# GW - 28

# REPORTS

# YEAR(S): 1997

# Results of the EM34 Terrain Conductivity Investigations to Identify Preferential Pathways for Fluid Migration at the Navajo Refinery, Artesia, New Mexico

## Interim Report

Navajo

*prepared for:*

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*September 1997*

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# 1.0 Introduction

Gravel zones within silt and clay deposits east of and immediately adjacent to the Navajo Refinery have been observed to serve as preferential pathways for fluid and contaminant migration. These gravel zones are related to alluvial fan deposits from the Sacramento Mountains to the west, and their distribution beneath the surficial clayey silt and silty clay soils has not been mapped. The depth at which gravels may be encountered is dependent on location within the study area. Gravels have been found at depths from 10 to greater than 40 feet, but the most likely depths in the study area are from 15 to 25 feet. In some areas immediately east of the refinery, no shallow gravels have been observed. When found, gravel thickness' may range from less than 1 foot up to 7 feet. Some deposits may be up to 300 feet wide.

A typical gravel cross-section is shown in Figure 1. These zones have been identified in soil borings during environmental investigations at the refinery, but their distribution and orientation have not been determined. The gravel zones have no surface manifestation and therefore identification and mapping of these features would provide useful information for future environmental work, including placement of monitor wells and remedial activities.

To assist in location and delineation of the gravel zones, a short-duration pilot study was performed in May 1996 in a field east of the refinery using the electromagnetic induction (EM) method to map the gravel zones within the clays. This was followed by more extensive EM surveys in July and August 1996, and May and June 1997. Partial confirmatory drilling to verify and assist in interpretation of the EM survey results and prepare the interpretive map was performed in October 1996 and May 1997. Completion of the confirmatory drilling has been delayed due to current crop cultivation in the fields where the drilling is to occur. It is expected that drilling will be completed in the fall of 1997 with an additional 10 to 12 boreholes followed by modification of the interpretive map as necessary.

This report provides a explanation of the geophysical methods considered and selected, a description of the field data collection and data reduction, and the interpretive methods utilized to analyze and map the EM survey data. The material presented in this report does not include the lithologic logs for the confirmatory drilling, nor the logs of other boreholes drilled and monitor wells installed in the area. That information is provided in a companion volume of data for the groundwater investigation entitled "Borehole Lithologic Data, Subsurface Hydrocarbon Investigation, Navajo Refinery, Artesia, New Mexico, 1991 - 1997."

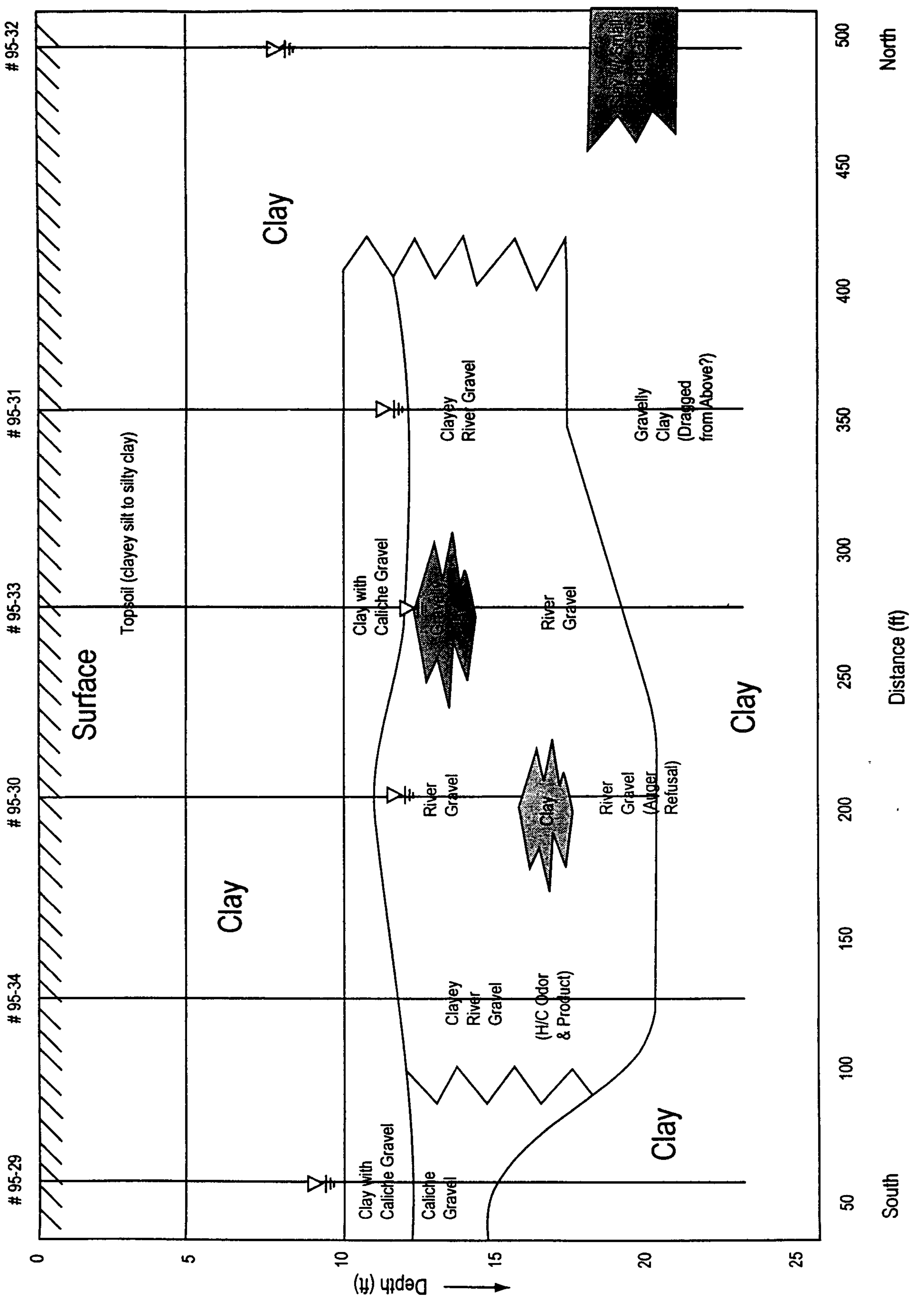



**Figure 1: Geologic Cross Section Showing Gravel Zones in Clay at Navajo Refinery**

# 2.0 Electromagnetic Induction (EM) Methods

## *2.1 Description of the Methods*

A number of geophysical methods were considered for mapping of subsurface features in the vicinity of the refinery (Table 1). Based upon an evaluation of the geologic setting at Navajo Refinery, and the objectives of the study, it was determined that the electromagnetic induction (EM) method would provide the best approach. This is because EM methods detect vertical and lateral variations in conductivity of subsurface materials, and gravels are typically resistive relative to clays. In addition, EM surveys are relatively inexpensive, non-intrusive, and allow rapid data acquisition.

A wire loop through which a current flows may be viewed as a dipole, as it produces a magnetic field similar to a field produced by a bar magnet. When the coil is in a horizontal position (i.e. parallel to the ground), the dipole derived from the induced magnetic field is in a vertical position. Similarly, a vertical coil produces a horizontal dipole. A constant current in a wire loop will create a constant magnetic field. By Faraday's Law, an alternating magnetic field will induce electromotive force in a conductive material, and create an electric current. This process, known as electromagnetic induction, is the fundamental principle by which terrain conductivity meters operate.

The value measured by the terrain conductivity meters is termed "apparent" conductivity because of heterogeneity and anisotropy of subsurface materials. This value is a composite of a range of true conductivity values for the subsurface materials in the range of detection by the instrument. Electromagnetic methods are most useful for detecting lateral and vertical variations in electrical conductivity of the subsurface.

A Geonics Model EM34-3 terrain conductivity meter was used for the study. The pilot study also utilized a Geonics Model EM31-D meter. Both instruments consist of a transmitting coil, a receiving coil, a battery and a control unit with phase sensing circuits that display conductivity in millisiemens per meter (mS/M). An alternating primary magnetic field is produced at the transmitting coil by an alternating electric current. The primary magnetic field creates an electromotive force that creates secondary electrical current loops in the subsurface. The receiving coil measures the electromotive force generated by the primary magnetic field from the transmitting coil and the secondary magnetic fields generated in the subsurface.

The depth of investigation for EM instruments depends upon coil spacing and orientation. In general, the depth of investigation increases with increased intercoil spacing, and vertical dipole orientation provides a greater depth of investigation than horizontal dipole orientation. The EM34-3 instrument has coils that can be spaced 10, 20, and 40 meters apart in both vertical and horizontal dipole orientation. The EM31-D instrument has coils contained in a boom at a fixed distance of 3.7 meters apart. Both vertical and horizontal dipole measurements can be taken with

**Table 1. SURFACE GEOPHYSICAL METHODS FOR ENVIRONMENTAL INVESTIGATIONS**

| GEOPHYSICAL METHOD | PRINCIPLE OF OPERATION | APPLICATIONS | ADVANTAGES | LIMITATIONS |
|---|---|---|---|---|
| Ground Penetrating Radar (GPR) | Reflection of pulses of electromagnetic energy. | Define lateral and vertical variations in electrical properties of subsurface materials. Map stratigraphic horizons and locate buried objects. | Rapid data acquisition, direct depth interpretation, continuous profiles. Effective in cultured areas. | Severe attenuation in conductive soils, complex instrument to operate. |
| Magnetics | Measures variations in the earth's magnetic field. | Identify buried, ferrous objects and underground utilities. | Inexpensive, easy to operate, relatively rapid data acquisition. | Does not detect non-ferrous metal, susceptible to cultural interference. |
| Seismic Refraction | Uses the measured velocity of refracted seismic waves to calculate depth. | Identify stratigraphic horizons, and locate bedrock lows and channels. | Directly provides seismic wave propagation velocities and depth to layers of concern. Effective in shallow environments. | Subject to errors from blind zones, inversions, and hidden layers. |
| Seismic Reflection | Reflection of seismic energy at velocity interfaces. | Identify stratigraphic horizons, map geologic structures, faults, fractures and void spaces. | Provides "cross-section" of stratigraphy and geologic structures. | Ineffective for shallow targets (<20 ft), expensive, labor intensive. |
| EM 31 Instrument | Induction of electromagnetic energy with a time-varied primary electric field. | Map lateral charges in electrical conductivity of soils, identify buried metal, and high TDS groundwater. | Inexpensive, easy to operate, rapid data acquisition. Detects non-ferrous metal. | Limited investigation depth, susceptible to cultural interference. |
| EM 34 Instrument | Induction of electromagnetic energy with a time-varied primary electric field. | Map lateral and vertical charges in the electrical conductivity of soils, and identify high TDS groundwater. | Inexpensive, easy to operate, can be used to map vertical variations in conductivity. | Susceptible to cultural interference, difficult to operate in rough or heavily vegetated terrain. |
| DC Resistivity | Generation of an electric charge and measurement of propagation through earth materials. | Map stratigraphic horizons, identify resistive groundwater plumes. Map vertical (soundings) and lateral (profiling) changes in resistivity. | Inexpensive, easy to operate, relatively rapid data acquisition. | Susceptible to cultural interference, requires good couple between electrodes and the ground. |

the EM31-D instrument by changing the orientation of the boom (i.e. changing the loop from the normal vertical position perpendicular to the ground, to a horizontal position parallel to the ground). Table 2 lists the total investigation depth and depth of major response for the EM31-D and EM34-3 instruments at all possible intercoil spacings and orientations.

Based upon the depth of interest (approximately 20 feet), the pilot study collected EM data using both instruments with the EM34-3 instrument having 10 and 20 meter intercoil spacing in both directions, and in the horizontal dipole orientation at the 40 meter intercoil spacing. After evaluation of pilot study data, the main survey was conducted entirely using the EM34-3 at the 10 meter horizontal and vertical intercoil spacing except for the portion of the study in the Chase pecan orchard. Because some deeper gravel beds were detected during drilling of KWB-11A and -11B and installation of Bolton Road recovery trenches, both 10 and 20 meter intercoil spacings were utilized in the orchard.

**Table 2. Depths of Total Investigation and Major Response for Terrain Conductivity Instruments**

| Instrument (Geonics Ltd.) | Coil Separation Distance | Dipole Orientation | Maximum Investigation Depth | Major Response Depth |
|---|---|---|---|---|
| EM31-D | 3.7 meters | horizontal | 9 feet | shallow |
| | 3.7 meters | vertical | 18 feet | 5 feet |
| EM34-3 | 10 meters | horizontal | 25 feet | shallow |
| | 10 meters | vertical | 50 feet | 13 feet |
| | 20 meters | horizontal | 50 feet | shallow |
| | 20 meters | vertical | 100 feet | 26 feet |
| | 40 meters | horizontal | 100 feet | shallow |
| | 40 meters | vertical | 200 feet | 52 feet |

## *2.2 Method limitations*

Typical terrain conductivity values for saturated clays and saturated sand/gravels are about 100 mS/M and 3 mS/M, respectively. Based upon the contrast in conductivity and the thickness of the zone of interest relative to the overlying layers, it appears that the EM method identified gravel zones at this location. However, some of the limitations of the method need to be noted to properly interpret and understand the results presented in the following sections.

- All EM methods are sensitive to interference in the form of metal objects, especially powerlines and underground pipelines. The location of the study in an area of cultivated fields and orchards with minimum metal objects to cause interference provided an almost optimum setting for use of the EM geophysical technique. However, even in this area, a minimum distance of 100 feet from overhead powerlines, and 50 feet from metal fences and concrete objects reinforced with metal rebar was maintained.

- The EM method identifies contrasts in conductivity, such as the typical contrast between gravels and clay. However, if gravels are predominantly in a clay matrix (as commonly occurs at the Navajo site), the conductivity contrast is somewhat less pronounced. At this site the difference in values of clay and gravel for the vertical dipole rarely exceeded 20 mS/M while the difference for the horizontal dipole seldom exceeded 40 mS/M.

- The conductivity of saturated geologic materials is strongly dependent upon pore fluid composition. Waters with a high total dissolved solids (TDS) within the gravel zones will elevate the apparent conductivity readings, and also may reduce the conductivity contrast. However, where waters in the clays have higher TDS than waters within the gravel zones, the conductivity will be enhanced. The water in the discontinuous near-surface gravel zones at the site ranges from 2,000 to 6,000 mg/L which is quite elevated above concentrations generally found in deeper transmissive formations at the site (700 - 3,000 mg/L TDS). The TDS concentrations in the gravels, although elevated, are still considerably less than concentrations typically found in interstitial soil solutions. The presence of non-aqueous phase hydrocarbons (free product) in pores will also change apparent conductivity readings. A relatively high volume of product in gravels will enhance the conductivity contrast with surrounding materials, while elevated concentrations in the clay matrix will decrease the conductivity contrast. For optimum interpretation, it is hoped that most free product remains in the more transmissive materials while the clays have been largely unimpacted with free product.

- Relatively thin gravel zones may not have been resolved by the EM method, particularly as their depth beneath the clays increases. However, as noted above, the presence of free product in these thin lenses, may have actually enhanced their detection.

Notwithstanding these limitations, the method generally has succeeded in defining major channels as determined by the confirmatory drilling performed to date. However, several key areas remain to be evaluated by the drilling, and final interpretation of the data must await completion of the planned drilling.

## 3.0 Data Collection

The two-person field team collected data from a total of 78 transects in the farm properties immediately adjacent to the eastern fence line of the refinery. Data were also collected from three additional transects in the pecan orchard east of Bolton Road. Both horizontal dipole and vertical dipole data were collected at 5 meter intervals along the length of each transect using the Geonics EM34-3 terrain conductivity instrument. At this interval, horizontal dipole readings measure the apparent conductivity of materials from the ground surface to depths of approximately 25 feet, while the vertical dipole readings measure apparent conductivity of materials from approximately 13 to 50 feet below ground surface. The data for each transect were recorded electronically on a digital Omnidata Polycorder DL720 with Dat31 software. The Polycorder data were downloaded, graphed, and preliminarily interpreted at the end of each working day to assure correct operation of the equipment and to identify areas for data collection for the following day.

EM34 instrument readings are affected by strong electrical currents and metal objects; in general, readings were not collected within 100 feet of overhead power lines and 50 feet of barbed wire fences and rebar-reinforced concrete. Transects 1 through 34 were collected in July, 1996; transects 35 through 49 were collected in August, 1996; and transects 50 through 78 were collected in late May and early June 1997. The location of each transect was hand-surveyed (with accuracy of +/- one foot) using a 300-foot fiberglass measuring tape with the locations were plotted onto existing maps of the Navajo Refinery and surrounding properties. It should be noted that when plotting the transect locations, it was determined that the existing maps were inaccurate and could not be used to plot the transects. As a result, the transects were re-mapped on separate graph paper.

# 4.0 Data Reduction

## *4.1 Field Data Reduction*

Upon completion of each day's data collection activities, the raw horizontal and vertical dipole data from each transect were downloaded from the Polycorder and entered onto a computer spreadsheet. The vertical and horizontal measurements were then plotted onto X-Y graphs for preliminary field interpretation. All raw Polycorder data, spreadsheet data, and graphed data were saved onto computer discs for later in-office processing.

## *4.2 Office Data Reduction*

Following field data collection, the data were further processed in the office in preparation for final interpretation. The initial data analyzed were the vertical dipole measurements. The absolute value of the vertical dipole measurements were mapped and were found to produce indications of underground linear features. Because the conductivity values varied significantly between each of the various farm fields that were surveyed, it was necessary to look at relative differences in conductivity values along and between transects (rather than looking solely at the absolute conductivity values). During the interpretation process, the data from all of the transects were graphed at the same scale to allow for a consistent interpretation of the results. As a result, the final graphs generated for interpretation used a consistent linear scale (1 inch = approx. 60 meters) and a consistent scale of apparent conductivities (1 inch = approx. 22 millisiemens per meter [mS/m]). Because of the low signal to noise ratio of the vertical data in some areas, some vertical data were reprocessed using a smoothing program (with a smoothing factor of five data points around a center point) to aid in the interpretation of trends in the data. The smoothed data were then graphed on the same scale as the raw data. All graphs used in production of the interim map are presented in the report Appendix.

# 5.0 Data Mapping and Interpretation

## *5.1 Horizontal Dipole Data (Near-Surface Measurements)*

When the graphs of the horizontal data were laid out side-by-side, significant conductivity variations in the data were identified. Areas of significant lows, minor lows, and significant highs in the conductivity readings were marked on each transect, and these areas were plotted on a scale map of the site (Draft map-Horizontal Dipole Data [Shallow]). Based upon the trends identified on the graphs, and on the data plotted on the base map, boundary lines were added to define the extent of the low and high conductivity areas. Although a southwest to northeast trend was seen in some mapped data, apparent conductivity variations were generally quite dramatic within and among transects.

Based upon the specifications for the EM34 instrument and the clayey silt to silty clay lithology known to be present near the surface at the site, it was estimated that the shallow measurements provided information on an envelope of materials from the surface to approximately 25 feet below ground surface with the greatest response at the ground surface. Because many areas of the study site were actively undergoing cultivation and/or irrigation immediately prior to or during the time of the measurements, it was determined that the large variation in shallow conductivity may be due to irrigation effects near the surface and are not representative of subsurface lithology. This was confirmed by the many past and current borings that show mostly undifferentiated clayey silt and silty clay from the surface to about 15 feet. Because the observed wide variation in conductivity does not correlate well with the shallow subsurface data, a final version of the horizontal dipole data (shallow) map was not prepared for this report.

## *5.2 Vertical Dipole Data (Deep Measurements)*

As with the horizontal dipole data, the relative variability of vertical conductivity readings along transects and between adjacent transects was used to identify gravel-rich zones. This approach was used because the variation in vertical conductivity readings from field-to-field precluded interpretations from comparing "absolute" conductivity readings. Areas of significant lows, minor lows, and significant highs in the vertical conductivity readings were marked on each transect, and these areas were plotted on a scale map of the site (Draft map-Vertical Dipole Data [Deep] Map). Based upon the trends identified on the graphs, and on the data plotted on the base map, boundary-lines were added to define the extent of the low and high conductivity areas. A distinct southwest-northeast trend was seen in the deep data in some locations, and the interpreted data showed three general "ethology-types" (major channels [gravel-rich], minor channels [sand/gravel rich], lessor channels, and clay-rich areas). The boundaries of the clay-rich areas and the channel areas should not be construed as sharp boundaries, but rather they indicate gradational changes in lithologies perpendicular to the directional trends. Also, boundaries tend to be less defined due to the natural "averaging" of conductivities resulting from measuring the conductivity of a larger, deeper volume of materials.

Another approach used to map variations in the vertical conductivity measurements was to map the occurrence of three or more consecutive data points that fall below a given vertical conductivity. These locations were assigned a color and plotted on a draft map. The color contrasts provided an immediate visual picture of areas of low, medium and high conductivity. For example, Figure 2 shows the use of color to outline a possible channel. Areas with three or more points less than 40 mS/m are blue, those with three or more points less than 45 mS/m are green, and so on.

Still a third approach was to plot the transects in an Excel spreadsheet chart and use the chart tool to produce a three-dimension view of the channels. After truncating high data peaks, the "valleys" correspond to areas of low conductivity and can be interpreted as permeable channels. This creative method for showing conductivity data clearly shows areas that have been confirmed to have coarse grained deposits, especially the area east of Bolton Road. However, in other areas, a low signal to noise ratio causes numerous relatively ragged "shallow" valleys that are not as easily interpreted. The area immediately west of Bolton Road is one such area where the actual lithology is unknown below about 15 to 20 feet and awaits confirmatory drilling to complete interpretation.

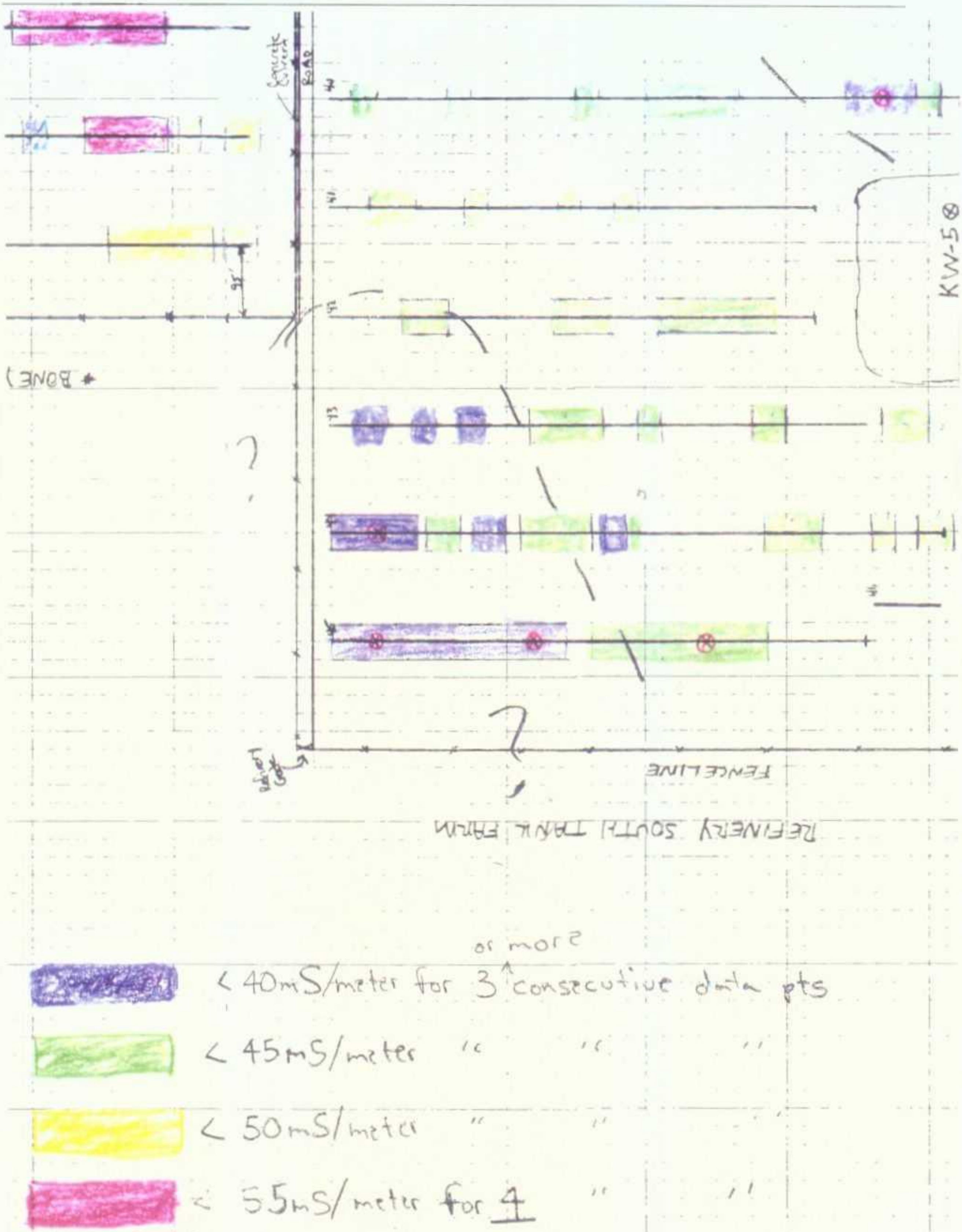



Figure 2. Example of color and visual evaluation of EM Survey numerical data

## 6.0 Summary of Results

The mapped results for the vertical dipole (deep) data are shown in Plate 1. These results were compared to known lithologies from boreholes logged (to depths of 20 feet or greater) during current and previous drilling and sampling programs. The comparisons of the EM34 vertical dipole data and the borehole logs generally showed good correlation.

Interpretation of the vertical dipole measurements found areas of significant conductivity lows in the relatively deep subsurface, all of which trended from the southwest to the northeast. These major conductivity lows were interpreted to be major channels, rich in sands and gravels, and potentially significant conduits for contaminant transport.

A major area of very low conductivity (Channel 1) was found along most of transect line 45 and trending to the northeast. However, the feature does not appear to extend much to the east of the northern end of transect 41. This conductivity low is believed to be the major channel closest to the refinery. It is possible that the channel, on the northern end of lines 43-45, may have significant free-phase hydrocarbons in the subsurface together with sand and gravel rich sediments. One borehole (96-24) was drilled in the area and detected a thick gravel zone, but auger refusal and lost core samples did not provide complete information. Further drilling in this area and to the east would help to confirm the exact nature of this conductivity low.

A second major conductivity low (Channel 2) was found starting at the southern end of line 40 and continuing to the northeast where it appears to leave the mapped area at the northern end of line 35 and continues across the dirt farm road to the vicinity of Transect 57. Although confirmatory drilling verifying gravels has been completed along and west of the road, no drilling has been performed in the fields east of the road. Drilling completed along the road shows 7 to 8 feet of hydrocarbon-containing gravels from 16 to 24 feet. The coarse material at this location provides an excellent site for hydrocarbon recovery.

Possibly the longest channel (Channel 3) was found starting at the southern end of line 16 and trending to the northeast where it was also present at the northern ends of lines 5 and 6. This channel is also believed to continue from line 16 to the southwest under the boneyard area and toward the refinery (because of the metal in the boneyard, further conductivity measurements could not be taken in that area to confirm this interpretation). Because the conductivity measurements within the boundaries of the interpreted channel were generally low, it is possible that the conductivity low may correlate to a sand and gravel enriched area containing hydrocarbons throughout. Indeed, free-phase petroleum hydrocarbons were detected in this channel northeast to the vicinity of transect 1.

A fourth major channel (Channel 4) also was detected in the area east of Bolton Road in the pecan grove. Plate 1 shows areas of very low conductivity in the area as far east as the two KWB-11 wells. In the area 250 feet east of Bolton Road and 300 feet north of Highway 82 a boring (97-04) detected a sand/gravel rich area at a depth from 18 to 28 feet that contained free-phase hydrocarbon. Further east, confirmatory drilling and the KWB-11B logs show gravel zones from 32-43 in a boring 250 feet north of the KWB-11 wells, and a deeper zone to 48 feet in the monitor well. These several relatively thick and vertically dispersed zones of coarse material produced the deep conductivity low seen in the EM data. The lack of shallow channels further east near the KWB-11 wells likely acts to retard shallow hydrocarbon movement. This predominance of coarse grained material would allow installation of one or more recovery wells in the orchard without unduly disturbing the existing trees as a trench would do.

In general, given the available subsurface lithologic data, there was a correlation in many areas between the vertical dipole measurements and the subsurface information. Although many shallow borings were advanced in 1991 and 1992, their purpose was the delineation of the hydrocarbon extent. Therefore, there are areas where no meaningful subsurface information exists beneath the first sign of saturation (approximately 15 to 20 feet below the surface). In these areas deeper drilling is necessary to more completely correlate and interpret the EM conductivity data with the actual lithologic measurements.

## 7.0 Conclusions and Recommendations

The EM-34 surveys successfully identified four subsurface channels that could serve as major conduits for lost product from the refinery. The channels were identified by mapping trends of low electrical conductivity that indicate areas of sand and gravel enrichment. Areas of significantly low electrical conductivity, potentially resulting from hydrocarbons in the subsurface, were also identified. The interpreted EM34 data compared favorably with lithologic data collected from previously drilled boreholes; however, additional confirmatory borings using split-spoon or coring sampling methods are recommended.

The following eleven additional boring locations are recommended to confirm the presence of gravels and sands in areas interpreted as major channels, to confirm the presence of fine-grained silt and clay materials, and to further evaluate the hypothesis that hydrocarbons in the subsurface could be influencing the conductivity readings along some channels. However, depending on the results of these proposed borings, it may be necessary to drill at several other boring locations to provide satisfactory subsurface lithologic coverage.

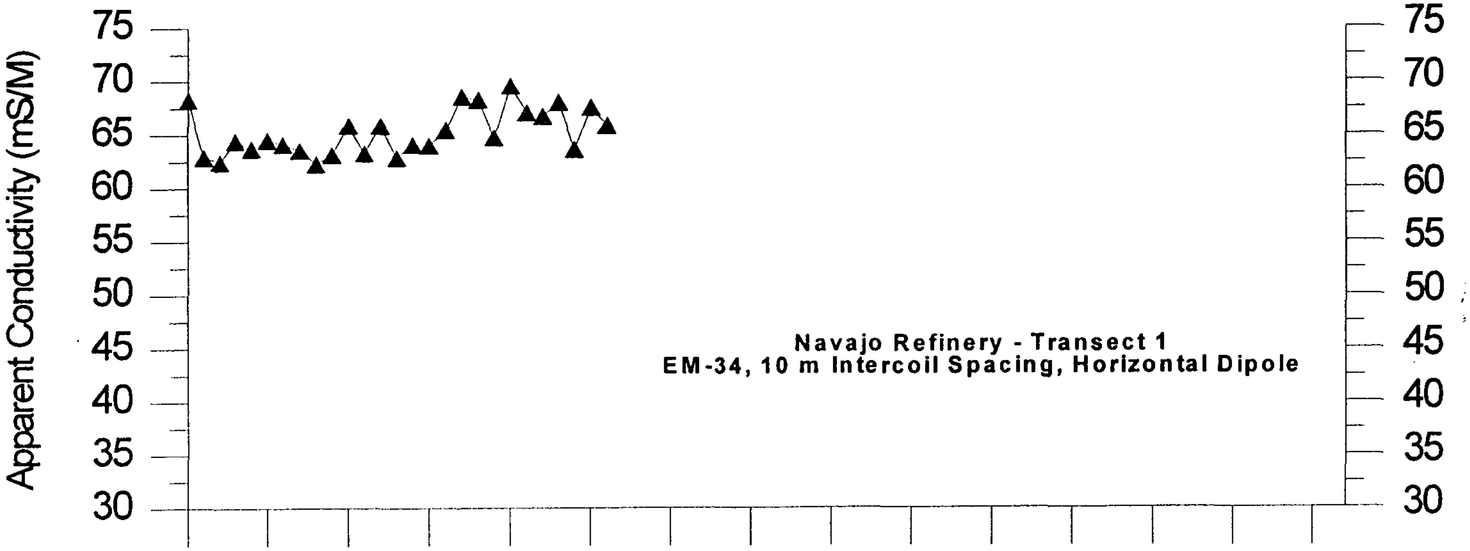
**Table 3. Proposed Additional Confirmatory Borehole Locations**

| Proposed Confirmatory Borehole Locations | Anticipated Lithologies |
|---|---|
| Transect 24, 250 and 650 feet south of southernmost power line | Thin sand and gravelly zones. Possible floating product. |
| Transect 33, 700 feet south of open concrete irrigation culvert | Sand and gravel zones. Possible northeast extension of Channel 1. |
| Transect 40, 150 feet south of open concrete irrigation culvert | Sand and gravel zones. Possible eastward extension of Channel 1. |
| Transect 43, 350 feet south of fire training center | Sand and gravel zones. Possible eastward extension of Channel 1. |
| Transect 45, 150 feet south of refinery security fence | Additional coring to confirm and complete the partial information from boring OS 96-24 |
| Transect 60, 300 feet south of farm road | Sand and gravel zones. |
| Transect 66, 700 feet north of Highway 82 fence | Sand and gravel zones. Possible eastward extension of Channel 2. |
| Transect 71, 700 feet north of Highway 82 fence | Sand and gravel zones. Possible floating product. |
| Transect 77, 125 and 625 feet south of Highway 82 fence | Sand and gravel zones. Possible floating_product. |

Based upon the successful correlation of the EM34 data with existing borehole data, the EM34 surveys are capable of identifying potential conduits in undeveloped areas of the refinery. Findings from this investigation will reduce costs by decreasing the number of exploratory boreholes needed and optimizing the placement of hydrocarbon recovery operations. However, some additional drilling always should be performed in the immediate vicinity of any proposed recovery operation to more precisely delineate subsurface lithology and hydrocarbon extent prior to detailed remediation system design and installation.

Terrian Conductivity Graphs

Terrain Conductivity Graphs


Navajo Refinery - Transect 1
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
75
70
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60
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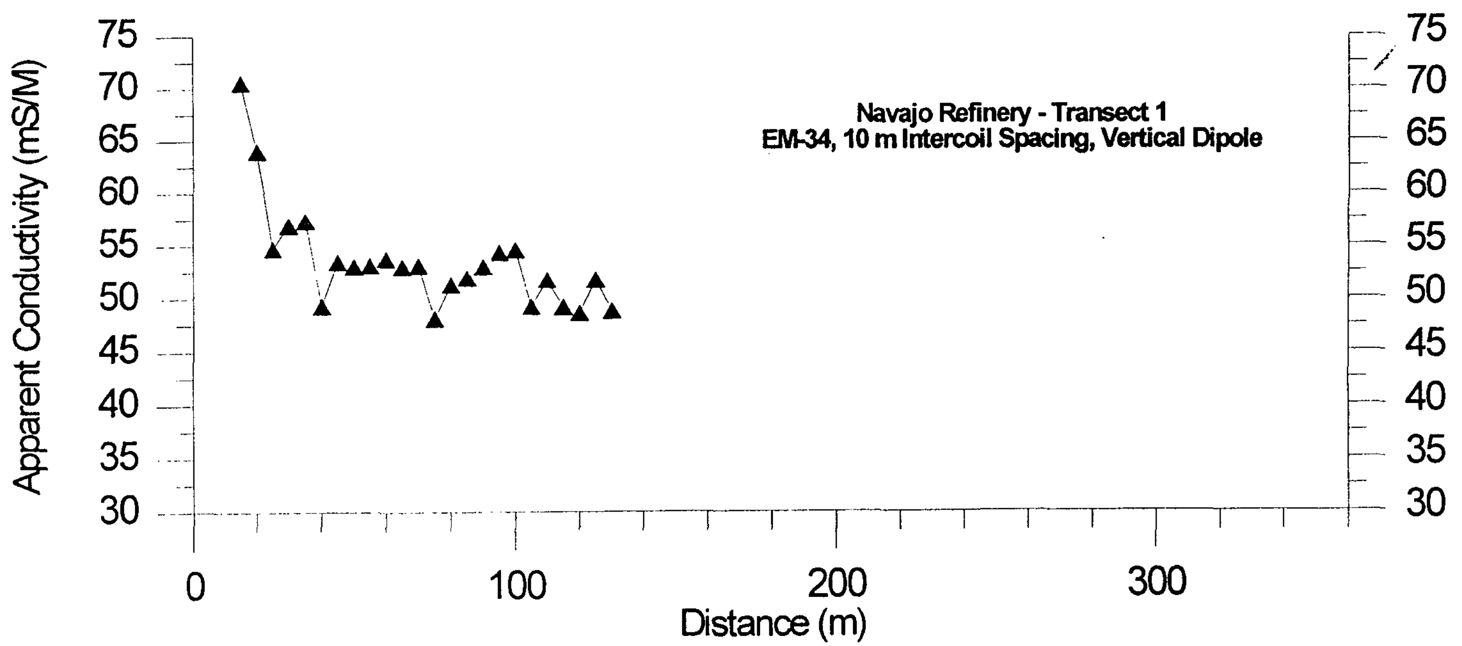
45
40
35
30


Navajo Refinery - Transect 1
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
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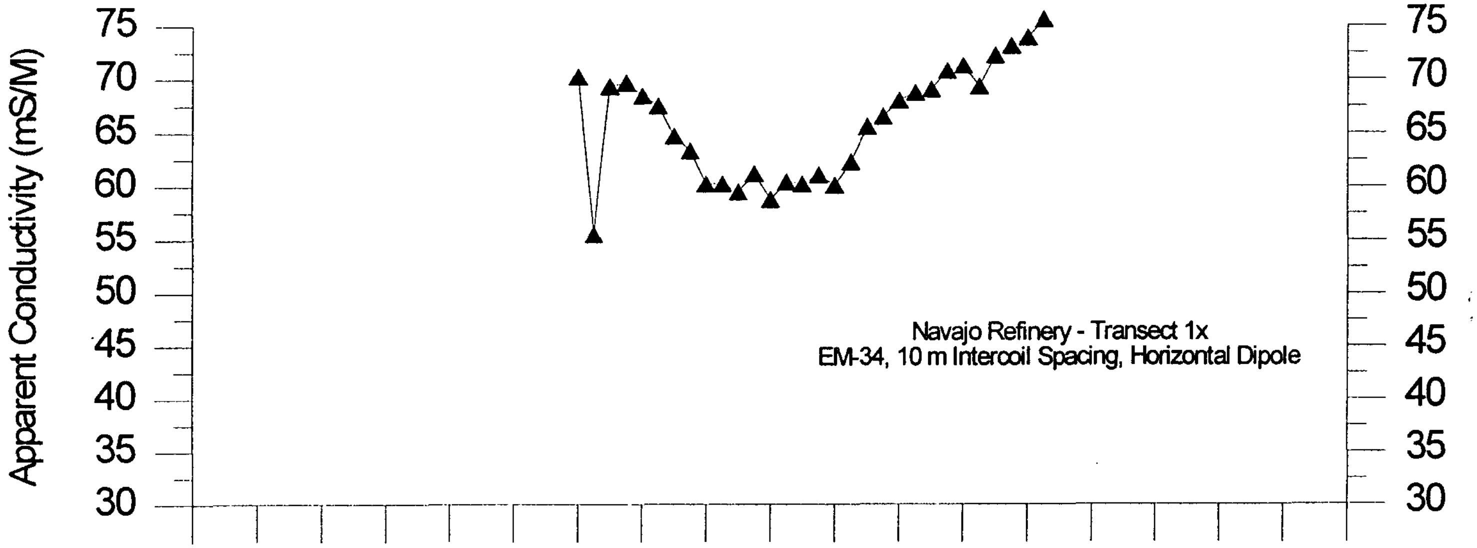
Distance (m)


Navajo Refinery - Transect 1x
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
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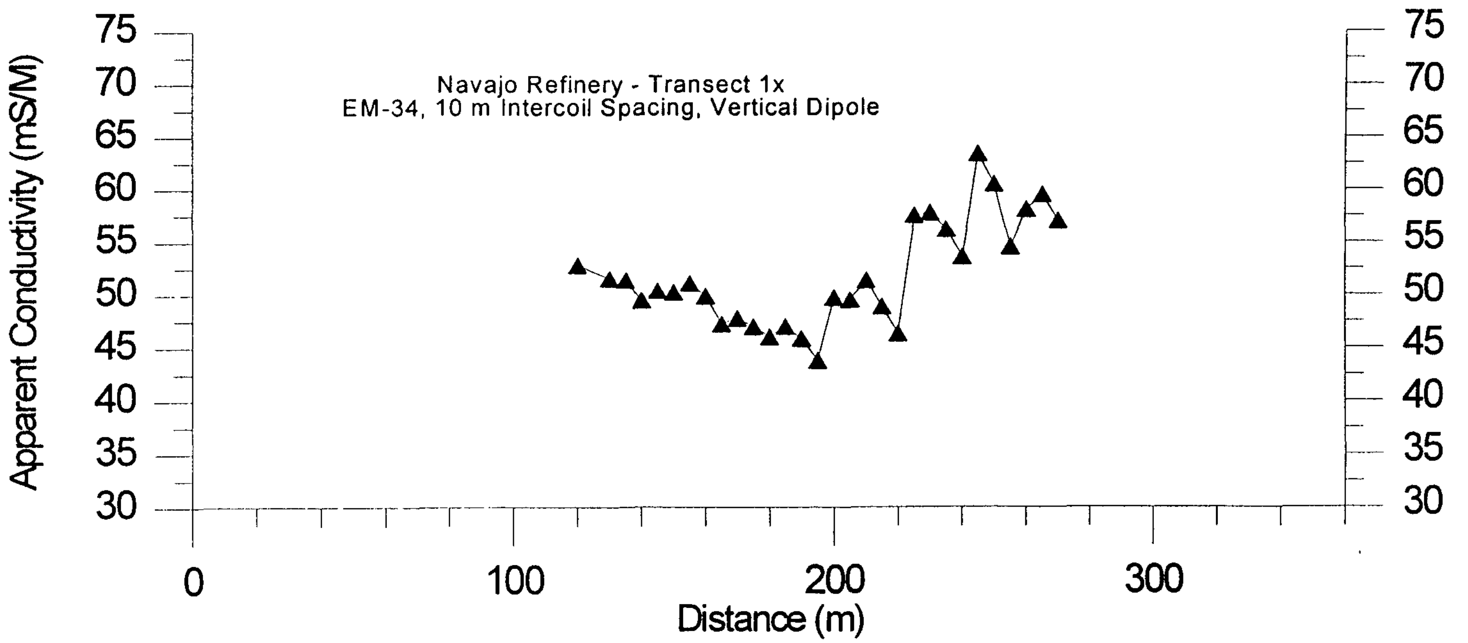
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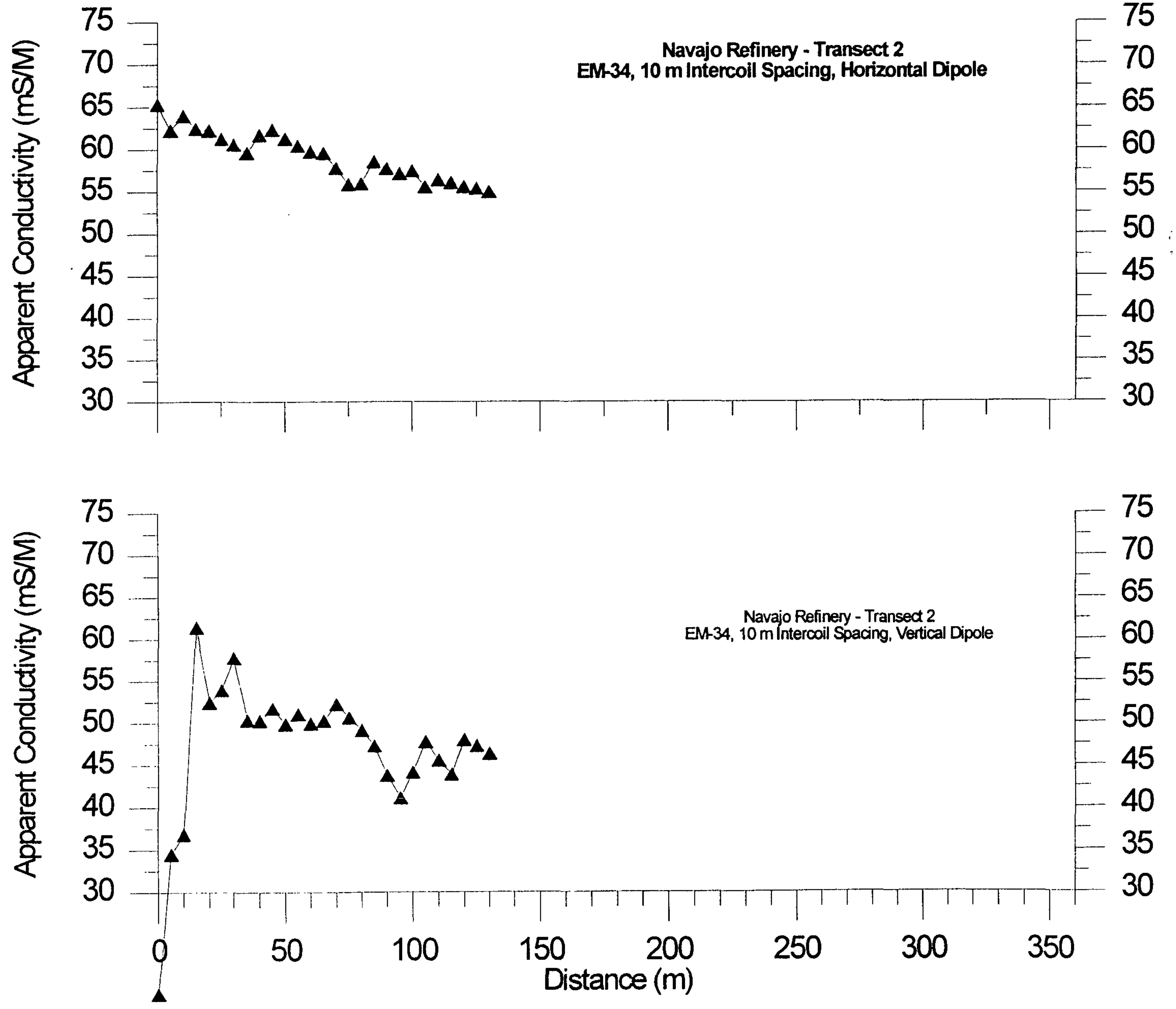
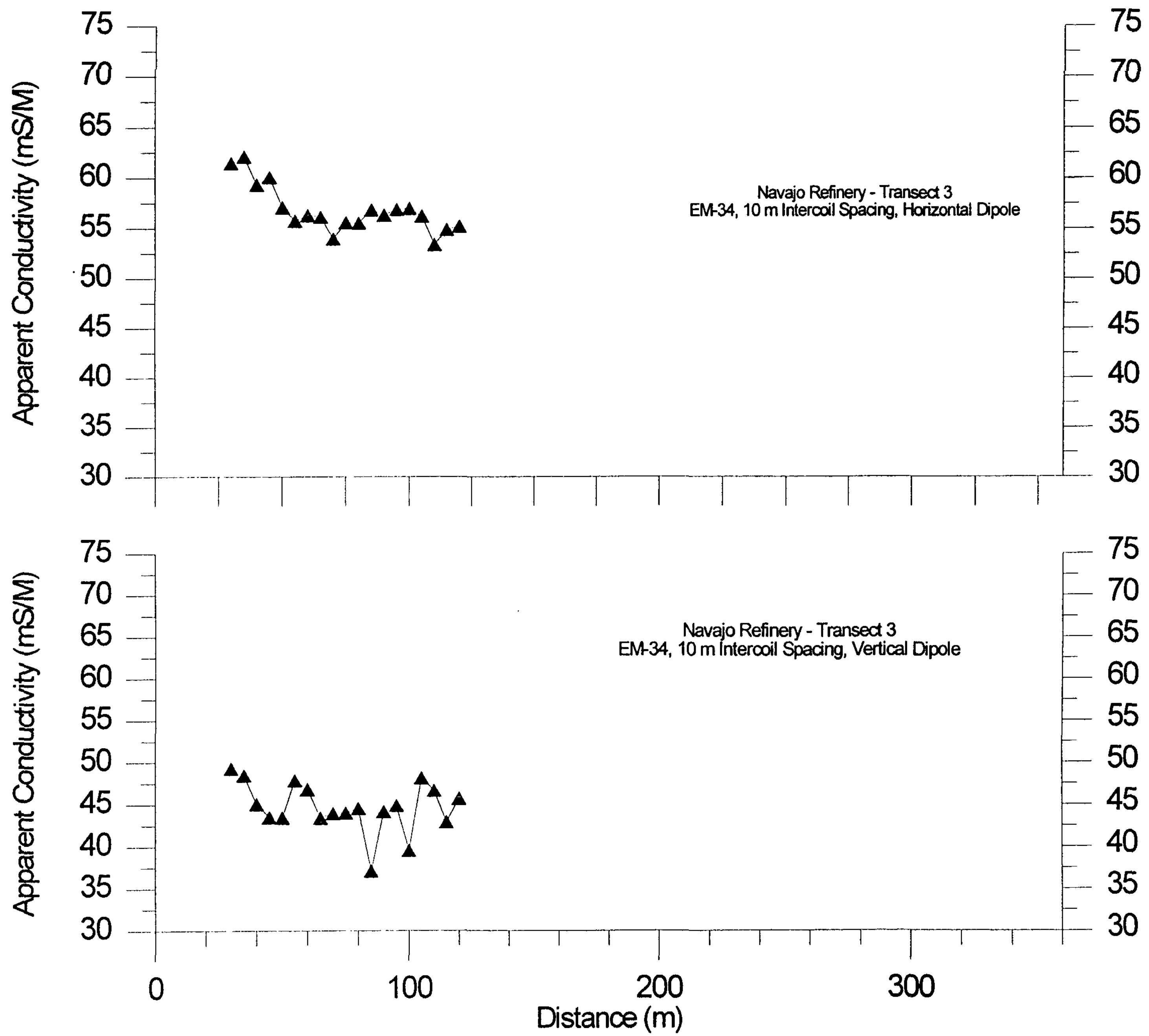
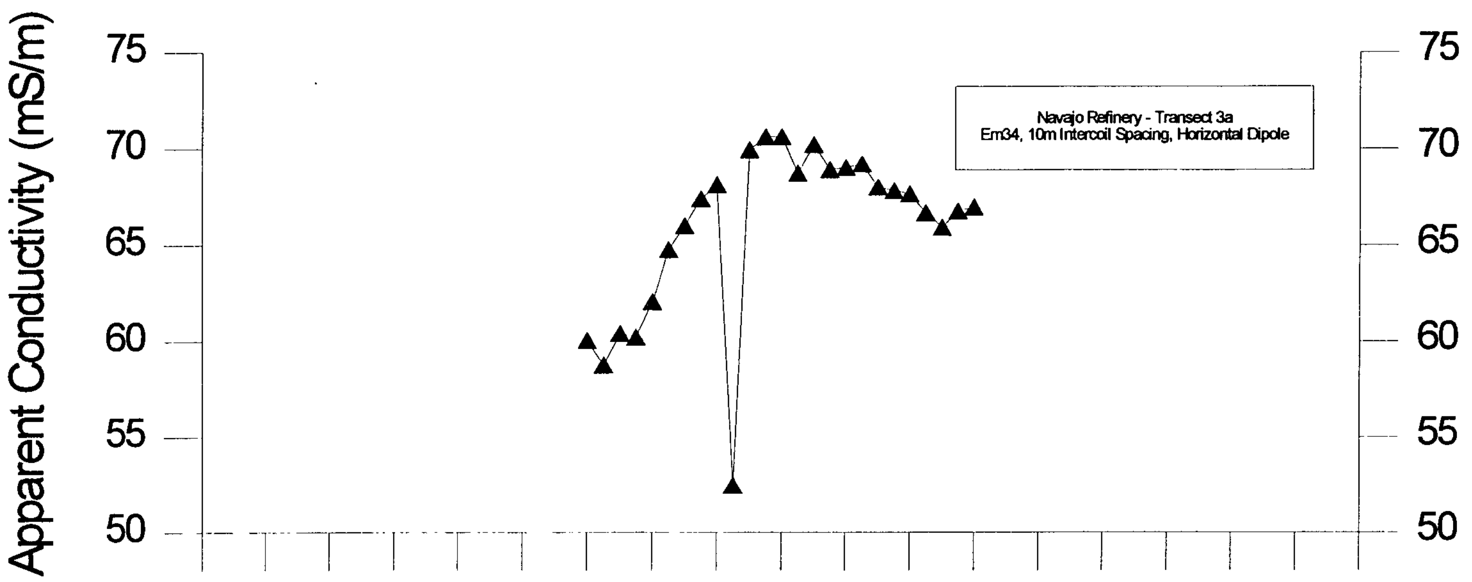

Navajo Refinery - Transect 2
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
Navajo Refinery - Transect 2
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)


Navajo Refinery - Transect 3
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
Navajo Refinery - Transect 3
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)


Navajo Refinery - Transect 3a
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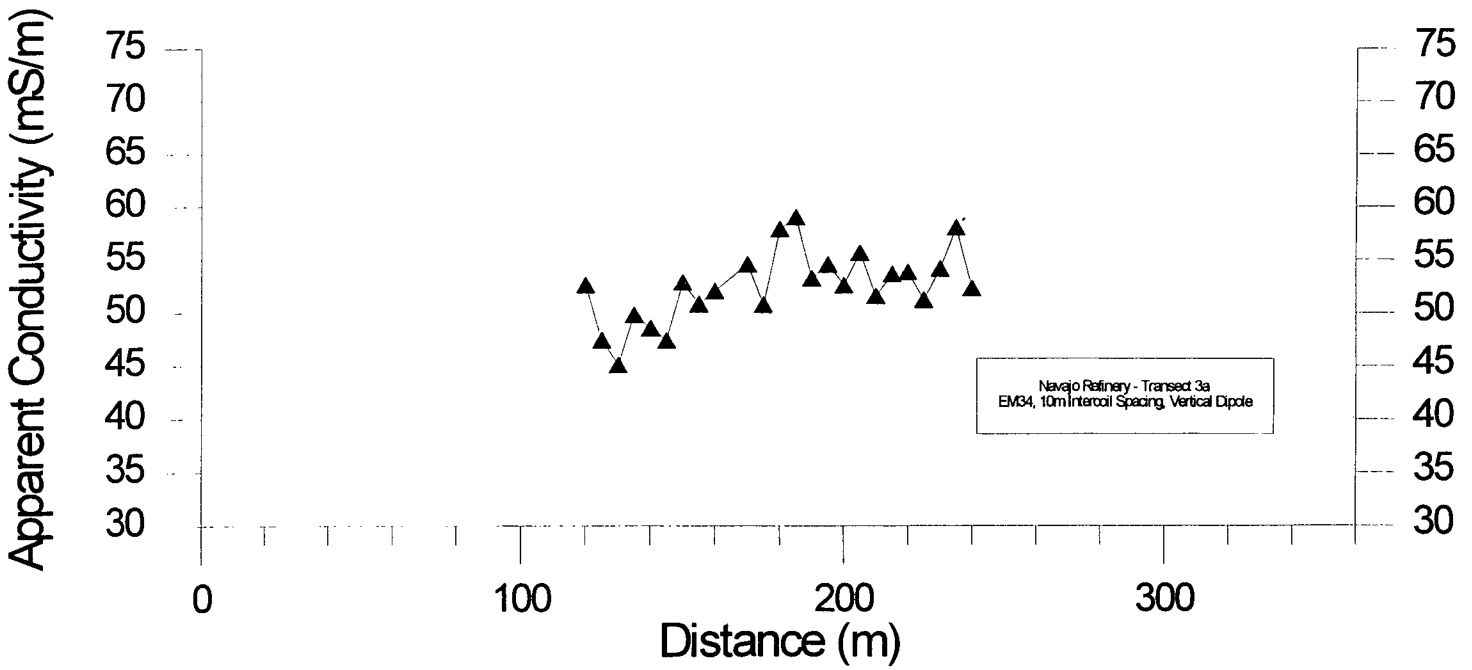
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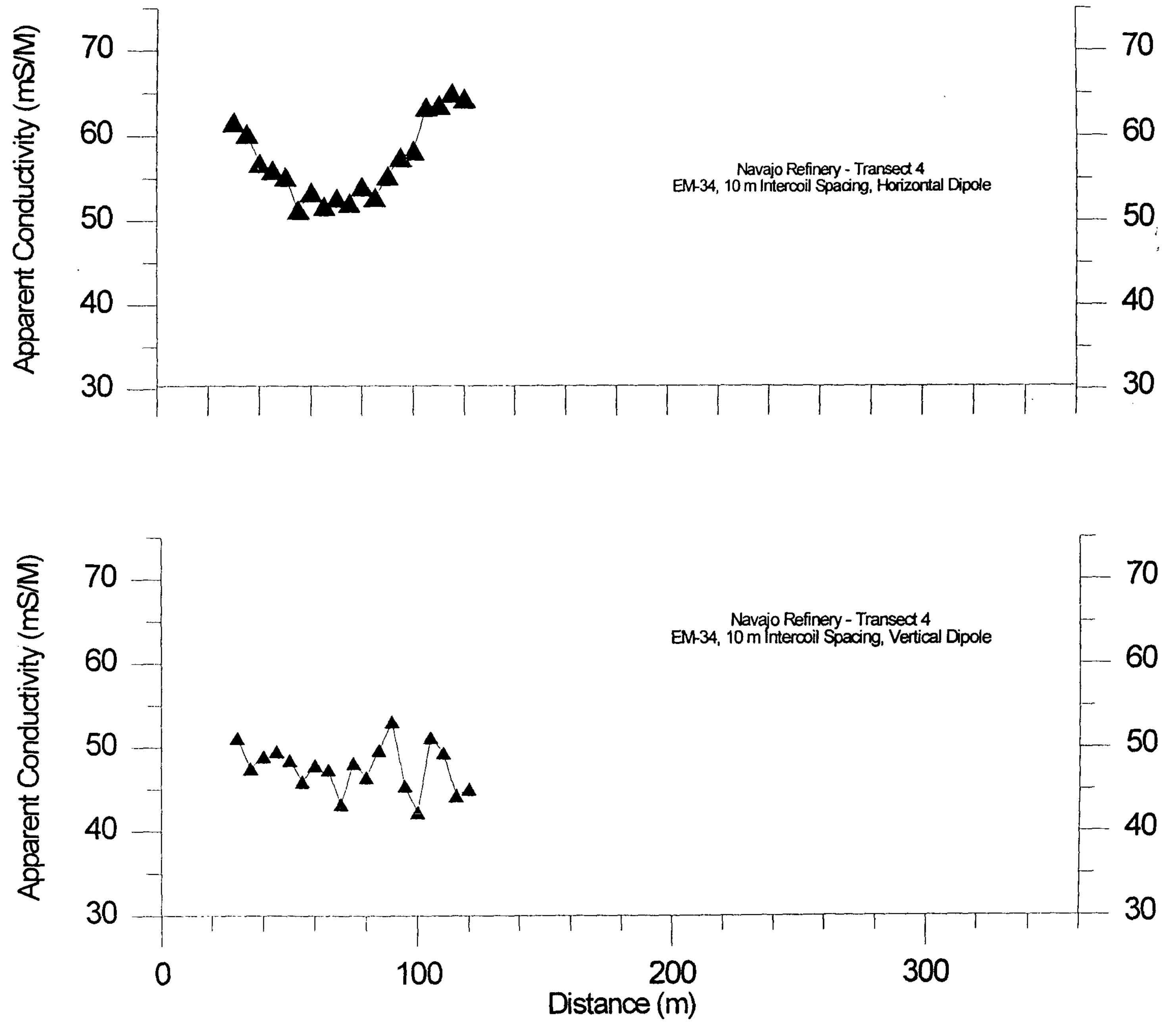

Navajo Refinery - Transect 4
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
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Navajo Refinery - Transect 4
EM-34, 10 m Intercoil Spacing, Vertical Dipole
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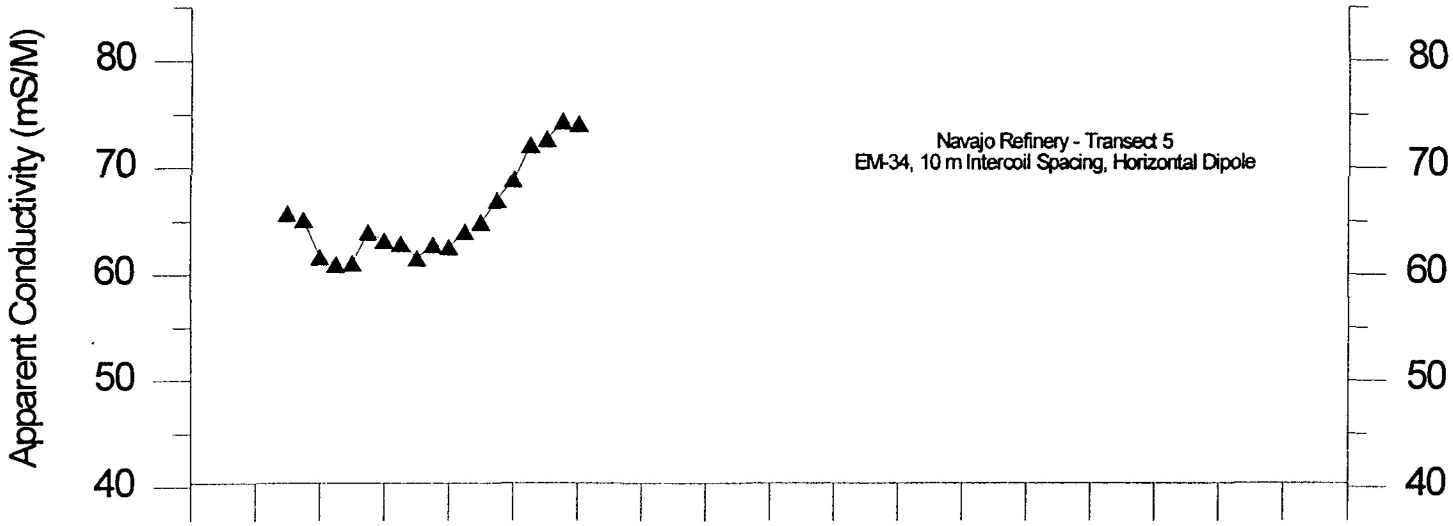
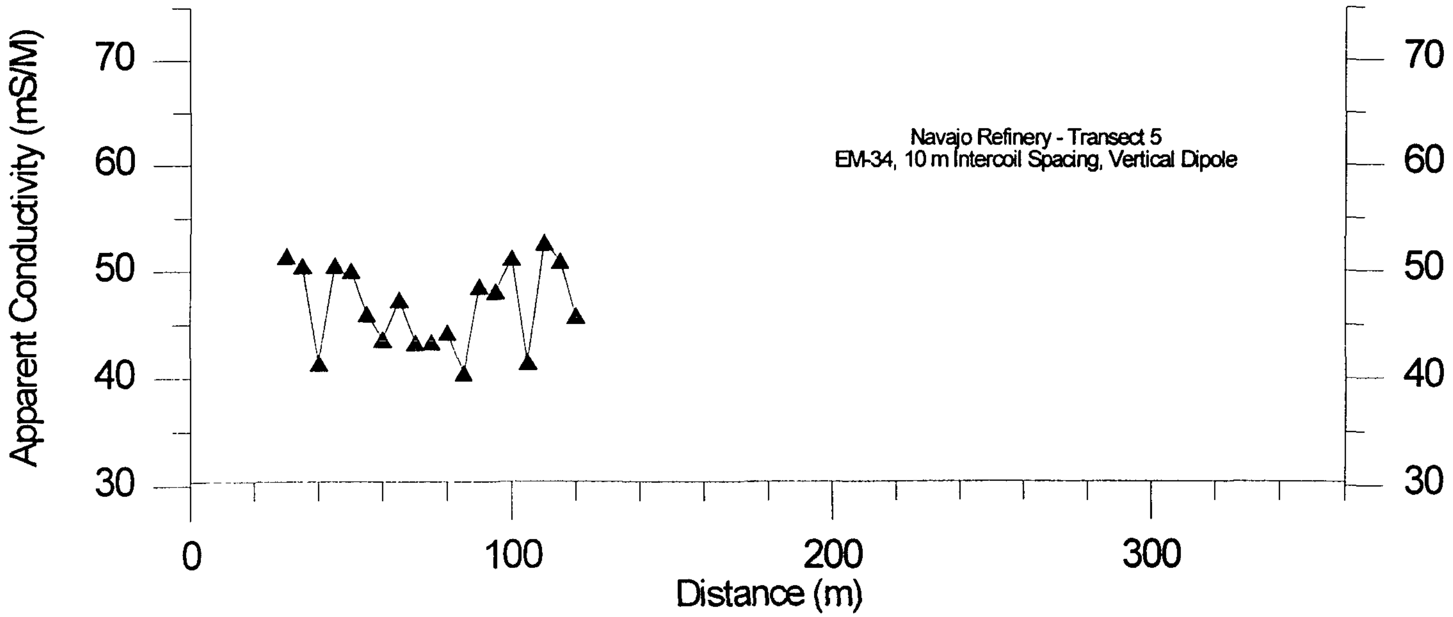
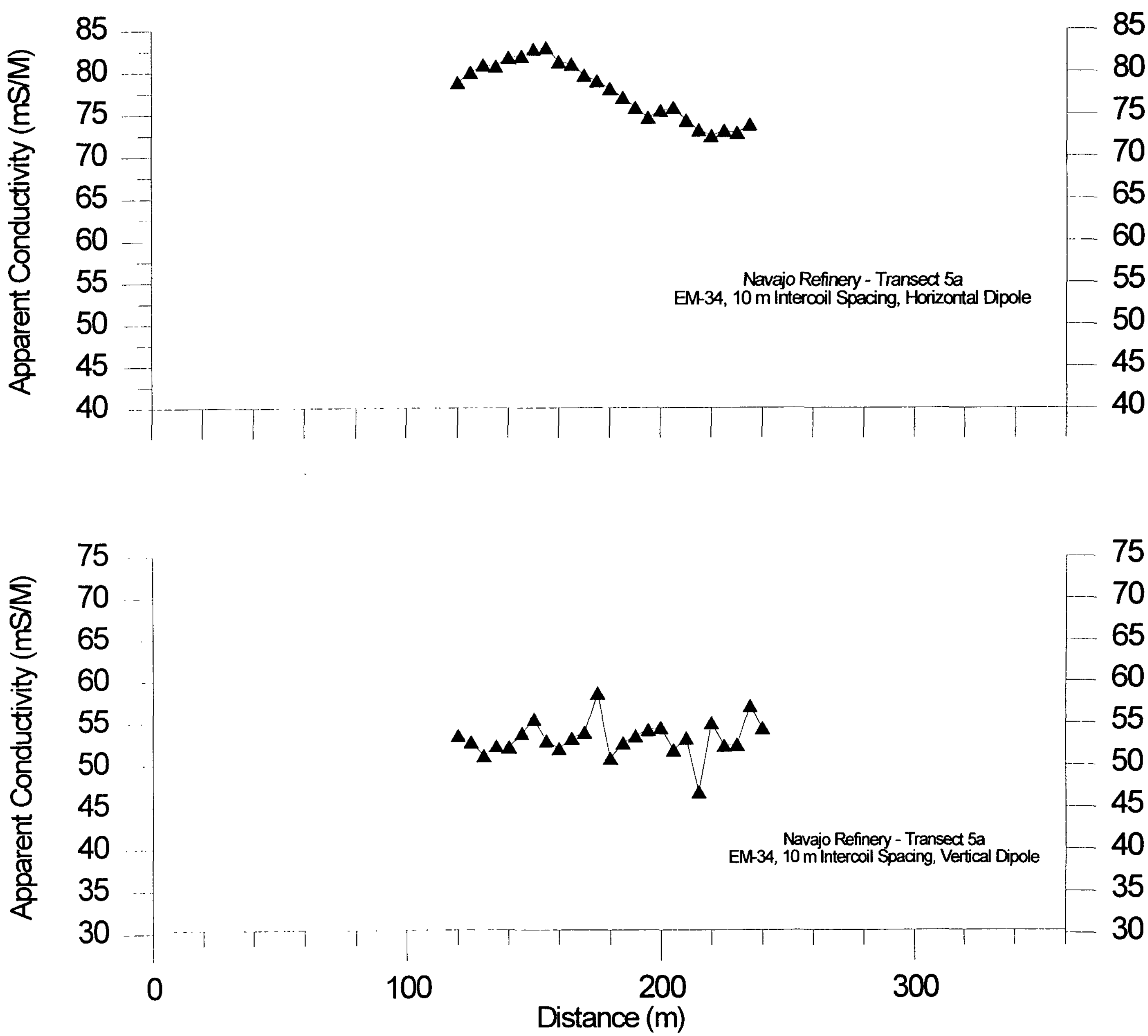
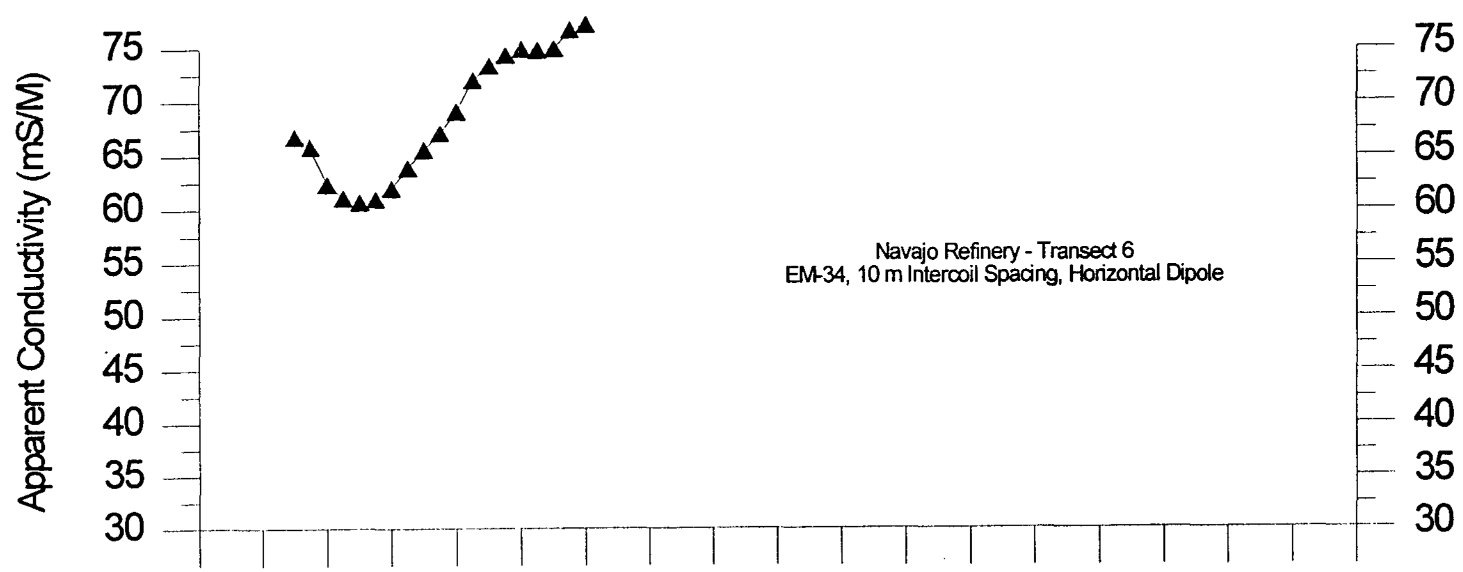
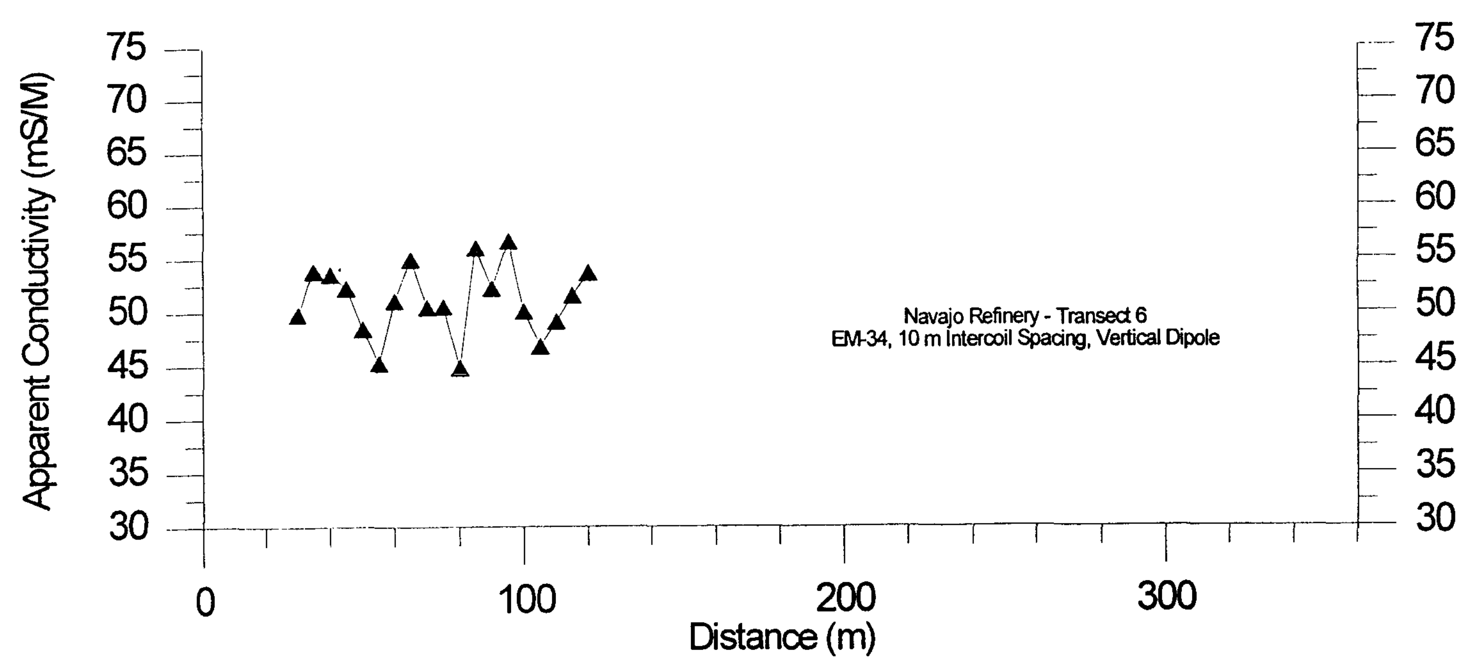
300
Distance (m)

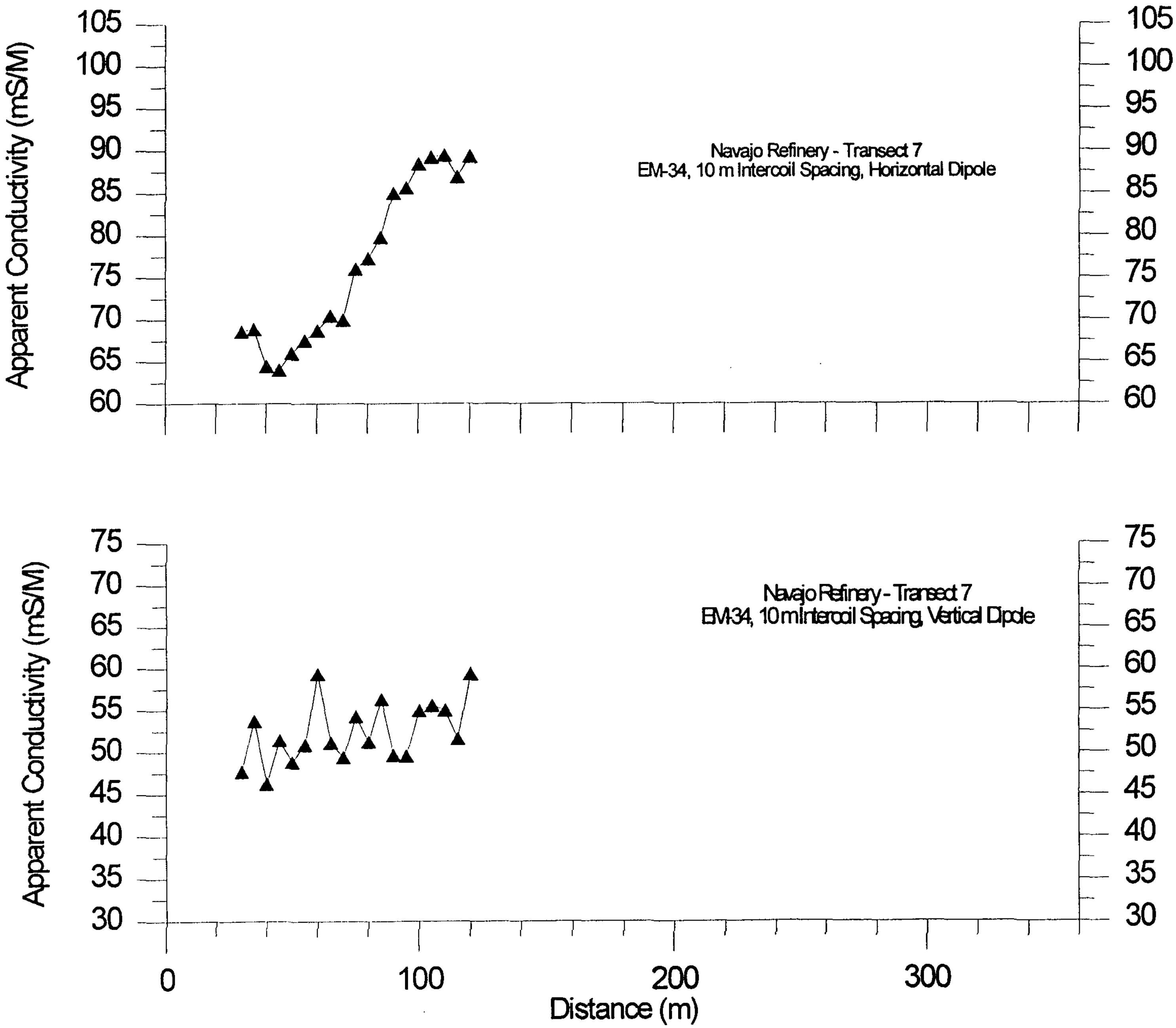

Navajo Refinery - Transect 5
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
80
70
60
50
40

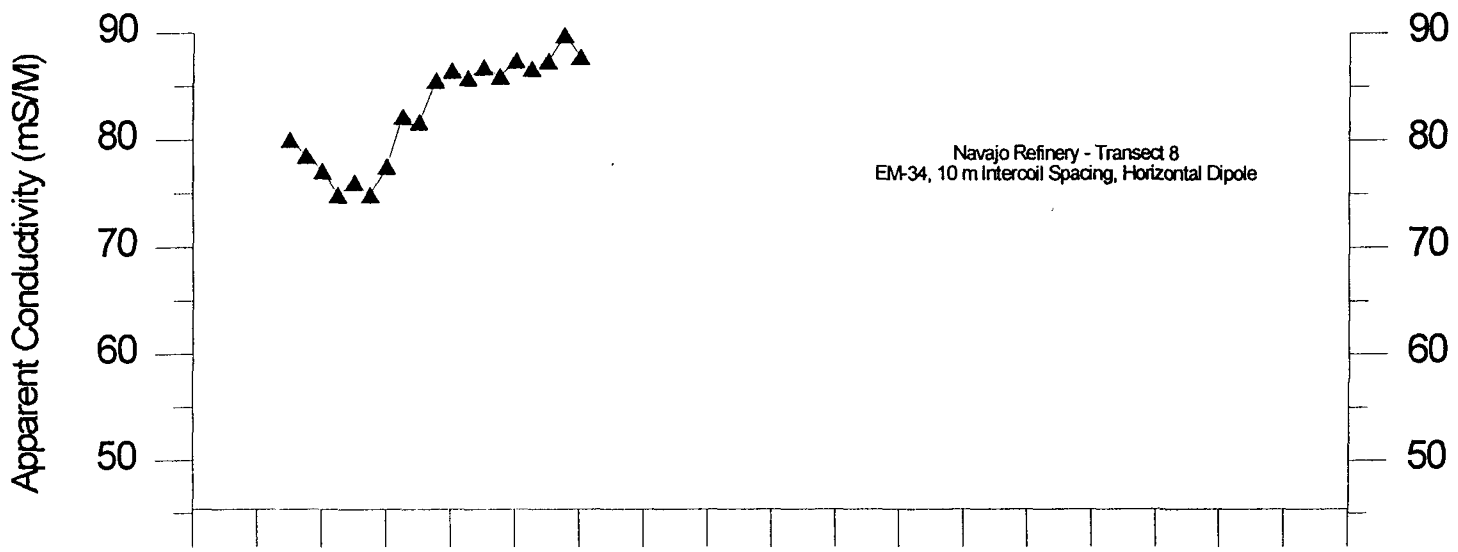

Navajo Refinery - Transect 5
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
70
60
50
40
30
0
100
200
300
Distance (m)

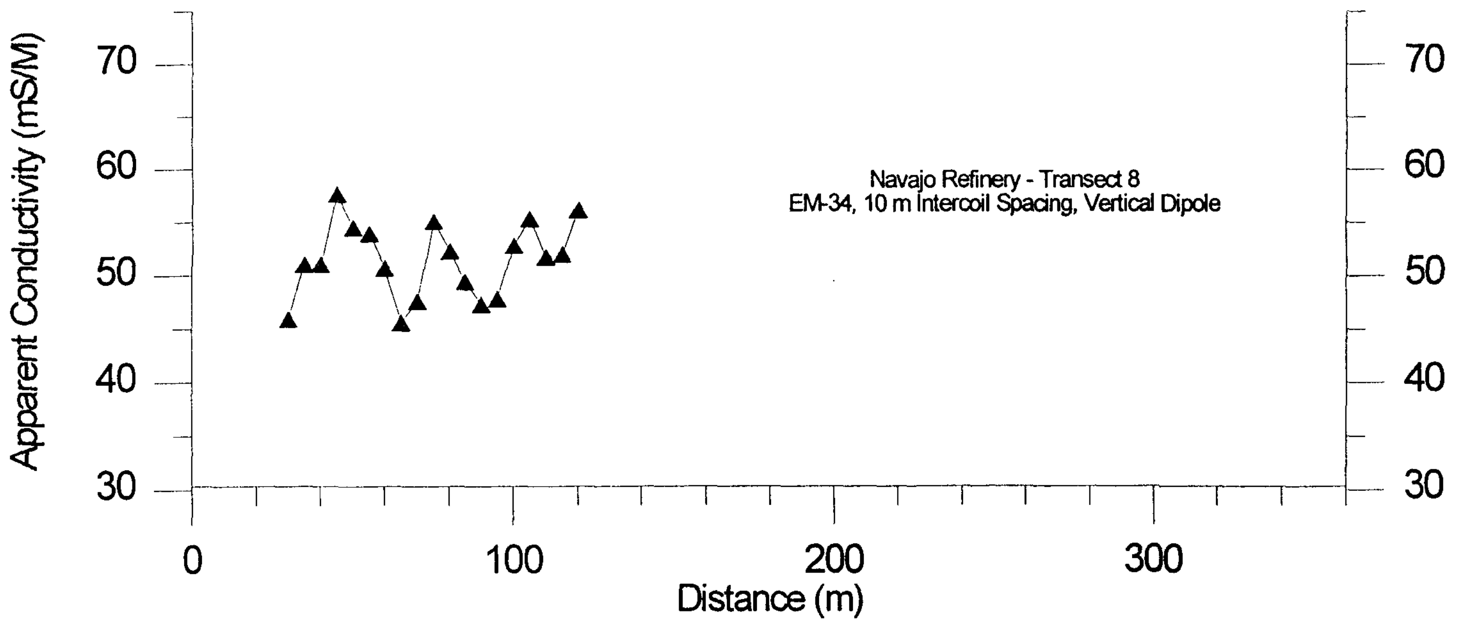

Navajo Refinery - Transect 5a
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
85
80
75
70
65
60
55
50
45
40
Navajo Refinery - Transect 5a
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

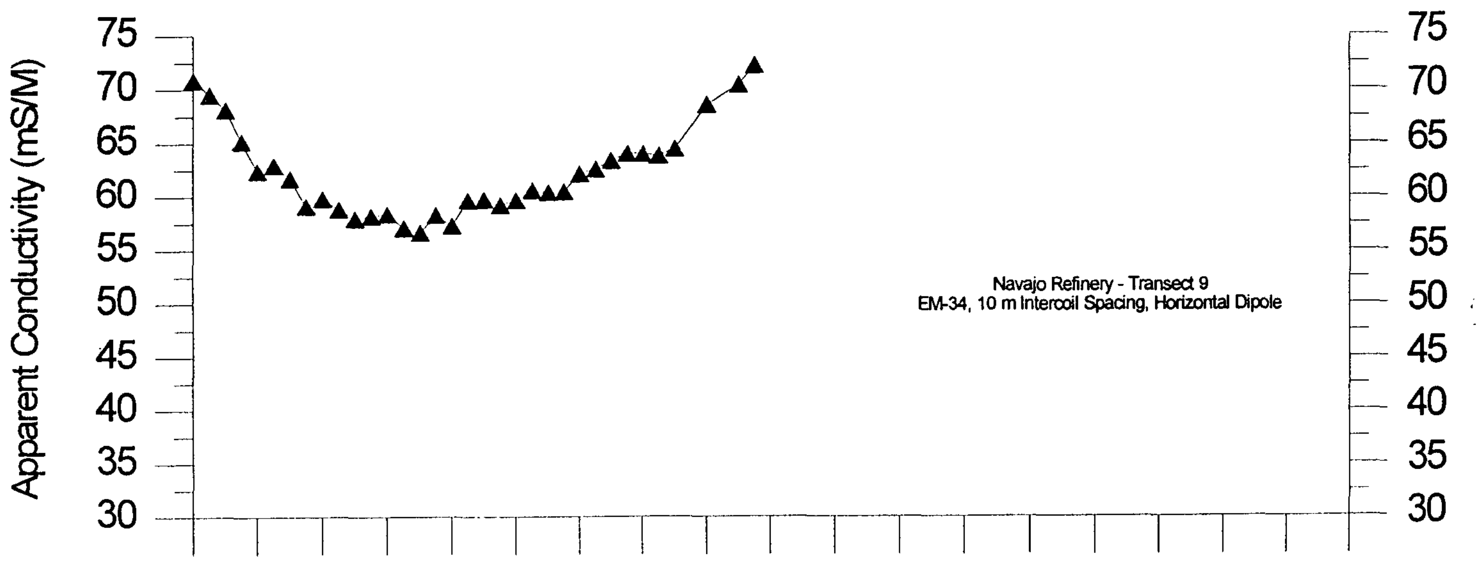

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
Navajo Refinery - Transect 6
EM-34, 10 m Intercoil Spacing, Horizontal Dipole

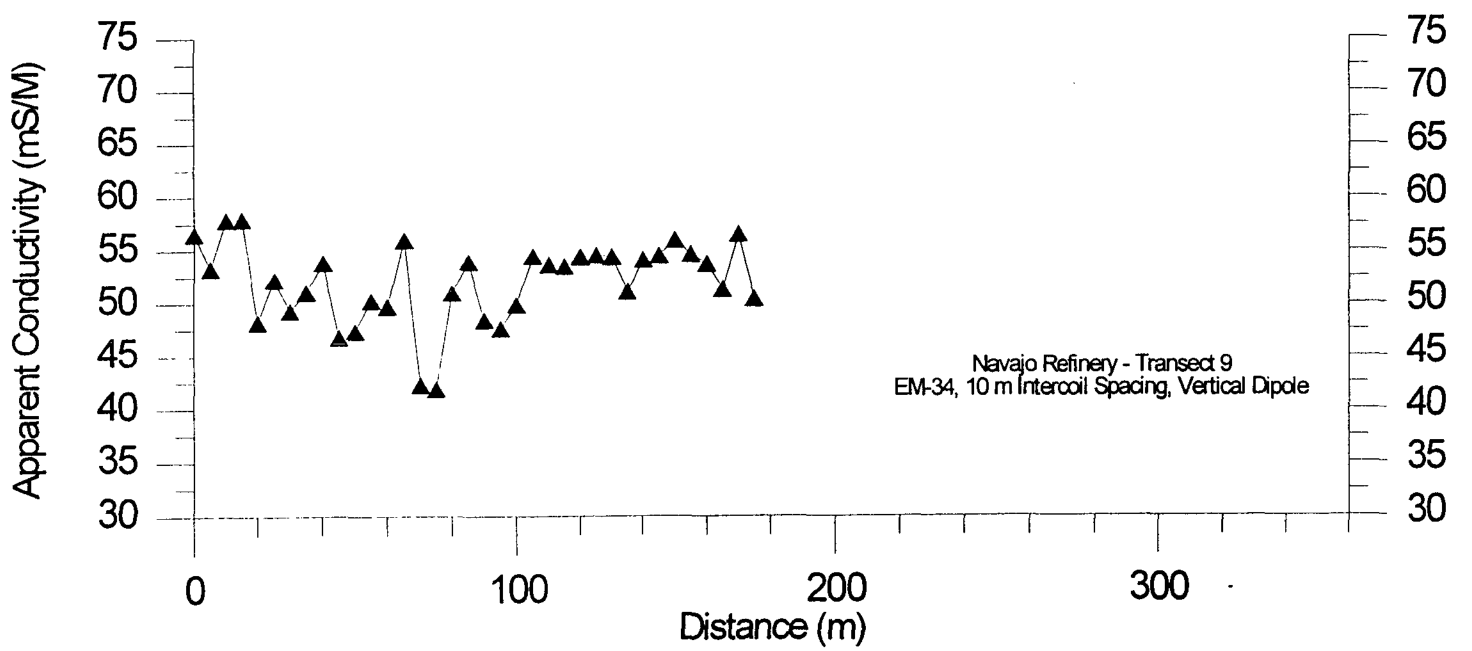

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
Navajo Refinery - Transect 6
EM-34, 10 m Intercoil Spacing, Vertical Dipole
0
100
200
300
Distance (m)

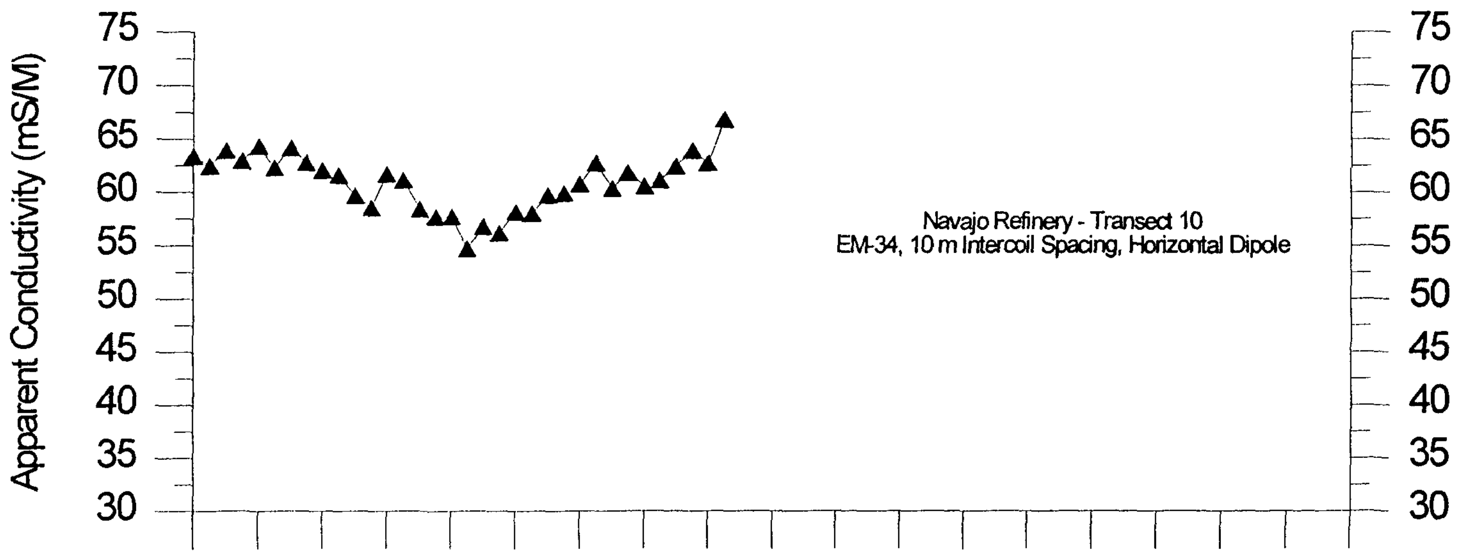

Navajo Refinery - Transect 7
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
105
100
95
90
85
80
75
70
65
60
Navajo Refinery - Transect 7
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

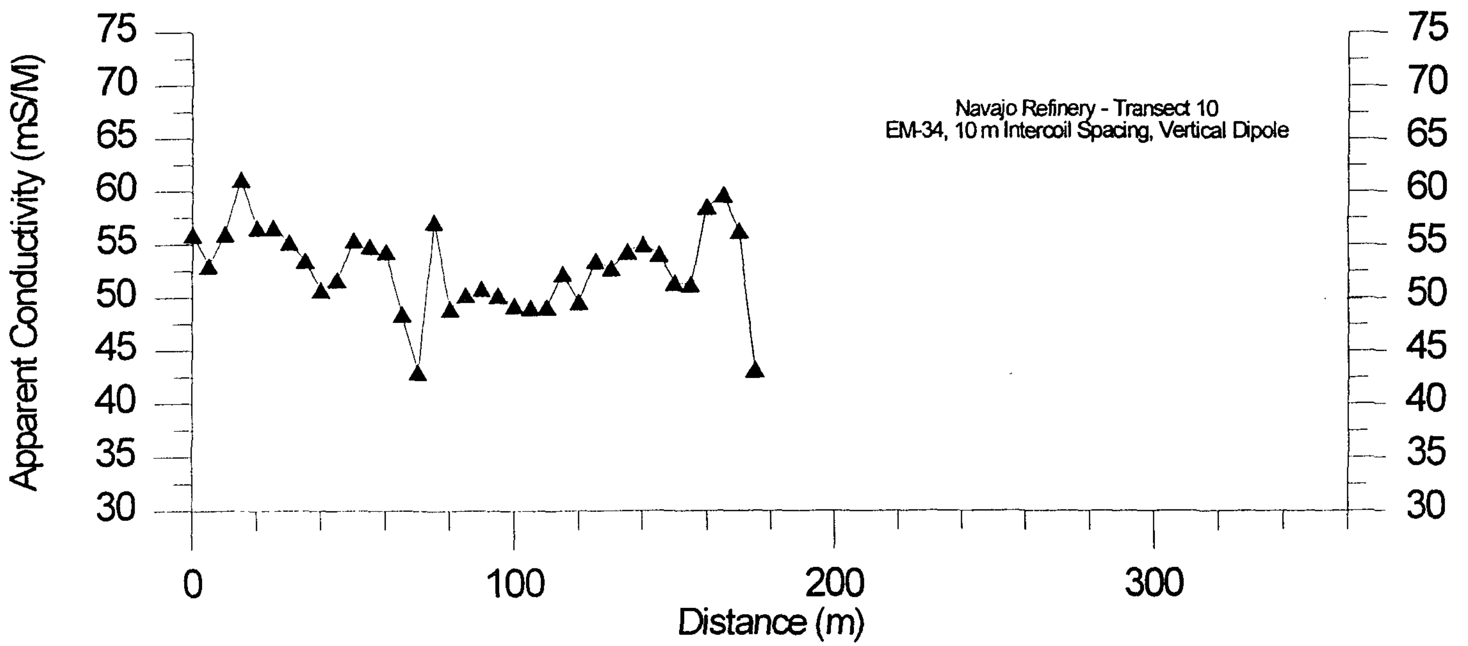

Navajo Refinery - Transect 8
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
90
80
70
60
50

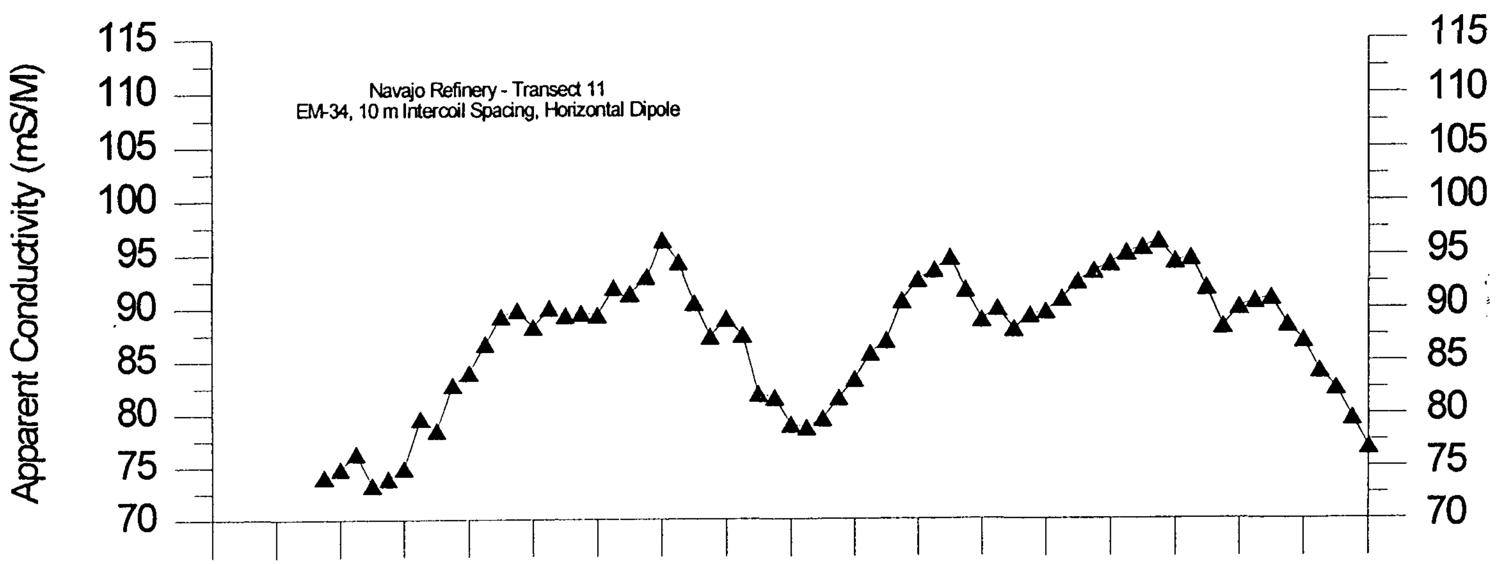

Navajo Refinery - Transect 8
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
70
60
50
40
30
0
100
200
300
Distance (m)

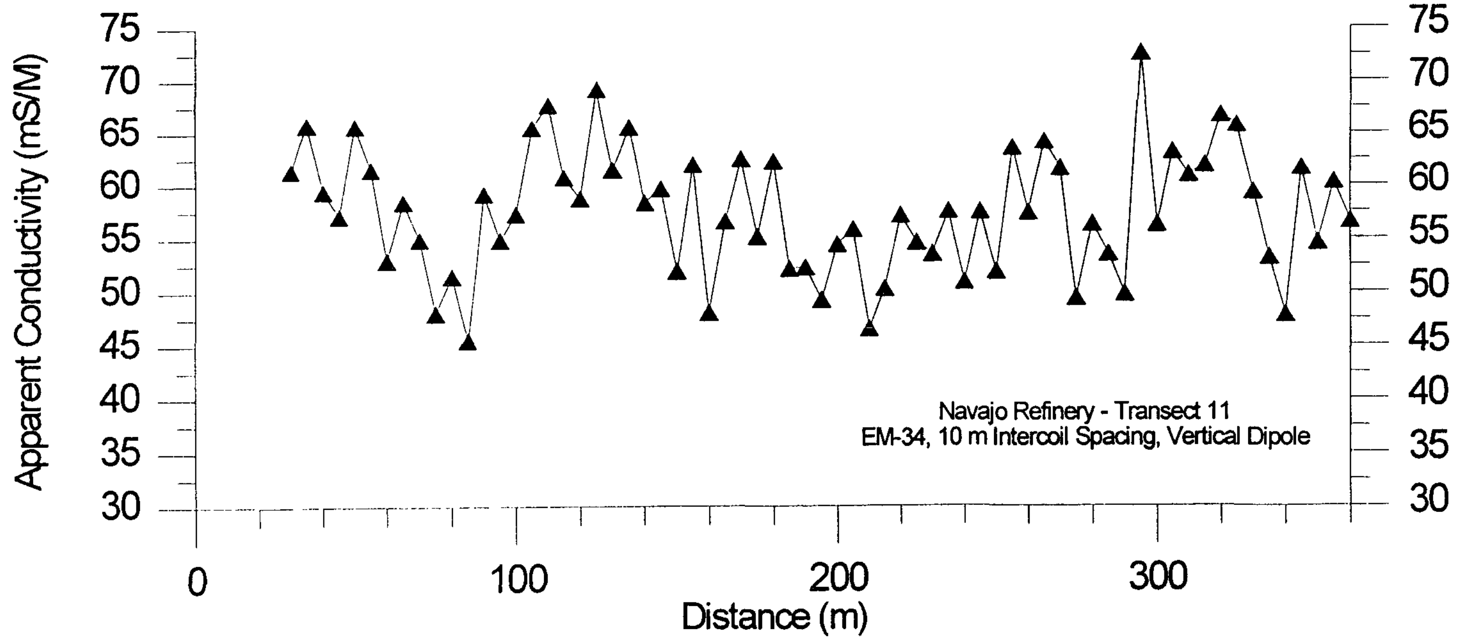

Navajo Refinery - Transect 9
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30

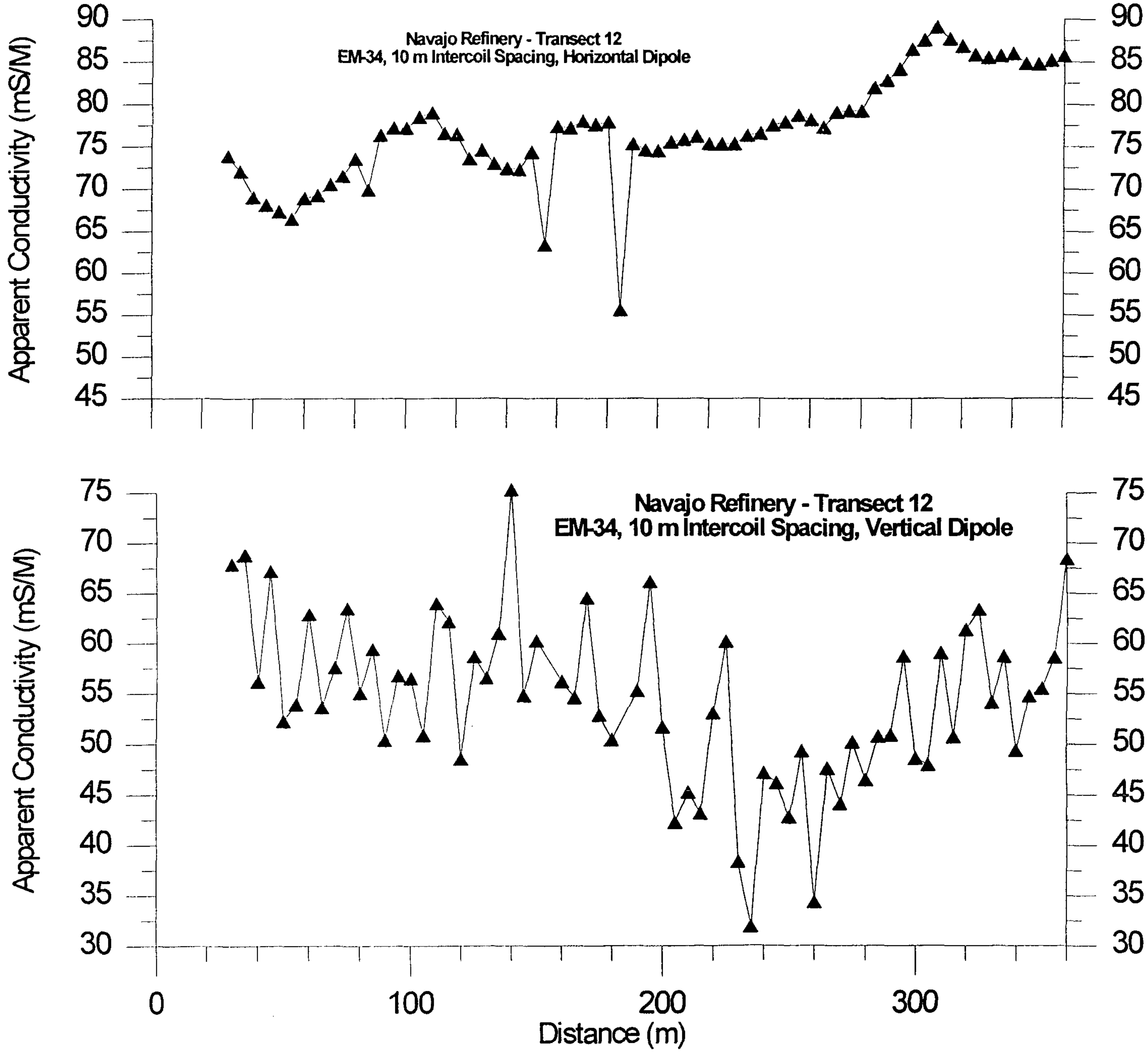

Navajo Refinery - Transect 9
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

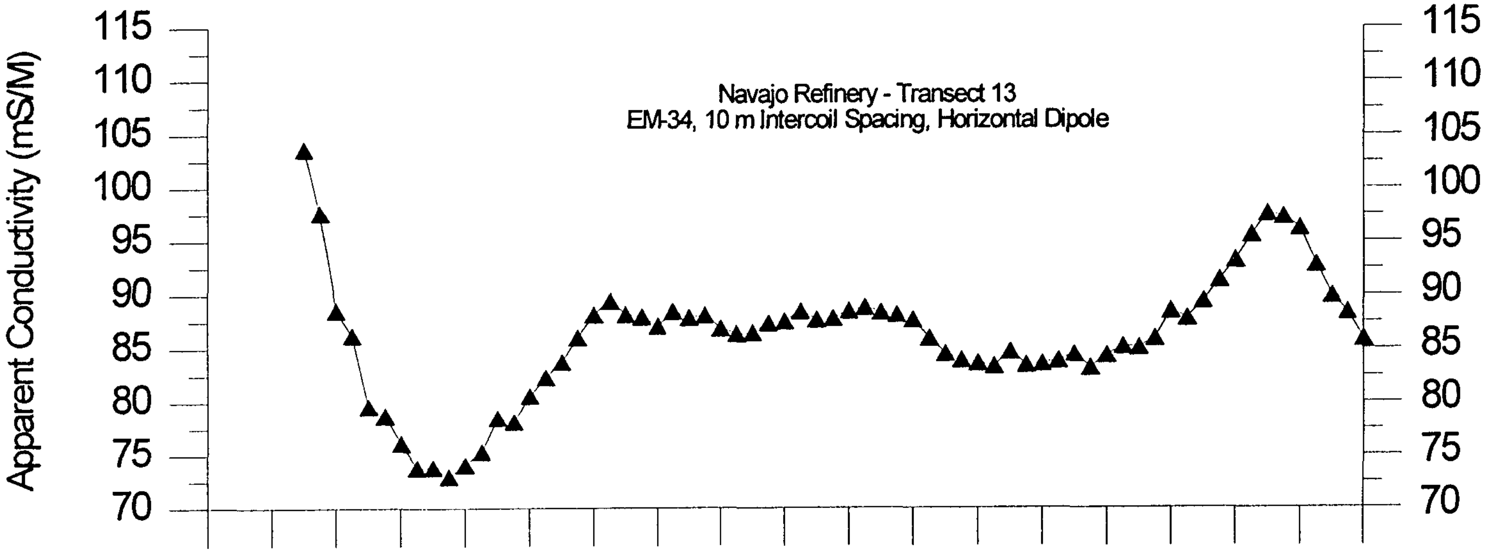

Navajo Refinery - Transect 10
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30

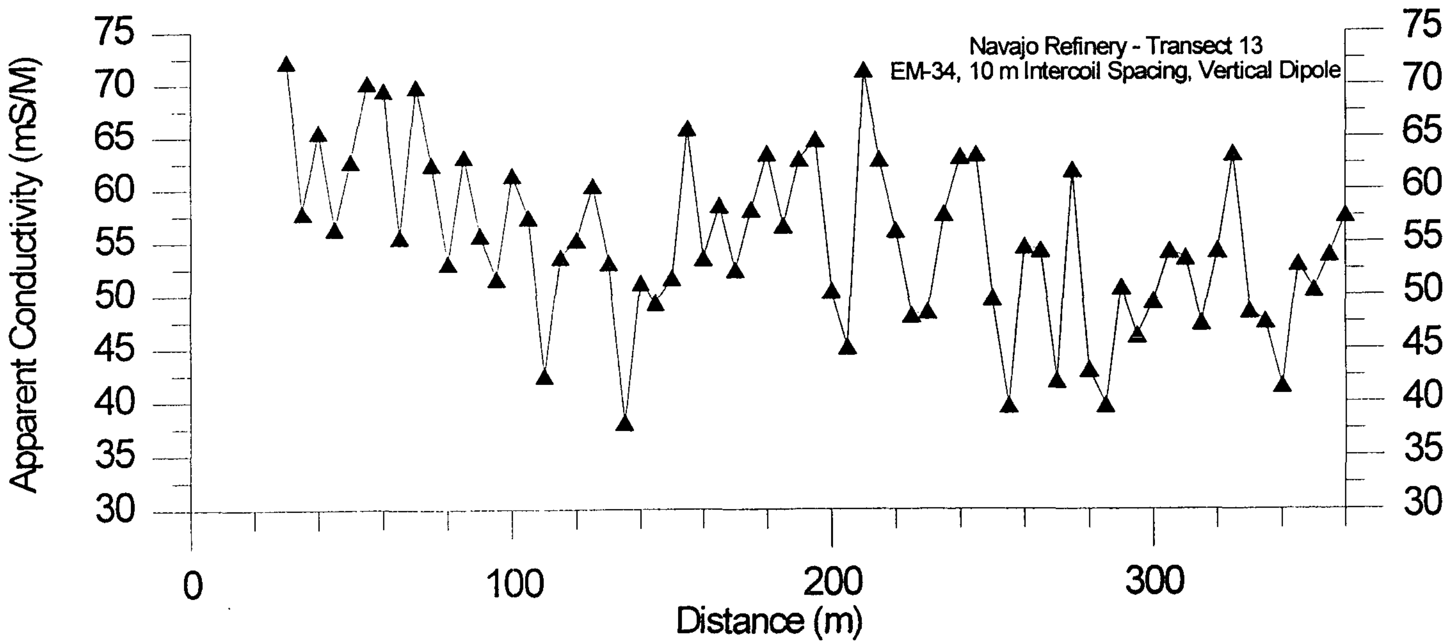

Navajo Refinery - Transect 10
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

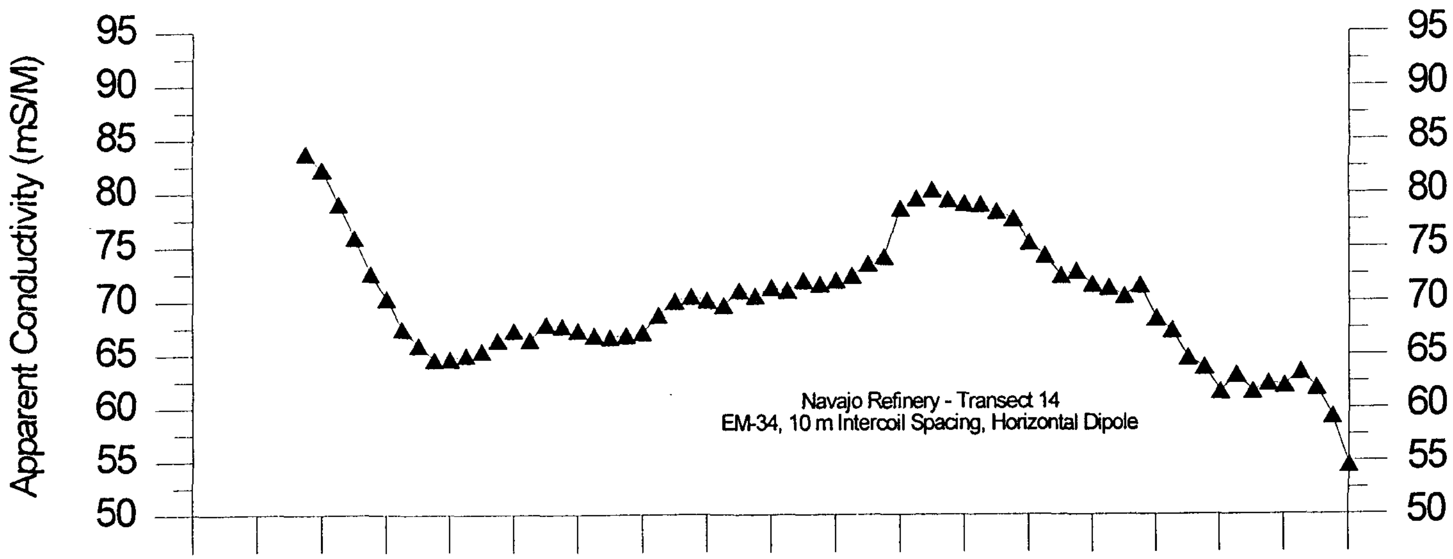

Navajo Refinery - Transect 11
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
115
110
105
100
95
90
85
80
75
70

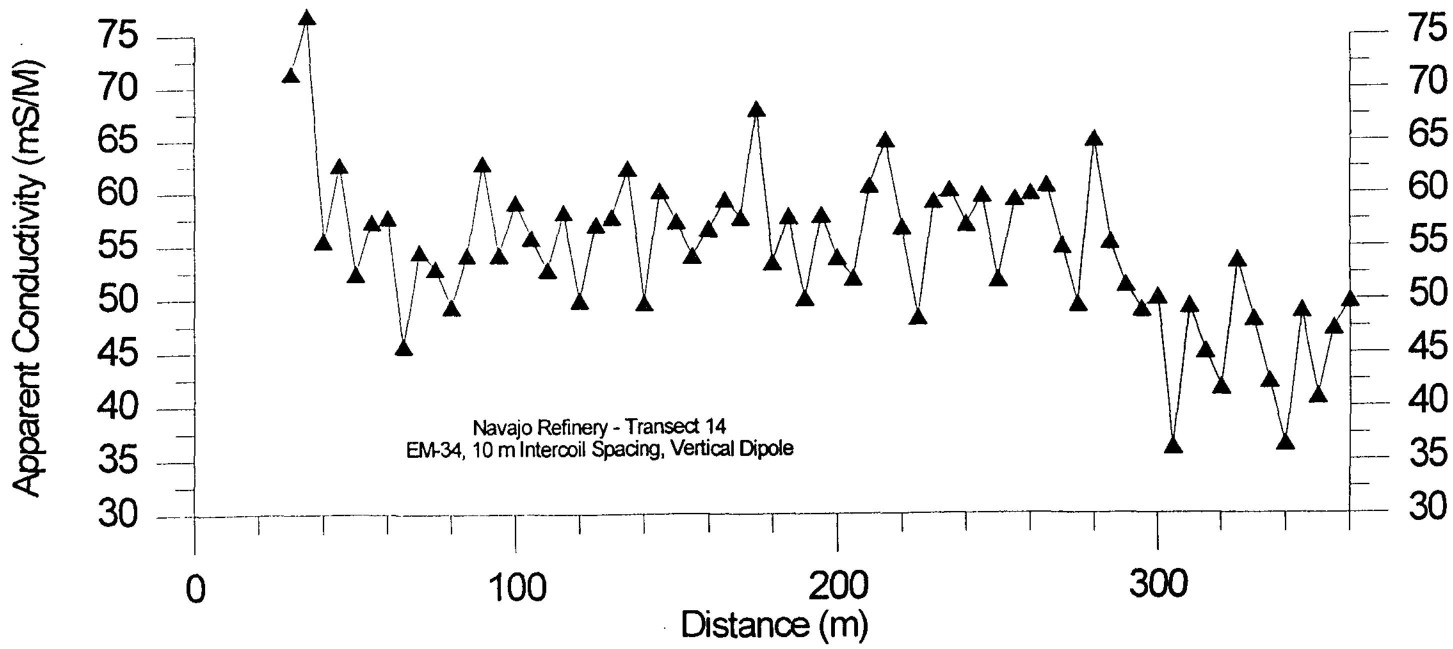

Navajo Refinery - Transect 11
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

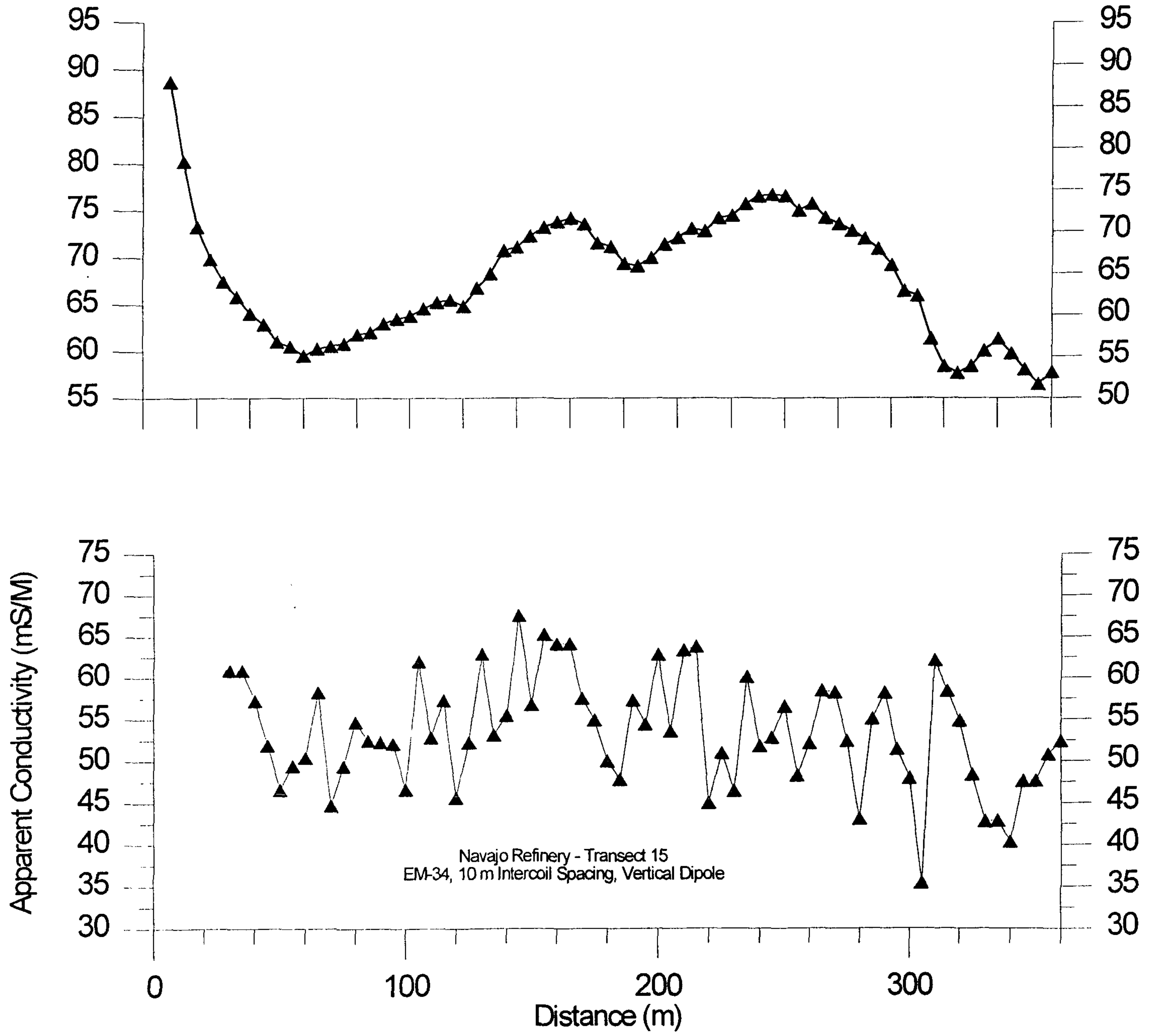

Navajo Refinery - Transect 12
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Navajo Refinery - Transect 12
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Apparent Conductivity (mS/M)
Distance (m)
90
85
80
75
70
65
60
55
50
45
75
70
65
60
55
50
45
40
35
30
0
100
200
300


Navajo Refinery - Transect 13
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
115
110
105
100
95
90
85
80
75
70

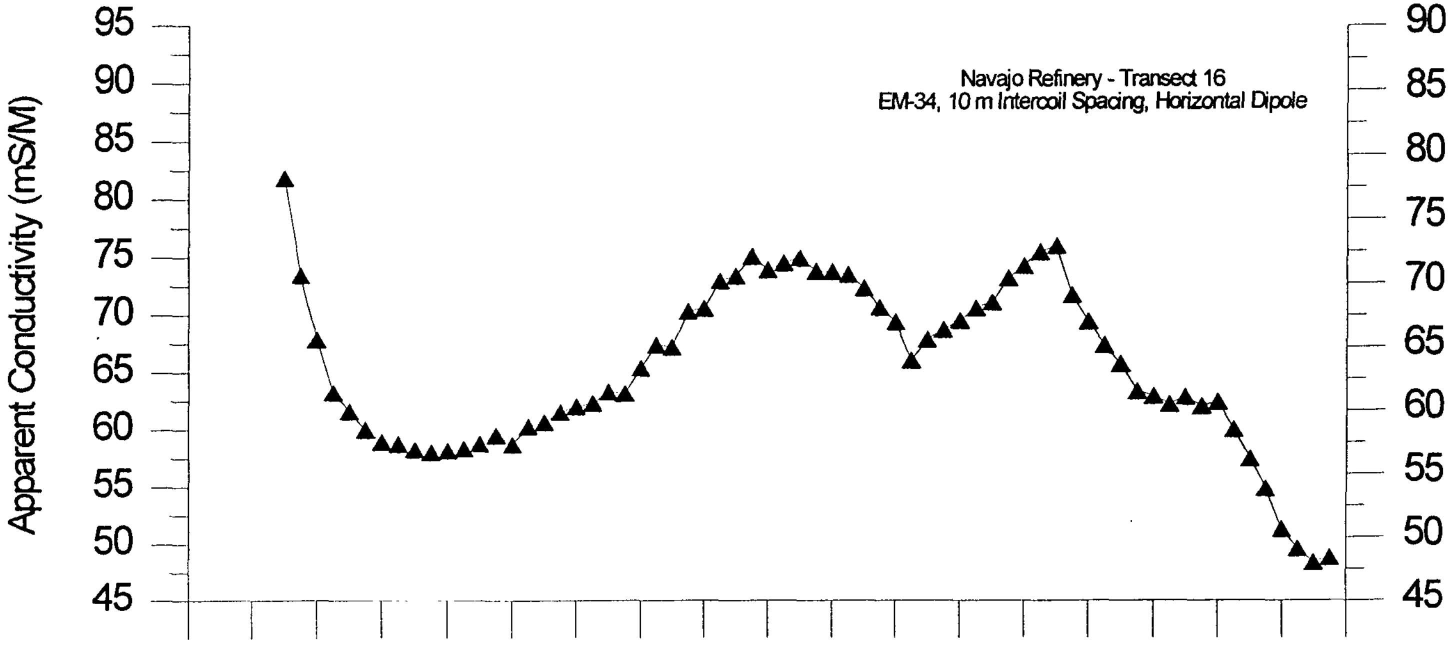

Navajo Refinery - Transect 13
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

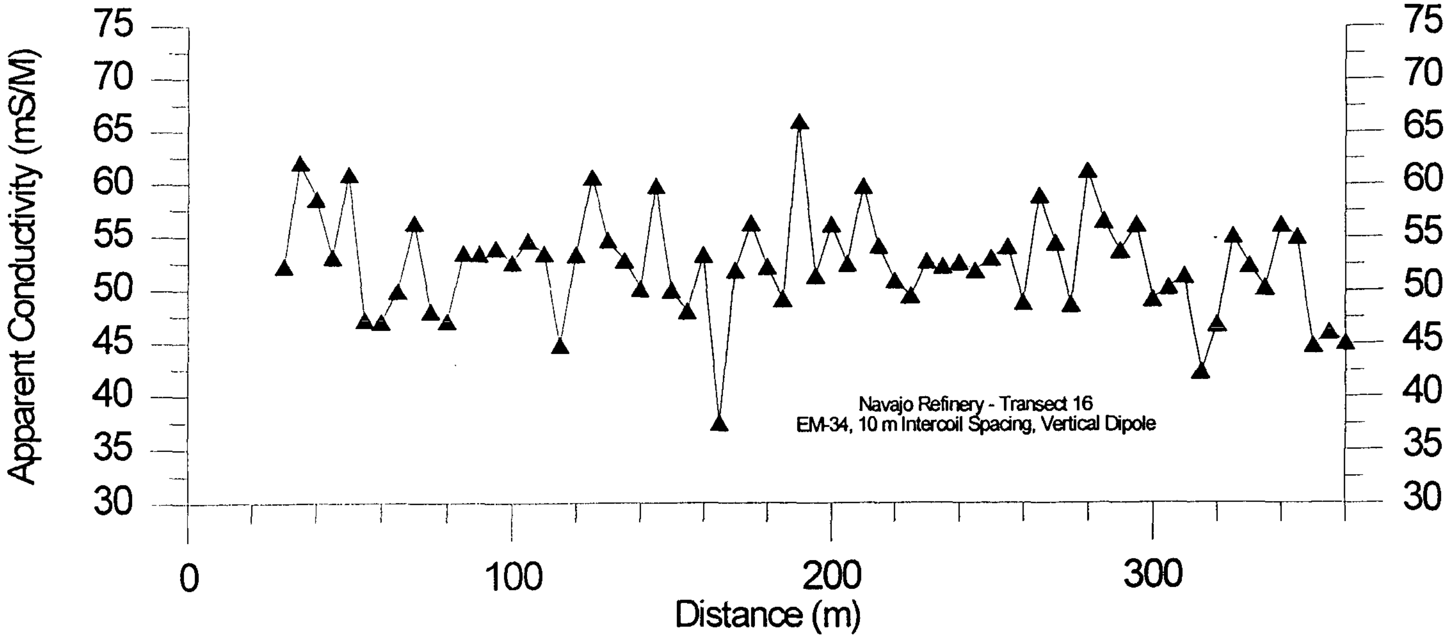

Apparent Conductivity (mS/M)
95
90
85
80
75
70
65
60
55
50
Navajo Refinery - Transect 14
EM-34, 10 m Intercoil Spacing, Horizontal Dipole

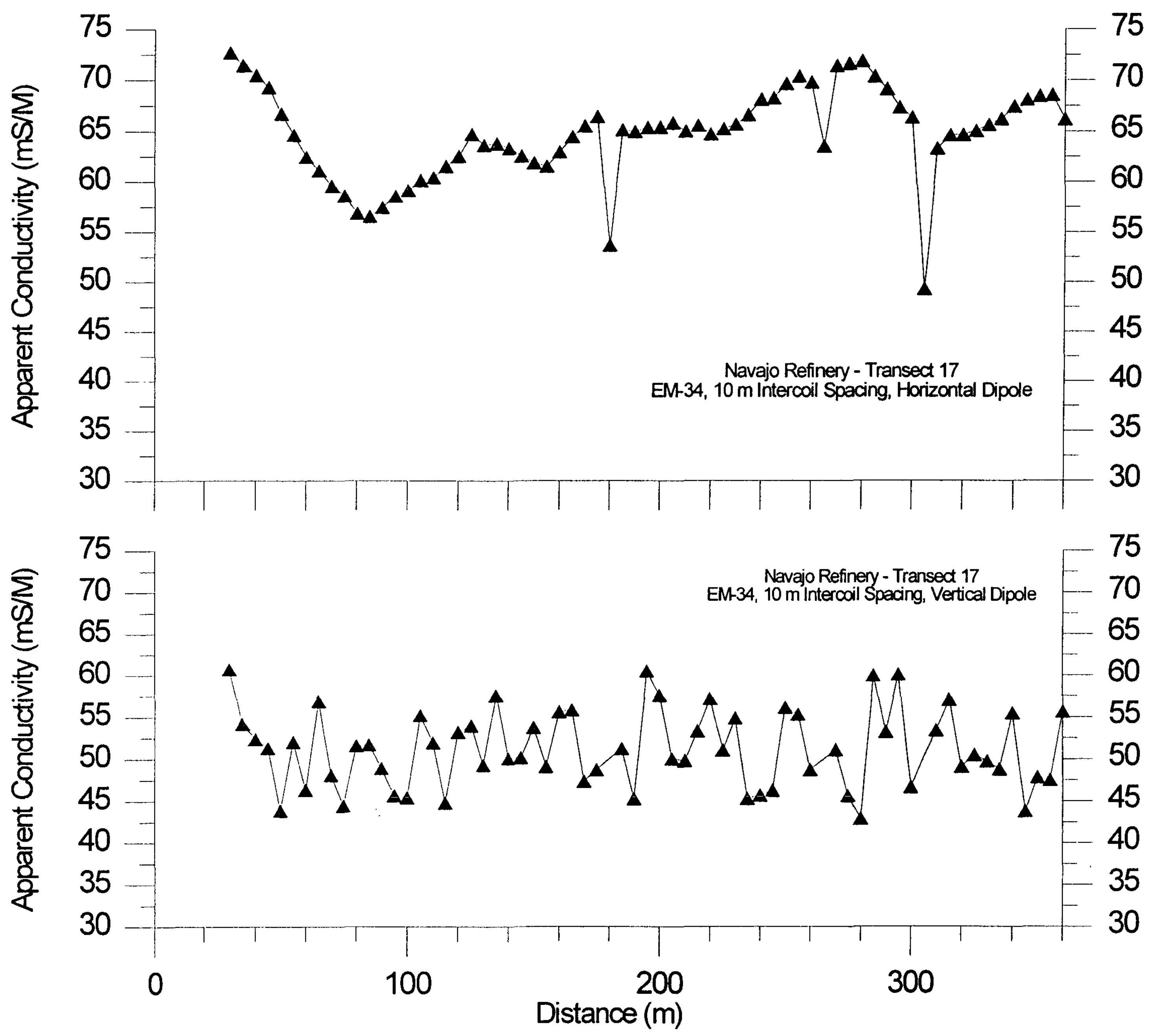

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
Navajo Refinery - Transect 14
EM-34, 10 m Intercoil Spacing, Vertical Dipole
0
100
200
300
Distance (m)

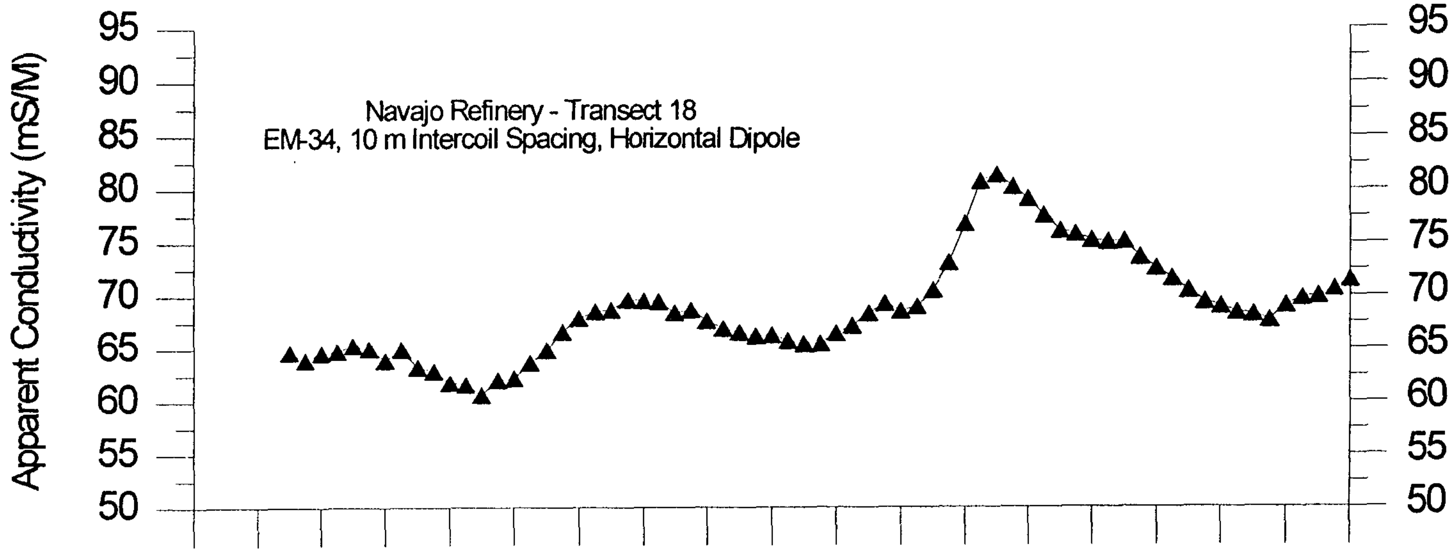


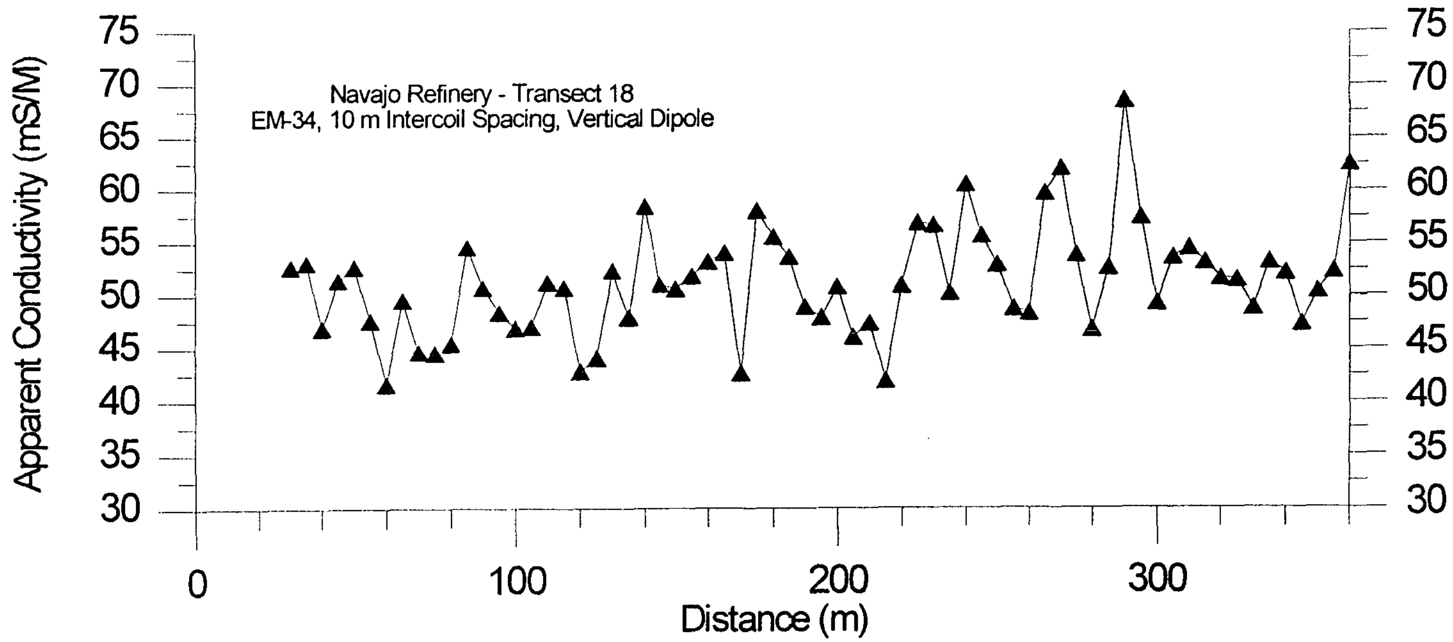
95
90
85
80
75
70
65
60
55
50
75
70
65
60
55
50
45
40
35
30
Apparent Conductivity (mS/M)
Navajo Refinery - Transect 15
EM-34, 10 m Intercoil Spacing, Vertical Dipole
0
100
200
300
Distance (m)

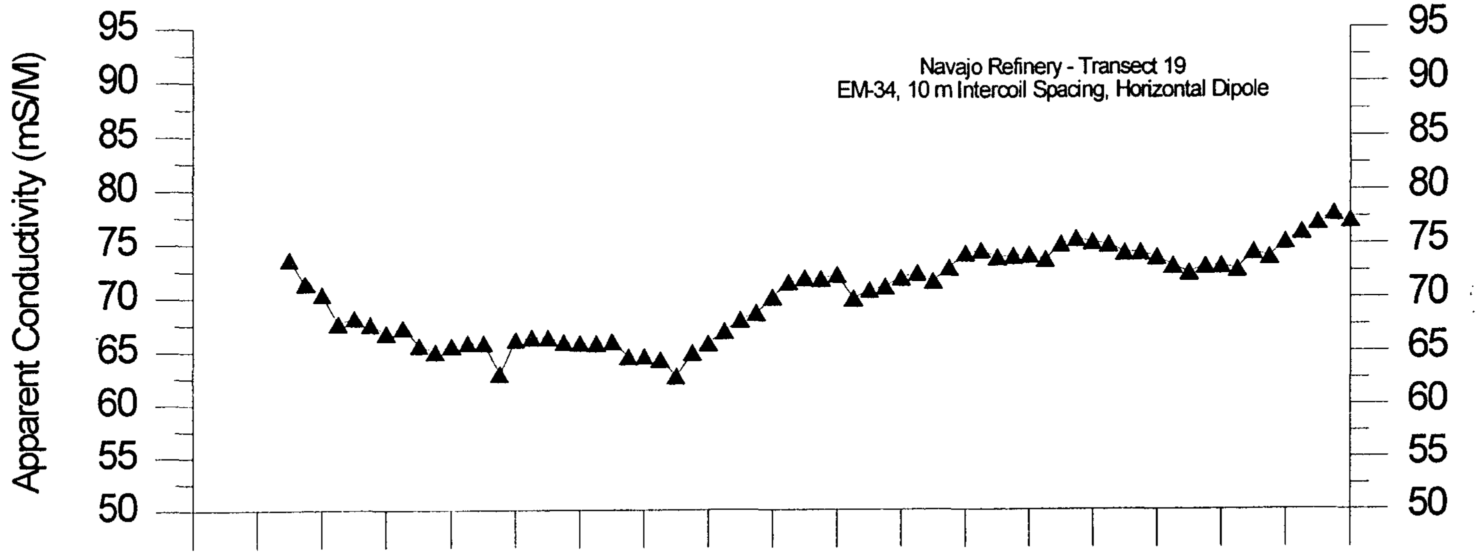

Navajo Refinery - Transect 16
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
95
90
85
80
75
70
65
60
55
50
45

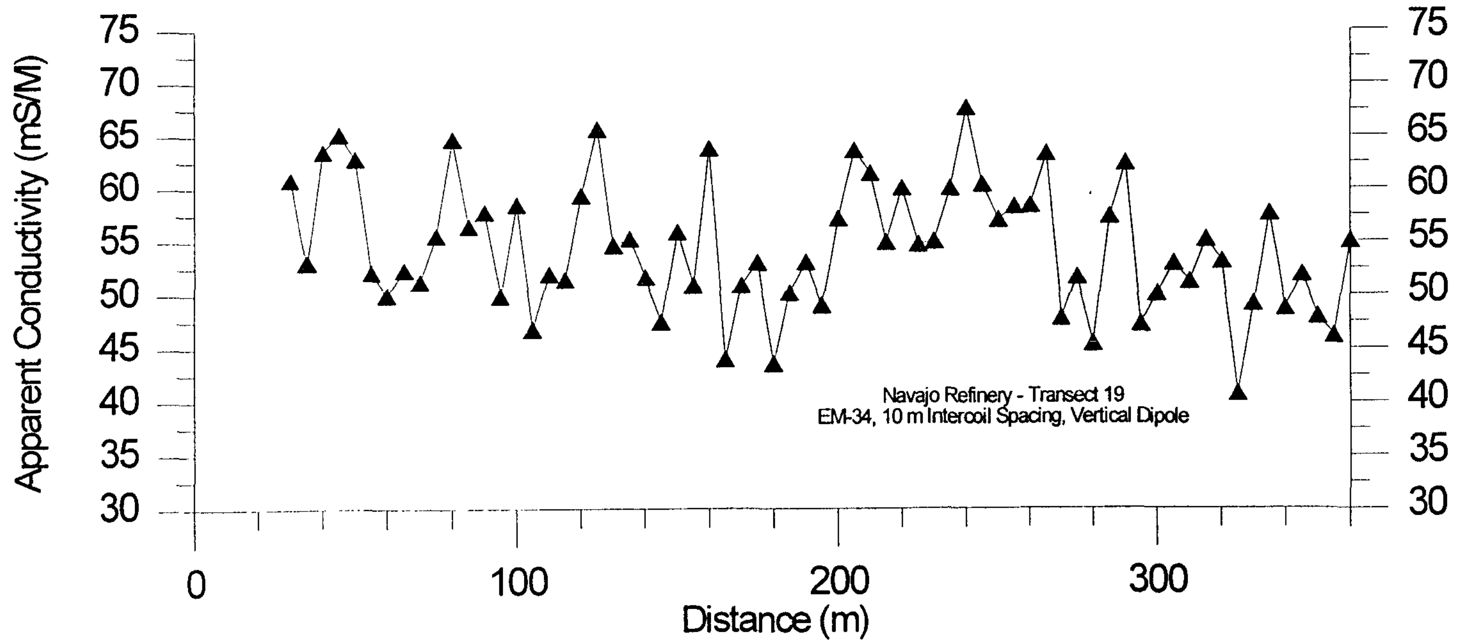

Navajo Refinery - Transect 16
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

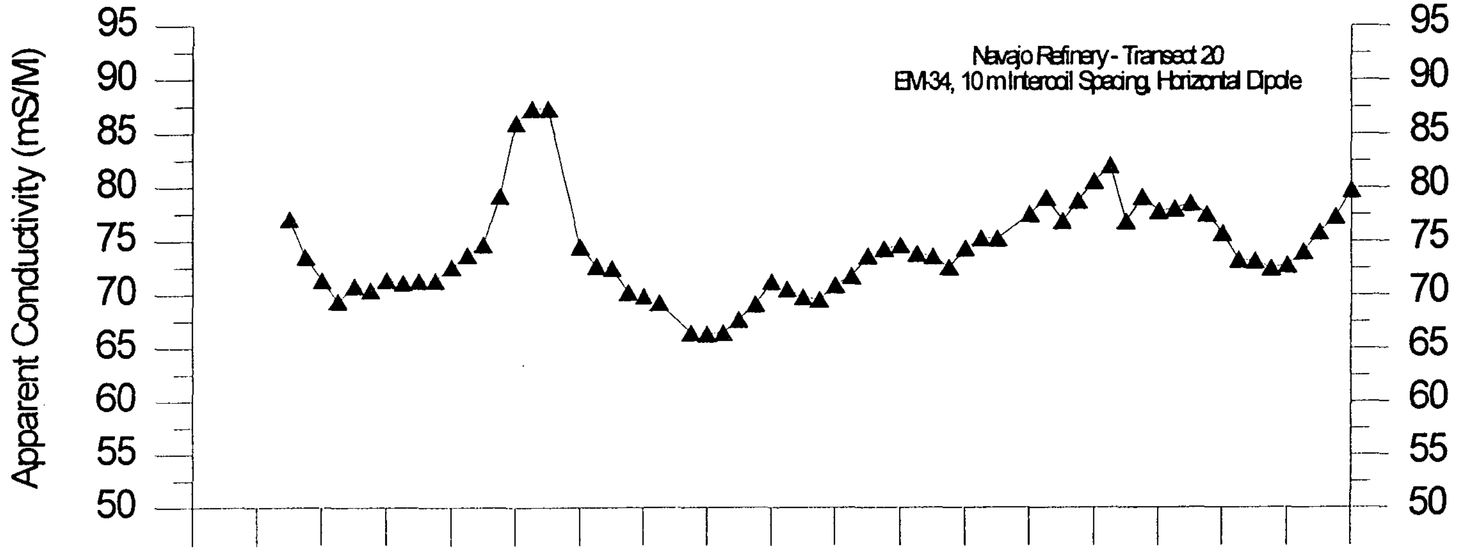

Navajo Refinery - Transect 17
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Navajo Refinery - Transect 17
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

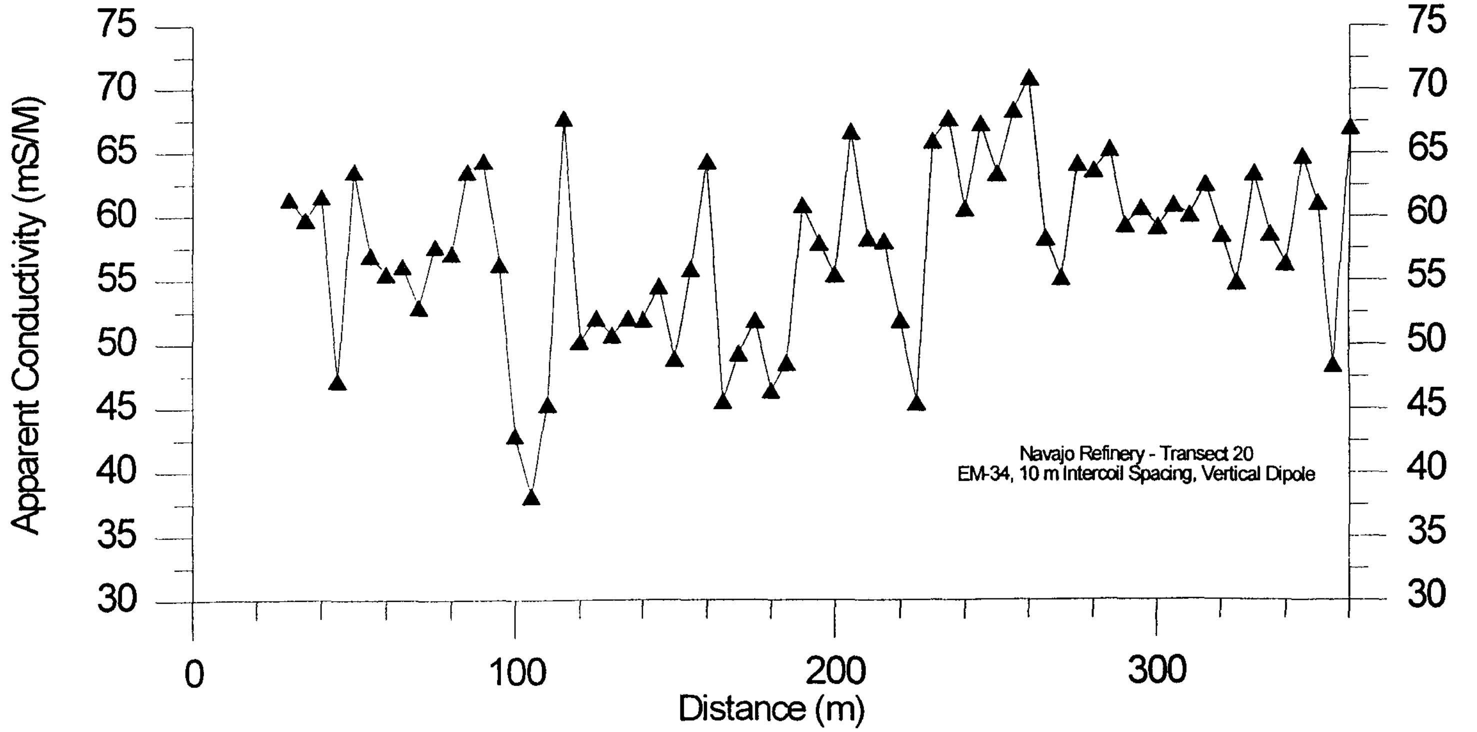

Navajo Refinery - Transect 18
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
95
90
85
80
75
70
65
60
55
50

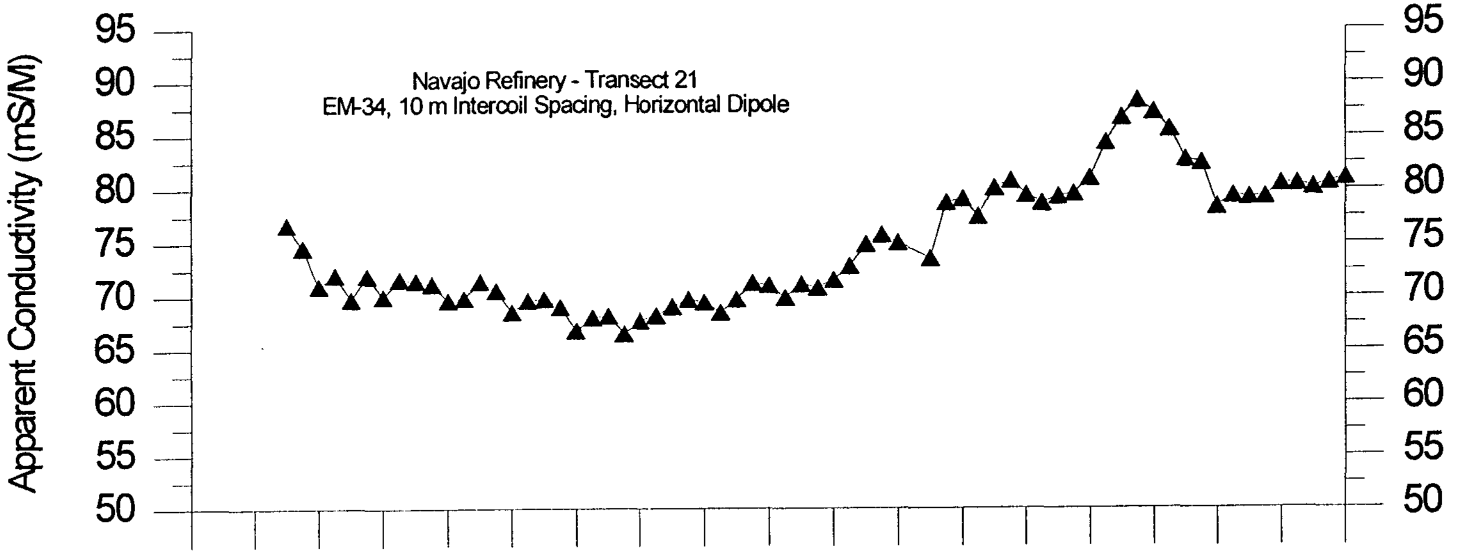

Navajo Refinery - Transect 18
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

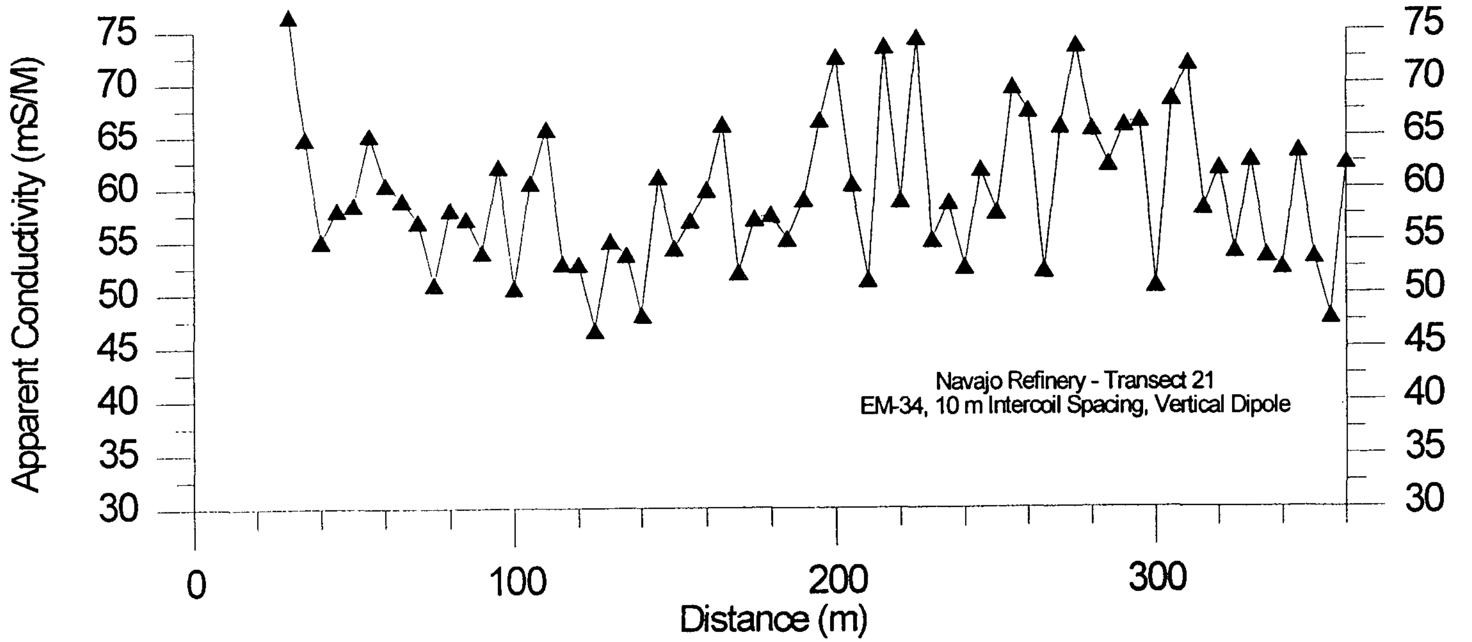

Navajo Refinery - Transect 19
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
95
90
85
80
75
70
65
60
55
50

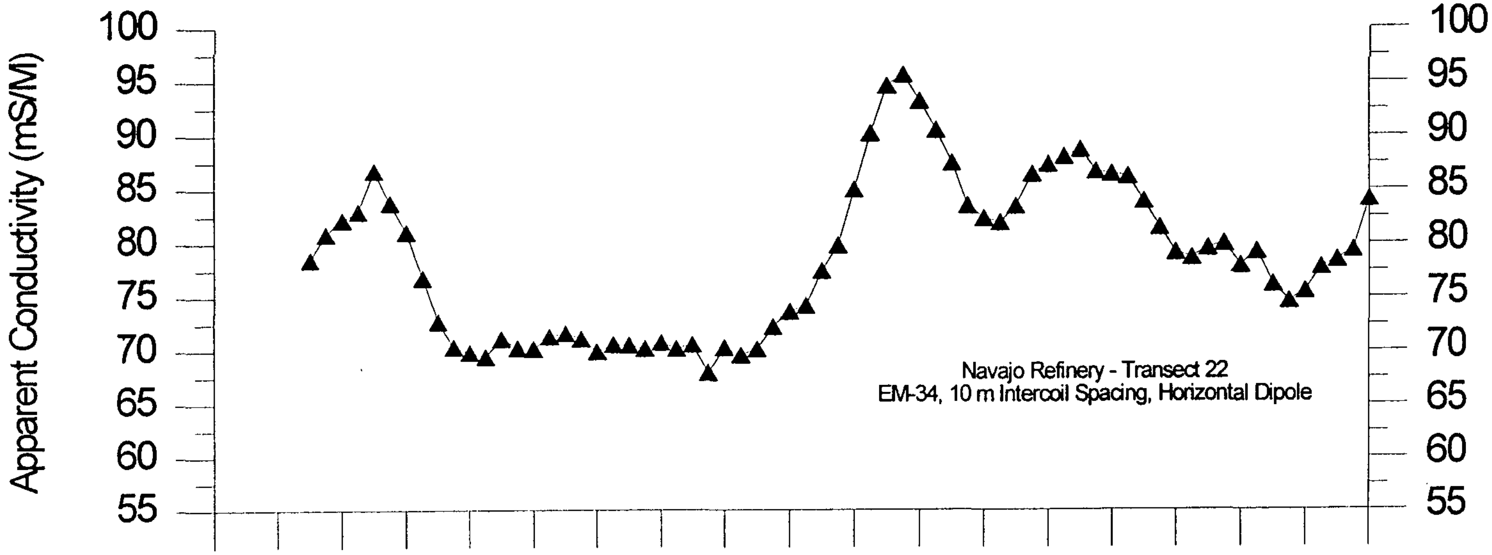

Navajo Refinery - Transect 19
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)


Navajo Refinery - Transect 20
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
95
90
85
80
75
70
65
60
55
50

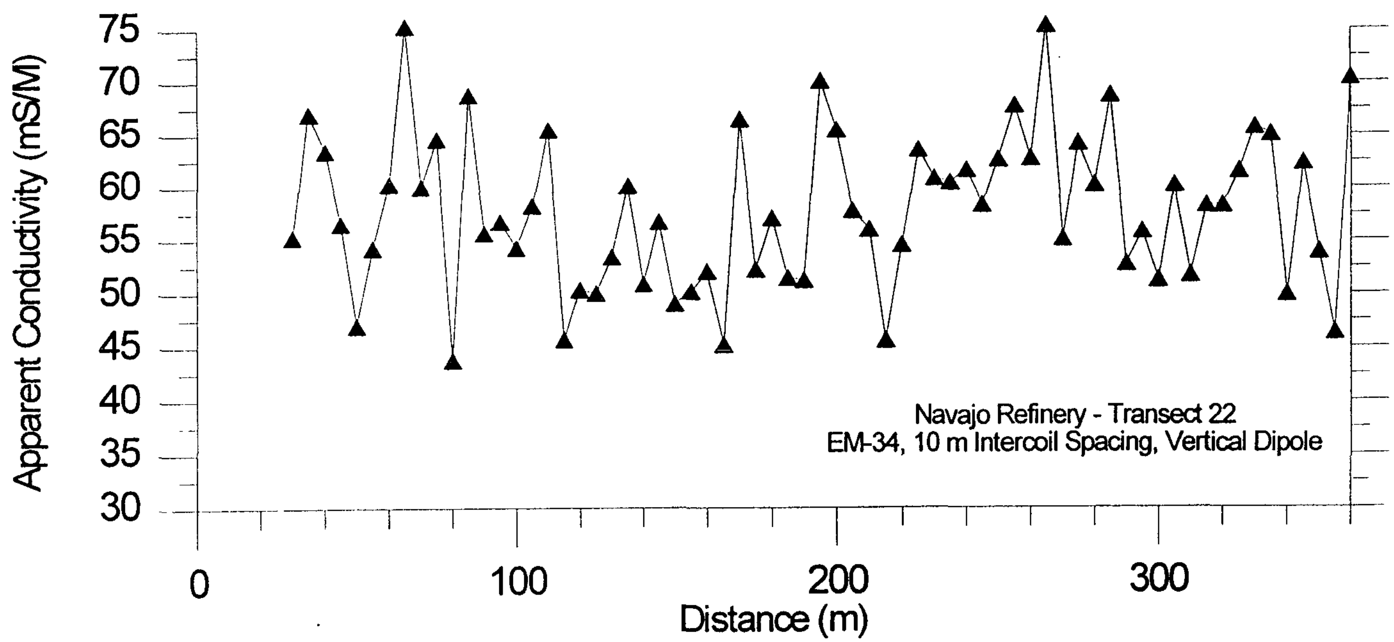

Navajo Refinery - Transect 20
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)


Navajo Refinery - Transect 21
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
95
90
85
80
75
70
65
60
55
50

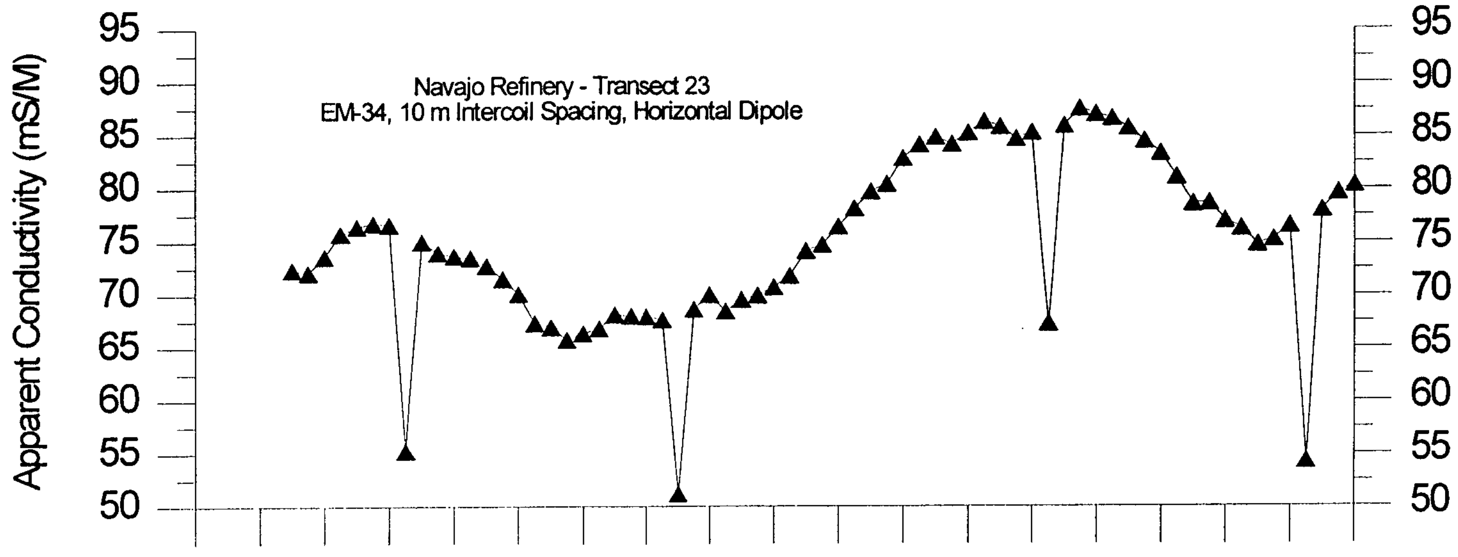

Navajo Refinery - Transect 21
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

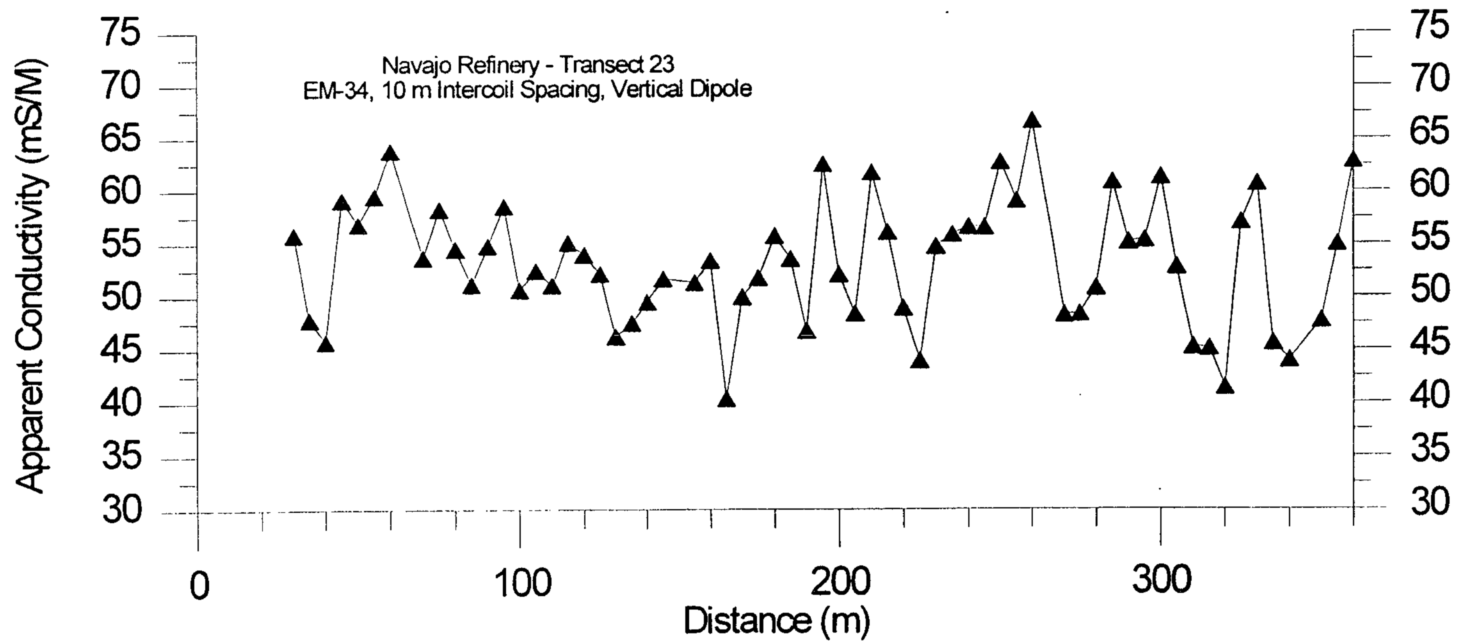


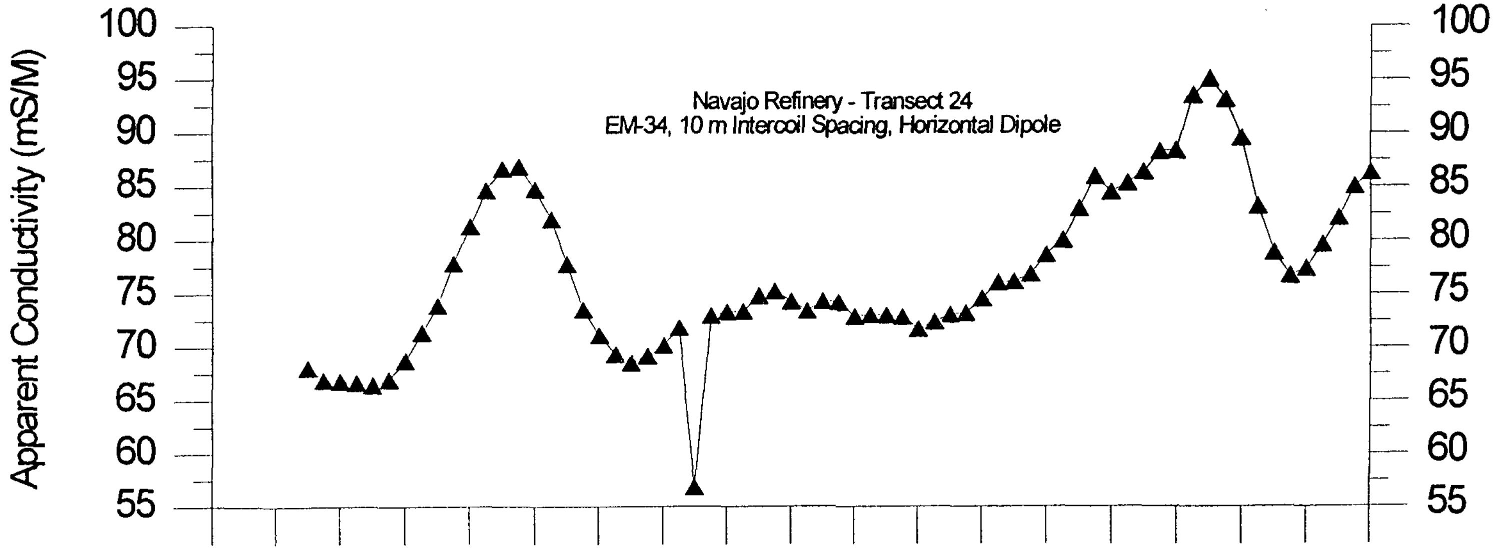
Apparent Conductivity (mS/M)
100
95
90
85
80
75
70
65
60
55
Navajo Refinery - Transect 22
EM-34, 10 m Intercoil Spacing, Horizontal Dipole

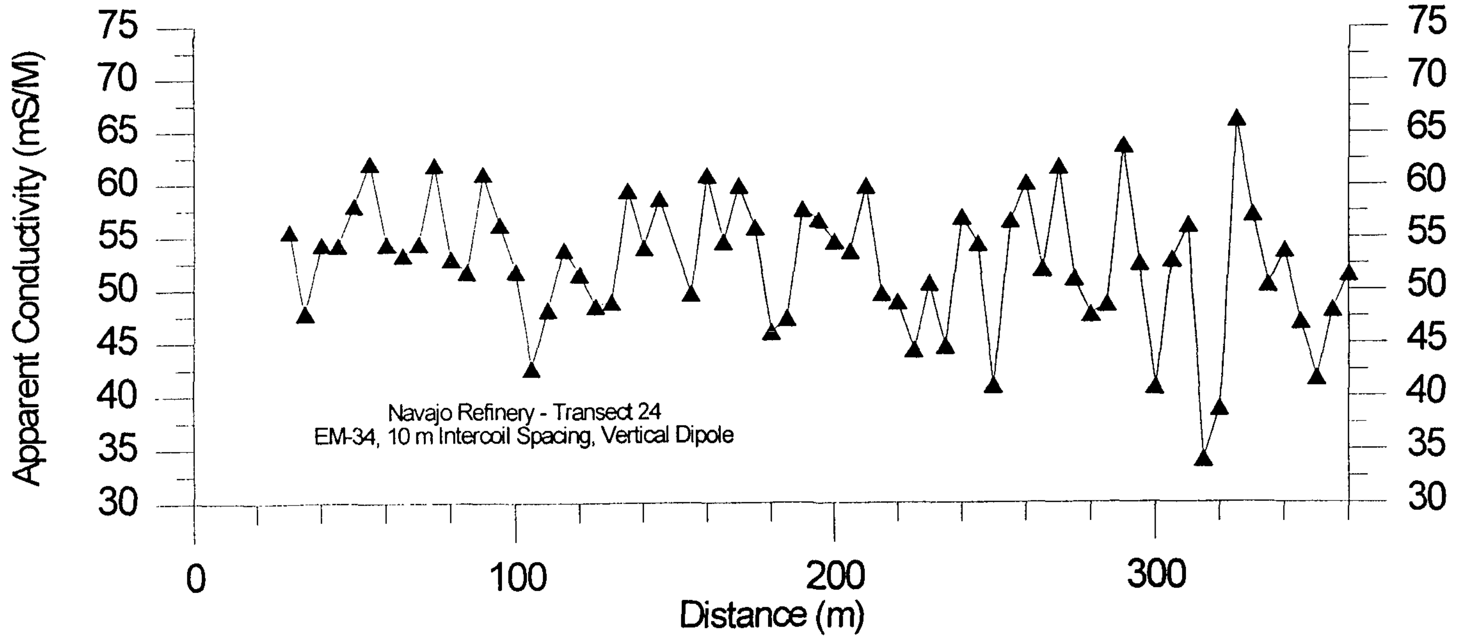



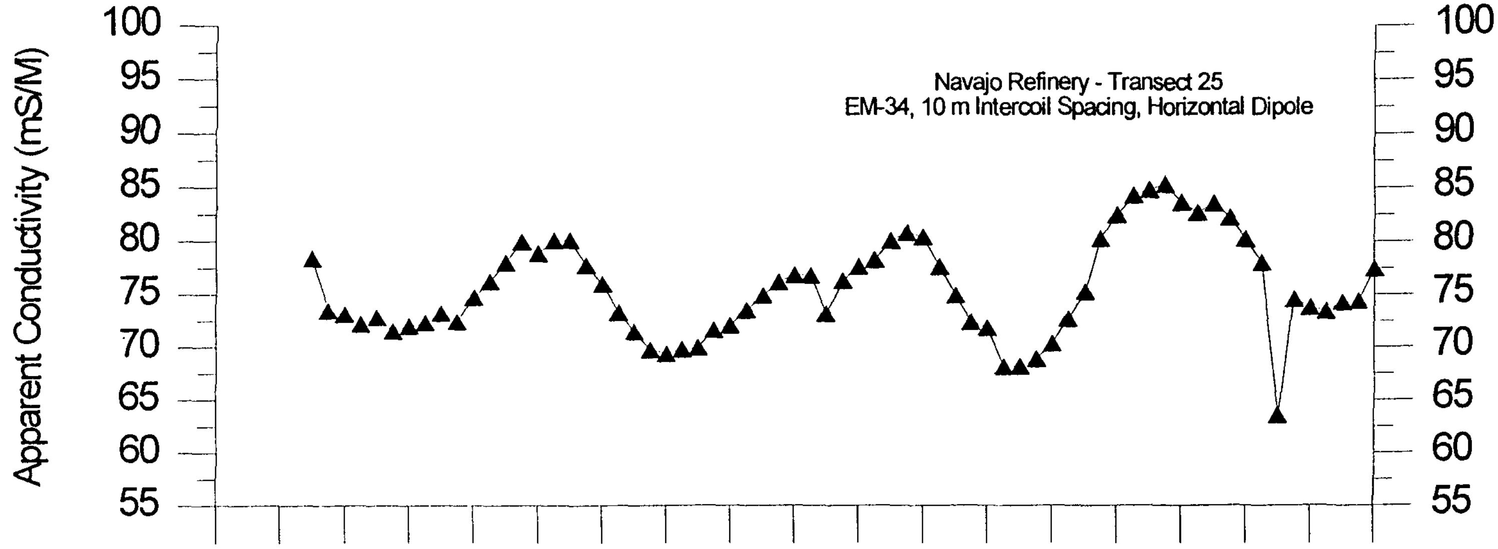
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
Navajo Refinery - Transect 22
EM-34, 10 m Intercoil Spacing, Vertical Dipole
0
100
200
300
Distance (m)


Navajo Refinery - Transect 23
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
95
90
85
80
75
70
65
60
55
50

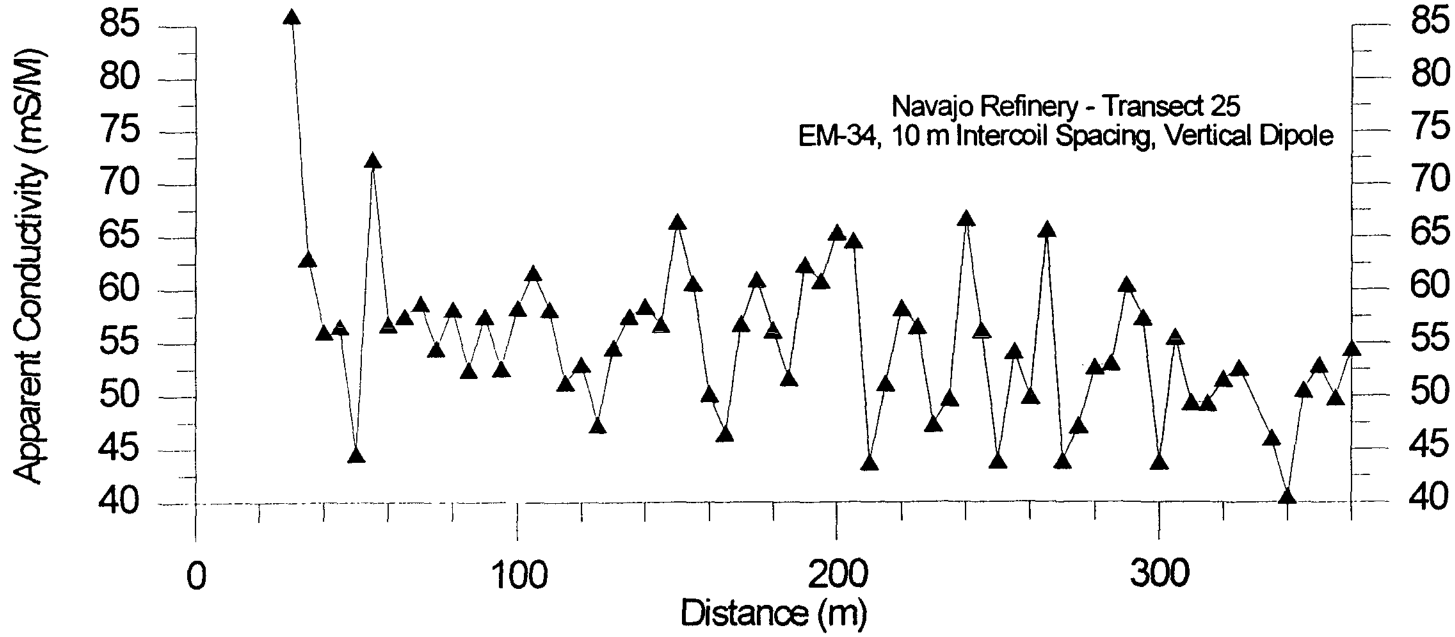

Navajo Refinery - Transect 23
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)


Navajo Refinery - Transect 24
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
100
95
90
85
80
75
70
65
60
55

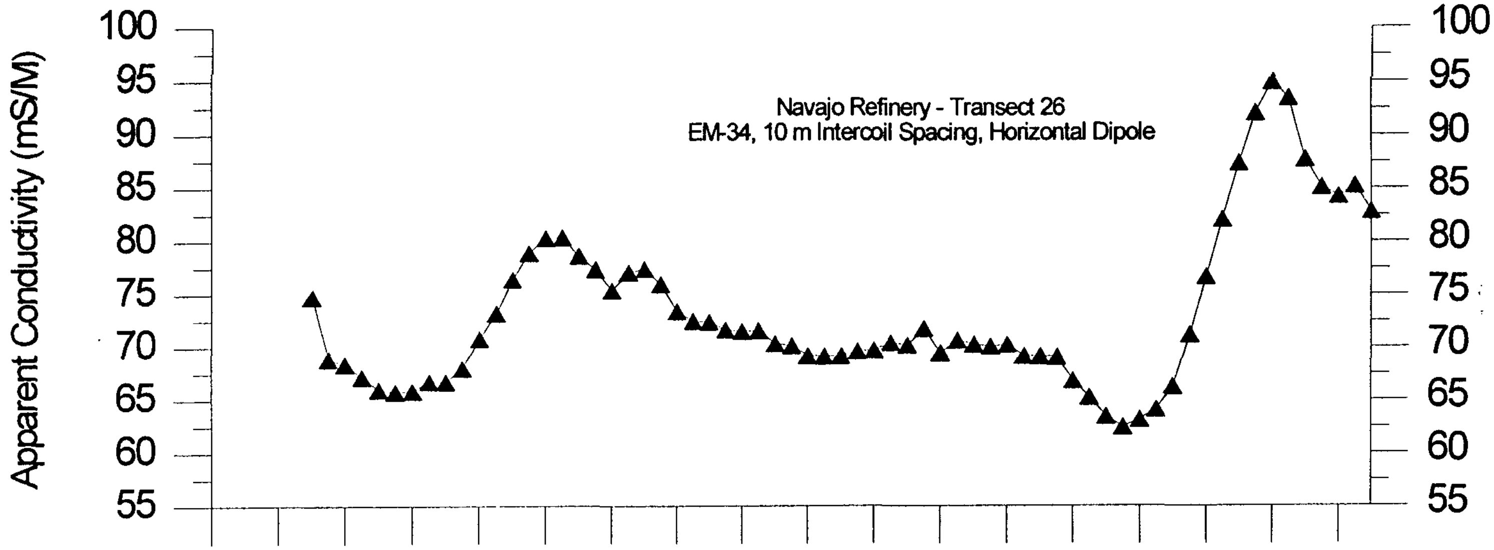

Navajo Refinery - Transect 24
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)



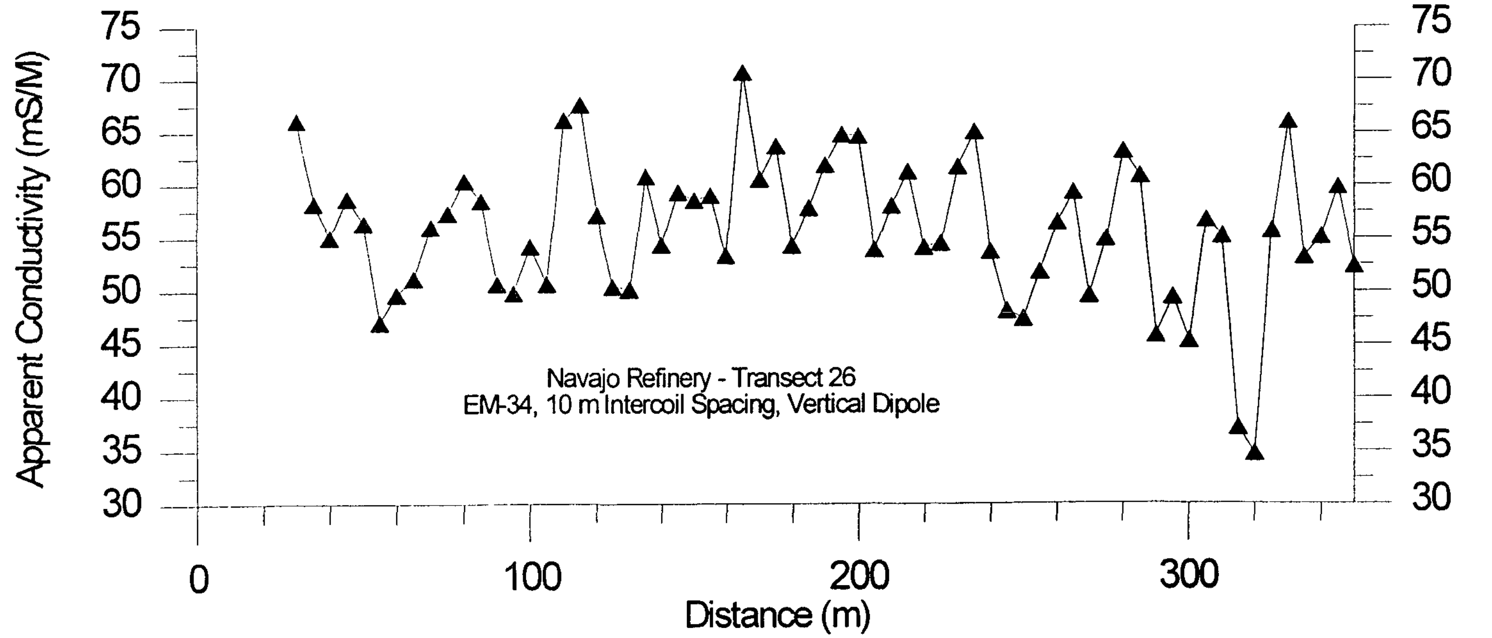
Navajo Refinery - Transect 25
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
100
95
90
85
80
75
70
65
60
55

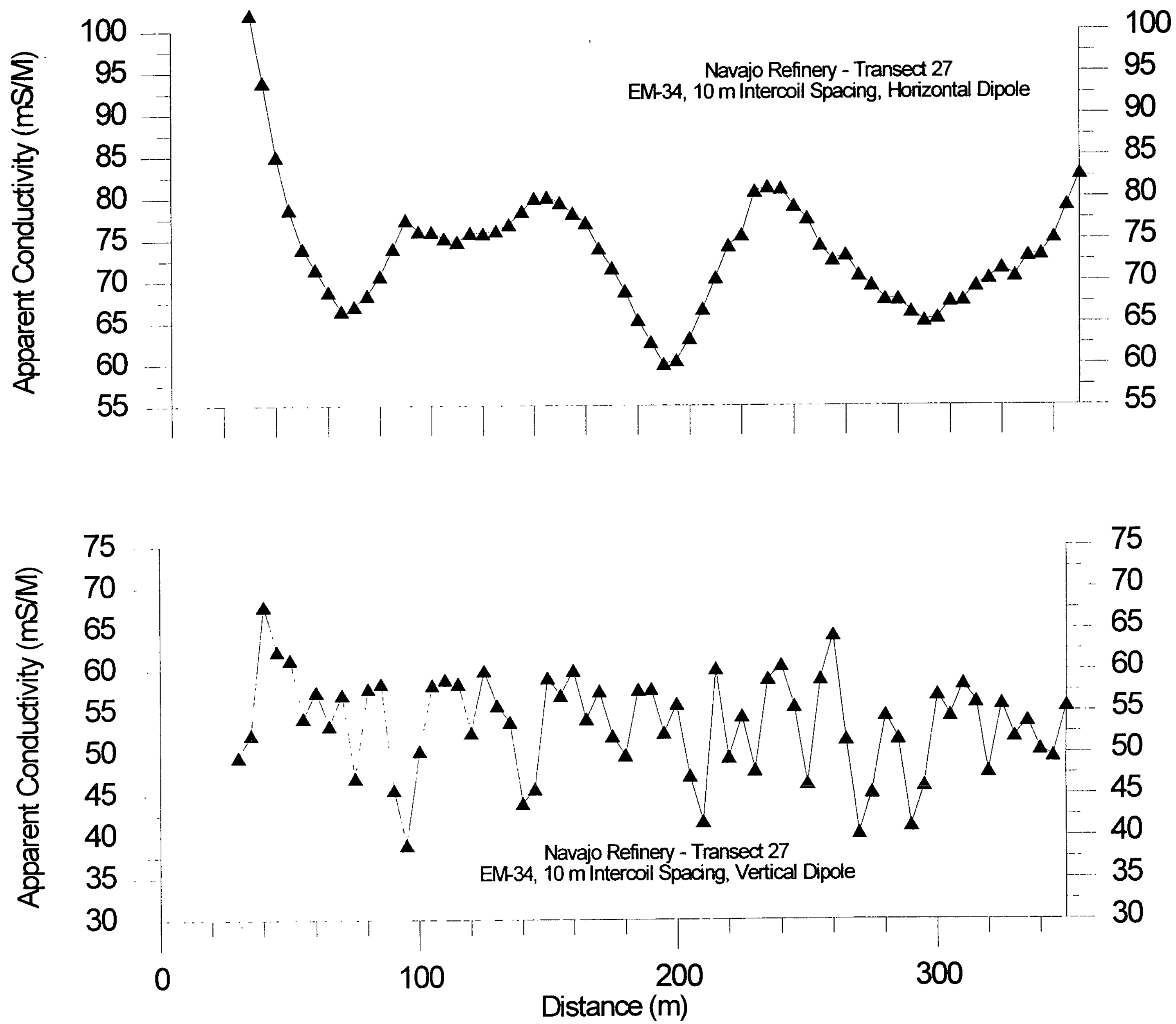
Navajo Refinery - Transect 25
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
85
80
75
70
65
60
55
50
45
40
0
100
200
300
Distance (m)



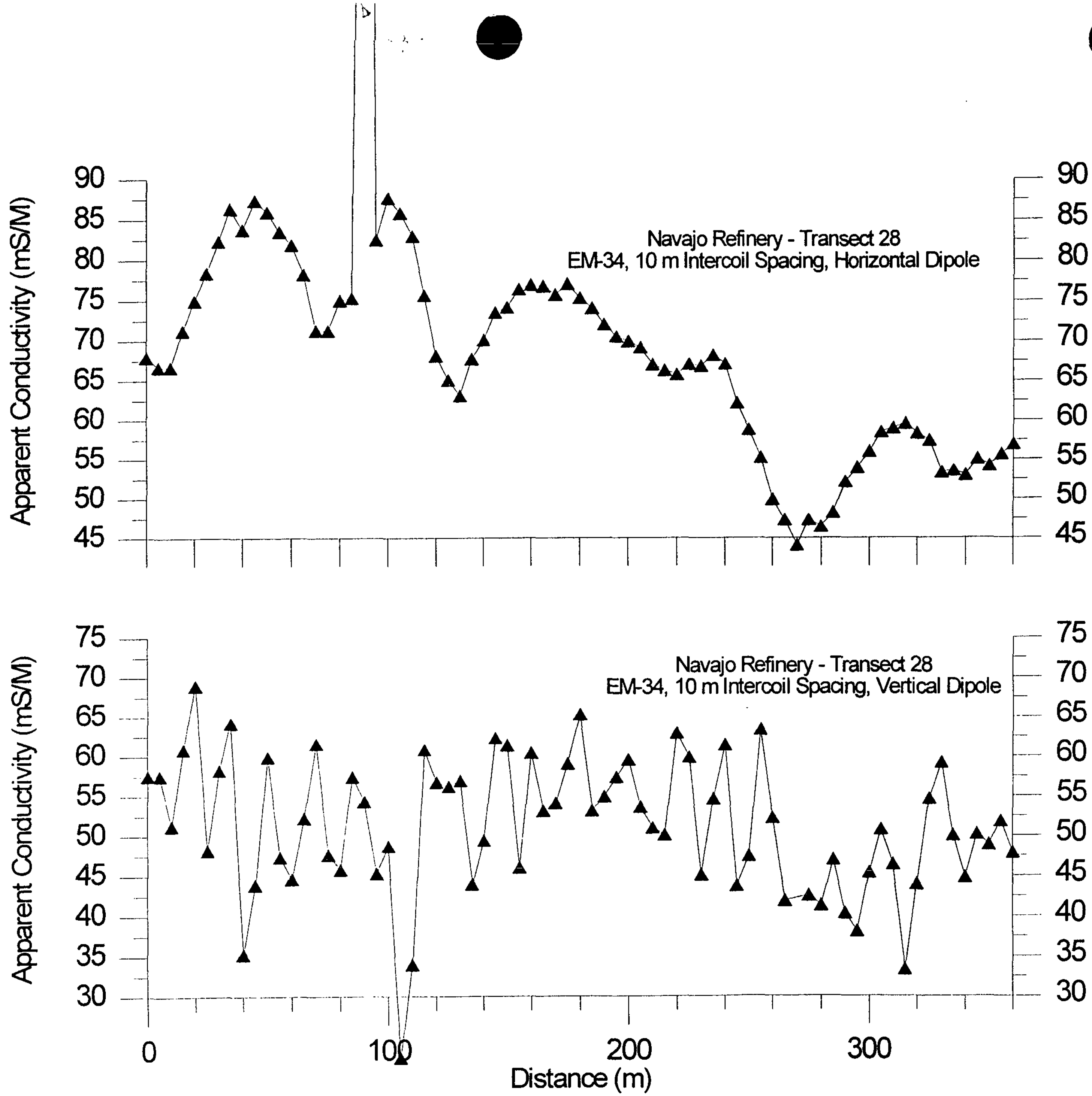
Navajo Refinery - Transect 26
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
100
95
90
85
80
75
70
65
60
55

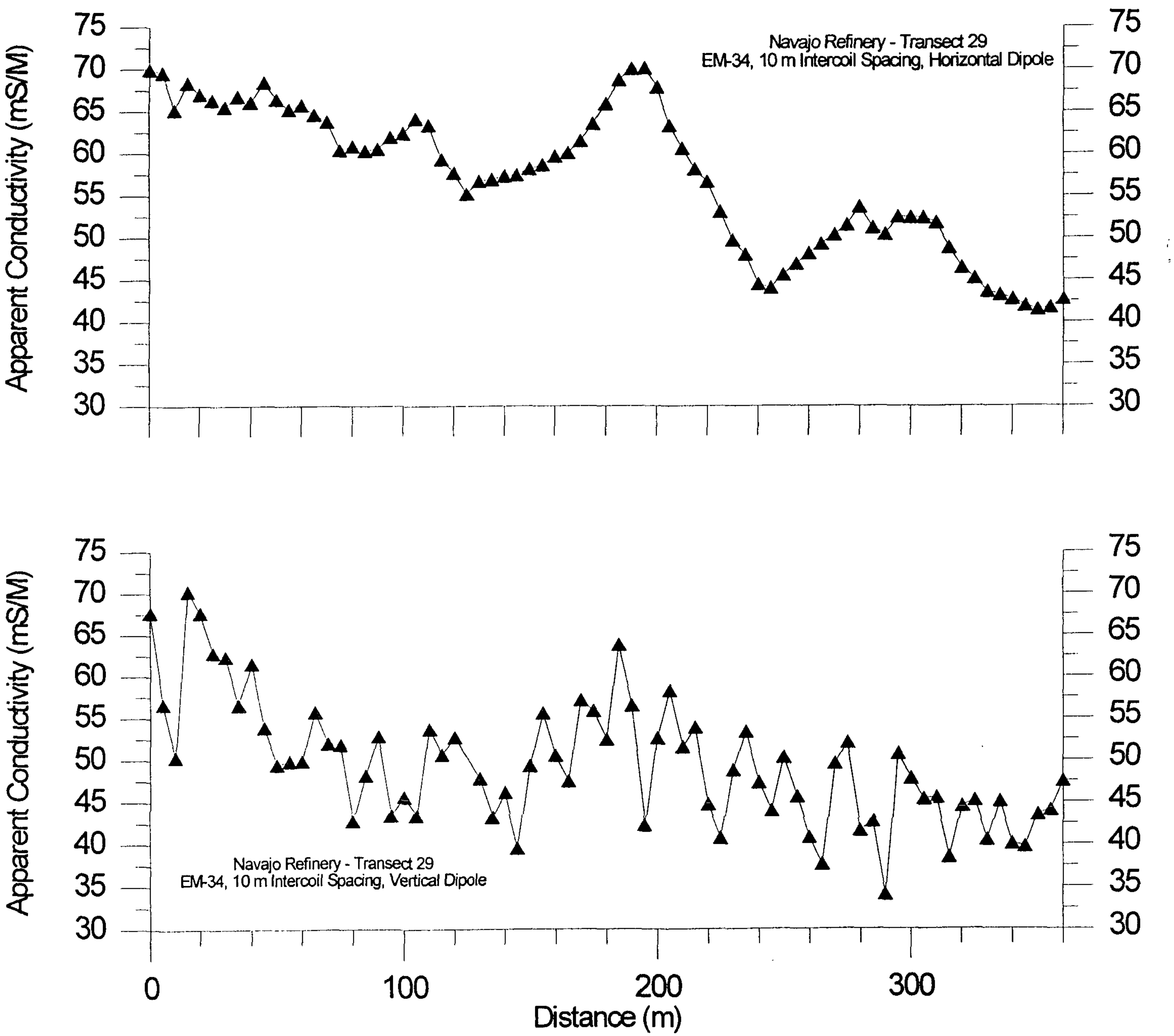



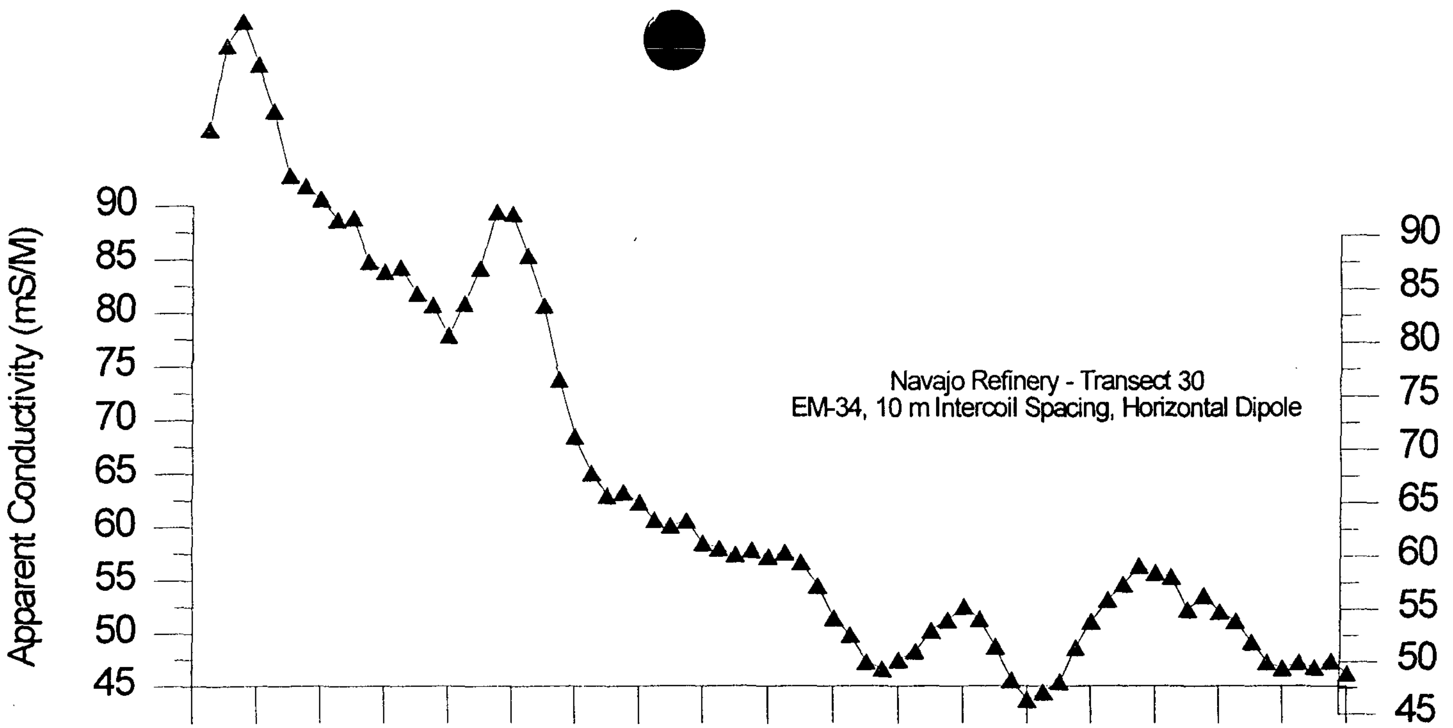
Navajo Refinery - Transect 26
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

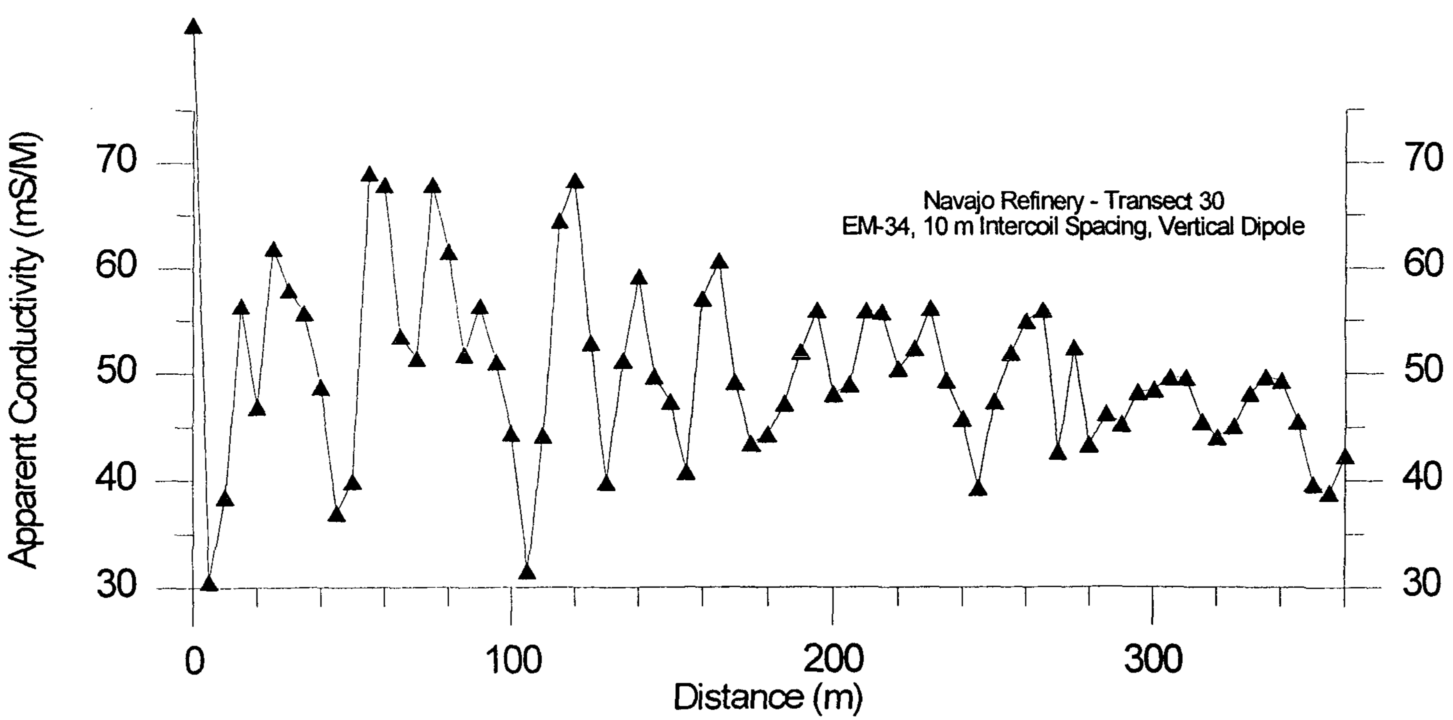


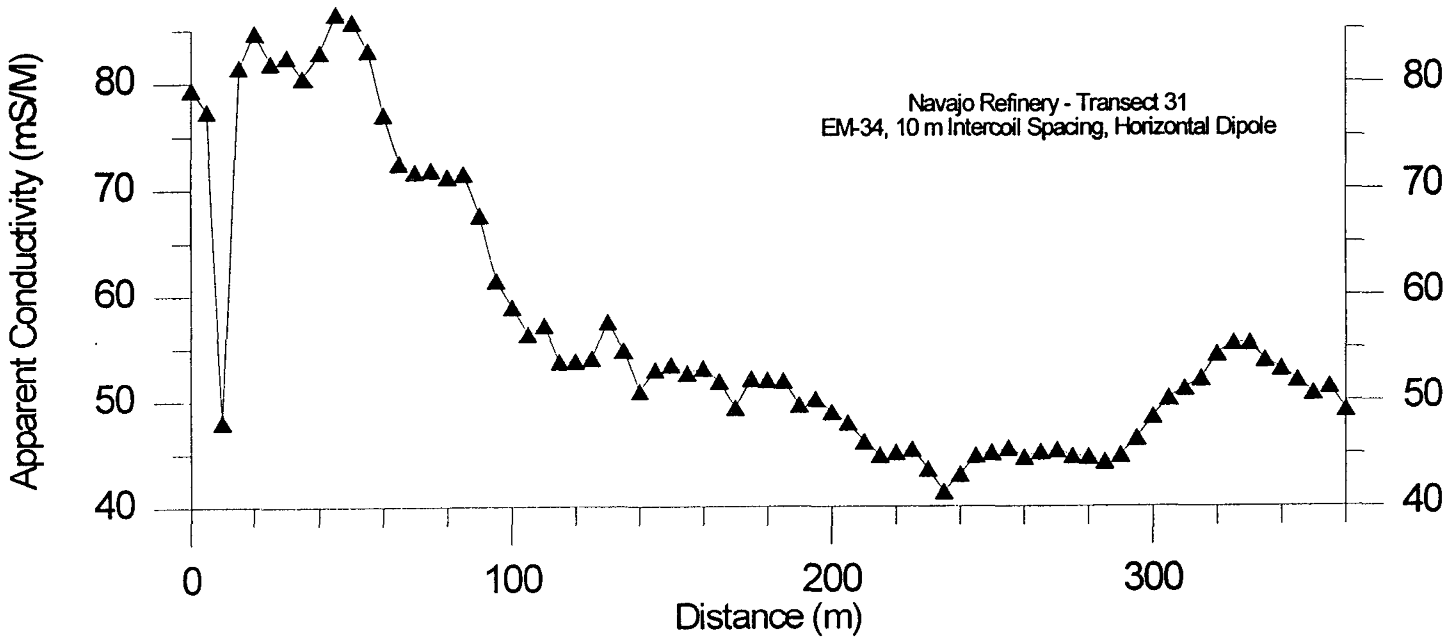
Navajo Refinery - Transect 27
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
Navajo Refinery - Transect 27
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)

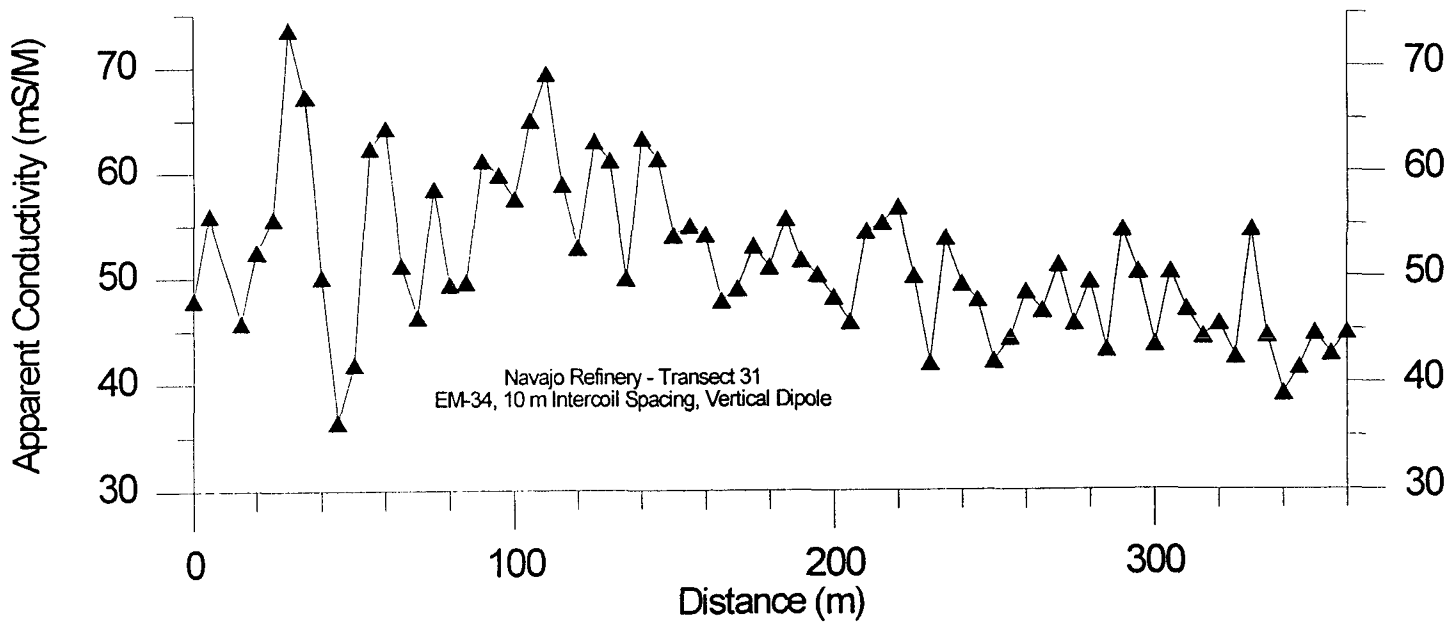

Navajo Refinery - Transect 28
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
90
85
80
75
70
65
60
55
50
45
Navajo Refinery - Transect 28
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

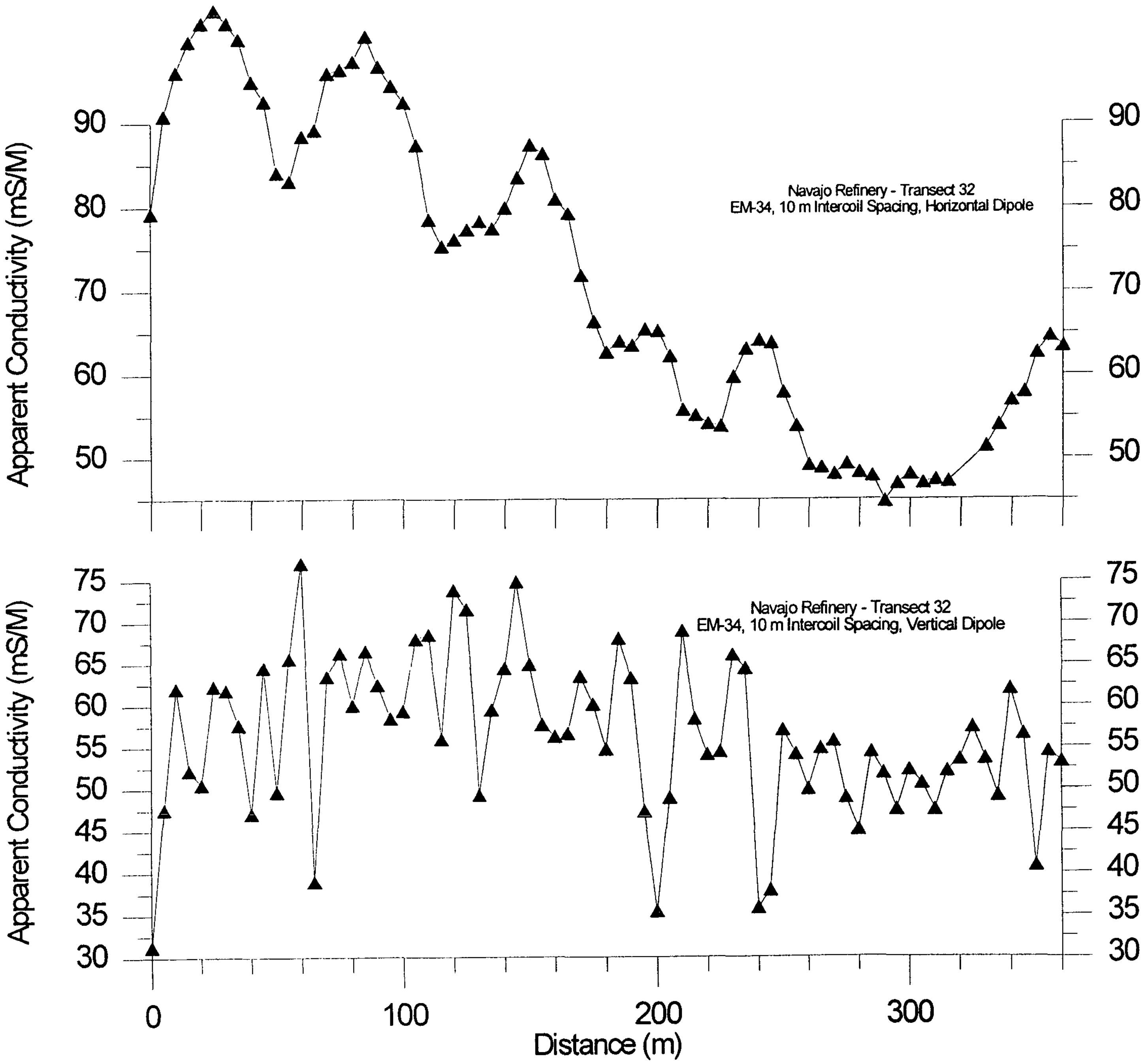

Navajo Refinery - Transect 29
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
Navajo Refinery - Transect 29
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
0
100
200
300
Distance (m)

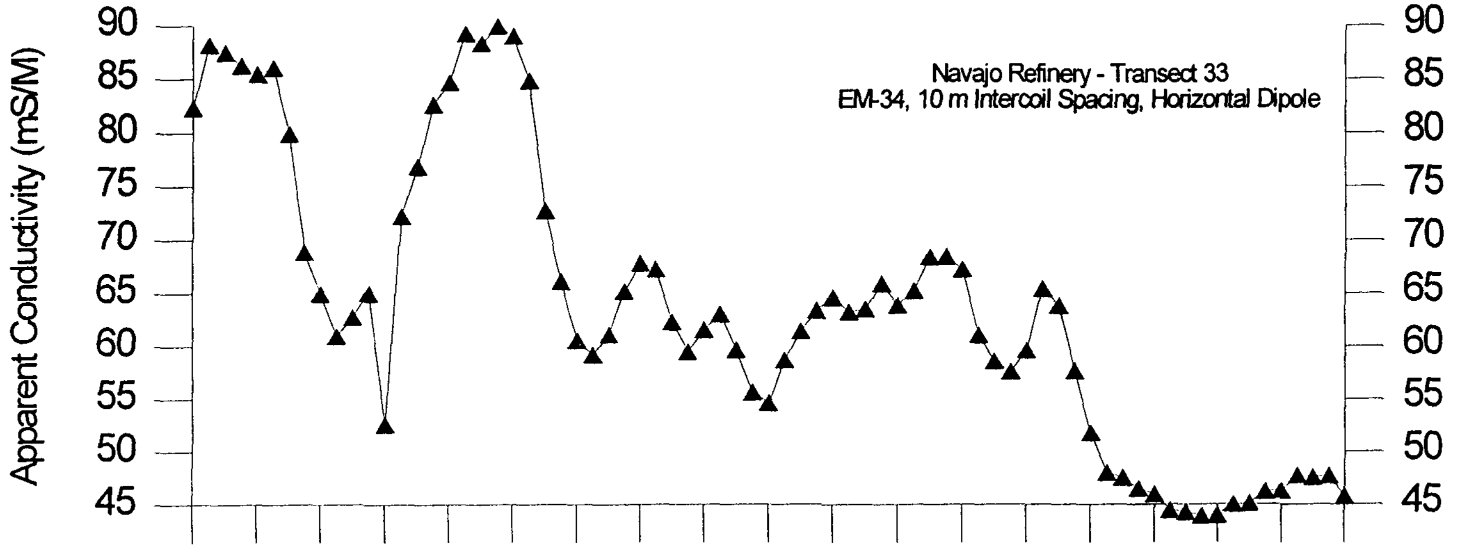

Apparent Conductivity (mS/M)
90
85
80
75
70
65
60
55
50
45
Navajo Refinery - Transect 30
EM-34, 10 m Intercoil Spacing, Horizontal Dipole


Apparent Conductivity (mS/M)
70
60
50
40
30
Navajo Refinery - Transect 30
EM-34, 10 m Intercoil Spacing, Vertical Dipole
0
100
200
300
Distance (m)

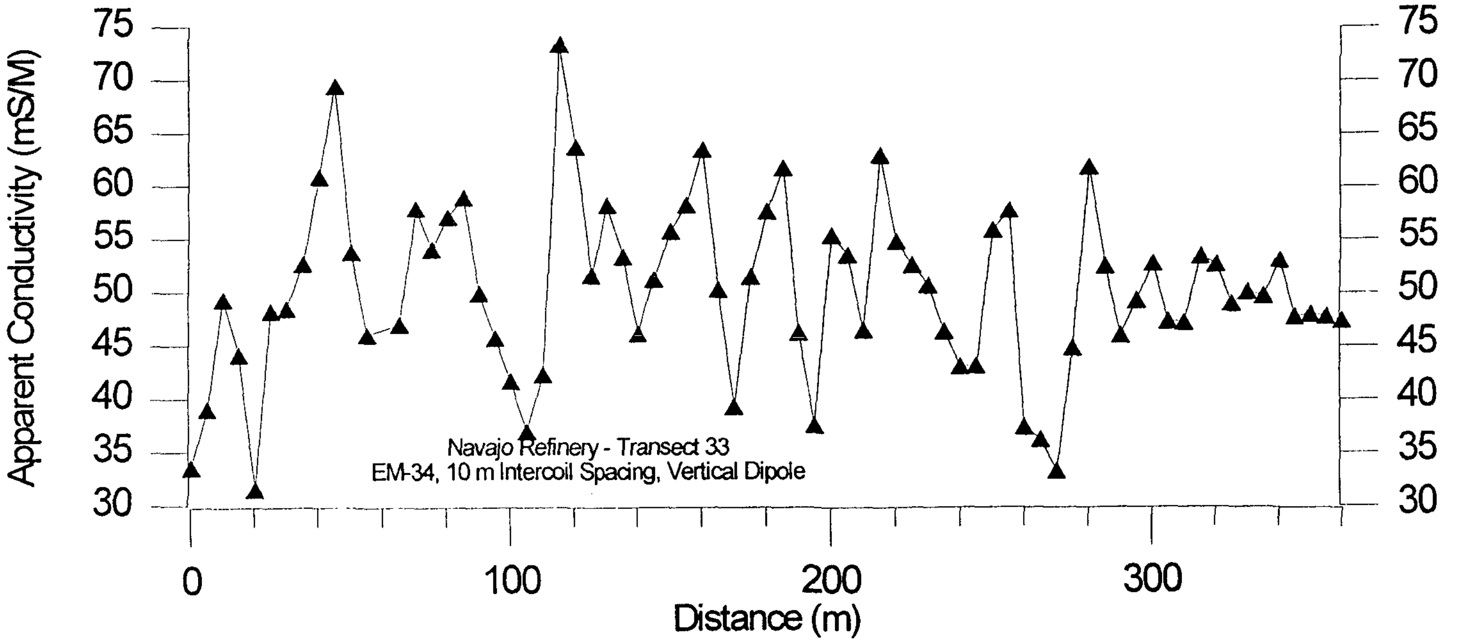

Navajo Refinery - Transect 31
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
Distance (m)
0
100
200
300
40
50
60
70
80


Navajo Refinery - Transect 31
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)
0
100
200
300
30
40
50
60
70

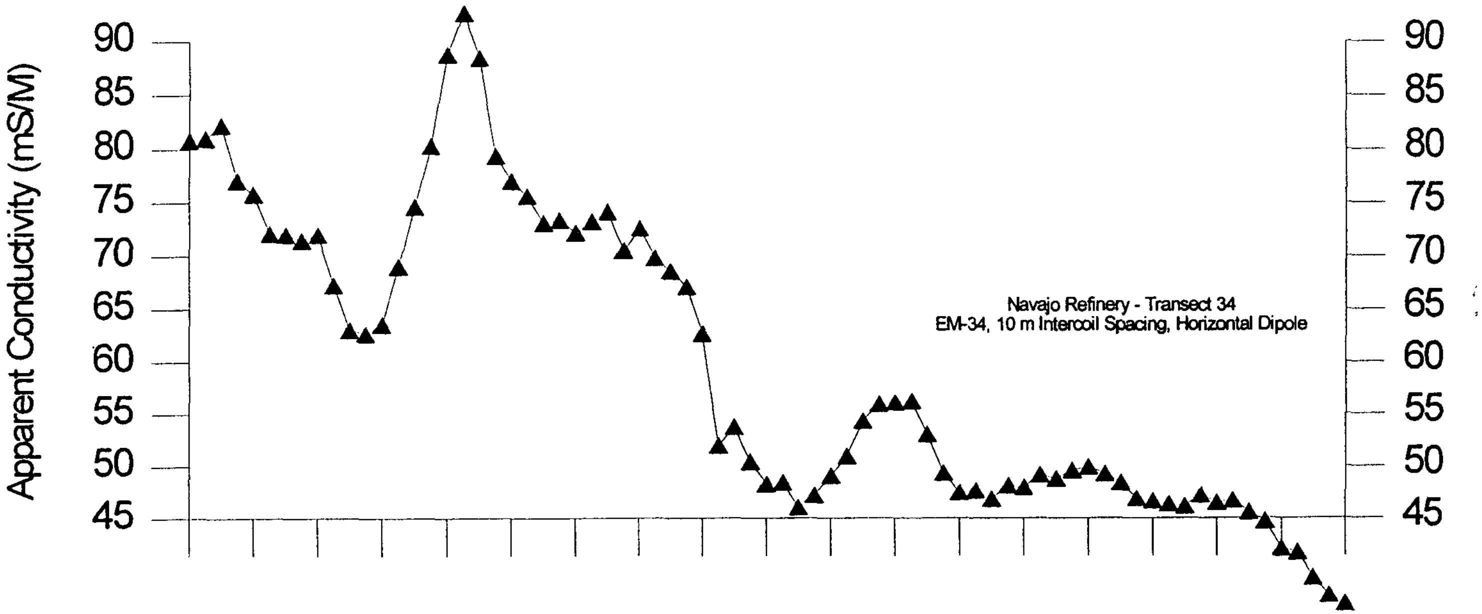

Navajo Refinery - Transect 32
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Navajo Refinery - Transect 32
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Apparent Conductivity (mS/M)
Distance (m)

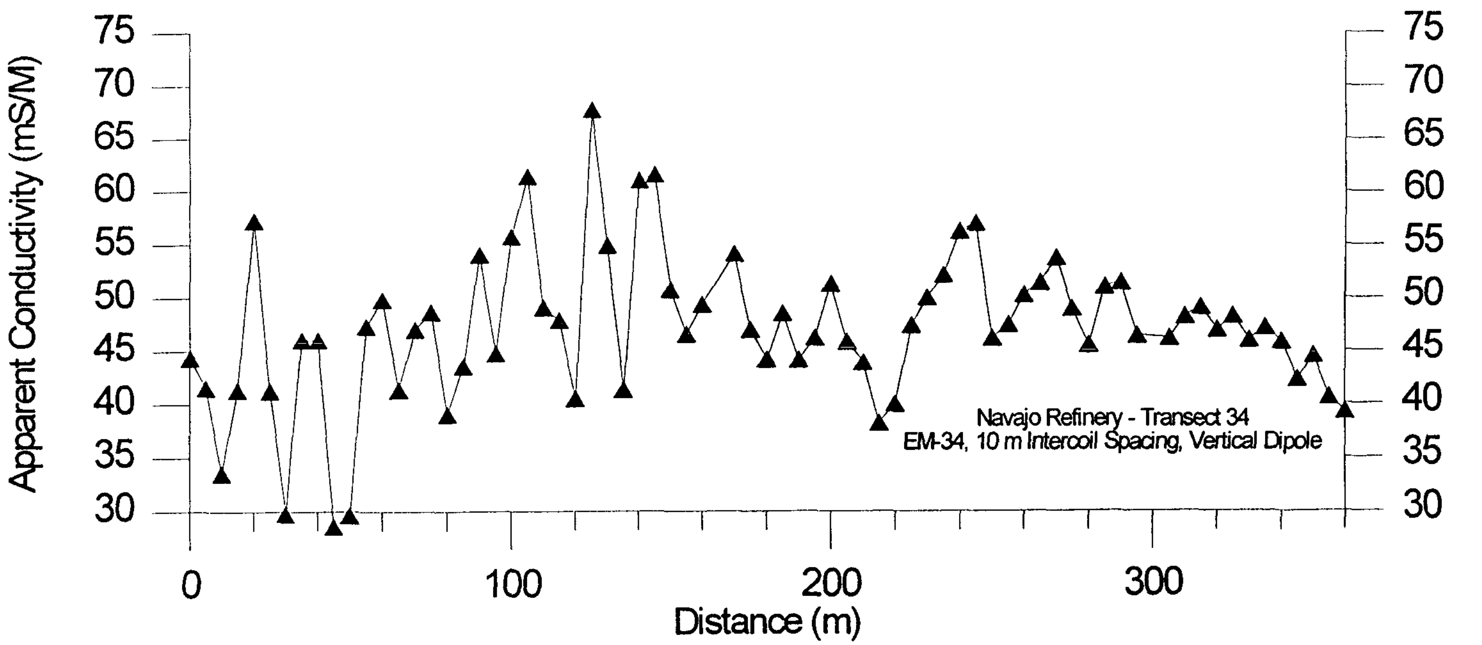


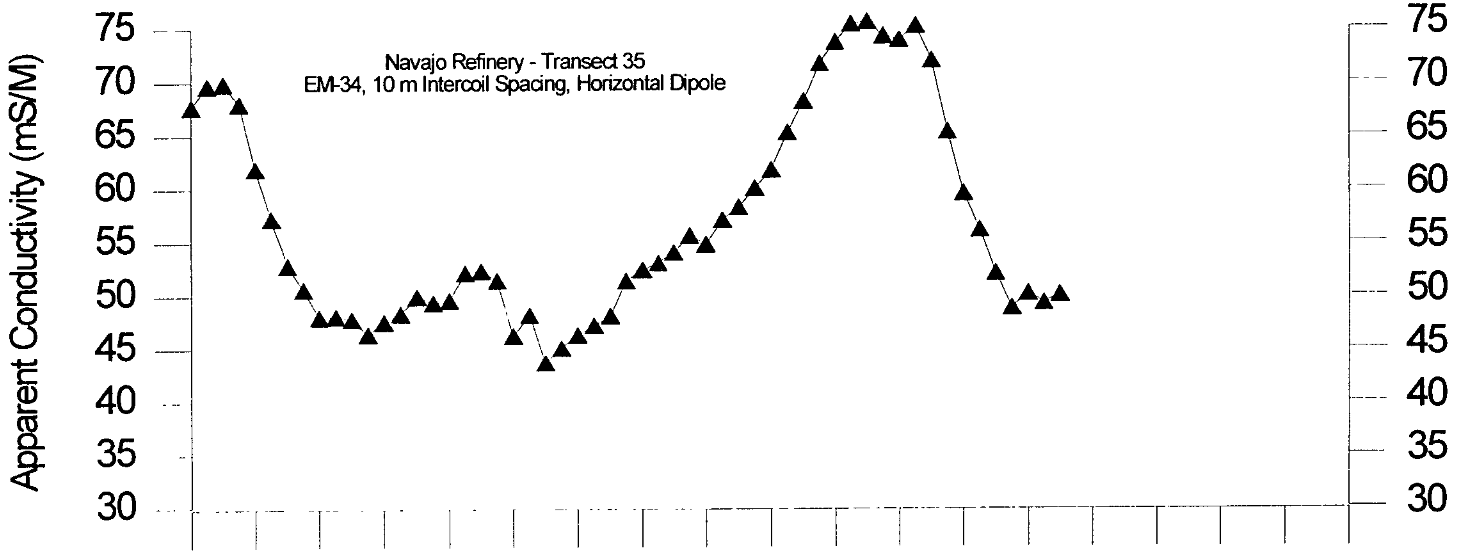
Navajo Refinery - Transect 33
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
90
85
80
75
70
65
60
55
50
45

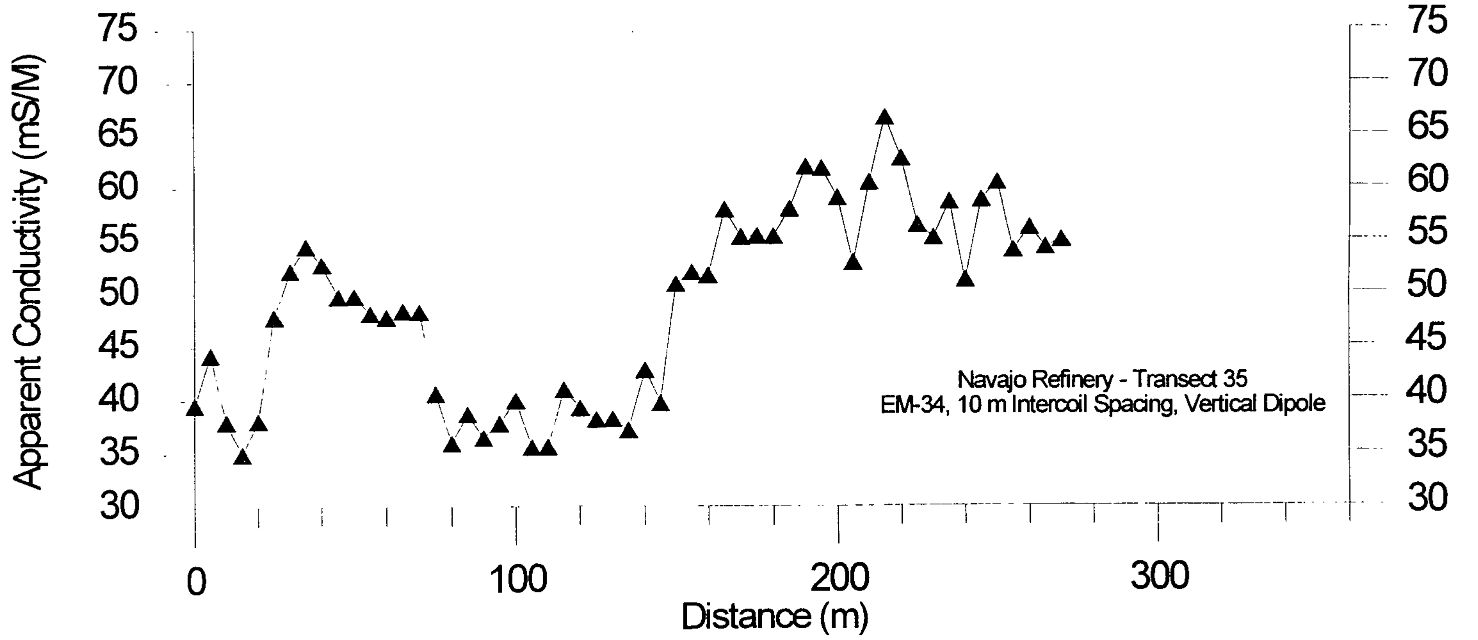



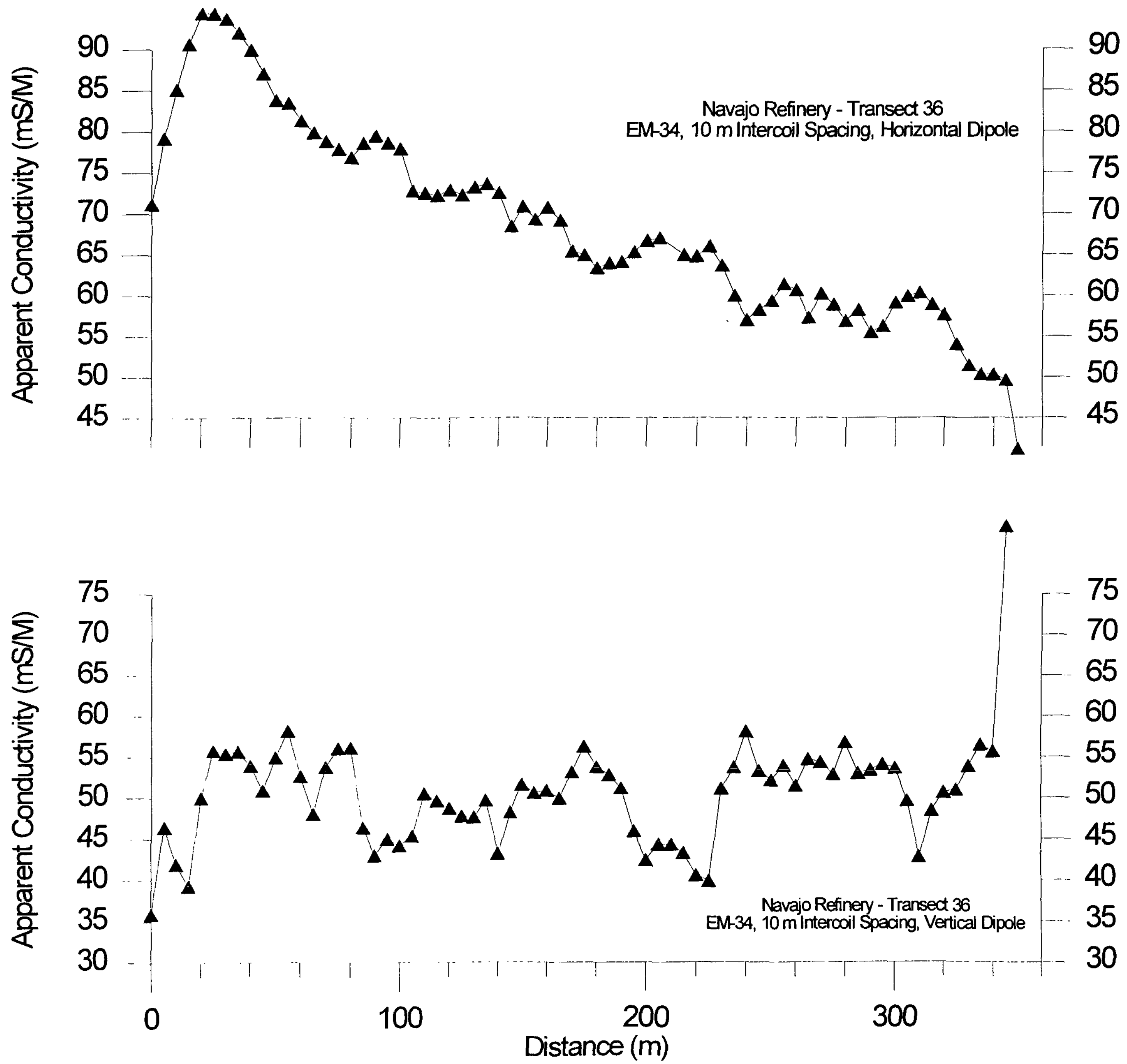
Navajo Refinery - Transect 33
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

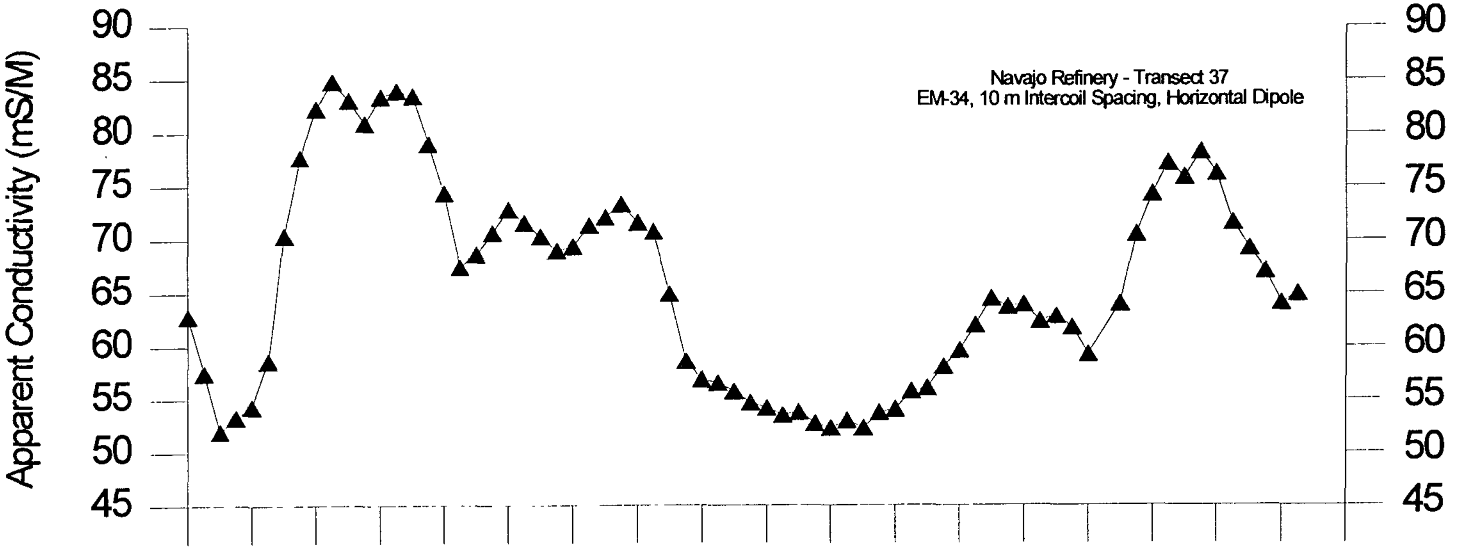

Apparent Conductivity (mS/M)
90
85
80
75
70
65
60
55
50
45
Navajo Refinery - Transect 34
EM-34, 10 m Intercoil Spacing, Horizontal Dipole

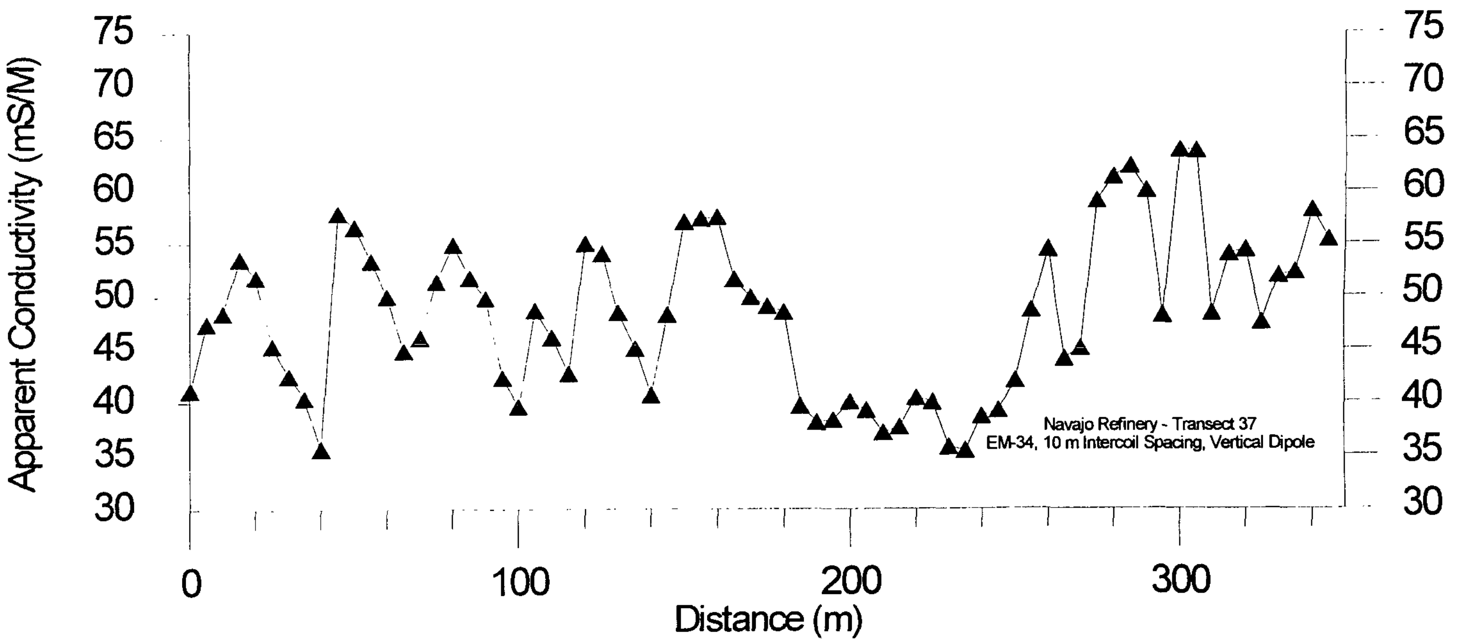

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
Navajo Refinery - Transect 34
EM-34, 10 m Intercoil Spacing, Vertical Dipole
0
100
200
300
Distance (m)

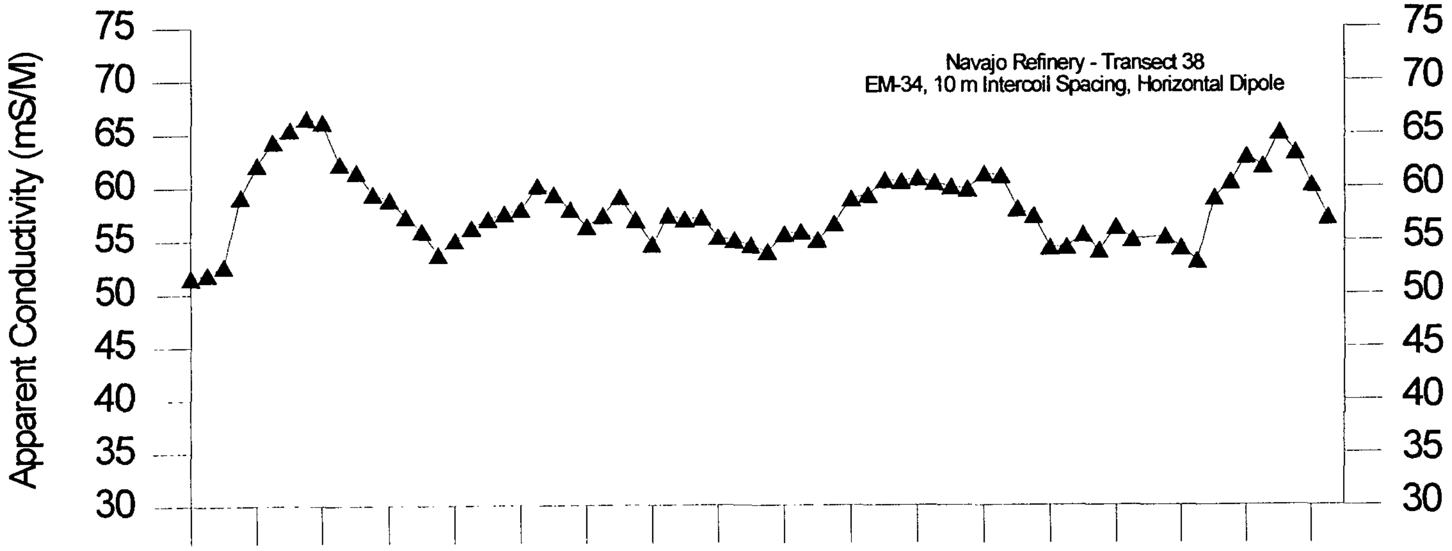

Navajo Refinery - Transect 35
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30

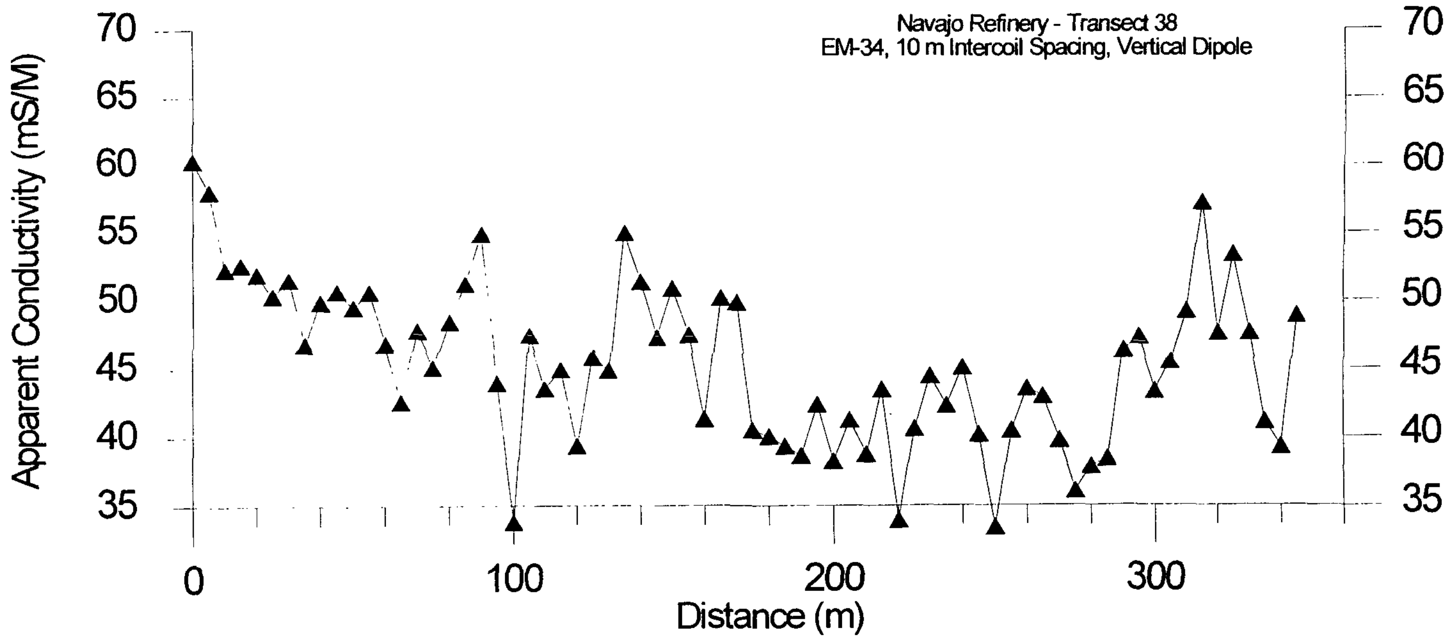

Navajo Refinery - Transect 35
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

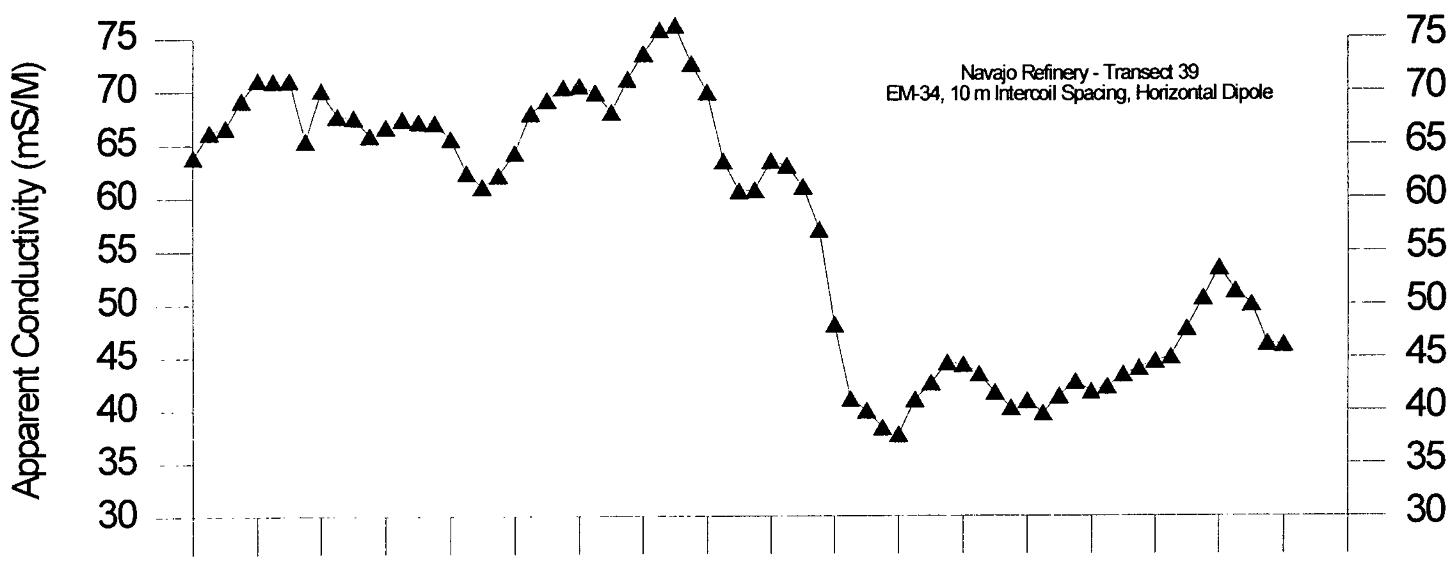

Navajo Refinery - Transect 36
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
90
85
80
75
70
65
60
55
50
45
Navajo Refinery - Transect 36
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

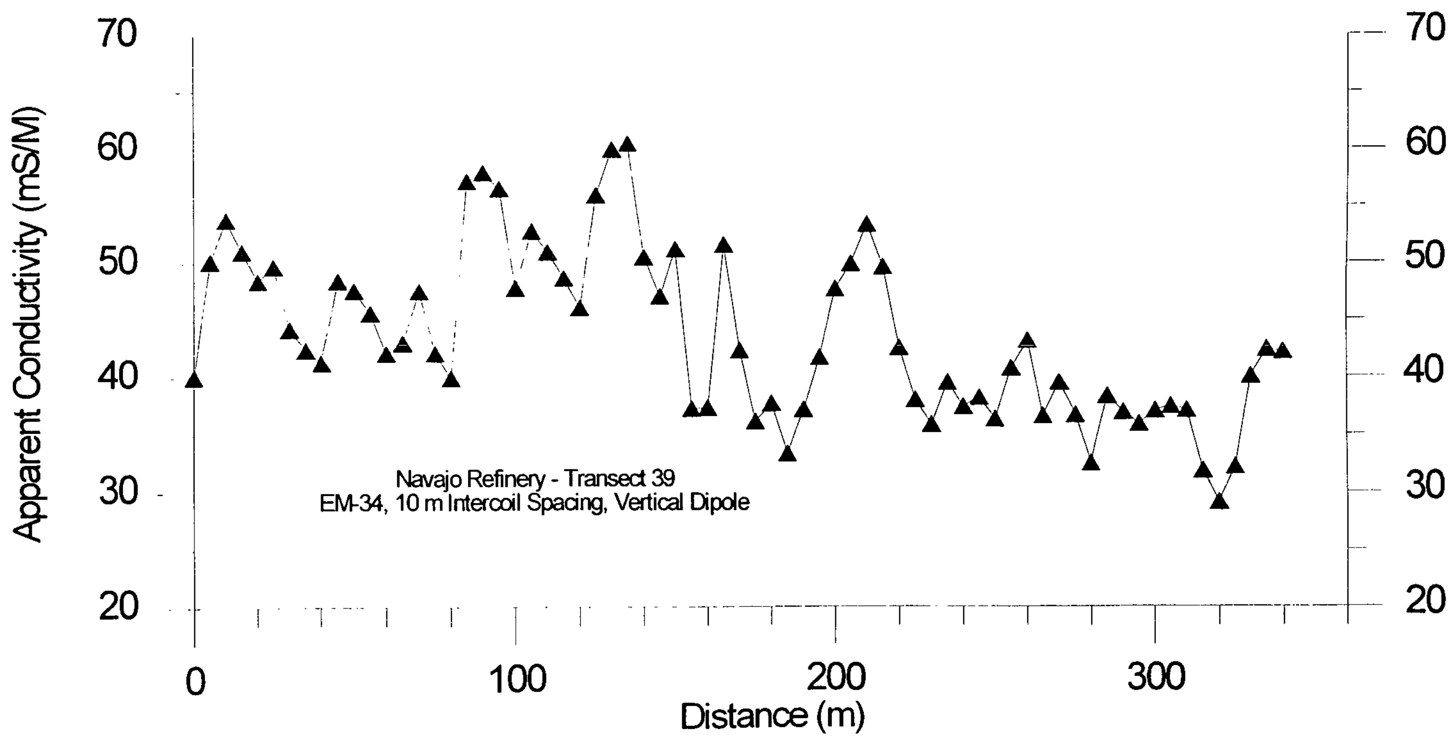

Navajo Refinery - Transect 37
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
90
85
80
75
70
65
60
55
50
45

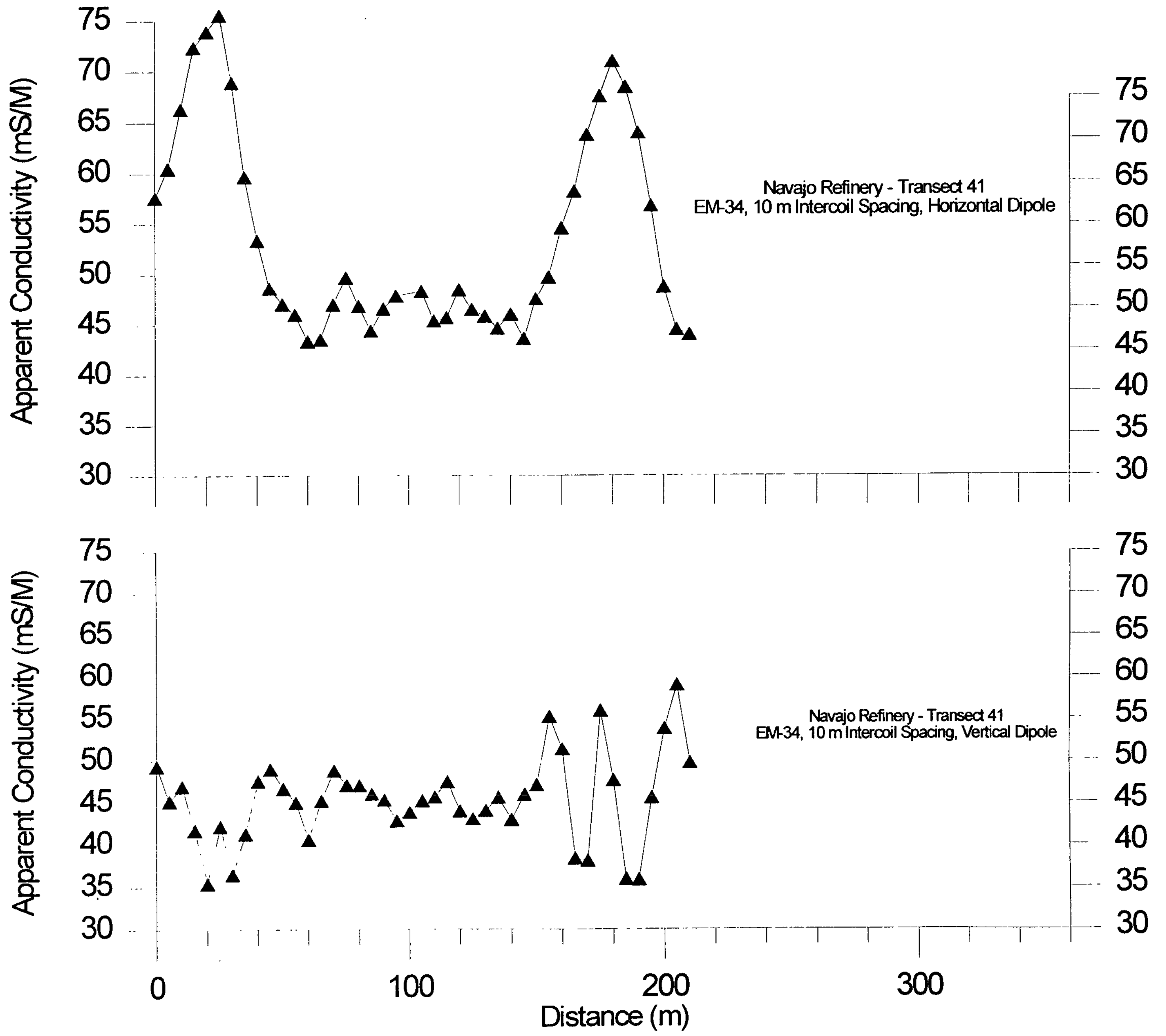

Navajo Refinery - Transect 37
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

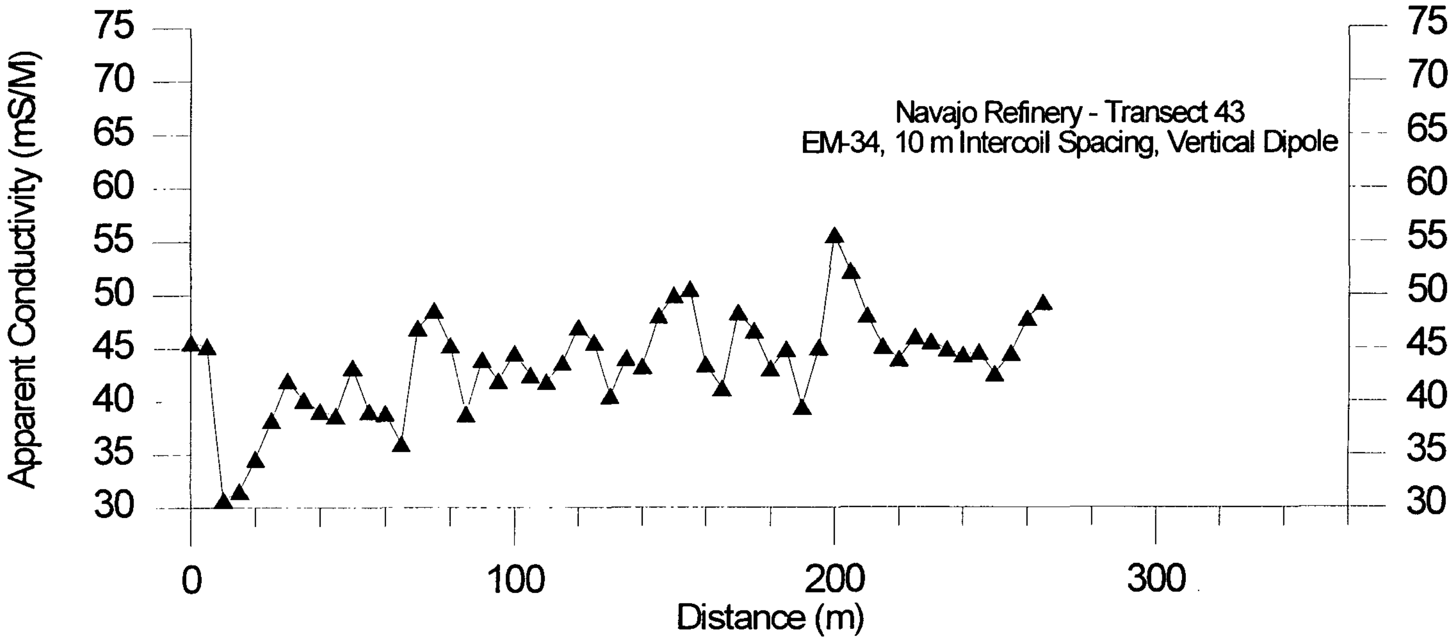

Navajo Refinery - Transect 38
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30

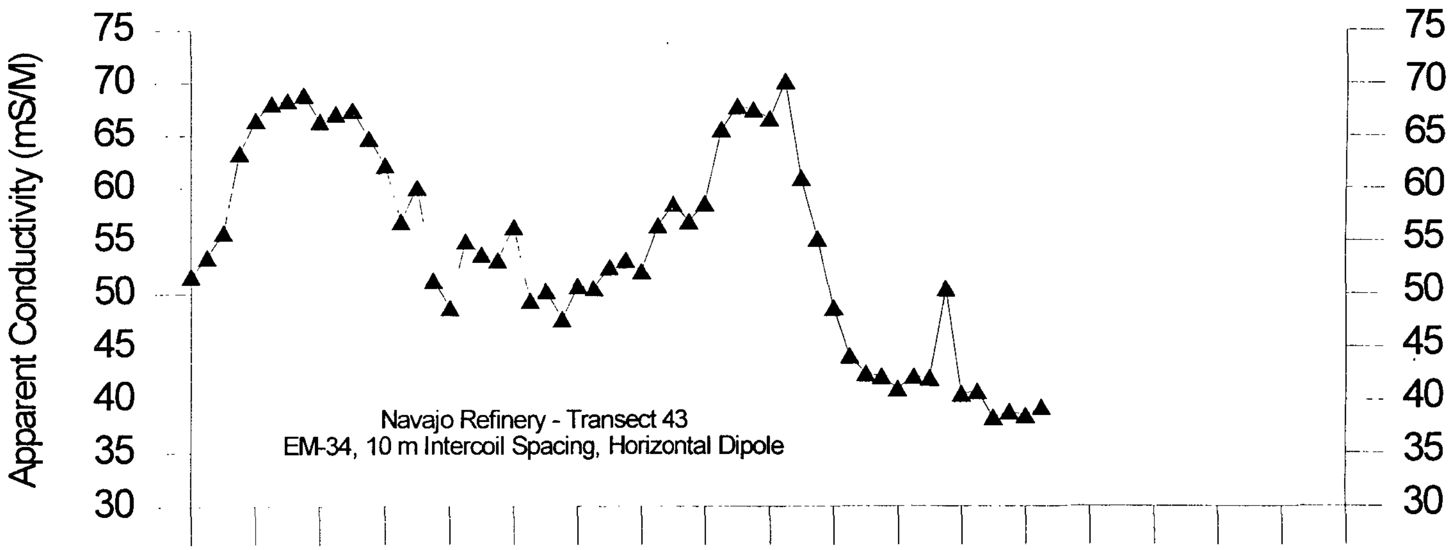

Navajo Refinery - Transect 38
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
70
65
60
55
50
45
40
35
0
100
200
300
Distance (m)

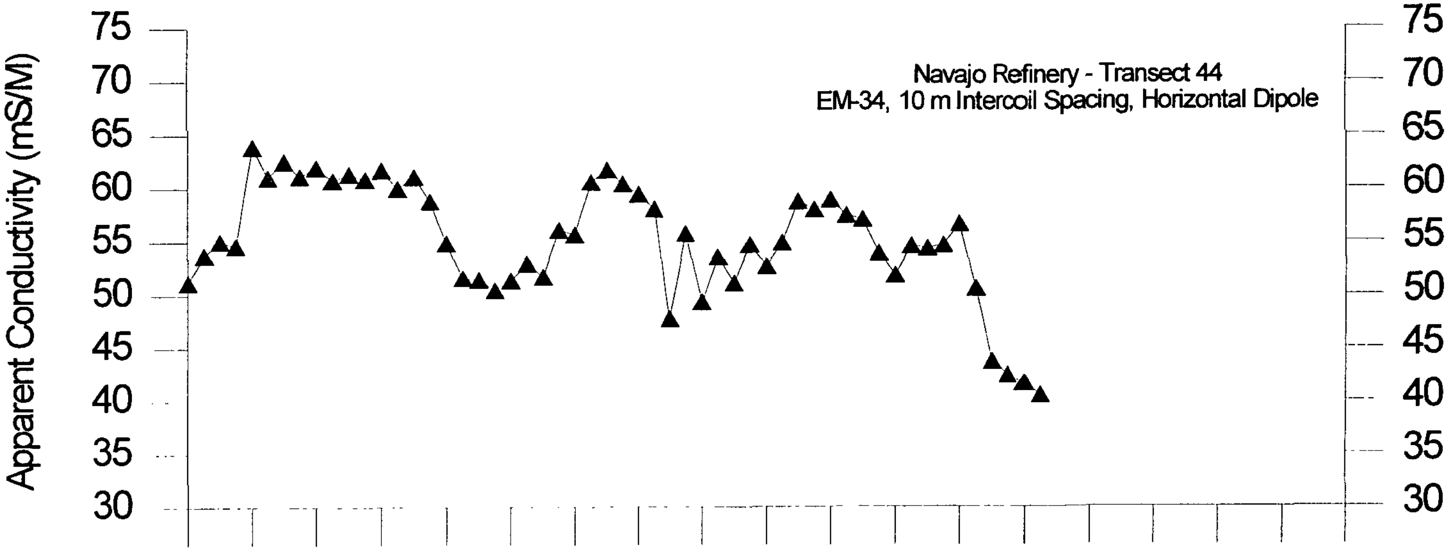

Navajo Refinery - Transect 39
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30

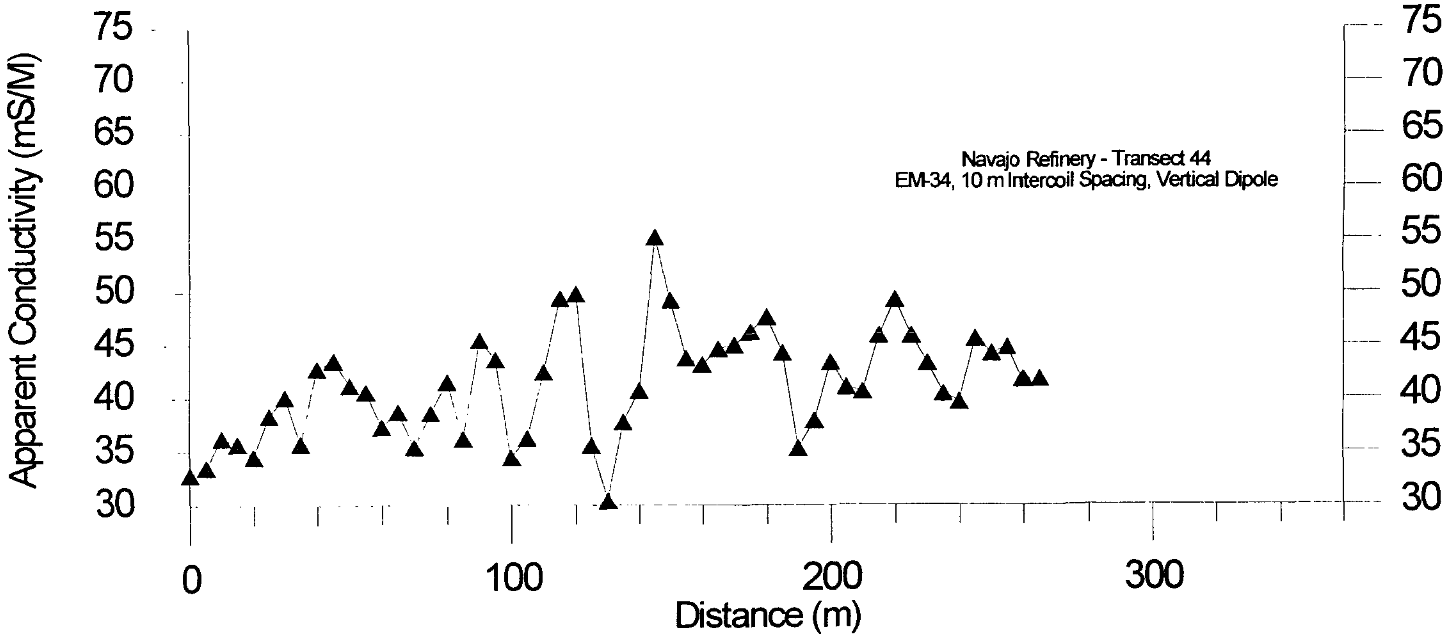

Navajo Refinery - Transect 39
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
70
60
50
40
30
20
0
100
200
300
Distance (m)

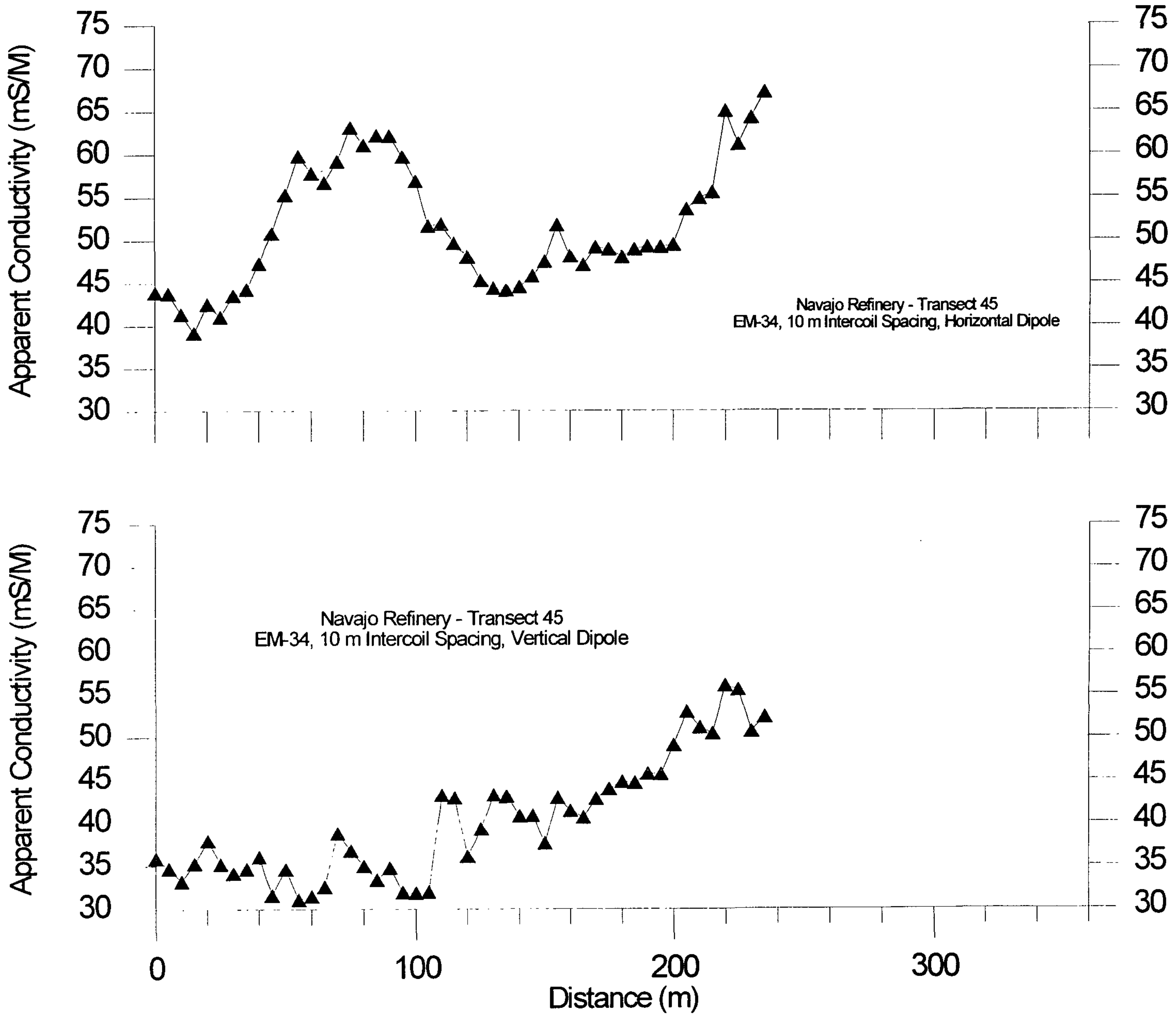

Navajo Refinery - Transect 41
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Navajo Refinery - Transect 41
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

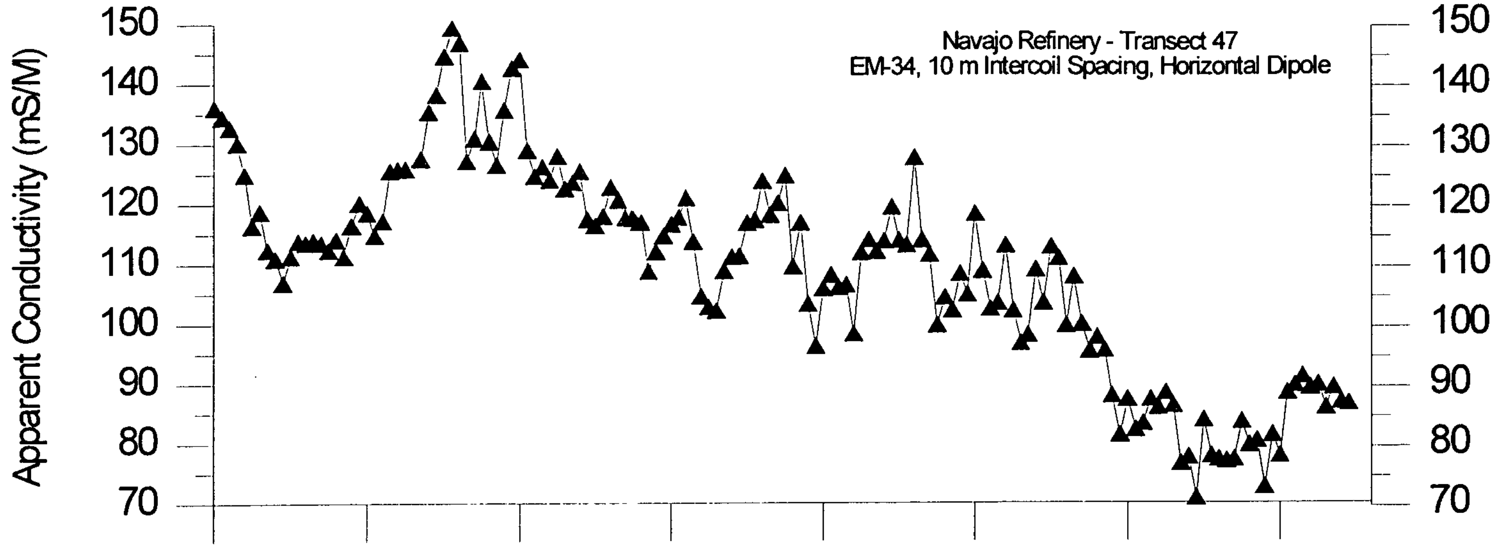

Navajo Refinery - Transect 43
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)

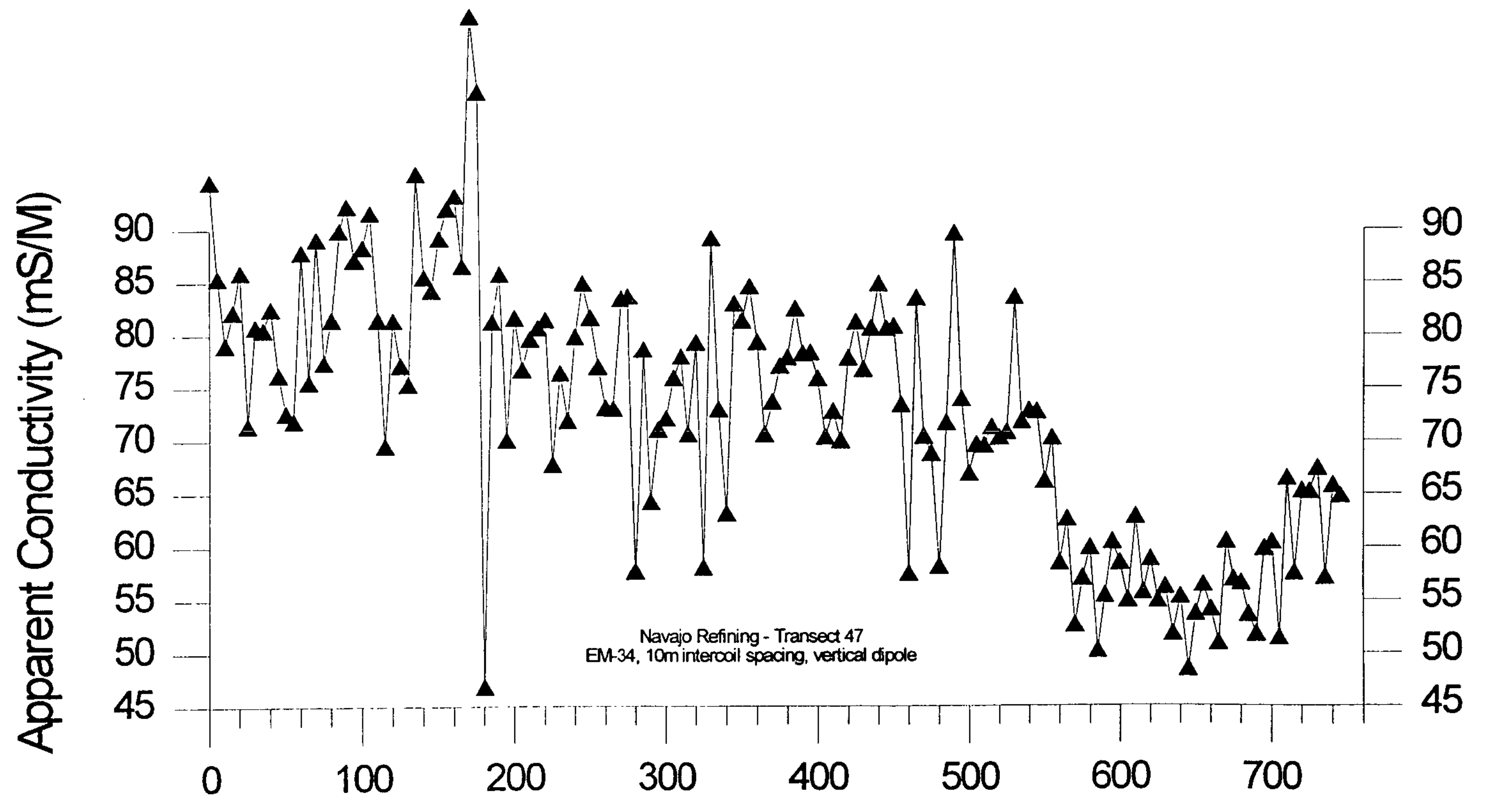

Navajo Refinery - Transect 43
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)

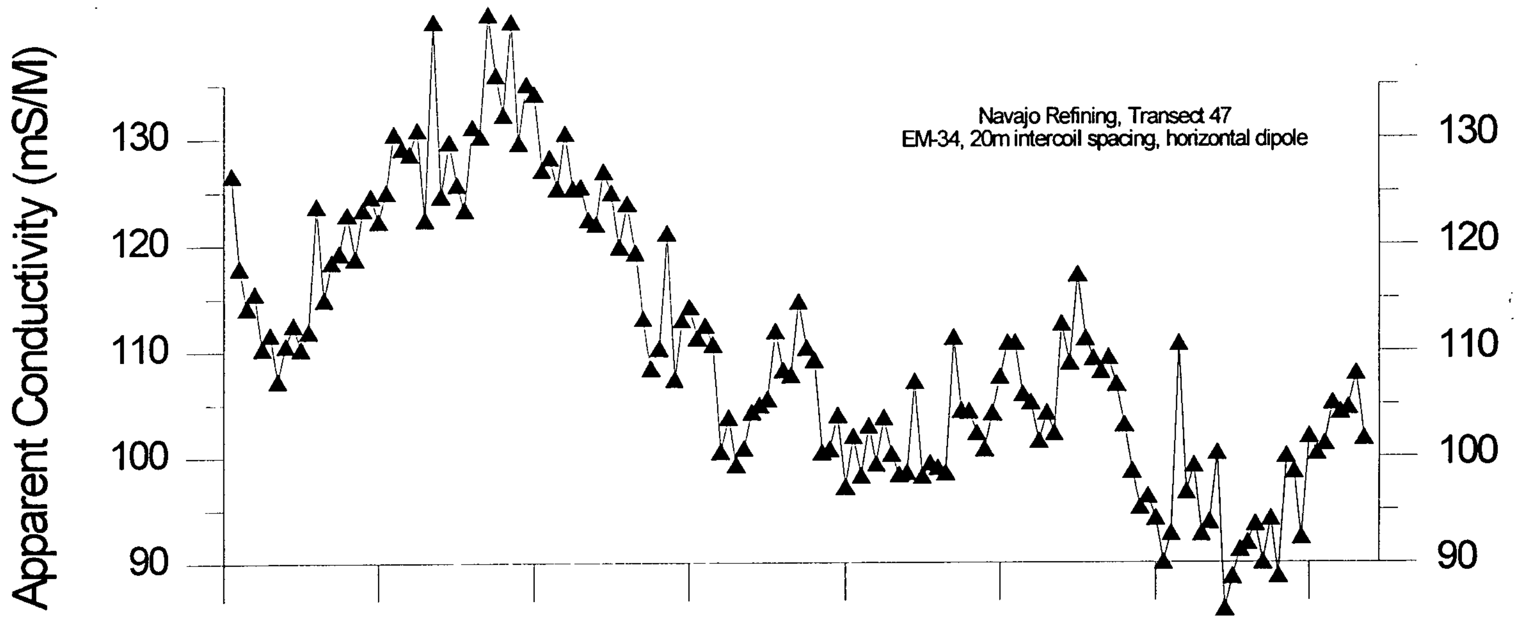

Navajo Refinery - Transect 44
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30

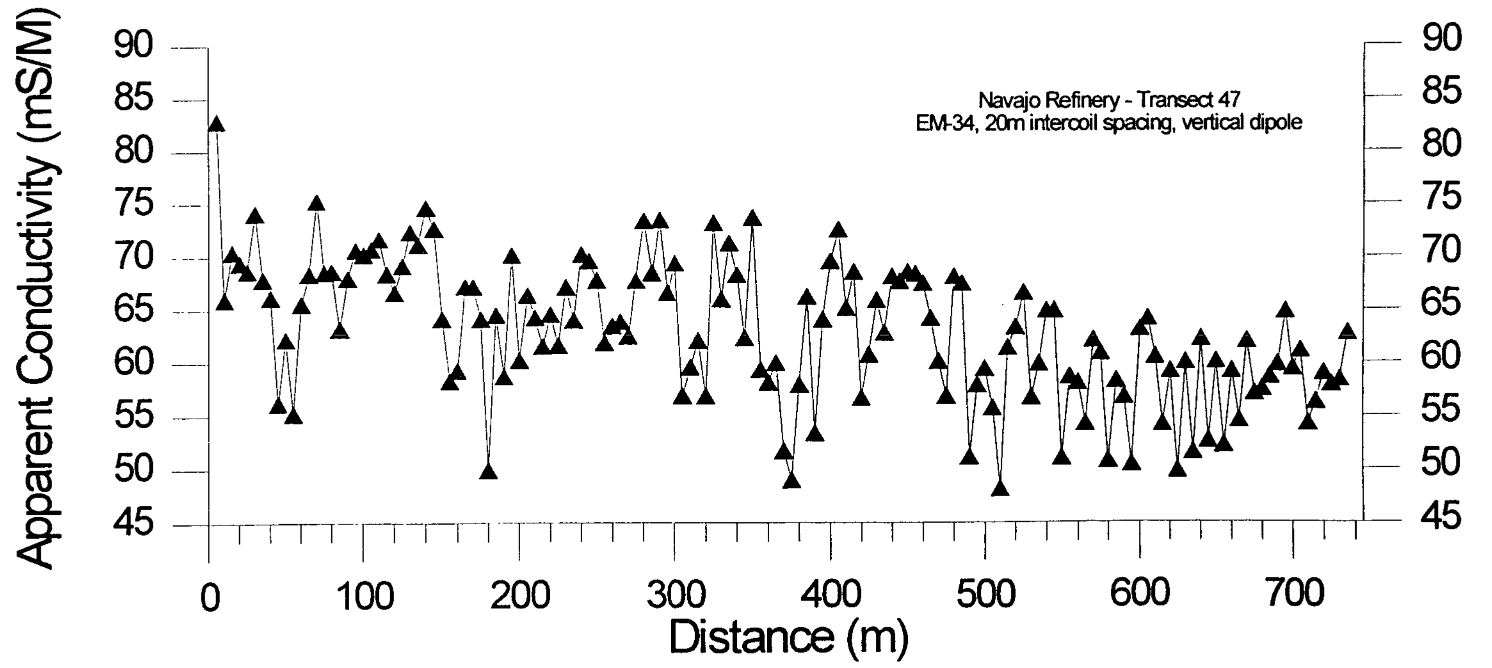

Navajo Refinery - Transect 44
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

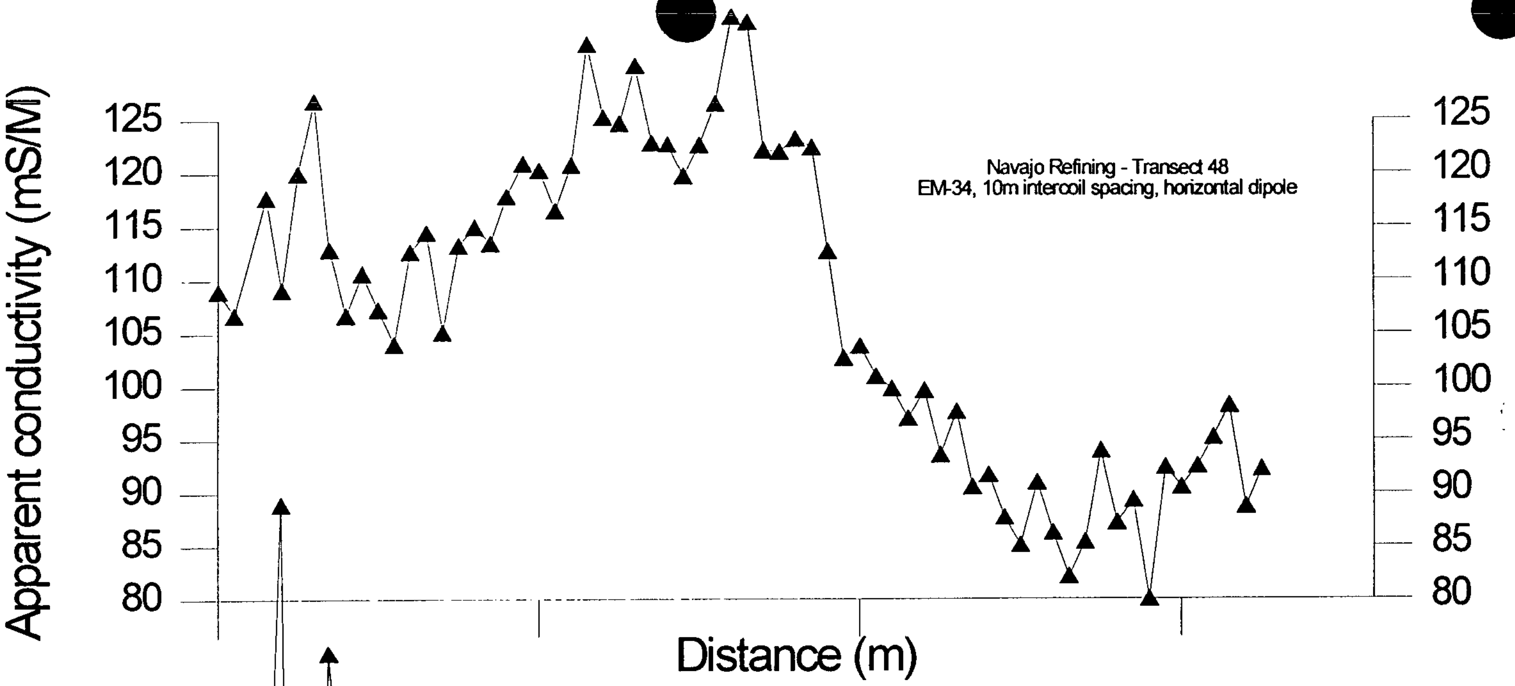

Navajo Refinery - Transect 45
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Navajo Refinery - Transect 45
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)
75
70
65
60
55
50
45
40
35
30
0
100
200
300

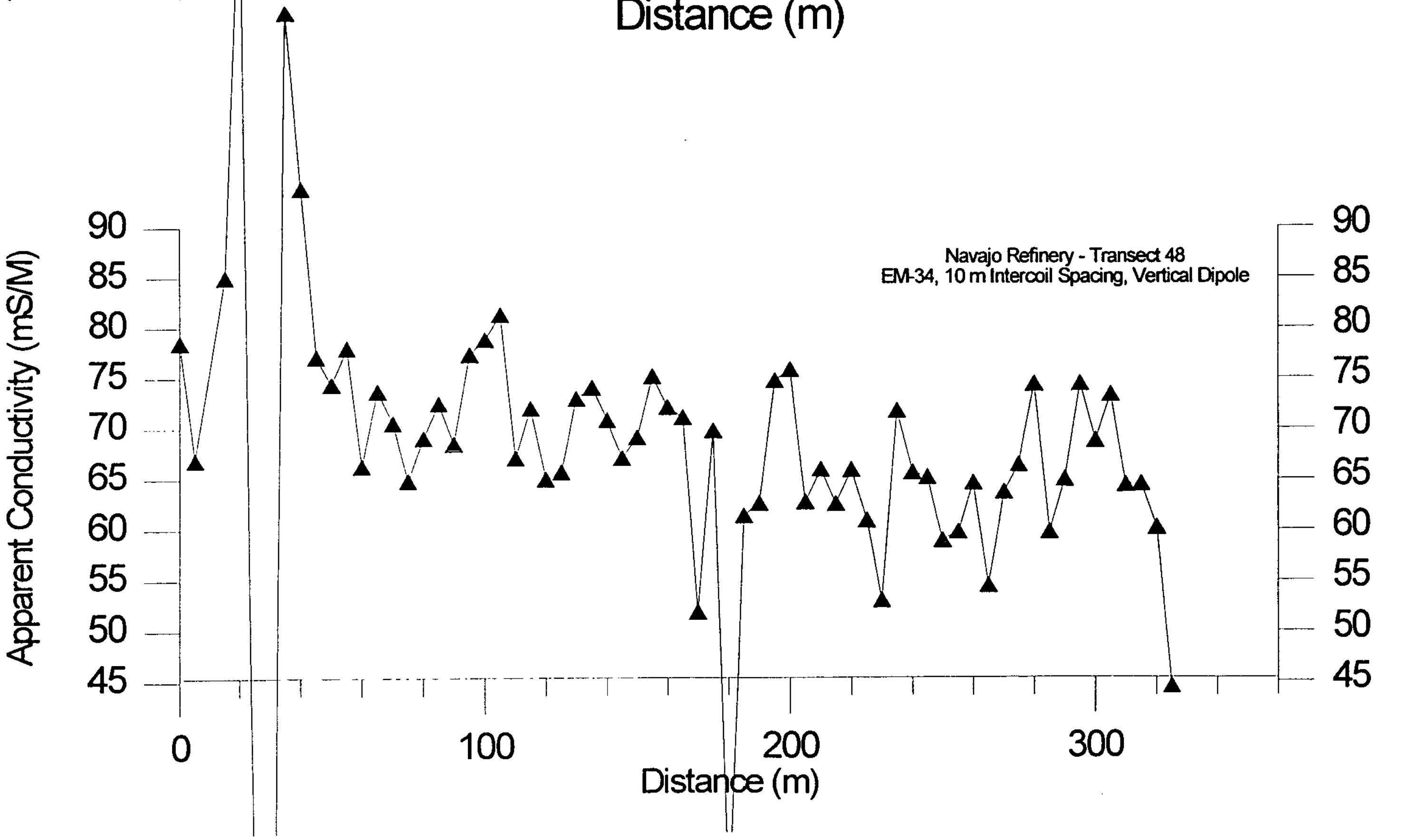

Navajo Refinery - Transect 47
EM-34, 10 m Intercoil Spacing, Horizontal Dipole
Apparent Conductivity (mS/M)
150
140
130
120
110
100
90
80
70

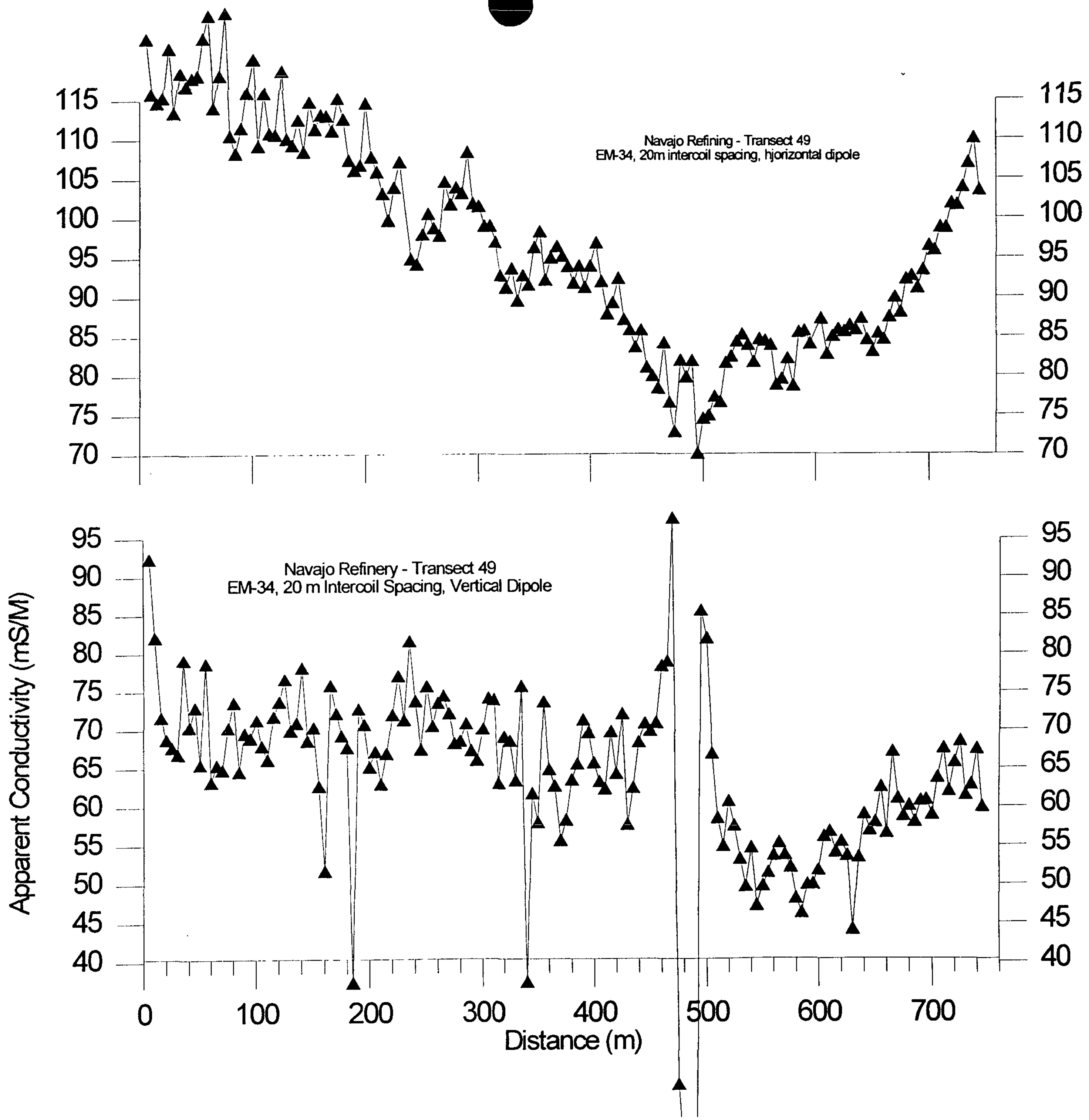

Navajo Refining - Transect 47
EM-34, 10m intercoil spacing, vertical dipole
Apparent Conductivity (mS/M)
90
85
80
75
70
65
60
55
50
45
0
100
200
300
400
500
600
700

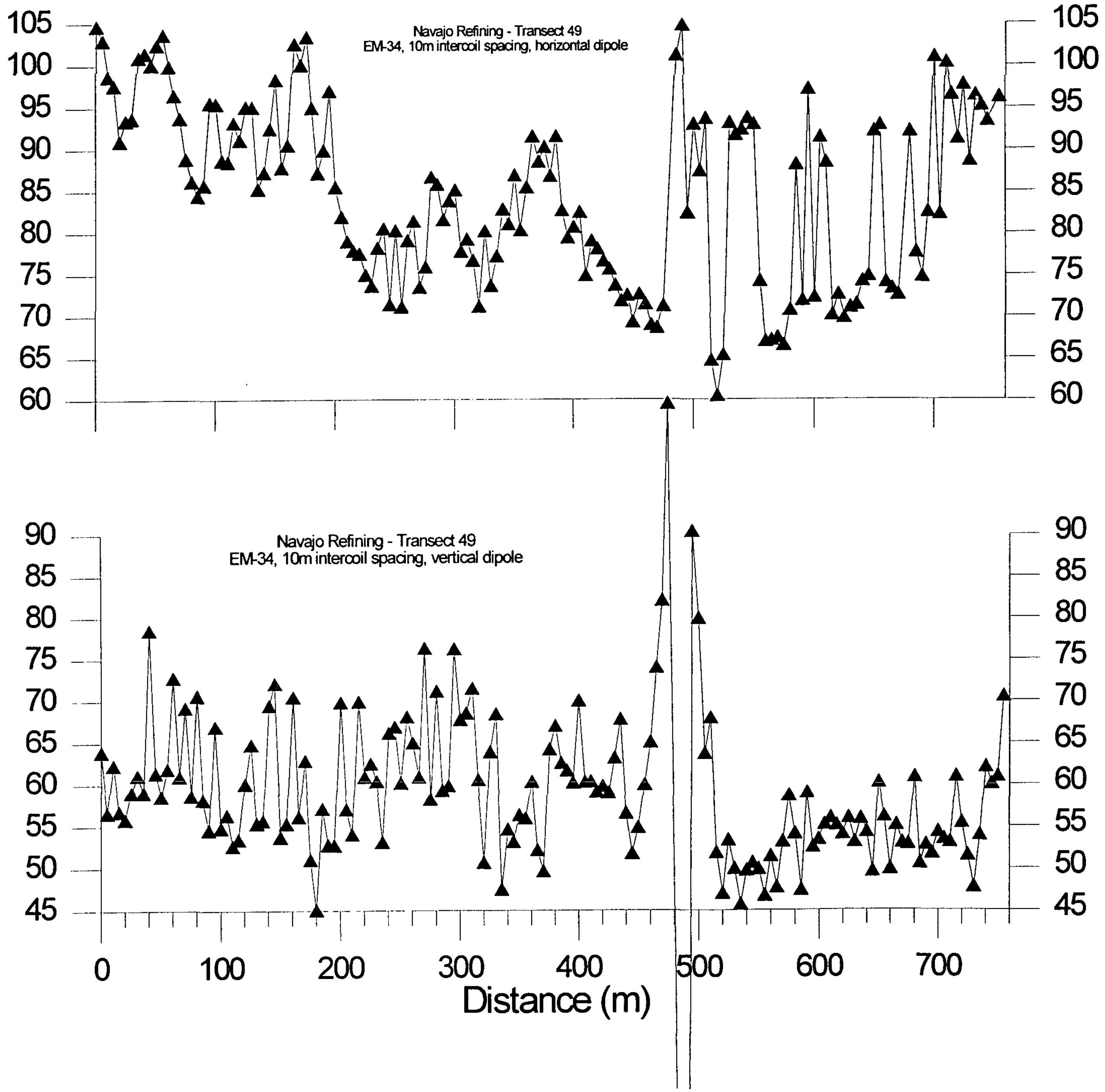

Navajo Refining, Transect 47
EM-34, 20m intercoil spacing, horizontal dipole
Apparent Conductivity (mS/M)
130
120
110
100
90


Navajo Refinery - Transect 47
EM-34, 20m intercoil spacing, vertical dipole
Apparent Conductivity (mS/M)
90
85
80
75
70
65
60
55
50
45
0
100
200
300
400
500
600
700
Distance (m)

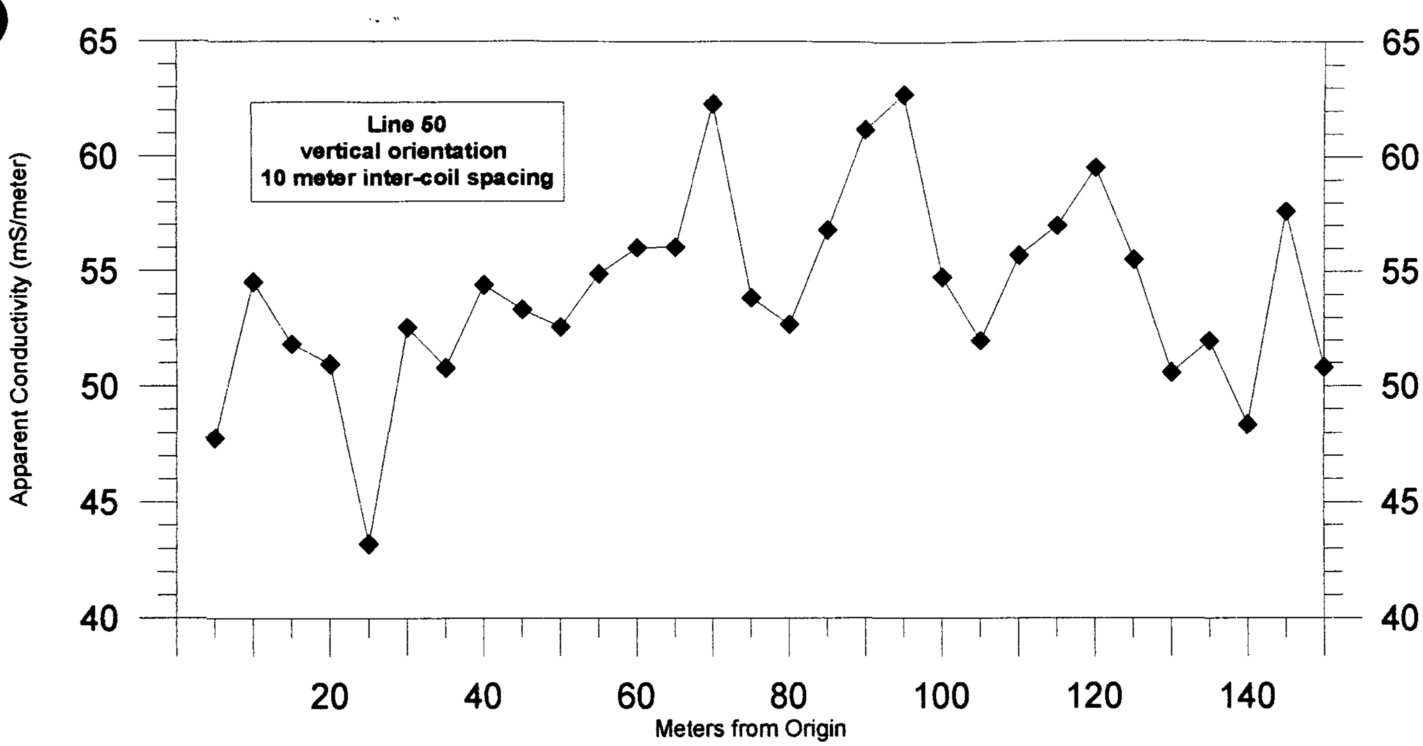

Navajo Refining - Transect 48
EM-34, 10m intercoil spacing, horizontal dipole
Apparent conductivity (mS/M)
125
120
115
110
105
100
95
90
85
80
Distance (m)

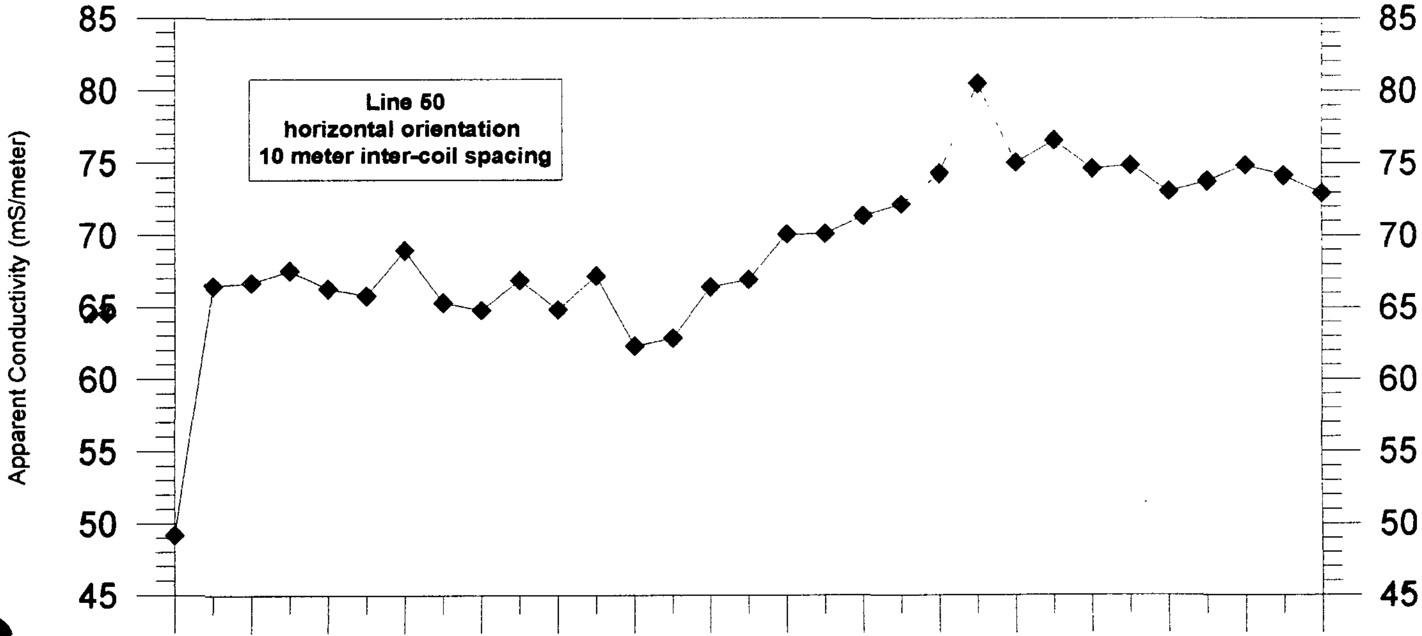

Navajo Refinery - Transect 48
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
90
85
80
75
70
65
60
55
50
45
0
100
200
300
Distance (m)

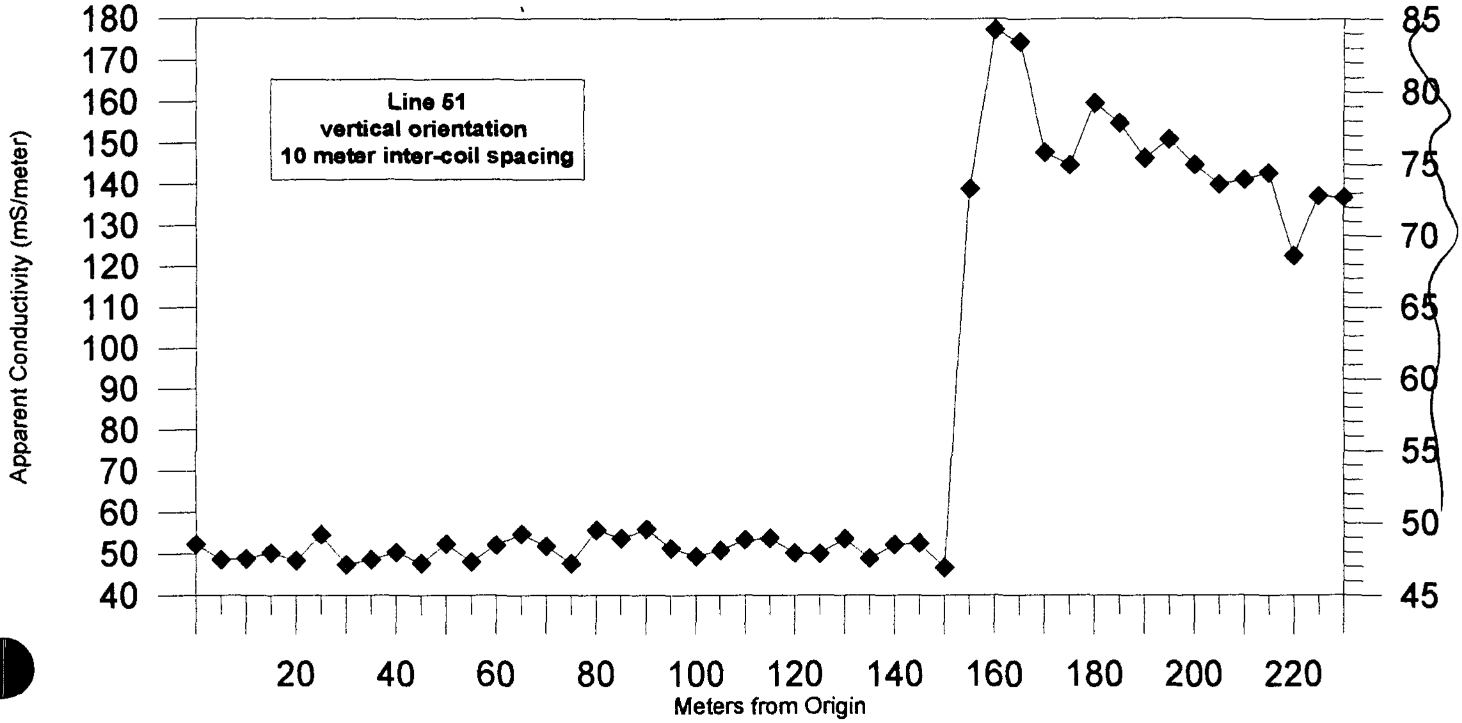

Navajo Refining - Transect 49
EM-34, 20m intercoil spacing, hjorizontal dipole
Navajo Refinery - Transect 49
EM-34, 20 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)

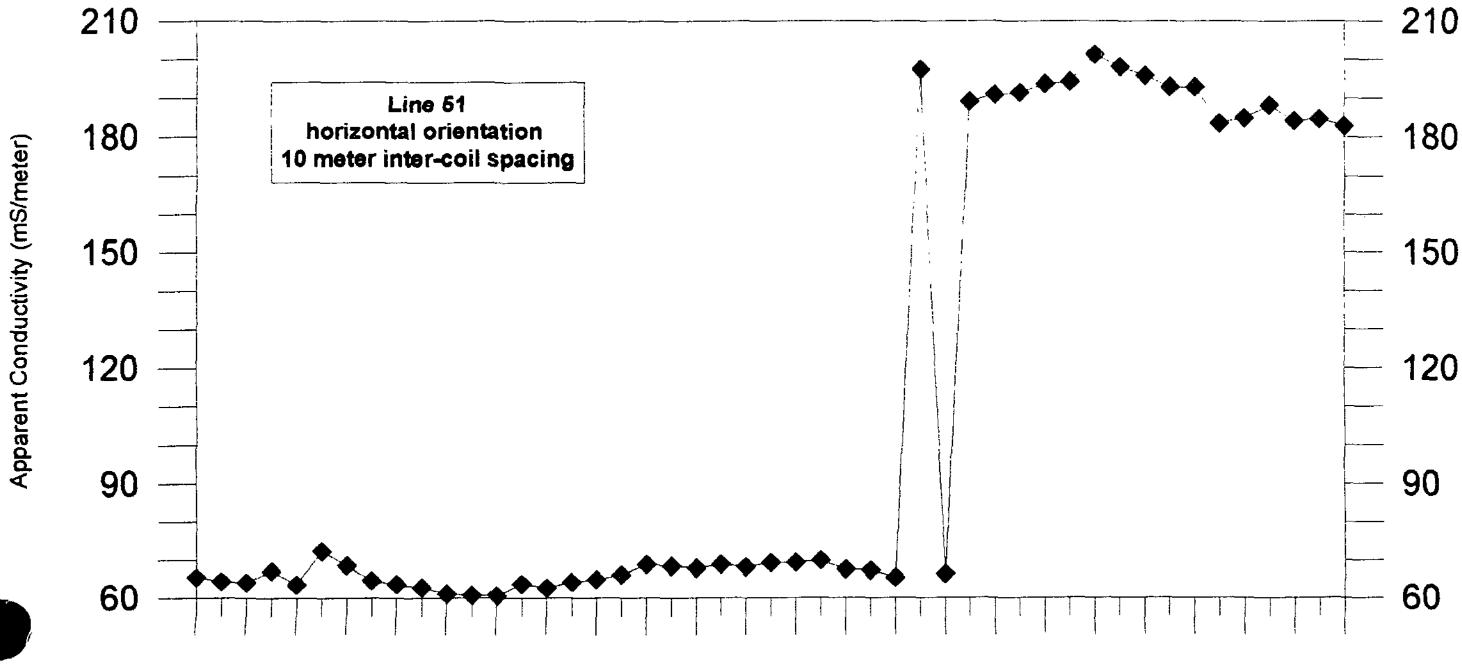


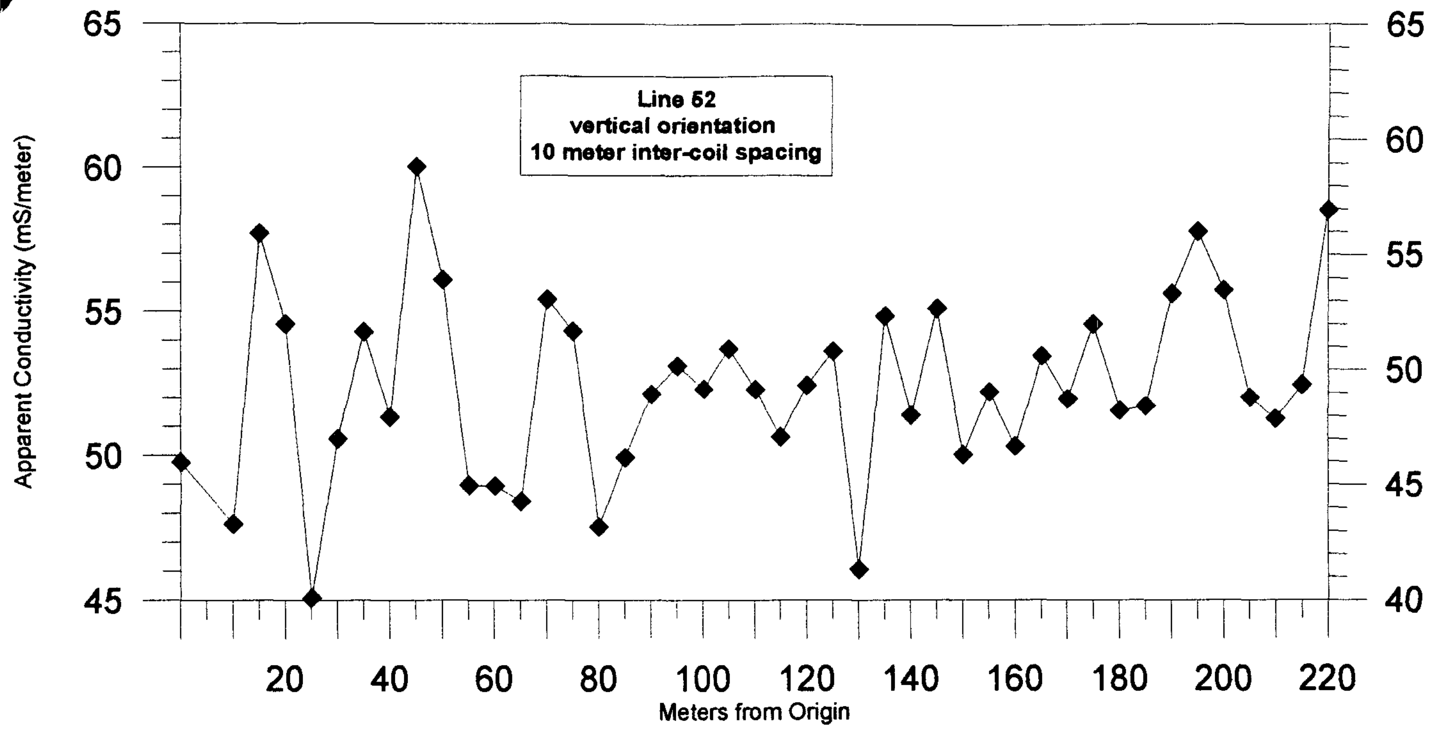
Navajo Refining - Transect 49
EM-34, 10m intercoil spacing, horizontal dipole
105
100
95
90
85
80
75
70
65
60
Navajo Refining - Transect 49
EM-34, 10m intercoil spacing, vertical dipole
90
85
80
75
70
65
60
55
50
45
0
100
200
300
400
500
600
700
Distance (m)

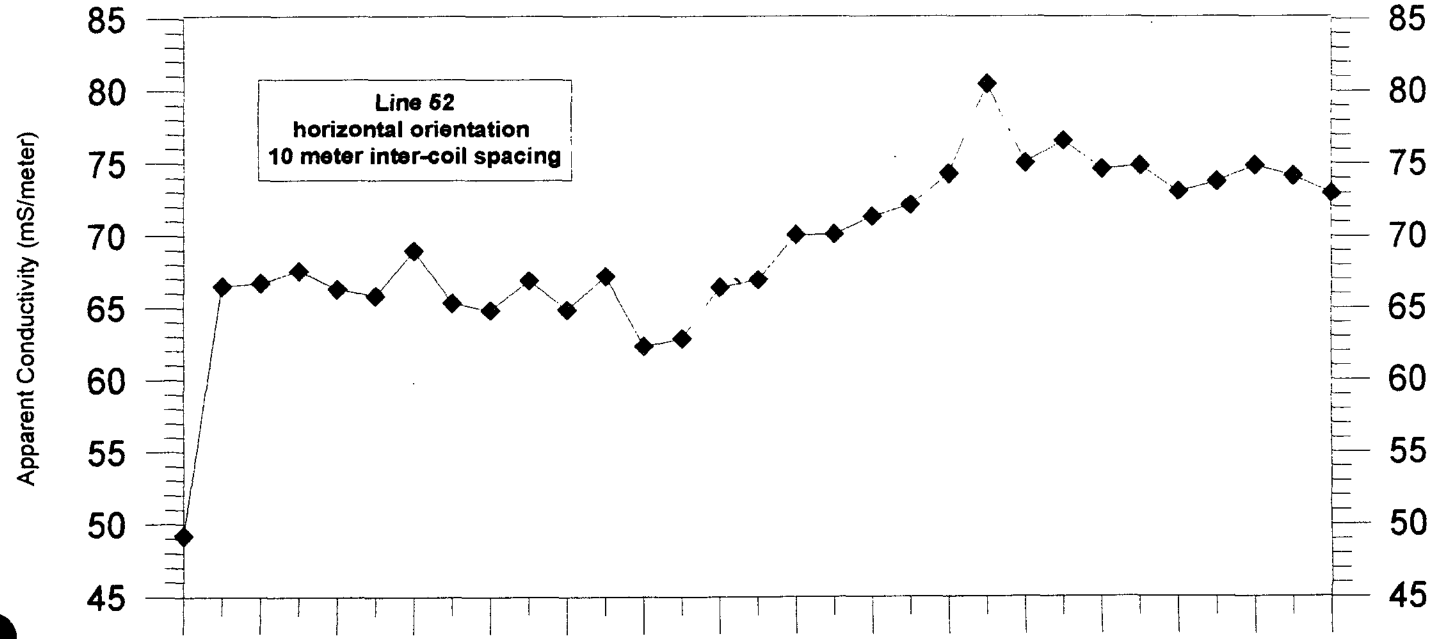

Line 50
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin

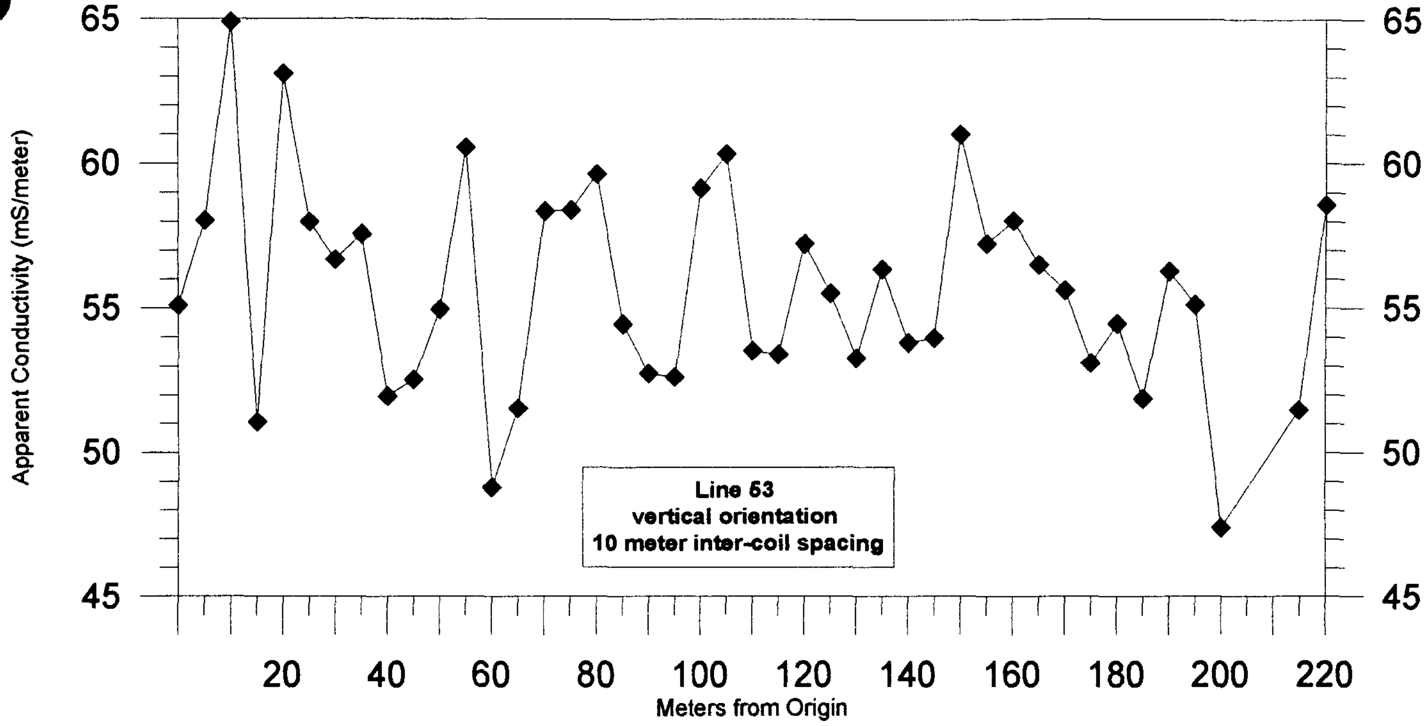

Line 50
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)


Line 51
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
85
80
75
70
65
60
55
50
45
20
40
60
80
100
120
140
160
180
200
220

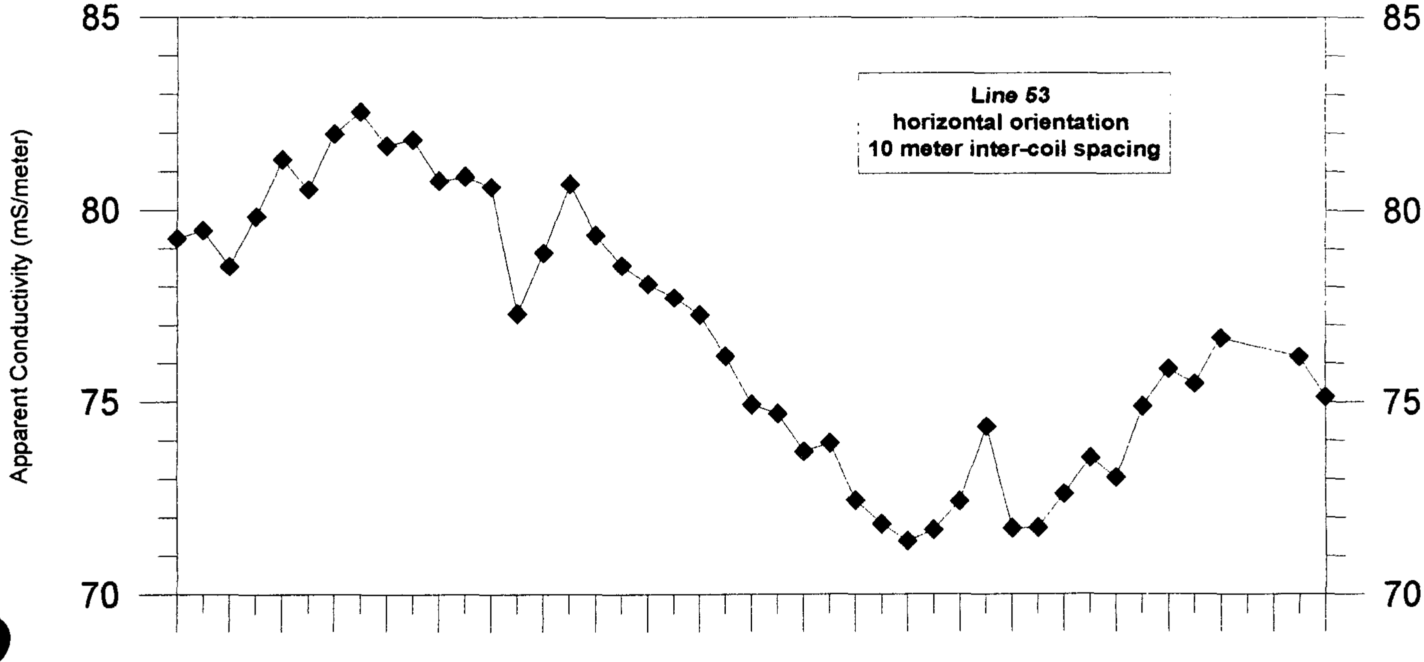

Line 51
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
210
180
150
120
90
60


Line 52
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
65
60
55
50
45
40
20
40
60
80
100
120
140
160
180
200
220

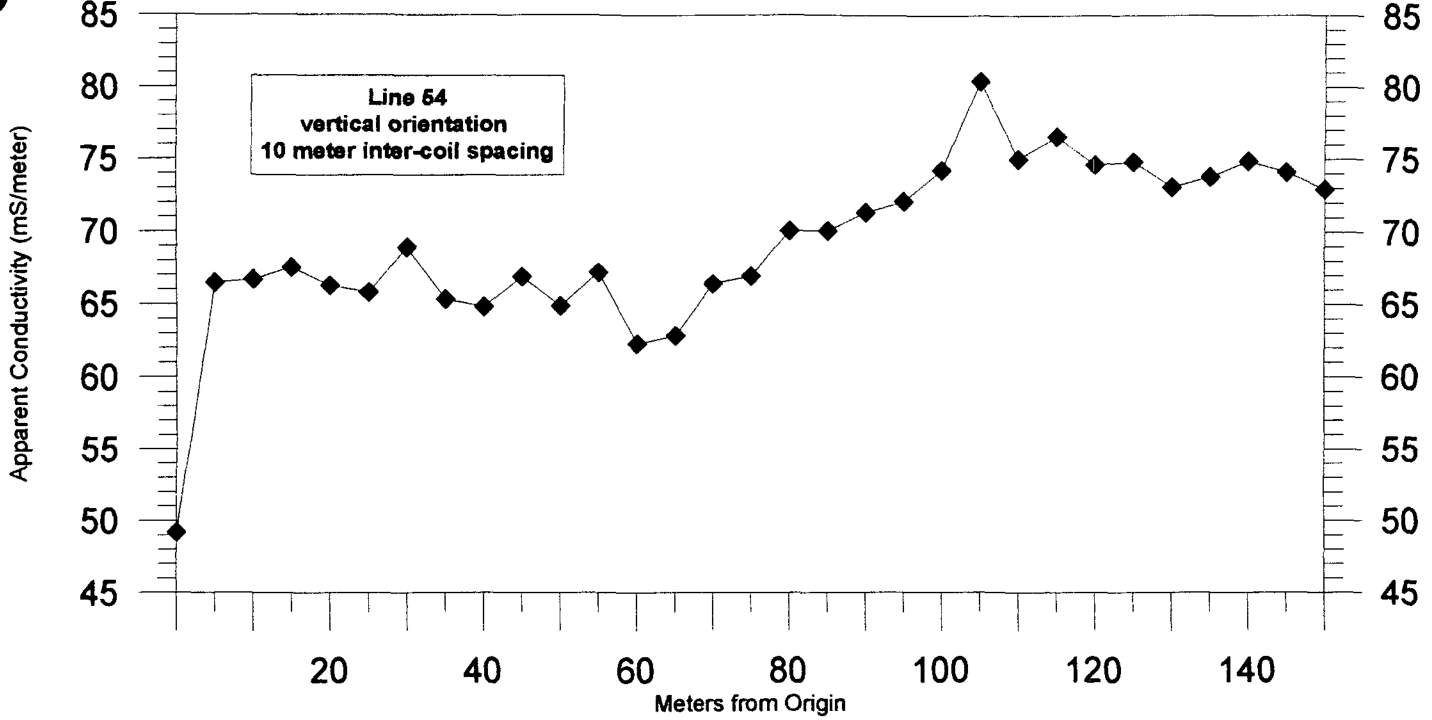

Line 52
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
85
80
75
70
65
60
55
50
45

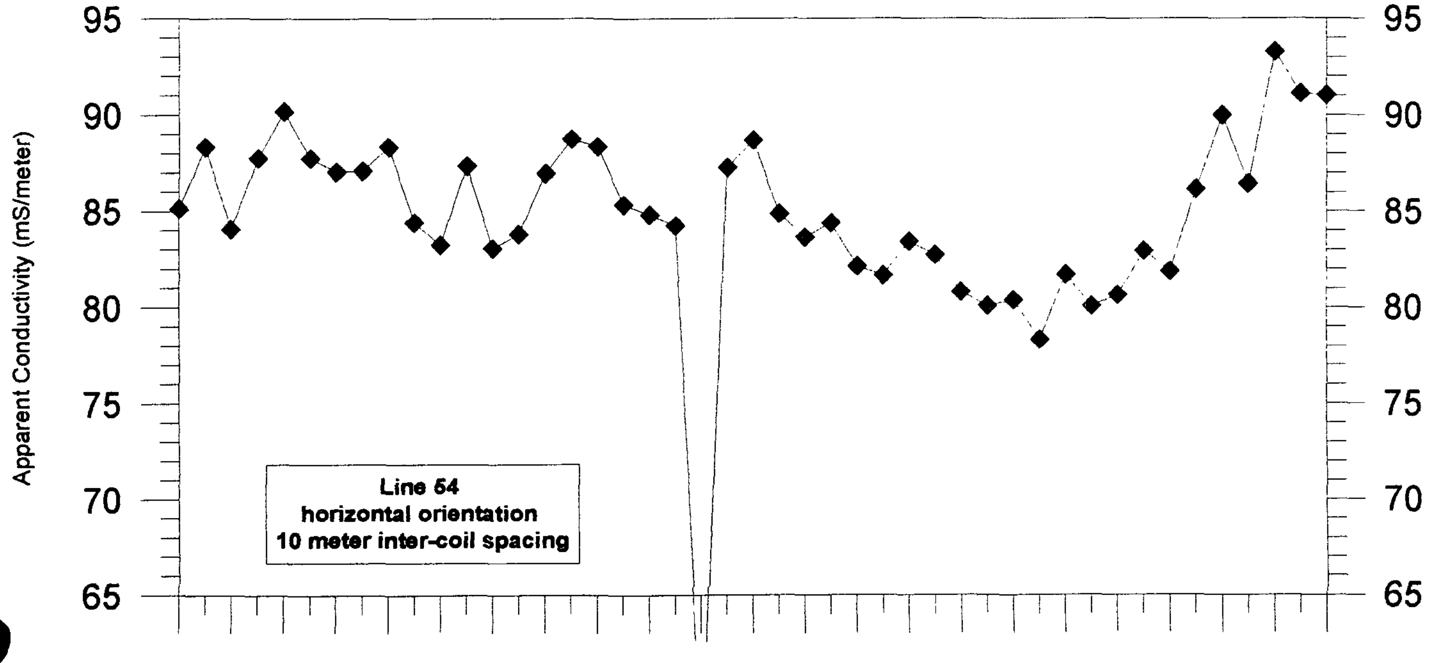


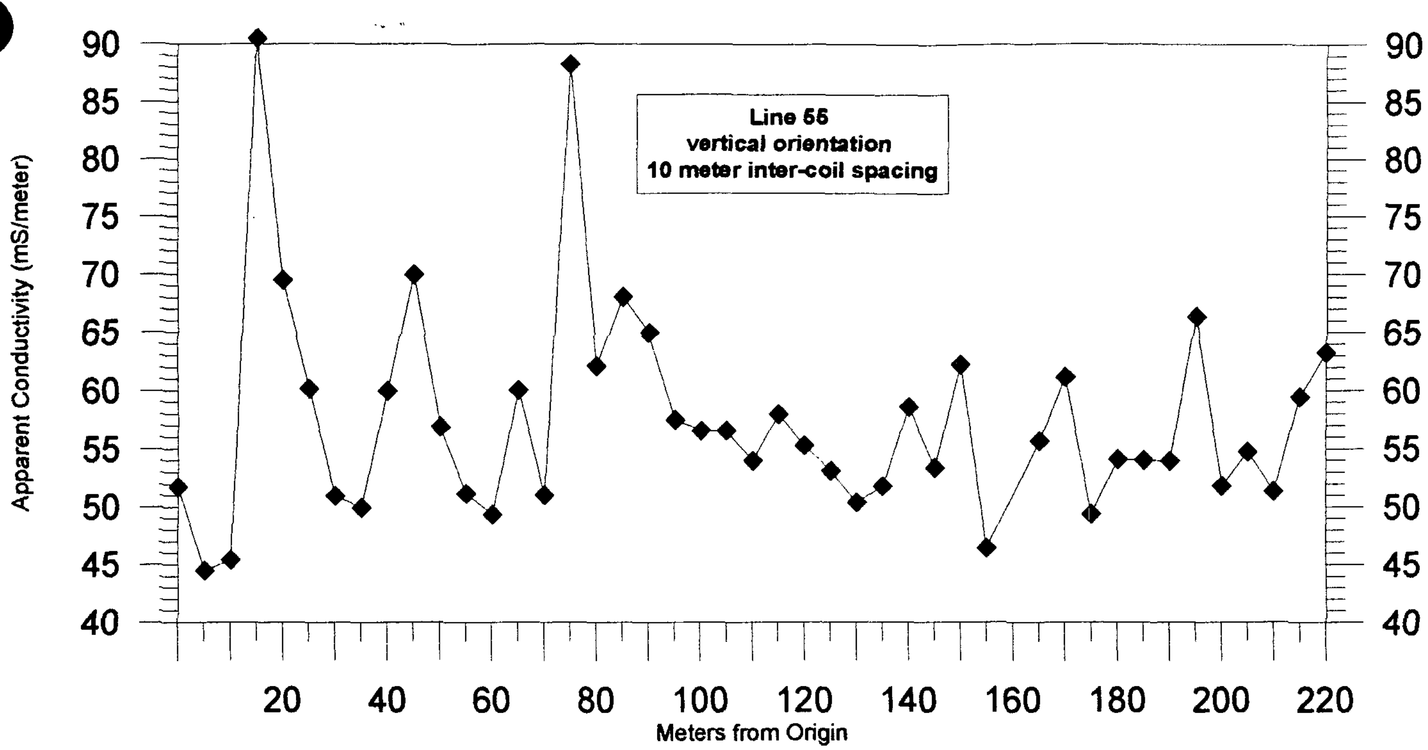
65
60
55
50
45
Apparent Conductivity (mS/meter)
Line 53
vertical orientation
10 meter inter-coil spacing
20
40
60
80
100
120
140
160
180
200
220
Meters from Origin

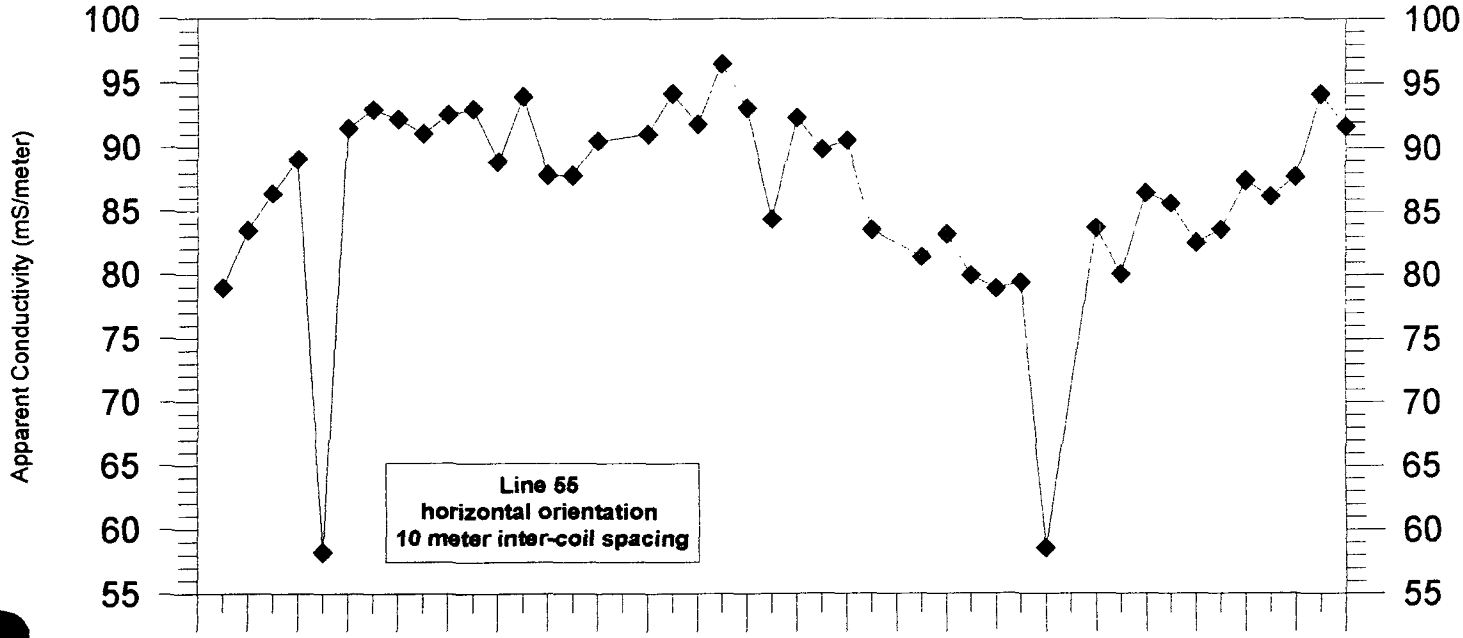



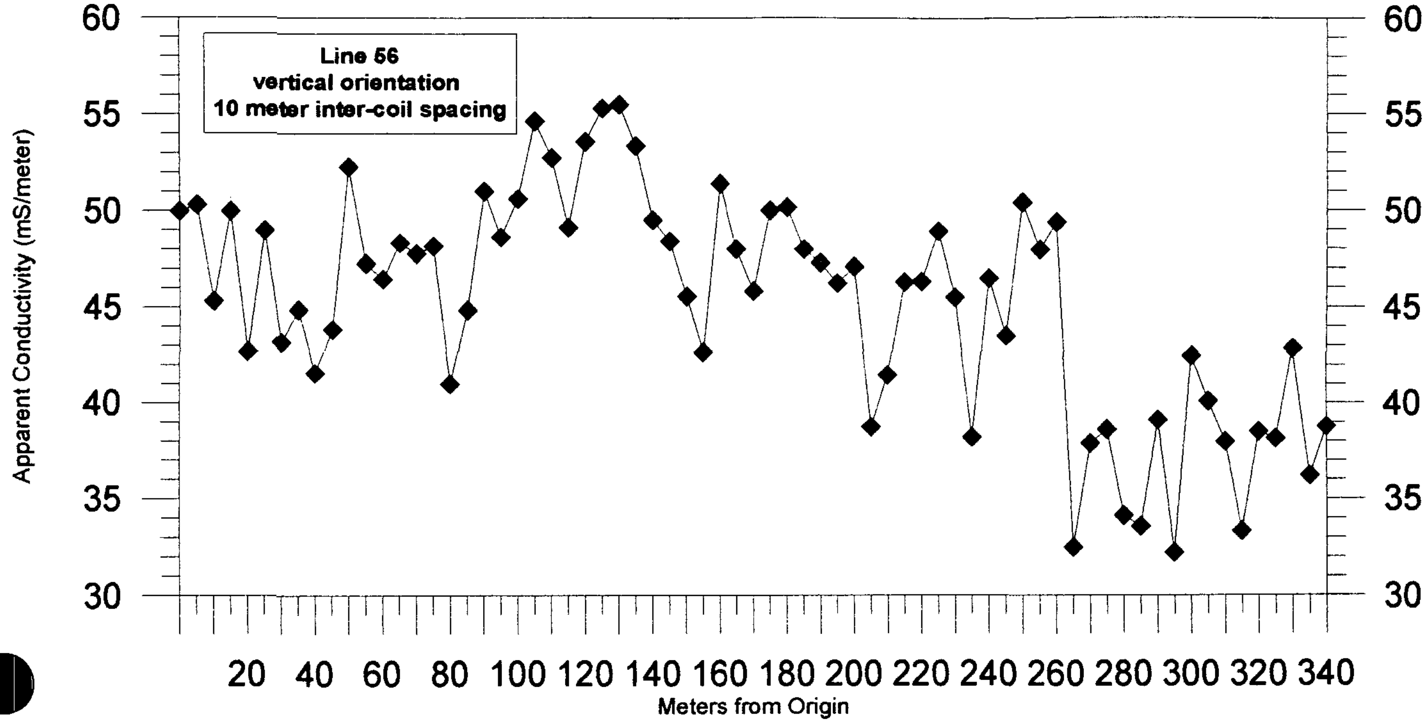
85
80
75
70
Apparent Conductivity (mS/meter)
Line 53
horizontal orientation
10 meter inter-coil spacing

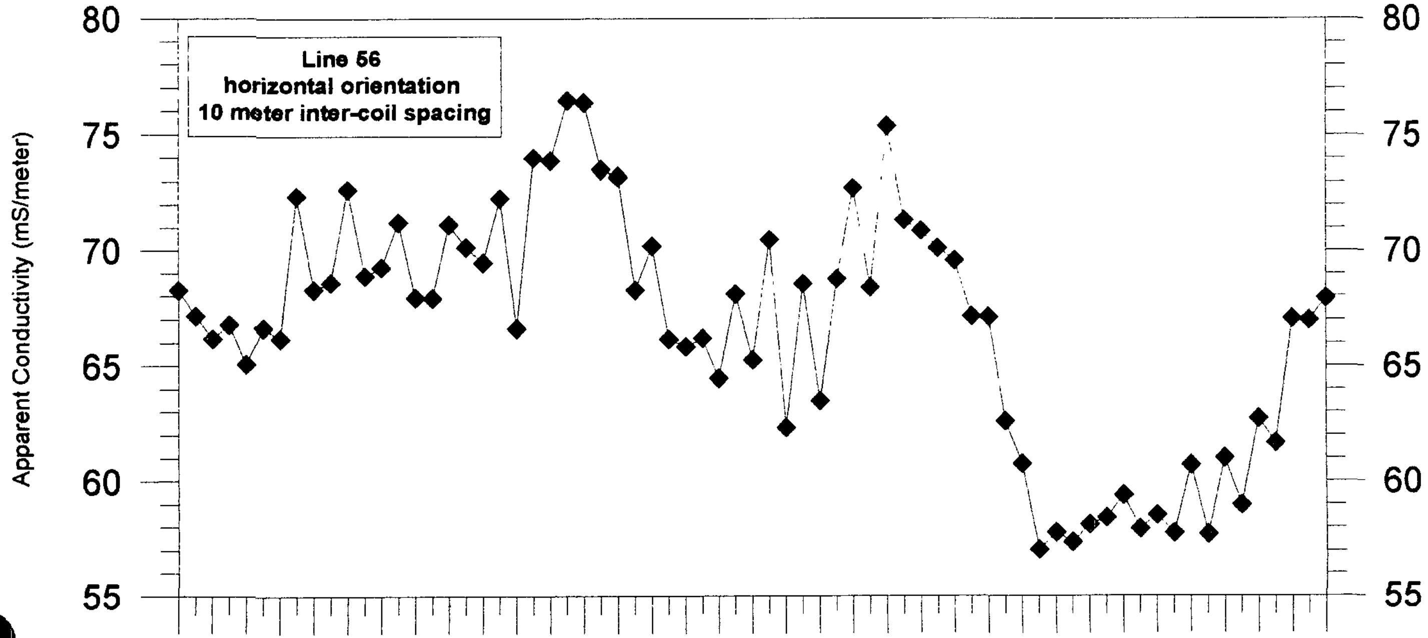

Line 54
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
85
80
75
70
65
60
55
50
45
20
40
60
80
100
120
140
Meters from Origin

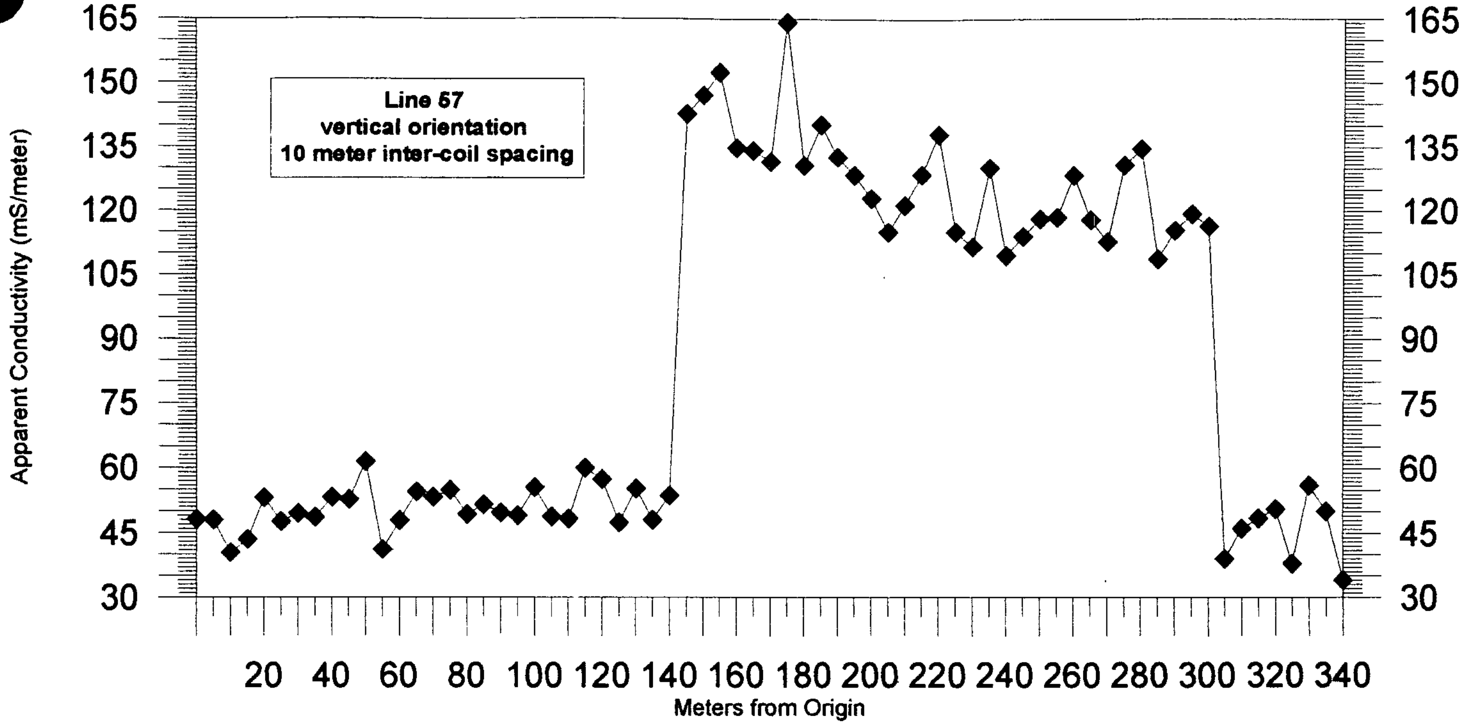

Line 54
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
95
90
85
80
75
70
65

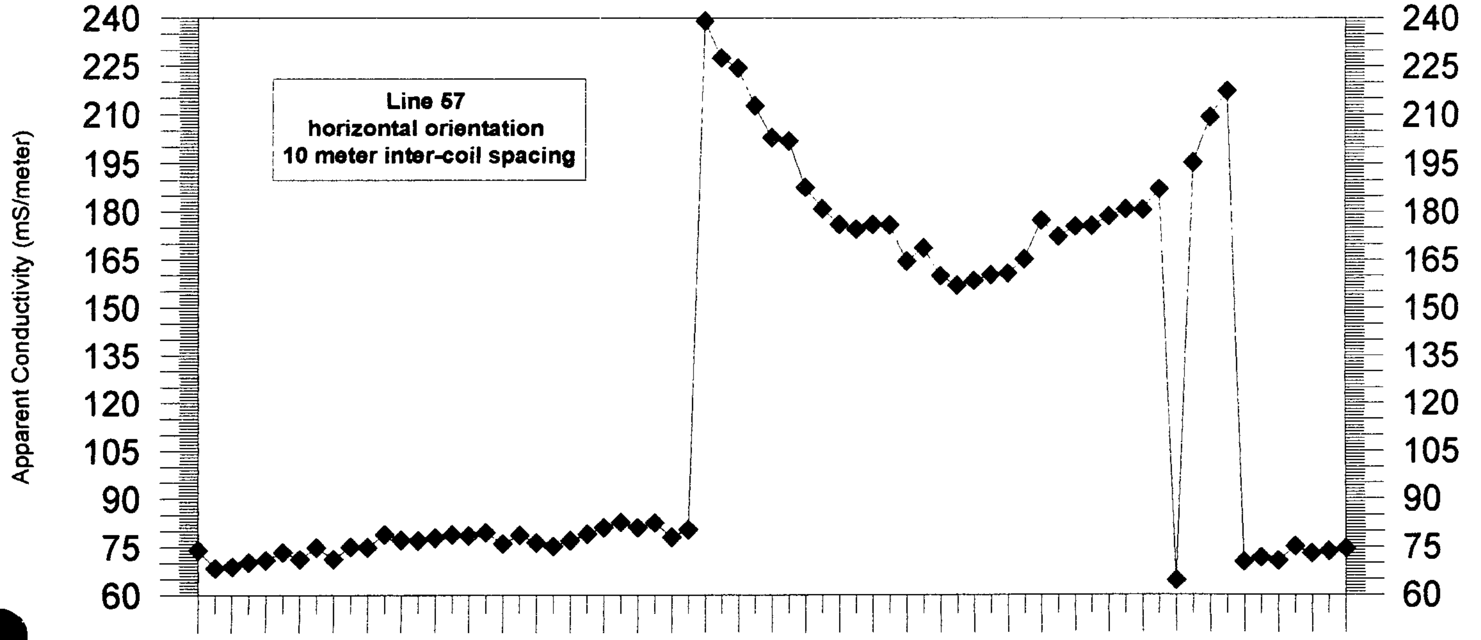

Line 55
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
90
85
80
75
70
65
60
55
50
45
40
20
40
60
80
100
120
140
160
180
200
220

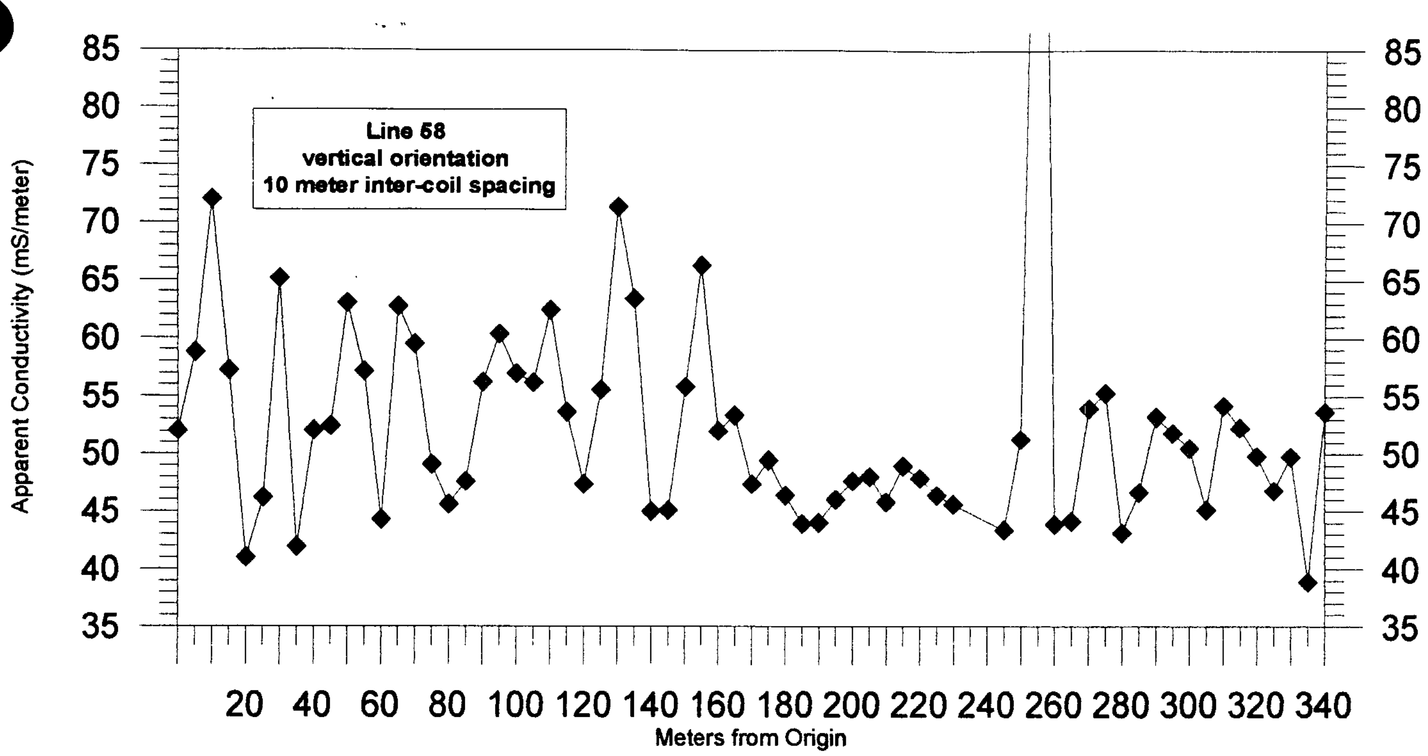

Line 55
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
100
95
90
85
80
75
70
65
60
55

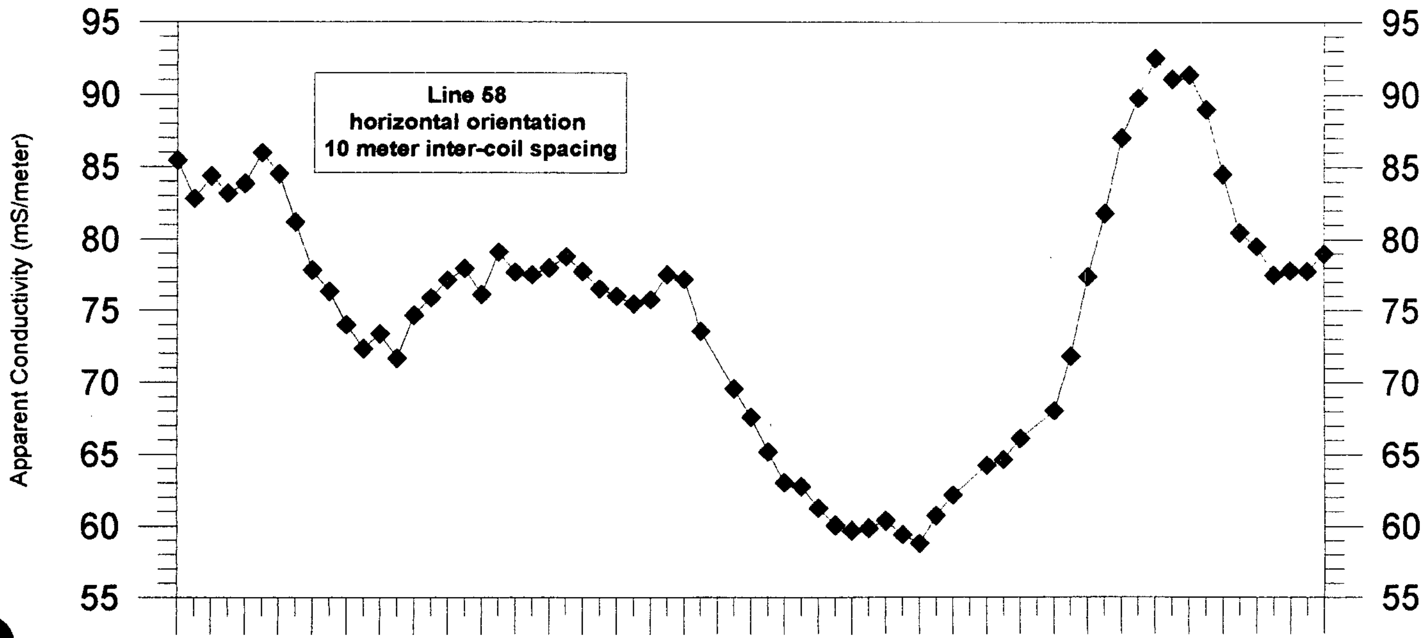

Line 56
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
60
55
50
45
40
35
30
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340
Meters from Origin

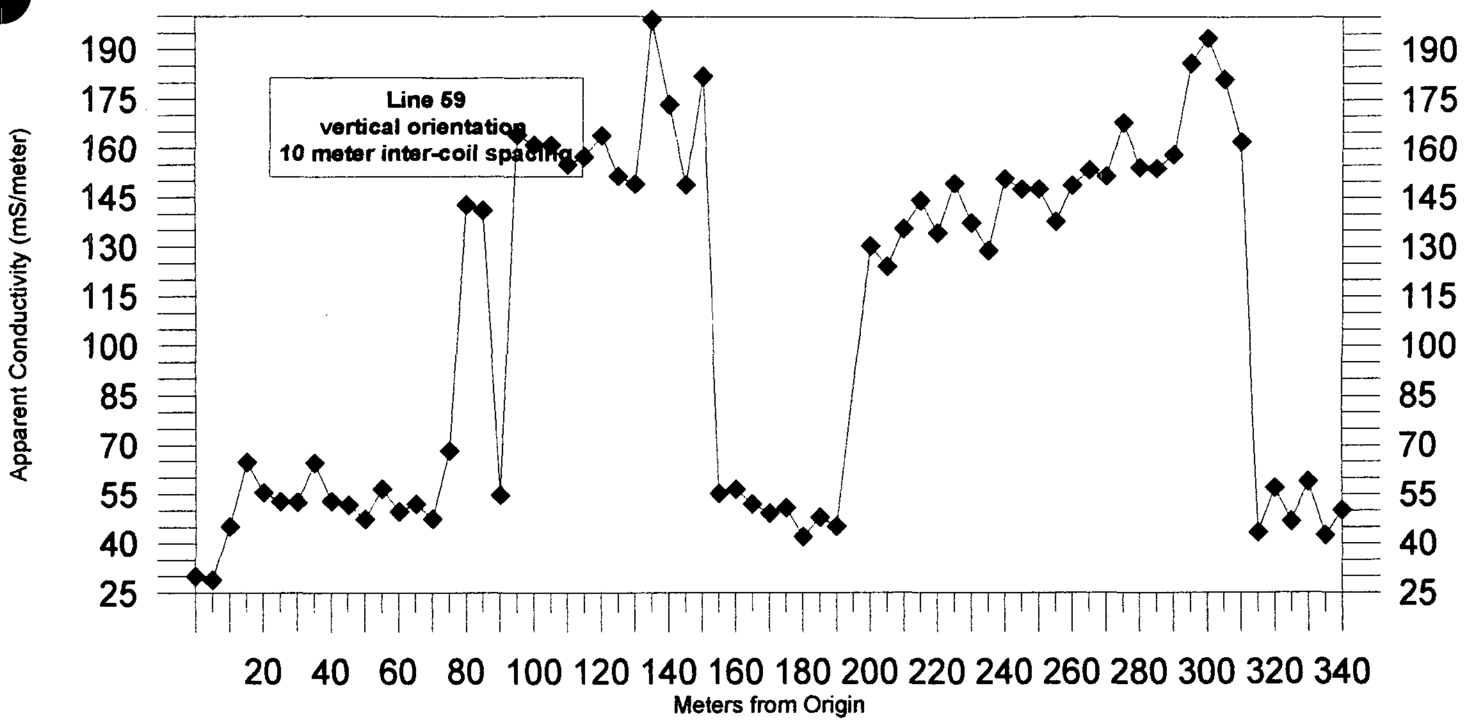

Line 56
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
80
75
70
65
60
55

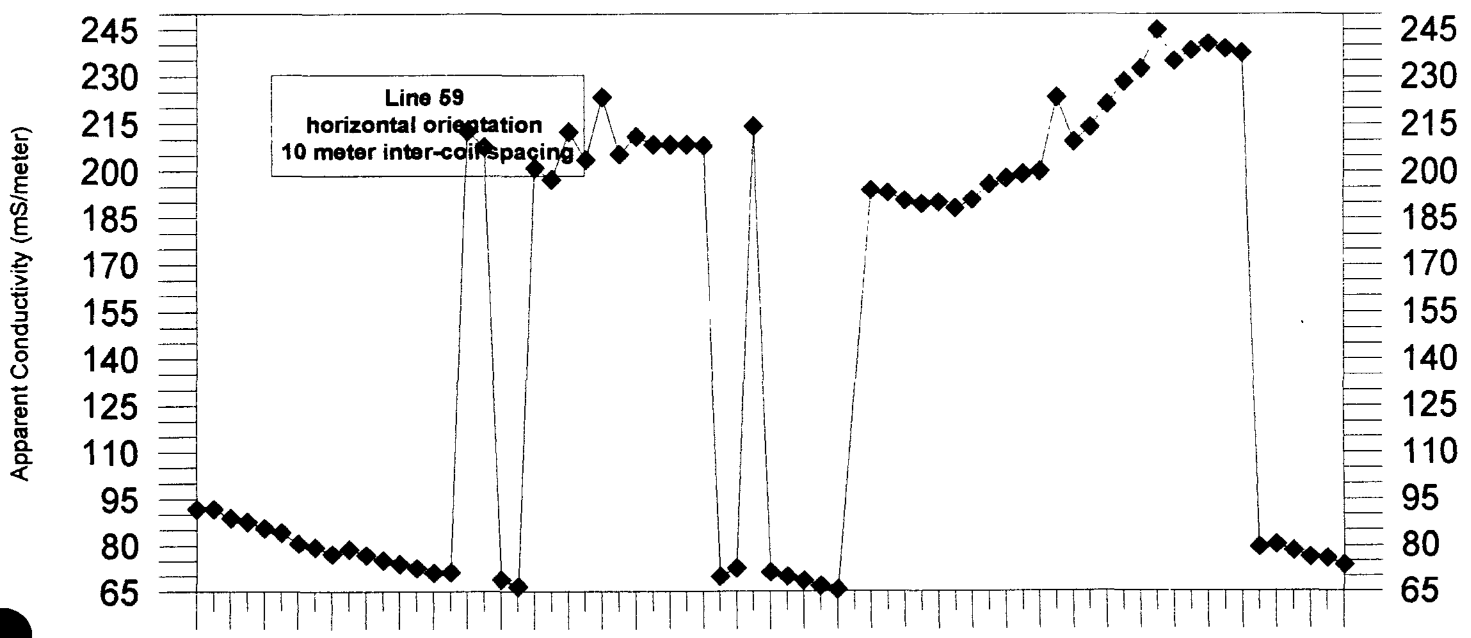

Line 57
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
165
150
135
120
105
90
75
60
45
30
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340
Meters from Origin

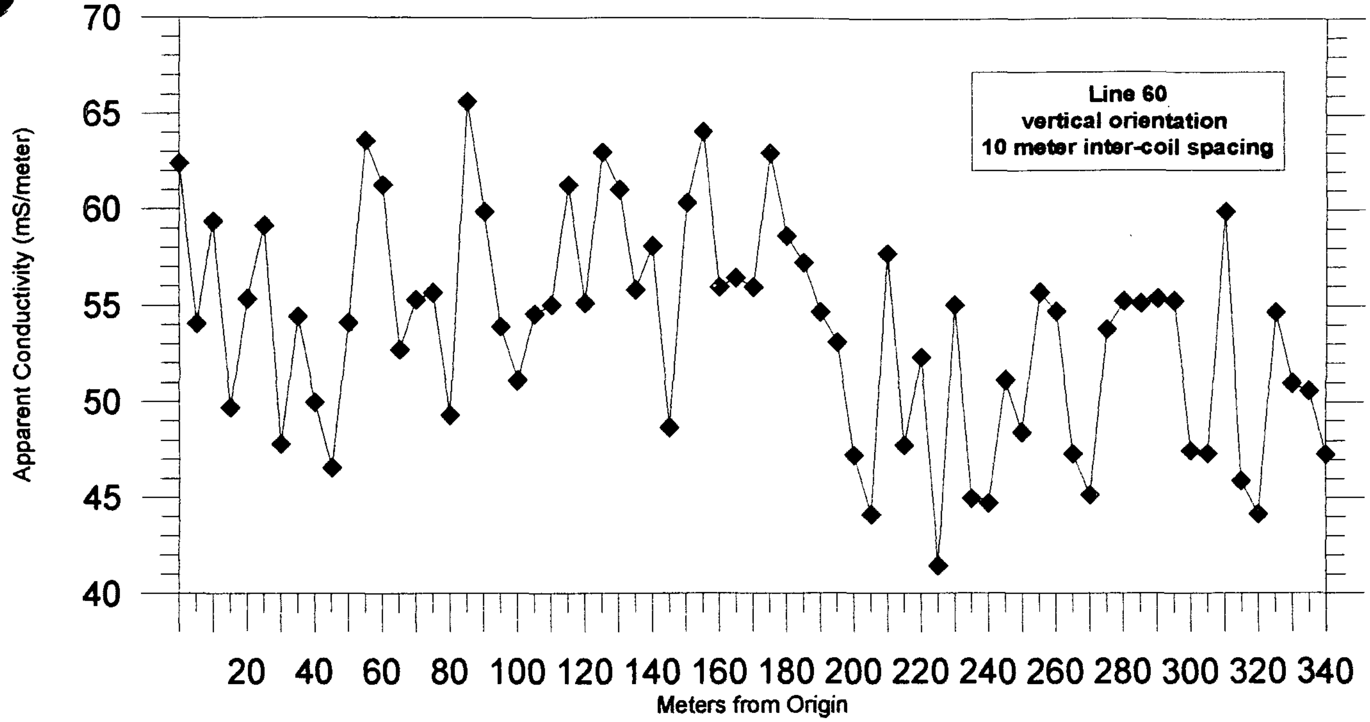

Line 57
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
240
225
210
195
180
165
150
135
120
105
90
75
60


Line 58
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
35
40
45
50
55
60
65
70
75
80
85
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340
Meters from Origin

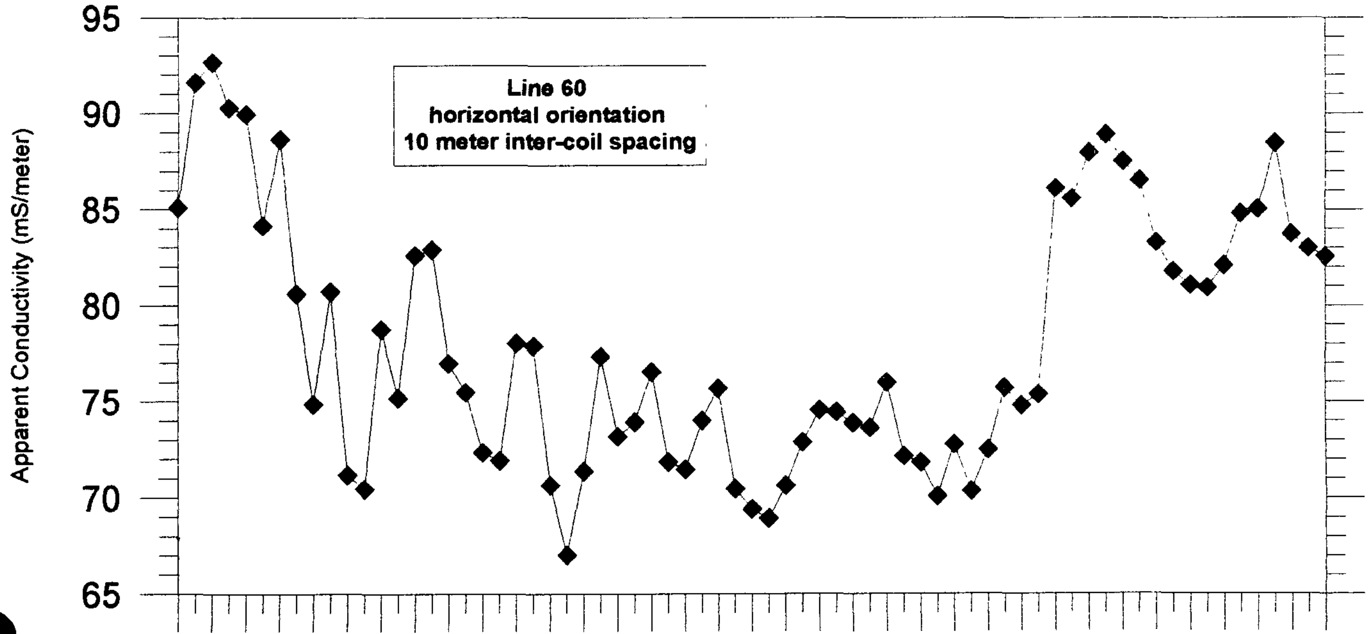

Line 58
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
55
60
65
70
75
80
85
90
95


Line 59
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
190
175
160
145
130
115
100
85
70
55
40
25
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340

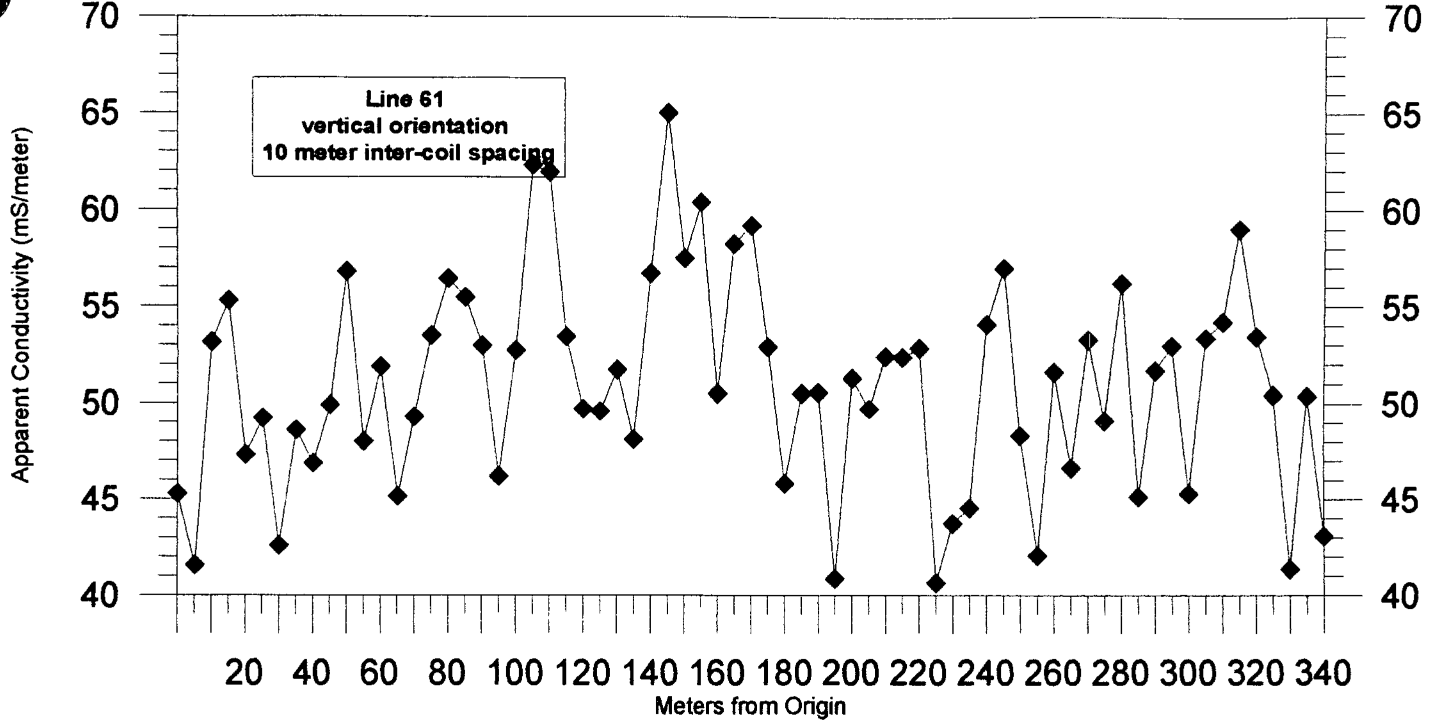

Line 59
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
245
230
215
200
185
170
155
140
125
110
95
80
65

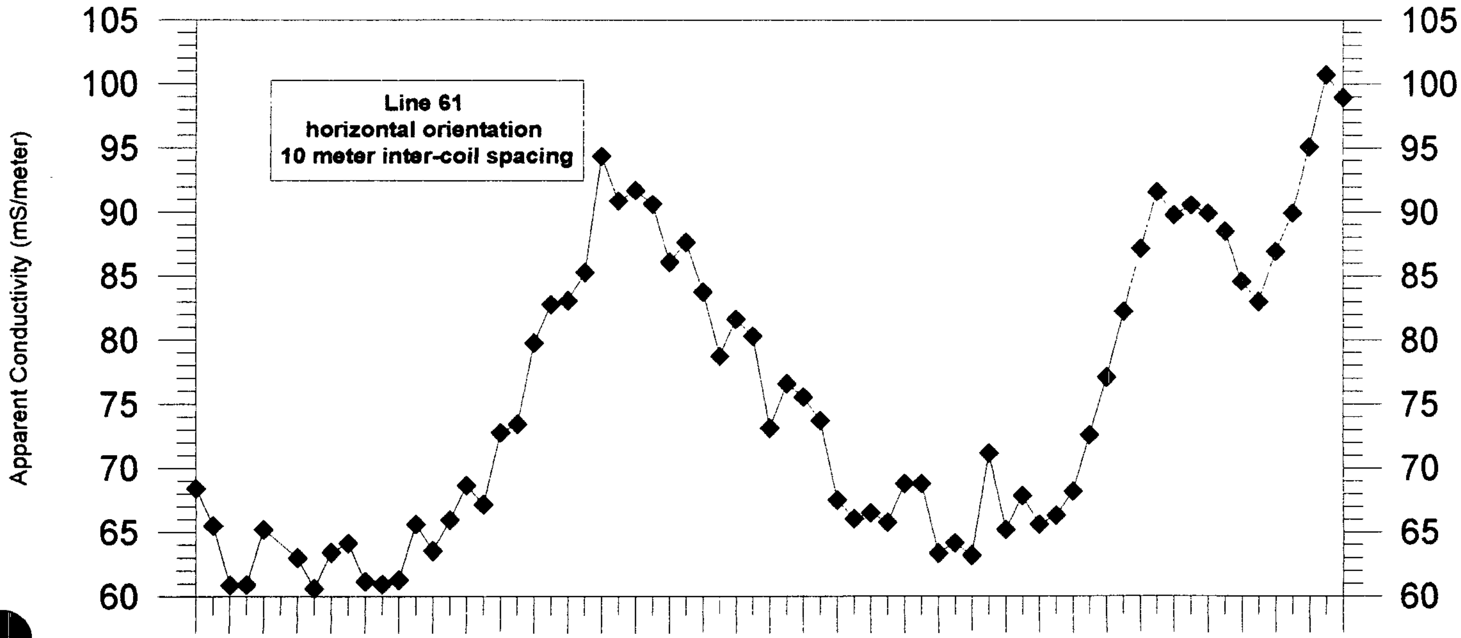


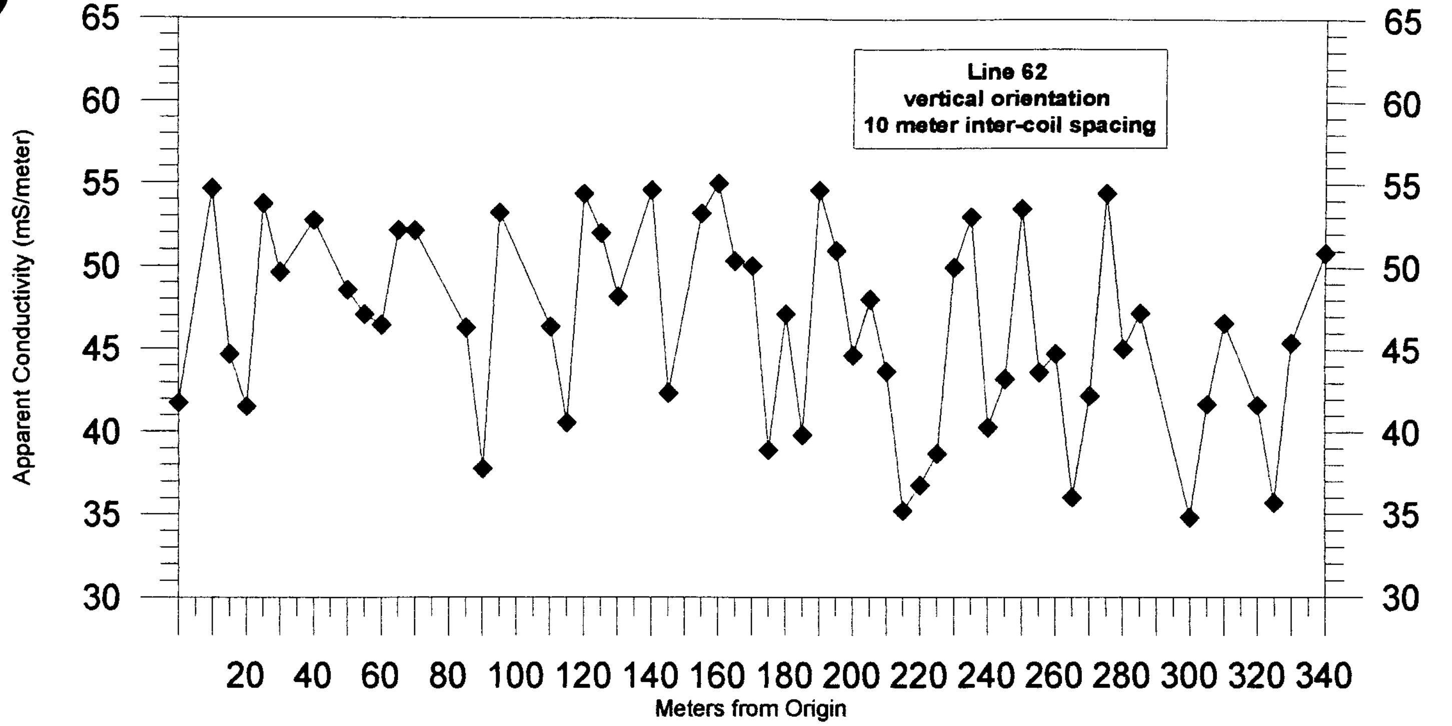
Line 60
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
70
65
60
55
50
45
40
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340

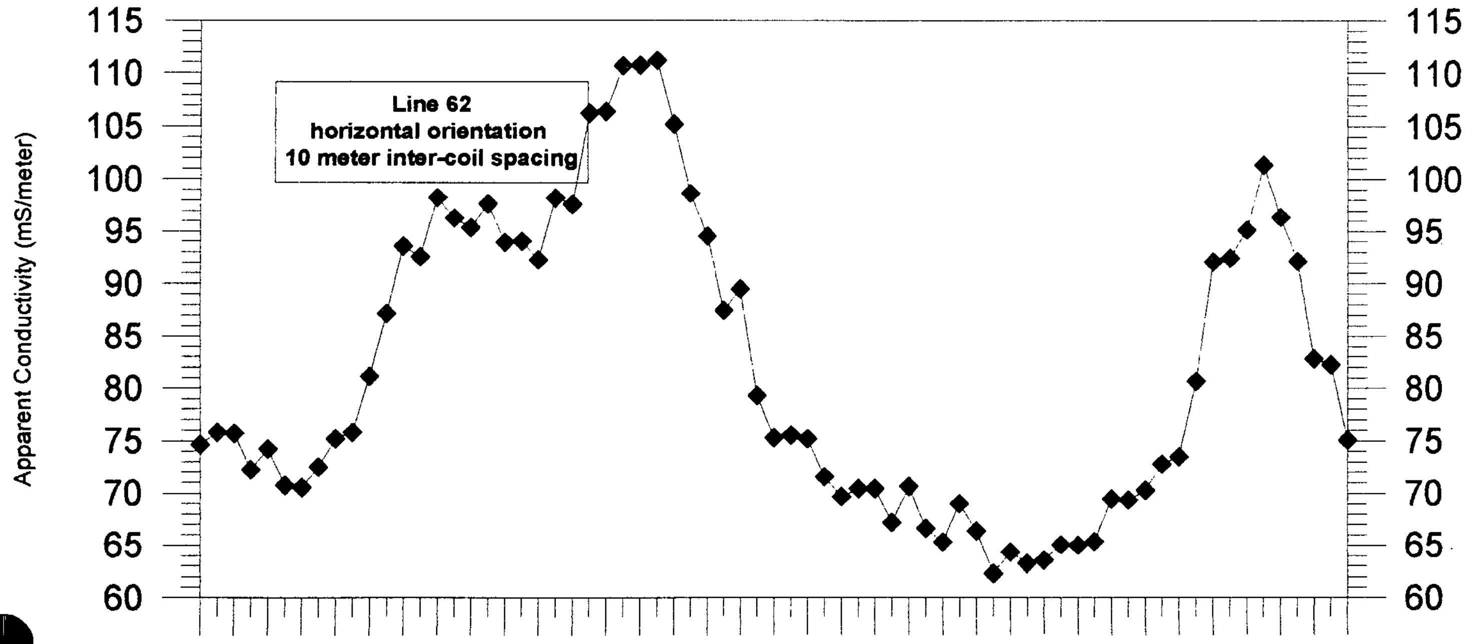



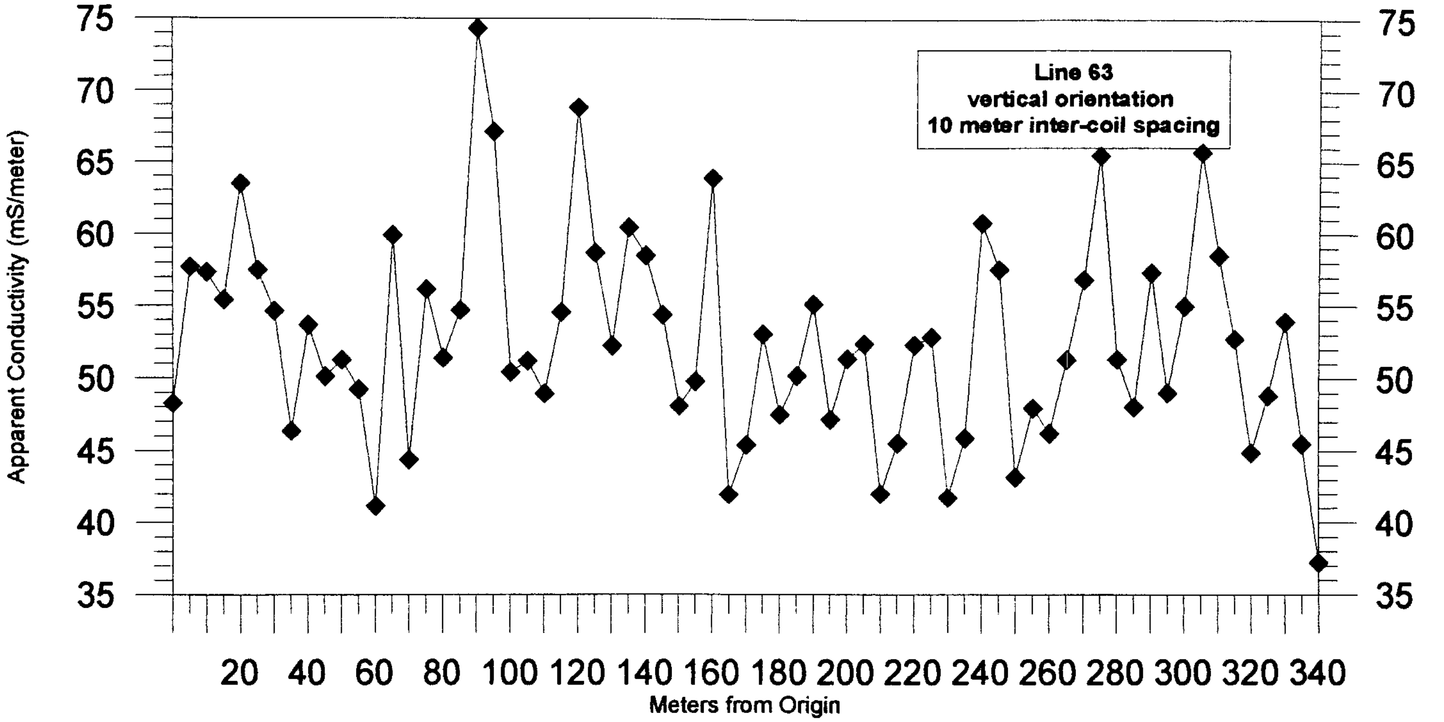
Line 60
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
95
90
85
80
75
70
65

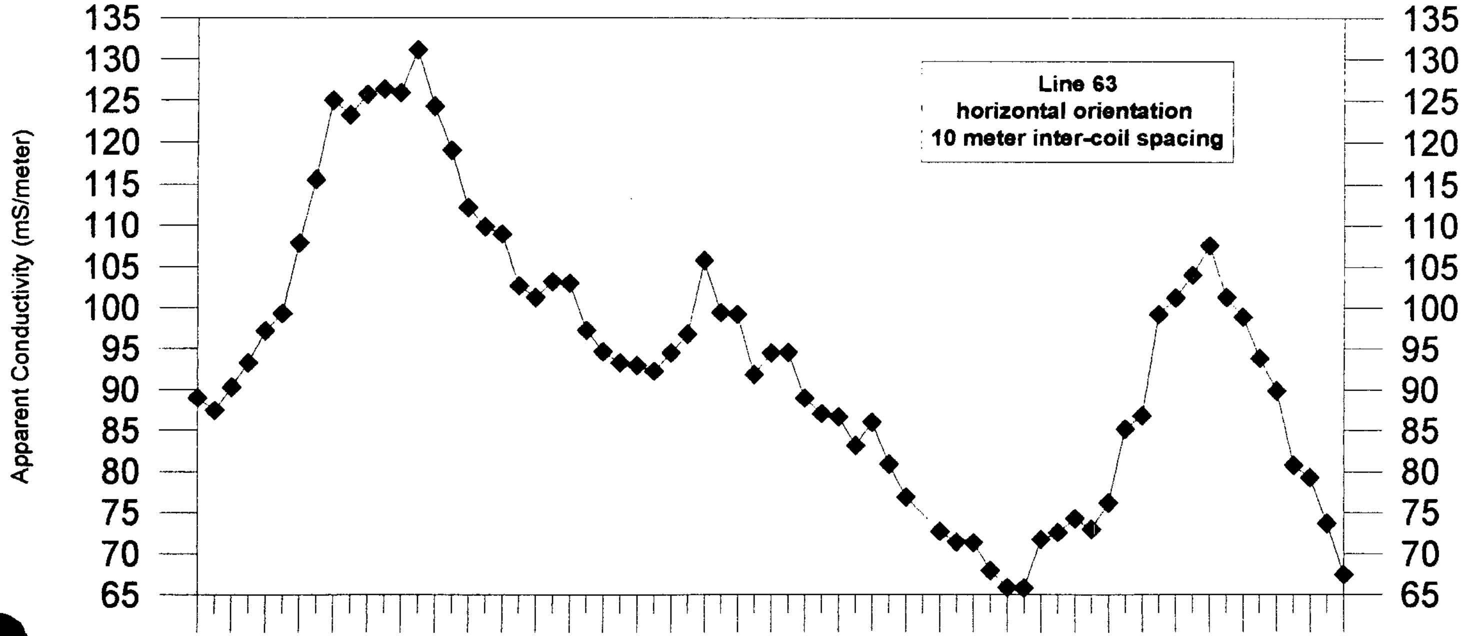

Line 61
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
70
65
60
55
50
45
40
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340

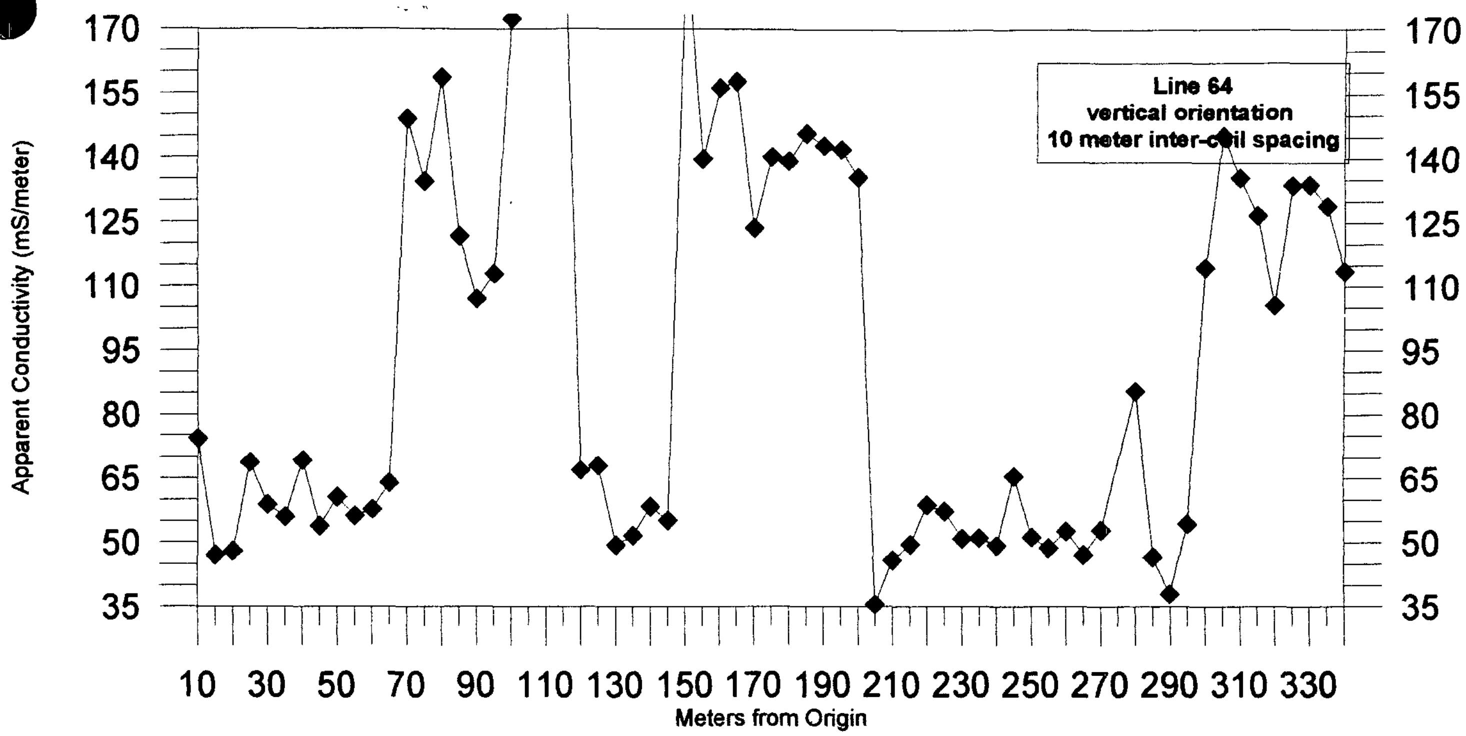

Line 61
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
105
100
95
90
85
80
75
70
65
60

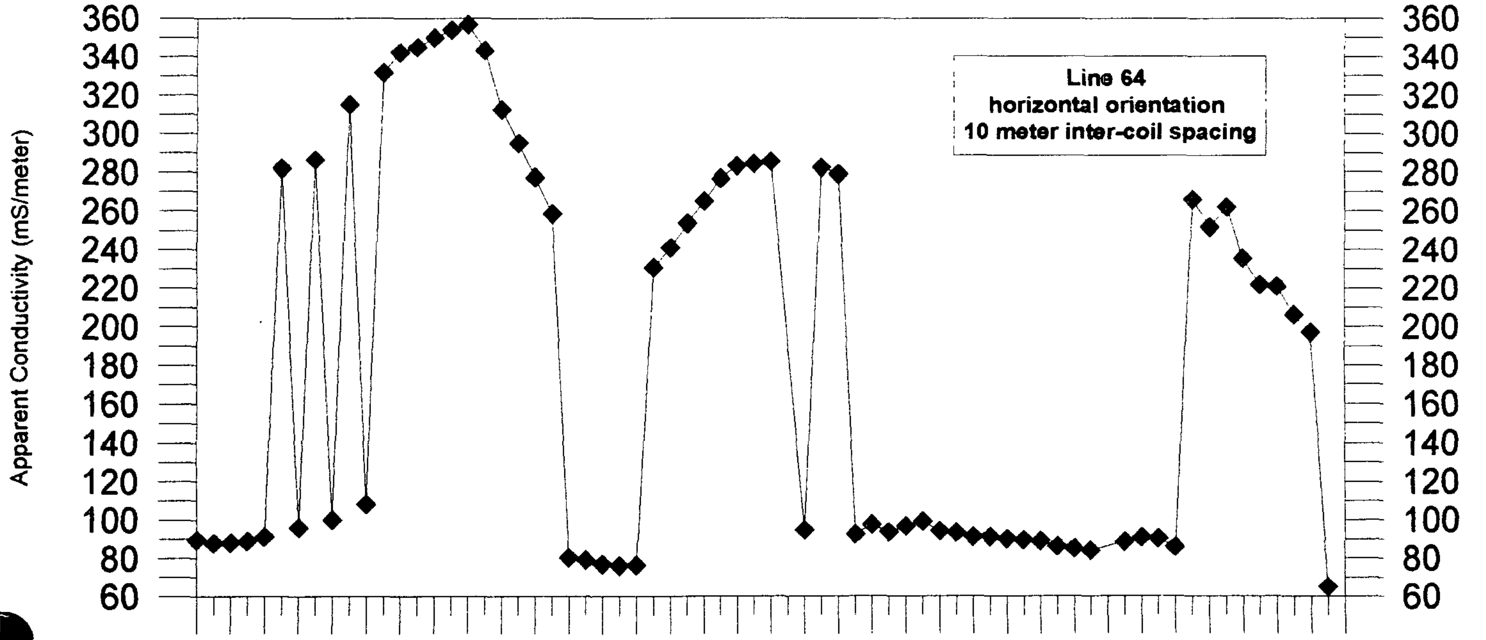

Line 62
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
65
60
55
50
45
40
35
30
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340

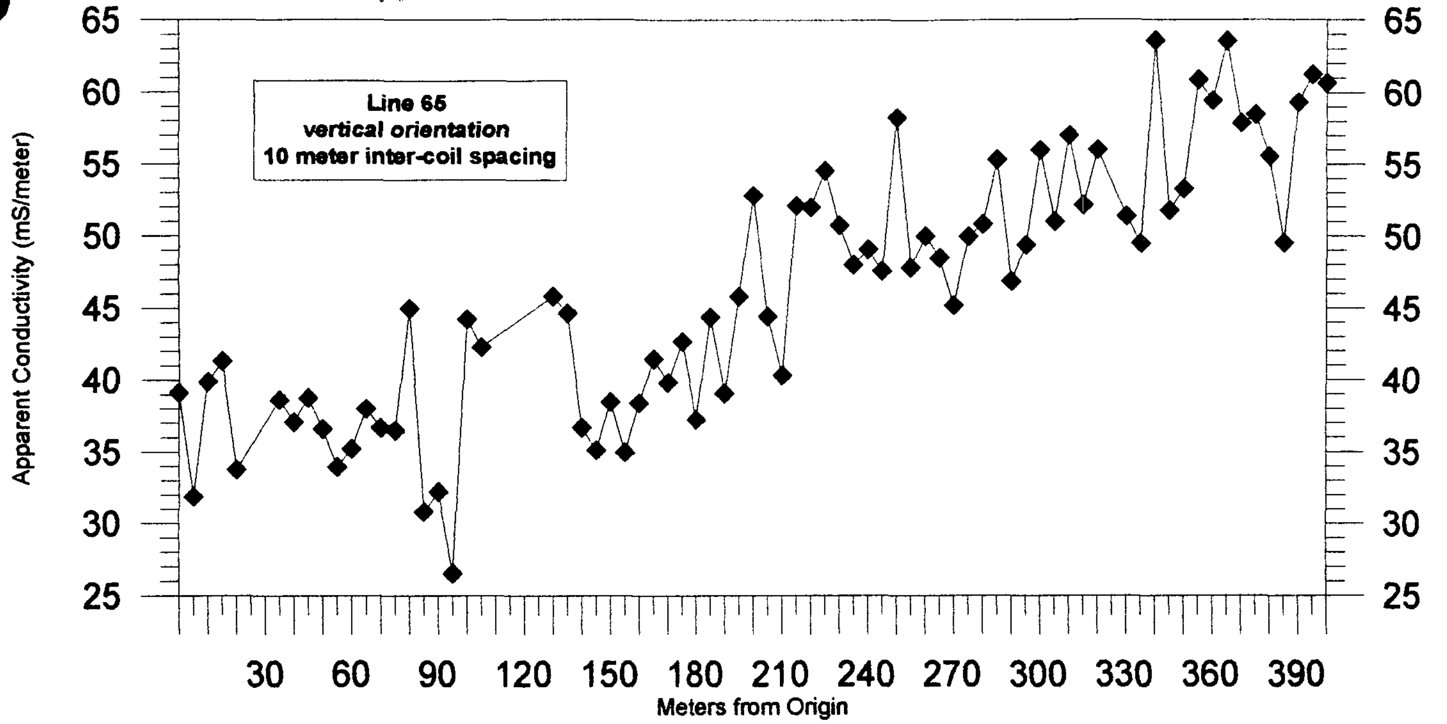

Line 62
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
115
110
105
100
95
90
85
80
75
70
65
60


Line 63
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
75
70
65
60
55
50
45
40
35
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340

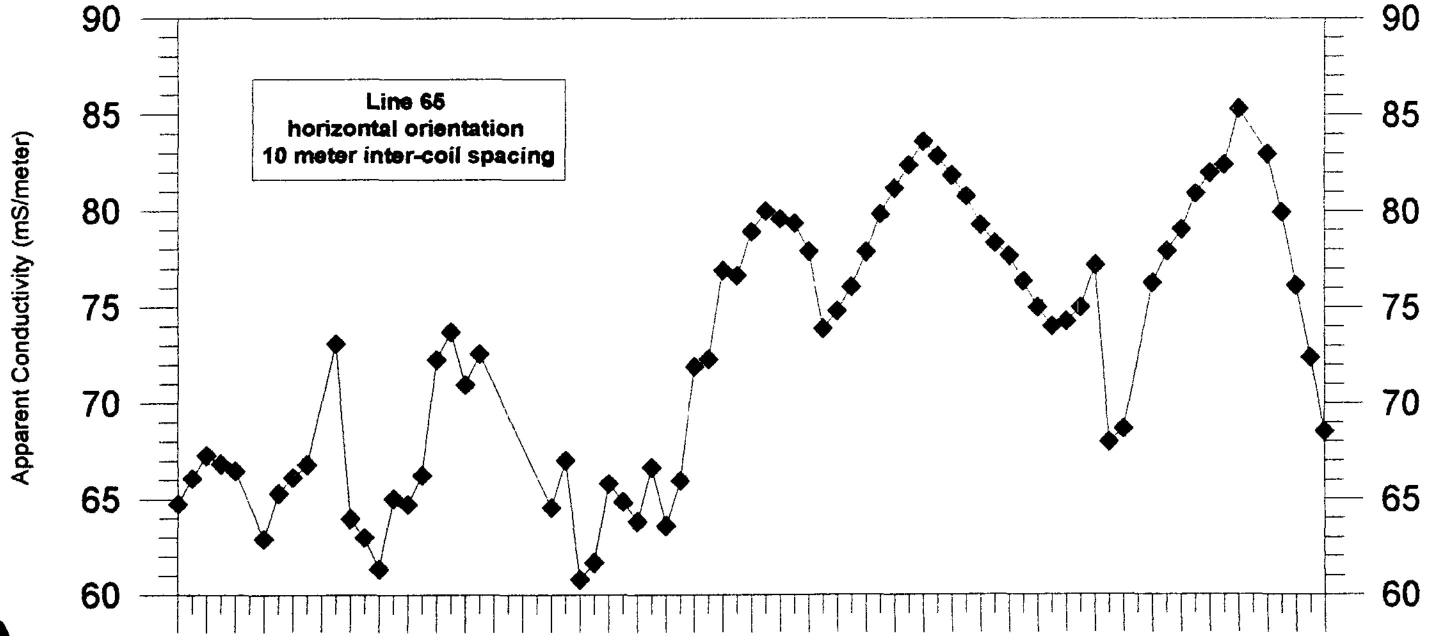

Line 63
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65


Line 64
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
170
155
140
125
110
95
80
65
50
35
10 30 50 70 90 110 130 150 170 190 210 230 250 270 290 310 330
Meters from Origin

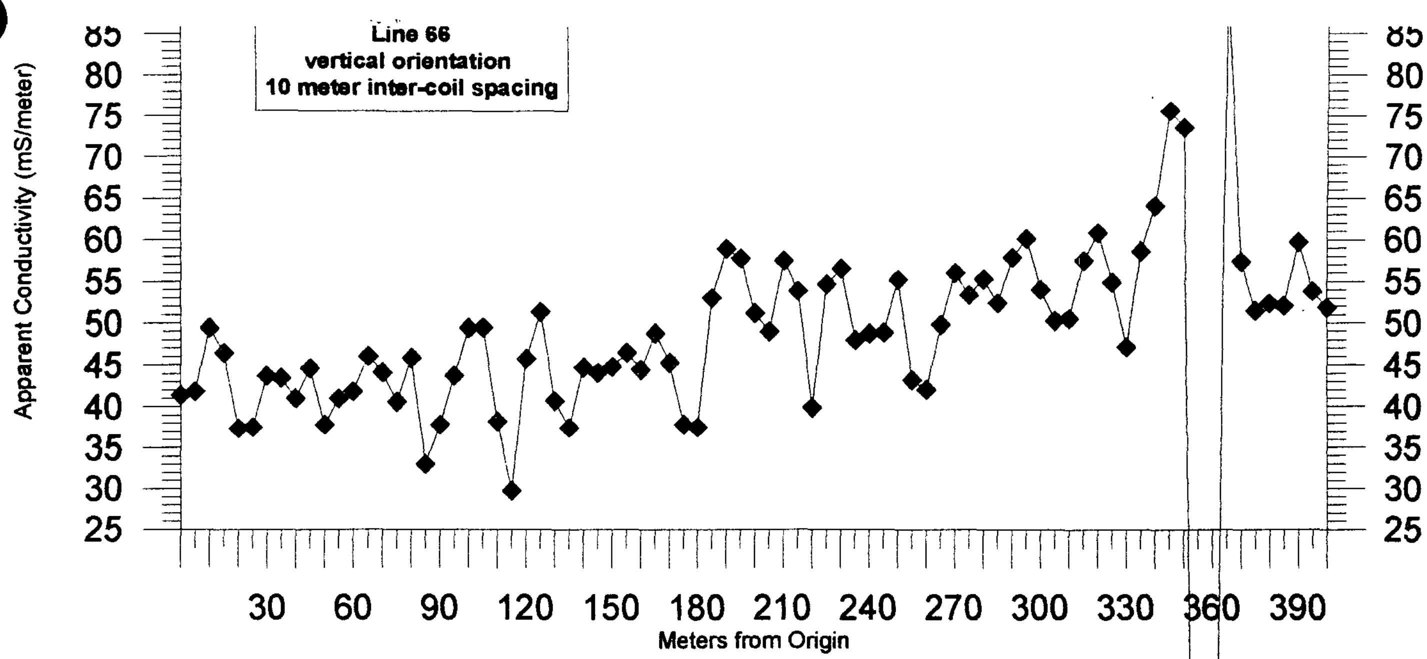

Line 64
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60

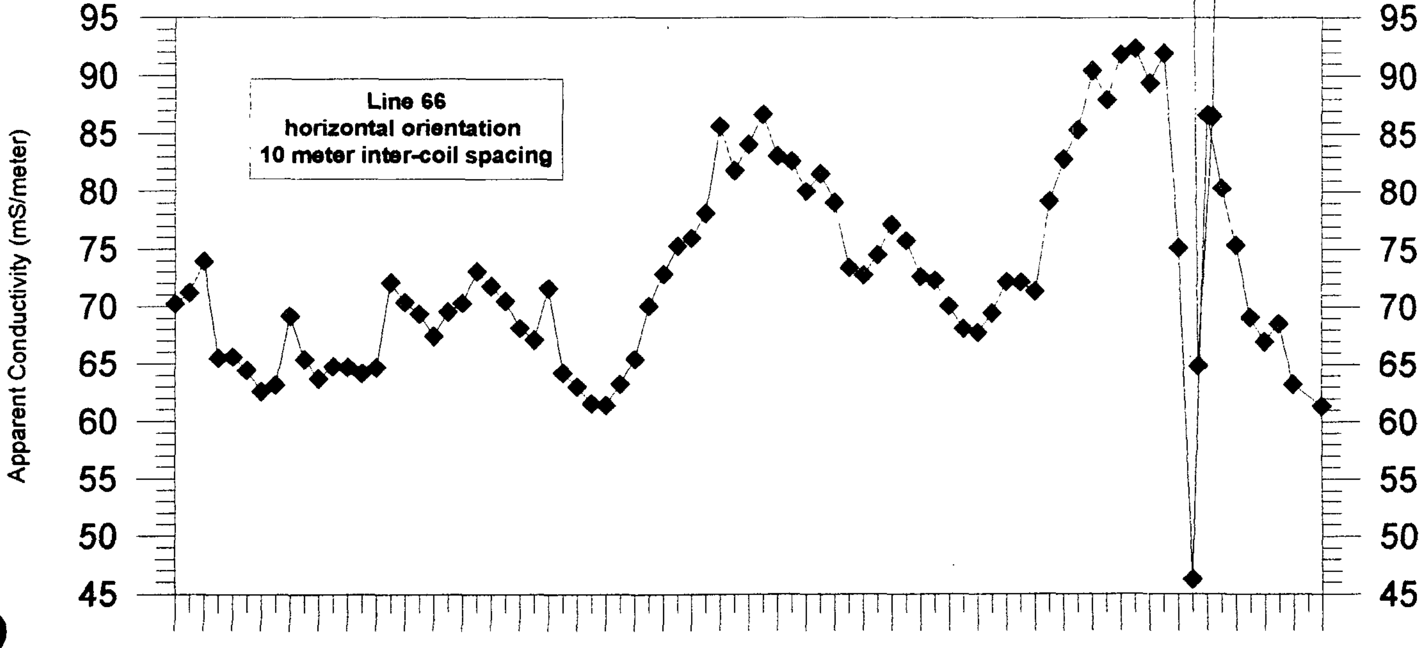


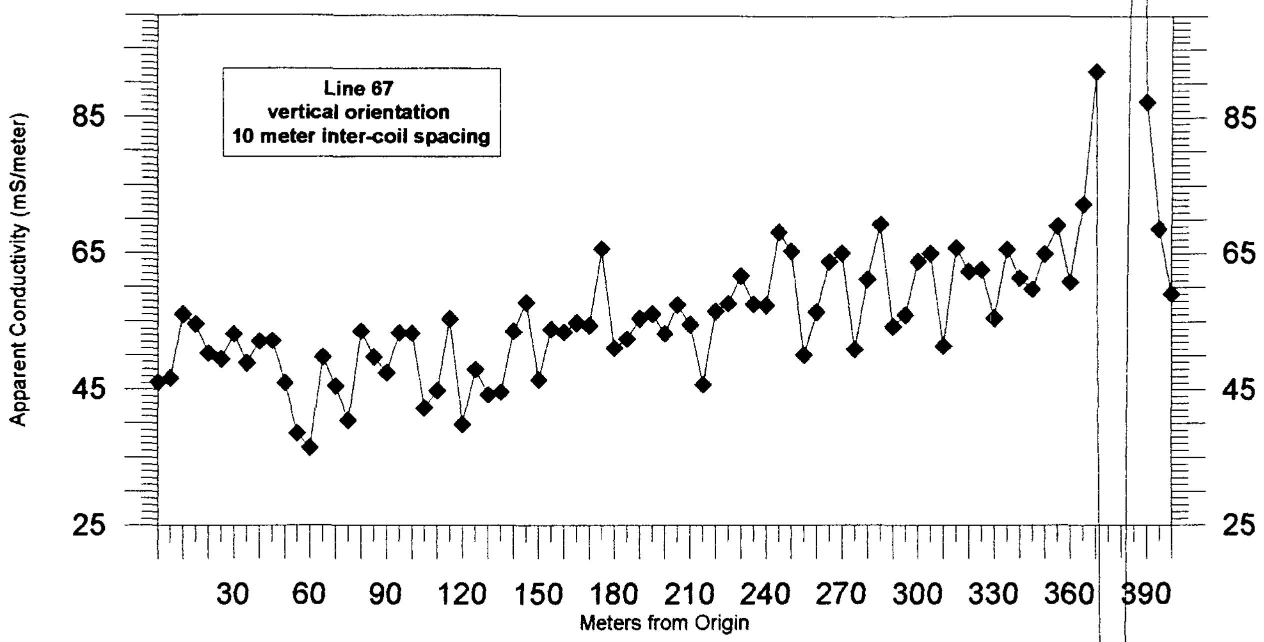
Line 65
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
65
60
55
50
45
40
35
30
25
30
60
90
120
150
180
210
240
270
300
330
360
390
Meters from Origin

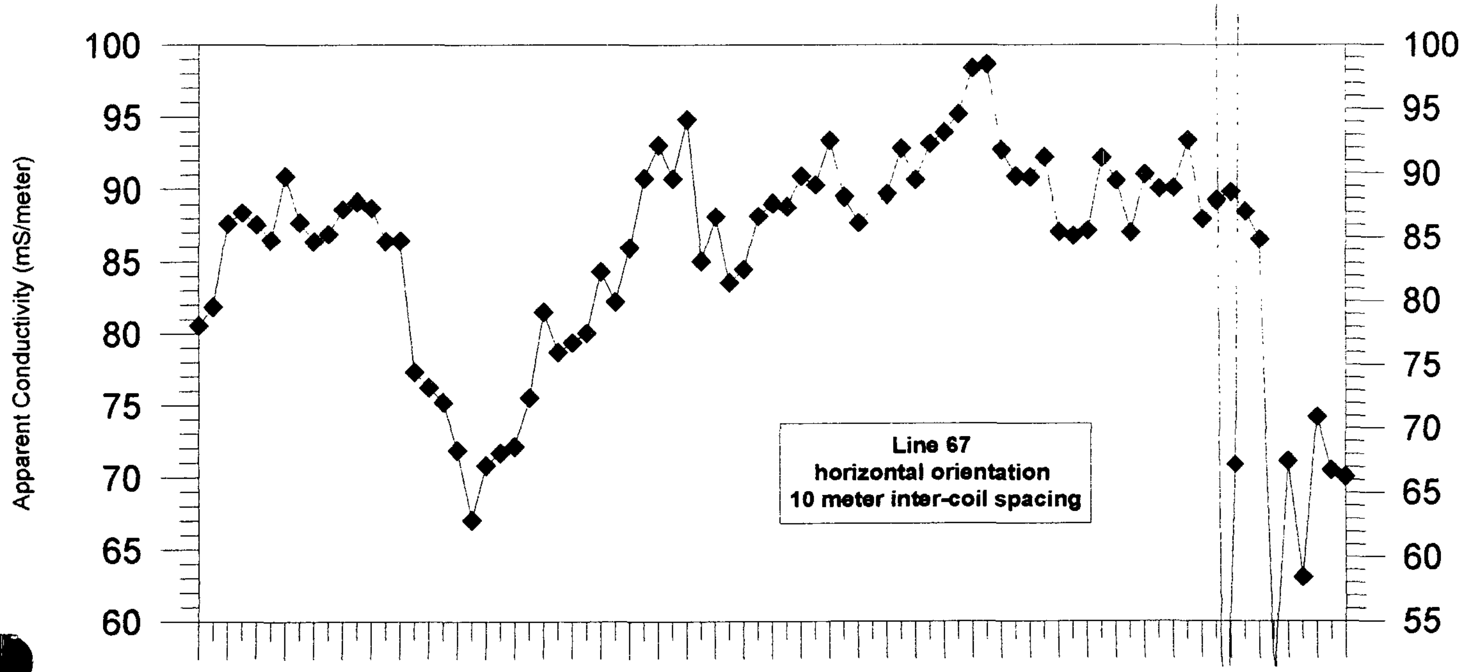



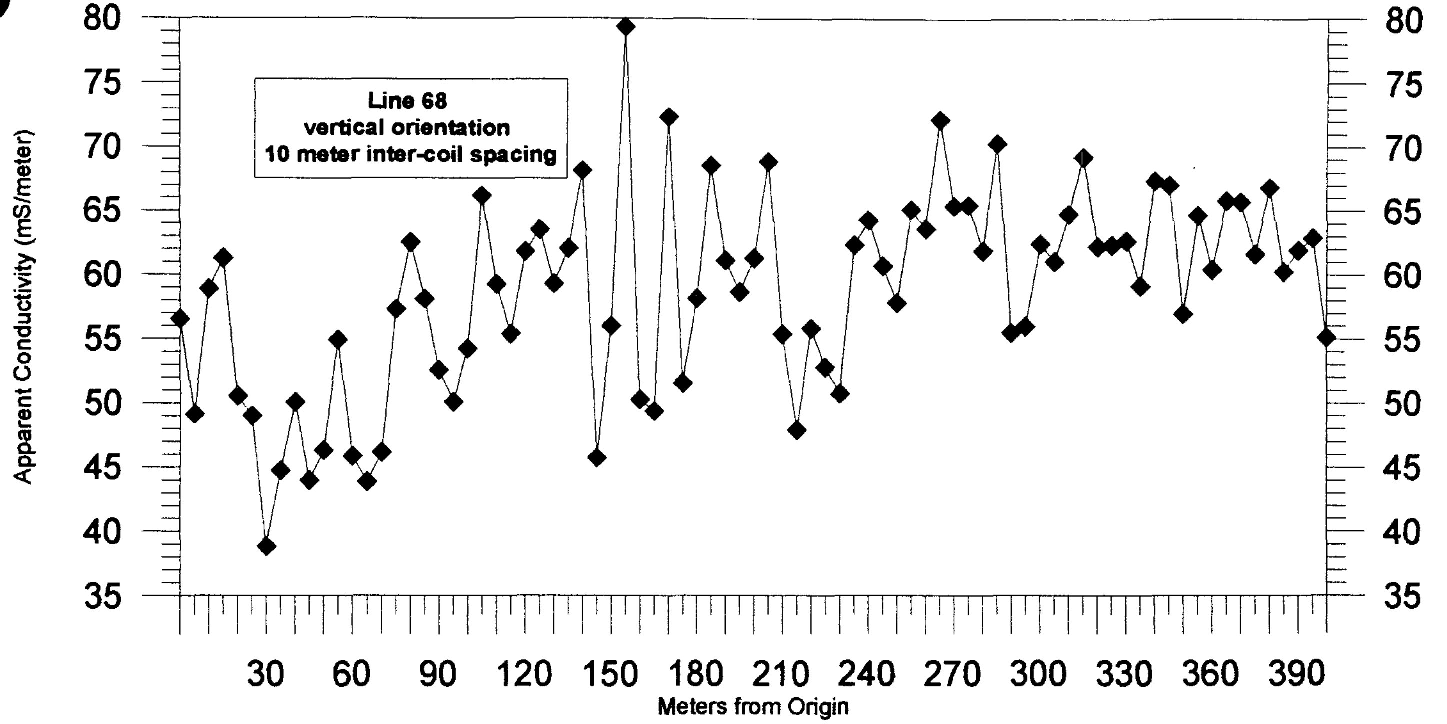
Line 65
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
90
85
80
75
70
65
60

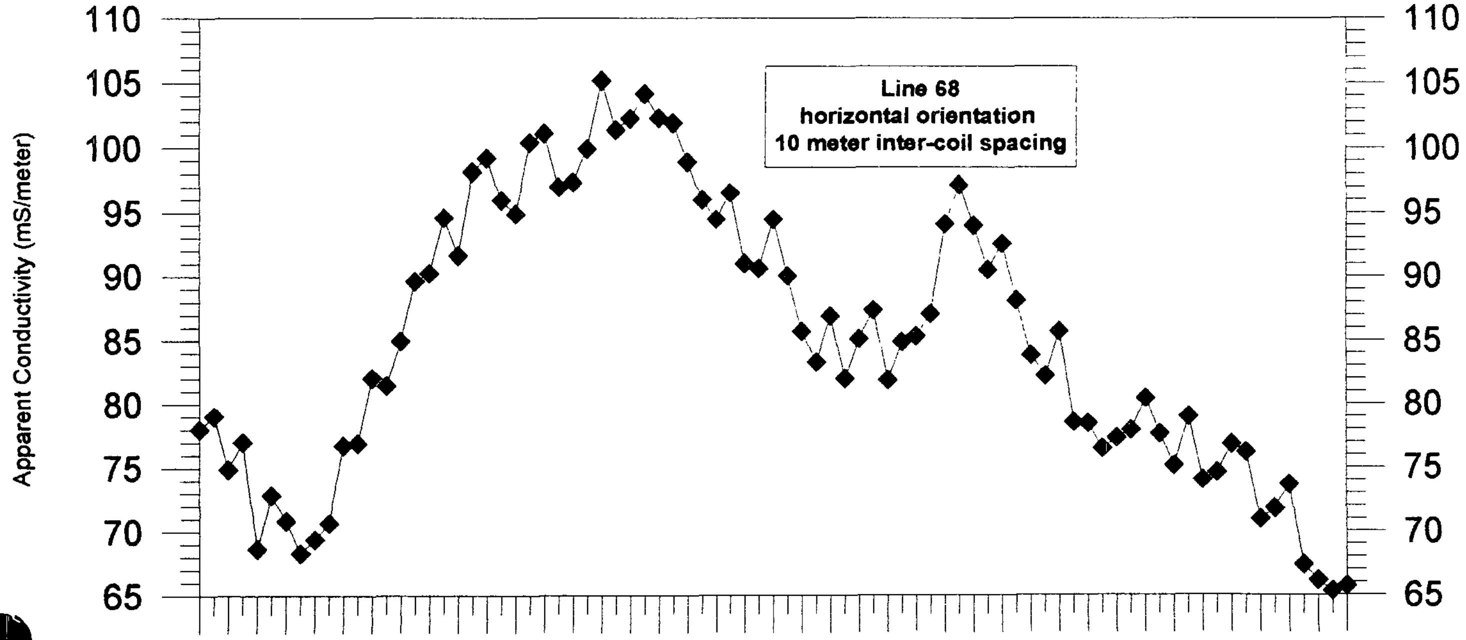

Line 66
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
85
80
75
70
65
60
55
50
45
40
35
30
25
30
60
90
120
150
180
210
240
270
300
330
360
390
Meters from Origin

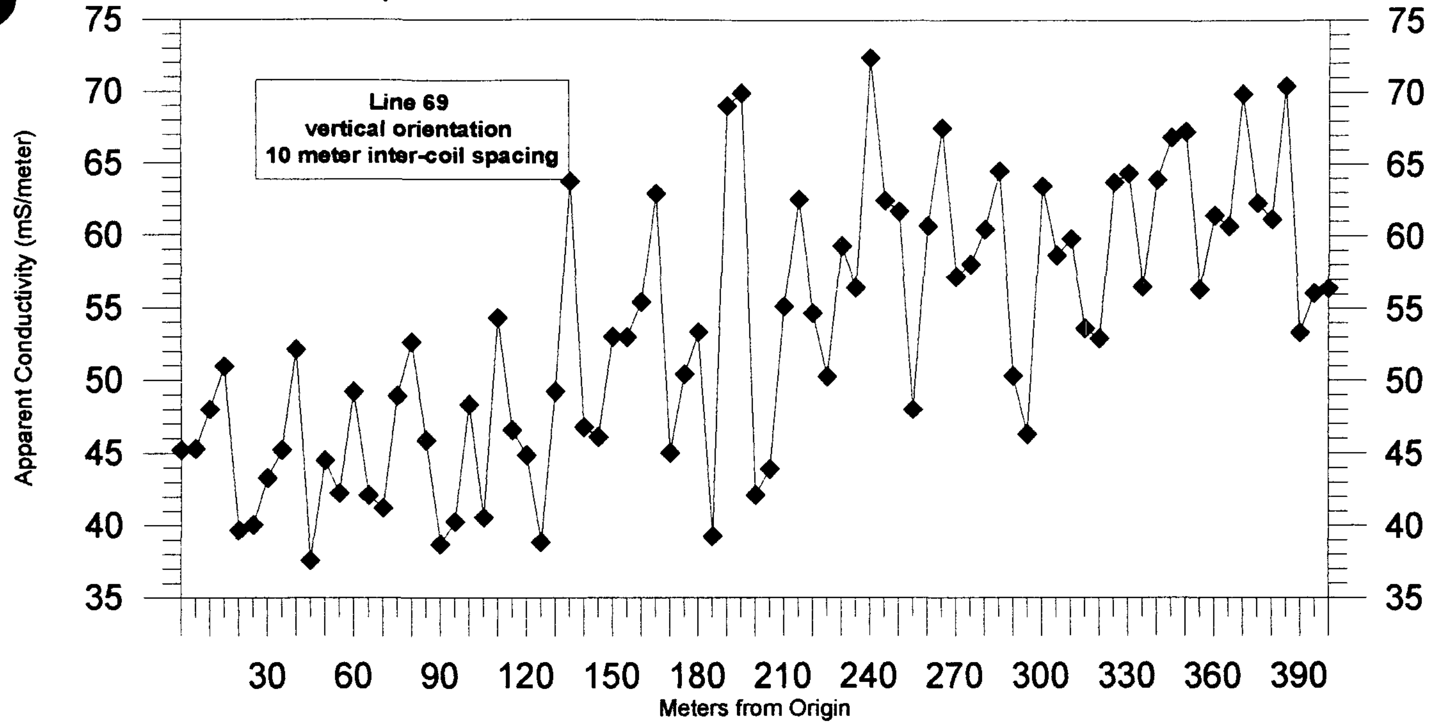

Line 66
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
95
90
85
80
75
70
65
60
55
50
45

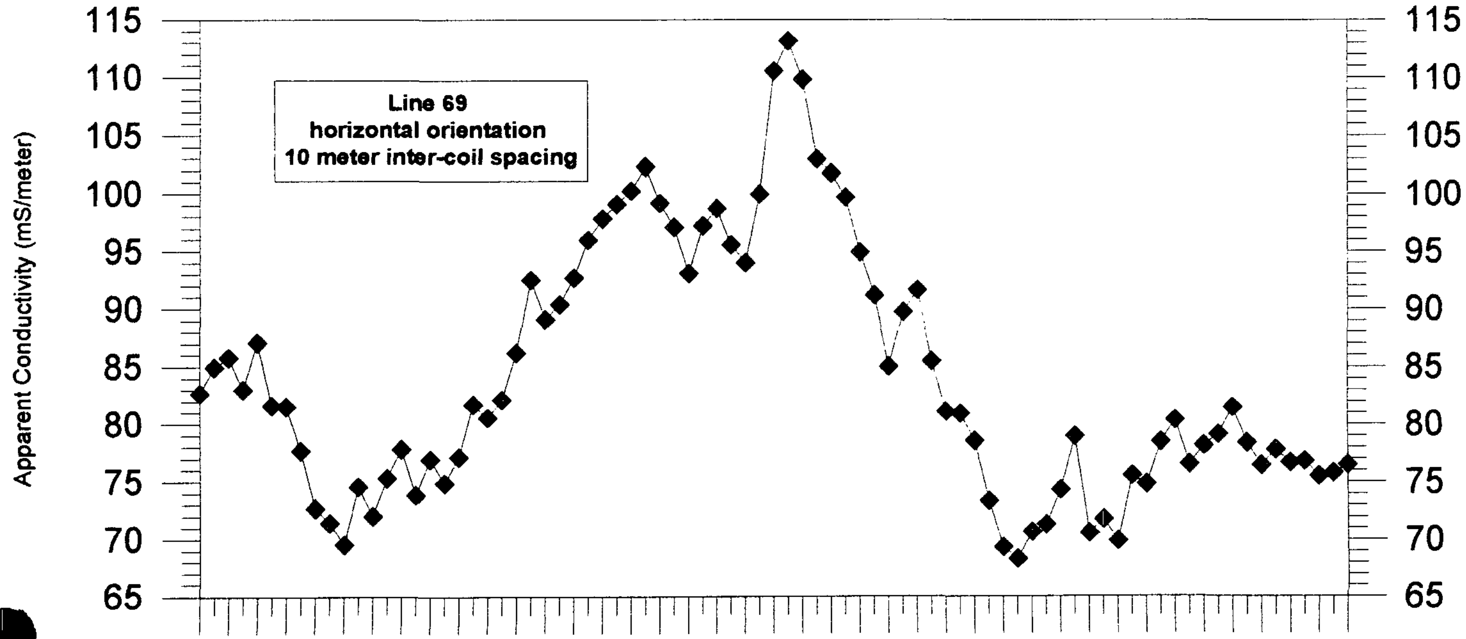

Line 67
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
85
65
45
25
30
60
90
120
150
180
210
240
270
300
330
360
390
Meters from Origin

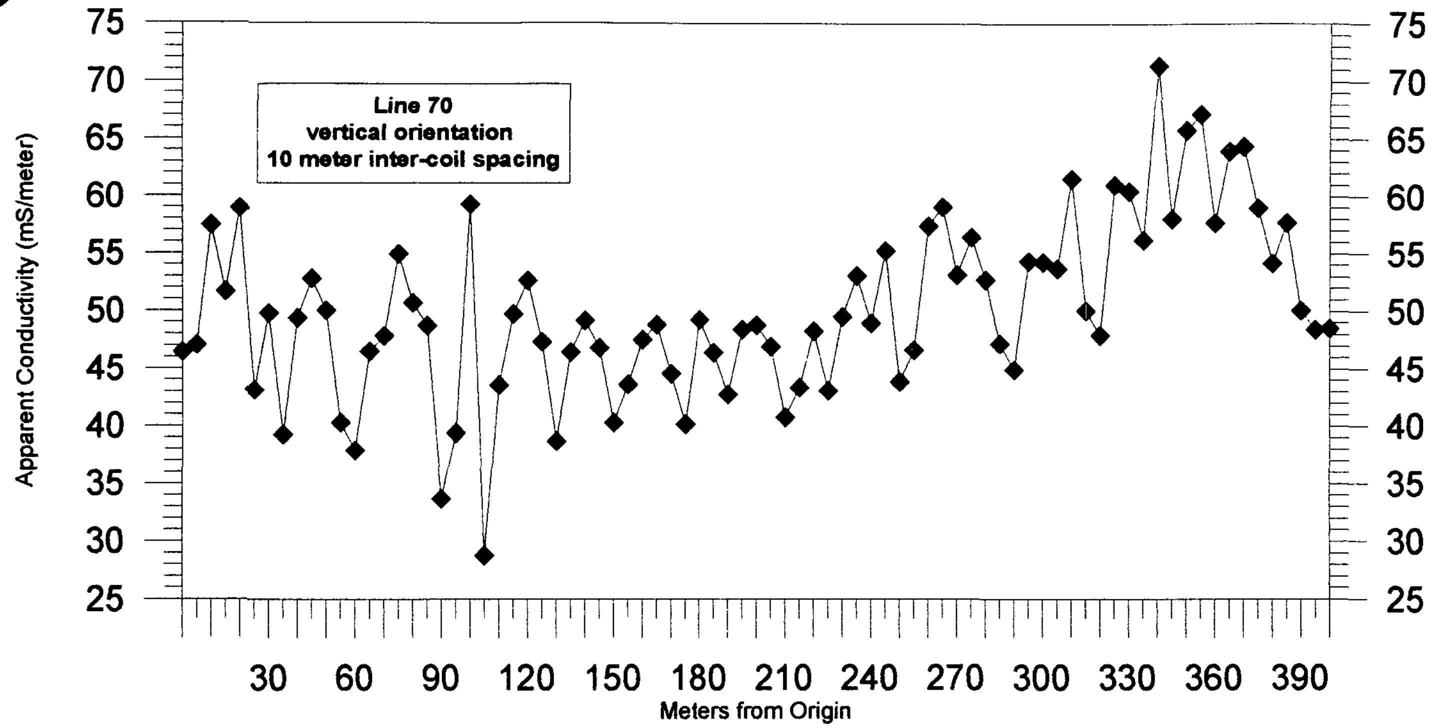

Line 67
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
100
95
90
85
80
75
70
65
60
55

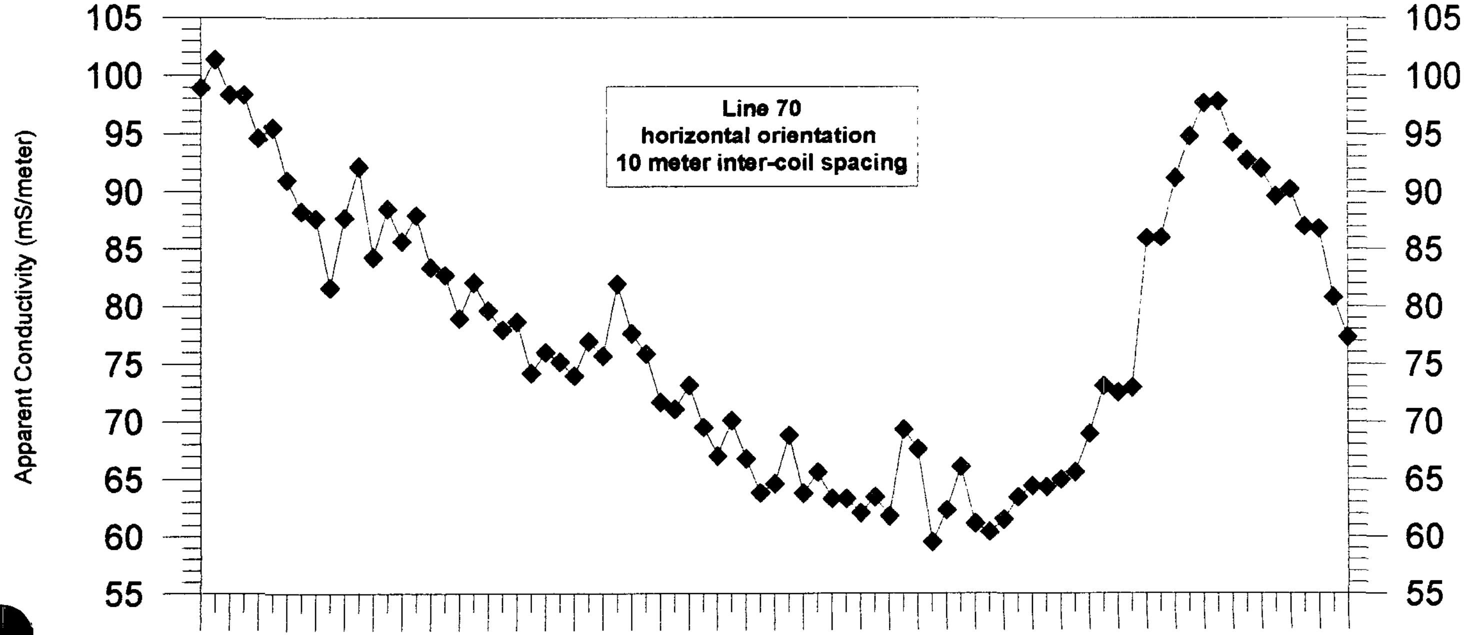

Line 68
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
80
75
70
65
60
55
50
45
40
35
30
60
90
120
150
180
210
240
270
300
330
360
390

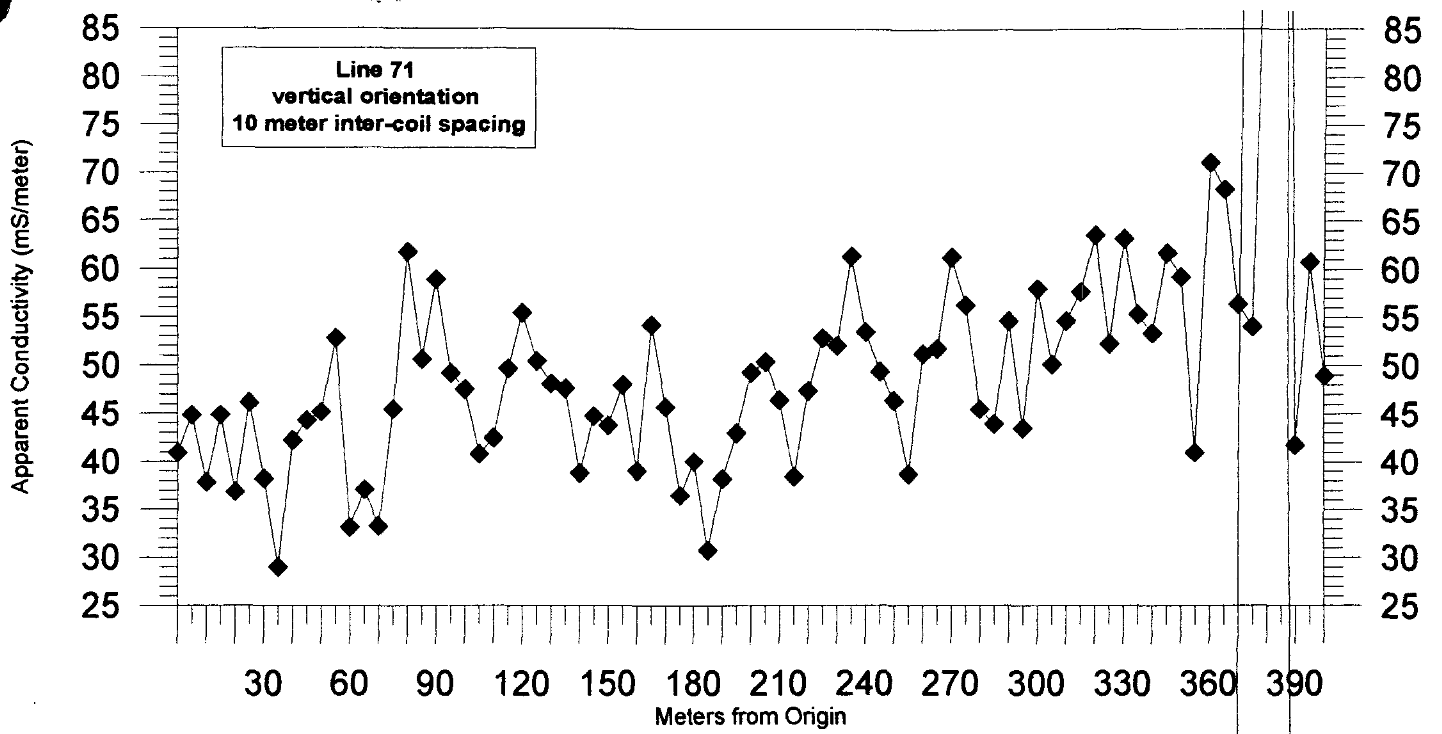

Line 68
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
110
105
100
95
90
85
80
75
70
65

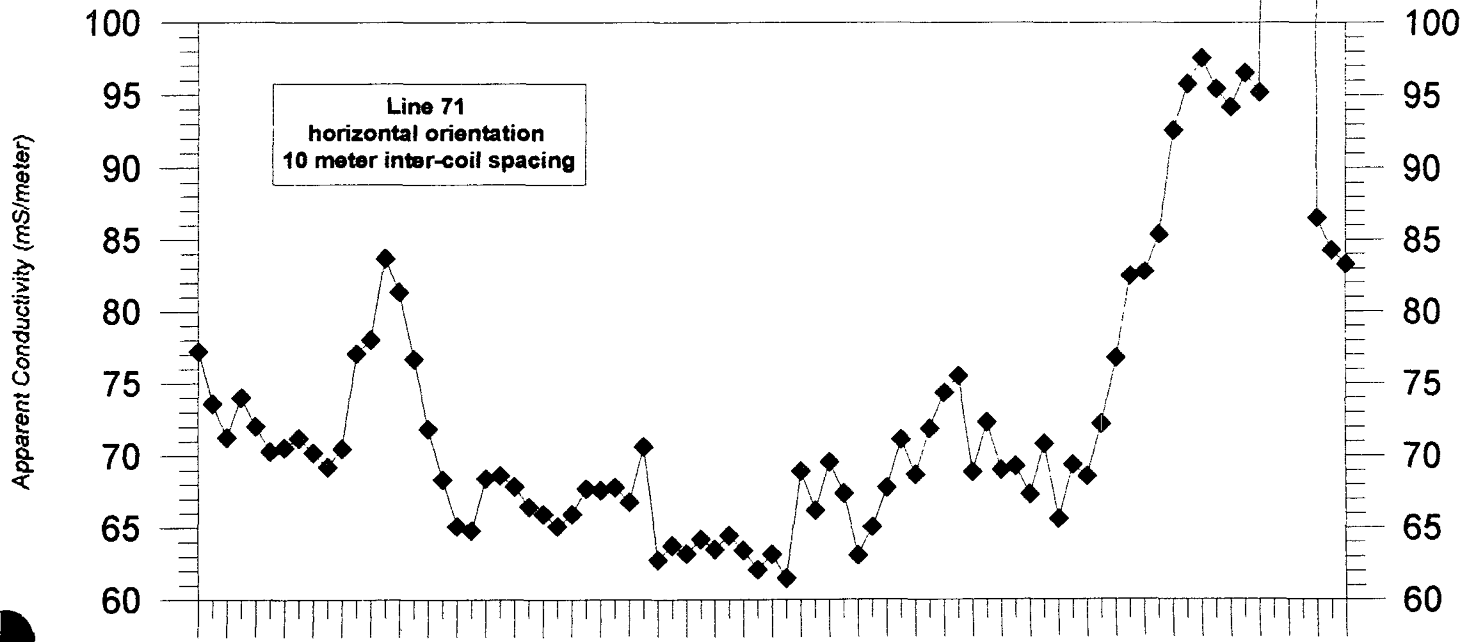

Line 69
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
75
70
65
60
55
50
45
40
35
30
60
90
120
150
180
210
240
270
300
330
360
390
Meters from Origin

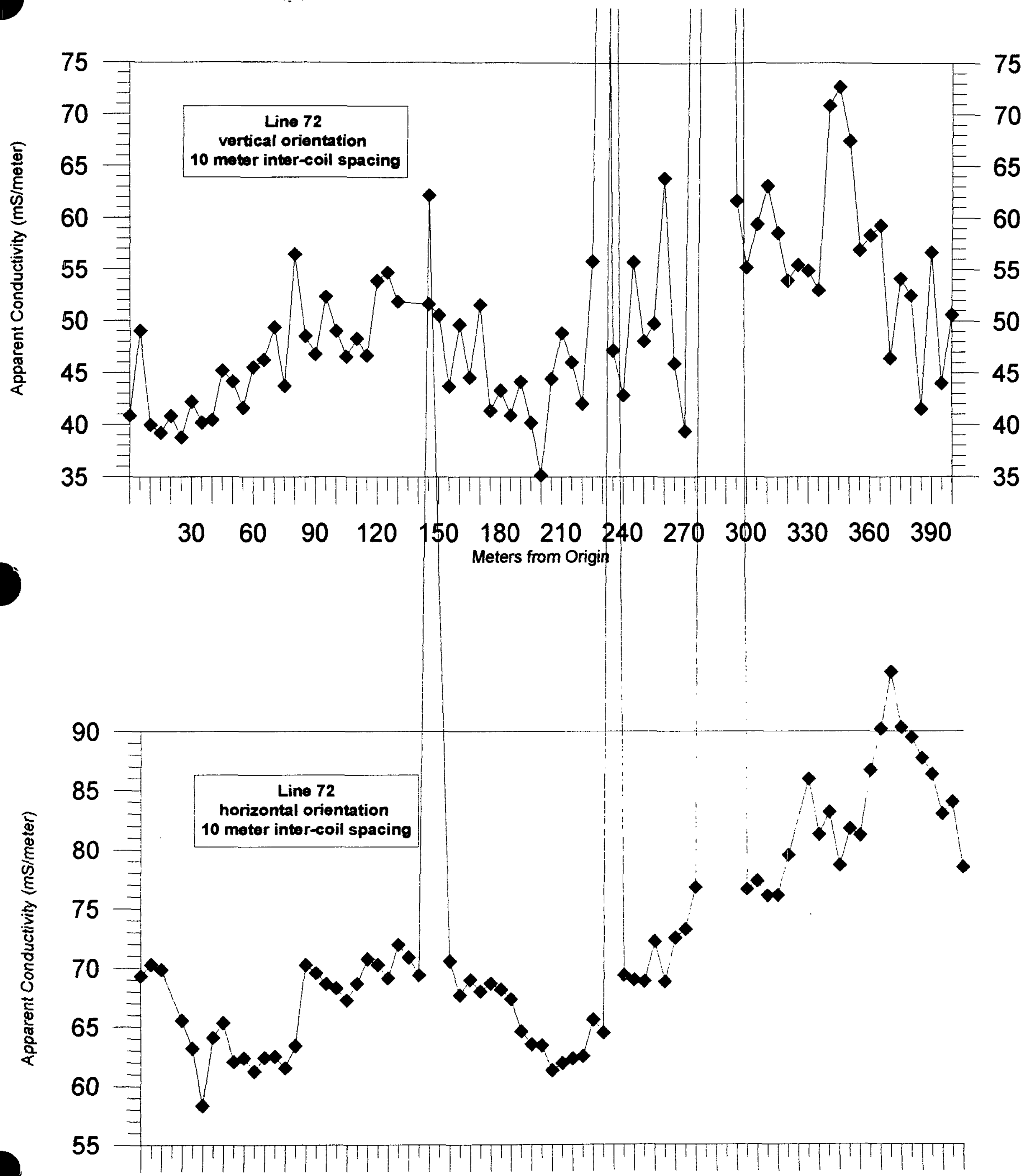

Line 69
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
115
110
105
100
95
90
85
80
75
70
65


Line 70
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
75
70
65
60
55
50
45
40
35
30
25
30 60 90 120 150 180 210 240 270 300 330 360 390

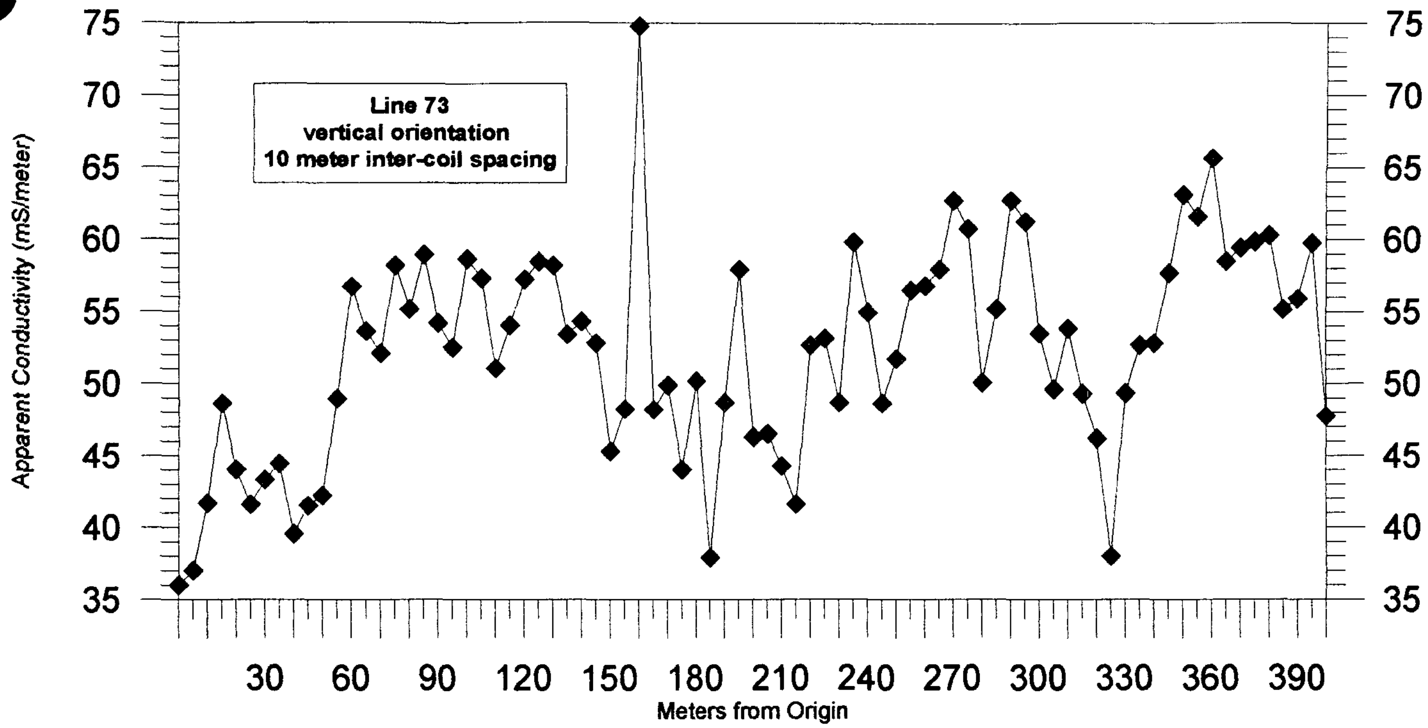

Line 70
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
105
100
95
90
85
80
75
70
65
60
55

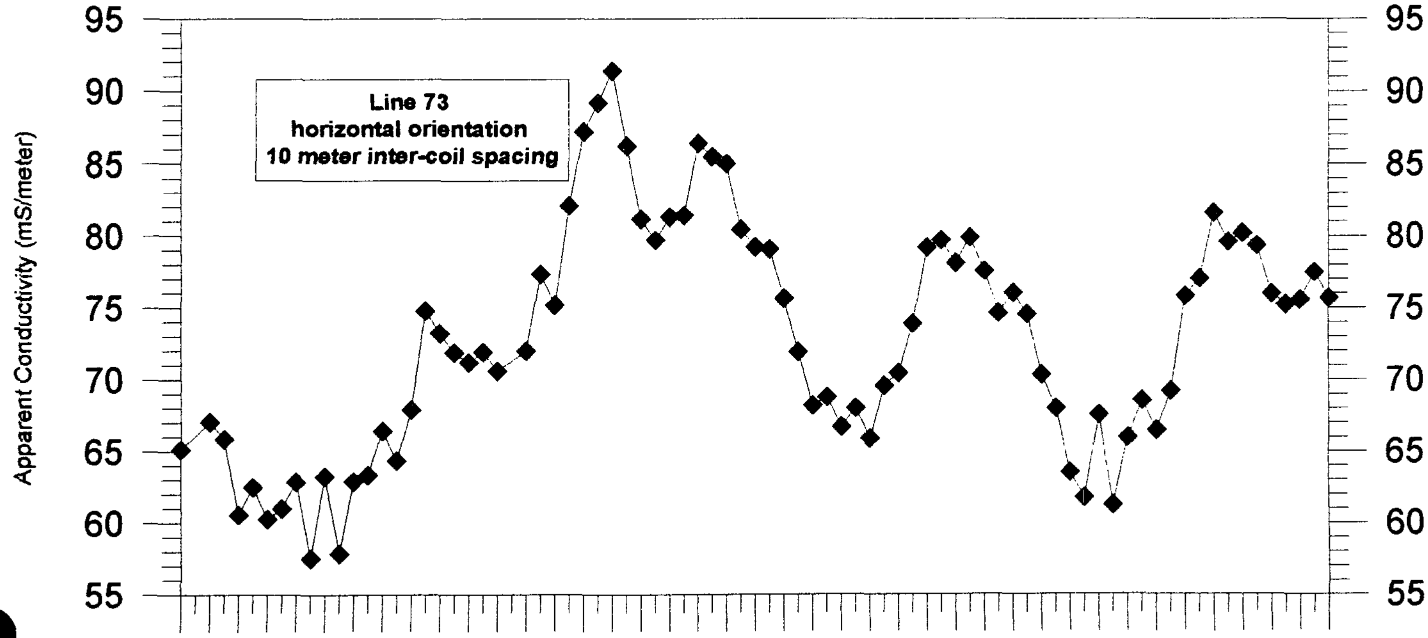

Line 71
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
85
80
75
70
65
60
55
50
45
40
35
30
25
30 60 90 120 150 180 210 240 270 300 330 360 390
Meters from Origin

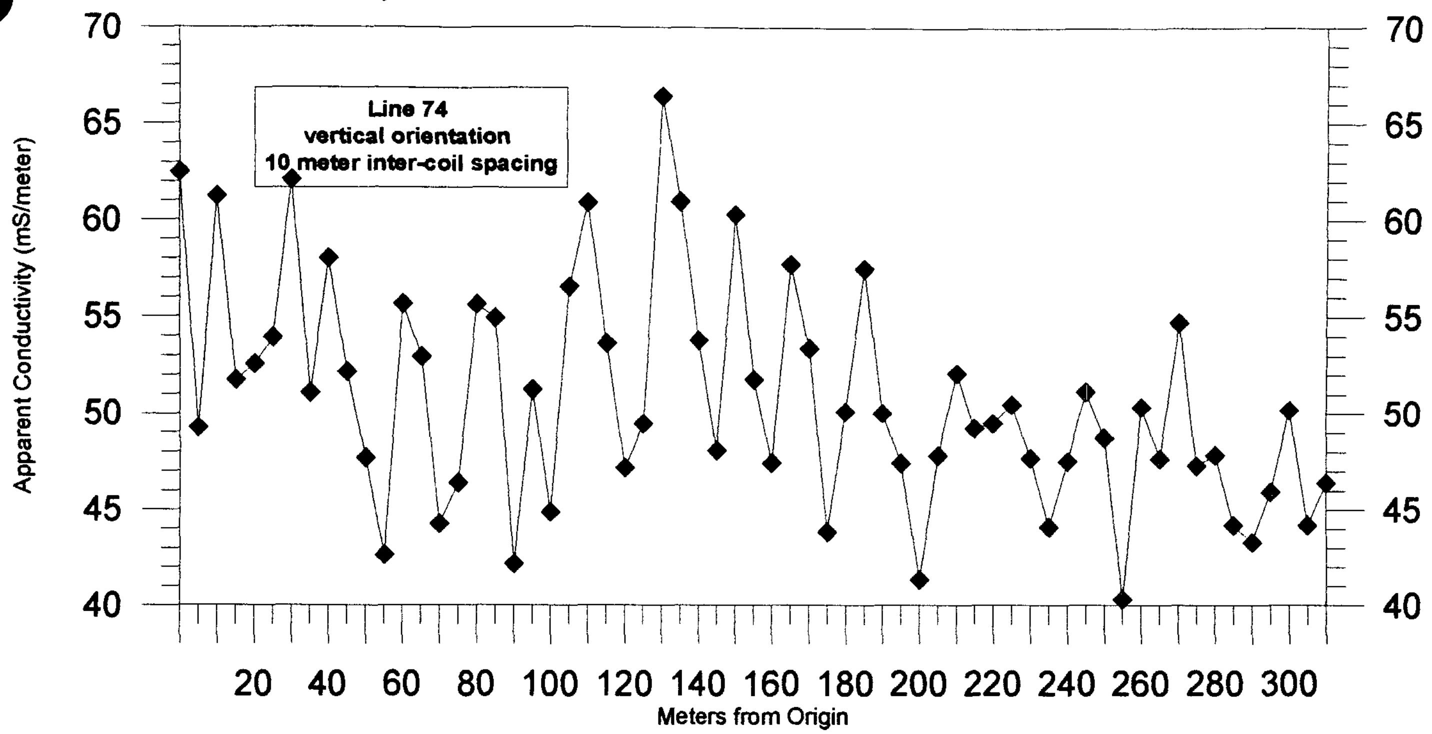

Line 71
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
100
95
90
85
80
75
70
65
60

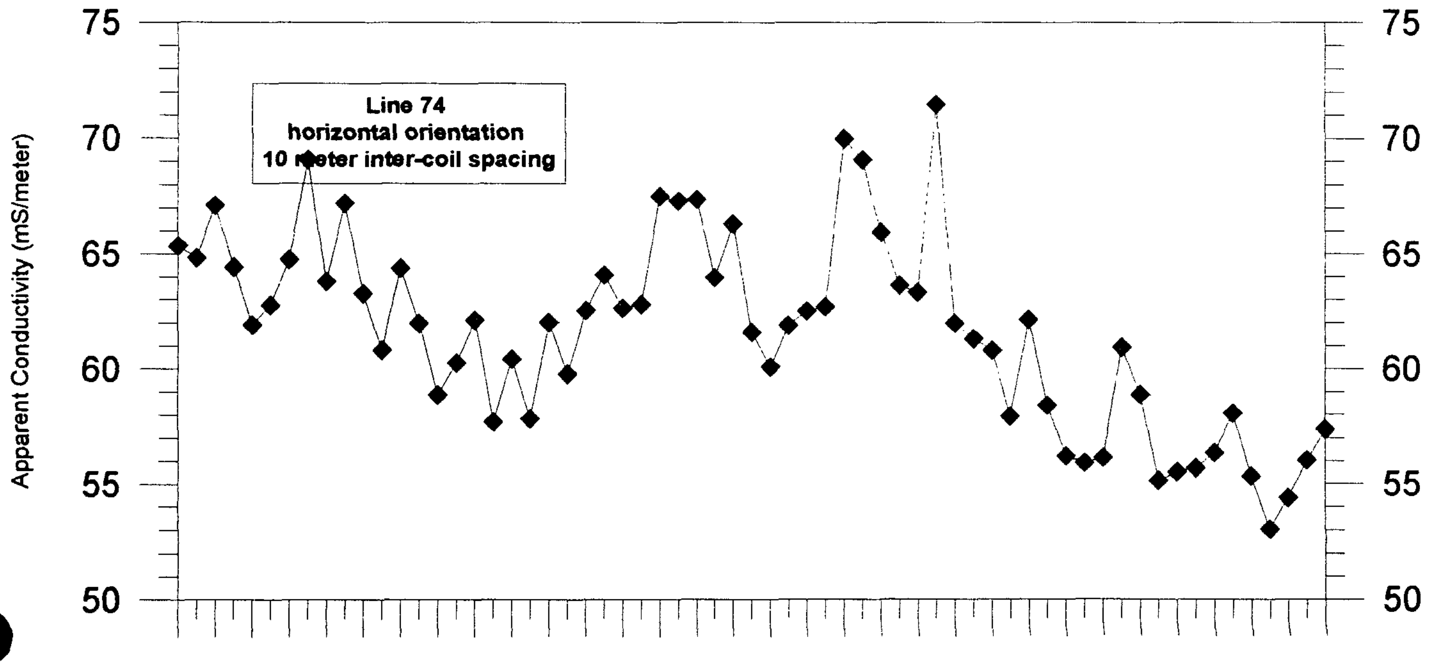


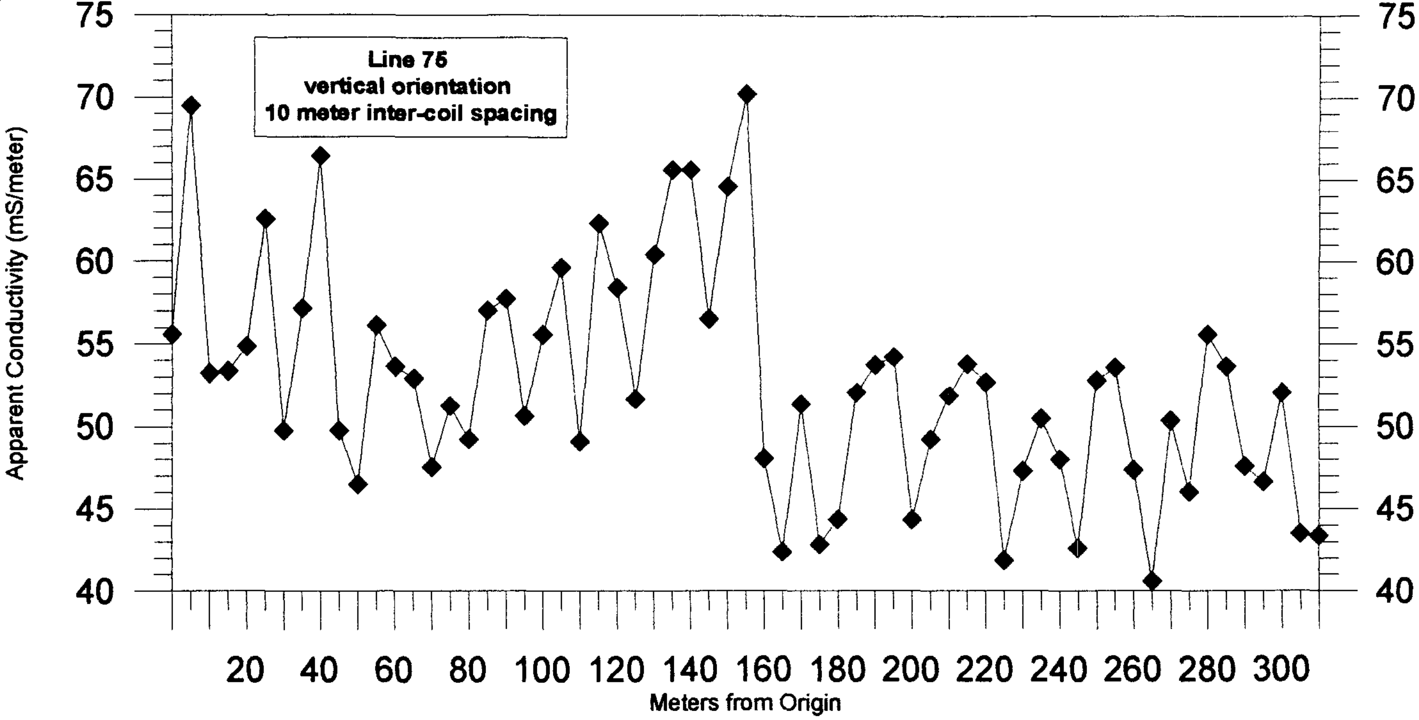
Line 72
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
75
70
65
60
55
50
45
40
35
30 60 90 120 150 180 210 240 270 300 330 360 390
Meters from Origin
Line 72
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
90
85
80
75
70
65
60
55

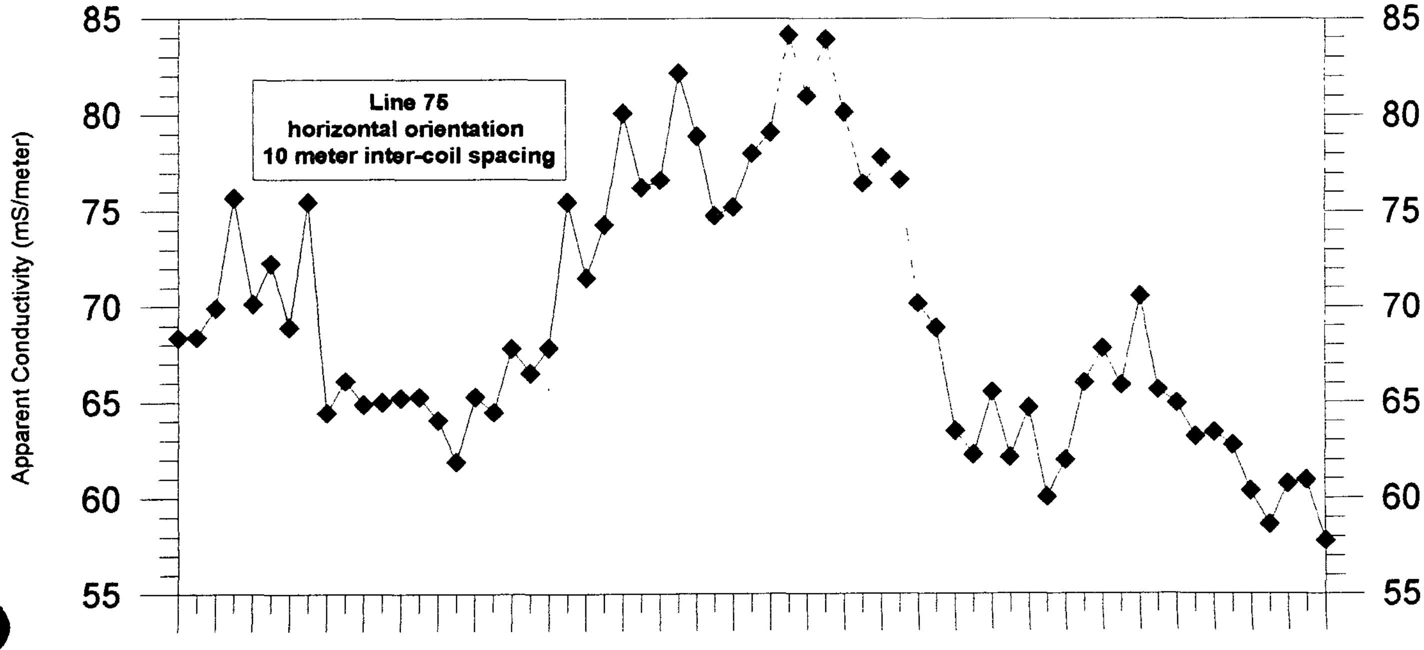

Line 73
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
75
70
65
60
55
50
45
40
35
30 60 90 120 150 180 210 240 270 300 330 360 390
Meters from Origin

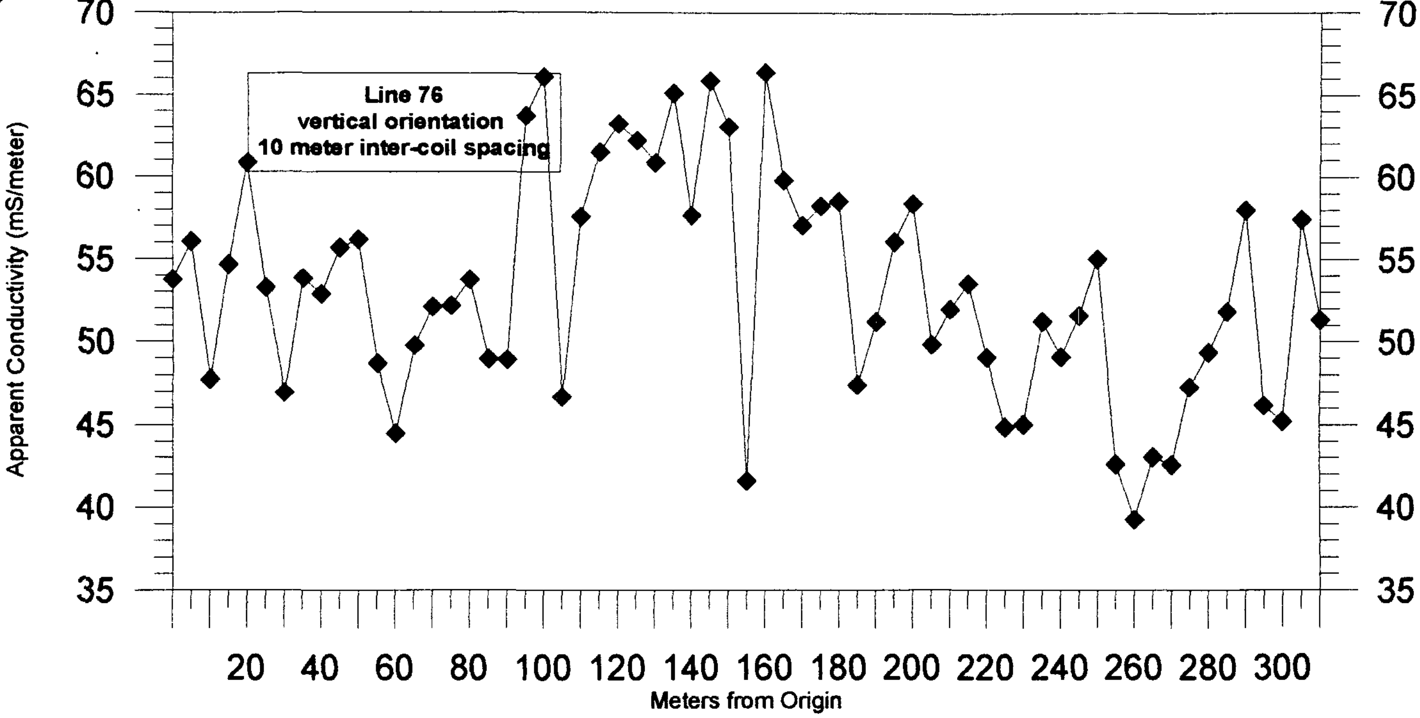

Line 73
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
95
90
85
80
75
70
65
60
55


Line 74
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
70
65
60
55
50
45
40
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

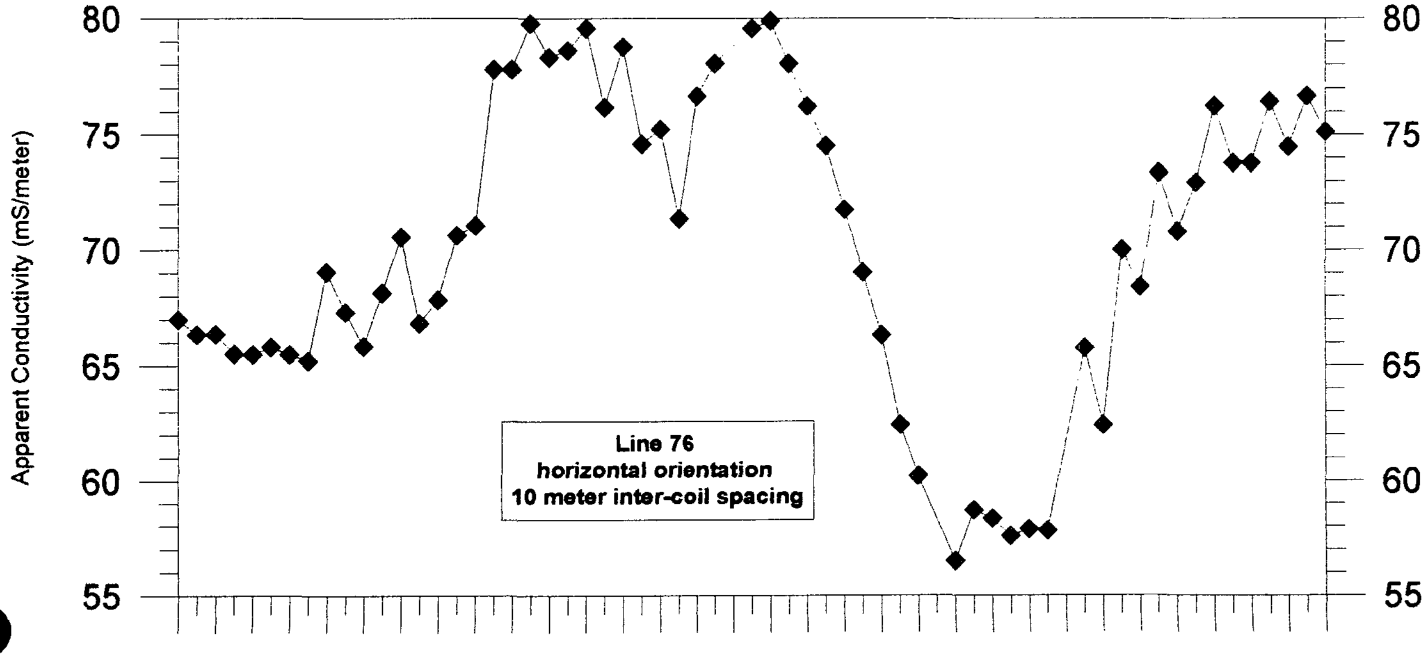

Line 74
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
75
70
65
60
55
50


Line 75
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
75
70
65
60
55
50
45
40
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Meters from Origin

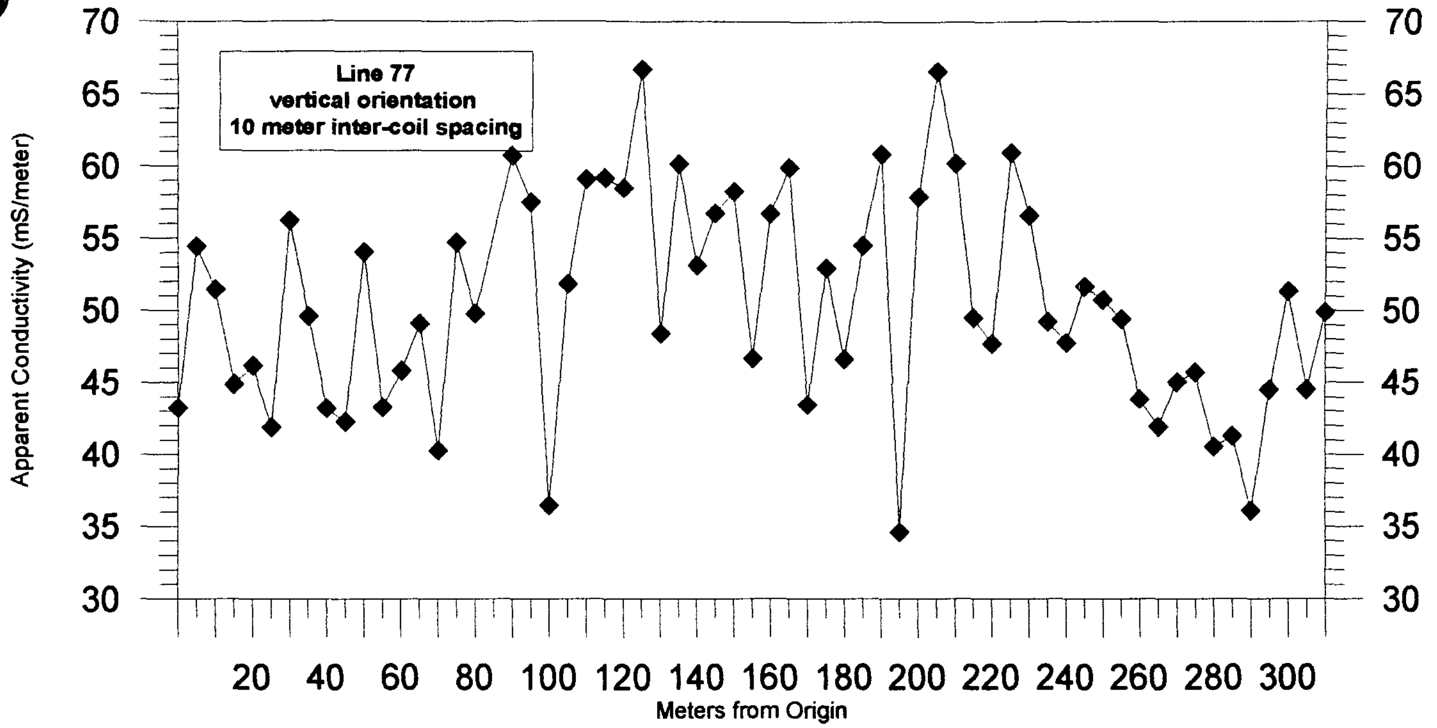

Line 75
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
85
80
75
70
65
60
55

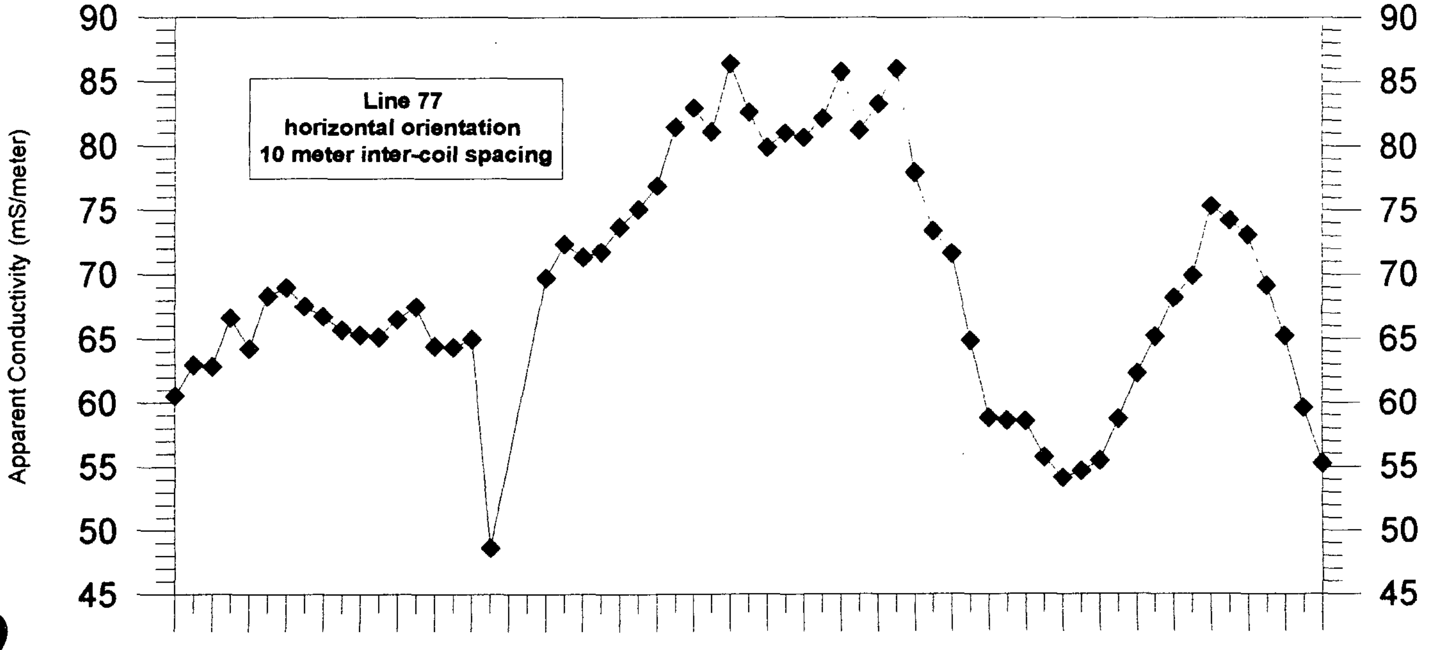


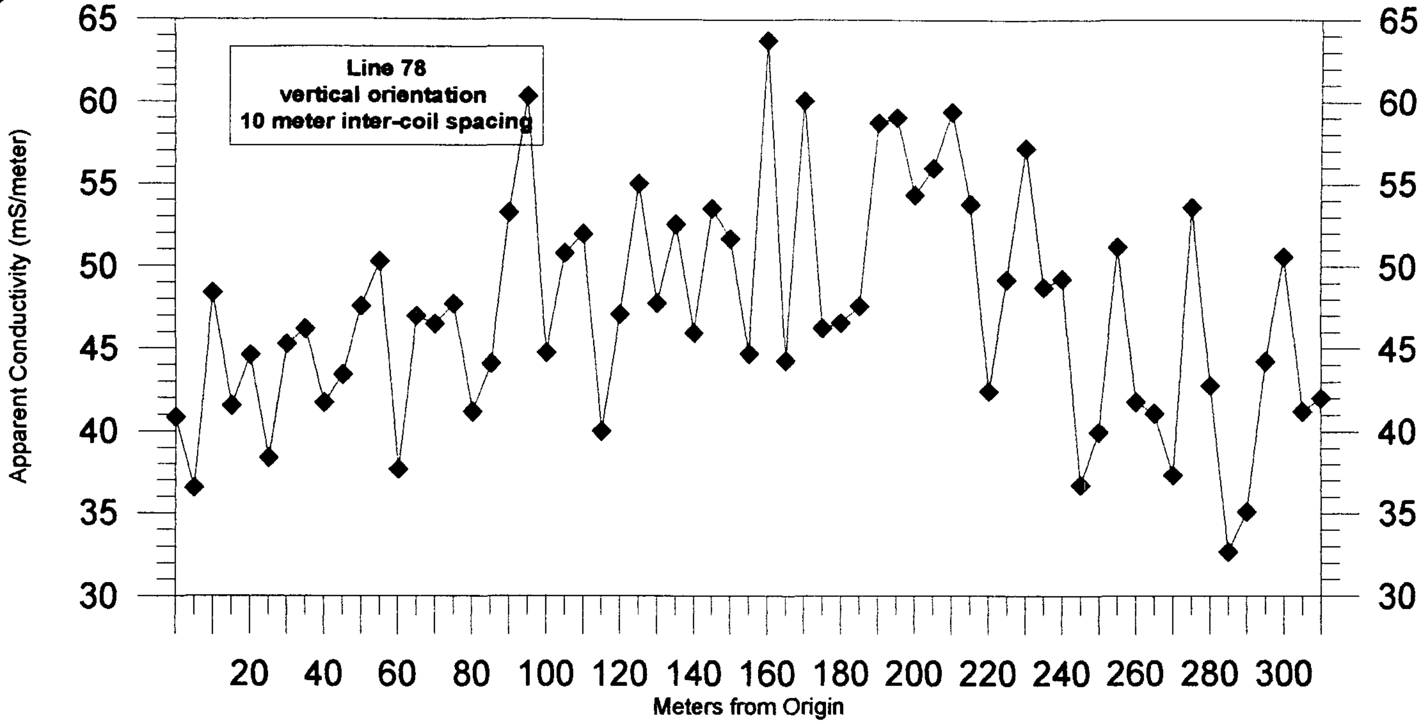
Line 76
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
35
40
45
50
55
60
65
70
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
Meters from Origin

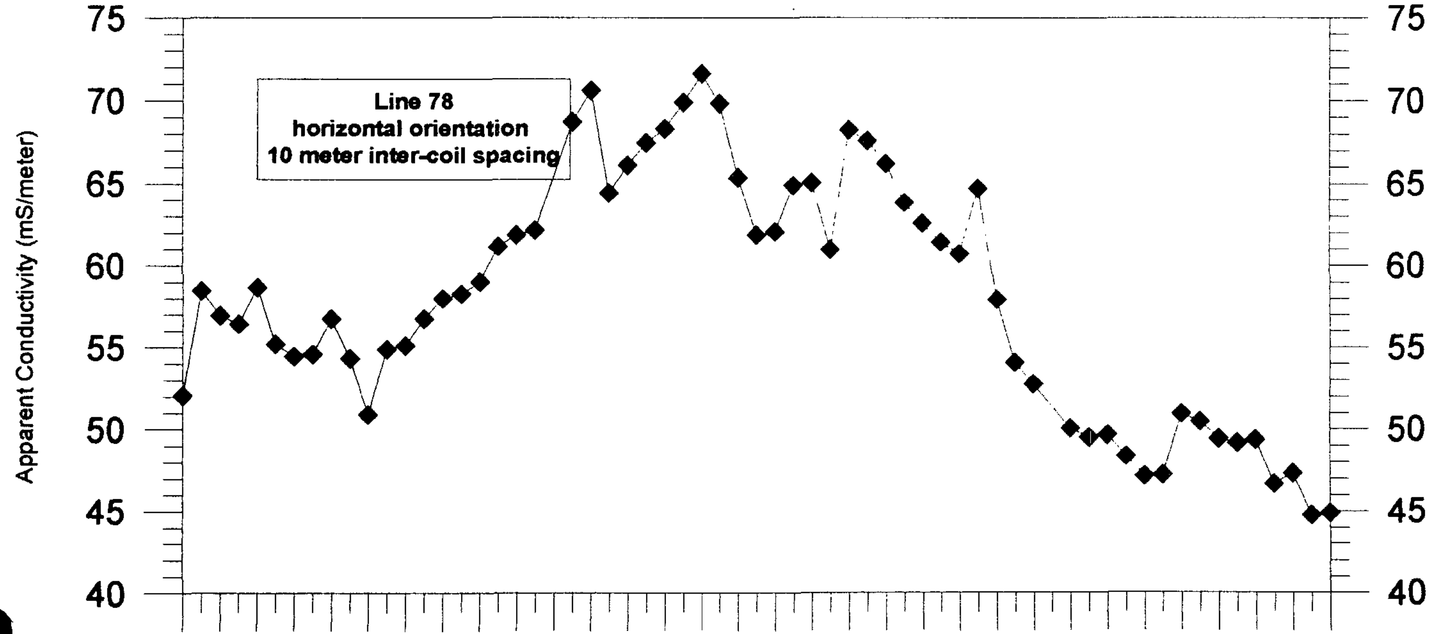
Line 76
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
55
60
65
70
75
80


Line 77
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin


Line 77
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)



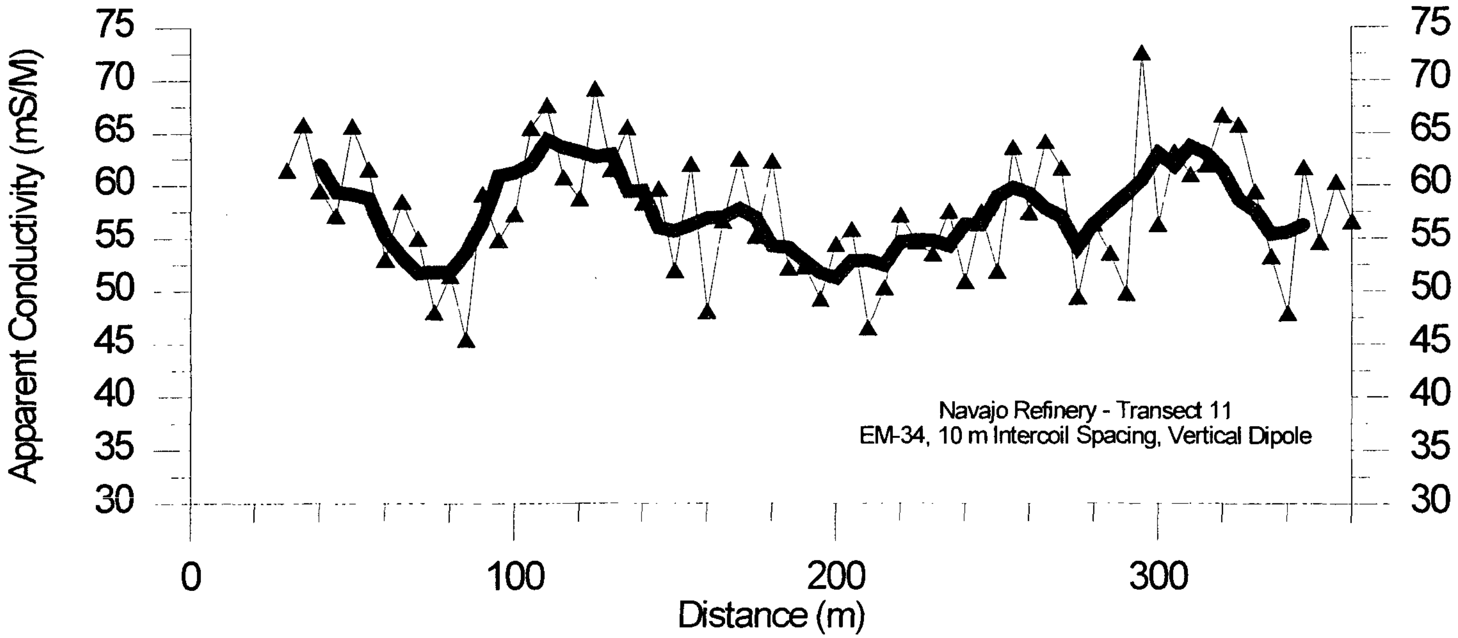
Line 78
vertical orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
Meters from Origin
65
60
55
50
45
40
35
30
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300

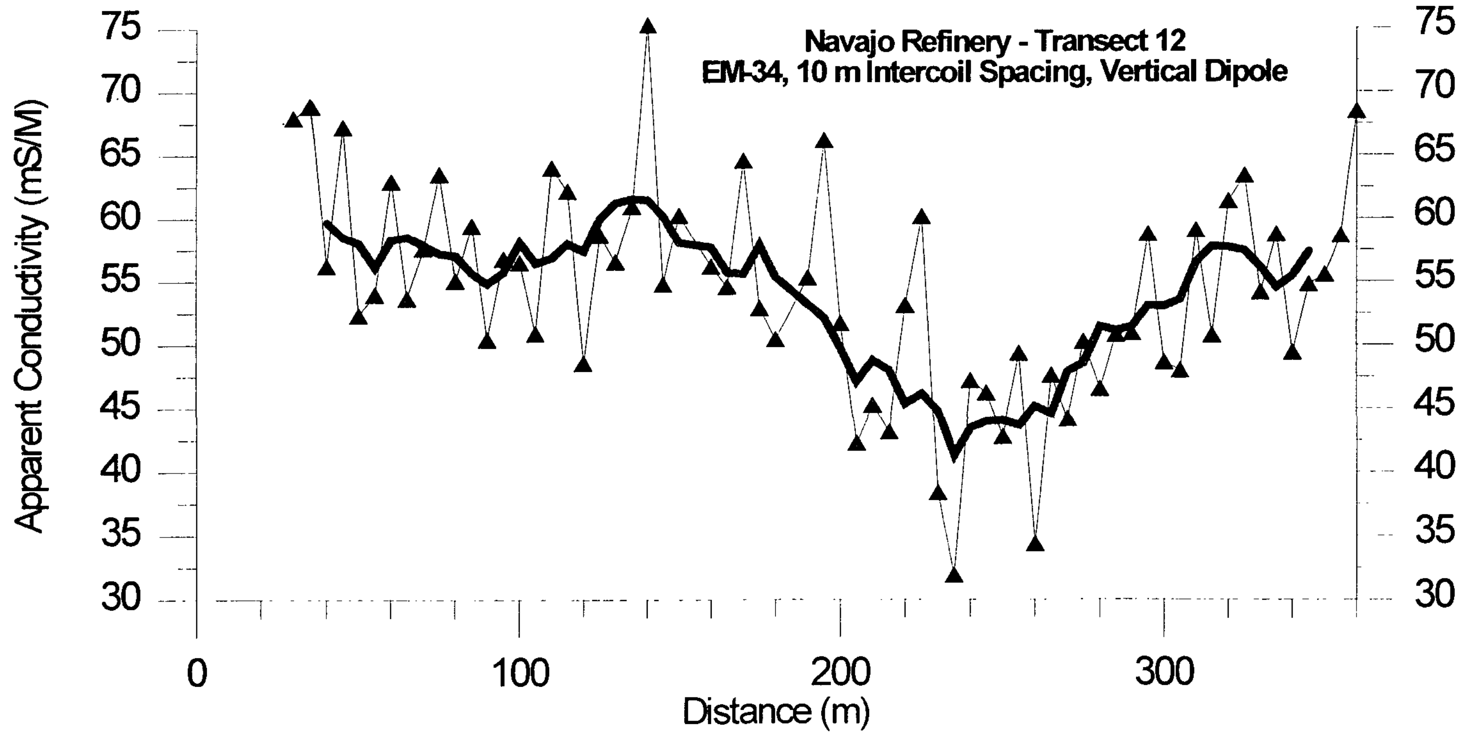
Line 78
horizontal orientation
10 meter inter-coil spacing
Apparent Conductivity (mS/meter)
75
70
65
60
55
50
45
40

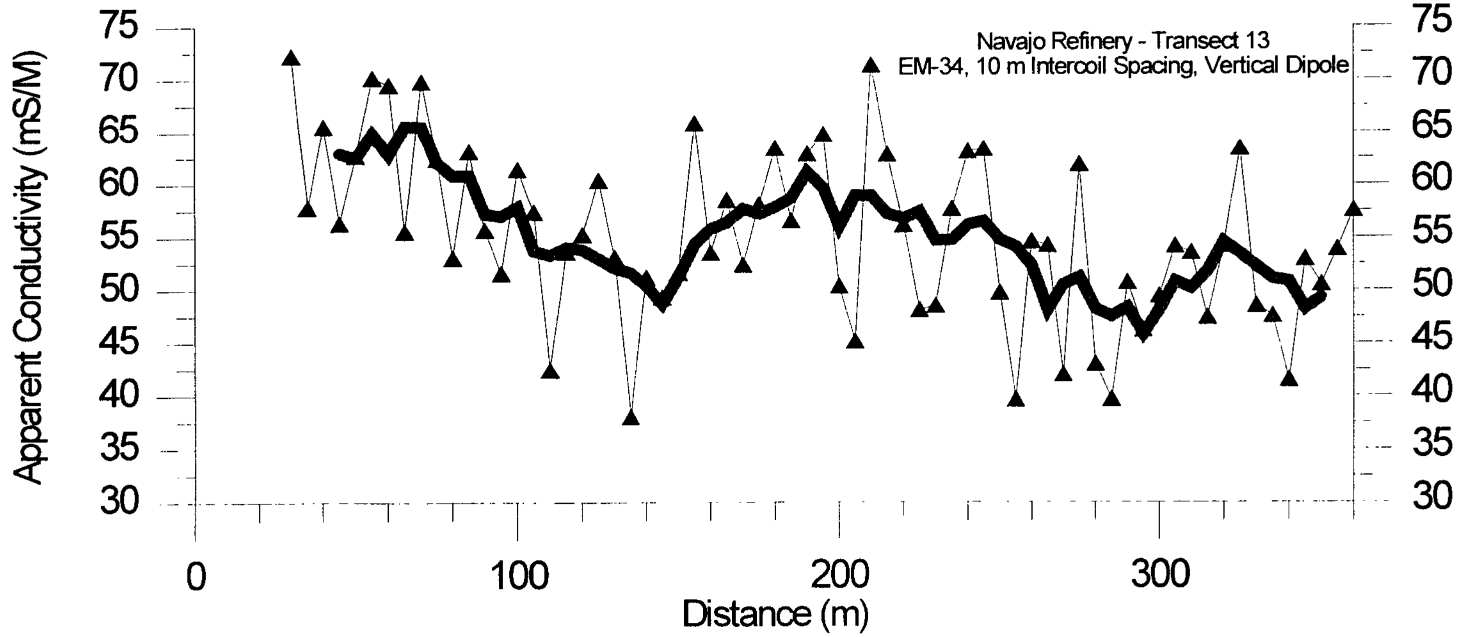
Filtered Conductivity Graphs

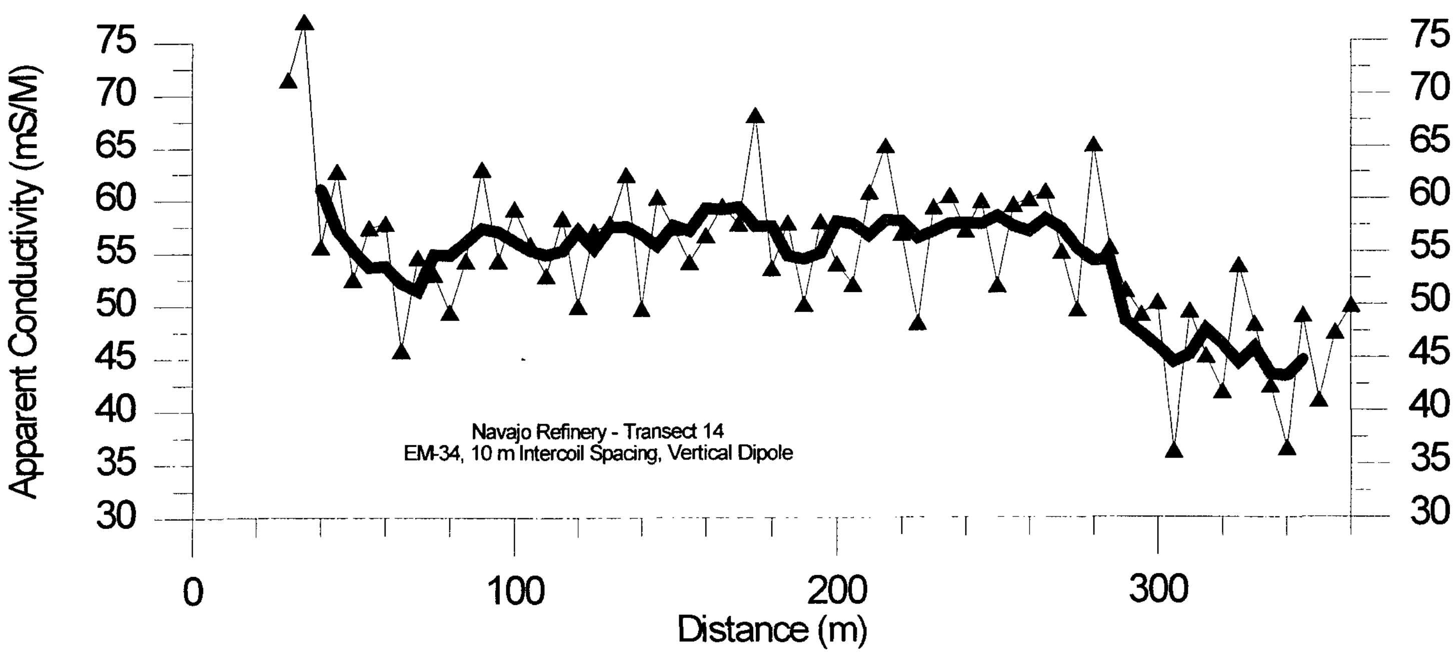
Filtered Conductivity Graphs

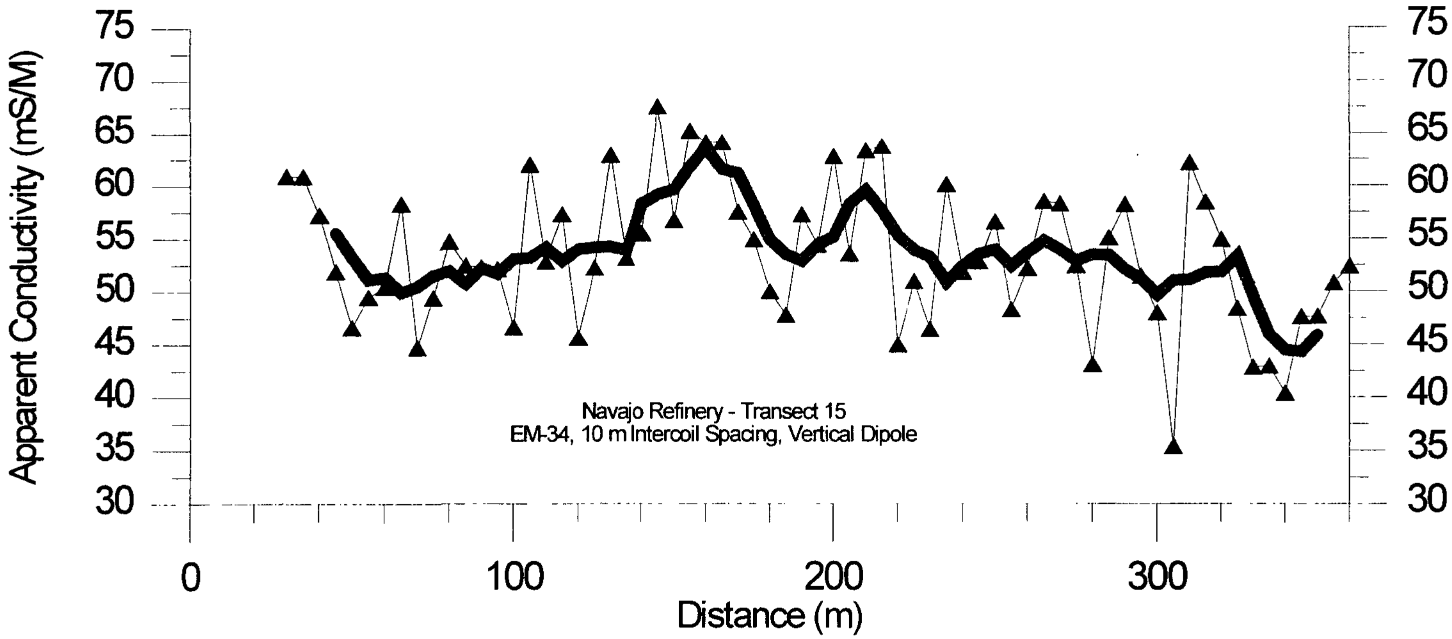


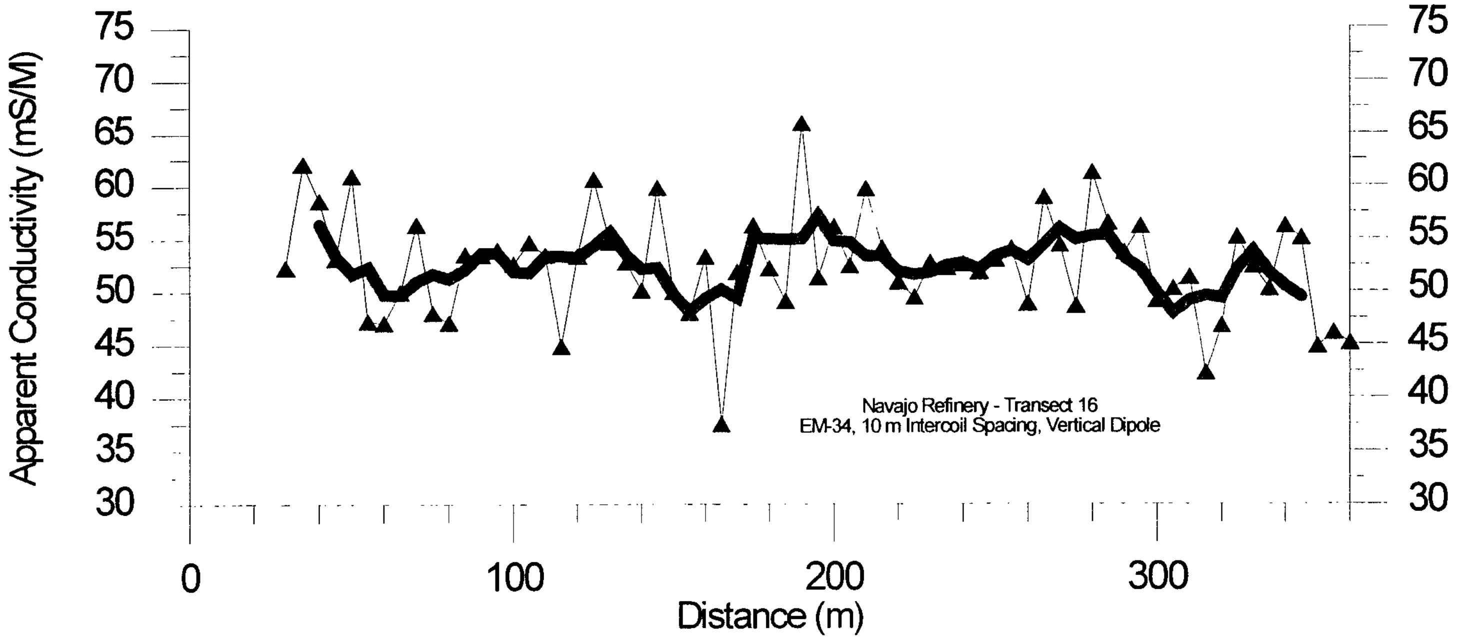
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 11
EM-34, 10 m Intercoil Spacing, Vertical Dipole


Navajo Refinery - Transect 12
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

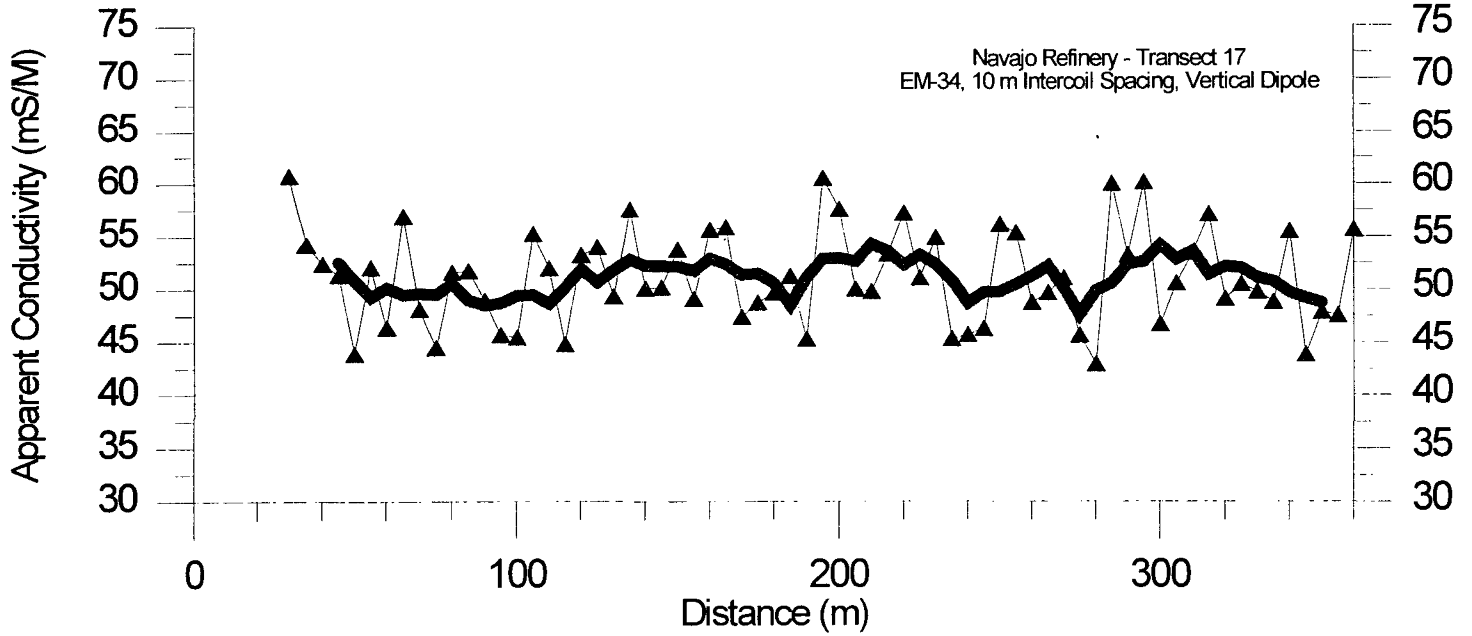

Navajo Refinery - Transect 13
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)
75
70
65
60
55
50
45
40
35
30
0
100
200
300

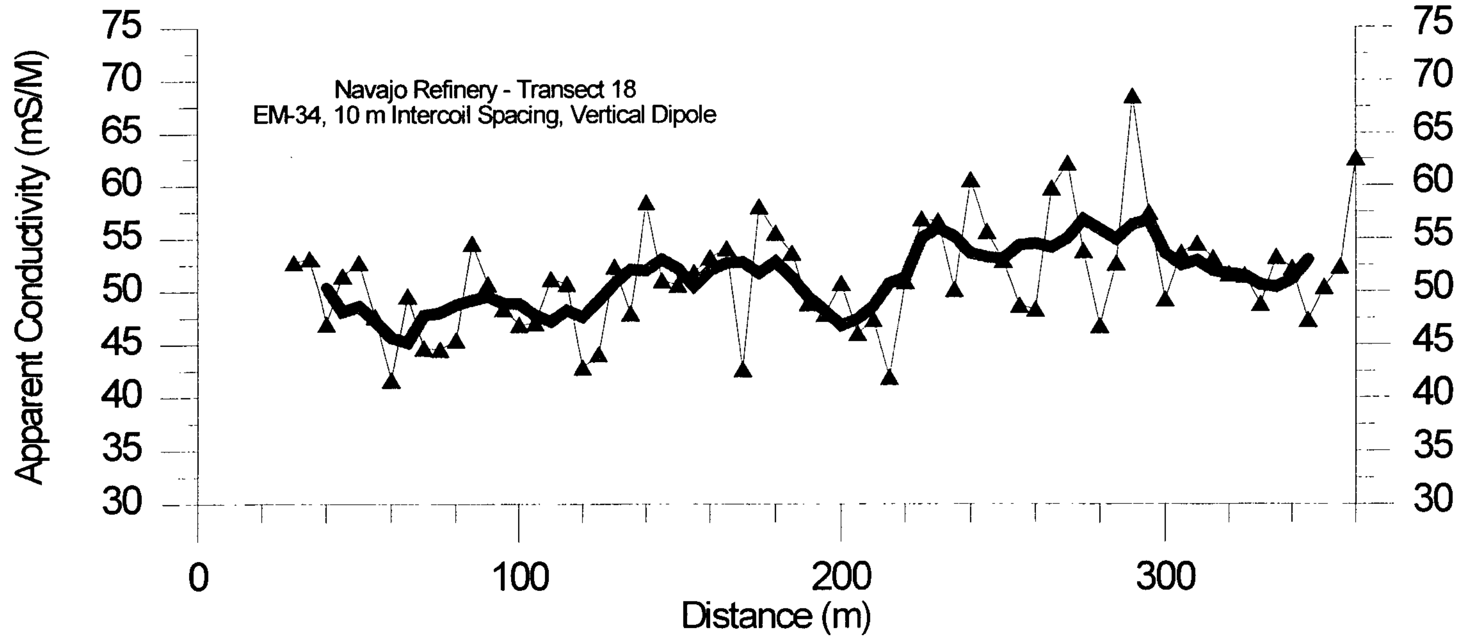

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 14
EM-34, 10 m Intercoil Spacing, Vertical Dipole


Navajo Refinery - Transect 15
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

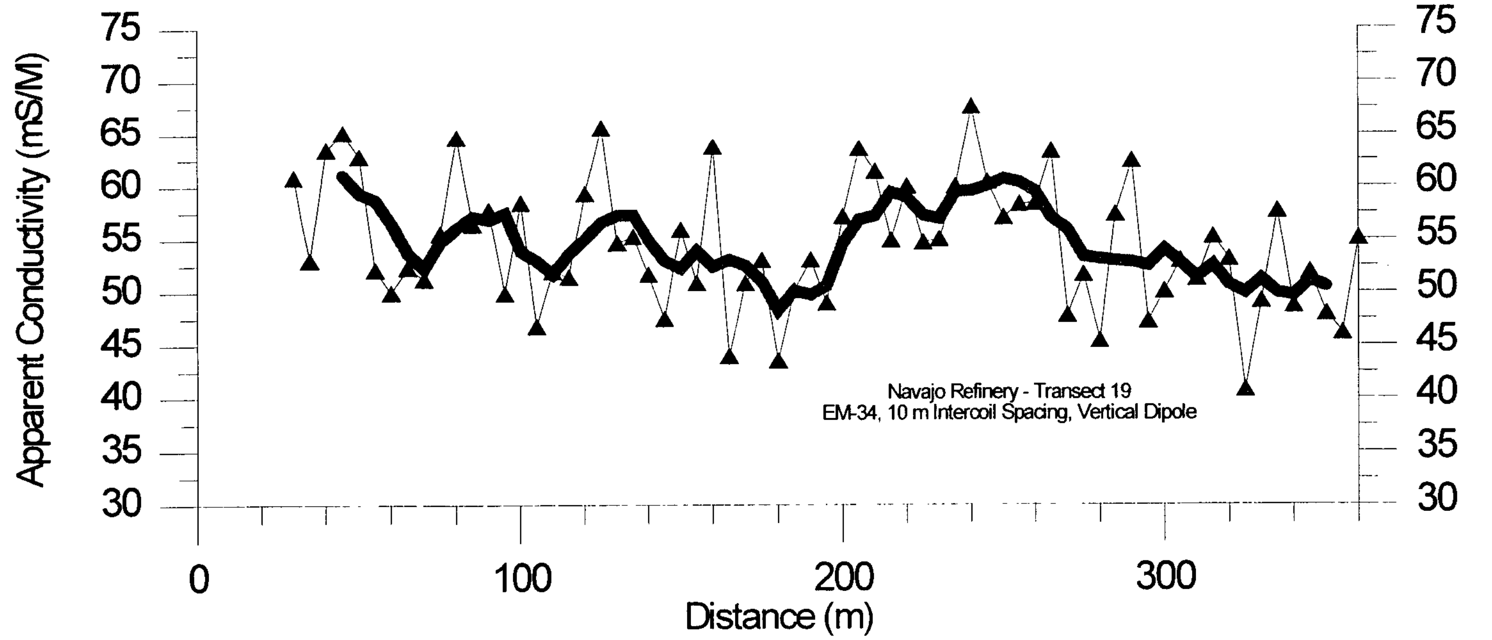


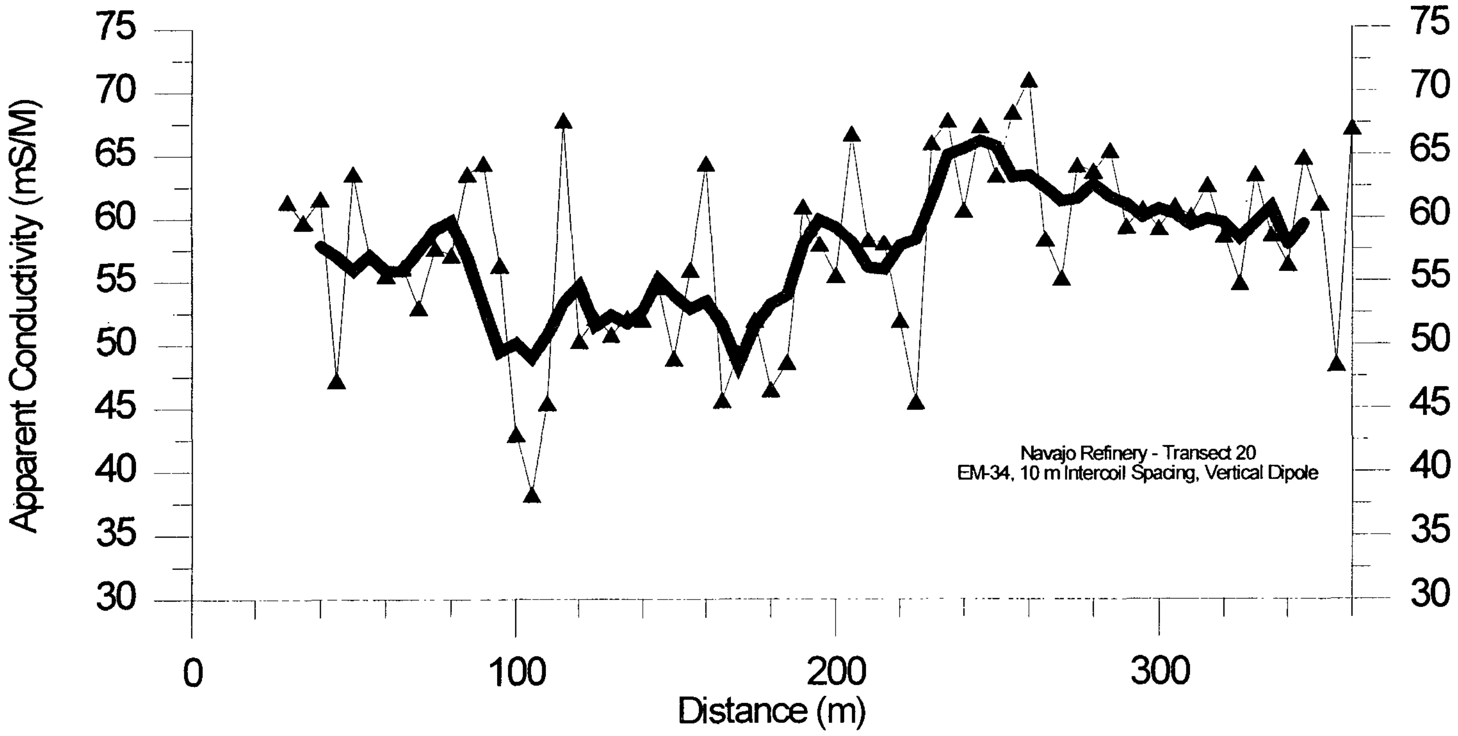
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 16
EM-34, 10 m Intercoil Spacing, Vertical Dipole

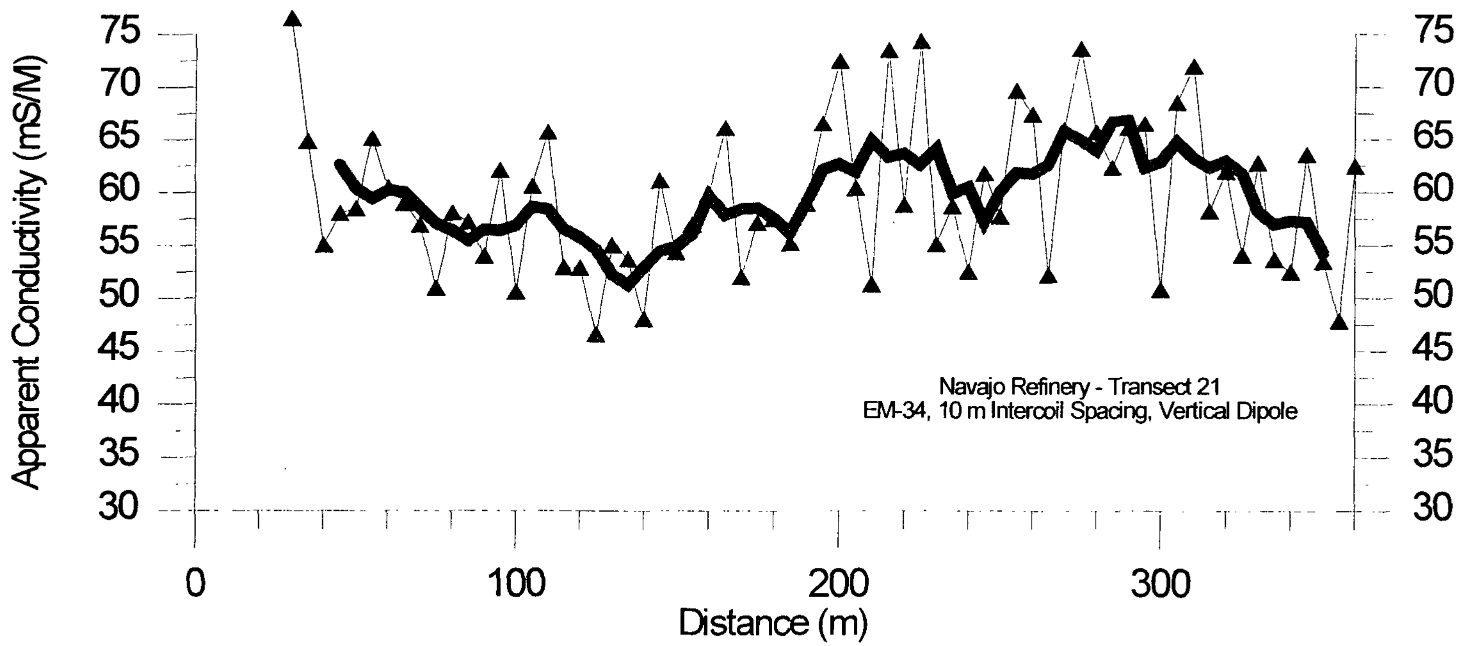

Navajo Refinery - Transect 17
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)



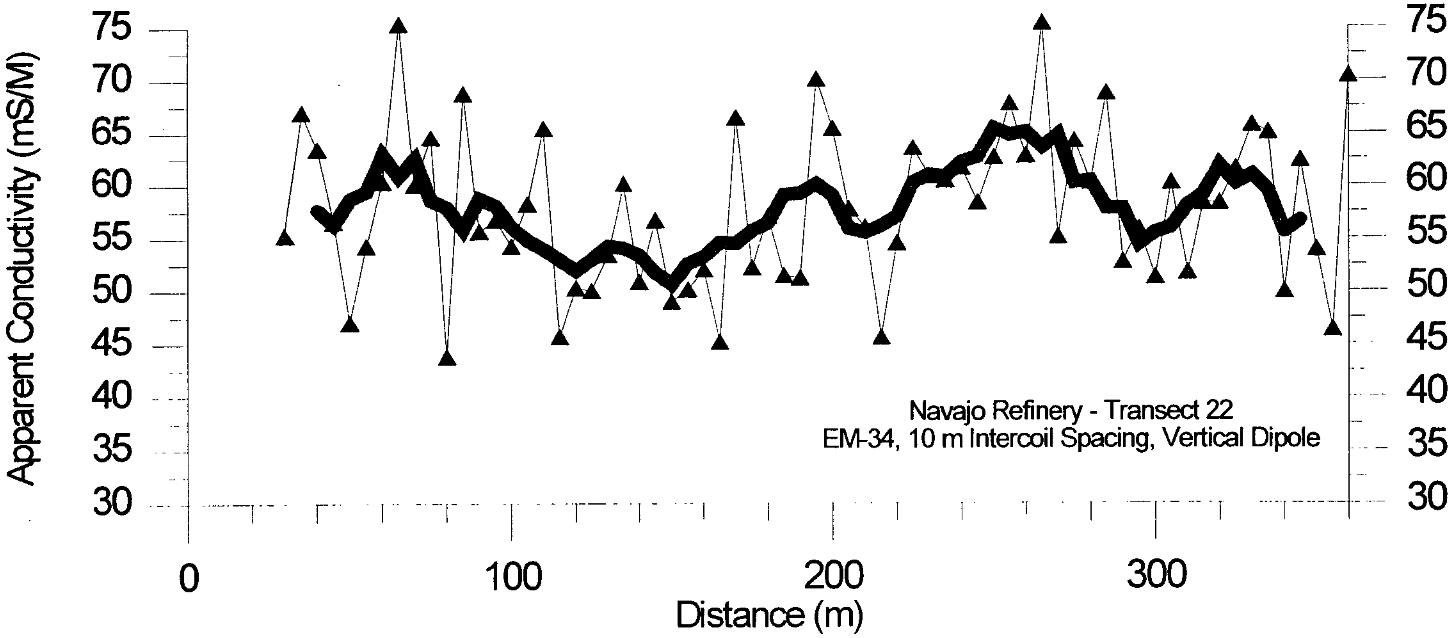
Navajo Refinery - Transect 18
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)
75
70
65
60
55
50
45
40
35
30
0
100
200
300

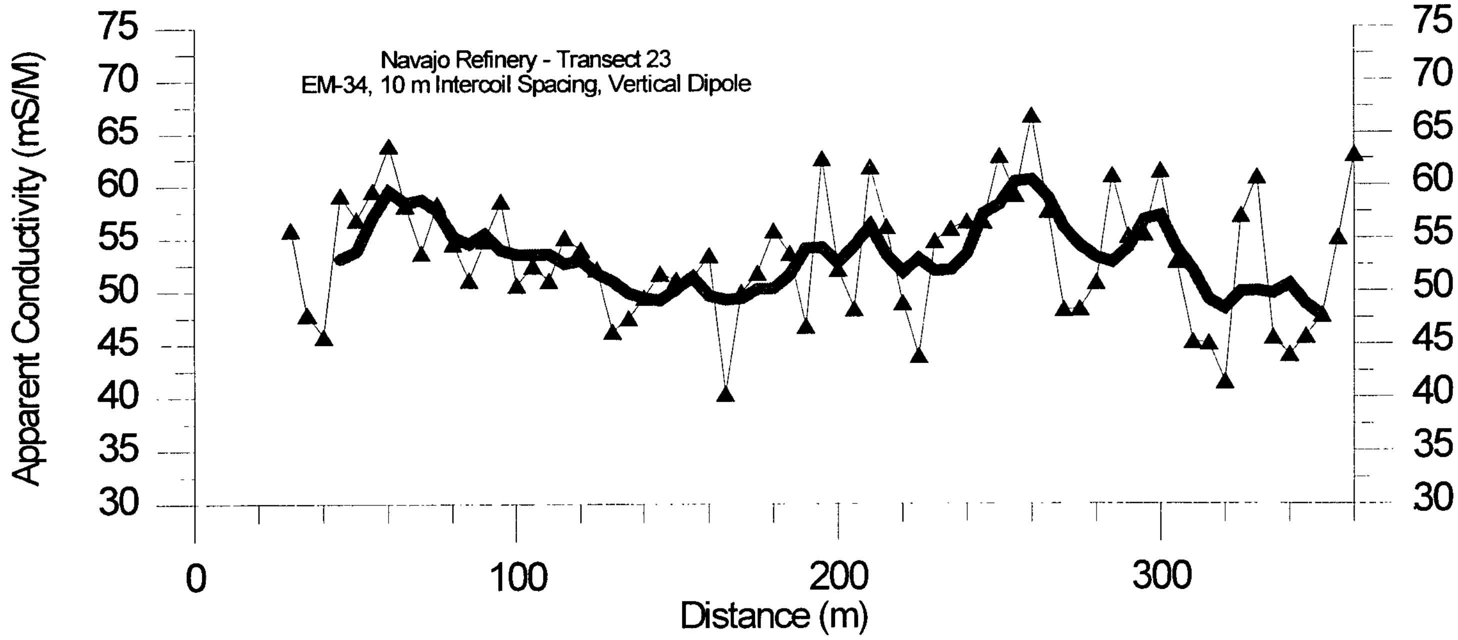

Navajo Refinery - Transect 19
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)


Navajo Refinery - Transect 20
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)
0
100
200
300
75
70
65
60
55
50
45
40
35
30

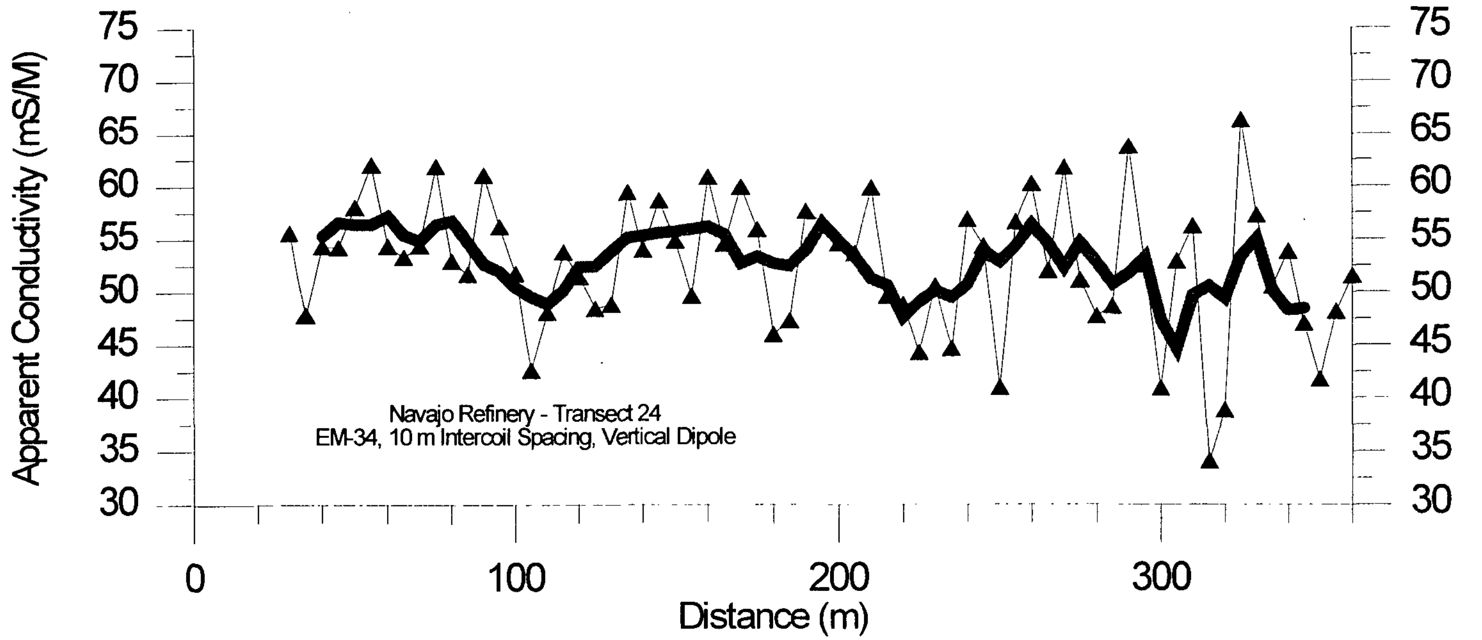


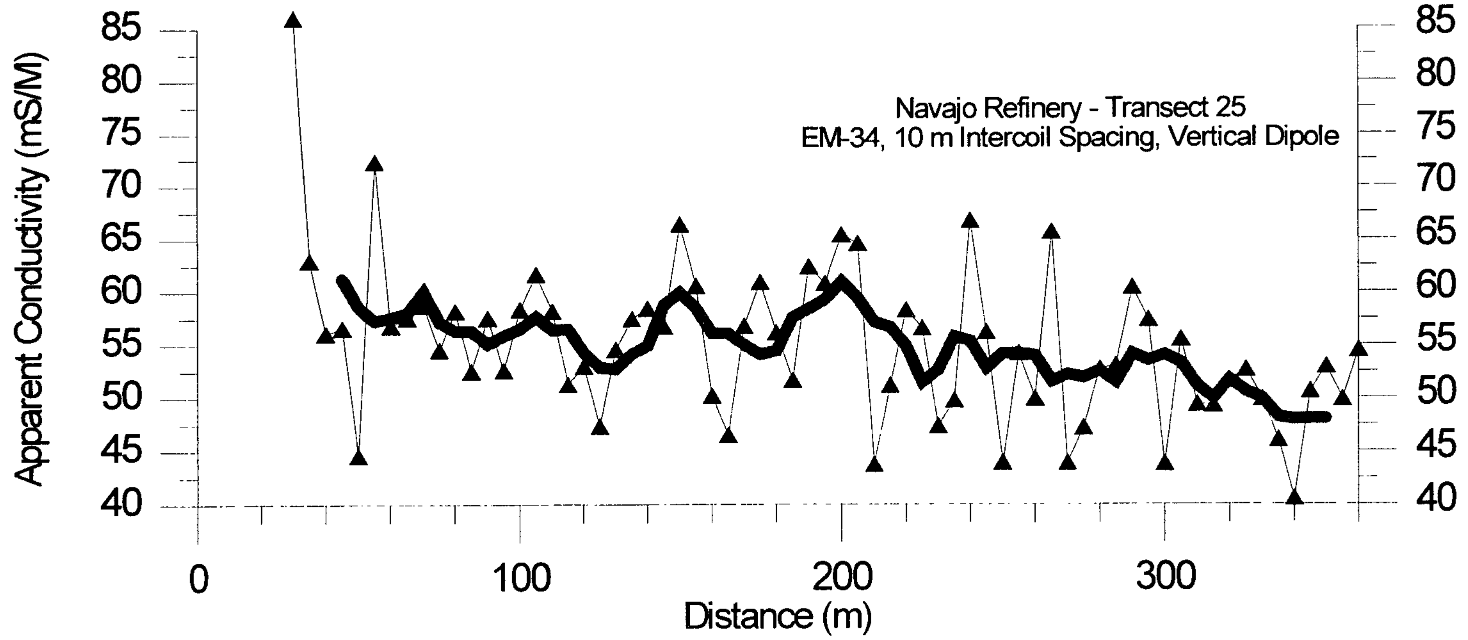
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 21
EM-34, 10 m Intercoil Spacing, Vertical Dipole

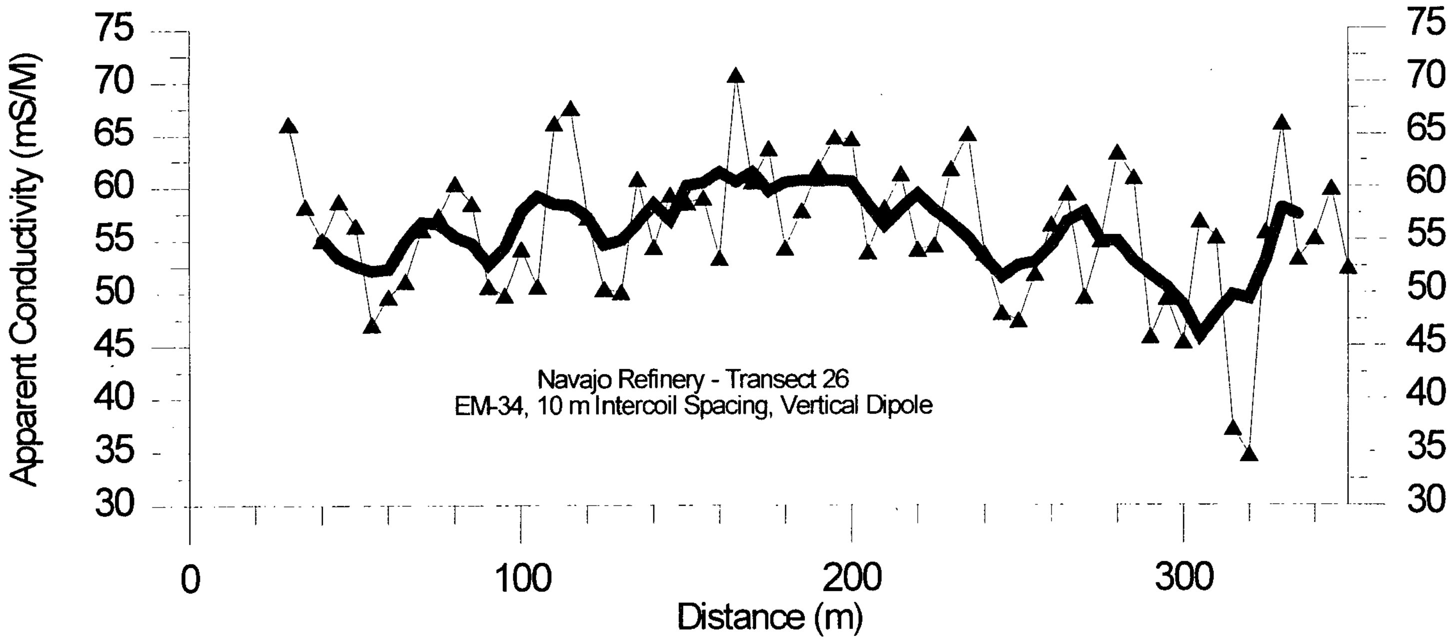

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 22
EM-34, 10 m Intercoil Spacing, Vertical Dipole

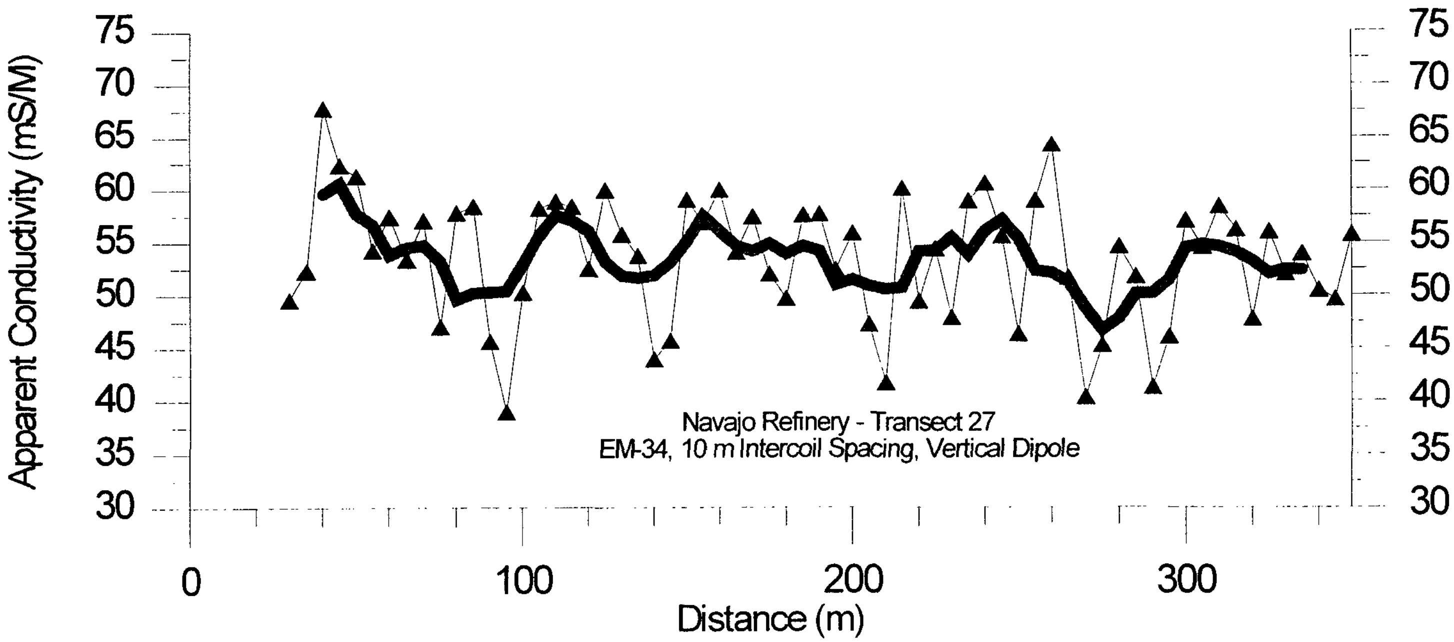


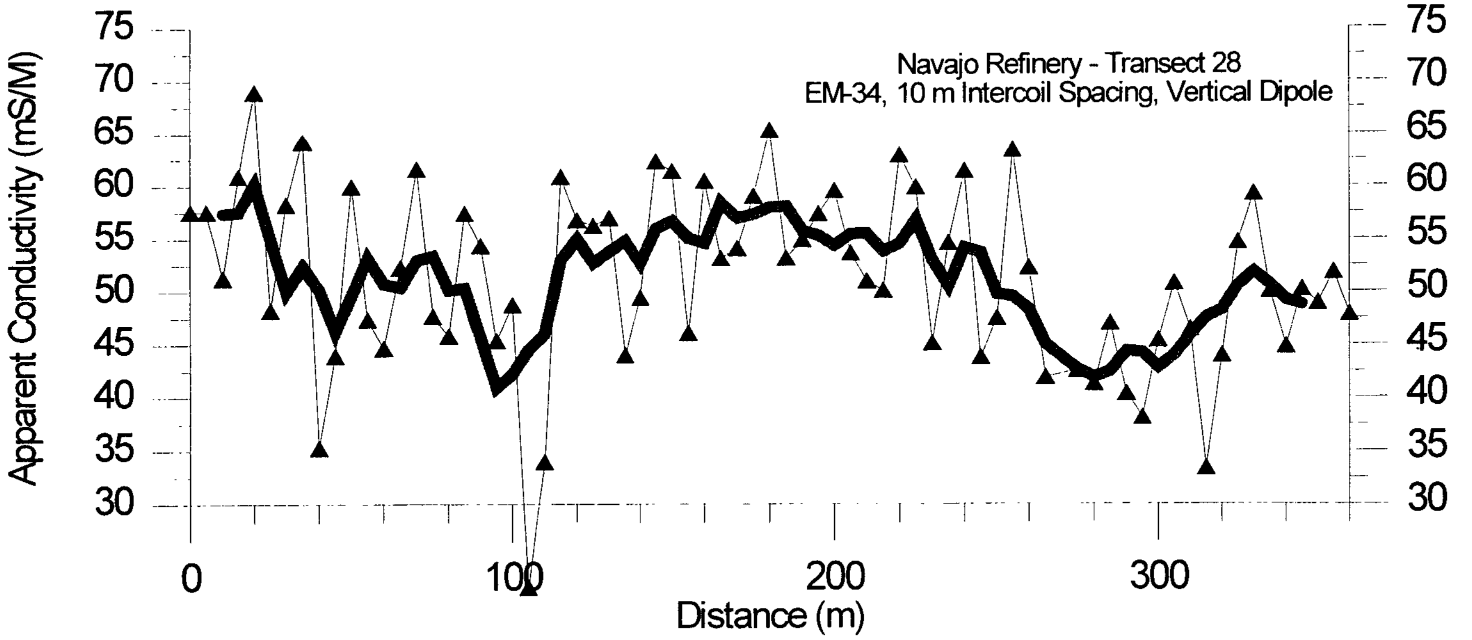
Navajo Refinery - Transect 23
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

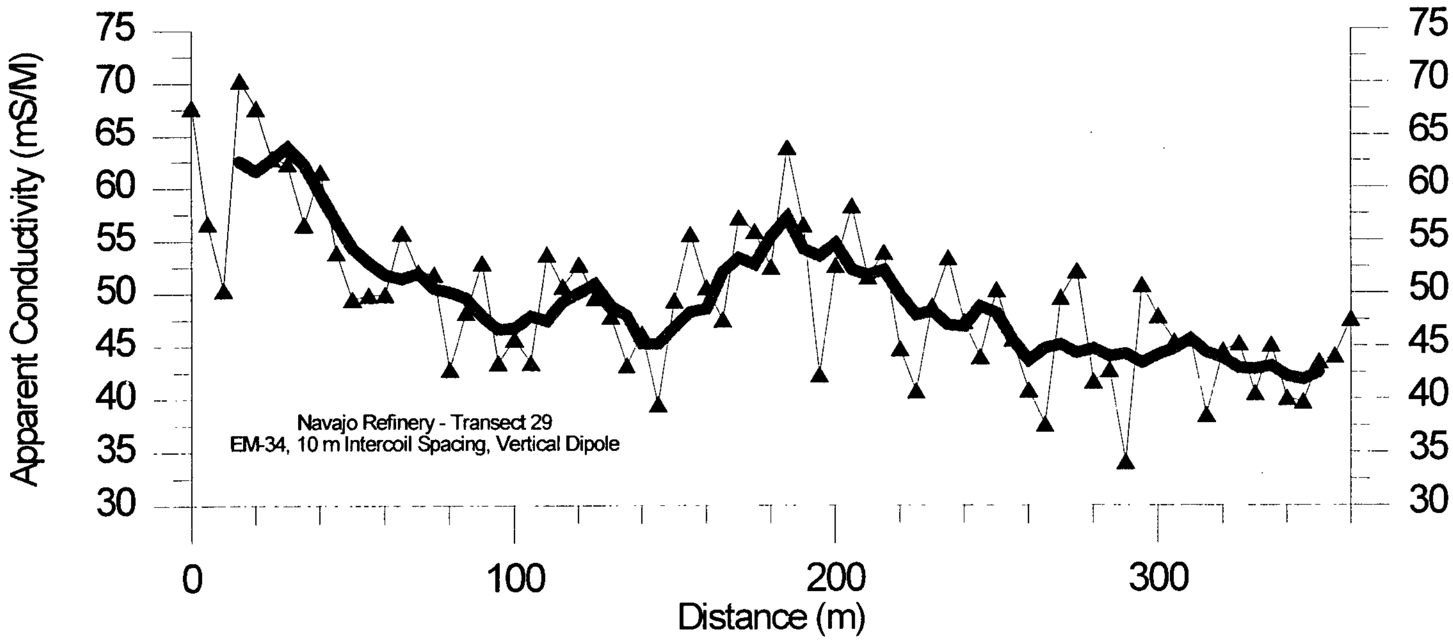

Navajo Refinery - Transect 24
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)
75
70
65
60
55
50
45
40
35
30
0
100
200
300

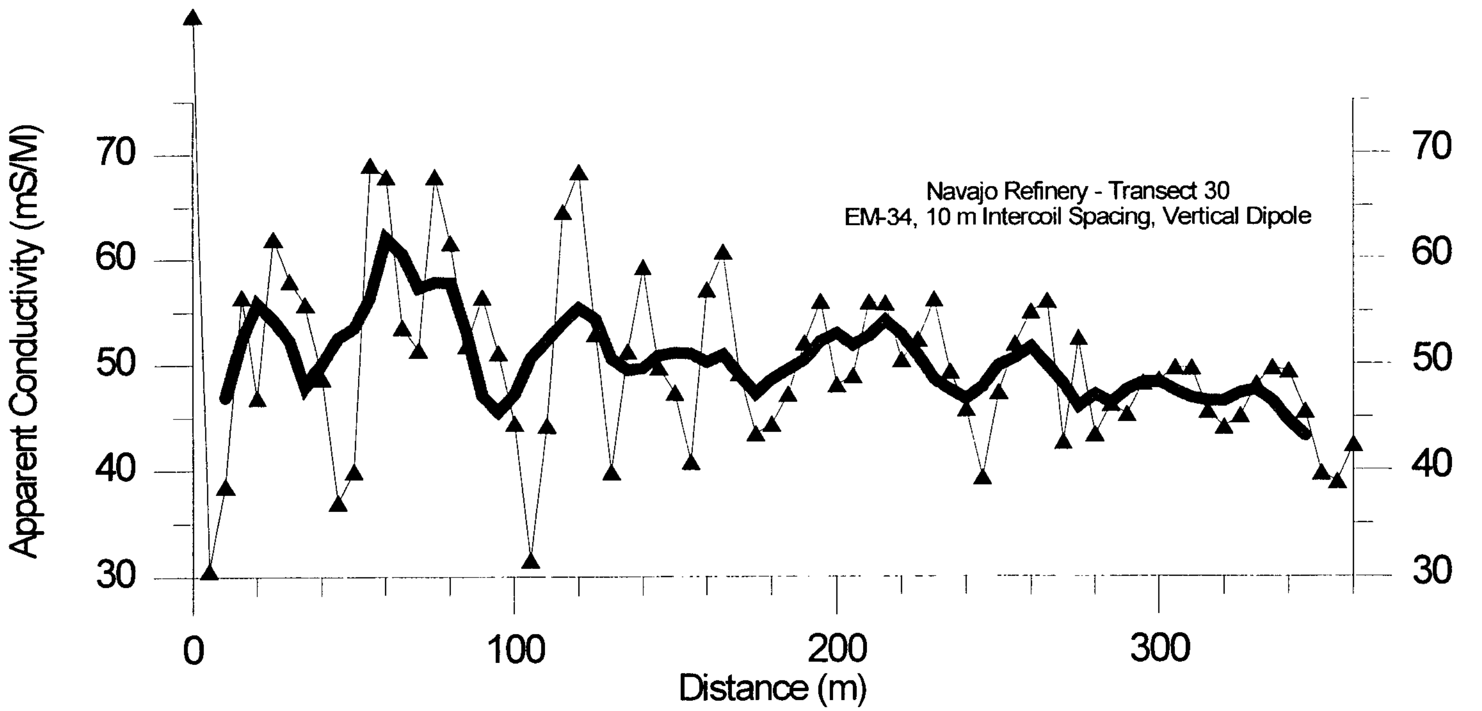

Navajo Refinery - Transect 25
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
85
80
75
70
65
60
55
50
45
40
0
100
200
300
Distance (m)

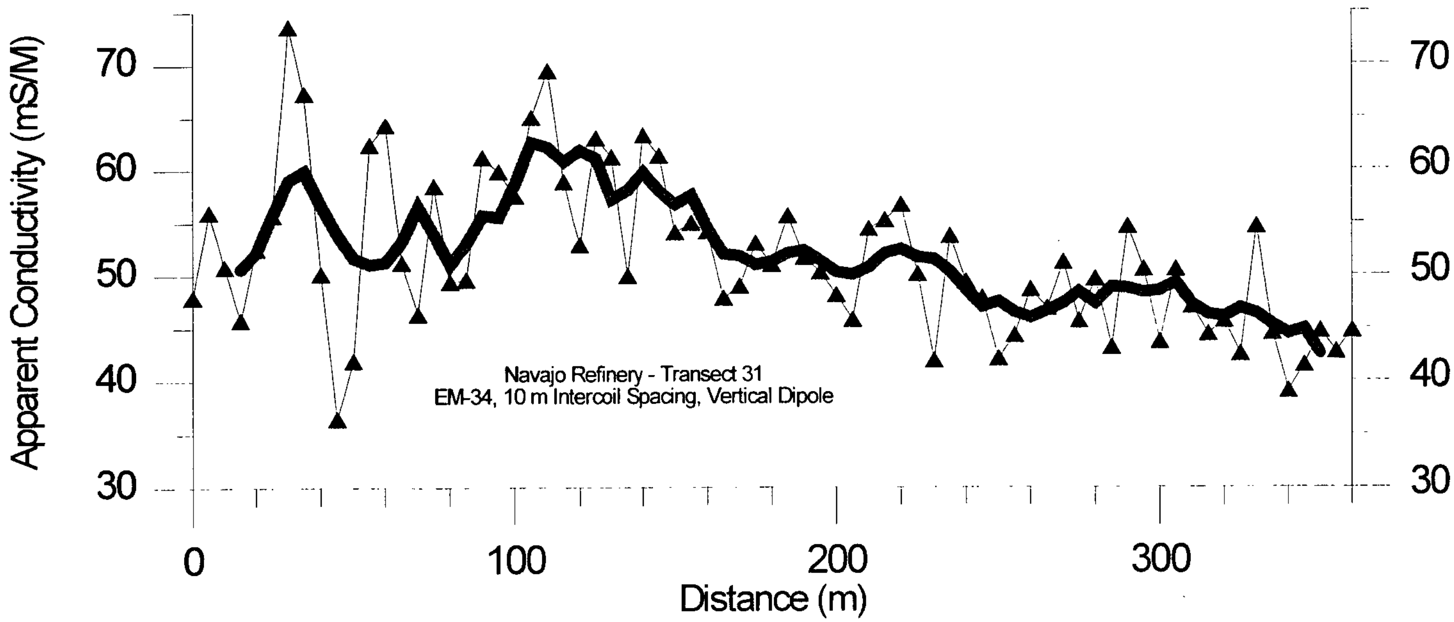

Navajo Refinery - Transect 26
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)
0
100
200
300
75
70
65
60
55
50
45
40
35
30

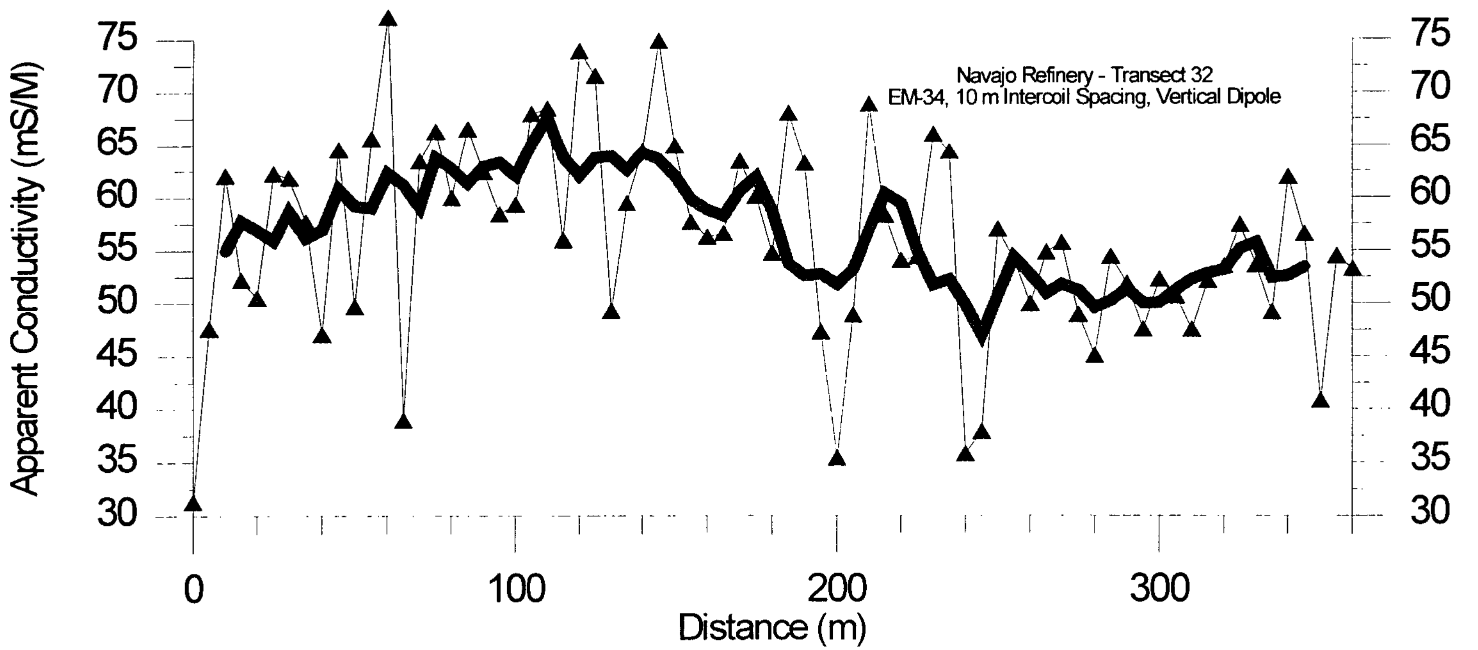

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 27
EM-34, 10 m Intercoil Spacing, Vertical Dipole


Navajo Refinery - Transect 28
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

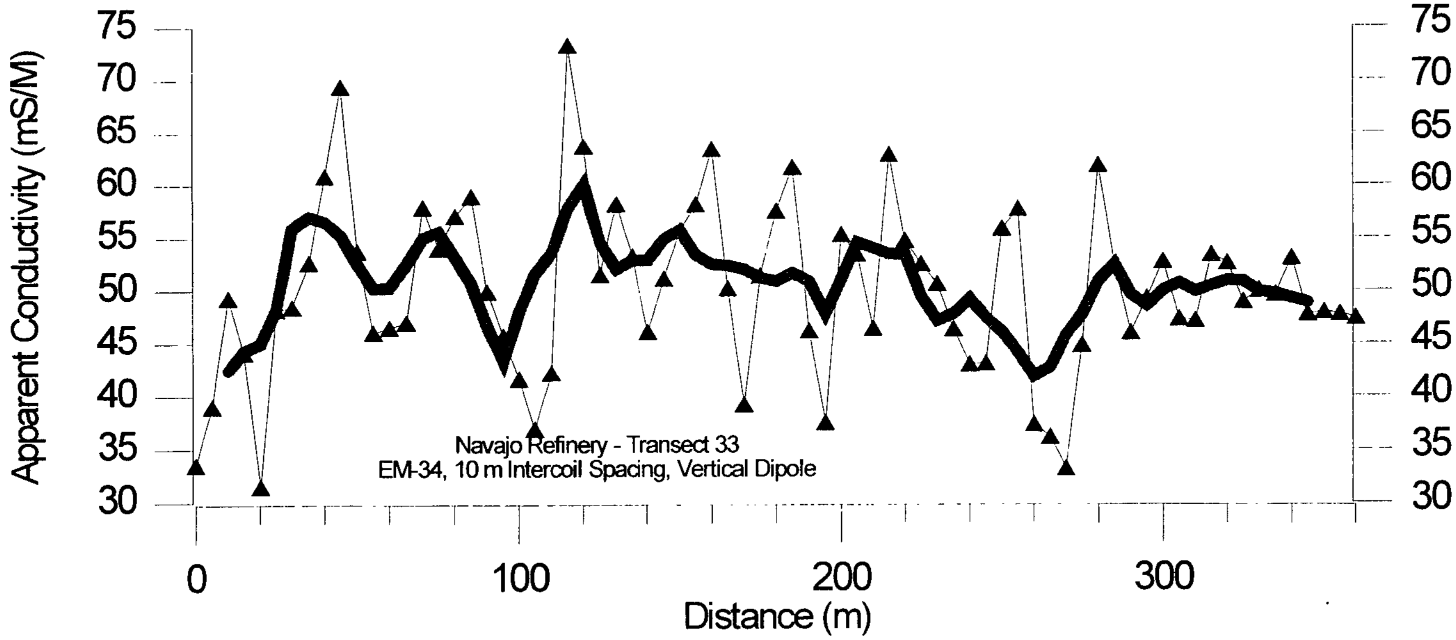

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 29
EM-34, 10 m Intercoil Spacing, Vertical Dipole

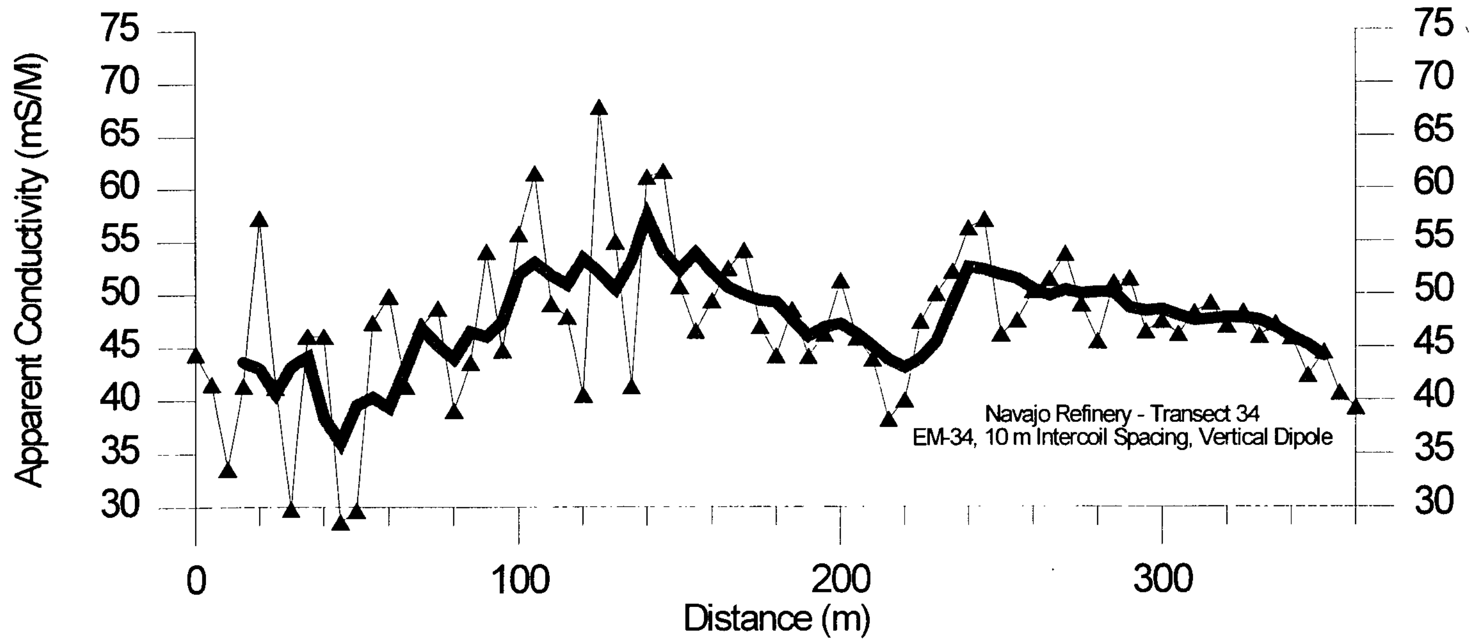

Navajo Refinery - Transect 30
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
70
60
50
40
30
0
100
200
300
Distance (m)

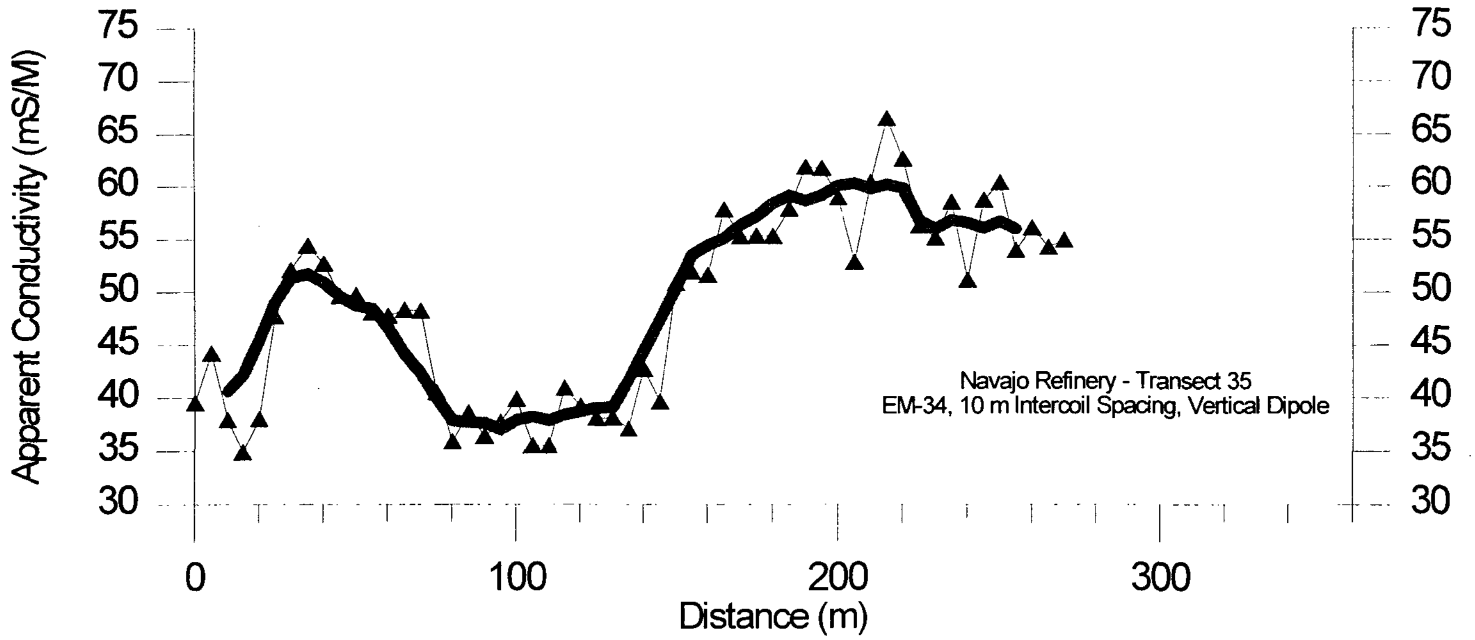

Apparent Conductivity (mS/M)
70
60
50
40
30
Navajo Refinery - Transect 31
EM-34, 10 m Intercoil Spacing, Vertical Dipole
0
100
200
300
Distance (m)

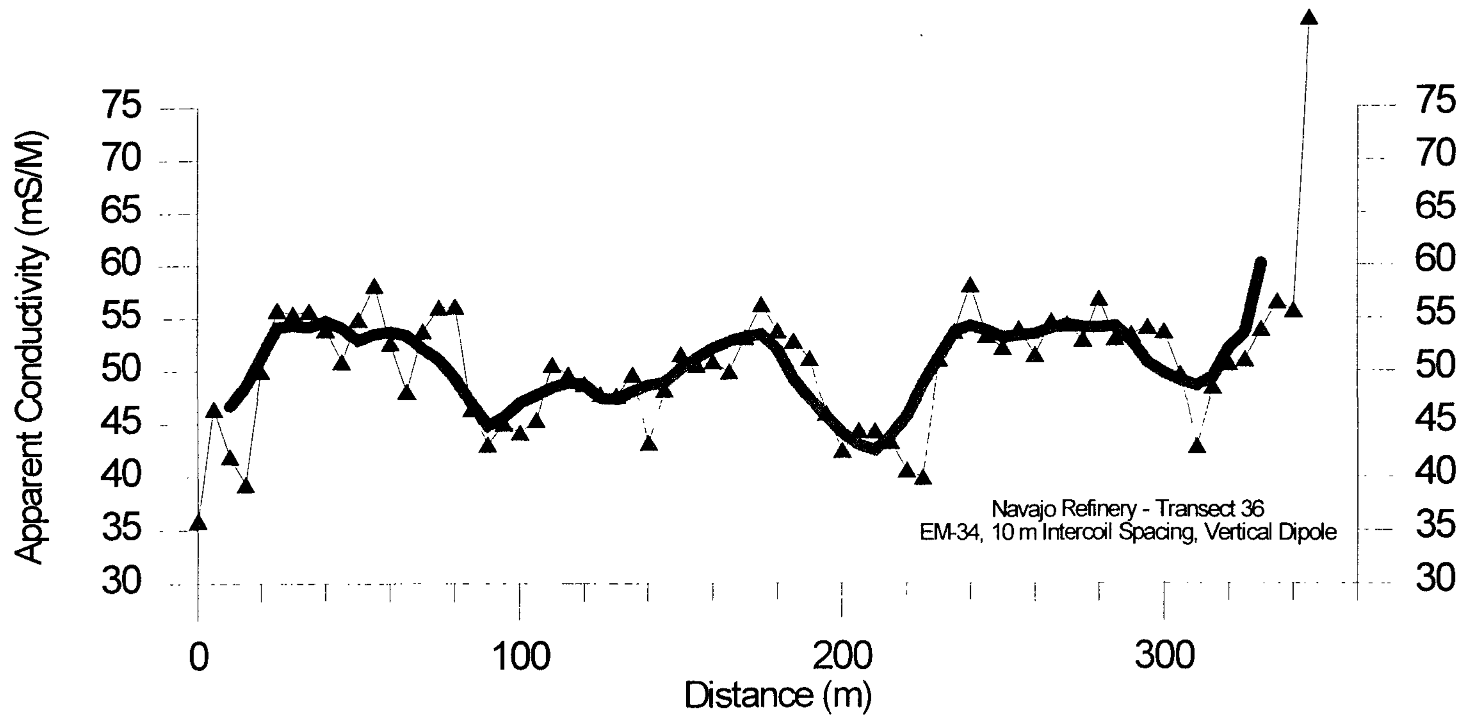


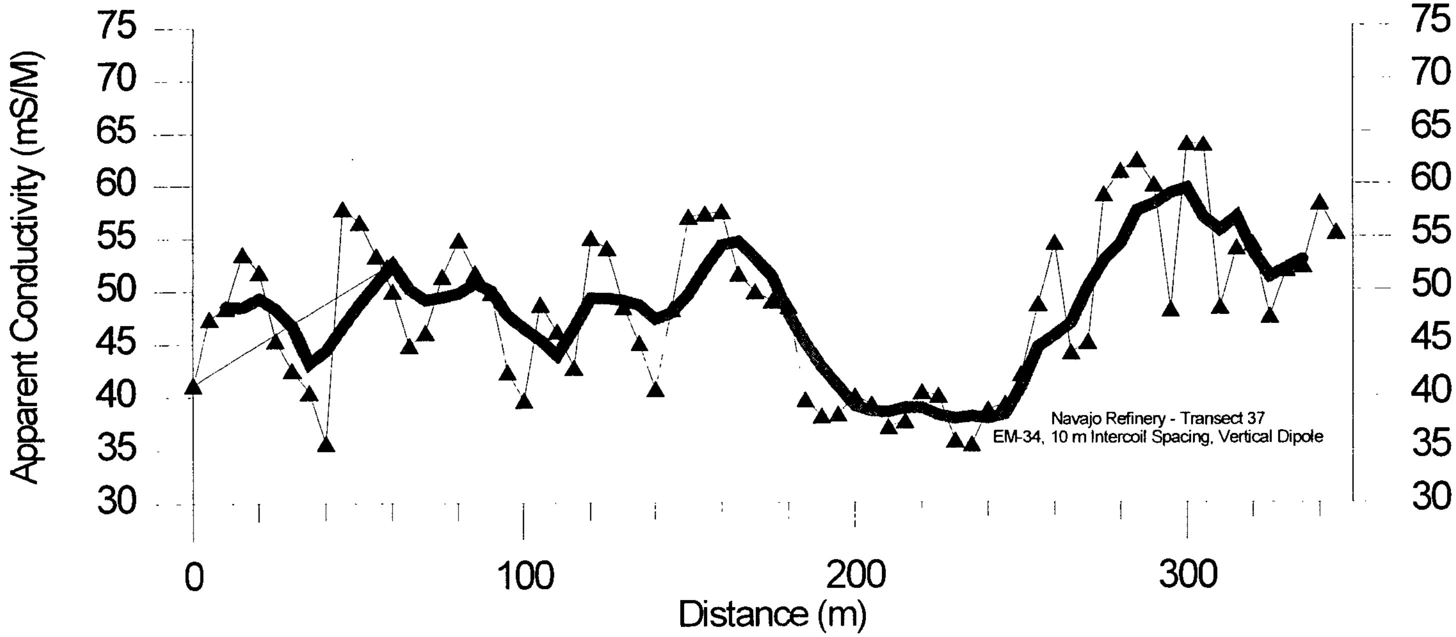
Navajo Refinery - Transect 32
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)


Navajo Refinery - Transect 33
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

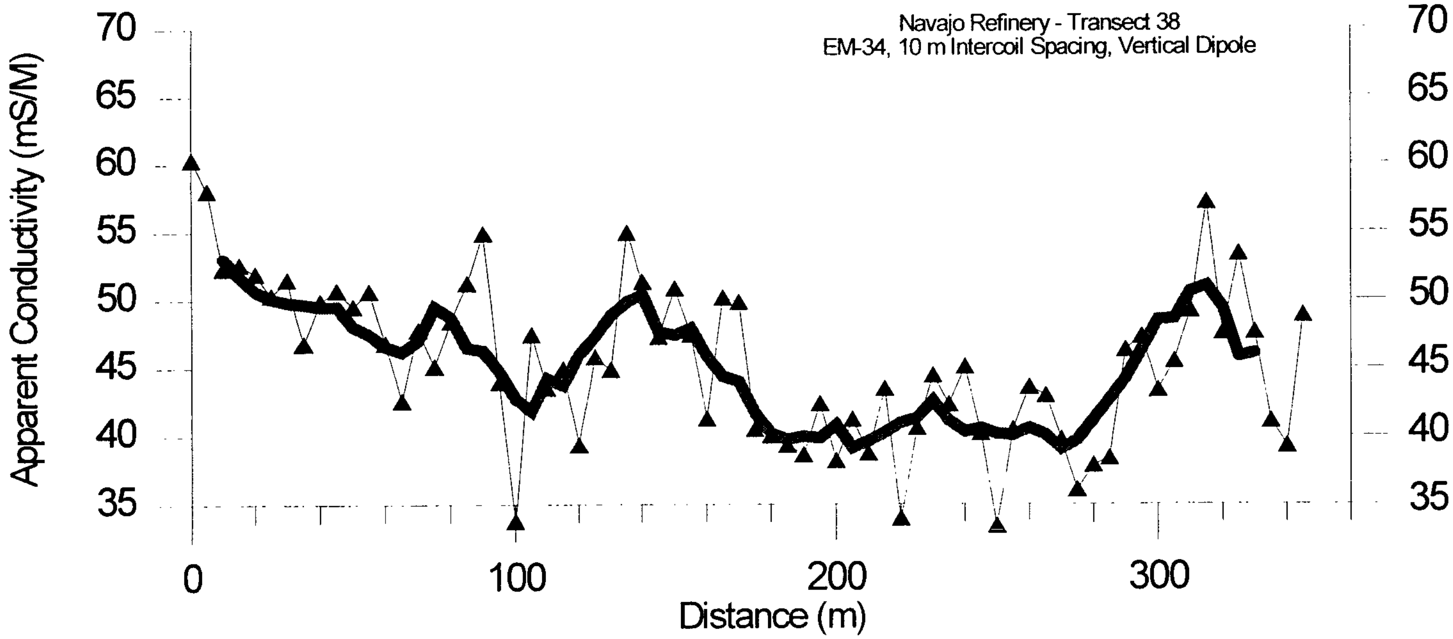

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 34
EM-34, 10 m Intercoil Spacing, Vertical Dipole

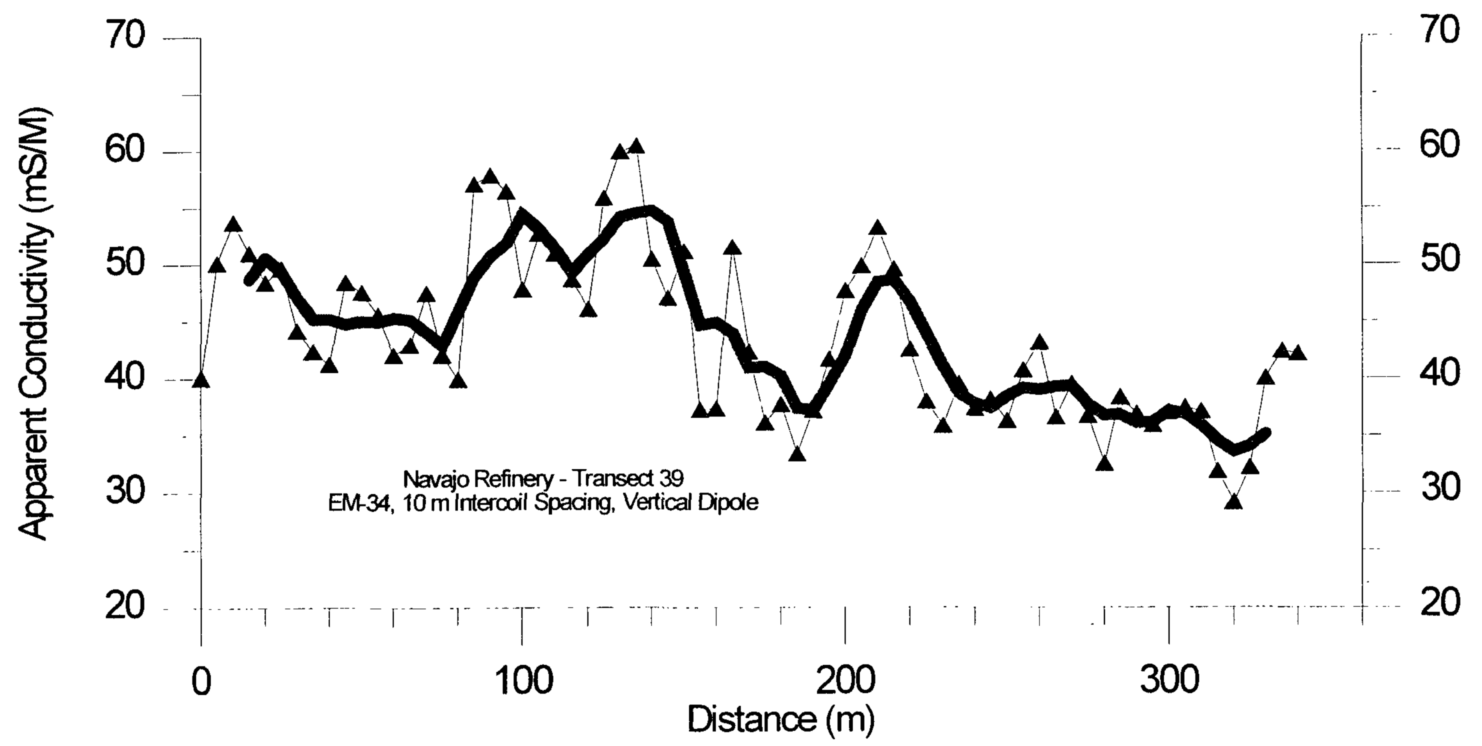

Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 35
EM-34, 10 m Intercoil Spacing, Vertical Dipole

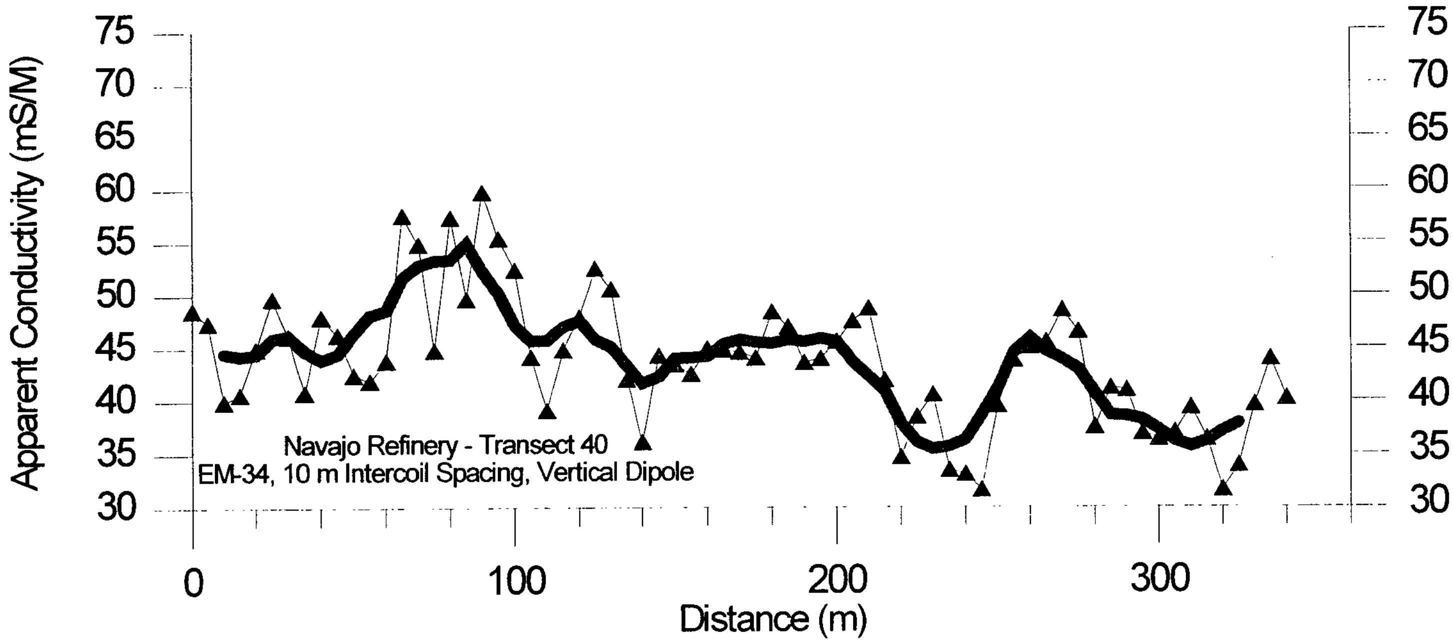

Navajo Refinery - Transect 36
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

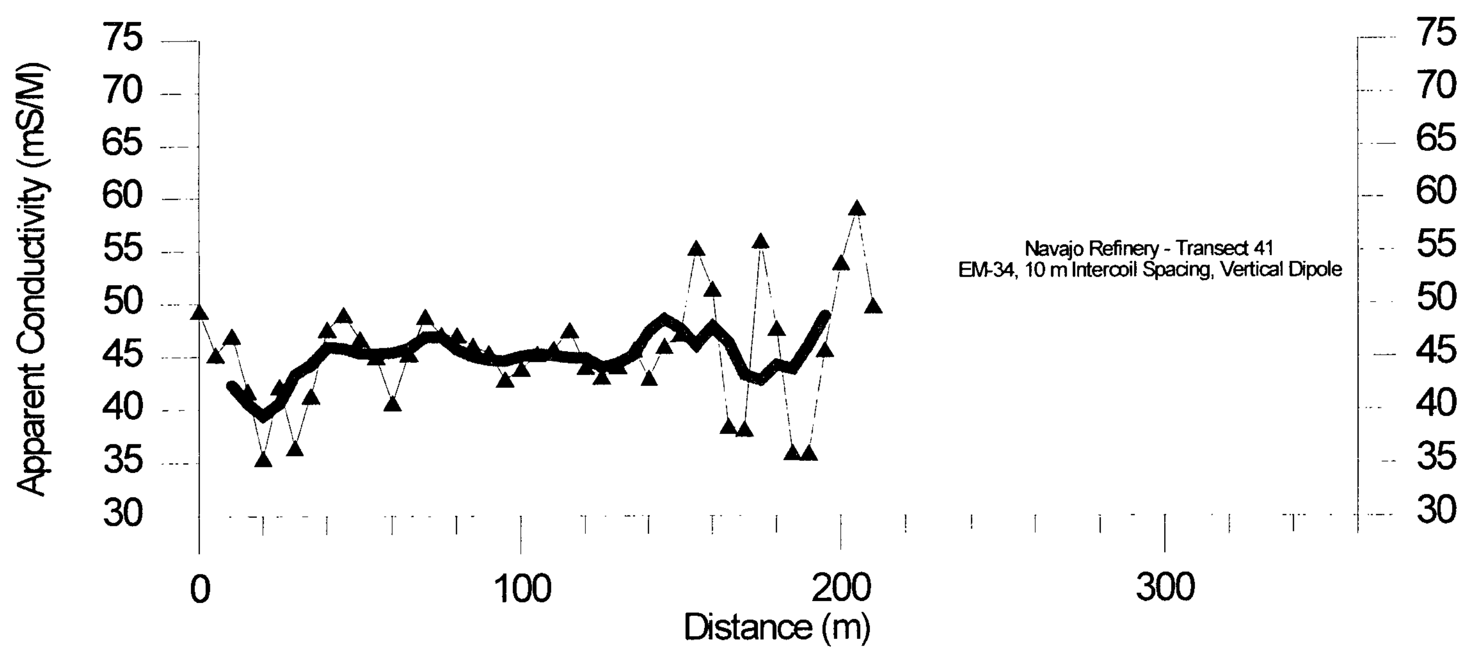


Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 37
EM-34, 10 m Intercoil Spacing, Vertical Dipole

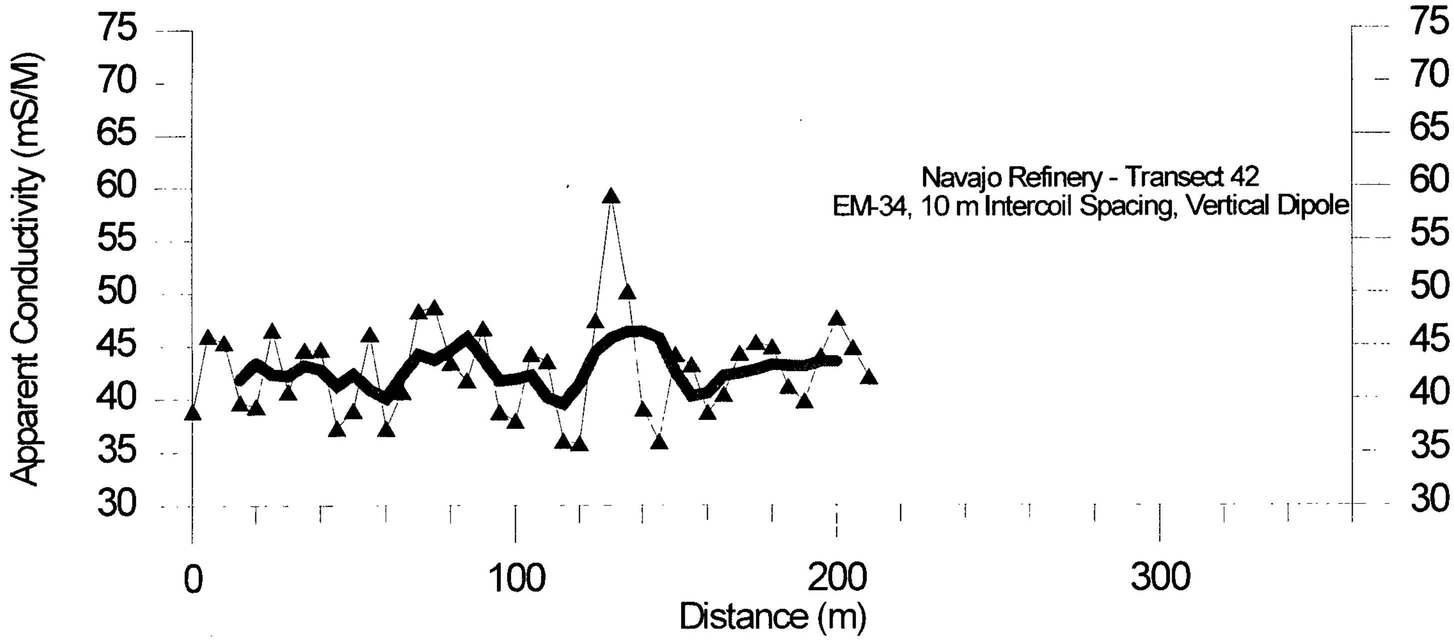

Navajo Refinery - Transect 38
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
70
65
60
55
50
45
40
35
0
100
200
300
Distance (m)

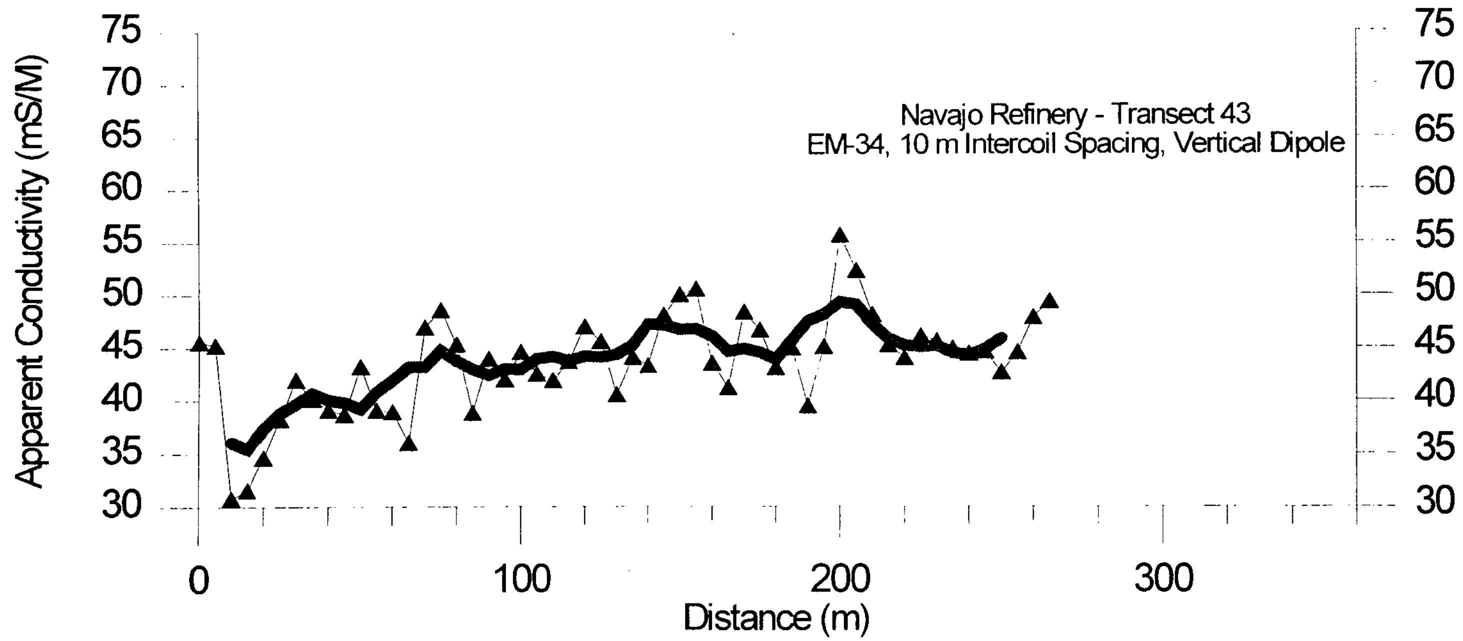

Navajo Refinery - Transect 39
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)
0
100
200
300
20
30
40
50
60
70


Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)
Navajo Refinery - Transect 40
EM-34, 10 m Intercoil Spacing, Vertical Dipole

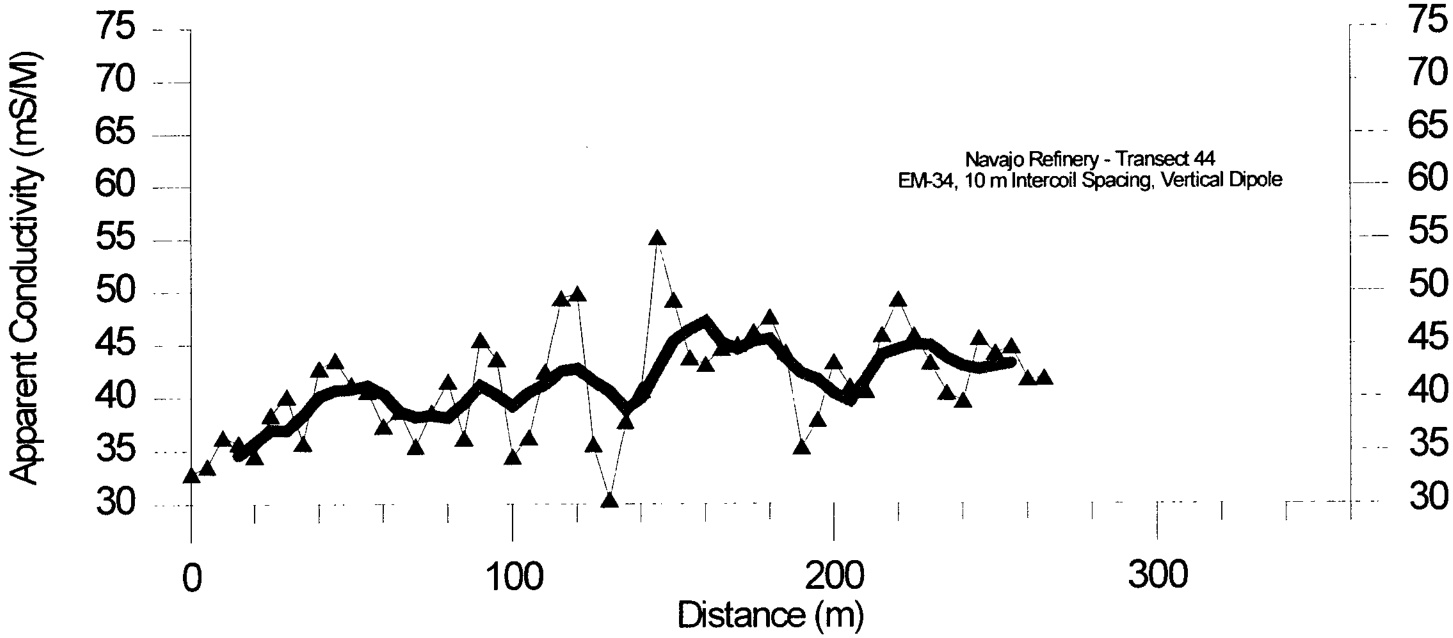


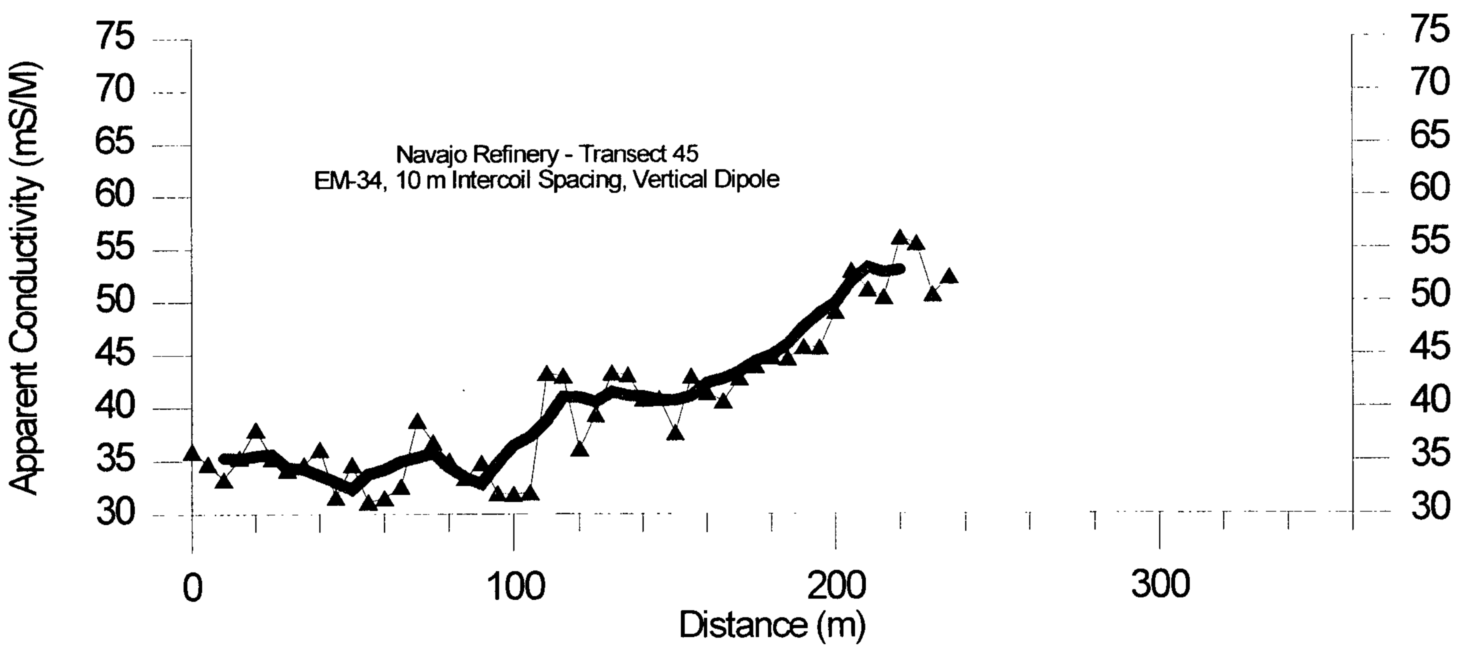
Navajo Refinery - Transect 41
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)


Navajo Refinery - Transect 42
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
Distance (m)
75
70
65
60
55
50
45
40
35
30
0
100
200
300



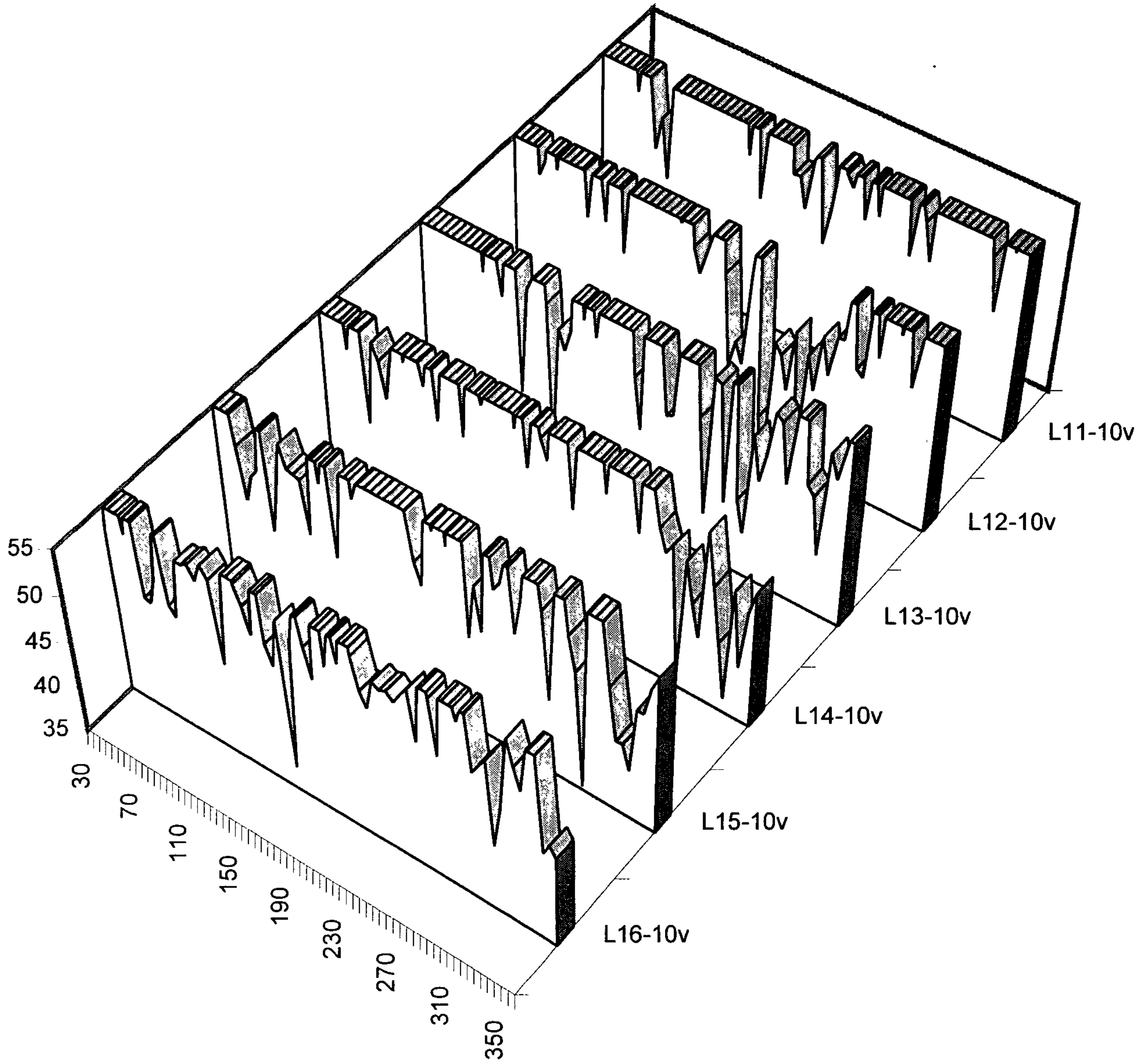
Navajo Refinery - Transect 43
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)


Navajo Refinery - Transect 44
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

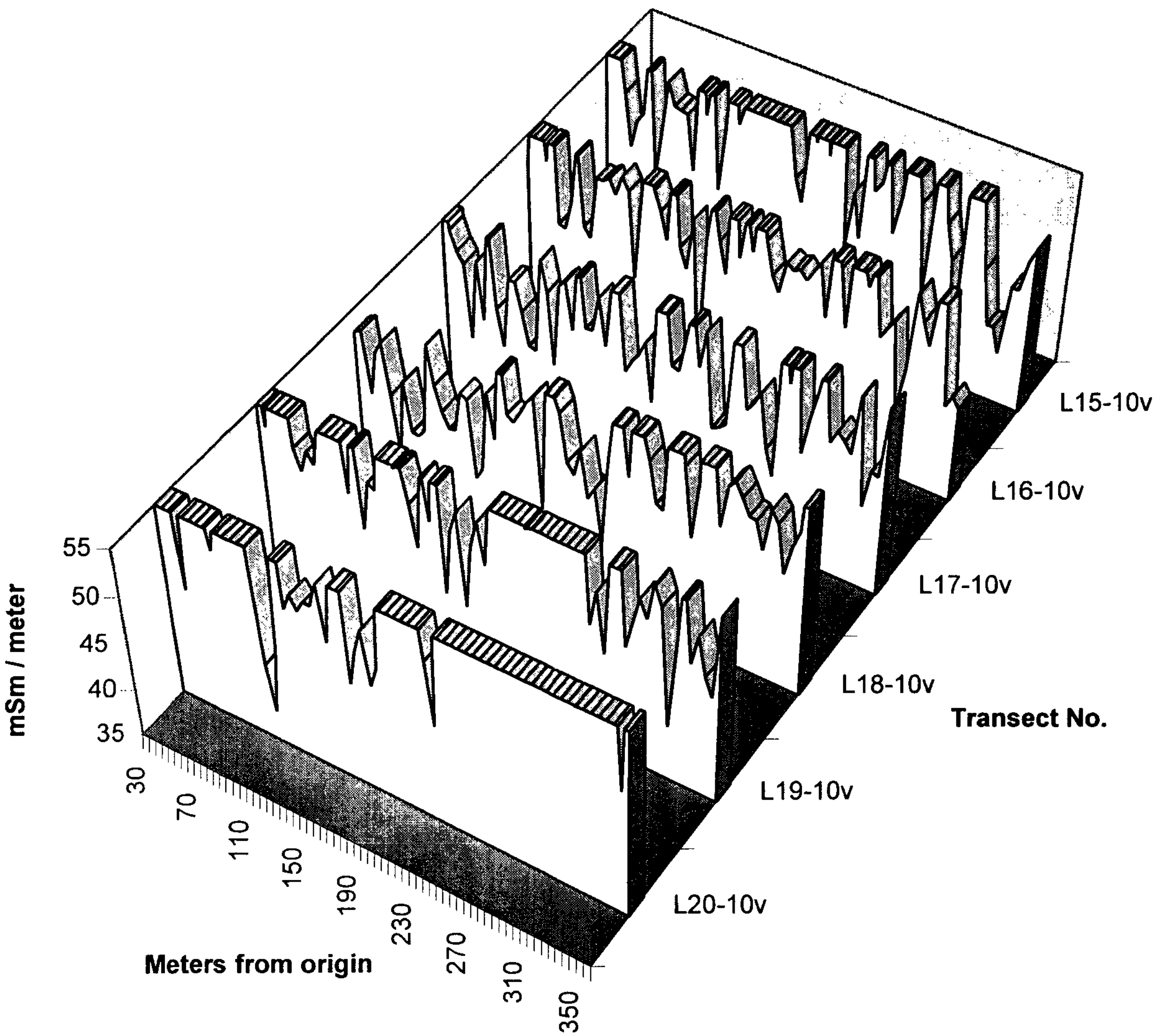

Navajo Refinery - Transect 45
EM-34, 10 m Intercoil Spacing, Vertical Dipole
Apparent Conductivity (mS/M)
75
70
65
60
55
50
45
40
35
30
0
100
200
300
Distance (m)

Three Dimensional Depictions

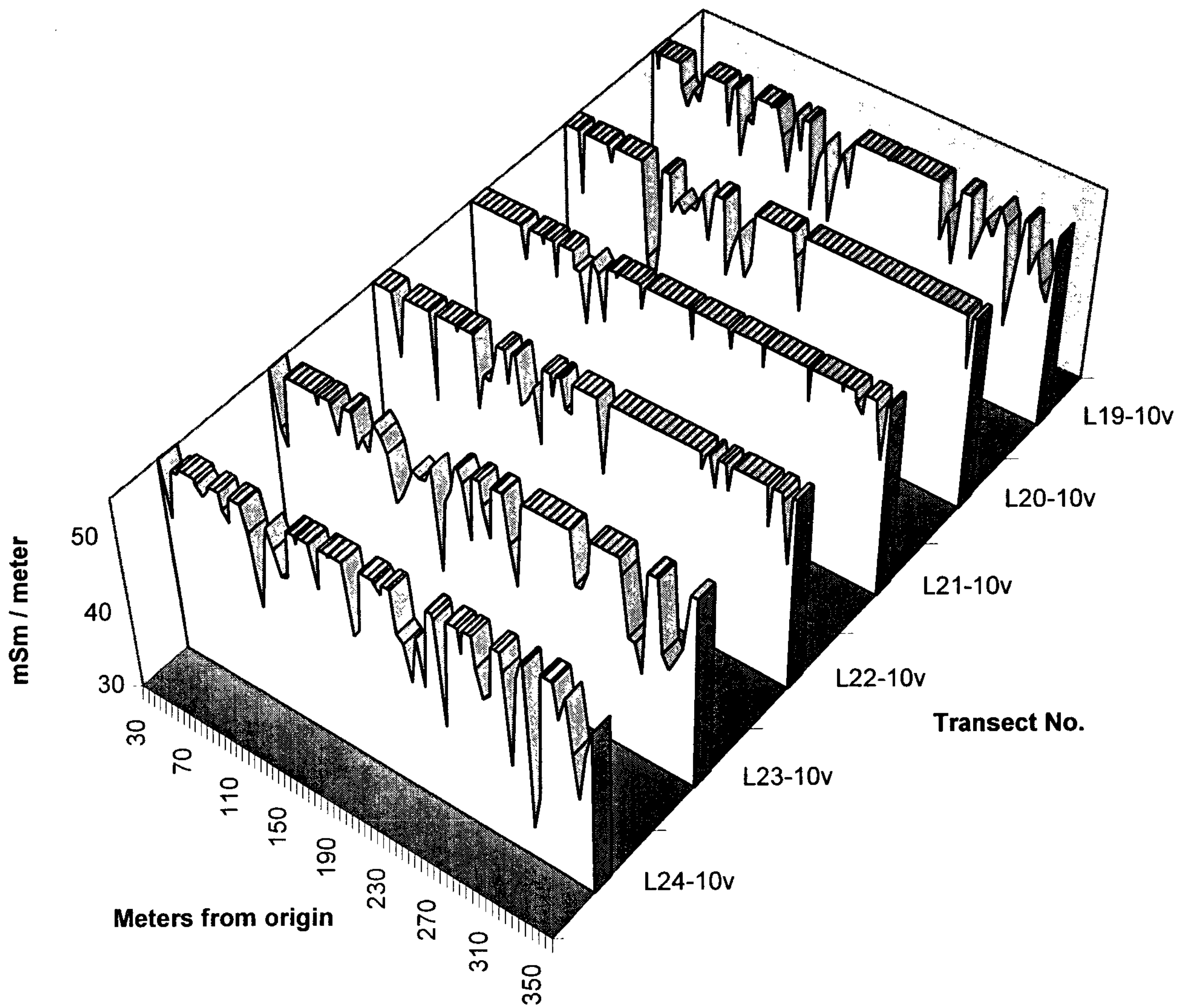
Three Dimensional Depictions


55
50
45
40
35
30
70
110
150
190
230
270
310
350
L11-10v
L12-10v
L13-10v
L14-10v
L15-10v
L16-10v

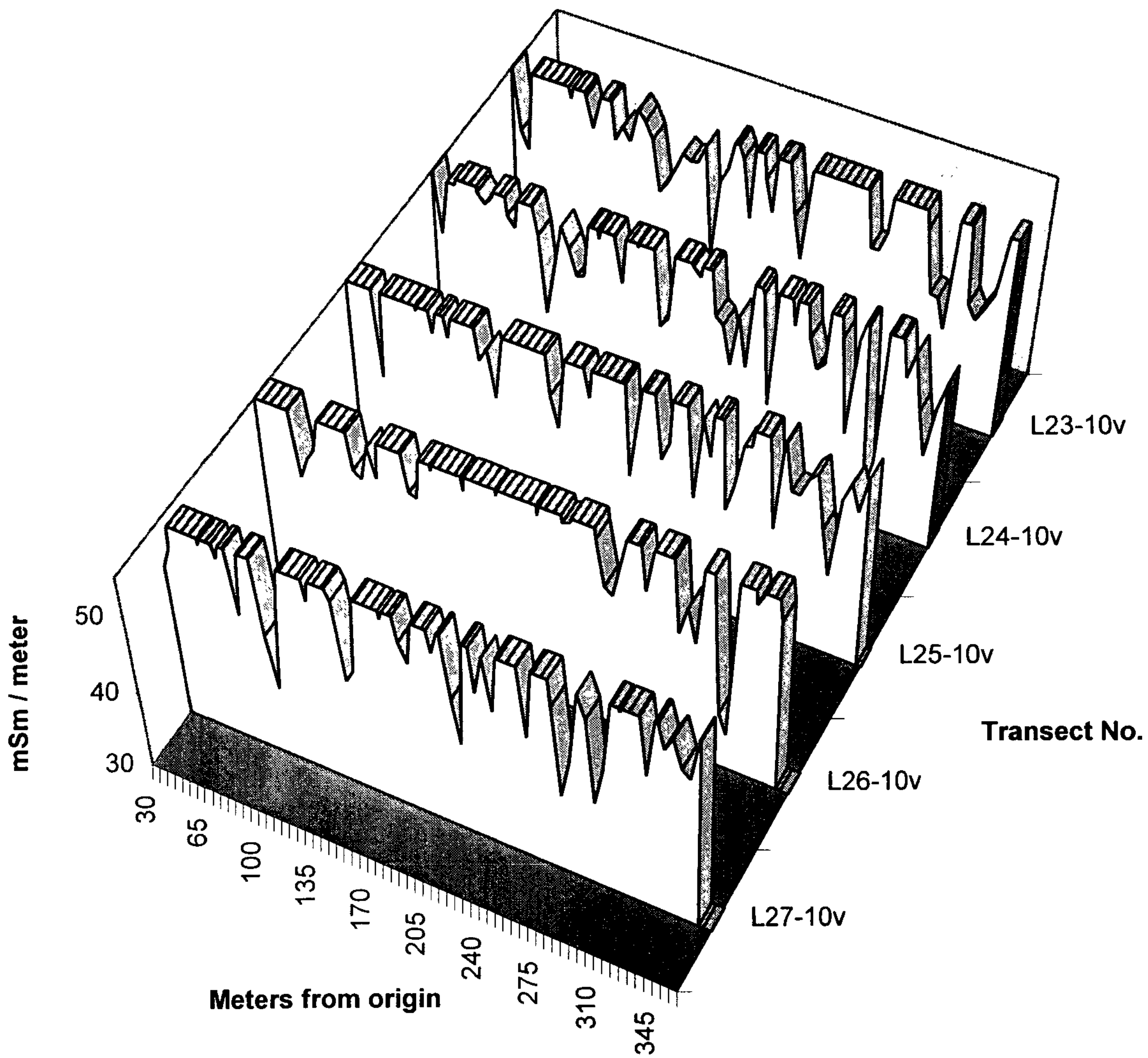
## L15-20v


mSm / meter
55
50
45
40
35
30
70
110
150
190
230
270
310
350
Meters from origin
L15-10v
L16-10v
L17-10v
L18-10v
L19-10v
L20-10v
Transect No.

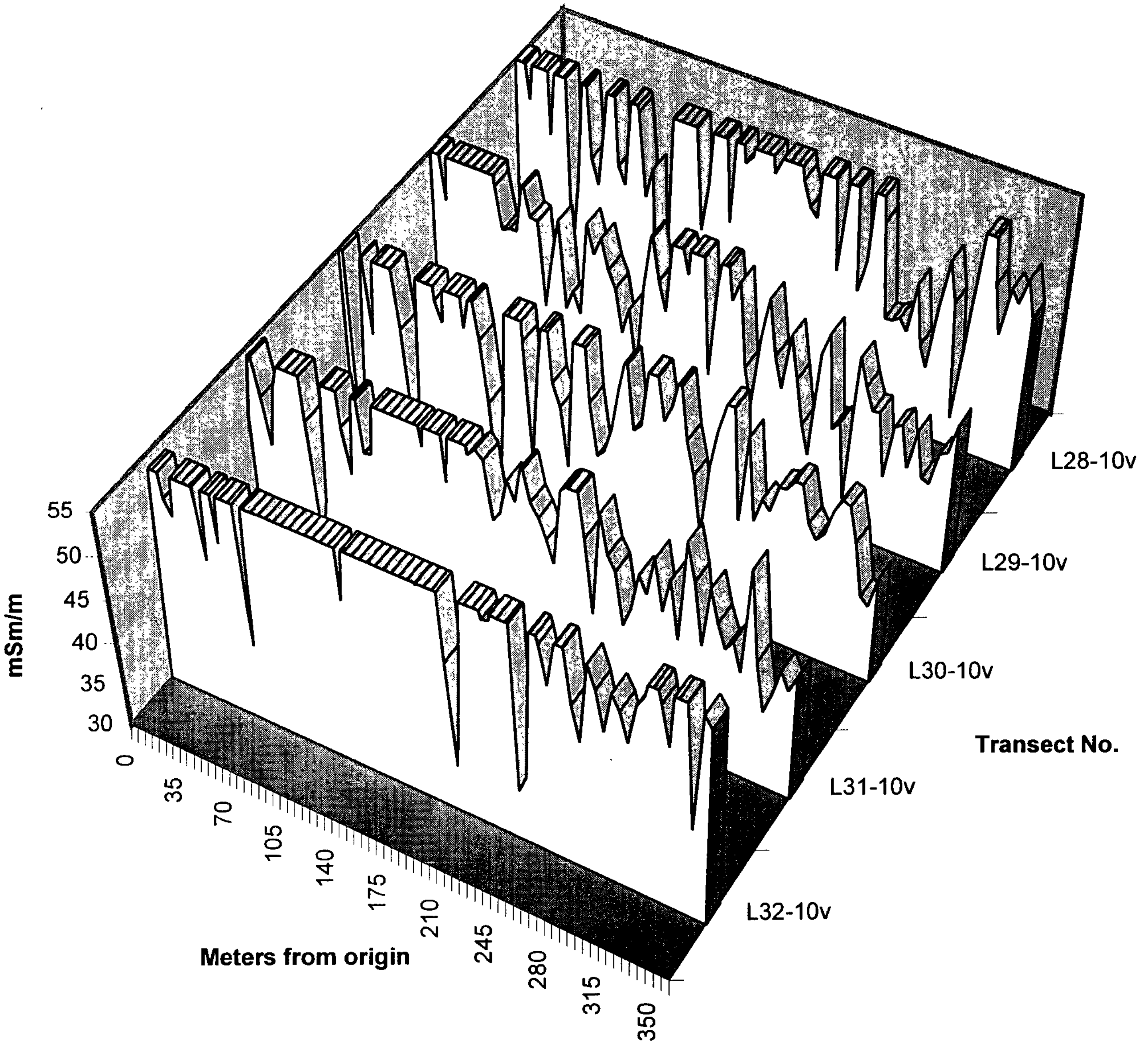
## L19-24v

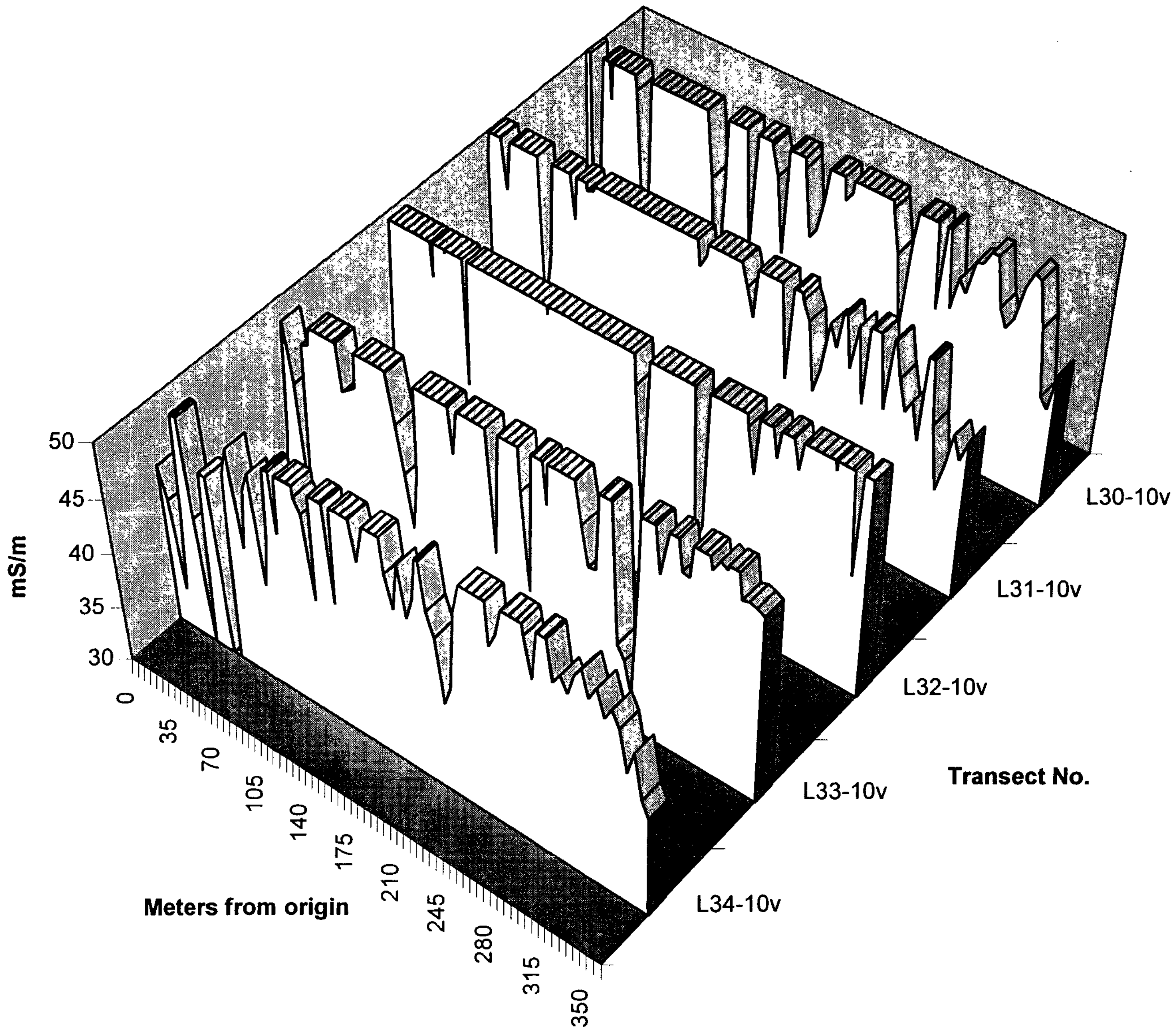

mSm / meter
50
40
30
30
70
110
150
190
230
270
310
350
Meters from origin
L19-10v
L20-10v
L21-10v
L22-10v
L23-10v
L24-10v
Transect No.

## L23-27v

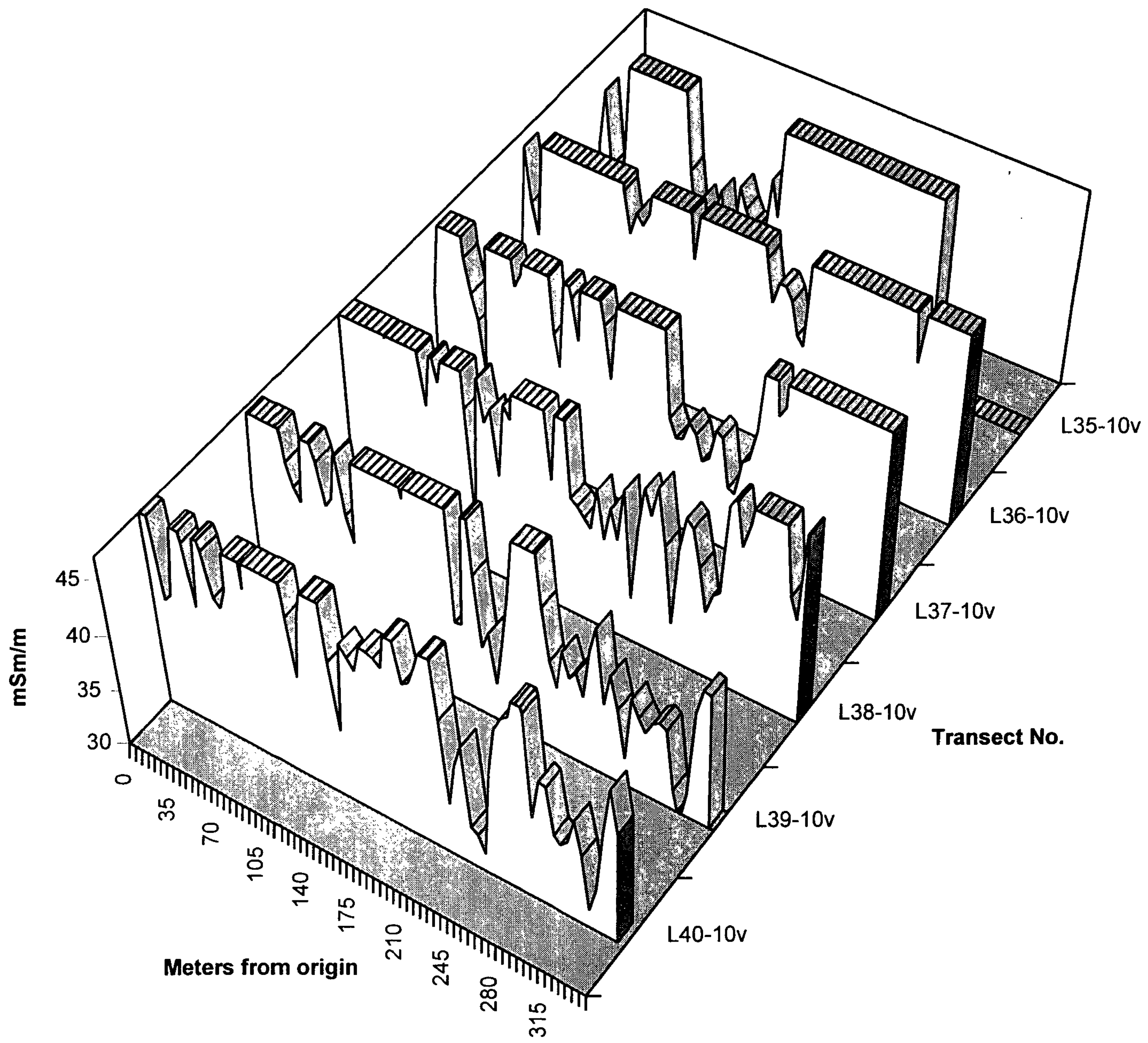


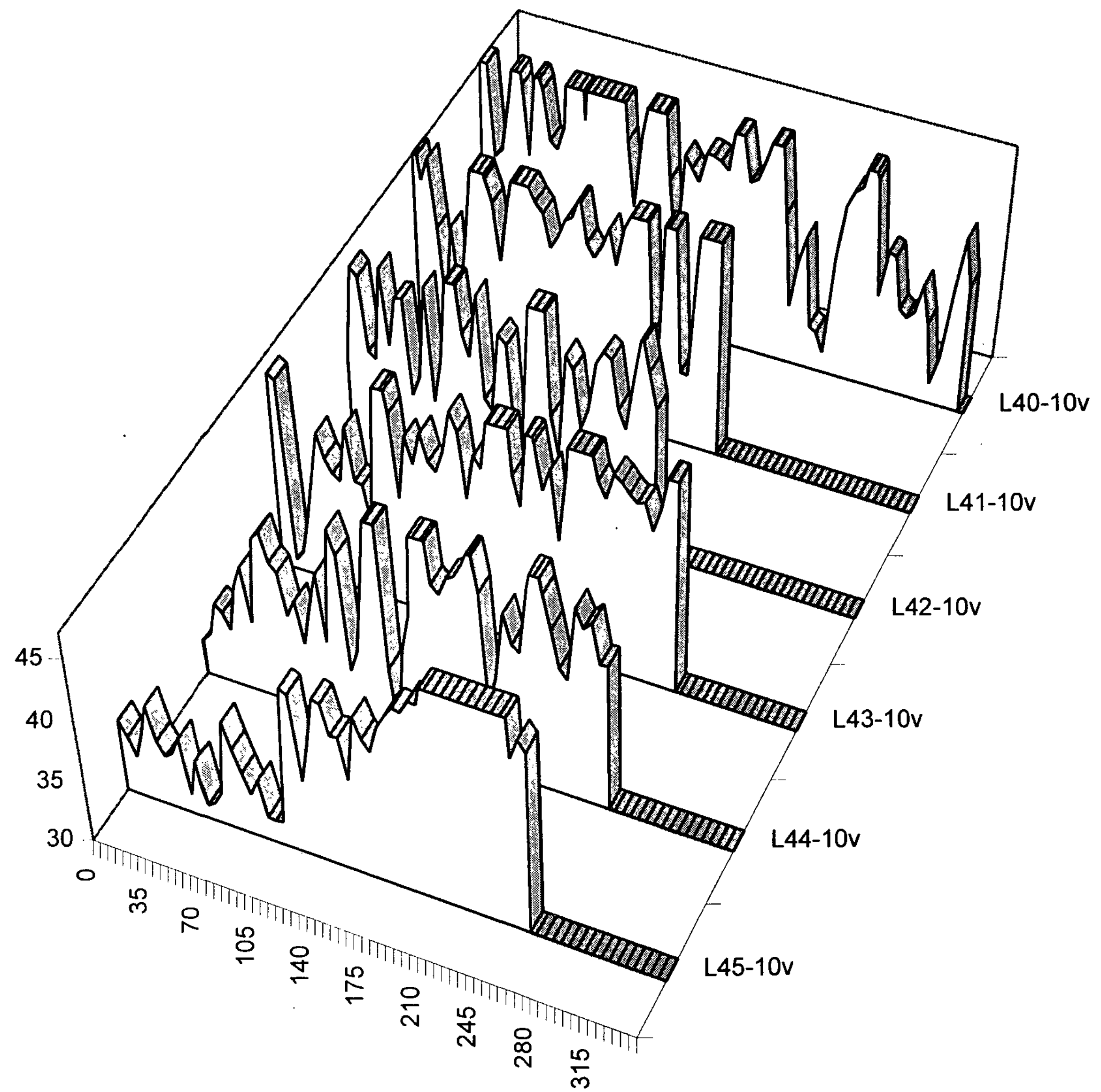
mSm / meter
50
40
30
30
65
100
135
170
205
240
275
310
345
Meters from origin
L23-10v
L24-10v
L25-10v
L26-10v
L27-10v
Transect No.

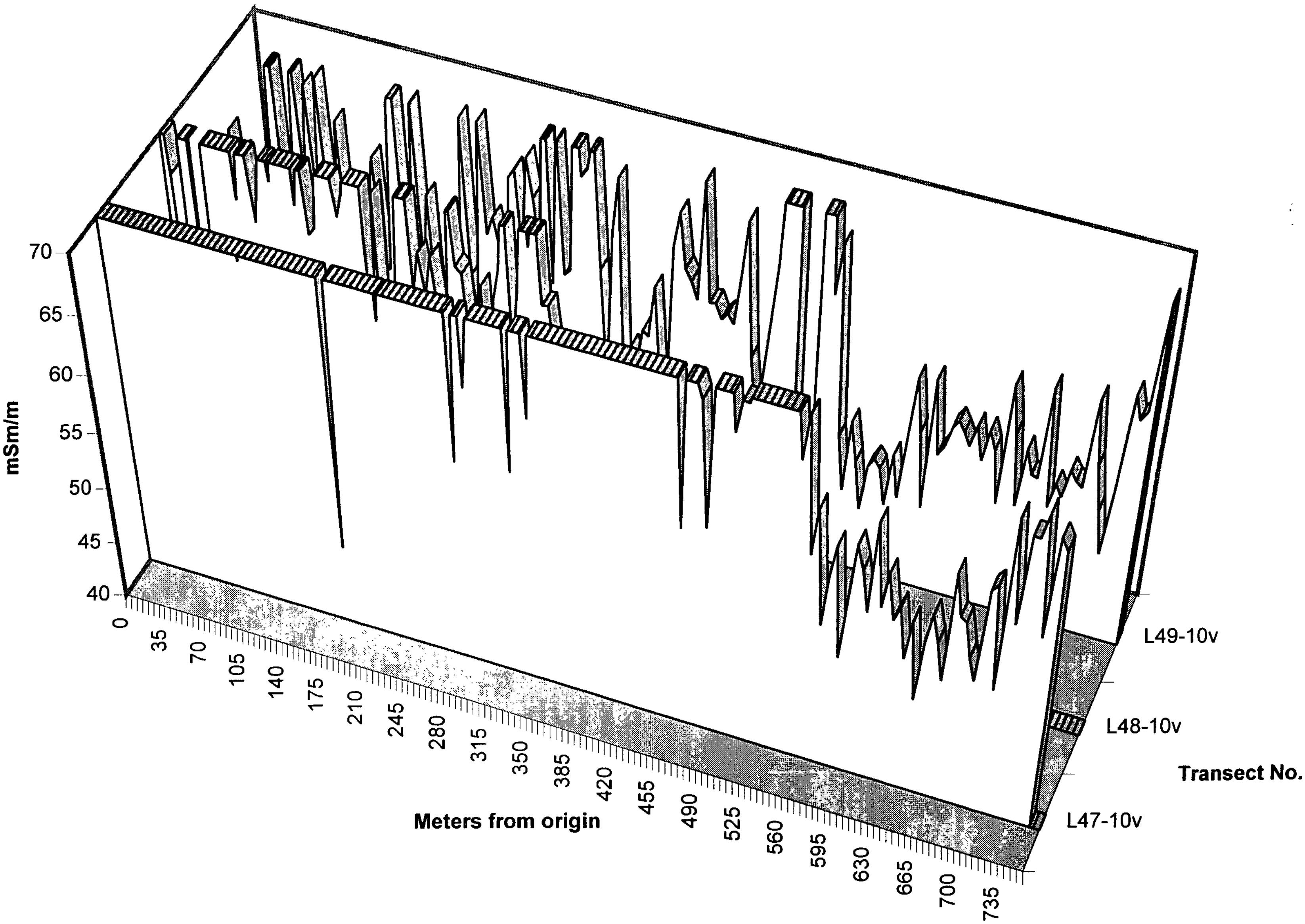

mSm/m
55
50
45
40
35
30
0
35
70
105
140
175
210
245
280
315
350
Meters from origin
L28-10v
L29-10v
L30-10v
L31-10v
L32-10v
Transect No.


50
45
40
35
30
mS/m
0
35
70
105
140
175
210
245
280
315
350
Meters from origin
L30-10v
L31-10v
L32-10v
L33-10v
L34-10v
Transect No.

35-40_3d

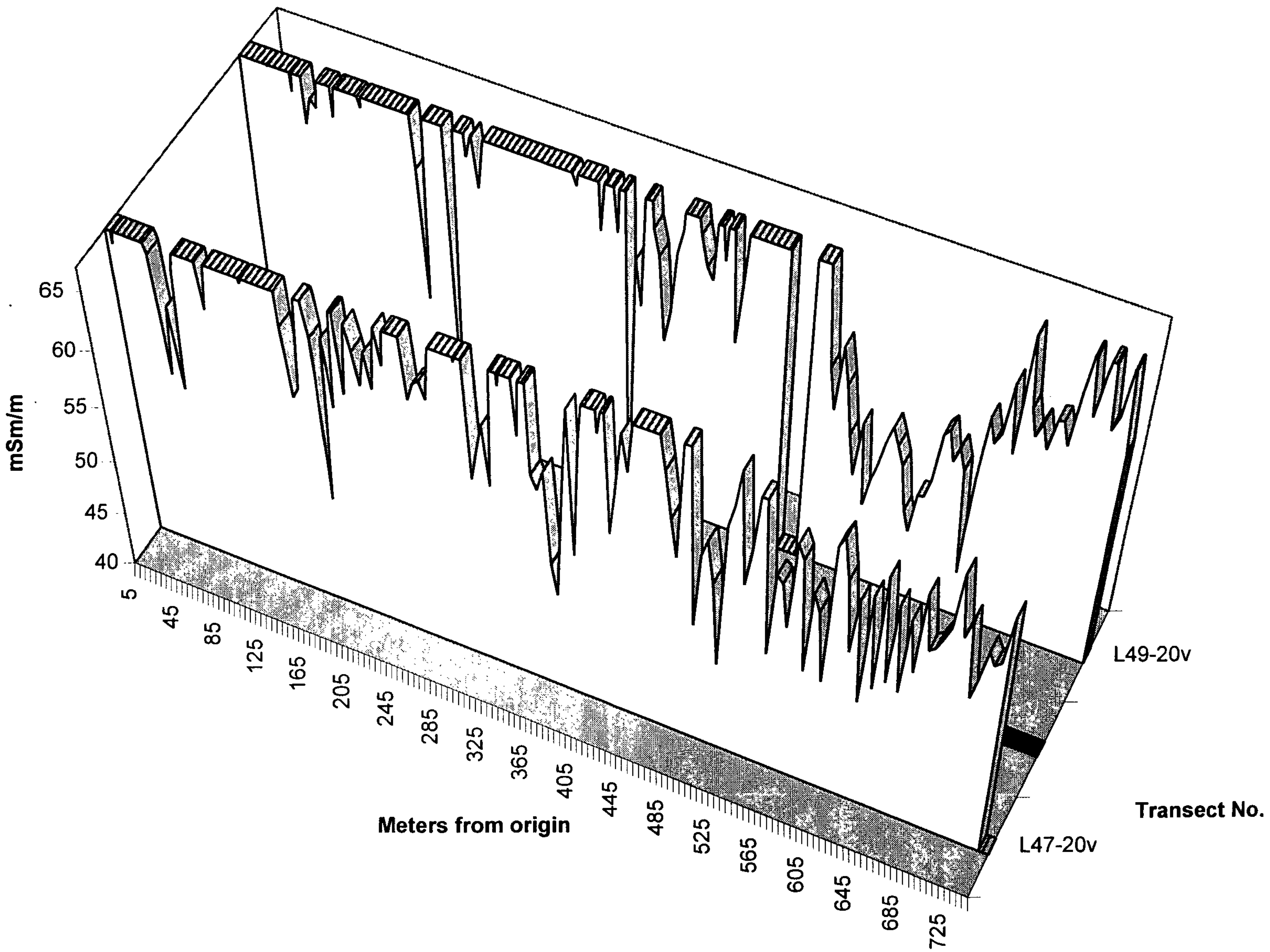

mSm/m
45
40
35
30
0
35
70
105
140
175
210
245
280
315
Meters from origin
L35-10v
L36-10v
L37-10v
L38-10v
L39-10v
L40-10v
Transect No.


45
40
35
30
0
35
70
105
140
175
210
245
280
315
L40-10v
L41-10v
L42-10v
L43-10v
L44-10v
L45-10v

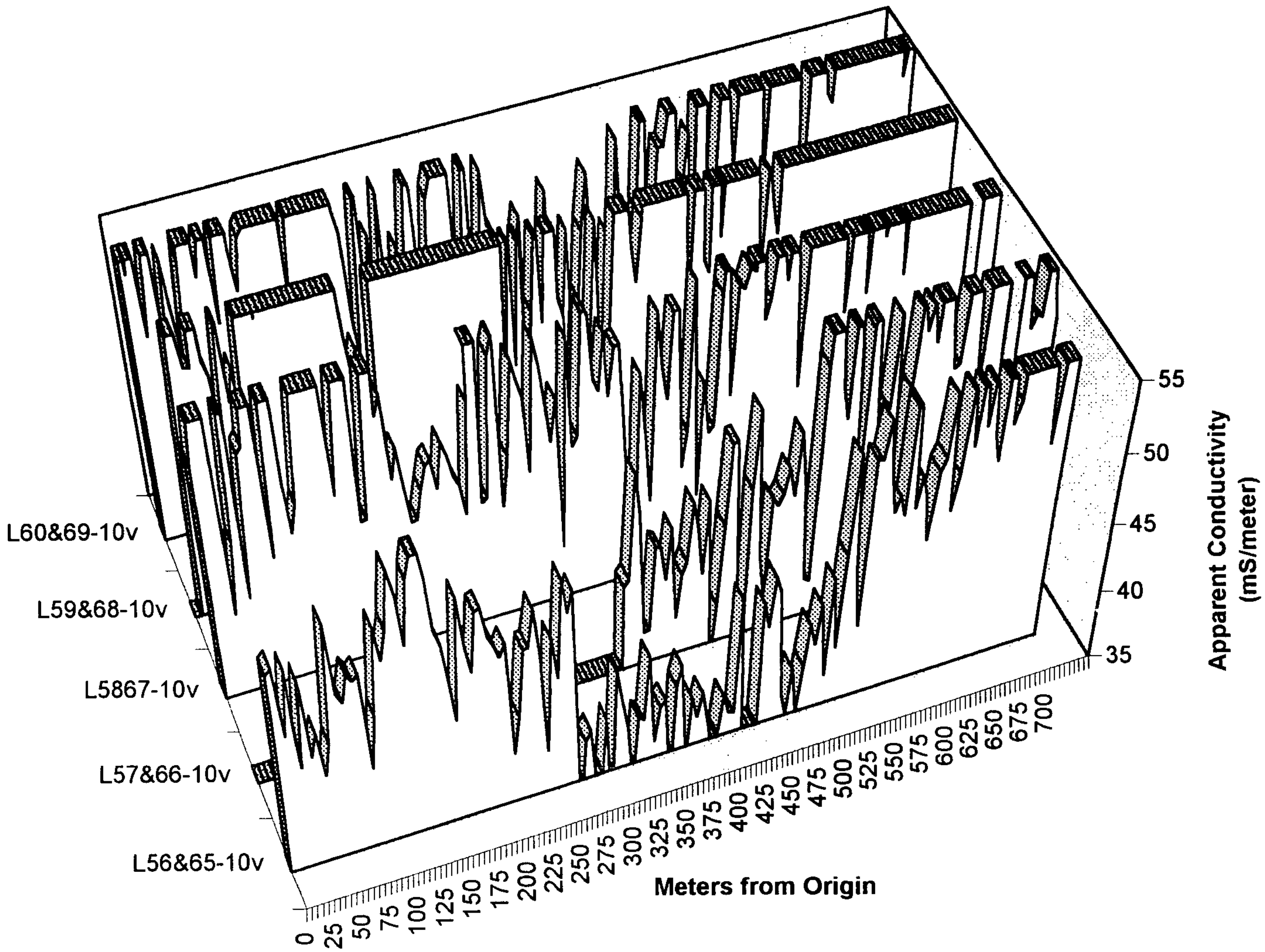


mSm/m
70
65
60
55
50
45
40
0
35
70
105
140
175
210
245
280
315
350
385
420
455
490
525
560
595
630
665
700
735
Meters from origin
L49-10v
L48-10v
L47-10v
Transect No.

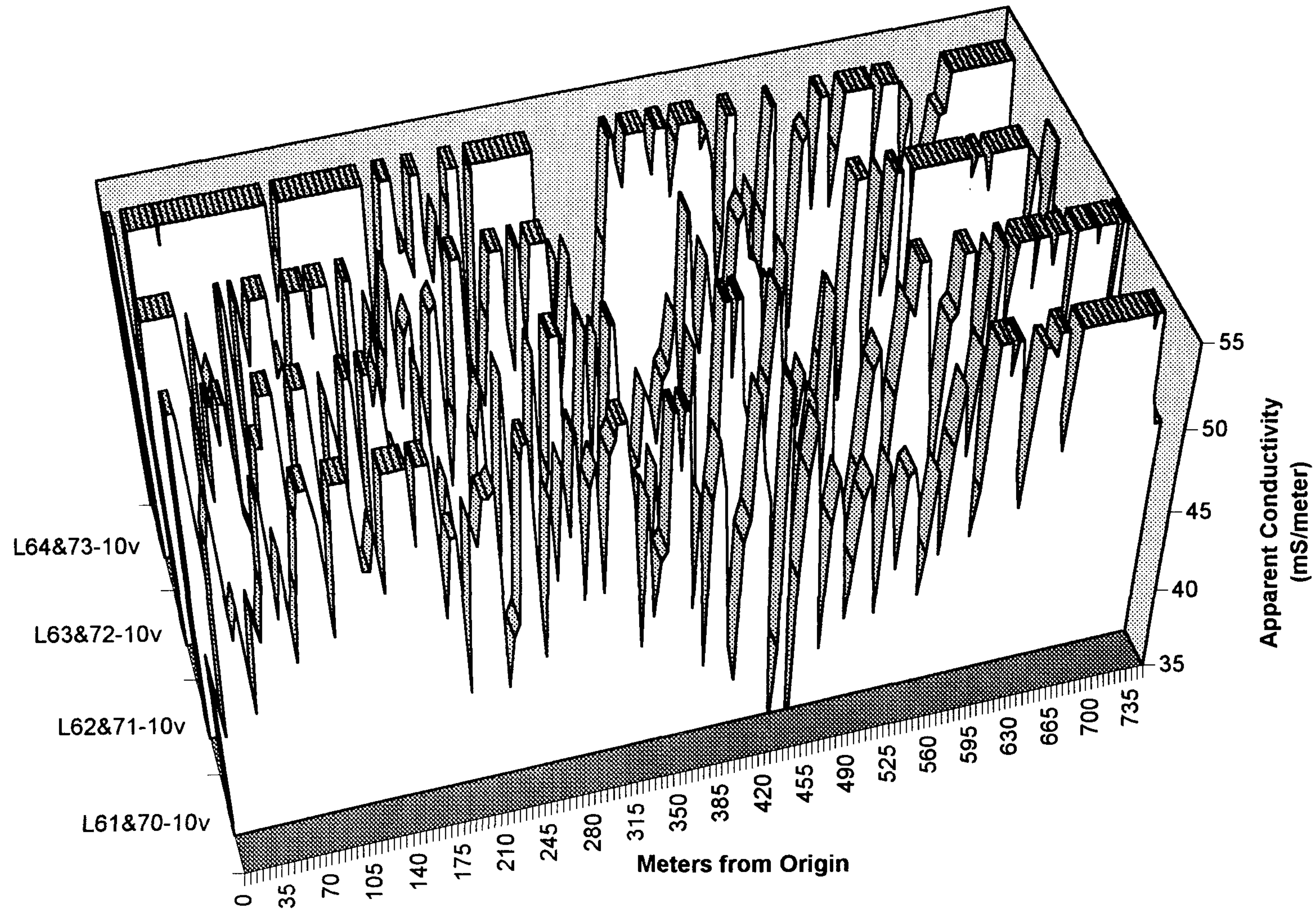
L47&49-20v_3d


65
60
55
50
45
40
mSm/m
5
45
85
125
165
205
245
285
325
365
405
445
485
525
565
605
645
685
725
Meters from origin
L49-20v
L47-20v
Transect No.

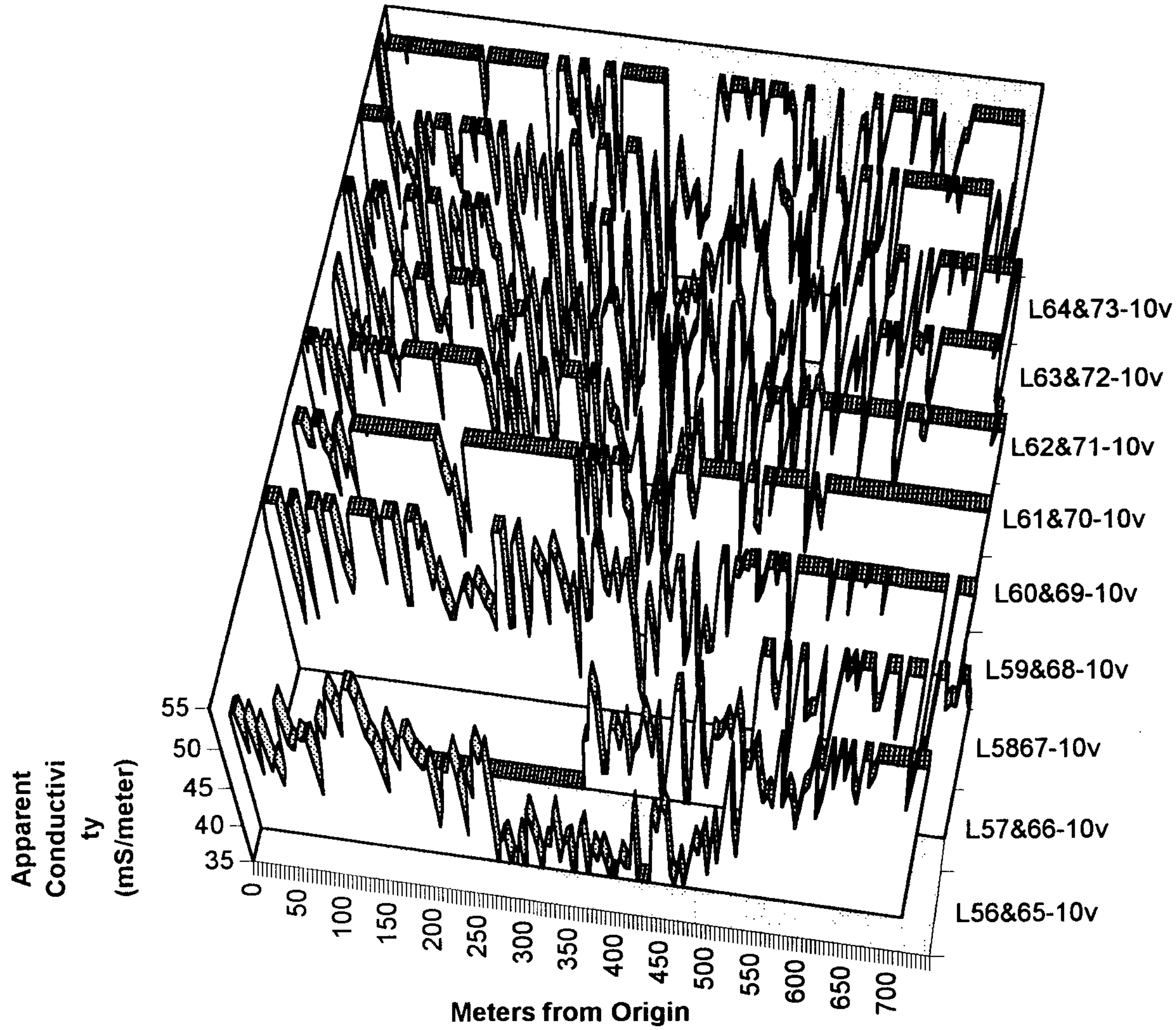
## L56-60, 65-69, vertical orientation, 10 meter intercoil spacing



## L61-64, 70-73, vertical orientation, 10 meter intercoil spacing



## L56-60, 65-69, vertical orientation, 10 meter intercoil spacing



## L74-77, vertical orientation, 10 meter intercoil spacing

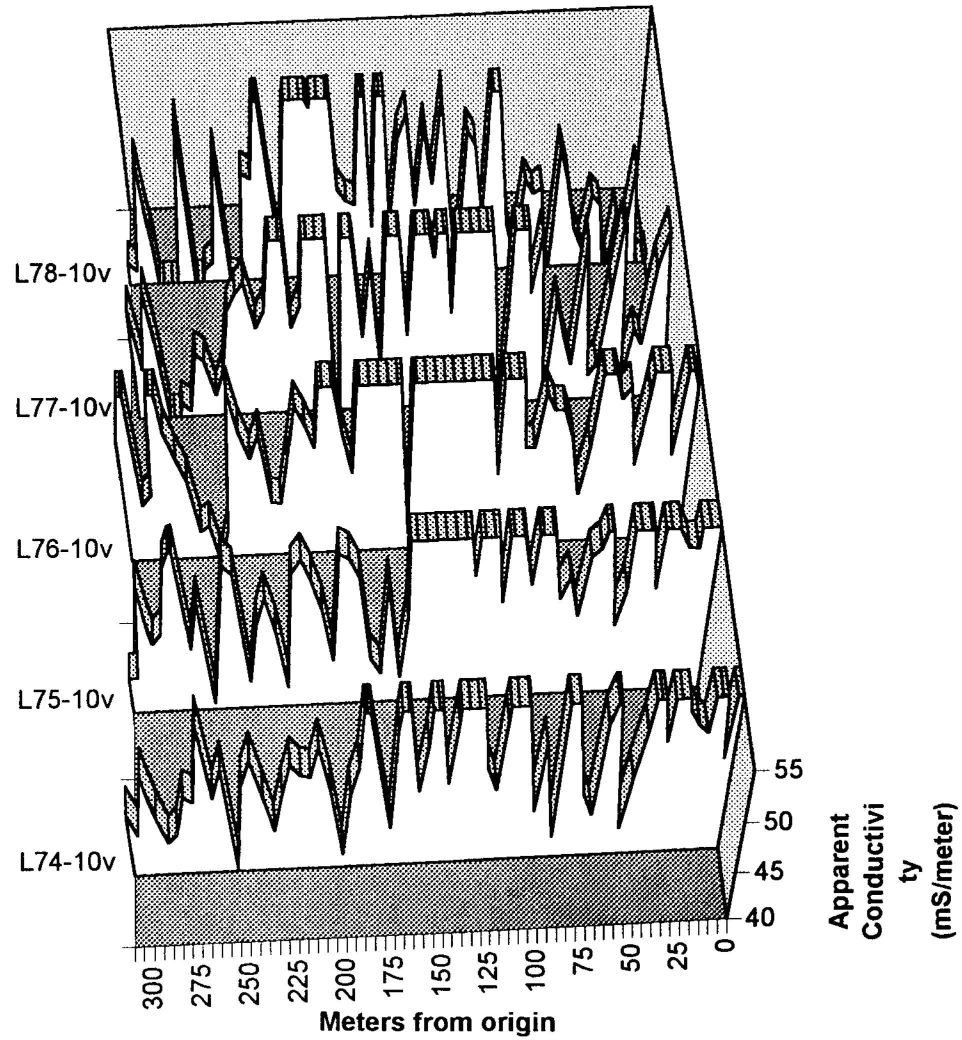


Plate 1

Plate 1


## LEGEND

MAJOR CHANNELS:
Areas of very low electrical conductivity relative to surroundings. Indicative of a continuous and very sandy/gravelly environment, high transmissivity, and preferential flow of pore fluids.

MINOR CHANNELS:
Areas of low electrical conductivity relative to surroundings. Likely indicative of minor layered sand/gravel enriched environments, potentially higher transmissivity, and preferential flow of pore fluids. Lowered electrical conductivity also can indicate the possible presence of hydrocarbon fluids having low electrical conductivity properties.

LESSOR CHANNELS:
Areas of reduced electrical conductivity relative to surroundings. Likely indicative of thin discontinuous layered sand/gravel zones in clay-rich surroundings providing localized zones of higher transmissivity for preferential fluid flow. Reduced electrical conductivity also can indicate the possible presence of hydrocarbon fluids having low electrical conductivity properties. The presence of hydrocarbon fluids may result in reduced electrical conductivity readings appearing as localized sand/gravel zones.

? Areas where additional confirmatory drilling is suggested to enhance EM survey interpretation.

28, 29, 30 — ELECTROMAGNETIC SURVEY TRANSECTS

• BORING LOCATION – DRILLING DATE KEY:

#18 – 1991 DRILLING
B75 – 1992 DRILLING
95-50 – 1995 DRILLING
96-20 – 1996 DRILLING
97-04 – 1997 DRILLING

MONITOR WELL

PIEZOMETER LOCATION

WATER WELL – SHALLOW VALLEY FILL AQUIFER

WATER WELL – DEEP, ARTESIAN AQUIFER

OIL/GAS EXPLORATION WELL CONVERTED TO WATER WELL

SECTION CORNER

RA-397 STATE ENGINEER OFFICE WELL NUMBER, ROSWELL ARTESIAN BASIN

AD-1917 AGE OF WELL, RECORD ON FILE SEO, NO "RA" NUMBER ASSIGNED

N
W E
S

RECEIVED
OCT 06 1997
Environmental Bureau
Oil Conservation Division

150' 0 300' 600' 1200'
225' 75'
SCALE

NOTES

REFERENCE DRAWINGS

| NO. | REVISIONS | BY | CHK. | DATE | APPR. | APPR. |
|---|---|---|---|---|---|---|

| NO. | REVISIONS | BY | CHK. | DATE | APPR. | APPR. |
|---|---|---|---|---|---|---|

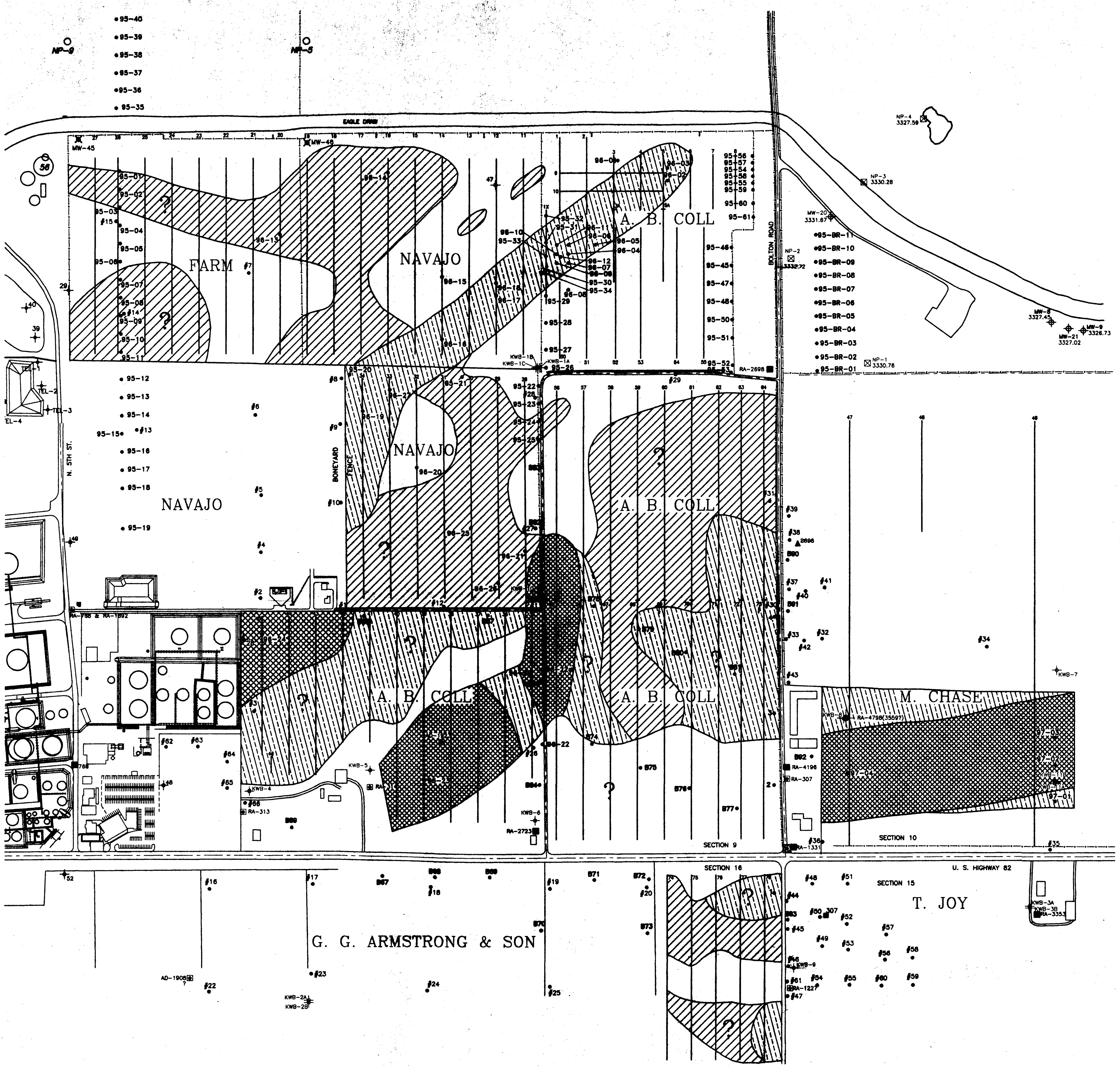
PLATE 1

ELECTROMAGNETIC SURVEY
TRANSECTS AND
INTERPRETIVE RESULTS
EAST OF NAVAJO REFINERY
SEPTEMBER 1997

Navajo
NAVAJO REFINING, CO.
P.O. DRAWER 159
ARTESIA, NEW MEXICO

| DRAWN BY | CHK'D BY | SCALE |
|---|---|---|
| EJS | DB | 1" = 300'-0" |
| DATE | APPR BY | DRAWING NUMBER |
| 9-29-97 | – | NAVREF02.DWG |

0




## LEGEND

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Areas of low electrical conductivity relative to surroundings. Likely indicative of minor layered sand/gravel enriched environments, potentially higher transmissivity, and preferential flow of pore fluids. Lowered electrical conductivity also can indicate the possible presence of hydrocarbon fluids having low electrical conductivity properties.

LESSOR CHANNELS:
Areas of reduced electrical conductivity relative to surroundings. Likely indicative of thin discontinuous layered sand/gravel zones in clay-rich surroundings providing localized zones of higher transmissivity for preferential fluid flow. Reduced electrical conductivity also can indicate the possible presence of hydrocarbon fluids having low electrical conductivity properties. The presence of hydrocarbon fluids may result in reduced electrical conductivity readings appearing as localized sand/gravel zones.

? Areas where additional confirmatory drilling is suggested to enhance EM survey interpretation.

28, 29, 30 ELECTROMAGNETIC SURVEY TRANSECTS

• BORING LOCATION – DRILLING DATE KEY:

| | | | |
|---|---|---|---|
| #18 | – 1991 DRILLING | 96-20 | – 1996 DRILLING |
| B75 | – 1992 DRILLING | 97-04 | – 1997 DRILLING |
| 95-50 | – 1995 DRILLING | | |

MONITOR WELL

PIEZOMETER LOCATION

WATER WELL – SHALLOW VALLEY FILL AQUIFER

WATER WELL – DEEP, ARTESIAN AQUIFER

OIL/GAS EXPLORATION WELL CONVERTED TO WATER WELL

SECTION CORNER

RA-397 STATE ENGINEER OFFICE WELL NUMBER, ROSWELL ARTESIAN BASIN

AD-1917 AGE OF WELL, RECORD ON FILE SEO, NO "RA" NUMBER ASSIGNED

N
W E
S

RECEIVED
SEP 30 1997
Environmental Bureau
Oil Conservation Division

150' 0 300' 600' 1200'
225' 75'
SCALE

| NOTES | REFERENCE DRAWINGS | NO. | REVISIONS | BY | CHK. | DATE | APPR. | APPR. | NO. | REVISIONS | BY | CHK. | DATE | APPR. | APPR. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

PLATE 1

ELECTROMAGNETIC SURVEY TRANSECTS AND INTERPRETIVE RESULTS EAST OF NAVAJO REFINERY SEPTEMBER 1997

NAVAJO REFINING CO.
P.O. DRAWER 159
ARTESIA, NEW MEXICO

| DRAWN BY | CHK'D BY | SCALE |
|---|---|---|
| EJS | DB | 1" = 300'-0" |
| DATE | APPR BY | DRAWING NUMBER |
| 9-29-97 | – | NAVREF02.DWG 0 |