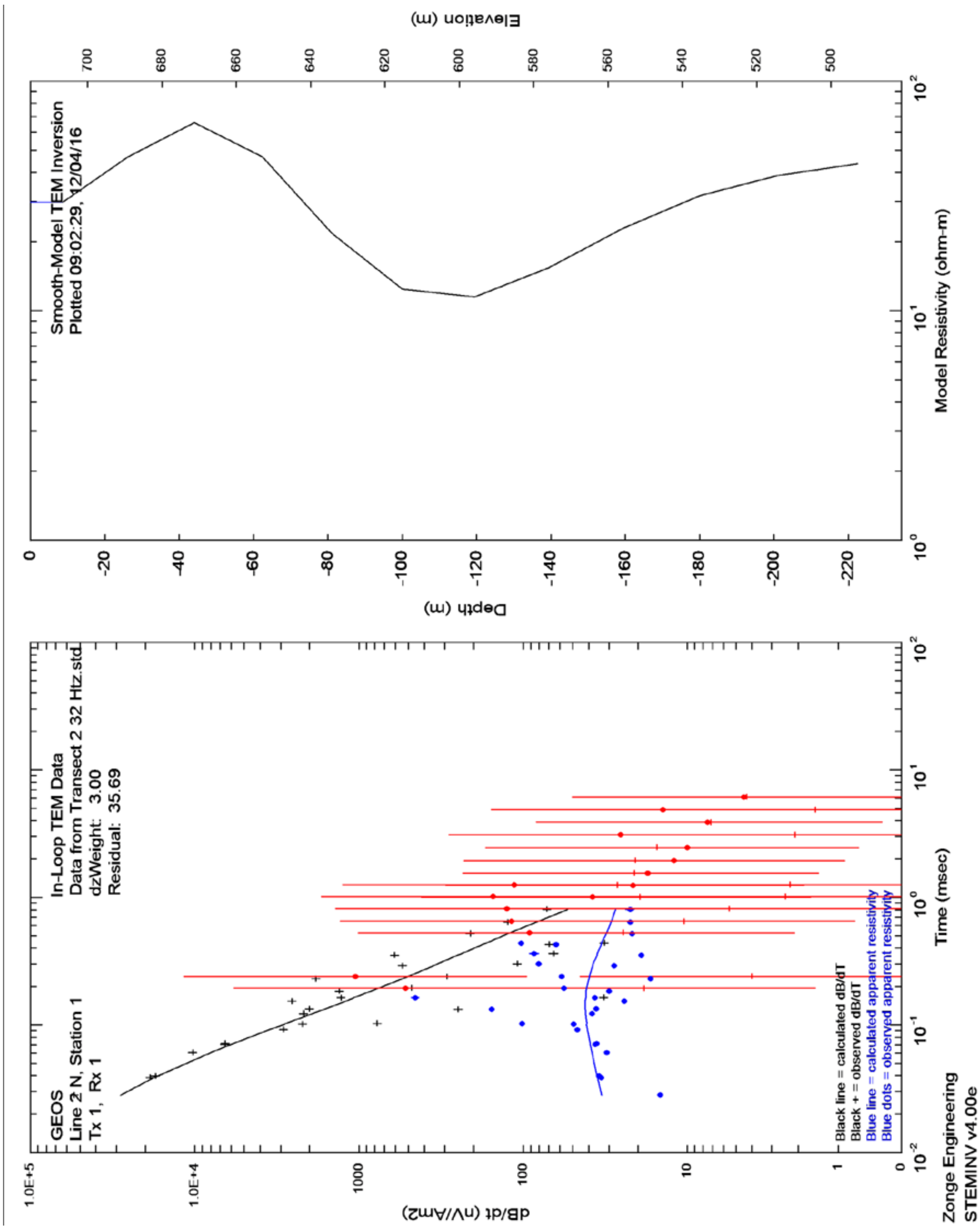
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 08:54:21, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.17



GEOS
Line 2 N, Station 1
Tx 1, Rx 1
In-Loop TEM Data
Data from Transect 2 32 Htz.std
dzWeight: 3.00
Residual: 35.69
Black line = calculated dB/dT
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 09:02:29, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.18

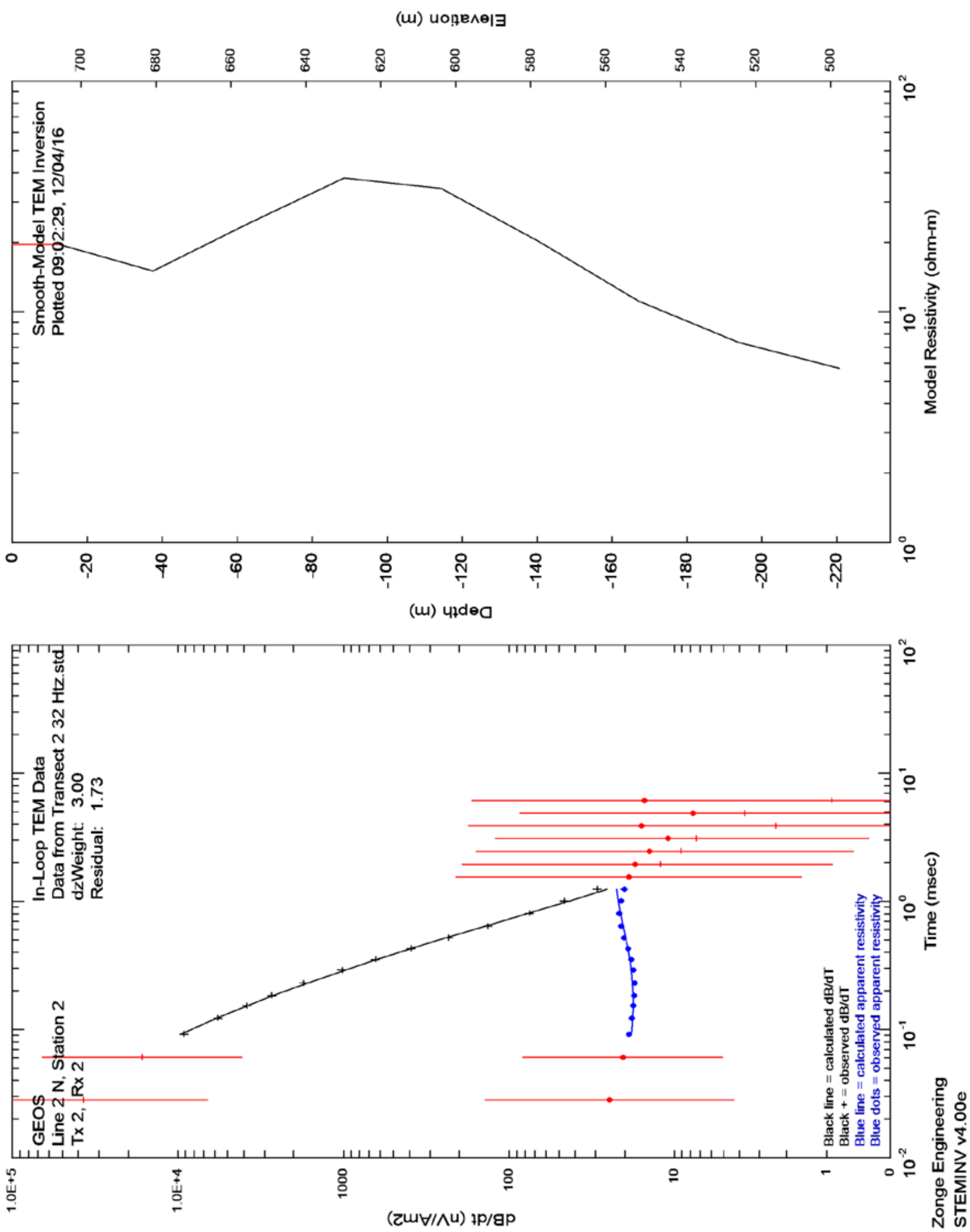
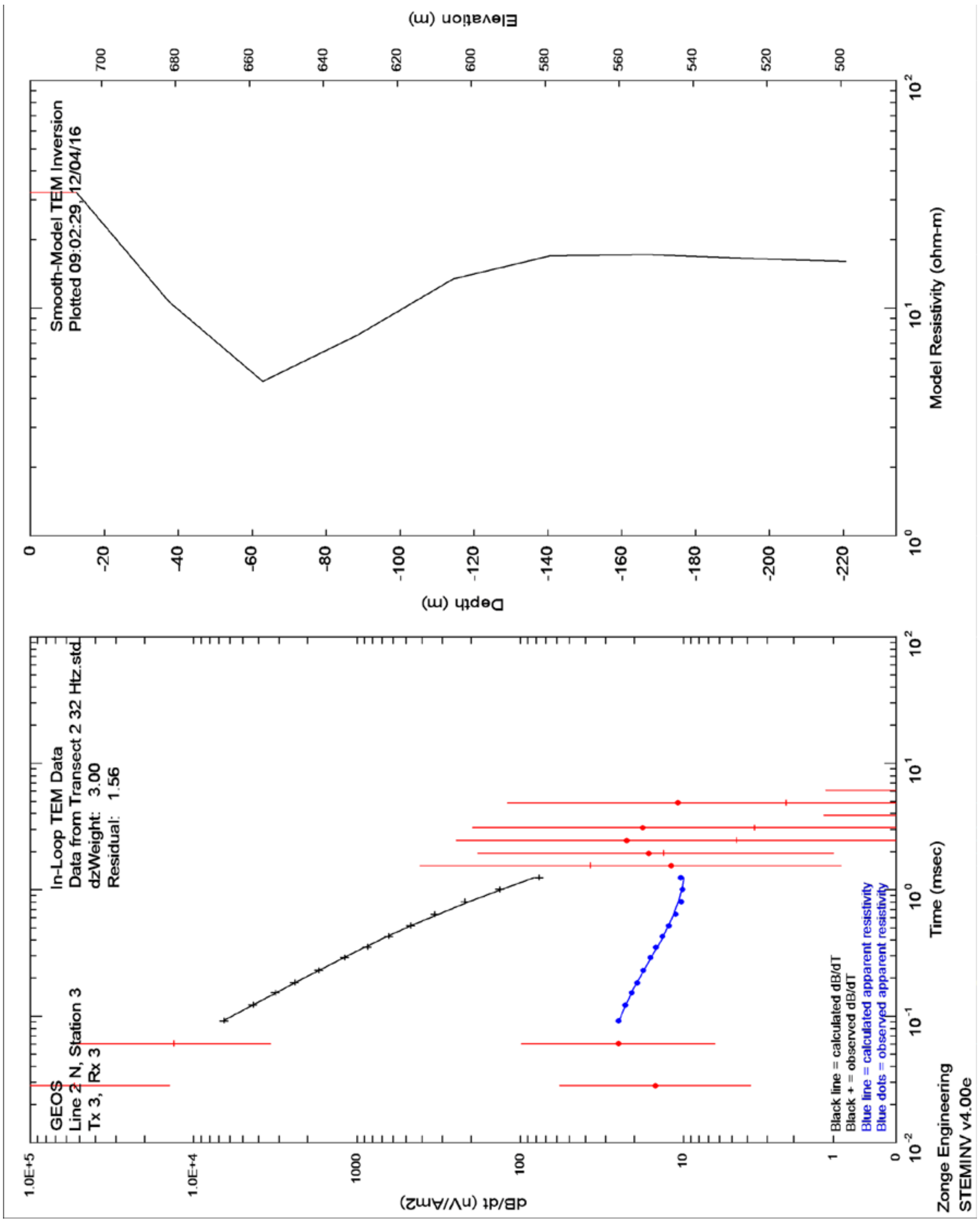
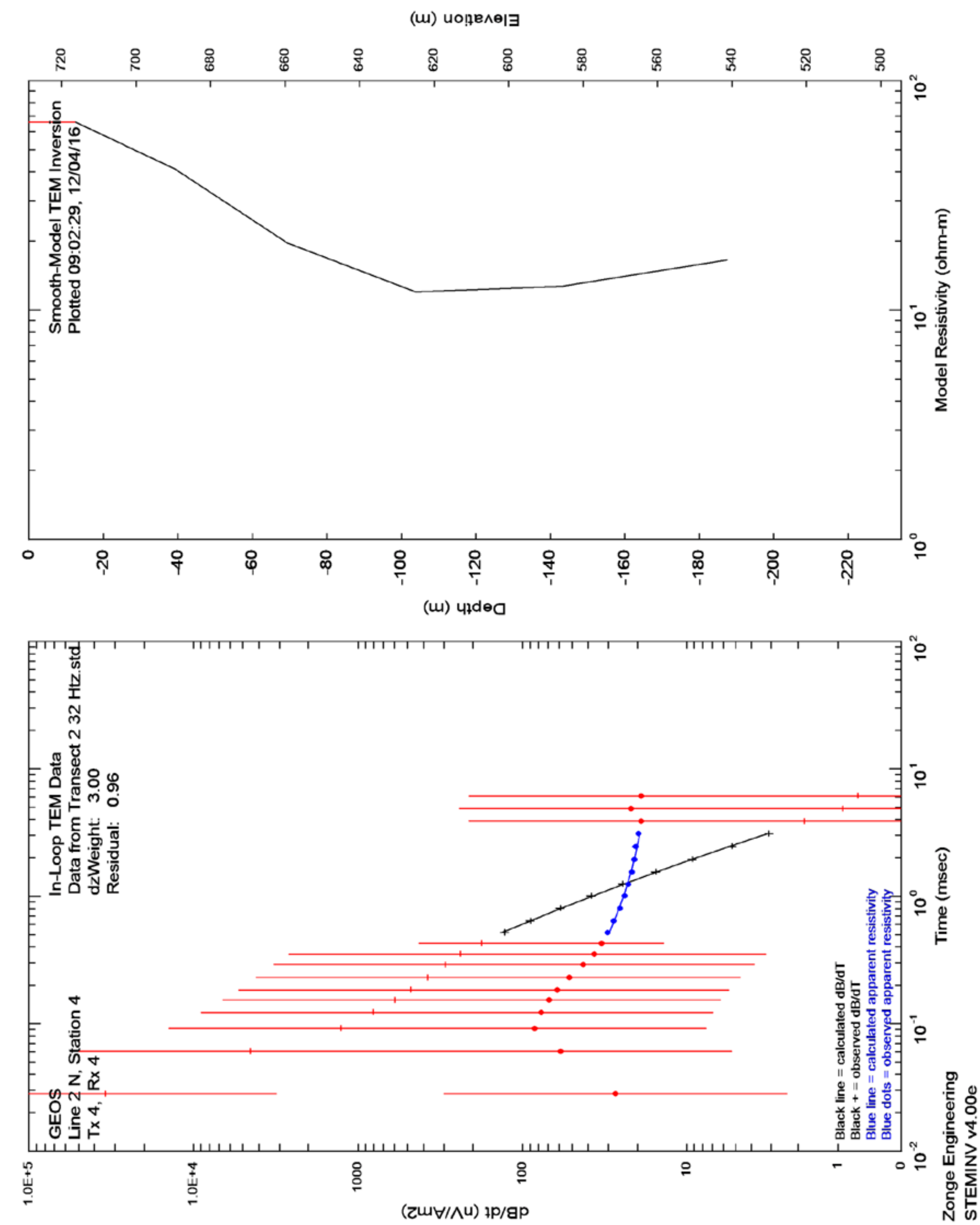

GEOS
Line 2 N, Station 2
Tx 2, Rx 2
In-Loop TEM Data
Data from Transect 2 32 Hz.std
dzWeight: 3.00
Residual: 1.73
Black line = calculated dB/dT
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
Time (msec)
dB/dt (nV/Am2)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 09:02:29, 12/04/16
Model Resistivity (ohm-m)
Depth (m)
Elevation (m)

Figure A.18



GEOS
Line 2 N, Station 3
Tx 3, Rx 3
In-Loop TEM Data
Data from Transect 2 32 Htz.std
dzWeight: 3.00
Residual: 1.56
Black line = calculated dB/dT
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 09:02:29, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.19



GEOS
Line 2 N, Station 4
Tx 4, Rx 4
In-Loop TEM Data
Data from Transect 2 32 Hz.std
dzWeight: 3.00
Residual: 0.96
Black line = calculated dB/dT
Black + = observed dB/dT
Blue line = calculated apparent resistivity
Blue dots = observed apparent resistivity
dB/dt (nV/Am2)
Time (msec)
Zonge Engineering
STEMINV v4.00e
Smooth-Model TEM Inversion
Plotted 09:02:29, 12/04/16
Depth (m)
Elevation (m)
Model Resistivity (ohm-m)

Figure A.20

Station	Transect	Receiver Coordinates (UTM)		Elevation at Receiver (m)	Loop Size (m)	Receiver Hertz	Transmitter Amps
		Easting	Northing				
-372	1	488700	3575265	782.42	50	16, 32	6
-326		488669	3575299	780.59			
101		488403	3575555	746.91			
154		488365	3575592	746.46			
202		488333	3575627	749.81			
-555	2	489570	3575808	728.78	100	8,16,32	3.5
-233		489355	3576056	719.25			
179		489130	3576391	718.32			
243		489084	3576438	715.37			

Table A.1

Appendix B. Gravity Surveys

Table 1. Measured and calculated data for transect 1.

Transect 1							
Station	Time	Coordinates (UTM)		Elevation (m)	Delta z (m)	Absolute Gravity Directly Converted from Measured Relative Gravity,	Abosolute Gravity with Bouguer & Free Air Correction (mGal)
		Easting	Northing				
-250	15:50	488668	3575335	763.3	19.9	979259.00	979262.89
-250	15:51	488668	3575335	763.3	19.9	979259.04	979262.94
-200	15:33	488659	35753543	766.0	22.6	979254.94	979259.37
-150	15:13	488634	3575366	779.9	36.5	979258.03	979265.18
-150	15:14	488634	3575366	779.9	36.5	979258.03	979265.18
-150	15:15	488634	3575366	779.9	36.5	979258.04	979265.19
-150	15:16	488634	3575366	779.9	36.5	979258.05	979265.20
-100	14:51	488595	3575391	769.6	26.2	979258.44	979263.59
-100	14:52	488595	3575391	769.6	26.2	979258.44	979263.59
-100	14:53	488595	3575391	769.6	26.2	979258.45	979263.59
-100	14:54	488595	3575391	769.6	26.2	979258.52	979263.66
-50	14:40	488557	3575421	764.5	21.1	979260.68	979264.82
-50	14:41	488557	3575421	764.5	21.1	979260.68	979264.82
-50	14:42	488557	3575421	764.5	21.1	979260.67	979264.81
0	10:28	488475	3575479	754.4	11.0	979261.14	979263.30
0	10:29	488475	3575479	754.4	11.0	979261.14	979263.30
0	14:24	488475	3575479	754.4	11.0	979261.21	979263.37
0	14:25	488475	3575479	754.4	11.0	979261.21	979263.37
0	14:26	488475	3575479	754.4	11.0	979261.14	979263.29
0	16:12	488475	3575479	754.4	11.0	979261.24	979263.40
0	16:13	488475	3575479	754.4	11.0	979261.24	979263.40
0	16:14	488475	3575479	754.4	11.0	979261.24	979263.40
0	16:15	488475	3575479	754.4	11.0	979261.13	979263.29
0	16:16	488475	3575479	754.4	11.0	979261.13	979263.29
50	14:04	488440	3575514	754.7	11.3	979261.41	979263.64
50	14:05	488440	3575514	754.7	11.3	979261.42	979263.64
50	14:06	488440	3575514	754.7	11.3	979261.42	979263.64
50	14:07	488440	3575514	754.7	11.3	979261.45	979263.67
100	13:51	488405	3575549	750.3	6.9	979262.37	979263.72
100	13:52	488405	3575549	750.3	6.9	979262.37	979263.72
100	13:53	488405	3575549	750.3	6.9	979262.36	979263.71
150	13:35	488372	3575584	749.6	6.2	979262.36	979263.58
150	13:36	488372	3575584	749.6	6.2	979262.36	979263.58
150	13:37	488372	3575584	749.6	6.2	979262.79	979264.01
200	12:58	488335	3575620	747.8	4.4	979262.88	979263.75
200	12:59	488335	3575620	747.8	4.4	979262.94	979263.81
250	13:09	488299	3575655	745.4	2.0	979263.21	979263.60
250	13:10	488299	3575655	745.4	2.0	979263.26	979263.65
300	13:19	488266	3575691	746.2	2.8	979263.74	979264.28
300	13:20	488266	3575691	746.2	2.8	979263.77	979264.31
Harshbarger	8:17	501185	3568015	743.4	0.0	979240.15	979240.15
Harshbarger	8:18	501185	3568015	743.4	0.0	979240.15	979240.15

Table 2. Measured and calculated data for transect

Transect 2								
Station	Time	Coordinates (UTM)		Elevation (m)	Delta z (m)	Measured Gravity, mGal	Bouguer & Free Air Corrected Gravity (mGal)	B&FA, and Tare Corrected Gravity (mGal)
		Easting	Northing					
-497	14:56	489574	3575888	725.8	-17.6	979263.48	979260.03	979260.76
-497	14:57	489574	3575888	725.8	-17.6	979263.49	979260.03	979260.77
-497	14:58	489574	3575888	725.8	-17.6	979263.49	979260.03	979260.77
-447	14:44	489539	3575926	724.4	-19.0	979264.13	979260.40	979261.14
-447	14:45	489539	3575926	724.4	-19.0	979264.13	979260.40	979261.14
-397	14:35	489508	3575964	721.0	-22.4	979264.49	979260.10	979260.83
-397	14:36	489508	3575964	721.0	-22.4	979264.49	979260.09	979260.83
-382	14:14	489466	3575950	720.0	-23.4	979264.41	979259.81	979260.55
-382	14:15	489466	3575950	720.0	-23.4	979264.41	979259.82	979260.55
-367	13:57	489425	3575943	719.8	-23.6	979264.07	979259.44	979260.18
-367	13:58	489425	3575943	719.8	-23.6	979264.07	979259.44	979260.18
-270	13:36	489371	3576022	719.0	-24.4	979265.29	979260.51	979260.51
-270	13:37	489371	3576022	719.0	-24.4	979265.30	979260.51	979260.51
-235	13:16	489377	3576069	717.5	-25.9	979265.83	979260.74	979260.74
-235	13:17	489377	3576069	717.5	-25.9	979265.83	979260.74	979260.74
-235	13:17	489377	3576069	717.5	-25.9	979265.83	979260.75	979260.75
-200	13:05	489380	3576119	716.3	-27.1	979266.11	979260.80	979260.80
-200	13:06	489380	3576119	716.3	-27.1	979266.11	979260.80	979260.80
-150	12:56	489350	3576152	715.1	-28.3	979266.35	979260.80	979260.80
-150	12:57	489350	3576152	715.1	-28.3	979266.35	979260.81	979260.81
-100	12:47	489320	3576191	714.7	-28.7	979266.48	979260.85	979260.85
-100	12:48	489320	3576191	714.7	-28.7	979266.48	979260.85	979260.85
-50	12:38	489284	3576229	714.9	-28.5	979266.59	979261.00	979261.00
-50	12:39	489284	3576229	714.9	-28.5	979266.59	979261.01	979261.01
0	9:54	489074	3576504	714.2	-29.2	979266.64	979260.91	979260.91
0	9:55	489074	3576504	714.2	-29.2	979266.64	979260.91	979260.91
0	9:57	489074	3576504	714.2	-29.2	979266.64	979260.91	979260.91
0	9:58	489074	3576504	714.2	-29.2	979266.64	979260.91	979260.91
0	12:07	489074	3576504	714.2	-29.2	979266.65	979260.92	979260.92
0	15:19	489074	3576504	714.2	-29.2	979265.91	979260.18	979260.91
0	15:20	489074	3576504	714.2	-29.2	979265.92	979260.19	979260.92
0	15:20	489074	3576504	714.2	-29.2	979265.92	979260.19	979260.92
0	15:21	489074	3576504	714.2	-29.2	979265.90	979260.17	979260.91
0	15:21	489074	3576504	714.2	-29.2	979265.92	979260.19	979260.93
50	10:10	489109	3576469	713.5	-29.9	979267.04	979261.17	979261.17
50	10:11	489109	3576469	713.5	-29.9	979267.05	979261.18	979261.18
50	10:12	489109	3576469	713.5	-29.9	979267.05	979261.18	979261.18
50	10:13	489109	3576469	713.5	-29.9	979267.04	979261.18	979261.18
50	10:14	489109	3576469	713.5	-29.9	979267.04	979261.18	979261.18
100	10:24	489137	3576427	714.1	-29.3	979266.50	979260.76	979260.76
100	10:25	489137	3576427	714.1	-29.3	979266.50	979260.76	979260.76
100	10:26	489137	3576427	714.1	-29.3	979266.50	979260.77	979260.77
152	10:56	489165	3576384	716.5	-26.9	979265.99	979260.71	979260.71
152	10:57	489165	3576384	716.5	-26.9	979265.99	979260.72	979260.72
152	10:58	489165	3576384	716.5	-26.9	979265.99	979260.71	979260.71
152	10:59	489165	3576384	716.5	-26.9	979265.99	979260.71	979260.71
152	11:00	489165	3576384	716.5	-26.9	979266.01	979260.73	979260.73
152	11:01	489165	3576384	716.5	-26.9	979265.99	979260.71	979260.71
200	11:26	489196	3576341	714.1	-29.3	979266.93	979261.19	979261.19
200	11:27	489196	3576341	714.1	-29.3	979266.93	979261.19	979261.19
250	11:37	489227	3576305	714.0	-29.4	979266.74	979260.97	979260.97
300	11:50	489260	3576264	717.2	-26.2	979265.96	979260.83	979260.83
300	11:51	489260	3576264	717.2	-26.2	979265.96	979260.83	979260.83
Harshbarger	8:11	501185	3568015	743.4	0.0	979240.15	979240.15	979240.15
Harshbarger	8:12	501185	3568015	743.4	0.0	979240.16	979240.15	979240.15
Harshbarger	8:13	501185	3568015	743.4	0.0	979240.17	979240.17	979240.17
Harshbarger	8:14	501185	3568015	743.4	0.0	979240.17	979240.17	979240.17

Appendix C. Magnetic surveys.

Table AC.1. Station locations, measured magnetic readings, applied drift corrections, and corrected magnetic readings for all stations.

Transect	Section	Easting	Northing	Elevation (m)	UTM source	Tape location (m)	Time (12-hr)	Uncorrected reading (nT)	Correction (nT)	Corrected reading (nT)	Notes
1	NW	488472	3575482		Interpolated	5.00	12:25	47271.8	-0.4	47271.4	
1	NW	488472	3575482		Interpolated	5.00	12:25	47271.7	-0.4	47271.3	
1	NW	488468	3575486		Interpolated	10.00	12:27	47301.2	-0.7	47300.5	
1	NW	488468	3575486		Interpolated	10.00	12:27	47301.1	-0.7	47300.4	
1	NW	488465	3575489		Interpolated	15.00	12:28	47154.0	-0.9	47153.1	
1	NW	488465	3575489		Interpolated	15.00	12:28	47150.3	-0.9	47149.4	
1	NW	488461	3575493		Interpolated	20.00	12:29	47214.5	-1.1	47213.4	
1	NW	488461	3575493		Interpolated	20.00	12:29	47211.9	-1.1	47210.8	
1	NW	488458	3575496		Interpolated	25.00	12:30	47231.1	-1.3	47229.8	
1	NW	488458	3575496		Interpolated	25.00	12:30	47231.3	-1.3	47230.0	
1	NW	488454	3575500		Interpolated	30.00	12:33	47187.4	-1.8	47185.6	
1	NW	488454	3575500		Interpolated	30.00	12:33	47187.3	-1.8	47185.5	
1	NW	488451	3575503		Interpolated	35.00	12:34	47156.2	-2.0	47154.2	
1	NW	488451	3575503		Interpolated	35.00	12:34	47156.7	-2.0	47154.7	

1	NW	488447	3575507		Interp olated	40.00	12:35	47134.1	-2.2	47131.9	
1	NW	488447	3575507		Interp olated	40.00	12:35	47132.4	-2.2	47130.2	
1	NW	488444	3575510		Interp olated	45.00	12:36	47126.6	-2.4	47124.2	
1	NW	488444	3575510		Interp olated	45.00	12:36	47126.3	-2.4	47123.9	
1	NW	488440	3575514	749.81	GPS measu rement	50.00	12:38	47217.6	-2.7	47214.9	
1	NW	488440	3575514	749.81	GPS measu rement	50.00	12:38	47216.4	-2.7	47213.7	
1	NW	488436	3575518		Interp olated	55.00	12:42	47243.5	-3.5	47240.0	
1	NW	488436	3575518		Interp olated	55.00	12:42	47243.4	-3.5	47239.9	
1	NW	488433	3575521		Interp olated	60.00	12:44	47215.7	-3.8	47211.9	
1	NW	488433	3575521		Interp olated	60.00	12:44	47282.2	-3.8	47278.4	
1	NW	488429	3575525		Interp olated	65.00	12:45	47300.7	-4.0	47296.7	
1	NW	488429	3575525		Interp olated	65.00	12:45	47299.7	-4.0	47295.7	
1	NW	488426	3575528		Interp olated	70.00	12:48	47300.3	-4.6	47295.7	
1	NW	488426	3575528		Interp olated	70.00	12:48	47301.5	-4.6	47296.9	
1	NW	488422	3575532		Interp olated	75.00	12:50	47471.1	-4.9	47466.2	
1	NW	488422	3575532		Interp olated	75.00	12:50	47473.7	-4.9	47468.8	
1	NW	488419	3575535		Interp olated	80.00	12:51	47493.8	-5.1	47488.7	Significant metal in Area

1	NW	488419	3575535		Interpolated	80.00	12:51	47490.3	-5.1	47485.2	
1	NW	488415	3575539		Interpolated	85.00	12:52	47120.3	-5.3	47115.0	
1	NW	488415	3575539		Interpolated	85.00	12:52	47121.6	-5.3	47116.3	
1	NW	488412	3575542		Interpolated	90.00	12:53	47110.5	-5.5	47105.0	Some Metal in area
1	NW	488412	3575542		Interpolated	90.00	12:53	47110.4	-5.5	47104.9	
1	NW	488408	3575546		Interpolated	95.00	12:56	47132.9	-6.0	47126.9	Significant metal in Area
1	NW	488408	3575546		Interpolated	95.00	12:56	47133.2	-6.0	47127.2	
1	NW	488405	3575549	747.37	GPS measurement	100.00	12:57	47151.4	-6.2	47145.2	Metal In Area
1	NW	488405	3575549	747.37	GPS measurement	100.00	12:57	47151.7	-6.2	47145.5	
1	NW	488401	3575553		Interpolated	105.00	1:02	47183.4	-7.1	47176.3	Metal In Area
1	NW	488401	3575553		Interpolated	105.00	1:02	47184.3	-7.1	47177.2	
1	NW	488398	3575556		Interpolated	110.00	1:03	47270.9	-7.3	47263.6	Metal In Area
1	NW	488398	3575556		Interpolated	110.00	1:03	47265.4	-7.3	47258.1	
1	NW	488394	3575560		Interpolated	115.00	1:05	47215.1	-7.7	47207.4	
1	NW	488394	3575560		Interpolated	115.00	1:05	47215.0	-7.7	47207.3	
1	NW	488391	3575563		Interpolated	120.00	1:06	47167.3	-7.8	47159.5	Down Small Hill
1	NW	488391	3575563		Interpolated	120.00	1:06	47167.2	-7.8	47159.4	

1	NW	488387	3575567		Interpolated	125.00	1:07	47174.7	-8.0	47166.7	
1	NW	488387	3575567		Interpolated	125.00	1:07	47174.8	-8.0	47166.8	
1	NW	488384	3575570		Interpolated	130.00	1:07	47188.6	-8.0	47180.6	
1	NW	488384	3575570		Interpolated	130.00	1:08	47187.2	-8.2	47179.0	
1	NW	488380	3575574		Interpolated	135.00	1:08	47193.9	-8.2	47185.7	Wash
1	NW	488380	3575574		Interpolated	135.00	1:08	47194.5	-8.2	47186.3	
1	NW	488377	3575577		Interpolated	140.00	1:09	47223.4	-8.4	47215.0	
1	NW	488377	3575577		Interpolated	140.00	1:09	47224.0	-8.4	47215.6	
1	NW	488373	3575581		Interpolated	145.00	1:09	47268.3	-8.5	47259.8	Up Small Hill
1	NW	488373	3575581		Interpolated	145.00	1:09	47268.3	-8.5	47259.8	
1	NW	488372	3575584		GPS measurement	150.00	1:10	47282.4	-8.6	47273.8	
1	NW	488372	3575584		GPS measurement	150.00	1:10	47284.3	-8.6	47275.7	
1	NW	488368	3575588		Interpolated	155.00	1:10	47159.3	-8.7	47150.6	Down Small Hill
1	NW	488368	3575588		Interpolated	155.00	1:10	47157.9	-8.7	47149.2	
1	NW	488365	3575591		Interpolated	160.00	1:11	47184.5	-8.8	47175.7	
1	NW	488365	3575591		Interpolated	160.00	1:11	47183.8	-8.8	47175.0	
1	NW	488361	3575595		Interpolated	165.00	1:11	47224.0	-8.8	47215.2	

1	NW	488361	3575595		Interp olated	165.00	1:11	47224.3	-8.8	47215.5	
1	NW	488358	3575598		Interp olated	170.00	1:12	47251.8	-8.9	47242.9	
1	NW	488358	3575598		Interp olated	170.00	1:12	47249.9	-8.9	47241.0	
1	NW	488354	3575602		Interp olated	175.00	1:13	47238.0	-9.1	47228.9	
1	NW	488354	3575602		Interp olated	175.00	1:13	47238.8	-9.1	47229.7	
1	NW	488351	3575605		Interp olated	180.00	1:14	47233.8	-9.3	47224.5	
1	NW	488351	3575605		Interp olated	180.00	1:14	47245.3	-9.3	47236.0	
1	NW	488347	3575609		Interp olated	185.00	1:14	47226.5	-9.4	47217.1	
1	NW	488347	3575609		Interp olated	185.00	1:14	47226.2	-9.4	47216.8	
1	NW	488344	3575612		Interp olated	190.00	1:15	47253.5	-9.5	47244.0	
1	NW	488344	3575612		Interp olated	190.00	1:15	47252.2	-9.5	47242.7	
1	NW	488340	3575616		Interp olated	195.00	1:16	47251.4	-9.7	47241.7	
1	NW	488340	3575616		Interp olated	195.00	1:16	47255.0	-9.7	47245.3	
1	NW	488335	3575620	749.50	GPS measu rement	200.00	1:16	47271.9	-9.8	47262.1	
1	NW	488335	3575620	749.50	GPS measu rement	200.00	1:16	47271.8	-9.8	47262.0	
1	NW	488331	3575624		Interp olated	205.00	1:17	47266.5	-9.9	47256.6	
1	NW	488331	3575624		Interp olated	205.00	1:17	47271.8	-9.9	47261.9	

1	NW	488328	3575627		Interpolated	210.00	1:17	47263.8	-10.0	47253.8	
1	NW	488328	3575627		Interpolated	210.00	1:17	47264.3	-10.0	47254.3	
1	NW	488324	3575631		Interpolated	215.00	1:18	47247.9	-10.0	47237.9	
1	NW	488324	3575631		Interpolated	215.00	1:18	47252.5	-10.0	47242.5	
1	NW	488321	3575634		Interpolated	220.00	1:19	47210.7	-10.2	47200.5	
1	NW	488321	3575634		Interpolated	220.00	1:19	47210.3	-10.2	47200.1	
1	NW	488317	3575638		Interpolated	225.00	1:20	47251.8	-10.4	47241.4	
1	NW	488317	3575638		Interpolated	225.00	1:20	47251.7	-10.4	47241.3	
1	NW	488314	3575641		Interpolated	230.00	1:21	47289.1	-10.6	47278.5	
1	NW	488314	3575641		Interpolated	230.00	1:21	47282.7	-10.6	47272.1	
1	NW	488310	3575645		Interpolated	235.00	1:22	47137.1	-10.8	47126.3	
1	NW	488310	3575645		Interpolated	235.00	1:22	47145.6	-10.8	47134.8	
1	NW	488307	3575648		Interpolated	240.00	1:23	47300.3	-10.9	47289.4	
1	NW	488307	3575648		Interpolated	240.00	1:23	47298.2	-10.9	47287.3	
1	NW	488303	3575652		Interpolated	245.00	1:24	47387.4	-11.1	47376.3	
1	NW	488303	3575652		Interpolated	245.00	1:24	47407.8	-11.1	47396.7	
1	NW	488299	3575655	748.59	GPS measurement	250.00	1:25	47287.6	-11.3	47276.3	

1	NW	488299	3575655	748.59	GPS measurement	250.00	1:25	47325.0	-11.3	47313.7	
1	NW	488295	3575659		Interpolated	255.00	1:26	47272.2	-11.5	47260.7	
1	NW	488295	3575659		Interpolated	255.00	1:26	47272.2	-11.5	47260.7	
1	NW	488292	3575662		Interpolated	260.00	1:26	47340.0	-11.6	47328.4	
1	NW	488292	3575662		Interpolated	260.00	1:26	47339.3	-11.6	47327.7	
1	NW	488288	3575666		Interpolated	265.00	1:27	47240.3	-11.7	47228.6	
1	NW	488288	3575666		Interpolated	265.00	1:27	47230.4	-11.7	47218.7	
1	NW	488285	3575669		Interpolated	270.00	1:28	47085.0	-11.9	47073.1	
1	NW	488285	3575669		Interpolated	270.00	1:28	47086.4	-11.9	47074.5	
1	NW	488281	3575673		Interpolated	275.00	1:28	47222.1	-11.9	47210.2	
1	NW	488281	3575673		Interpolated	275.00	1:28	47223.3	-11.9	47211.4	
1	NW	488278	3575676		Interpolated	280.00	1:29	47281.5	-12.0	47269.5	
1	NW	488278	3575676		Interpolated	280.00	1:29	47280.9	-12.0	47268.9	
1	NW	488274	3575680		Interpolated	285.00	1:30	47302.5	-12.2	47290.3	
1	NW	488274	3575680		Interpolated	285.00	1:30	47301.7	-12.2	47289.5	
1	NW	488271	3575683		Interpolated	290.00	1:32	47338.5	-12.6	47325.9	
1	NW	488271	3575683		Interpolated	290.00	1:32	47338.8	-12.6	47326.2	

1	NW	488267	3575687		Interpolated	295.00	1:33	47349.7	-12.8	47336.9	
1	NW	488267	3575687		Interpolated	295.00	1:33	47349.4	-12.8	47336.6	
1	NW	488266	3575691		GPS measurement	300.00	1:33	47380.8	-12.8	47368.0	
1	NW	488266	3575691		GPS measurement	300.00	1:33	47399.1	-12.8	47386.3	
1	SE	488488	3575471		Interpolated	15.00	2:01	47121.7	-2.6	47119.1	fences at 0 and 7 m, so took first measurement at 15 m
1	SE	488488	3575471		Interpolated	15.00	2:01	47122.3	-2.6	47119.7	
1	SE	488492	3575468		Interpolated	20.00	2:02	47218.5	-2.8	47215.8	
1	SE	488492	3575468		Interpolated	20.00	2:02	47233.5	-2.8	47230.8	
1	SE	488497	3575465		Interpolated	25.00	2:02	47258.8	-2.8	47256.1	
1	SE	488497	3575465		Interpolated	25.00	2:02	47258.7	-2.8	47256.0	
1	SE	488501	3575462		Interpolated	30.00	2:03	47252.6	-2.9	47249.7	
1	SE	488501	3575462		Interpolated	30.00	2:03	47252.5	-2.9	47249.6	
1	SE	488505	3575459		Interpolated	35.00	2:04	47238.7	-3.0	47235.7	
1	SE	488505	3575459		Interpolated	35.00	2:04	47241.9	-3.0	47238.9	

1	SE	488509	3575457		Interp olated	40.00	2:05	47177.2	-3.1	47174.1	at 42 m: telephone pole, metal chains, and metal nails in boards on ground
1	SE	488509	3575457		Interp olated	40.00	2:05	47191.1	-3.1	47188.0	
1	SE	488514	3575454		Interp olated	45.00	2:06	47245.3	-3.2	47242.1	
1	SE	488514	3575454		Interp olated	45.00	2:06	47249.1	-3.2	47245.9	
1	SE	488518	3575451	758.95	GPS measu rement	50.00	2:06	43548.3	-3.2	43545.1	metal poles embedded in ground from 50 to 55 m
1	SE	488518	3575451	758.95	GPS measu rement	50.00	2:06	46861.3	-3.2	46858.1	Aiza had 47652.5; metal poles embedded in ground from 50 to 55 m
1	SE	488522	3575448		Interp olated	55.00	2:07	47645.9	-3.3	47642.6	Aiza shifted +1 station
1	SE	488522	3575448		Interp olated	55.00	2:07	47632.5	-3.3	47629.2	
1	SE	488526	3575445		Interp olated	60.00	2:08	47177.9	-3.4	47174.5	at 60 m: metal pole embedded ~2 m off line; topo change up, steep cut ~1 m high
1	SE	488526	3575445		Interp olated	60.00	2:08	47179.7	-3.4	47176.3	
1	SE	488530	3575442		Interp olated	65.00	2:09	47234.6	-3.5	47231.1	

1	SE	488530	3575442		Interpolated	65.00	2:09	47235.5	-3.5	47232.0	
1	SE	488534	3575439		Interpolated	70.00	2:10	47153.9	-3.6	47150.3	
1	SE	488534	3575439		Interpolated	70.00	2:10	47153.6	-3.6	47150.0	
1	SE	488538	3575436		Interpolated	75.00	2:11	47151.2	-3.7	47147.5	metal trash on ground
1	SE	488538	3575436		Interpolated	75.00	2:11	47150.6	-3.7	47146.9	
1	SE	488541	3575433		Interpolated	80.00	2:12	47150.6	-3.8	47146.8	gradually sloping up (~50 deg)
1	SE	488541	3575433		Interpolated	80.00	2:12	47151.4	-3.8	47147.6	
1	SE	488545	3575430		Interpolated	85.00	2:13	46921.6	-4.0	46917.6	large metal rod on ground; Aiza had 46912.6
1	SE	488545	3575430		Interpolated	85.00	2:13	46981.0	-4.0	46977.0	
1	SE	488549	3575427		Interpolated	90.00	2:14	47135.9	-4.1	47131.8	
1	SE	488549	3575427		Interpolated	90.00	2:14	47136.4	-4.1	47132.3	
1	SE	488553	3575424		Interpolated	95.00	2:15	47142.2	-4.2	47138.0	at 97.5 m: metal embedded in concrete blocks
1	SE	488553	3575424		Interpolated	95.00	2:15	47140.6	-4.2	47136.4	
1	SE	488557	3575421	769.32	GPS measurement	100.00	2:16	47234.8	-4.3	47230.5	

1	SE	488557	3575421	769.32	GPS measurement	100.00	2:16	47235.0	-4.3	47230.7	
1	SE	488561	3575418		Interpolated	105.00	2:16	47123.2	-4.3	47118.9	
1	SE	488561	3575418		Interpolated	105.00	2:16	47110.4	-4.3	47106.1	
1	SE	488565	3575415		Interpolated	110.00	2:17	47270.2	-4.4	47265.8	
1	SE	488565	3575415		Interpolated	110.00	2:17	47271.4	-4.4	47267.0	
1	SE	488568	3575412		Interpolated	115.00	2:18	47226.2	-4.5	47221.7	
1	SE	488568	3575412		Interpolated	115.00	2:18	47226.2	-4.5	47221.7	
1	SE	488572	3575409		Interpolated	120.00	2:18	47175.2	-4.5	47170.7	road edge, ~0.5 m drop, built up with stone facing
1	SE	488572	3575409		Interpolated	120.00	2:18	47174.6	-4.5	47170.1	
1	SE	488576	3575406		Interpolated	125.00	2:20	47183.5	-4.7	47178.8	
1	SE	488576	3575406		Interpolated	125.00	2:20	47183.6	-4.7	47178.9	
1	SE	488580	3575403		Interpolated	130.00	2:22	47212.6	-5.0	47207.7	metal trash partially buried in ground, continues to 135 m
1	SE	488580	3575403		Interpolated	130.00	2:22	47213.0	-5.0	47208.1	
1	SE	488584	3575400		Interpolated	135.00	2:23	47217.1	-5.1	47212.0	
1	SE	488584	3575400		Interpolated	135.00	2:23	47248.8	-5.1	47243.7	

1	SE	488587	3575397		Interpolated	140.00	2:23	47121.3	-5.1	47116.2	
1	SE	488587	3575397		Interpolated	140.00	2:24	47121.0	-5.2	47115.8	
1	SE	488591	3575394		Interpolated	145.00	2:25	47205.8	-5.3	47200.5	
1	SE	488591	3575394		Interpolated	145.00	2:25	46403.6	-5.3	46398.3	
1	SE	488595	3575391	770.53	GPS measurement	150.00	2:26	47320.6	-5.4	47315.2	wire fence at 152.2 m
1	SE	488595	3575391	770.53	GPS measurement	150.00	2:26	47322.1	-5.4	47316.7	
1	SE	488599	3575389		Interpolated	155.00	2:28	47270.5	-5.6	47264.9	
1	SE	488599	3575389		Interpolated	155.00	2:28	47272.0	-5.6	47266.4	
1	SE	488603	3575386		Interpolated	160.00	2:29	47293.1	-5.7	47287.4	Karen had 47291.1
1	SE	488603	3575386		Interpolated	160.00	2:29	47293.1	-5.7	47287.4	
1	SE	488607	3575384		Interpolated	165.00	2:30	47299.9	-5.8	47294.1	
1	SE	488607	3575384		Interpolated	165.00	2:30	47299.6	-5.8	47293.8	
1	SE	488611	3575381		Interpolated	170.00	2:31	47294.0	-5.9	47288.1	
1	SE	488611	3575381		Interpolated	170.00	2:31	47294.7	-5.9	47288.8	
1	SE	488615	3575379		Interpolated	175.00	2:32	47262.8	-6.1	47256.8	
1	SE	488615	3575379		Interpolated	175.00	2:32	47262.0	-6.1	47256.0	

1	SE	488618	3575376		Interp olated	180.00	2:33	47192.9	-6.2	47186.7	at 182 m: pass wire fence and filled-in open shaft. Ends at 185 m
1	SE	488618	3575376		Interp olated	180.00	2:33	47198.0	-6.2	47191.8	
1	SE	488622	3575374		Interp olated	185.00	2:34	47278.5	-6.3	47272.2	Aiza had 47278.1
1	SE	488622	3575374		Interp olated	185.00	2:34	47279.4	-6.3	47273.1	Aiza had 47271.4
1	SE	488626	3575371		Interp olated	190.00	2:35	47248.6	-6.4	47242.2	peak of hill at 194 m
1	SE	488626	3575371		Interp olated	190.00	2:35	47248.5	-6.4	47242.1	Aiza had 47248.1
1	SE	488630	3575369		Interp olated	195.00	2:36	47233.8	-6.5	47227.3	
1	SE	488630	3575369		Interp olated	195.00	2:36	47234.3	-6.5	47227.8	
1	SE	488634	3575366	786.08	GPS measu rement	200.00	2:36	47238.0	-6.5	47231.5	after 200 m: steep downhill slope with loose cover
1	SE	488634	3575366	786.08	GPS measu rement	200.00	2:36	47237.8	-6.5	47231.3	
1	SE	488659	3575343	763.52	GPS measu rement	237.00	3:29	47371.4	-3.5	47367.9	skipped 200-237 m b/c too steep
1	SE	488659	3575343	763.52	GPS measu rement	237.00	3:30	47371.0	-3.6	47367.4	
1	SE	488662	3575340		Interp olated	240.00	3:31	47350.5	-3.7	47346.8	
1	SE	488662	3575340		Interp olated	240.00	3:31	47349.4	-3.7	47345.7	

1	SE	488665	3575338		Interpolated	245.00	3:31	47258.7	-3.7	47255.0	gradient changed from -0.01 to +0.01
1	SE	488665	3575338		Interpolated	245.00	3:31	47258.9	-3.7	47255.2	Karen had 47258.8
1	SE	488668	3575335	760.78	GPS measurement	250.00	3:32	47187.4	-3.8	47183.6	
1	SE	488668	3575335	760.78	GPS measurement	250.00	3:33	47186.6	-3.9	47182.7	Aiza had 47181.2
1	SE	488671	3575332		Interpolated	255.00	3:36	47181.2	-4.1	47177.1	
1	SE	488671	3575332		Interpolated	255.00	3:36	47181.2	-4.1	47177.1	
1	SE	488674	3575328		Interpolated	260.00	3:37	47151.3	-4.2	47147.1	
1	SE	488674	3575328		Interpolated	260.00	3:37	47152.8	-4.2	47148.6	
1	SE	488677	3575325		Interpolated	265.00	3:38	47220.1	-4.3	47215.8	
1	SE	488677	3575325		Interpolated	265.00	3:38	47219.6	-4.3	47215.3	
1	SE	488680	3575321		Interpolated	270.00	3:39	47262.6	-4.4	47258.2	after 270 m became uphill slope again
1	SE	488680	3575321		Interpolated	270.00	3:39	47233.0	-4.4	47228.6	
1	SE	488684	3575318		Interpolated	275.00	3:45	47258.5	-4.9	47253.6	gradient changed back to -0.01
1	SE	488684	3575318		Interpolated	275.00	3:45	47258.9	-4.9	47254.0	
1	SE	488687	3575314		Interpolated	280.00	3:45	47260.2	-4.9	47255.3	

1	SE	488687	3575314		Interpolated	280.00	3:46	47260.4	-5.0	47255.4	Aiza had 42260.1
1	SE	488690	3575311		Interpolated	285.00	3:46	47247.2	-5.0	47242.2	
1	SE	488690	3575311		Interpolated	285.00	3:46	47246.8	-5.0	47241.8	
1	SE	488693	3575307		Interpolated	290.00	3:47	47238.9	-5.0	47233.9	Karen had 47278.9
1	SE	488693	3575307		Interpolated	290.00	3:47	47237.7	-5.0	47232.7	Karen had 47277.7
1	SE	488696	3575304		Interpolated	295.00	3:47	47215.7	-5.0	47210.7	gradient changed back to +0.01
1	SE	488696	3575304		Interpolated	295.00	3:48	47216.2	-5.1	47211.1	
1	SE	488699	3575300	763.22	GPS measurement	300.00	3:48	47219.2	-5.1	47214.1	gradient -0.01
1	SE	488699	3575300	763.22	GPS measurement	300.00	3:48	47219.1	-5.1	47214.0	
2	NW	489254	3576271		Interpolated	5.00	9:41	47518.4	-0.3	47518.1	
2	NW	489254	3576271		Interpolated	5.00	9:41	47517.4	-0.4	47517.0	
2	NW	489251	3576275		Interpolated	10.00	9:42	47490.2	-0.5	47489.7	
2	NW	489251	3576275		Interpolated	10.00	9:42	47491.0	-0.6	47490.4	
2	NW	489248	3576279		Interpolated	15.00	9:42	47453.2	-0.7	47452.5	
2	NW	489248	3576279		Interpolated	15.00	9:42	47453.5	-0.7	47452.8	
2	NW	489245	3576283		Interpolated	20.00	9:43	47408.5	-0.9	47407.6	

2	NW	489245	3576283		Interpolated	20.00	9:43	47402.9	-0.9	47402.0	
2	NW	489242	3576287		Interpolated	25.00	9:44	47349.2	-1.1	47348.1	
2	NW	489242	3576287		Interpolated	25.00	9:44	47358.8	-1.1	47357.7	time wasn't recorded, so used time from first 25 m reading
2	NW	489238	3576291		Interpolated	30.00	9:44	47316.7	-1.3	47315.4	
2	NW	489238	3576291		Interpolated	30.00	9:44	47316.7	-1.3	47315.4	
2	NW	489235	3576295		Interpolated	35.00	9:45	47281.6	-1.5	47280.1	
2	NW	489235	3576295		Interpolated	35.00	9:45	47280.8	-1.5	47279.3	
2	NW	489232	3576299		Interpolated	40.00	9:45	47250.9	-1.6	47249.3	
2	NW	489232	3576299		Interpolated	40.00	9:45	47250.2	-1.4	47248.8	
2	NW	489229	3576303		Interpolated	45.00	9:46	47234.3	-1.8	47232.5	
2	NW	489229	3576303		Interpolated	45.00	9:46	47234.0	-1.8	47232.2	
2	NW	489226	3576306	715.67	GPS measurement	50.00	9:47	47210.7	-2.0	47208.7	
2	NW	489226	3576306	715.67	GPS measurement	50.00	9:47	47210.2	-2.0	47208.2	
2	NW	489223	3576310		Interpolated	55.00	9:47	47199.1	-2.1	47197.0	
2	NW	489223	3576310		Interpolated	55.00	9:44	47198.3	-1.3	47197.0	

2	NW	489219	3576314		Interp olated	60.00	9:48	47166.3	-2.3	47164.0	
2	NW	489219	3576314		Interp olated	60.00	9:48	47166.3	-2.3	47164.0	
2	NW	489216	3576318		Interp olated	65.00	9:49	47150.8	-2.7	47148.1	
2	NW	489216	3576318		Interp olated	65.00	9:49	47150.2	-2.7	47147.5	
2	NW	489213	3576322		Interp olated	70.00	9:50	47144.6	-2.9	47141.7	
2	NW	489213	3576322		Interp olated	70.00	9:50	47144.6	-2.9	47141.7	
2	NW	489210	3576325		Interp olated	75.00	9:50	47142.2	-3.0	47139.2	
2	NW	489210	3576325		Interp olated	75.00	9:51	47142.0	-3.1	47138.9	
2	NW	489206	3576329		Interp olated	80.00	9:51	47145.7	-3.2	47142.5	
2	NW	489206	3576329		Interp olated	80.00	9:51	47144.7	-3.2	47141.5	
2	NW	489203	3576333		Interp olated	85.00	9:52	47159.3	-3.4	47155.9	
2	NW	489203	3576333		Interp olated	85.00	9:52	47158.5	-3.4	47155.1	
2	NW	489200	3576337		Interp olated	90.00	9:52	47169.0	-3.6	47165.4	90m on line was in cactus patch, so measurements actually taken ~0.5m south of line
2	NW	489200	3576337		Interp olated	90.00	9:53	47168.9	-3.6	47165.3	
2	NW	489196	3576340		Interp olated	95.00	9:53	47185.4	-3.8	47181.6	

2	NW	489196	3576340		Interp olated	95.00	9:53	47185.3	-3.8	47181.5	
2	NW	489193	3576344	718.11	GPS measu rement	100.00	9:54	47193.0	-3.9	47189.1	
2	NW	489193	3576344	718.11	GPS measu rement	100.00	9:54	47193.2	-4.0	47189.2	
2	NW	489191	3576349		Interp olated	105.00	10:05	47190.8	+3.0	47193.8	contin. Of traverse
2	NW	489191	3576349		Interp olated	105.00	10:05	47190.7	+3.1	47193.8	
2	NW	489188	3576353		Interp olated	110.00	10:05	47191.7	+3.2	47194.9	
2	NW	489188	3576353		Interp olated	110.00	10:06	47191.3	+3.3	47194.6	
2	NW	489185	3576357		Interp olated	115.00	10:06	47186.3	+3.4	47189.7	
2	NW	489185	3576357		Interp olated	115.00	10:06	47186.3	+3.5	47189.8	
2	NW	489182	3576361		Interp olated	120.00	10:07	47185.7	+3.6	47189.3	
2	NW	489182	3576361		Interp olated	120.00	10:07	47185.5	+3.6	47189.1	
2	NW	489179	3576365		Interp olated	125.00	10:07	47181.3	+3.7	47185.0	
2	NW	489179	3576365		Interp olated	125.00	10:07	47181.1	+3.8	47184.9	
2	NW	489176	3576369		Interp olated	130.00	10:08	47160.7	+3.9	47164.6	
2	NW	489176	3576369		Interp olated	130.00	10:08	47159.9	+3.9	47163.8	
2	NW	489173	3576373		Interp olated	135.00	10:08	47106.7	+4.0	47110.7	
2	NW	489173	3576373		Interp olated	135.00	10:08	47105.9	+4.1	47110.0	

2	NW	489170	3576377		Interpolated	140.00	10:09	47232.7	+4.2	47236.9	
2	NW	489170	3576377		Interpolated	140.00	10:09	47234.3	+4.2	47238.5	
2	NW	489167	3576381		Interpolated	145.00	10:09	47170.4	+4.2	47174.6	
2	NW	489167	3576381		Interpolated	145.00	10:09	47170.5	+4.4	47174.9	
2	NW	489164	3576385	720.24	GPS measurement	150.00	10:10	47144.6	+4.5	47149.1	
2	NW	489164	3576385	720.24	GPS measurement	150.00	10:10	47144.8	+4.5	47149.3	
2	NW	489162	3576389		Interpolated	155.00	10:11	47130.4	+4.7	47135.1	
2	NW	489162	3576389		Interpolated	155.00	10:11	47130.0	+4.7	47134.7	
2	NW	489159	3576393		Interpolated	160.00	10:11	47145.6	+4.8	47150.4	
2	NW	489159	3576393		Interpolated	160.00	10:11	47145.1	+4.9	47150.0	
2	NW	489156	3576398		Interpolated	165.00	10:12	47137.0	+5.0	47142.0	
2	NW	489156	3576398		Interpolated	165.00	10:12	47137.4	+5.1	47142.5	
2	NW	489153	3576402		Interpolated	170.00	10:13	47138.4	+5.3	47143.7	
2	NW	489153	3576402		Interpolated	170.00	10:13	47138.4	+5.3	47143.7	
2	NW	489151	3576406		Interpolated	175.00	10:14	47130.5	+5.7	47136.2	
2	NW	489151	3576406		Interpolated	175.00	10:14	47129.8	+5.7	47135.5	
2	NW	489148	3576410		Interpolated	180.00	10:15	47116.4	+5.9	47122.3	

2	NW	489148	3576410		Interp olated	180.00	10:15	47115.9	+5.9	47121.8	
2	NW	489145	3576414		Interp olated	185.00	10:15	47123.2	+6.0	47129.2	
2	NW	489145	3576414		Interp olated	185.00	10:16	47122.8	+6.1	47128.9	
2	NW	489142	3576419		Interp olated	190.00	10:16	47129.7	+6.2	47135.9	
2	NW	489142	3576419		Interp olated	190.00	10:16	47130.1	+6.2	47136.3	
2	NW	489140	3576423		Interp olated	195.00	10:17	47144.4	+6.4	47150.8	
2	NW	489140	3576423		Interp olated	195.00	10:17	47143.6	+6.4	47150.0	
2	NW	489137	3576427	713.84	GPS measu rement	200.00	10:17	47100.7	+6.5	47107.2	
2	NW	489137	3576427	713.84	GPS measu rement	200.00	10:17	47099.9	+6.6	47106.5	
2	NW	489134	3576431		Interp olated	205.00	10:33	47081.8	+10.7	47092.5	contin. Of traverse
2	NW	489134	3576431		Interp olated	205.00	10:33	47081.5	+10.8	47092.2	
2	NW	489131	3576435		Interp olated	210.00	10:33	47070.9	+10.9	47081.8	
2	NW	489131	3576435		Interp olated	210.00	10:33	47070.3	+11.0	47081.3	
2	NW	489129	3576439		Interp olated	215.00	10:34	47054.9	+11.1	47066.0	
2	NW	489129	3576439		Interp olated	215.00	10:34	47052.7	+11.1	47063.8	
2	NW	489126	3576444		Interp olated	220.00	10:35	47062.2	+11.4	47073.6	
2	NW	489126	3576444		Interp olated	220.00	10:35	47062.2	+11.5	47073.7	

2	NW	489123	3576448		Interp olated	225.00	10:36	47081.4	+11.6	47093.0	
2	NW	489123	3576448		Interp olated	225.00	10:36	47081.2	+11.6	47092.8	
2	NW	489120	3576452		Interp olated	230.00	10:37	47097.7	+11.8	47109.5	
2	NW	489120	3576452		Interp olated	230.00	10:37	47097.0	+11.9	47108.9	
2	NW	489118	3576456		Interp olated	235.00	10:37	47106.1	+12.0	47118.1	
2	NW	489118	3576456		Interp olated	235.00	10:37	47106.2	+12.0	47118.2	
2	NW	489115	3576460		Interp olated	240.00	10:38	47105.2	+12.1	47117.3	
2	NW	489115	3576460		Interp olated	240.00	10:38	47105.0	+12.2	47117.2	
2	NW	489112	3576464		Interp olated	245.00	10:38	47096.6	+12.3	47108.9	
2	NW	489112	3576464		Interp olated	245.00	10:38	47096.1	+12.3	47108.4	
2	NW	489109	3576469	713.54	GPS measu rement	250.00	10:39	47091.1	+12.4	47103.5	
2	NW	489109	3576469	713.54	GPS measu rement	250.00	10:39	47090.7	+12.5	47103.2	
2	NW	489106	3576472		Interp olated	255.00	10:39	47085.1	+12.5	47097.6	
2	NW	489106	3576472		Interp olated	255.00	10:40	47085.2	+12.6	47097.8	
2	NW	489102	3576476		Interp olated	260.00	10:40	47095.1	+12.8	47107.9	
2	NW	489102	3576476		Interp olated	260.00	10:40	47095.3	+12.8	47108.1	
2	NW	489099	3576479		Interp olated	265.00	10:41	47092.0	+12.9	47104.9	

2	NW	489099	3576479		Interpolated	265.00	10:41	47091.9	+13.0	47104.9	
2	NW	489095	3576483		Interpolated	270.00	10:41	47096.3	+13.1	47109.4	
2	NW	489095	3576483		Interpolated	270.00	10:41	47096.3	+13.2	47109.5	
2	NW	489092	3576486		Interpolated	275.00	10:42	47090.3	+13.3	47103.6	
2	NW	489092	3576486		Interpolated	275.00	10:42	47089.7	+13.4	47103.1	
2	NW	489088	3576490		Interpolated	280.00	10:43	47073.7	+13.5	47087.2	
2	NW	489088	3576490		Interpolated	280.00	10:43	47073.5	+13.6	47087.1	
2	NW	489085	3576493		Interpolated	285.00	10:43	47113.7	+13.7	47127.4	
2	NW	489085	3576493		Interpolated	285.00	10:43	47113.7	+13.7	47127.4	
2	NW	489081	3576497		Interpolated	290.00	10:44	47117.6	+13.9	47131.5	
2	NW	489081	3576497		Interpolated	290.00	10:44	47117.8	+13.9	47131.7	
2	NW	489078	3576500		Interpolated	295.00	10:45	47117.9	+14.1	47132.0	
2	NW	489078	3576500		Interpolated	295.00	10:45	47117.5	+14.1	47131.6	
2	NW	489074	3576504	714.76	GPS measurement	300.00	10:45	47135.3	+14.2	47149.5	~50 m from house (in direction of line)
2	NW	489074	3576504	714.76	GPS measurement	300.00	10:45	47134.9	+14.3	47149.2	
2	NW	489074	3576504	714.76	GPS measurement	300.00	10:46	47135.0	+14.4	47149.4	

2	SE	489280	3576234		Interp olated	45.00	11:03	47176.4	+19.0	47195.4	telephone poles from 0 to 41 m
2	SE	489280	3576234		Interp olated	45.00	11:04	47142.8	+19.2	47162.0	
2	SE	489283	3576231	714.76	GPS measu rement	50.00	11:04	47256.4	+19.2	47275.6	
2	SE	489283	3576231	714.76	GPS measu rement	50.00	11:04	47256.4	+19.2	47275.6	
2	SE	489286	3576227		Interp olated	55.00	11:05	47255.0	+19.5	47274.5	
2	SE	489286	3576227		Interp olated	55.00	11:05	47254.6	+19.5	47274.1	
2	SE	489290	3576223		Interp olated	60.00	11:06	47219.1	+19.8	47238.9	
2	SE	489290	3576223		Interp olated	60.00	11:06	47219.3	+19.8	47239.1	
2	SE	489293	3576219		Interp olated	65.00	11:06	47164.4	+19.8	47184.2	
2	SE	489293	3576219		Interp olated	65.00	11:06	47164.3	+19.8	47184.1	
2	SE	489296	3576216		Interp olated	70.00	11:07	47149.2	+20.1	47169.3	
2	SE	489296	3576216		Interp olated	70.00	11:07	47149.1	+20.1	47169.2	
2	SE	489300	3576212		Interp olated	75.00	11:08	47133.0	+20.3	47153.3	
2	SE	489300	3576212		Interp olated	75.00	11:08	47132.7	+20.3	47153.0	
2	SE	489303	3576209		Interp olated	80.00	11:08	47137.3	+20.3	47157.6	
2	SE	489303	3576209		Interp olated	80.00	11:09	47137.2	+20.6	47157.8	

2	SE	489307	3576205		Interpolated	85.00	11:09	47165.1	+20.6	47185.7	
2	SE	489307	3576205		Interpolated	85.00	11:09	47165.2	+20.6	47185.8	
2	SE	489310	3576201		Interpolated	90.00	11:09	47189.9	+20.6	47210.5	wash from 89-90 m
2	SE	489310	3576201		Interpolated	90.00	11:10	47190.0	+20.9	47210.9	
2	SE	489314	3576198		Interpolated	95.00	11:10	47226.6	+20.9	47247.5	
2	SE	489314	3576198		Interpolated	95.00	11:10	47227.2	+20.9	47248.1	
2	SE	489317	3576194	714.76	GPS measurement	100.00	11:11	47246.2	+21.2	47267.4	
2	SE	489317	3576194	714.76	GPS measurement	100.00	11:11	47245.7	+21.2	47266.9	
2	SE	489320	3576190		Interpolated	105.00	11:37	47250.3	-0.7	47249.6	
2	SE	489320	3576190		Interpolated	105.00	11:37	47250.3	-0.7	47249.6	
2	SE	489324	3576186		Interpolated	110.00	11:38	47274.1	-0.9	47273.2	
2	SE	489324	3576186		Interpolated	110.00	11:38	47274.4	-0.9	47273.5	
2	SE	489327	3576182		Interpolated	115.00	11:39	47280.6	-1.0	47279.6	
2	SE	489327	3576182		Interpolated	115.00	11:39	47280.2	-1.0	47279.2	
2	SE	489330	3576178		Interpolated	120.00	11:40	47280.6	-1.1	47279.5	
2	SE	489330	3576178		Interpolated	120.00	11:40	47280.6	-1.1	47279.5	
2	SE	489333	3576175		Interpolated	125.00	11:40	47275.1	-1.1	47274.0	

2	SE	489333	3576175		Interpolated	125.00	11:40	47275.2	-1.1	47274.1	
2	SE	489336	3576171		Interpolated	130.00	11:41	47273.1	-1.3	47271.8	wash from 130-141m
2	SE	489336	3576171		Interpolated	130.00	11:41	47272.9	-1.3	47271.6	
2	SE	489339	3576167		Interpolated	135.00	11:41	47296.4	-1.3	47295.1	
2	SE	489339	3576167		Interpolated	135.00	11:42	47296.4	-1.4	47295.0	
2	SE	489342	3576163		Interpolated	140.00	11:42	47301.8	-1.4	47300.4	
2	SE	489342	3576163		Interpolated	140.00	11:42	47301.6	-1.4	47300.2	
2	SE	489345	3576159		Interpolated	145.00	11:43	47318.0	-1.5	47316.5	
2	SE	489345	3576159		Interpolated	145.00	11:43	47318.1	-1.5	47316.6	
2	SE	489348	3576155	716.89	GPS measurement	150.00	11:43	47344.1	-1.5	47342.6	
2	SE	489348	3576155	716.89	GPS measurement	150.00	11:43	47343.8	-1.5	47342.3	
2	SE	489351	3576151		Interpolated	155.00	11:44	47356.1	-1.6	47354.5	
2	SE	489351	3576151		Interpolated	155.00	11:44	47356.0	-1.6	47354.4	
2	SE	489354	3576147		Interpolated	160.00	11:44	47366.5	-1.6	47364.9	
2	SE	489354	3576147		Interpolated	160.00	11:44	47366.4	-1.6	47364.8	
2	SE	489358	3576143		Interpolated	165.00	11:45	47390.6	-1.8	47388.8	
2	SE	489358	3576143		Interpolated	165.00	11:45	47390.6	-1.8	47388.8	

2	SE	489361	3576140		Interpolated	170.00	11:46	47418.4	-1.9	47416.5	
2	SE	489361	3576140		Interpolated	170.00	11:46	47418.1	-1.9	47416.2	
2	SE	489365	3576136		Interpolated	175.00	11:47	47399.9	-2.0	47397.9	
2	SE	489365	3576136		Interpolated	175.00	11:47	47400.2	-2.0	47398.2	
2	SE	489368	3576132		Interpolated	180.00	11:47	47422.1	-2.0	47420.1	
2	SE	489368	3576132		Interpolated	180.00	11:48	47422.3	-2.2	47420.1	
2	SE	489371	3576129		Interpolated	185.00	11:48	47459.2	-2.2	47457.0	
2	SE	489371	3576129		Interpolated	185.00	11:48	47460.2	-2.2	47458.0	
2	SE	489375	3576125		Interpolated	190.00	11:49	47482.4	-2.3	47480.1	
2	SE	489375	3576125		Interpolated	190.00	11:49	47481.2	-2.3	47478.9	
2	SE	489378	3576121		Interpolated	195.00	11:49	47408.2	-2.3	47405.9	
2	SE	489378	3576121		Interpolated	195.00	11:50	47408.2	-2.4	47405.8	
2	SE	489380	3576117	716.89	GPS measurement	200.00	11:50	47365.7	-2.4	47363.3	end of tape. Metal bar fence ~15m north of line
2	SE	489380	3576117	716.89	GPS measurement	200.00	11:50	47365.6	-2.4	47363.2	end of tape
2	SE	489380	3576112		Interpolated	200.00	12:41	47369.5	-2.4	47367.1	start of tape; deviates to south to avoid house

2	SE	489380	3576112		Interpolated	200.00	12:42	47369.3	-2.4	47366.9	start of tape; deviates to south to avoid house
2	SE	489379	3576107		Interpolated	203.48	12:42	47372.2	-2.4	47369.8	
2	SE	489379	3576107		Interpolated	203.48	12:43	47371.9	-2.5	47369.4	
2	SE	489379	3576102		Interpolated	206.96	12:43	47342.9	-2.5	47340.4	
2	SE	489379	3576102		Interpolated	206.96	12:43	47343.5	-2.5	47341.0	
2	SE	489379	3576097		Interpolated	210.45	12:43	47236.7	-2.5	47234.2	
2	SE	489379	3576097		Interpolated	210.45	12:43	47233.0	-2.5	47230.5	
2	SE	489378	3576092		Interpolated	213.93	12:43	47250.0	-2.5	47247.5	
2	SE	489378	3576092		Interpolated	213.93	12:43	47250.7	-2.5	47248.2	
2	SE	489378	3576087		Interpolated	217.41	12:44	47534.8	-2.5	47532.3	
2	SE	489378	3576087		Interpolated	217.41	12:44	47541.8	-2.5	47539.3	
2	SE	489378	3576082		Interpolated	220.89	12:45	47395.5	-2.6	47392.9	
2	SE	489378	3576082		Interpolated	220.89	12:45	47395.6	-2.6	47393.0	
2	SE	489377	3576077		Interpolated	224.37	12:45	47366.3	-2.6	47363.7	
2	SE	489377	3576077		Interpolated	224.37	12:45	47366.6	-2.6	47364.0	
2	SE	489377	3576072		Interpolated	227.86	12:46	47372.1	-2.6	47369.5	
2	SE	489377	3576072		Interpolated	227.86	12:46	47371.6	-2.6	47369.0	

2	SE	489377	3576067		Interpolated	231.34	12:46	47361.7	-2.6	47359.1	
2	SE	489377	3576067		Interpolated	231.34	12:46	47361.9	-2.6	47359.3	
2	SE	489376	3576062		Interpolated	234.82	12:47	47359.6	-2.7	47356.9	
2	SE	489376	3576062		Interpolated	234.82	12:47	47359.2	-2.7	47356.5	
2	SE	489375	3576057		Interpolated	238.30	12:48	47152.4	-2.7	47149.7	
2	SE	489375	3576057		Interpolated	238.30	12:48	47153.6	-2.7	47150.9	
2	SE	489375	3576052		Interpolated	241.78	12:48	46997.9	-2.7	46995.2	
2	SE	489375	3576052		Interpolated	241.78	12:48	46996.4	-2.7	46993.7	
2	SE	489374	3576047		Interpolated	245.27	12:50	47060.5	-2.8	47057.7	Fence ends at 263m
2	SE	489374	3576047		Interpolated	245.27	12:50	47061.2	-2.8	47058.4	
2	SE	489374	3576042		Interpolated	248.75	12:51	47163.2	-2.9	47160.3	
2	SE	489374	3576042		Interpolated	248.75	12:51	47165.2	-2.9	47162.3	
2	SE	489373	3576037		Interpolated	252.23	12:51	47195.5	-2.9	47192.6	
2	SE	489373	3576037		Interpolated	252.23	12:51	47194.4	-2.9	47191.5	
2	SE	489372	3576032		Interpolated	255.71	12:53	47246.9	-3.0	47243.9	
2	SE	489372	3576032		Interpolated	255.71	12:53	47247.0	-3.0	47244.0	
2	SE	489372	3576027		Interpolated	259.19	12:53	47346.1	-3.0	47343.1	
2	SE	489372	3576027		Interpolated	259.19	12:53	47346.1	-3.0	47343.1	

2	SE	489371	3576022		Interpolated	262.68	12:54	47261.5	-3.0	47258.5	
2	SE	489371	3576022		Interpolated	262.68	12:54	47261.1	-3.0	47258.1	
2	SE	489373	3576018		Interpolated	266.16	12:54	47270.1	-3.0	47267.1	
2	SE	489373	3576018		Interpolated	266.16	12:54	47270.7	-3.0	47267.7	
2	SE	489376	3576014	723.90	GPS measurement	269.64	12:55	47126.9	-3.1	47123.8	previous tape
2	SE	489376	3576014	723.90	GPS measurement	269.64	12:55	47126.8	-3.1	47123.7	previous tape
2	SE	489376	3576014		Interpolated	269.64	12:56	47152.9	-3.2	47149.7	next tape (deviates back?)
2	SE	489376	3576014		Interpolated	269.64	12:56	47153.8	-3.2	47150.6	next tape (deviates back?)
2	SE	489378	3576010		Interpolated	274.73	12:57	47209.1	-3.2	47205.9	
2	SE	489378	3576010		Interpolated	274.73	12:57	47209.1	-3.2	47205.9	
2	SE	489381	3576005		Interpolated	279.82	12:57	47264.4	-3.2	47261.2	
2	SE	489381	3576005		Interpolated	279.82	12:58	47263.3	-3.3	47260.0	
2	SE	489383	3576001		Interpolated	284.91	12:58	47289.0	-3.3	47285.7	
2	SE	489383	3576001		Interpolated	284.91	12:58	47289.6	-3.3	47286.3	
2	SE	489386	3575997		Interpolated	289.99	12:58	47280.0	-3.3	47276.7	
2	SE	489386	3575997		Interpolated	289.99	12:59	47279.5	-3.3	47276.2	

2	SE	489389	3575992		Interp olated	295.08	12:59	47286.5	-3.3	47283.2	
2	SE	489389	3575992		Interp olated	295.08	12:59	47286.9	-3.3	47283.6	
2	SE	489391	3575988		Interp olated	300.17	1:00	47211.7	-3.4	47208.3	
2	SE	489391	3575988		Interp olated	300.17	1:00	47212.0	-3.4	47208.6	
2	SE	489394	3575984		Interp olated	305.26	1:00	47325.3	-3.4	47321.9	
2	SE	489394	3575984		Interp olated	305.26	1:00	47325.7	-3.4	47322.3	
2	SE	489396	3575979		Interp olated	310.35	1:01	47289.6	-3.4	47286.2	
2	SE	489396	3575979		Interp olated	310.35	1:01	47290.5	-3.4	47287.1	
2	SE	489399	3575975		Interp olated	315.44	1:02	47175.1	-3.5	47171.6	house ~30m north of line
2	SE	489399	3575975		Interp olated	315.44	1:02	47176.1	-3.5	47172.6	
2	SE	489400	3575980	728.17	GPS measu rement	320.53	1:03	47086.3	-3.5	47082.8	line bends south to avoid garden
2	SE	489400	3575980	728.17	GPS measu rement	320.53	1:03	47086.4	-3.5	47082.9	
2	SE	489400	3575973	729.39	GPS measu rement	324.01	1:04	47115.0	-3.6	47111.4	Aiza had 47150
2	SE	489400	3575973	729.39	GPS measu rement	324.01	1:04	47114.5	-3.6	47110.9	Aiza had 47140.5
2	SE	489401	3575971	728.47	GPS measu rement	327.49	1:04	47103.4	-3.6	47099.8	

2	SE	489401	3575971	728.47	GPS measu rement	327.49	1:05	47103.6	-3.6	47100.0	
2	SE	489403	3575966	730.00	GPS measu rement	331.58	1:05	47122.4	-3.6	47118.8	
2	SE	489403	3575966	730.00	GPS measu rement	331.58	1:05	47122.2	-3.6	47118.6	
2	SE	489406	3575962	729.39	GPS measu rement	336.58	1:06	47170.6	-3.7	47166.9	
2	SE	489406	3575962	729.39	GPS measu rement	336.58	1:06	47170.9	-3.7	47167.2	
2	SE	489408	3575959	730.00	GPS measu rement	341.86	1:07	47211.2	-3.7	47207.5	
2	SE	489408	3575959	730.00	GPS measu rement	341.86	1:07	47210.7	-3.7	47207.0	
2	SE	489413	3575955	729.39	GPS measu rement	346.86	1:07	47218.9	-3.7	47215.2	
2	SE	489413	3575955	729.39	GPS measu rement	346.86	1:08	47218.8	-3.8	47215.0	
2	SE	489414	3575952	729.69	GPS measu rement	351.86	1:08	47178.6	-3.8	47174.8	
2	SE	489414	3575952	729.69	GPS measu rement	351.86	1:08	47179.9	-3.8	47176.1	
2	SE	489419	3575947	730.61	GPS measu rement	356.86	1:09	47089.9	-3.8	47086.1	

2	SE	489419	3575947	730.61	GPS measu rement	356.86	1:10	47088.9	-3.9	47085.0	
2	SE	489421	3575945	730.00	GPS measu rement	361.86	1:10	47048.4	-3.9	47044.5	
2	SE	489421	3575945	730.00	GPS measu rement	361.86	1:10	47048.9	-3.9	47045.0	
2	SE	489456	3575902	730.00	GPS measu rement	366.86	1:11	47015.1	-4.0	47011.1	
2	SE	489425	3575943	730.00	GPS measu rement	366.86	1:11	47013.9	-4.0	47009.9	
2	SE	489430	3575935	731.82	GPS measu rement	371.86	1:14	47054.1	-4.1	47050.0	
2	SE	489430	3575935	731.82	GPS measu rement	371.86	1:14	47054.5	-4.1	47050.4	
2	SE	489433	3575931	730.61	GPS measu rement	376.86	1:14	47132.8	-4.1	47128.7	
2	SE	489433	3575931	730.61	GPS measu rement	376.86	1:14	47133.3	-4.1	47129.2	Aiza had 47153.3
2	SE	489434	3575929	730.61	GPS measu rement	381.86	1:15	47211.6	-4.2	47207.4	
2	SE	489434	3575929	730.61	GPS measu rement	381.86	1:15	47210.8	-4.2	47206.6	
2	SE	489436	3575925	732.13	GPS measu rement	386.86	1:16	47369.4	-4.2	47365.2	

2	SE	489436	3575925	732.13	GPS measu rement	386.86	1:16	47368.5	-4.2	47364.3	
2	SE	489440	3575920	731.82	GPS measu rement	391.86	1:17	47554.1	-4.3	47549.8	start steep uphill
2	SE	489440	3575920	731.82	GPS measu rement	391.86	1:17	47552.9	-4.3	47548.6	
2	SE	489443	3575915	730.61	GPS measu rement	396.86	1:18	47648.2	-4.3	47643.9	
2	SE	489443	3575915	730.61	GPS measu rement	396.86	1:18	47648.3	-4.3	47644.0	
2	SE	489445	3575912	732.74	GPS measu rement	401.86	1:19	47814.6	-4.4	47810.2	
2	SE	489445	3575912	732.74	GPS measu rement	401.86	1:19	47815.0	-4.4	47810.6	
2	SE	489450	3575907	733.04	GPS measu rement	406.86	1:20	47755.7	-4.4	47751.3	
2	SE	489450	3575907	733.04	GPS measu rement	406.86	1:20	47754.3	-4.4	47749.9	
2	SE	489451	3575904	733.96	GPS measu rement	411.86	1:21	47756.7	-4.5	47752.2	
2	SE	489451	3575904	733.96	GPS measu rement	411.86	1:21	47756.7	-4.5	47752.2	
2	SE	489456	3575903	734.26	GPS measu rement	416.86	1:22	47787.7	-4.5	47783.2	line cuts sharply north

											and heads downhill
2	SE	489456	3575903	734.26	GPS measurement	416.86	1:22	47787.3	-4.5	47782.8	
2	SE	489456	3575907	734.57	GPS measurement	413.38	1:23	47772.6	-4.6	47768.0	
2	SE	489456	3575907	734.57	GPS measurement	413.38	1:23	47773.7	-4.6	47769.1	
2	SE	489455	3575913	734.26	GPS measurement	409.90	1:24	47851.5	-4.6	47846.9	
2	SE	489455	3575913	734.26	GPS measurement	409.90	1:24	47851.8	-4.6	47847.2	
2	SE	489457	3575915	732.13	GPS measurement	406.42	1:25	47703.0	-4.7	47698.3	
2	SE	489457	3575915	732.13	GPS measurement	406.42	1:25	47701.7	-4.7	47697.0	
2	SE	489459	3575920	730.61	GPS measurement	402.93	1:26	47327.1	-4.8	47322.3	
2	SE	489459	3575920	730.61	GPS measurement	402.93	1:26	47326.8	-4.8	47322.0	
2	SE	489461	3575926	730.61	GPS measurement	399.45	1:27	47396.7	-4.8	47391.9	
2	SE	489461	3575926	730.61	GPS measurement	399.45	1:27	47396.6	-4.8	47391.8	

2	SE	489461	3575930	729.69	GPS measu rement	395.97	1:28	47407.3	-4.9	47402.4	
2	SE	489461	3575930	729.69	GPS measu rement	395.97	1:28	47407.3	-4.9	47402.4	
2	SE	489462	3575935	729.39	GPS measu rement	392.49	1:32	47445.5	-5.1	47440.4	
2	SE	489462	3575935	729.39	GPS measu rement	392.49	1:32	47445.6	-5.1	47440.5	
2	SE	489463	3575940	729.08	GPS measu rement	389.01	1:33	47447.5	-5.1	47442.4	
2	SE	489463	3575940	729.08	GPS measu rement	389.01	1:33	47447.2	-5.1	47442.1	
2	SE	489465	3575946	729.69	GPS measu rement	385.52	1:33	47369.1	-5.1	47364.0	
2	SE	489465	3575946	729.69	GPS measu rement	385.52	1:33	47369.1	-5.1	47364.0	
2	SE	489468	3575947	728.17	GPS measu rement	382.04	1:34	47399.1	-5.2	47393.9	
2	SE	489466	3575950	728.17	GPS measu rement	382.04	1:34	47398.8	-5.2	47393.6	
2	SE	489470	3575946		Interp olated	387.04	2:02	47377.5	-0.5	47377.0	~10-15 m from house's garage
2	SE	489470	3575946		Interp olated	387.04	2:02	47378.1	-0.5	47377.6	
2	SE	489473	3575943		Interp olated	392.04	2:02	47406.2	-0.5	47405.7	

2	SE	489473	3575943		Interpolated	392.04	2:03	47406.0	-0.5	47405.5	
2	SE	489477	3575939		Interpolated	397.04	2:03	47427.3	-0.5	47426.8	
2	SE	489477	3575939		Interpolated	397.04	2:03	47427.2	-0.5	47426.7	
2	SE	489480	3575936		Interpolated	402.04	2:04	47465.7	-0.6	47465.1	
2	SE	489480	3575936		Interpolated	402.04	2:05	47465.7	-0.6	47465.1	
2	SE	489484	3575932		Interpolated	407.04	2:05	47460.1	-0.6	47459.5	
2	SE	489484	3575932		Interpolated	407.04	2:05	47460.0	-0.6	47459.4	
2	SE	489487	3575929		Interpolated	412.04	2:06	47525.5	-0.6	47524.9	
2	SE	489487	3575929		Interpolated	412.04	2:06	47525.6	-0.6	47525.0	
2	SE	489491	3575925		Interpolated	417.04	2:06	47618.4	-0.6	47617.8	Cross wire fence at 537m
2	SE	489491	3575925		Interpolated	417.04	2:07	47620.6	-0.6	47620.0	
2	SE	489494	3575922		Interpolated	422.04	2:10	47562.1	-0.7	47561.4	
2	SE	489494	3575922		Interpolated	422.04	2:10	47559.7	-0.7	47559.0	
2	SE	489498	3575918		Interpolated	427.04	2:11	47627.5	-0.8	47626.7	
2	SE	489498	3575918		Interpolated	427.04	2:11	47628.9	-0.8	47628.1	
2	SE	489501	3575915	728.17	GPS measurement	432.04	2:12	48404.1	-0.8	48403.3	Tape bends sharply (and goes NNW?)
2	SE	489501	3575915	728.17	GPS measurement	432.04	2:12	48395.5	-0.8	48394.7	

2	SE	489502	3575918		Interp olated	428.56	2:13	47853.8	-0.8	47853.0	
2	SE	489502	3575918		Interp olated	428.56	2:13	47851.9	-0.8	47851.1	
2	SE	489503	3575923		Interp olated	425.08	2:14	47696.3	-0.9	47695.4	
2	SE	489503	3575923		Interp olated	425.08	2:14	47695.6	-0.9	47694.7	
2	SE	489504	3575928		Interp olated	421.60	2:14	47580.8	-0.9	47579.9	
2	SE	489504	3575928		Interp olated	421.60	2:14	47580.6	-0.9	47579.7	
2	SE	489504	3575933		Interp olated	418.11	2:15	47539.3	-0.9	47538.4	
2	SE	489504	3575933		Interp olated	418.11	2:15	47539.8	-0.9	47538.9	
2	SE	489505	3575938		Interp olated	414.63	2:15	47475.4	-0.9	47474.5	
2	SE	489505	3575938		Interp olated	414.63	2:17	47475.7	-1.0	47474.7	Karen had 47474.7
2	SE	489505	3575943		Interp olated	411.15	2:16	47412.4	-0.9	47411.5	
2	SE	489505	3575943		Interp olated	411.15	2:16	47412.4	-0.9	47411.5	
2	SE	489506	3575948		Interp olated	407.67	2:17	47420.8	-1.0	47419.8	
2	SE	489506	3575948		Interp olated	407.67	2:18	47420.6	-1.0	47419.6	
2	SE	489507	3575953		Interp olated	404.19	2:18	47432.9	-1.0	47431.9	
2	SE	489507	3575953		Interp olated	404.19	2:18	47433.0	-1.0	47432.0	
2	SE	489507	3575958		Interp olated	400.70	2:19	47612.9	-1.0	47611.9	Cross wire fence at 596.6 m

2	SE	489507	3575958		Interp olated	400.70	2:19	47609.5	-1.0	47608.5	
2	SE	489508	3575963	723.90	GPS measu rement	397.22	2:27	47478.7	-1.3	47477.4	Tape bends sharply to get back on original SE profile
2	SE	489508	3575963	723.90	GPS measu rement	397.22	2:27	47480.4	-1.3	47479.1	
2	SE	489510	3575961		Interp olated	402.22	2:28	47479.9	-1.3	47478.6	
2	SE	489510	3575961		Interp olated	402.22	2:28	47478.5	-1.3	47477.2	
2	SE	489514	3575957		Interp olated	407.22	2:29	47606.9	-1.3	47605.6	Cross wire fence at 612 m
2	SE	489514	3575957		Interp olated	407.22	2:29	47610.0	-1.3	47608.7	
2	SE	489517	3575953		Interp olated	412.22	2:30	47222.2	-1.4	47220.8	
2	SE	489517	3575953		Interp olated	412.22	2:30	47216.3	-1.4	47214.9	
2	SE	489520	3575949		Interp olated	417.22	2:31	47628.8	-1.4	47627.4	
2	SE	489520	3575949		Interp olated	417.22	2:31	47627.8	-1.4	47626.4	
2	SE	489523	3575946		Interp olated	422.22	2:32	47570.3	-1.4	47568.9	
2	SE	489523	3575946		Interp olated	422.22	2:32	47570.2	-1.4	47568.8	
2	SE	489526	3575942		Interp olated	427.22	2:32	47590.2	-1.4	47588.8	
2	SE	489526	3575942		Interp olated	427.22	2:32	47590.3	-1.4	47588.9	
2	SE	489529	3575938		Interp olated	432.22	2:33	47636.3	-1.5	47634.8	

2	SE	489529	3575938		Interpolated	432.22	2:33	47636.4	-1.5	47634.9	
2	SE	489532	3575934		Interpolated	437.22	2:33	47706.9	-1.5	47705.4	
2	SE	489532	3575934		Interpolated	437.22	2:33	47705.7	-1.5	47704.2	
2	SE	489536	3575930		Interpolated	442.22	2:34	47778.4	-1.5	47776.9	
2	SE	489536	3575930		Interpolated	442.22	2:34	47778.8	-1.5	47777.3	
2	SE	489539	3575926	724.20	GPS measurement	447.22	2:34	47901.4	-1.5	47899.9	
2	SE	489539	3575926	724.20	GPS measurement	447.22	2:34	47900.0	-1.5	47898.5	
2	SE	489542	3575923		Interpolated	452.22	2:35	48019.6	-1.5	48018.1	
2	SE	489542	3575923		Interpolated	452.22	2:35	48016.2	-1.5	48014.7	
2	SE	489546	3575919		Interpolated	457.22	2:36	48085.6	-1.6	48084.0	
2	SE	489546	3575919		Interpolated	457.22	2:36	48088.8	-1.6	48087.2	
2	SE	489549	3575915		Interpolated	462.22	2:37	48032.7	-1.6	48031.1	
2	SE	489549	3575915		Interpolated	462.22	2:37	48032.2	-1.6	48030.6	Aiza had 48034.2
2	SE	489552	3575912		Interpolated	467.22	2:38	48148.3	-1.6	48146.7	
2	SE	489552	3575912		Interpolated	467.22	2:38	48149.3	-1.6	48147.7	
2	SE	489556	3575908		Interpolated	472.22	2:39	47910.6	-1.7	47908.9	
2	SE	489556	3575908		Interpolated	472.22	2:39	47910.9	-1.7	47909.2	

2	SE	489559	3575904		Interpolated	477.22	2:39	47581.3	-1.7	47579.6	
2	SE	489559	3575904		Interpolated	477.22	2:40	47581.0	-1.7	47579.3	
2	SE	489563	3575900		Interpolated	482.22	2:40	47451.9	-1.7	47450.2	
2	SE	489563	3575900		Interpolated	482.22	2:40	47451.3	-1.7	47449.6	
2	SE	489566	3575897		Interpolated	487.22	2:40	47390.0	-1.7	47388.3	
2	SE	489566	3575897		Interpolated	487.22	2:41	47391.1	-1.7	47389.4	
2	SE	489569	3575893		Interpolated	492.22	2:42	47218.4	-1.8	47216.6	
2	SE	489569	3575893		Interpolated	492.22	2:42	47217.8	-1.8	47216.0	
2	SE	489573	3575889	726.03	GPS measurement	497.22	2:42	47005.0	-1.8	47003.2	
2	SE	489573	3575889	726.03	GPS measurement	497.22	2:42	47005.5	-1.8	47003.7	

Appendix D. EM-31Conductivity and In-phase Surveys.

Table 1: EM-31, MK-1 conductivity and In-phase raw data for SE section of transect 1.

Tansect direction	Distance (m)	Conductivity [mS/m]				In-Phase [ppt]				Comments
		In-line Horizontal Coil	In-line Vertical Coil	Cross-line Horizontal Coil	Cross-line Vertical Coil	In-line Horizontal Coil	In-line Vertical Coil	Cross-line Horizontal Coil	Cross-line Vertical Coil	
SE	0			78				34		Reading not stable
SE	-5	50	14	54	16	37	2	42	1	
SE	-10			24	4			18	0	Fence at 11m
SE	-15	16	10	18	10	16	0	16	0	
SE	-20	10	8	10	8	6	0	5	0	
SE	-25	9	8	9	8	4	0	4	2	
SE	-30	10	8	10	8	5	0	6	0	
SE	-35	12	10	12	10	8	0	8	0	
SE	-40	12	8	14	8	0	0	16	0	Power line/ fence
SE	-45	14	11	14	8	14	1	10	0	
SE	-50	12	8	10	7	13	0	10	0	
SE	-55	11	8	11	8	10	0	14	0	Metal @ 53m
SE	-60	12	7	0	8	13	0	0	0	
SE	-65	8	6	8	10	6	0	8	3	Plenty metal @ 63m
SE	-70	10	8	8	8	18	0	10	0	Metal @ 68m
SE	-75	8	8	9	8	6	0	7	0	
SE	-80	10	8	10	9	6	0	6	0	
SE	-85	9	8	8	8	6	0	6	0	
SE	-90	11	8	11	10	6	0	8	0	
SE	-95	8	6	6	8	10	0	6	0	
SE	-100	6	6	6	6	8	10	8	0	profile line offset to
SE	-100	6	8	2	10	4	1	8	4	NE
SE	-105	6	7	6	6	8	2	4	2	Little metal
SE	-110	6	6	6	6	2	0	4	0	
SE	-115	6	7	6	7	6	0	4	0	
SE	-120	8	7	7	6	2	0	6	0	
SE	-125	0	14	0	18	10	0	0	17	large metal pieces
SE	-130	9	8	9	8	7	0	10	0	
SE	-135	10	8	10	8	4	0	8	0	
SE	-140	10	8	10	8	8	0	8	0	
SE	-145	14	10	14	10	6	0	6	0	
SE	-150	30	11	28	20	12	1	10	18	
SE	-155	0	160	100	100	0	240	100	0	Fence at 153m
SE	-160	12	8	12	8	14	0	10	0	
SE	-165	8	6	8	6	6	0	8	0	
SE	-170	8	6	8	7	9	0	5	4	
SE	-175	8	6	8	7	7	0	6	0	
SE	-180	8	8	8	8	4	0	5	0	
SE	-185	10	8	10	8	2	0	2	0	
SE	-190	10	8	10	9	6	0	14	0	
SE	-195	10	8	10	10	4	0	2	0	
SE	-215	14	14	16	15	18	0	8	0	about 15m jump over
SE	-220	14	10	14	10	18	0	10	0	valley
SE	-225	10	8	10	10	13	0	14	0	
SE	-230	10	9	10	10	6	4	8	0	
SE	-235	10	10	10	8	8	2	6	2	
SE	-240	8	8	8	7	8	2	8	2	
SE	-245	8	8	8	7	9	10	9	0	
SE	-250	8	7	8	8	8	0	8	0	
SE	-255	8	6	8	6	7	0	8	0	
SE	-260	8	8	9	6	6	0	8	0	
SE	-265	8	6	9	6	4	0	4	0	
SE	-270	8	8	9	6	4	0	4	0	
SE	-275	10	6	9	6	13	0	15	0	
SE	-280	10	6	9	6	12	0	10	0	
SE	-285	10	6	8	6	8	0	12	0	
SE	-290	8	8	8	8	4	0	3	0	
SE	-295	8	8	8	8	4	2	4	2	
SE	-300	8	6	8	6	4	0	4	0	
SE	-305	9	6	9	6	4	1	5	0	
SE	-310	9	8	9	8	4	2	5	2	
SE	-315	8	8	8	8	6	4	6	4	

Table 2: EM-31, MK-1 conductivity and In-phase raw data for NW section of transect 1.

Tansect direction	Distance (m)	Conductivity [mS/m]				In-Phase [ppt]				Comments
		In-line Horizontal Coil	In-line Vertical Coil	Cross-line Horizontal Coil	Cross-line Vertical Coil	In-line Horizontal Coil	In-line Vertical Coil	Cross-line Horizontal Coil	Cross-line Vertical Coil	
NW	50	11	8	11	10	8	0	8	0	little metal
NW	55	8	10	12	8	2	0	19	0	
NW	60	10	8	10	9	6	0	8	0	
NW	65	10	6	10	8	16	0	20	0	little metal
NW	70	9	6	9	8	18	0	20	0	
NW	75	9	6	10	8	12	0	16	0	considerable large
NW	80	4	12	12	10	10	0	18	0	amount metal
NW	85	12	8	12	8	19	0	16	0	Metal
NW	90	12	8	12	8	9	0	10	0	Metal
NW	95	11	8	12	8	10	0	10	0	Metal
NW	100	12	8	12	8	9	0	8	0	Metal
NW	105	12	8	12	8	12	0	11	0	Metal
NW	110	13	8	14	9	12	0	11	0	
NW	115	12	9	12	8	10	0	10	0	
NW	120	12	8	12	8	9	0	8	0	
NW	125	12	8	8	7	8	0	12	0	
NW	130	12	9	12	10	9	0	8	0	
NW	135	12	8	12	8	9	0	9	0	
NW	140	13	8	13	10	9	0	9	1	
NW	145	13	10	12	10	9	0	9	0	
NW	150	13	10	13	10	8	0	8	0	
NW	155	12	10	12	10	8	1	10	0	
NW	160	11	9	11	9	8	0	8	0	
NW	165	12	9	12	9	8	0	8	0	
NW	170	13	12	12	10	9	1	6	0	
NW	175	14	10	14	10	9	0	10	0	little metal
NW	180	12	10	11	10	8	0	7	0	
NW	185	12	10	12	9	6	0	7	0	
NW	190	12	10	11	9	6	0	7	0	
NW	195	12	10	12	9	8	0	8	0	
NW	200	12	10	12	10	8	0	8	0	
NW	205	13	10	13	9	11	0	10	0	
NW	210	14	10	13	10	10	0	8	0	
NW	215	12	10	12	9	10	0	11	0	
NW	220	11	9	10	9	10	0	10	0	
NW	225	11	9	10	8	12	0	14	0	
NW	230	10	8	10	8	10	0	10	0	
NW	235	10	8	10	8	12	0	12	0	
NW	240	10	9	10	8	2	0	2	0	
NW	245	12	10	12	10	16	0	18	0	
NW	250	14	10	14	10	16	0	26	0	
NW	255	16	12	15	10	12	0	12	0	
NW	260	16	12	16	12	12	0	12	0	
NW	265	18	14	17	12	10	0	9	0	
NW	270	17	12	17	12	10	0	11	0	
NW	275	16	12	16	12	9	0	9	0	
NW	280	14	10	14	12	8	1	8	1	
NW	285	15	12	14	12	6	1	7	2	spot 290m was not
NW	295	16	14	14	12	10	0	6	0	accessible
NW	300	10	10	10	8	8	0	8	0	

Table 3: EM-31, MK-2 conductivity and In-phase raw data for NW (0-70m) section of transect 1.

Tansect direction	Distance (m)	Conductivity [mS/m]				In-Phase [ppt]				Comments
		In-line Horizontal Coil	In-line Vertical Coil	Cross-line Horizontal Coil	Cross-line Vertical Coil	In-line Horizontal Coil	In-line Vertical Coil	Cross-line Horizontal Coil	Cross-line Vertical Coil	
NW-MK-2	0	-57	-101	2.9	-115	-4.3	-4.3	7.6	-20.5	
NW-MK-2	5	4.7	2.3	6.7	3.1	-7.0	3.5	6.3	4.2	
NW-MK-2	10	6.1	2.4	6.4	3.1	5.7	2.9	6.3	2.9	
NW-MK-2	15	4.8	3.2	4.4	3.7	5.0	3.1	5.3	3.7	
NW-MK-2	20	6.6	3.8	9.5	2.6	4.7	3.5	4.6	3.8	
NW-MK-2	25	5.2	3.1	6.4	3.1	5.9	3.3	5.1	2.3	
NW-MK-2	30	6.3	4.5	6.3	3.5	4.8	2.8	5.1	2.7	Metal trash scattered on ground
NW-MK-2	35	6.8	4.7	7.4	4.6	6.4	2.6	5.7	2.4	
NW-MK-2	40	6.3	4.1	6.7	4.4	5.4	2.4	5.6	2.8	
NW-MK-2	45	7.5	4.1	7.2	4.7	-6.8	-12.4	-7.4	-12.5	logger died, turned back on recalibrated & continuing
NW-MK-2	50	7.6	5.1	8.1	4.6	-8.3	-12.3	-8.0	-11.9	
NW-MK-2	55	4.4	6.6	6.5	6.3	-6.5	-12.1	-7.5	-11.9	
NW-MK-2	60	5.7	4.4	6.5	5.2	-9.4	-11.8	-8.4	-12.0	under power line
NW-MK-2	65	7.4	3.3	7.1	3.5	-7.4	-14.0	-7.4	-13.9	logger died again, restarted after lunch
NW-MK-2	70	5	3.1	5.5		-7.6	-13.7			

Table 4: EM-31, MK-2 conductivity and In-phase corrected data to fit with MK-1 profile for the NW (0-70m) section of transect 1.

Tansect direction	Distance (m)	Conductivity [mS/m]				In-Phase [ppt]				Comments
		In-line Horizontal Coil	In-line Vertical Coil	Cross-line Horizontal Coil	Cross-line Vertical Coil	In-line Horizontal Coil	In-line Vertical Coil	Cross-line Horizontal Coil	Cross-line Vertical Coil	
NW-MK-2	0	-53	-98	6	-110	12	8	30	-8	
NW-MK-2	5	9	5	10	8	9	16	28	16	
NW-MK-2	10	10	5	9	8	22	15	28	15	
NW-MK-2	15	9	6	7	9	21	15	27	16	
NW-MK-2	20	11	7	13	8	21	16	27	16	
NW-MK-2	25	9	6	9	8	22	15	27	14	
NW-MK-2	30	10	8	9	9	21	15	27	15	
NW-MK-2	35	11	8	10	10	22	15	28	14	
NW-MK-2	40	10	7	10	9	21	14	28	15	
NW-MK-2	45	12	7	10	10	9	0	15	0	
NW-MK-2	50	12	8	11	10	8	0	14	0	
NW-MK-2	55	8	10	10	11	10	0	15	0	
NW-MK-2	60	10	7	10	10	7	0	14	0	
NW-MK-2	65	11	6	10	9	9	-2	15	-2	
NW-MK-2	70	9	6	9						

Appendix E. EM34 Conductivity Surveys.

Direction	Distance (m)	Ground Conductivity (mS/m)		Note
		Vertical	Horizontal	
SE	-200	16	14	can't go further, end of line
SE	-190	16	15	
SE	-180	14	16	
SE	-170	14	15	
SE	-160	17	32	receiver coil at fence
SE	-150	13	-10	transmitter coil at fence/on slope
SE	-140	17	22	
SE	-130	16	16	bent around tree
SE	-120	16	17	
SE	-110	17	17	scrap metal
SE	-100	16	14	starting on new line
SE	-100	13	16	on slope
SE	-90	15	17	on slope
SE	-80	14	17	
SE	-70	17	20	scrap metal on ground
SE	-60	17	19	
SE	-49	19	22	
SE	-40	22	22	wire box/power line/metal on ground
SE	-30	17	21	
SE	-25	15	19	
SE	-20	16	22	fence/3m elevation between coils
SE	-15	18	25	near fence
SE	-4	14	-21	fence
SE	0	10	-3	fence
NW	10	14	18	
NW	22	17	15	
NW	32	17	16	
NW	40	18	17	
NW	50	18	17	tin cans
NW	61	18	21	
NW	70	15	19	
NW	80	17	23	scrap metal
NW	90	20	22	few scrap metal
NW	100	17	22	
NW	110	19	19	
NW	120	18	22	
NW	130	18	22	
NW	140	18	20	
NW	150	20	23	
NW	160	19	22	
NW	170	18	23	
NW	180	19	20	
NW	190	18	20	
NW	200	18	21	
NW	200	19	22	after re-null
NW	210	18	21	
NW	220	18	21	
NW	230	17	22	
NW	240	17	22	
NW	250	19	23	
NW	260	24	22	
NW	270	24	21	
NW	280	21	21	
NW	290	20	18	
NW	300	19	16	