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Geophysical Surveys of the Paleochannel Beneath MDAs T, A, and V at TA-21

Los Alamos National Laboratory
Los Alamos, New Mexico

December 4, 2003

Prepared for:

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1.0 EXECUTIVE SUMMARY

Advanced Geological Services, Inc. (AGS) performed an integrated geophysical survey for Washington Group International, Inc. (WGII) at Technical Area 21 (TA-21), Los Alamos National Laboratory, Los Alamos, New Mexico. The field surveys were performed during September 11 through 20, 2003. The purpose of the surveys was to locate and delineate the lateral and vertical extent of a suspected paleochannel beneath Material Disposal Areas (MDAs) A, T, and V. To achieve this objective, an integrated geophysical investigation was performed using capacitively coupled electrical resistivity and digital ground-penetrating radar (GPR) techniques.

The results of resistivity surveying identified a low resistivity anomaly that is attributed to the suspected paleochannel. Direct evidence from test borings and excavations that encountered paleochannel sediments corroborate the interpreted paleochannel location at MDA V and MDA T. The results were successfully used to map the lateral location of the paleochannel in an east-west direction across TA-21 by interpolating between resistivity lines. The depth and vertical configuration were estimated from the inverse modeling of the sounding data.

The paleochannel could not be confidently identified in the GPR data using 200 or 100 MHz antennas due to excessive noise and insufficient penetration. Since the entire GPR survey was completed in one day, only a limited amount of resources was expended to complete this task.

2.0 INTRODUCTION

Advanced Geological Services, Inc. (AGS) performed an integrated geophysical survey for Washington Group International, Inc. (WGII) at Technical Area 21 (TA-21), Los Alamos National Laboratory (LANL), Los Alamos, New Mexico. The field surveys were performed during September 11 through 20, 2003. The purpose of the surveys was to locate and delineate the lateral and vertical extent of a suspected paleochannel beneath Material Disposal Areas (MDAs) A, T, and V. To achieve this objective, an integrated geophysical investigation was performed using capacitively coupled electrical resistivity and digital ground-penetrating radar (GPR) techniques.

The geophysical methods were selected based on the anticipated response of the paleochannel compared to that of the surrounding material. Direct evidence from excavations and test borings indicate the paleochannel sediments are coarse-grained and more porous than the surrounding materials. In addition, these materials contained higher moisture content. These contrasts in physical properties suggest comparable contrasts in the electrical properties. For this reason, the electrical resistivity technique was chosen. The capacitively coupled resistivity system chosen for this investigation has a number of advantages over commonly used electrical resistivity systems. It allows data to be acquired without inserting electrodes into the ground. This has obvious advantages in areas where subsurface contamination may be encountered. In addition, the high resistivity materials present at the site creates problems with respect to electrode contacts using standard electrical resistivity techniques. The capacitively coupled system does not have this problem and works better in resistive than in conductive ground.

The ground penetrating radar (GPR) technique was chosen based on the successful results of using this technique in other areas at LANL. For example, the GPR data collected at MDA C was successfully used to map the thickness of cover materials in former disposal trenches. However, the depth of exploration required for this investigation is greater than the depths that have been previously achieved. For this reason, lower frequency antennas were used in an attempt to provide greater penetration.

3.0 BACKGROUND

Test borings and excavations revealed the presence of a paleochannel at MDAs T and V. No borings have been drilled at MDA A to confirm the presence or absence of paleochannel sediments. The sediments that are attributed to the paleochannel consist of a fining-up sequence of sand and gravel that is underlain by a channel lag deposit. Borehole logs also indicate the paleochannel sediments were consistently moist.

Drilling logs indicate the presence of paleochannel sediments between 8 and 35 feet below ground surface at MDA T. Logs from boreholes drilled at MDA V indicate the paleochannel sediments occur at depths between 3 and 29 feet below ground surface.

The presence of a paleochannel deposit beneath disposal units at TA-21 may have environmental implications if the channel is a preferential pathway for contaminant migration.

4.0 METHODOLOGY

4.1. GEODETIC POSITIONING

All geophysical instruments were configured with a differential global positioning system (DGPS) to allow real-time navigation, provide accurate location of geophysical measurements, eliminate the need to establish a local reference grid, and allow direct integration with LANL's geographic information system (GIS). The geographic positions of all measurement points were acquired as the geophysical data were collected. The data were acquired using a Trimble Pathfinder Pro XRS system, which allowed accurate positioning with real-time accuracy better than 1 meter.

4.2. CAPACITIVELY-COUPLED ELECTRICAL RESISTIVITY (CCR)

The electrical resistivity data was collected using an OhmMapper resistivity system manufactured by Geometrics, Inc. The OhmMapper is a capacitively coupled system that is designed to measure subsurface electrical resistivity in areas with high surface resistivity where exploration using traditional direct current resistivity systems is impractical. The OhmMapper consists of an ungrounded dipole transmitter and receiver. The system operates by delivering alternating current that is capacitively coupled into the earth at a particular frequency by the alternating voltage applied to the transmitting dipole. The resulting alternating current voltage coupled to the receiving dipole is measured. This voltage will be proportional to the resistivity of the earth separating the two dipoles and current delivered to the transmitter dipole. The transmitter and receiver are deployed in a dipole-dipole configuration with the transmitter and receiver placed in line and separated by an integer or binary fraction number of dipole lengths. The OhmMapper is designed to be pulled along the ground surface as a streamer and thereby provide an almost continuous apparent resistivity profiles.

The capacitively coupled resistivity technique was chosen to achieve the project objectives for a number of reasons:

1. The locally high surface resistivity at Los Alamos makes data collection using standard resistivity techniques difficult due to poor electrical contact between the electrodes and the ground.
2. Since this system is capacitively coupled, there is no need to insert electrodes into the ground. This has obvious advantages in areas where subsurface contamination may be encountered.
3. The data can be acquired rapidly as the transmitter and receivers are pulled along the ground surface.

The resistivity data were acquired by towing the array with an all-terrain vehicle (ATV). The GPS system was used for navigation and recording the locations of all measurements. Data were acquired in both sounding and profiling modes. Multiple passes using expanding electrodes separations are employed during soundings to produce a vertical cross-section showing the vertical changes in electrical resistivity along a line. Measurements were recorded using a 2.5-meter dipole length and separations of 5, 7.5, 10, 12.5, 15, 17.5, 20, and 22.5 meters. Profiling is performed by making single passes along closely spaced lines with a constant electrode separation to produce a plan map of the lateral changes in electrical resistivity.

4.3. GROUND PENETRATING RADAR (GPR)

The GPR technique uses the transmission and reflection of radio waves to image objects beneath the ground surface. The technique responds to changes in the electrical properties of the earth or buried materials. A GPR target must possess electrical characteristics that are different from the surrounding media in order to be detected. When the transmitted wave encounters an anomalous object or layer, the wave is reflected back to the surface where it is recorded and analyzed. The waves are transmitted rapidly such that a continuous subsurface image is generated as the transmitter is pulled along the ground surface.

The GPR survey was performed using a digital SIR-2 Subsurface Interface Radar System, manufactured by Geophysical Survey Systems, Inc. Data were acquired by towing the GPR antenna by an all-terrain vehicle. The GPS system was used for navigation and recording the locations of all measurements. Initial field tests were performed using 100 MHz bistatic and 200 MHz monostatic antennas to determine which antenna would provide the best results. Data were digitally recorded, displayed, and analyzed during acquisition to allow real-time interpretation. In-field signal velocity calculations and calibrations were performed by hyperbolic fitting on a notebook computer. This calibration was performed to estimate the maximum depth of signal penetration. The maximum depth of signal penetration using the 100 MHz antenna was approximately 30 feet.

5.0 RESULTS AND DISCUSSION

5.1. CAPACITIVELY COUPLED RESISTIVITY SURVEY

5.1.1. Resistivity Soundings

Figure 1 presents a plan map showing the locations of resistivity sounding lines and profiling areas. Multiple passes using expanding electrodes separations are employed during soundings to produce a vertical cross-section showing the vertical changes in electrical resistivity along a line. The locations of the sounding lines are shown in Figure 1 as Lines R-1 through R-6. Profiling is performed by making single passes along closely spaced lines with a constant electrode separation to produce a plan map of the lateral changes in electrical resistivity. Profiling was performed over MDA A and MDA T. Due to the limited amount of open space, resistivity data could not be acquired within MDA V. The maximum survey line lengths that could be achieved at MDA A, T, and V were 390, 300, and 230 feet, respectively.

The biggest limitation encountered during the resistivity data collection was related to obstructions and health and safety restrictions that prevented access in certain areas. At its greatest length, the resistivity array was over 120 ft long. Since the measuring point of the array is near the center, the entire length must be pulled across the survey area such that half of the array has crossed the survey boundaries. If the survey area is bounded by an obstruction such as a chain-link fence, it creates an area around the perimeter of the survey where data cannot be collected. The situation was commonly encountered around the Materials Disposal Areas since they are bounded by fences that could not be cut or taken down to permit data collection. Health and safety restrictions related to the use of the ATV over irregular surface topography and across paved roadways also limited data acquisition.

Figures 2 through 7 present resistivity cross-sections or pseudosections of Line R-1 through R-6. The top section presents a resistivity pseudosection of the raw apparent resistivity data. The middle section presents a pseudosection of the calculated resistivity data. The bottom section shows the results of the resistivity data inversion process from which the interpretations are made. Inversion is defined as the determination of a model whose calculated response matches observations within a given tolerance. Inversion computes a model of the subsurface resistivity distribution from measured voltage and current data.

Figure 2 presents the results obtained from resistivity line R-1. The inversion results indicate resistive materials beneath the southern portion of the line. A lens-shaped body of lower resistivity is observed near the northern portion of the line. The location of this anomaly is coincident with an area where paleochannel sediments were

encountered in test borings. Drilling logs indicate the paleochannel sediments consist of coarser grained materials with higher moisture content. Since an increase in soil moisture and porosity tends to decrease the electrical resistivity, the inherent assumption in identifying suspected paleochannel sediments is that they would show up as discrete bodies of low resistivity. Since this condition is met in an area where the presence of paleochannel sediments were confirmed by soil borings, this anomaly serves as a model by which to identify paleochannel sediments elsewhere in the survey area. The northern border of this anomaly is somewhat obscured by poorly fit data caused by edge effects created during the modeling process.

Figure 3 presents the results obtained from resistivity line R-2. The inversion results indicate resistive materials beneath the southern portion of the line. A lens-shaped body of lower resistivity is observed near the northern portion of the line. As in Line R-1, this anomaly is attributed to paleochannel sediments. Again, poorly fit data is observed in the northern portion of the line.

Figure 4 presents the results obtained from resistivity line R-3. The low resistivity anomaly located near the center of the line is interpreted as the paleochannel sediments. The vertical extent of the interpreted paleochannel cannot be accurately defined at this location due to insufficient data. Data could not be acquired at the greater electrodes separations because of poor signal reception over a paved parking area.

Figure 5 presents the results obtained from resistivity line R-4. The model results exhibited high lateral variability that is attributed to noise. The noise may have been caused by buried utilities since water valves and exposed gas mains were observed in the survey area.

Figure 6 and 7 present the results obtained from resistivity lines R-5 and R-6, respectively. Again, an area of low resistivity is observed and interpreted as paleochannel sediments.

5.1.2. Resistivity Profiling

Figure 8 presents a plan map of the electrical resistivity profiling data acquired at MDA T. The location of the survey area is shown in Figure 1. Data could not be acquired in the northwestern and southeastern portion of the site due to obstructions and health and safety restrictions related to the use of the ATV over irregular surface topography.

A bow shaped area of low resistivity is observed near the center of the survey area. The location of the anomaly is coincident with the occurrence of paleochannel sediments encountered in test borings. The locations of these borings are presented on the map for correlation. The anomaly character and correlation with drilling logs suggest the

anomaly is caused by paleochannel sediments. Resistivity soundings could not be acquired to determine the vertical configuration due to limited access.

The resistivity profiling data acquired over MDA A is shown in Figure 9. The survey area location is shown in Figure 1. The western portion of the survey area could not be surveyed due to health and safety restrictions related to the presence of the buried "Generals" Tanks located at MDA A.

A sharp contrast between a resistive area to the west and more conductive area to the east is observed in the plan map of MDA A shown on Figure 9. Historical documents indicate the presence of a former disposal pit coincident with the area of lower resistivity. Therefore, the contrasting resistivity observed in this area is attributed to man-made features and not paleochannel sediments. The presence of low resistivity sediments along the fence line in southern portion of the survey area is also consistent with the former disposal pit. Historical drawings show the access ramp into the pit was located in this area.

5.2. GROUND PENETRATING RADAR (GPR) SURVEY

Initial testing of the GPR technique was performed to evaluate the maximum depth of penetration that could be achieved using both the 200 and 100 MHz antennas. The results indicated the 200 MHz antenna would not provide enough signal penetration to achieve the project objectives. The data acquired with the 100 MHz bistatic antenna exhibited excessive "ringing" or multiple near-surface reflections that obscured reflections from and deeper objects or interfaces. Because of this unwanted noise, no coherent reflections were observed in the field that could be attributed to presence of a paleochannel. Nevertheless, data were acquired using the 100-MHz antenna with the hopes of being able to identify hidden reflections after the computer processing.

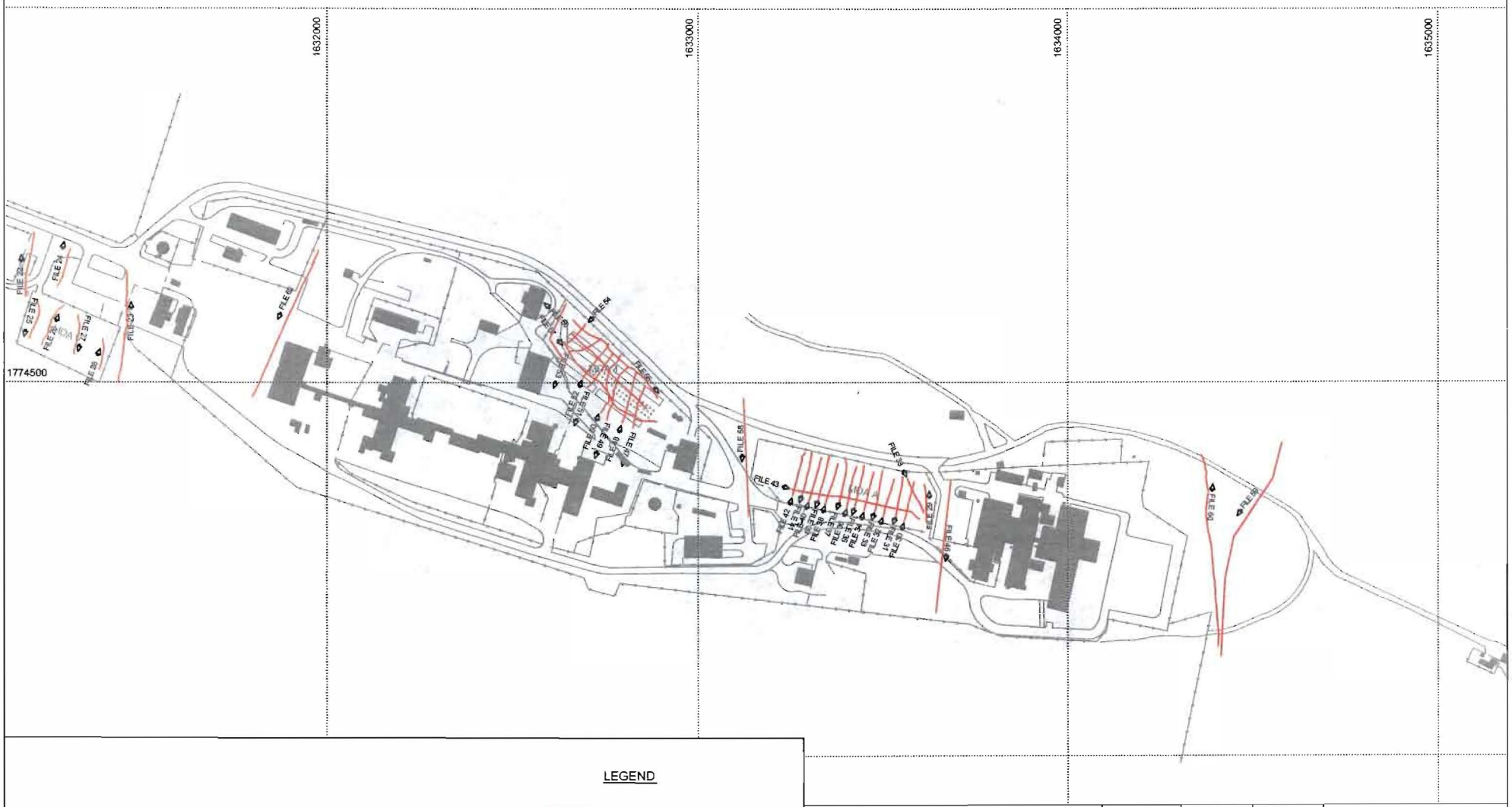
The locations of ground penetrating radar lines are shown in Figure 10. All of the GPR data collection was completed in one day. Data processing was performed at the end of the day to determine the efficacy of the technique to image the suspected paleochannel. However, the results were ambiguous and laterally inconsistent.

6.0 CONCLUSIONS

The results of resistivity surveying identify a low resistivity anomaly that is attributed to the suspected paleochannel. Direct evidence from test borings and excavations that encountered paleochannel sediments corroborate the interpreted paleochannel location at MDA V and MDA T.

The resistivity results were successfully used to map the lateral location of the paleochannel in an east-west direction across TA-21 by interpolating between resistivity lines. Figure 11 presents a plan map showing the interpreted extent of the paleochannel based upon the resistivity data. The channel location between survey locations is interpolated; therefore some variation could exist between measurement locations. The apparent bend in the channel location at MDA T is based on the resistivity profiling data collected there. A data gap exists near MDA A because the feature could not be confidently identified in resistivity line R-4 and the profiling data acquired over MDA A. The depth and vertical configuration were estimated from the inverse modeling of the sounding data. The estimated depths to the top of the paleochannel ranged from approximately 0 ft to 4 ft. The estimated depths to the bottom ranged from 10 ft to greater than 25 ft.

The paleochannel could not be confidently identified in the GPR data using 200 or 100 MHz antennas due to excessive noise and insufficient penetration. Since the entire GPR survey was completed in one day, only a limited amount of resources were expended to complete this task.



LEGEND

GPR Line Location

NAD83 / New Mexico CS83 Central Zone

125 0 125 250
(feet)

NOTE: Basemap provided by Washington Group International, Inc.

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FIGURE 10

Plan Map of GPR Survey Locations
Technical Area 21, Los Alamos National Laboratory
Los Alamos, New Mexico

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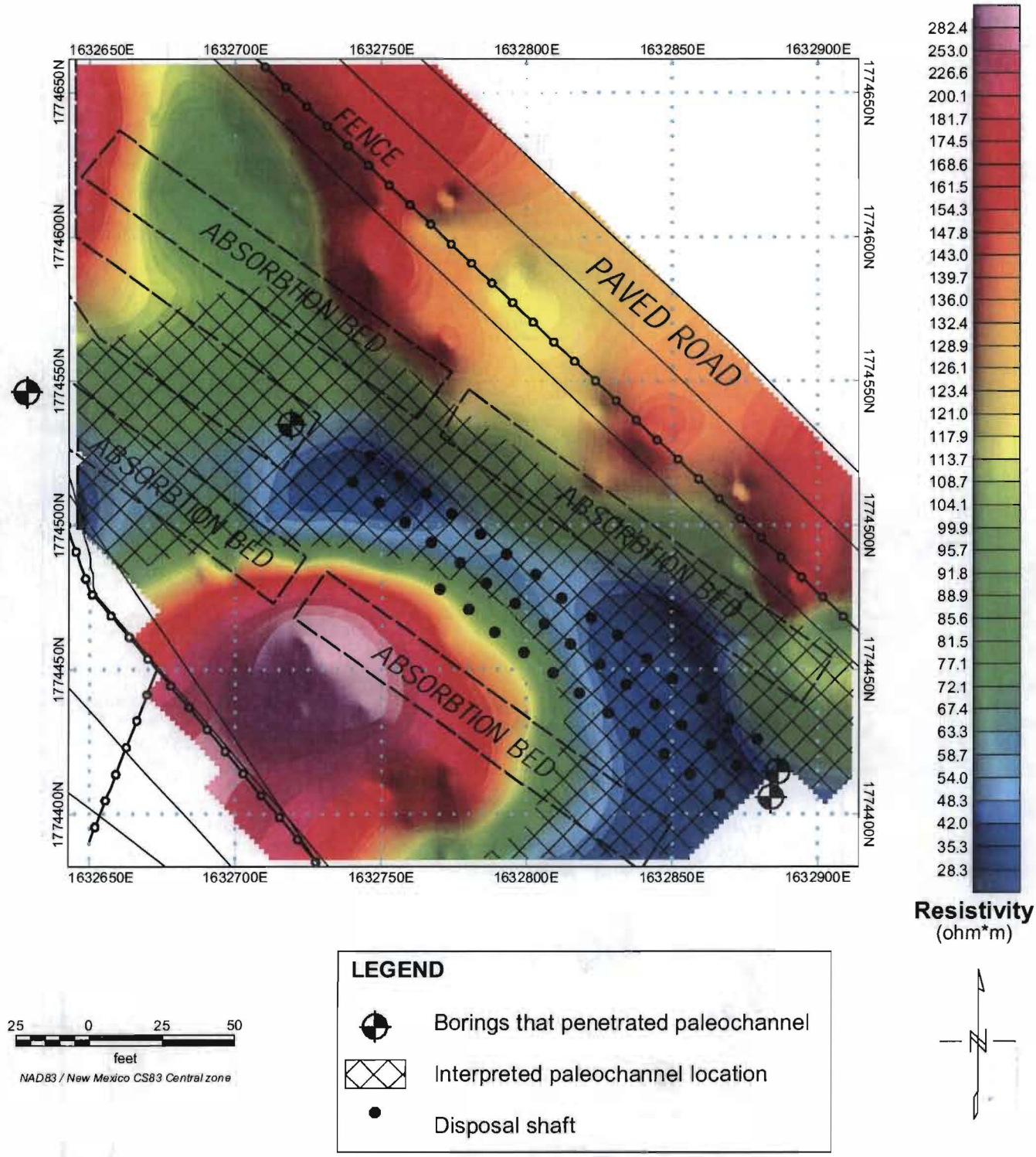
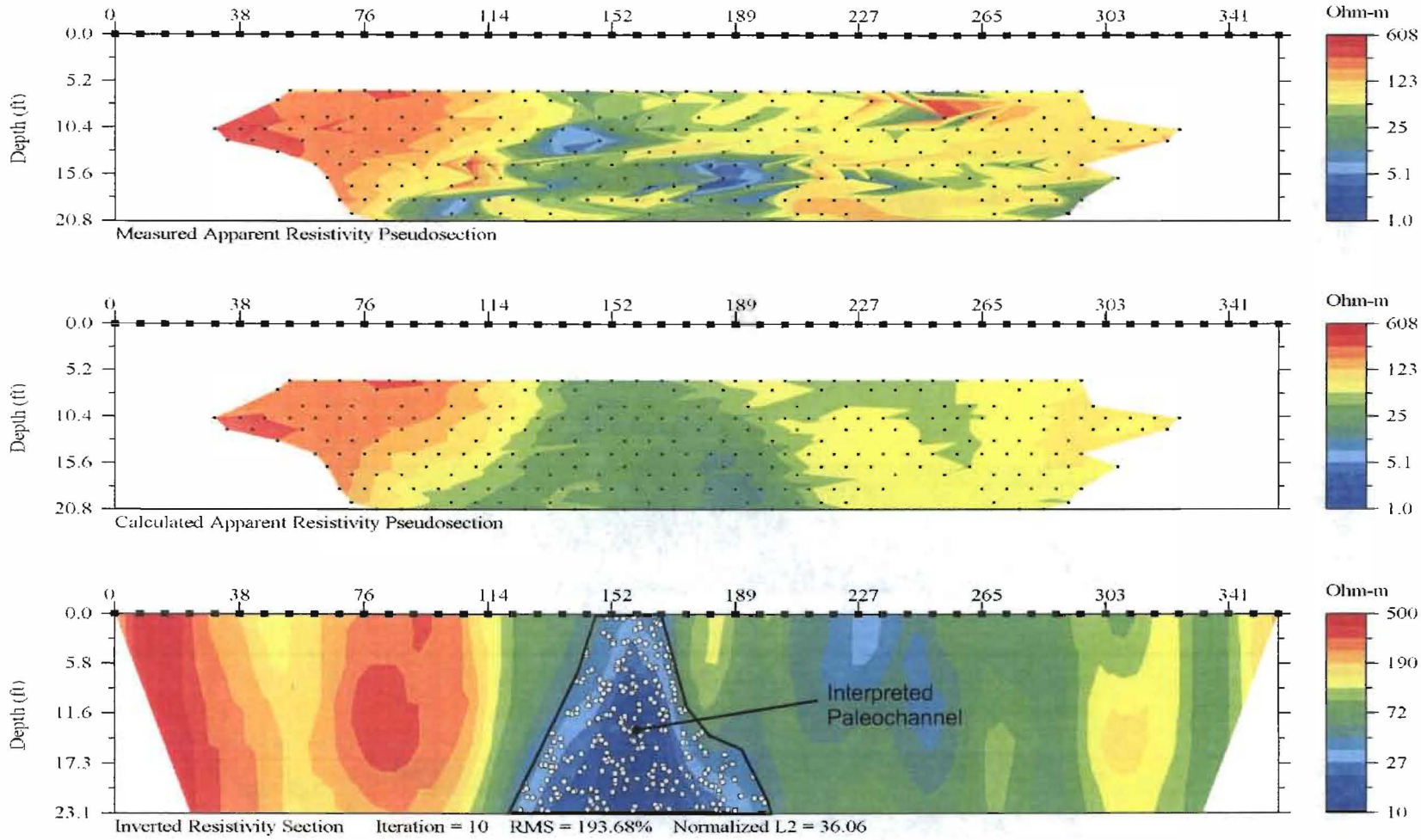
Figure 8
Plan Map of Profiling Data
Showing Interpreted Paleochannel Location
MDA T, TA-21





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Resistivity Pseudosection of Line R-5 TA-21, Los Alamos National Laboratory Los Alamos, NewMexico				Washington Group International, Inc. 2237Trinity Drive, Bldg. 2, 1st Floor LosAlamos, NewMexico 87544

FIGURE 6

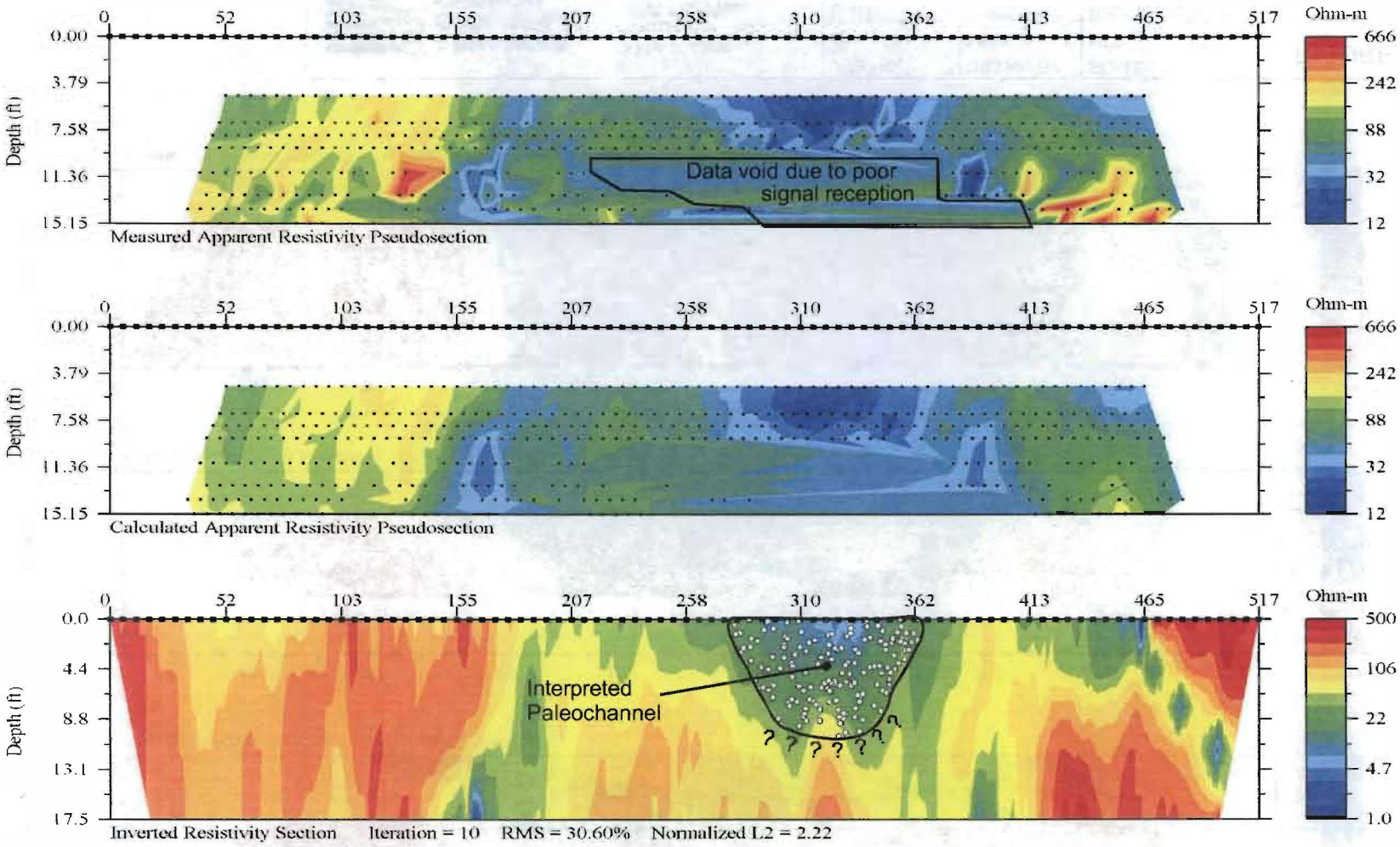

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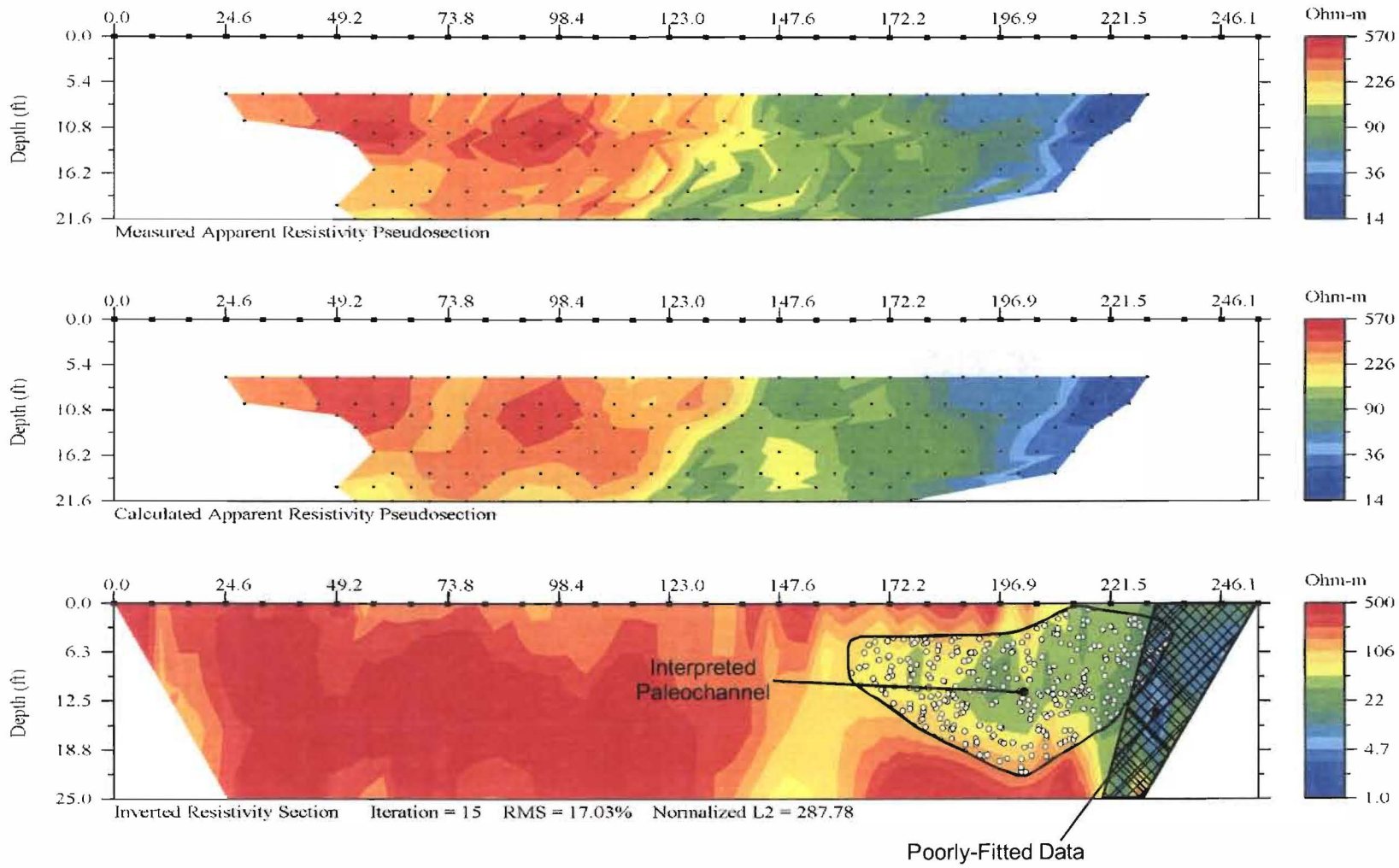
FIGURE 4



ADVANCED GEOLOGICAL SERVICES 3 Mystic Lane Malvern, PA 19355 (610) 722-5500 (610) 722-0250 (fax)	JOB NO: 03-137-01	DRAWN BY: MSM	SCALE: NTS	FIGURE 2
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Resistivity Pseudosection of Line R-1
TA-21, Los Alamos National Laboratory
Los Alamos, New Mexico

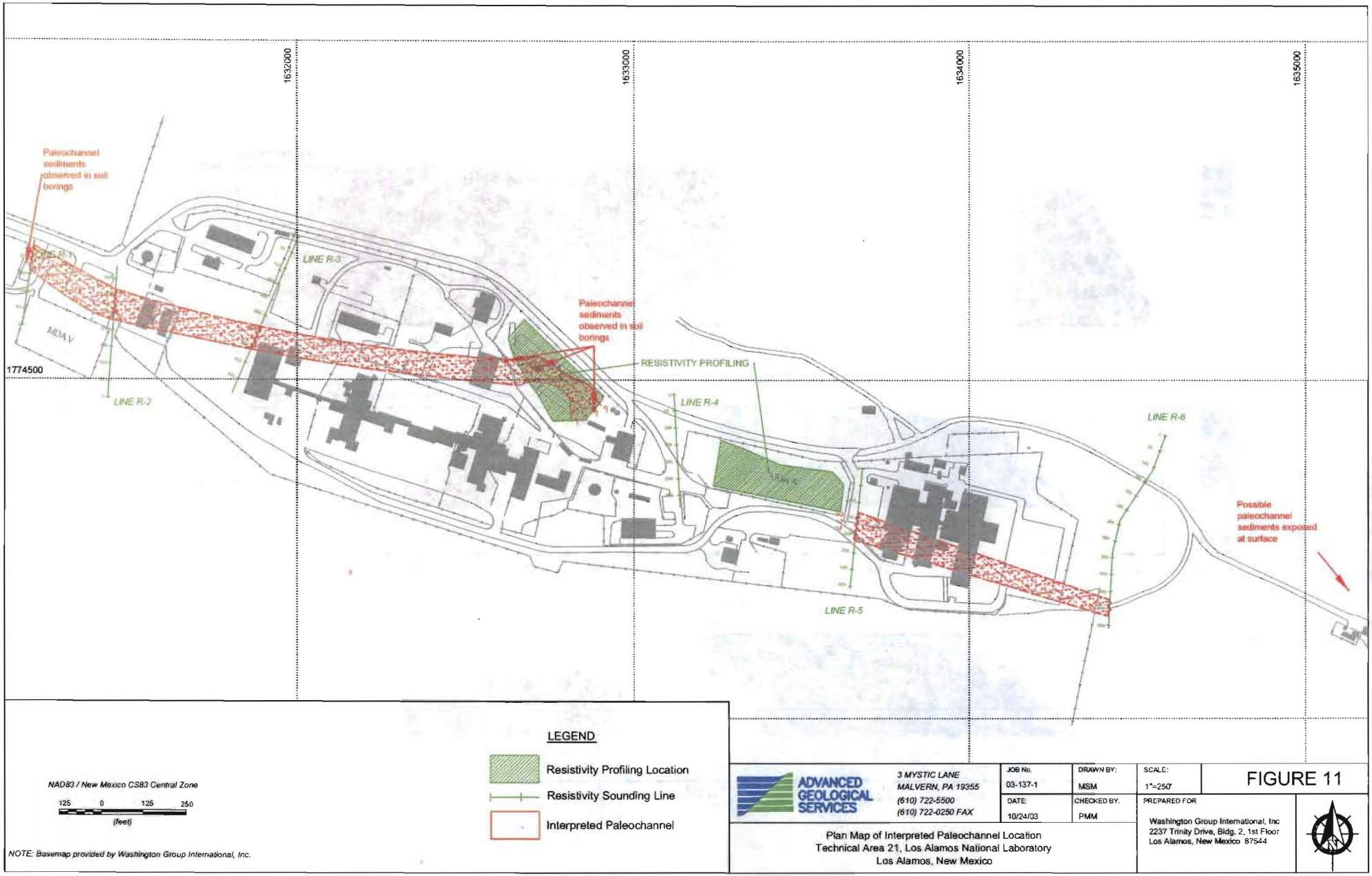
1632000
1633000
1634000
1635000
1774500
Paleochannel sediments observed in soil borings
LINE R-1
LINE R-2
LINE R-3
MDA V
Paleochannel sediments observed in soil borings
RESISTIVITY PROFILING
LINE R-4
LINE R-5
LINE R-6
Possible paleochannel sediments exposed at surface
LEGEND
Resistivity Profiling Location
Resistivity Sounding Line
Interpreted Paleochannel
NAD83 / New Mexico CS83 Central Zone
125 0 125 250
(feet)
NOTE: Basemap provided by Washington Group International, Inc.
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FIGURE 11
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Plan Map of Interpreted Paleochannel Location
Technical Area 21, Los Alamos National Laboratory
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Figure 9
Plan Map of Resistivity Profiling Data
MDA A, TA-21

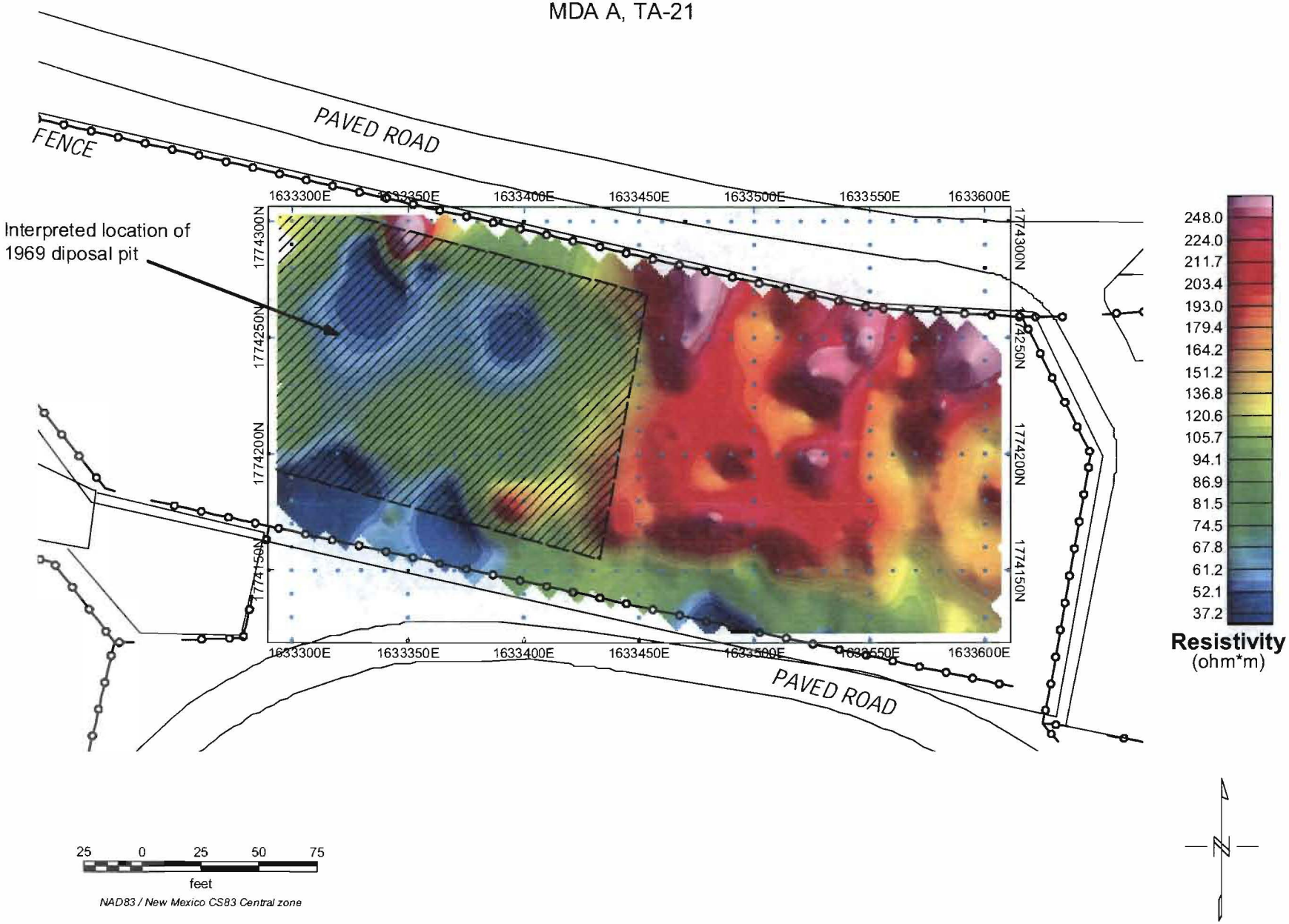
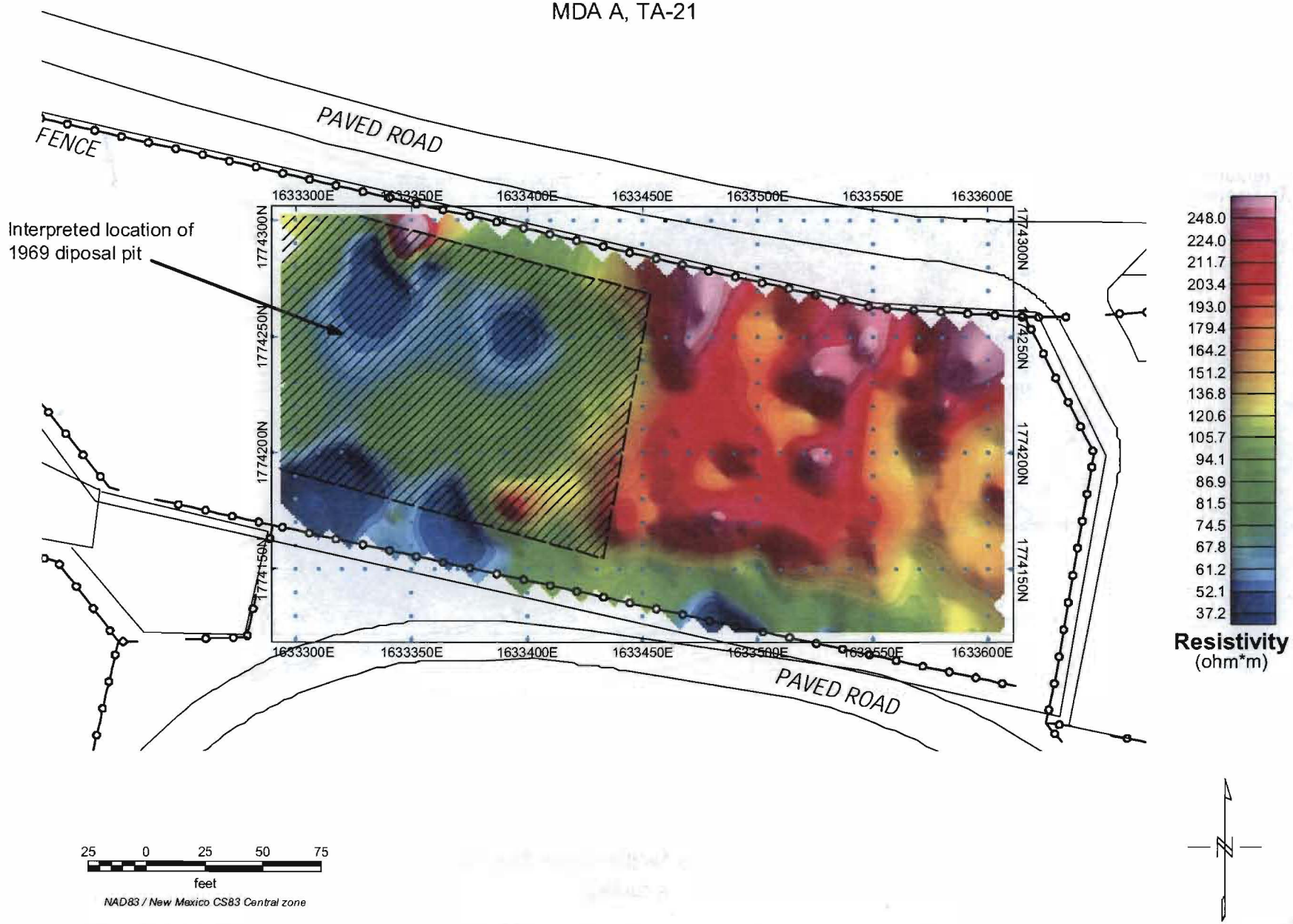
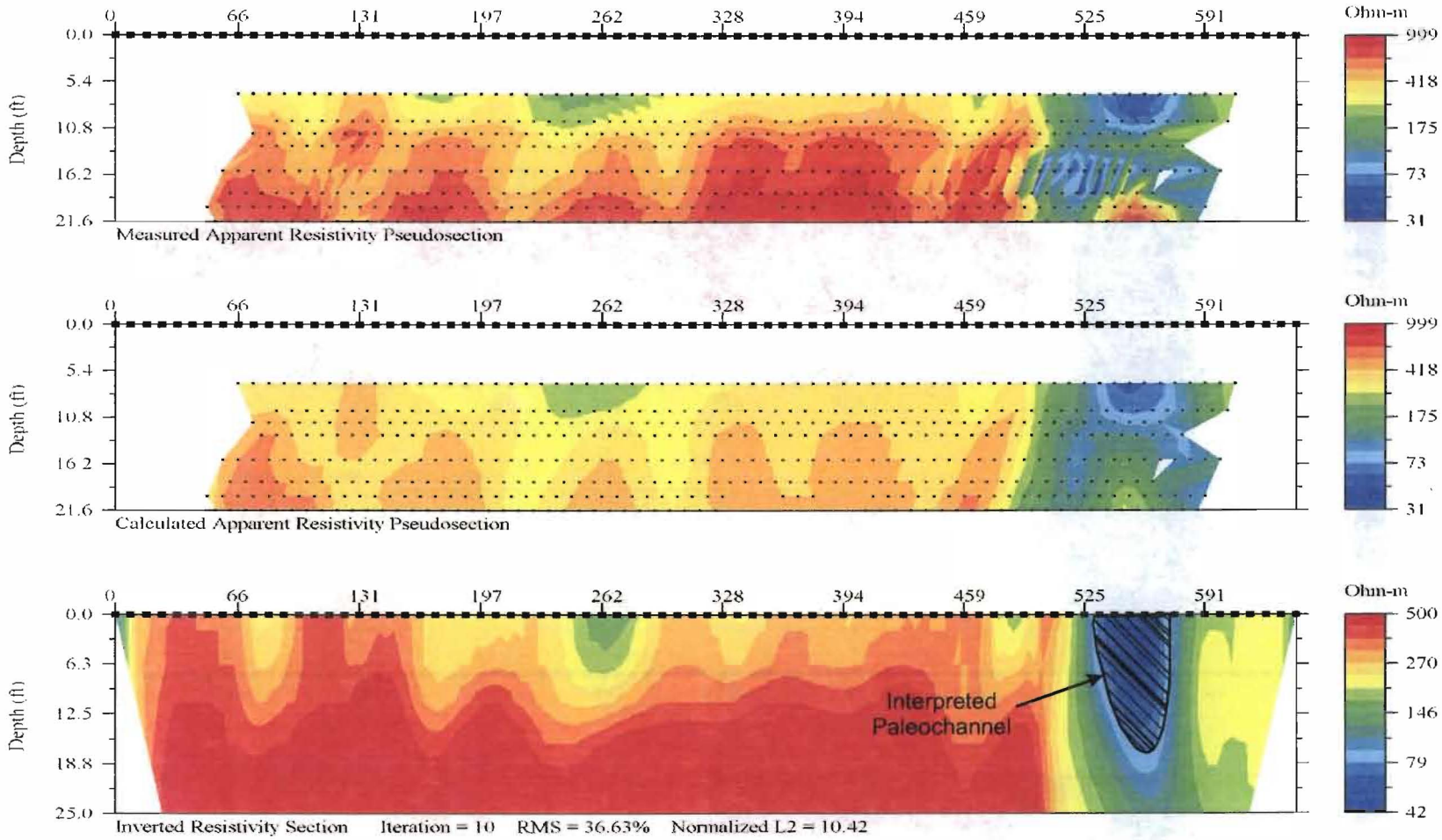


Figure 9
Plan Map of Resistivity Profiling Data
MDA A, TA-21





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Resistivity Pseudosection of Line R-6 TA-21, Los Alamos National Laboratory Los Alamos, NewMexico				Washington Group International, Inc. 2237Trinity Drive, Bldg. 2, 1st Floor LosAlamos, NewMexico 87544	

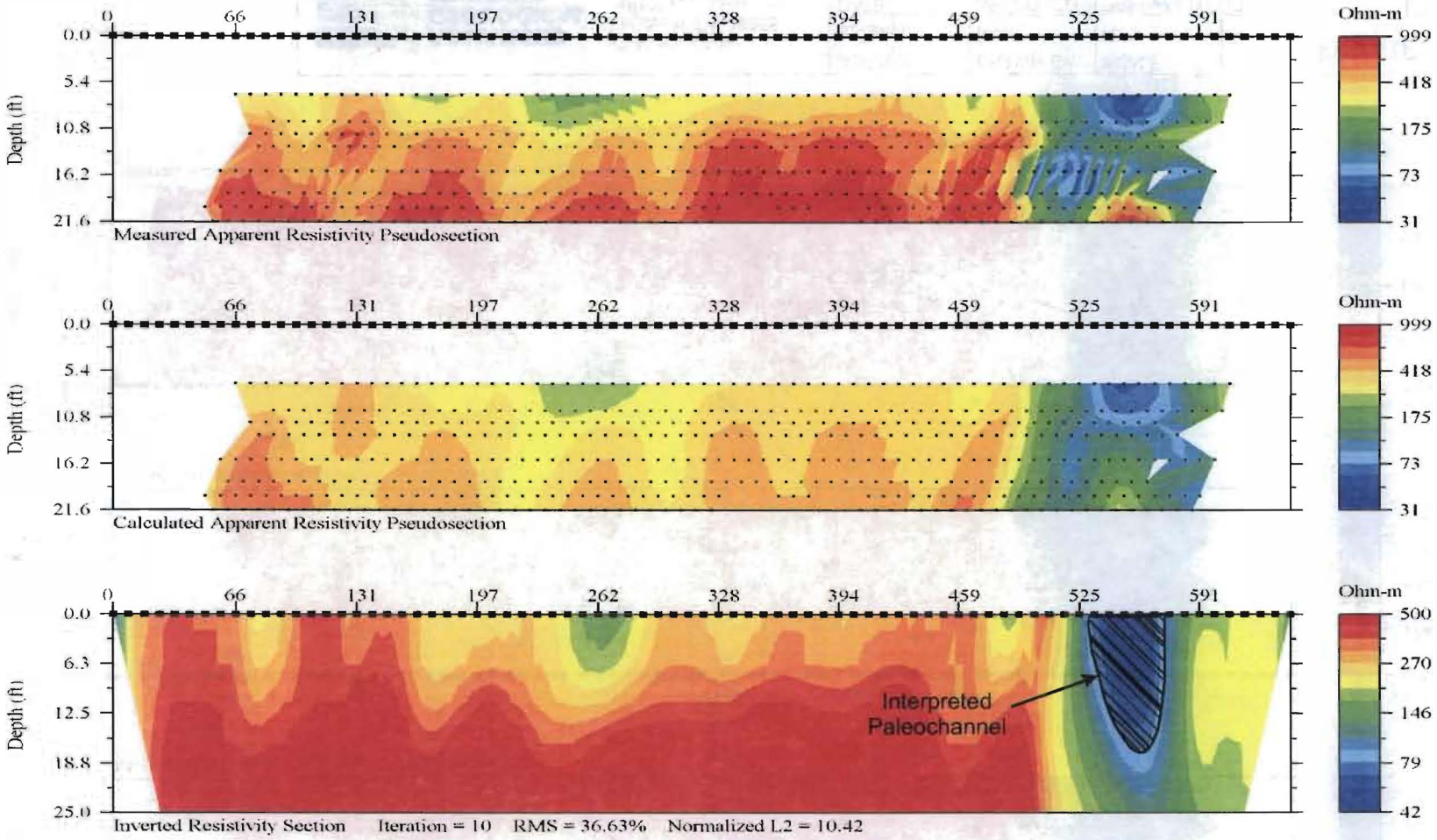

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FIGURE 7

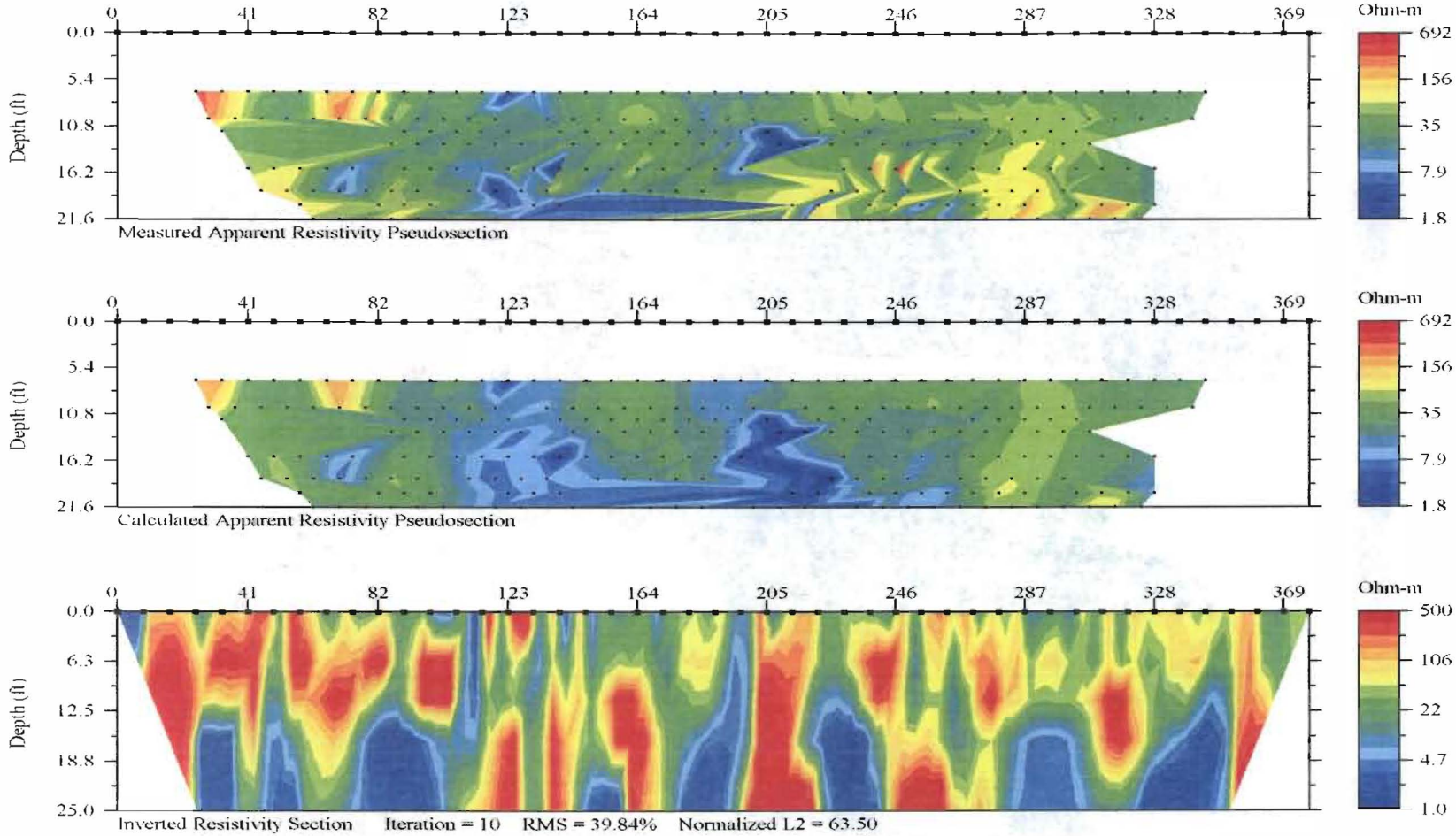

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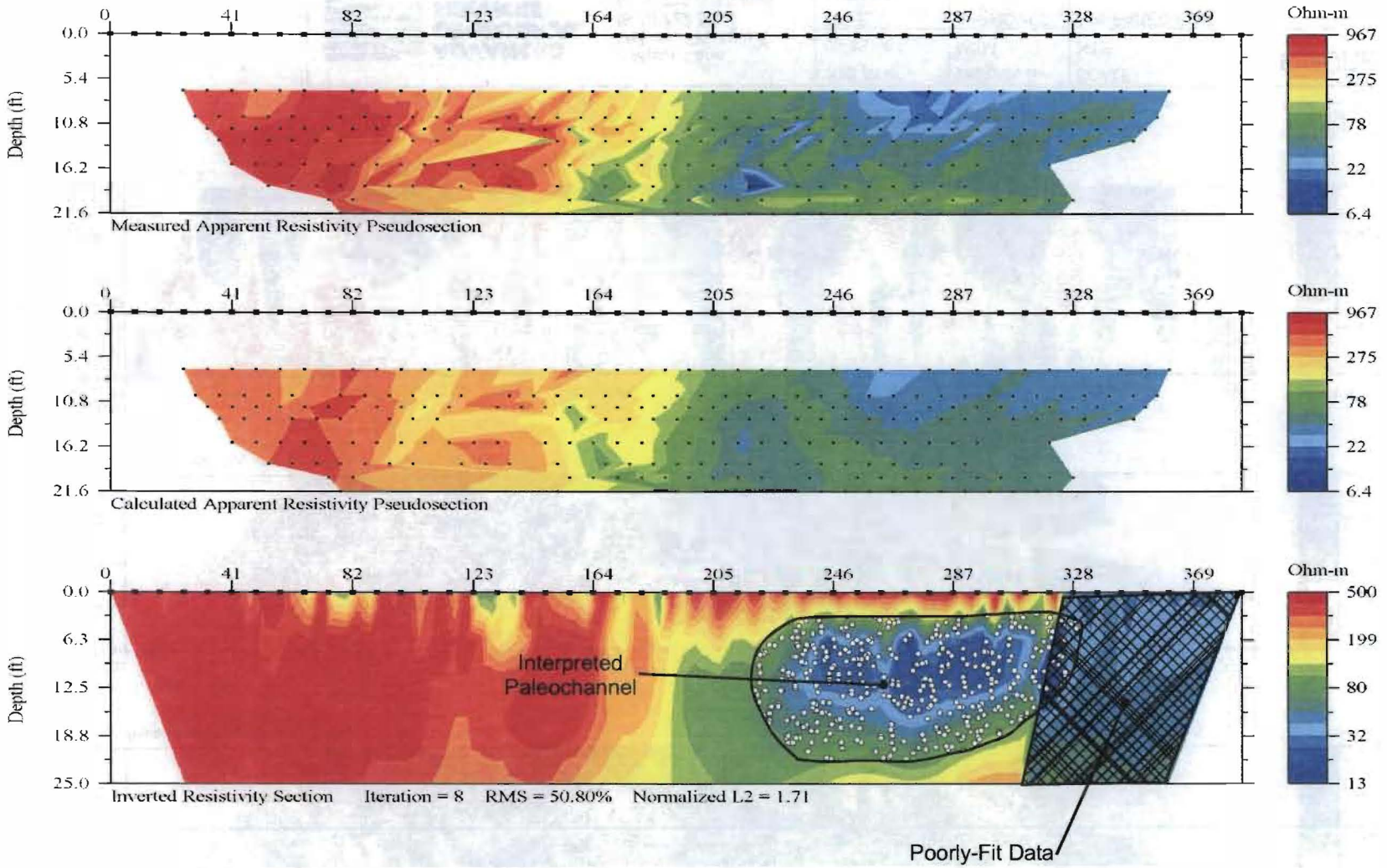
FIGURE 5



ADVANCED GEOLOGICAL SERVICES 3 Mystic Lane Malvern, PA 19355 (610) 722-5500 (610) 722-0250 (fax)	JOB NO: 03-137-01	DRAWN BY: MSM	SCALE: NTS	FIGURE 3
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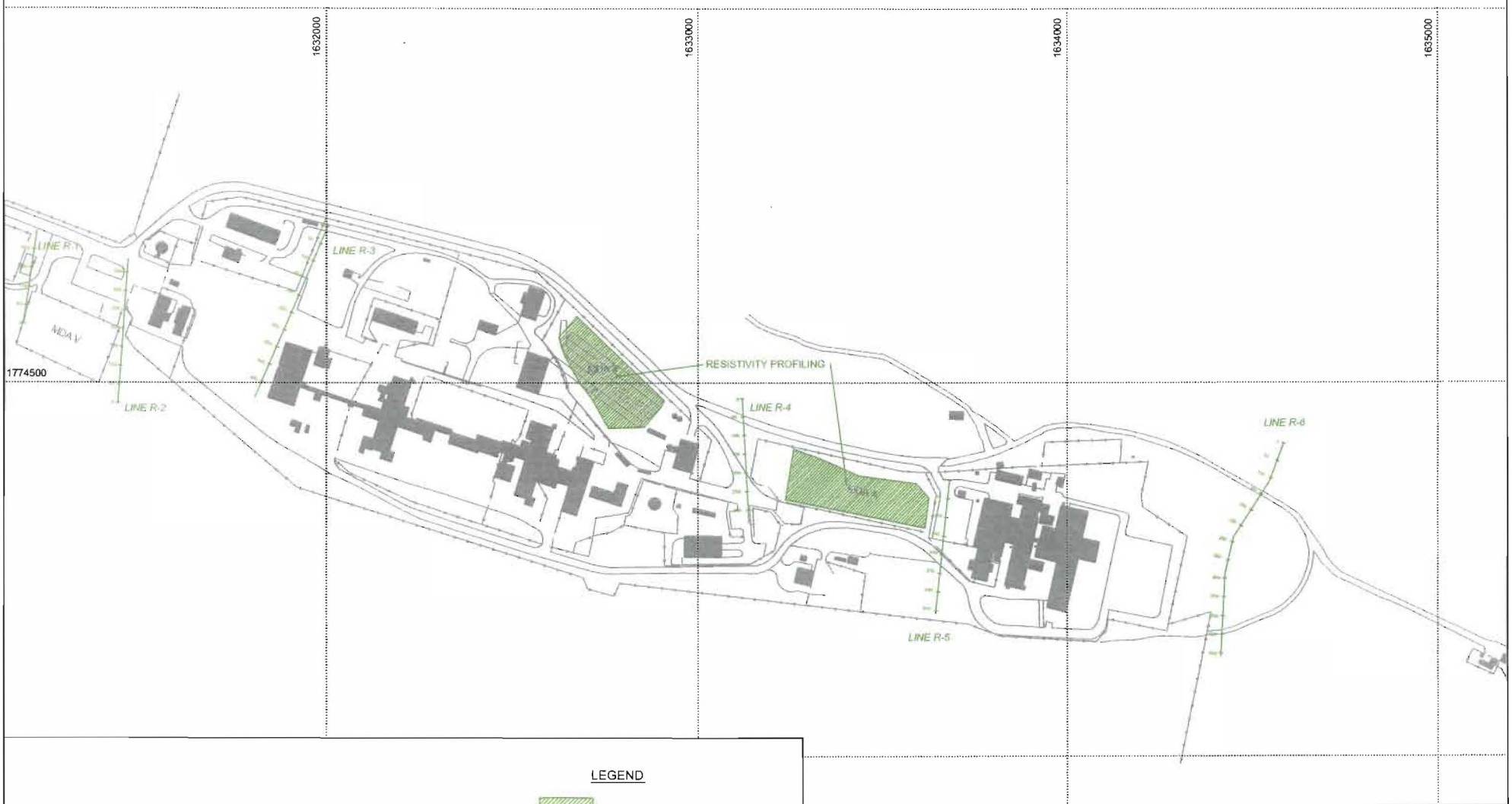
Resistivity Pseudosection of Line R-2
TA-21, Los Alamos National Laboratory
Los Alamos, NewMexico



LEGEND

Resistivity Profiling Location

Resistivity Sounding Line

NAD83 / New Mexico CS83 Central Zone

125 0 125 250

(feet)

NOTE: Basemap provided by Washington Group International, Inc.

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FIGURE 1

Plan Map of Resistivity Survey Locations
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Los Alamos, New Mexico

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