File Jim Doolittle

United States Department of Agriculture | Soil Conservation Service | 160 East 7th Street Chester, PA 19013-6092

Subject: GPR/EM Archaeological Studies in Ouachita and Lincoln Parishes, Louisiana, 27 to 29 July 1993

Date: 28 September 1993

To: Donald W. Gohmert
State Conservationist
USDA - Soil Conservation Service
Alexandria, Louisiana

Purpose:
To provide geophysical field assistance to archaeologists at Hedgepeth Mounds and Watson Break Archaeological Site.

Principal Participants:
Thurman Allen, Area Soil Scientist, Monroe, LA
Jim Doolittle, Soil Specialist, SCS, Chester, PA
Kim Doolittle, Volunteer, SCS, Chester, PA
Jimmy Edwards, Assistant State Soil Scientist, SCS, Alexandria, LA
Joe Saunders, Regional Archaeologist, NLU, Monroe, LA

Activities:
The afternoon of June 27 was spent at the Hedgepeth Mounds site. The site was toured and previous archaeological studies, terrain conditions, and field procedures were discussed. Electromagnetic induction studies were carried out at Hedgepeth Mounds on 28 June and at Watson Break on 29 June.

Equipment
Heavy rains had made roads into the sites impassable. As both Hedgepeth Mound and Watson Break Archaeological sites were inaccessible to the radar vehicle, ground-penetrating radar (GPR) techniques were not used in the studies.

The electromagnetic induction meters used were the EM31 and EM38 manufactured by Geonics Limited+. Both meters are portable and require only one person to operate. Principles of operation have been described by McNeill (1,2). At Hedgepeth Mounds, the EM38

+ Trade names have been used to provide specific information. Their mention does not constitute endorsement.

1. McNeill, J. D. 1980. Electromagnetic terrain conductivity measurements at low induction numbers. Geonics Ltd., Mississauga, Ontario. Technical Note TN-6. p. 15.

meter operated erratically and measurements were suspected of error. The meter was not used at Watson Break. Because of the inconsistent operation of the EM38 meter, only the results of the surveys conducted with the EM31 meter are summarized in this report.

With EM methods, depth of penetration is dependent upon intercoil spacing, transmission frequency, and coil orientation relative to the ground surface. The EM31 meter integrates values of apparent conductivity over the upper 2.75 m in the horizontal dipole orientation, and over the upper 6.0 m in the vertical dipole orientation. The EM38 meter integrates values of apparent conductivity over the upper 0.75 m in the horizontal dipole orientation, and over the upper 1.5 m in the vertical dipole orientation.

Field Procedures

Multiple transect lines were established at each site. Transects varied in length from 9 to 180 m. Along each transect line, survey flags were inserted in the ground at 3 m intervals. Nineteen transect lines were established along pathways at Hedgepeth Mounds. These lines contained 172 equally spaced observation points. Four transect lines were established at Watson Break. Three of these lines required the clearing and removal of brush. The lines at Watson Break contained 166 equally spaced observation points.

At each of the 338 observation points, measurements were taken with the EM31 meter in the horizontal and vertical dipole orientations. A transit was used to determine the relative elevation of each observation point. Elevation data helped to reveal and related patterns of apparent conductivity with both natural and artificial terrain conditions.

A 18 by 30 meter rectangular grid was established across a portion of a mound at Watson Break. The grid interval was 3 m. A transit was used was used to establish the grid and to determine relative elevations. At each of the 77 grid intersects, measurements were made with the EM31 meter in both the horizontal and vertical modes.

Results:

<u>Hedgepeth Mounds, Lincoln Parish</u>

Figures 1 thru 11, represent two-dimensional cross sections of eleven transects from Hedgepeth Mounds. Each figure consists of two plots: relative elevations (upper plot) and EM31 responses (lower plot). Cross sections were not prepared for eight transects because of the lack of a sufficient number of observation

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2. McNeill, J. D. 1986. Geonics EM38 ground conductivity meter operating instructions and survey interpretation techniques. Geonics Ltd., Mississauga, Ontario. Technical Note TN-21. p. 16.

lways greater than those taken in the horizonta
tation. These differences reflect variations i
bly land use.

everal observation points along transects 2 and 3
nd 14, respectively), measurements taken in the v
ntation were less than those taken in the horizont
ntation. This pattern commonly occurs in the slig
ng "swale" positions. This distribution may reflec
currence of finer-textured materials nearer to the s
one of thee lower-lying positions.

At watson Break, in the horizontal dipole orientation,
response averaged 57.2 mS/m and ranged from 15 to 86 mS,
vertical dipole orientation, the EM response averaged 6
ranged from 24 to 92 mS/m. At most observation points,
response in both orientations was closely similar. Typi
measurements collected in the vertical dipole orientatio
slightly greater than those in the horizontal dipole ori
This pattern indicates fairly homogeneous soil conditions
depth. The small increase in EM response with depth may
changes in the clay or soil moisture content.

Similar with observations made at Hedgepeth Mounds, value
apparent conductivity decreased with elevation. However,
Hedgepeth, no exceptions to this pattern were evident at
Break. The "terrain affect" was attributed to changes in
contents and stratigraphy. Higher-lying position have wa
at greater depths, soils which are generally drier, and m
layers of coarser-textured (less conductive) soil materia

Figure 16 is a two-dimensional contour plot of the grid s
surveyed at Watson Break. The contour interval is 0.5 me
Within the survey area relief was slightly greater than 4

Two-dimensional contour plots of apparent conductivity va
prepared from results of the EM grid survey. These conto
simulate data obtained with EM31 meter in the horizontal
17) and vertical (Figure 18) dipole modes. In each of th
figures, the contour interval is 2 mS/m.

Within the grid site, values of apparent conductivity dec
elevation. Values of apparent conductivities were lower
more sloping, upper backslope and summit positions. The
values on the higher-lying landscape positions are believe
manifestation of the terrain. As mentioned earlier, high
and more sloping areas are generally drier and less condu
lower-lying areas.

In figures 17 and 18, most isolines are widely spaced. T
pattern suggests gradual changes in soil type or material
However, in the upper right-hand corner of each figure, i
are more closely spaced. This pattern occurs in the lowe

portion of the grid site and suggests an abrupt and contrasting change in soil type.

A distinct anomaly is evident in Figure 18. This anomaly (see "A" in Figure 18) is highly contrasting and limited in extent. This feature may represent a deposit of more conductive materials, an erode area with thinner layers of coarser-textured materials, or a buried cultural feature. The identity of this anomalous feature should be confirmed.

Conclusions

1. This study was preliminary in nature. All participants received training in the use of EM techniques. The participants, as knowledgeable users of this technology, are better prepared to design and carry-out subsequent EM surveys.

2. With drier and more accessible field conditions, ground-penetrating radar techniques can be used effectively at the Hedgepeth site. The higher resolution provided with GPR, makes this a most appropriate geophysical tool for archaeological investigations in many areas of coarse and medium textured soils.

3. Electromagnetic induction techniques provided subsurface stratigraphic information which can be helpful in the assessment of archaeological sites. At both Hedgepeth and Watson Break, subsurface anomalies were detected. Several of these anomalies may represent cultural features. Observation pits are necessary to unravel these patterns.

It was my pleasure to work in your state and with member of your fine staff. I apologize for the delayed filing of this report.

With kind regards

James A Doolittle

James A. Doolittle

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Use of EM techniques in Archaeological Investigations in Ouachita and Lincoln Parishes, Louisiana

Electromagnetic induction is well suited to reconnaissance surveys requiring continuous data and moderate resolution of subsurface features. This technique has been used to locate and map buried structures, artifacts, mounds, and tombs (Bevan, 1983; Dalan, 1991; Frohlich and Lancaster, 1986).

Electromagnetic induction (EM) techniques generate electromagnetic fields to measure the bulk or apparent conductivity of underlying earthen materials. Apparent conductivity is the weighted average conductivity measurement for a column of earthen materials to a specified penetration depth (Greenhouse and Slaine; 1983). The averages are weighted according to the depth response function of the meter (Slavich and Petterson, 1990). The depth of penetration is dependent upon the intercoil spacing, transmission frequency, and coil orientation relative to the ground surface. Table 1 lists the anticipated depths of measurements for the EM meters with different intercoil spacings and coil orientations.

Because of the ease and efficiency of operation, EM can be used to rapidly survey large areas. Interpretations of EM results are based on the identification of spatial patterns in the data set appearing on two-dimensional contour plots or cross sections. Analysis of EM data provides stratigraphic information about a survey area and may reveal the location of buried cultural features. However, with increasing exploration depths and coarser resolution, detection is often limited to large, buried structures or prominent stratigraphic features.

TABLE 1

Depth of Measurement
(all measurements are in meters)

Meter	Intercoil Spacing	Depth of Measurement Horizontal	Vertical
EM31	3.7	2.75	6.0
EM34-3	10.0	7.5	15.0
	20.0	15.0	30.0
	40.0	30.0	60.0
EM38	1.0	0.75	1.5

The size, electrical properties, and depth to an artifact affects discernment. Large, electrically contrasting features tend to produce greater electrical responses and anomalous patterns which are easier to detect and identify with EM methods. Some features

may not be sufficiently large or contrasting for electromagnetic induction techniques to detect.

As only the EM31 meter was available for this survey concerns were expressed over the likelihood of this instrument to resolve small cultural features. The EM31 meter has a relatively large intercoil spacings (3.86 m) and profiles depths of 2.75 and 6 meters. At these spacings, because of the large volume of earthen materials contributing to the electrical response, electromagnetic induction methods provide relatively coarse resolution. While it was felt that EM methods would not discern small individual features, it was speculated that this tool would detect large buried anomalies and provide valuable information on the stratigraphy of the mounds and the encircling terrain. In addition, it was presumed that clusters of cultural anomalies could be distinguished from broad terrain patterns. This information may be useful in assessing the sites and the determining the extent of culturally disturbed lands.

References

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Dalan, Rinita A. 1991. Defining archaeological features with electromagnetic surveys at the Cahokia Mound State Historic Site. Geophysics 56(8):1280-1287.

Frohlich, Bruno and Warwick J. Lancaster. 1986. Electromagnetic surveying in current Middle Eastern archaeology: application and evaluation. Geophysics 51(7):1414-1425.

Greenhouse, J. P., and D. D. Slaine. 1983. The use of reconnaissance electromagnetic methods to map contaminant migration. Ground Water Monitoring Review 3(2):47-59.

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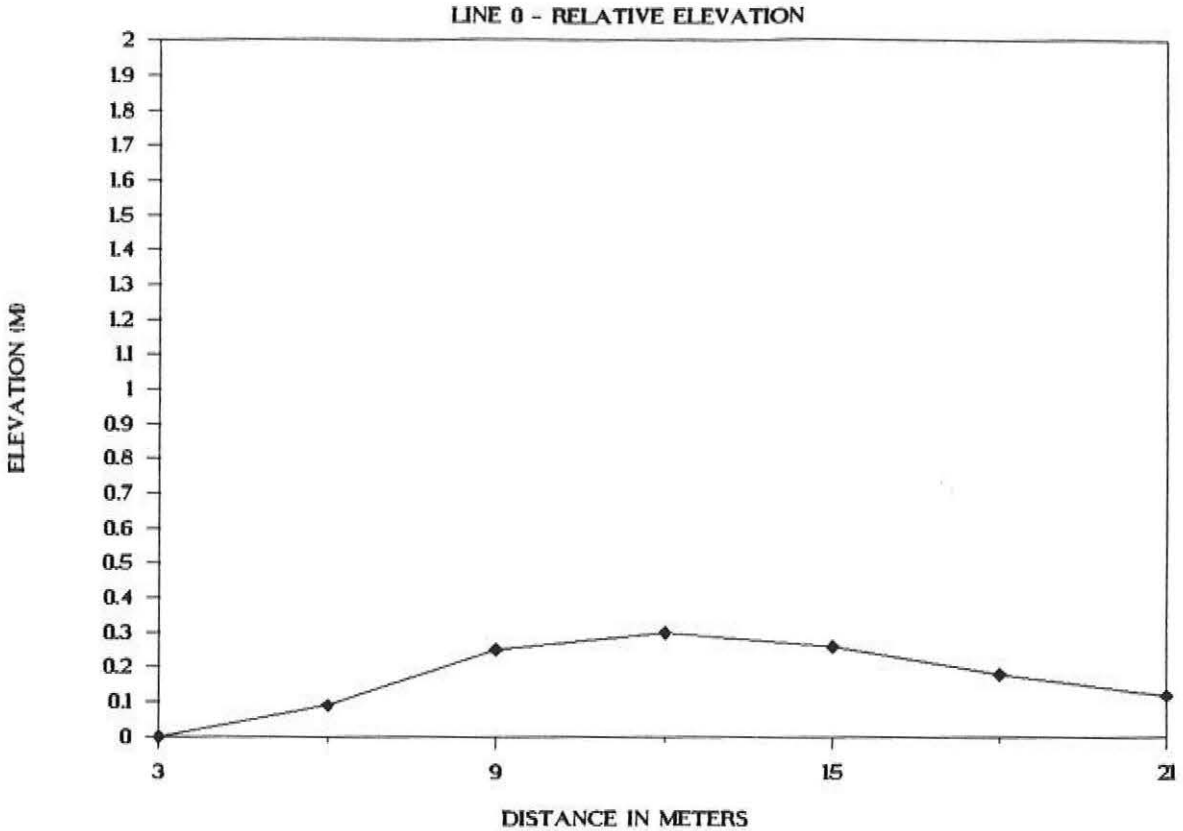
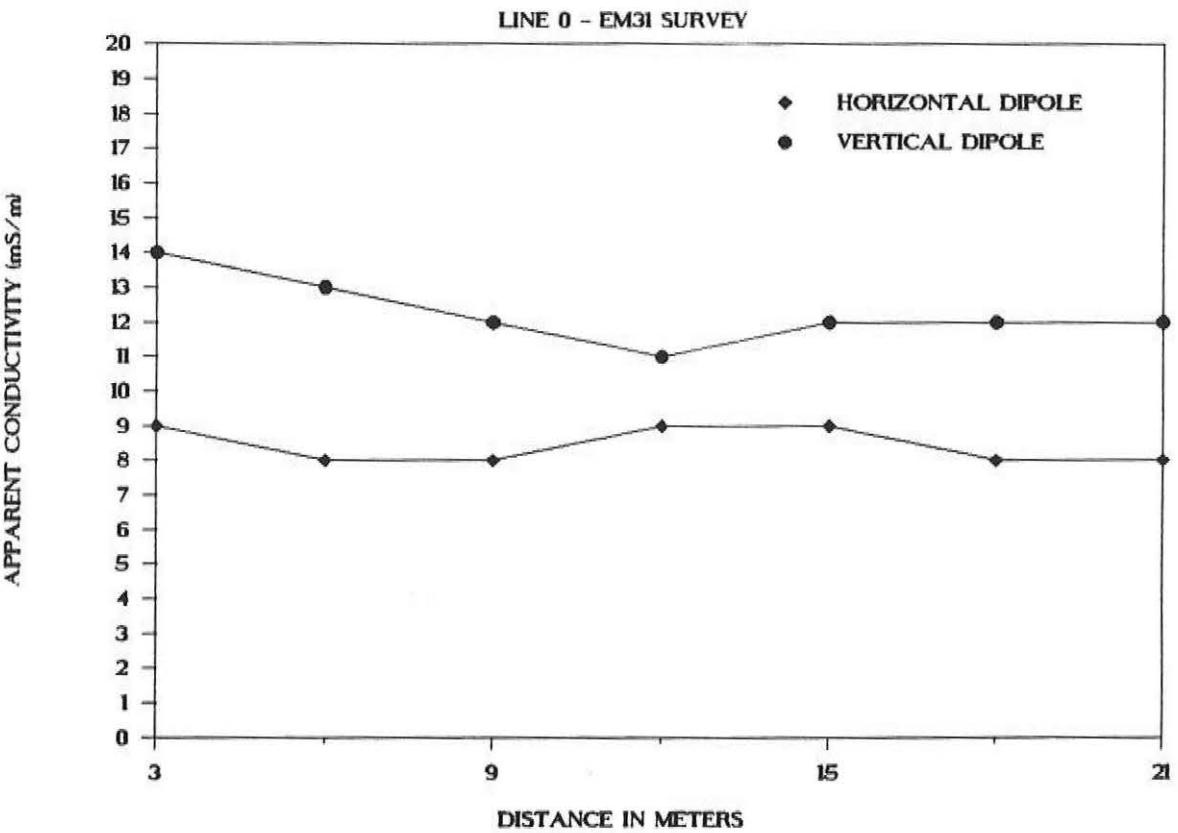
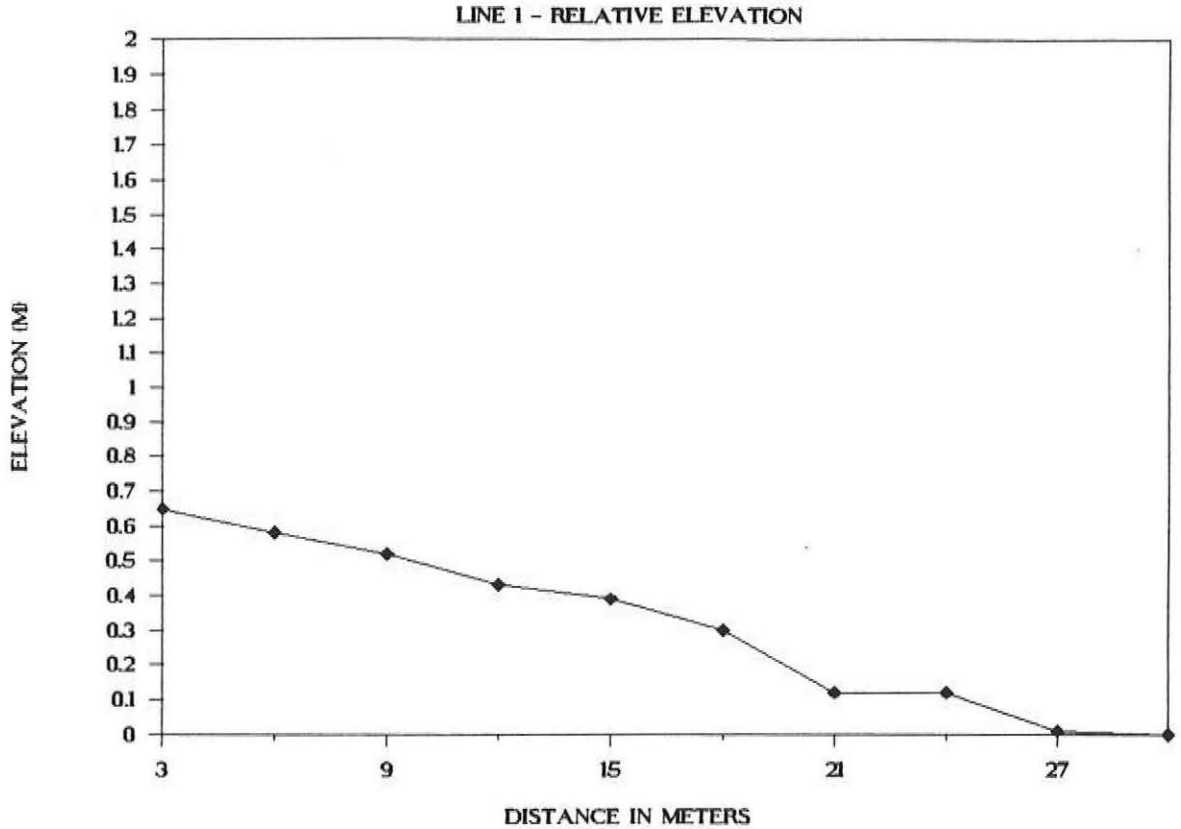
FIGURE 1

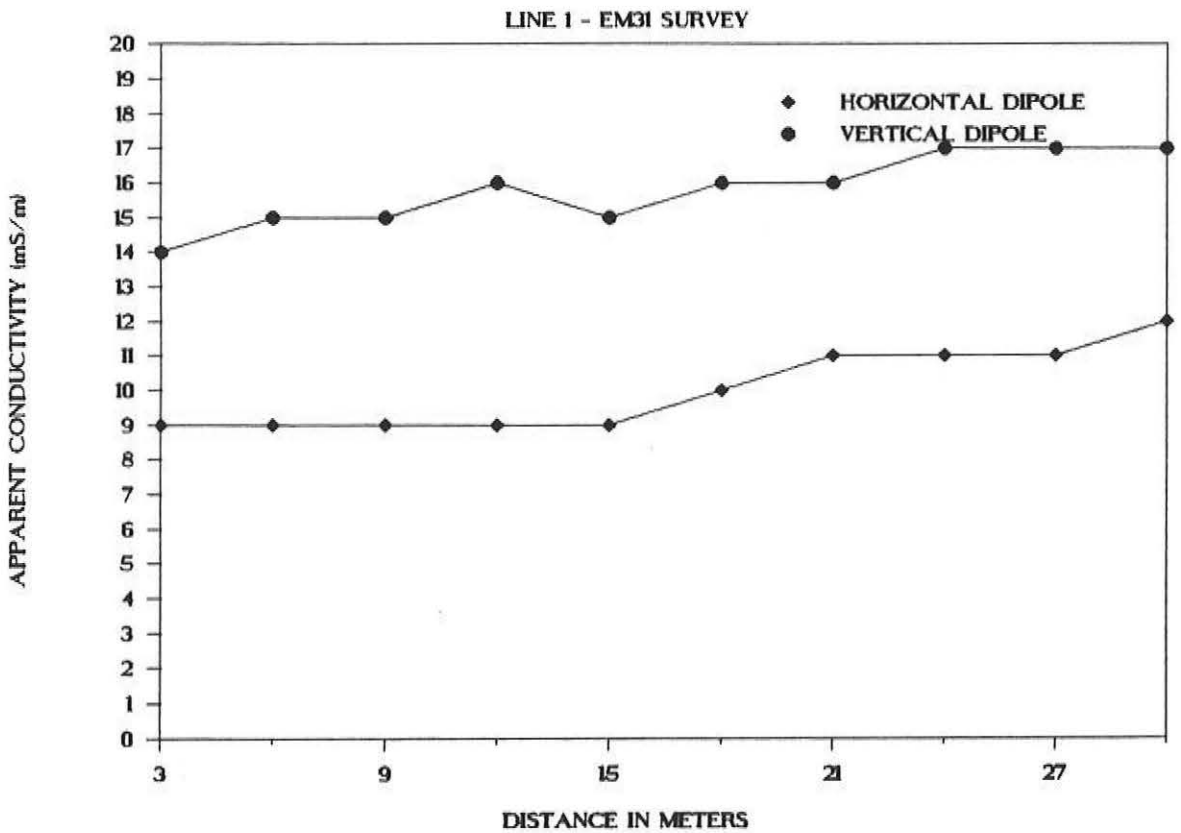
HEDGEPETH SITE





HEDGEPETH SITE





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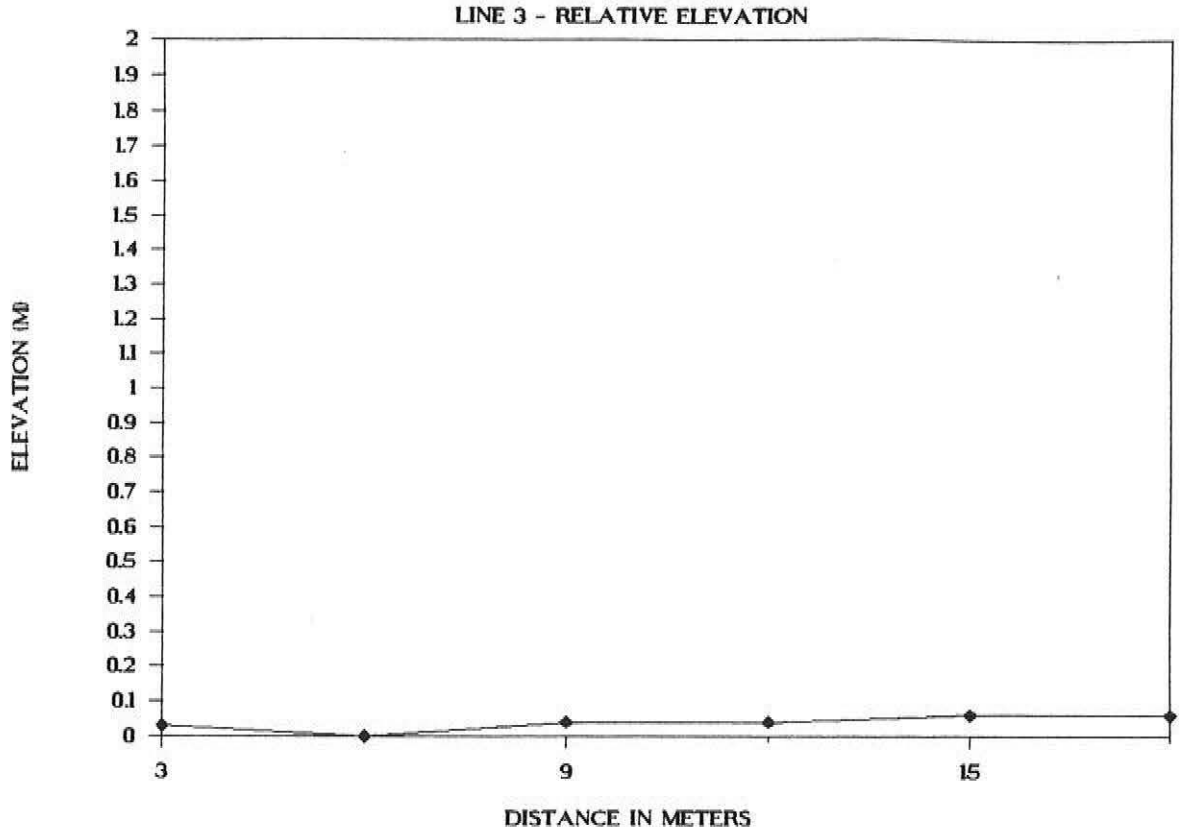

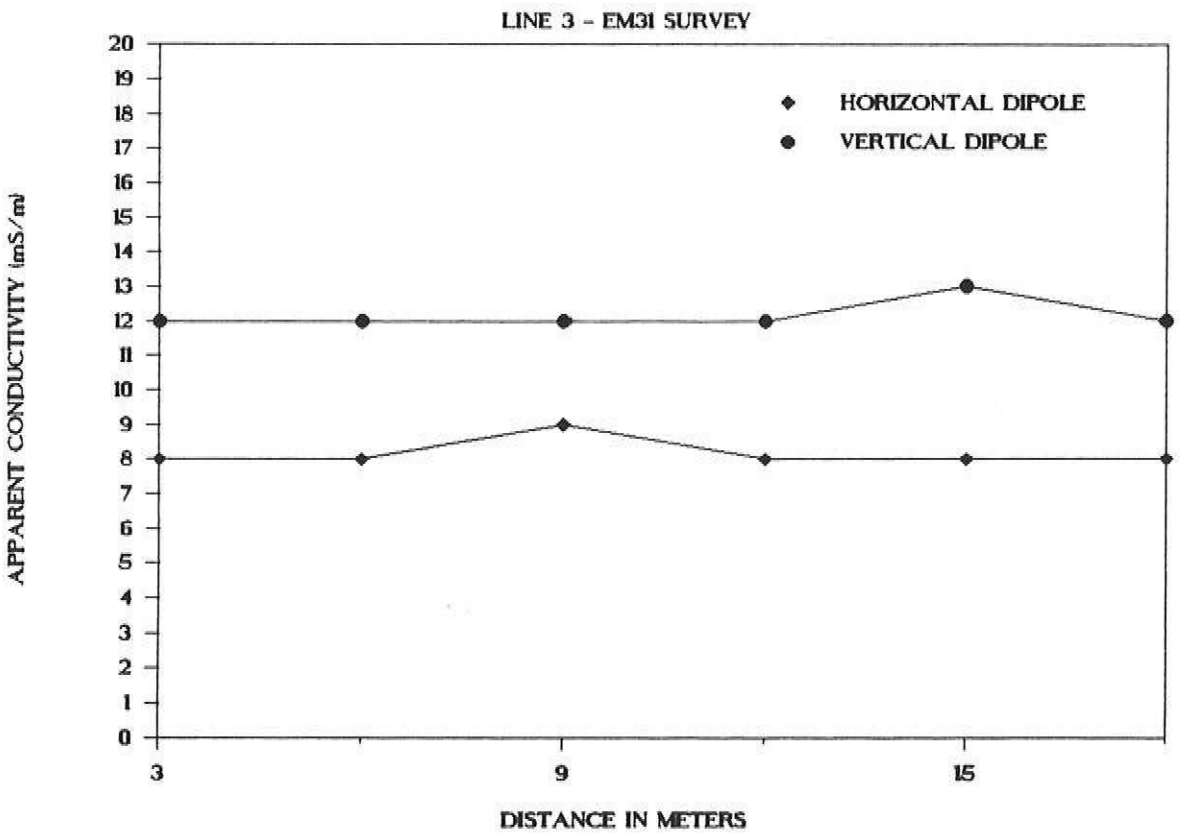

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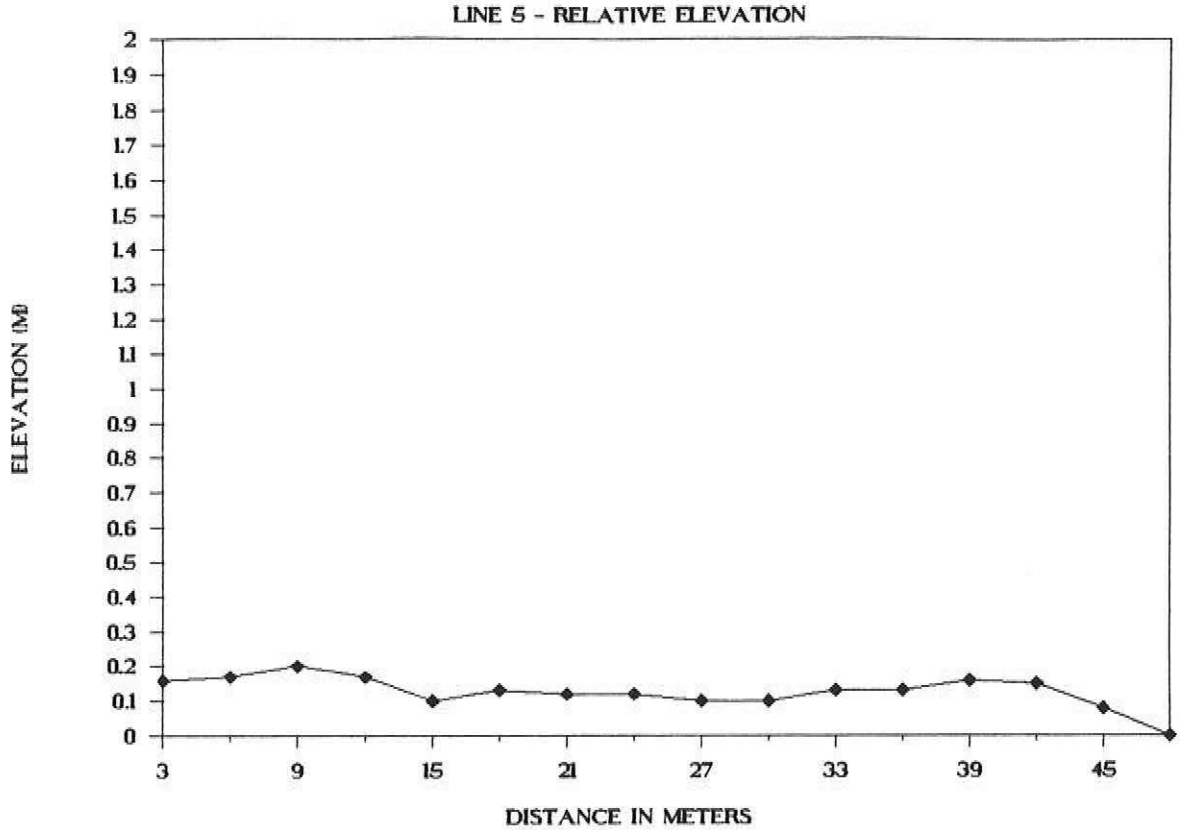

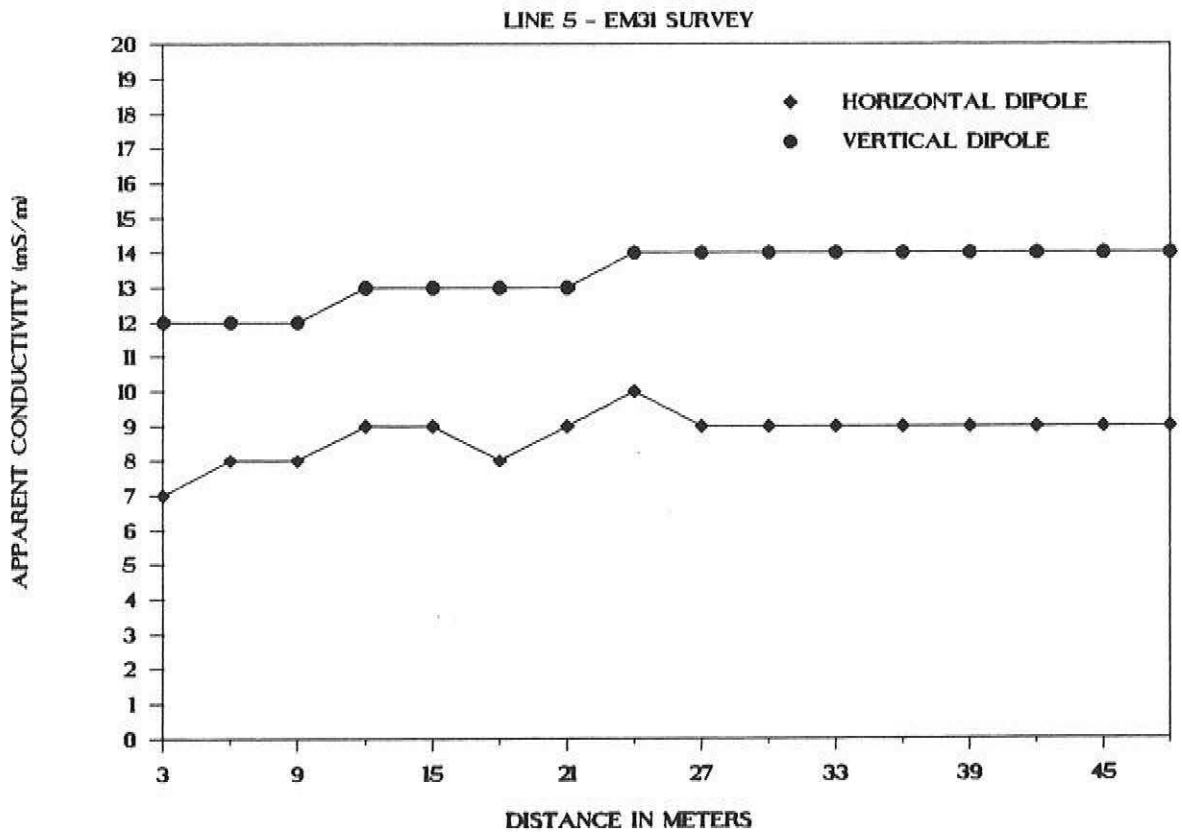

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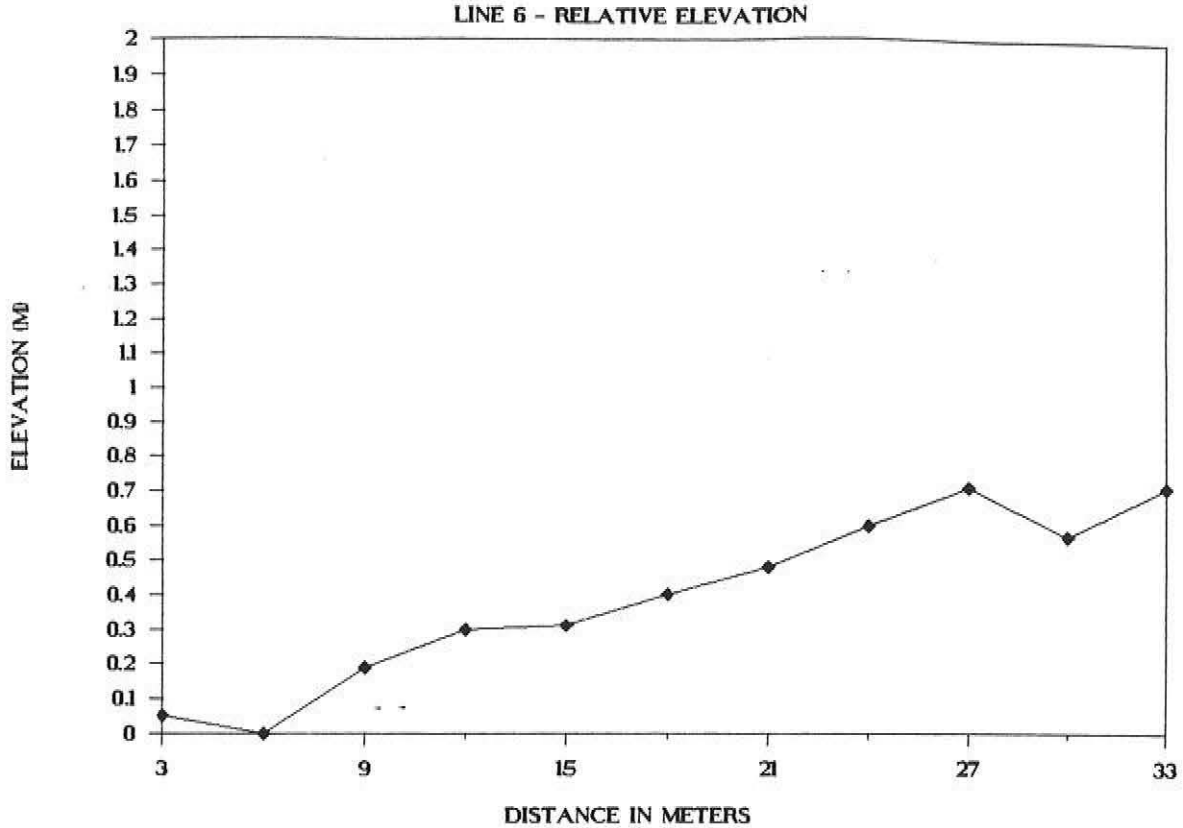

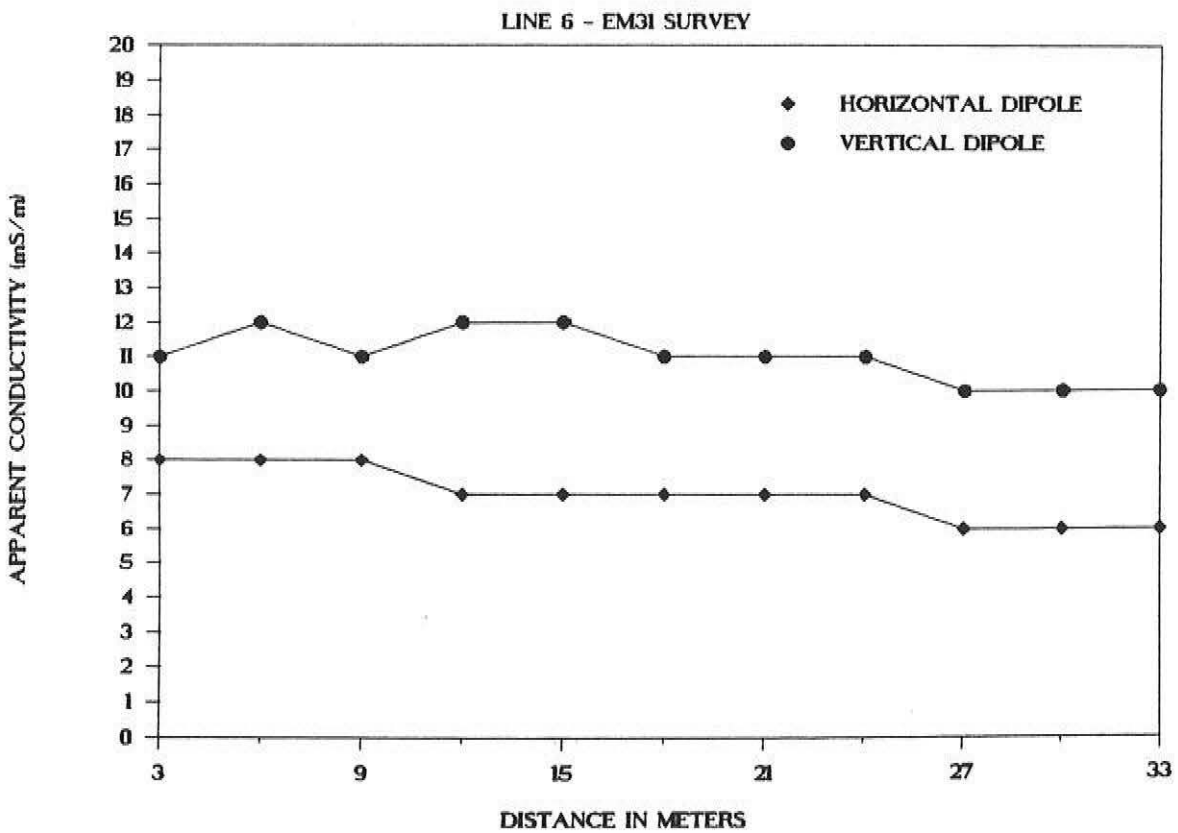

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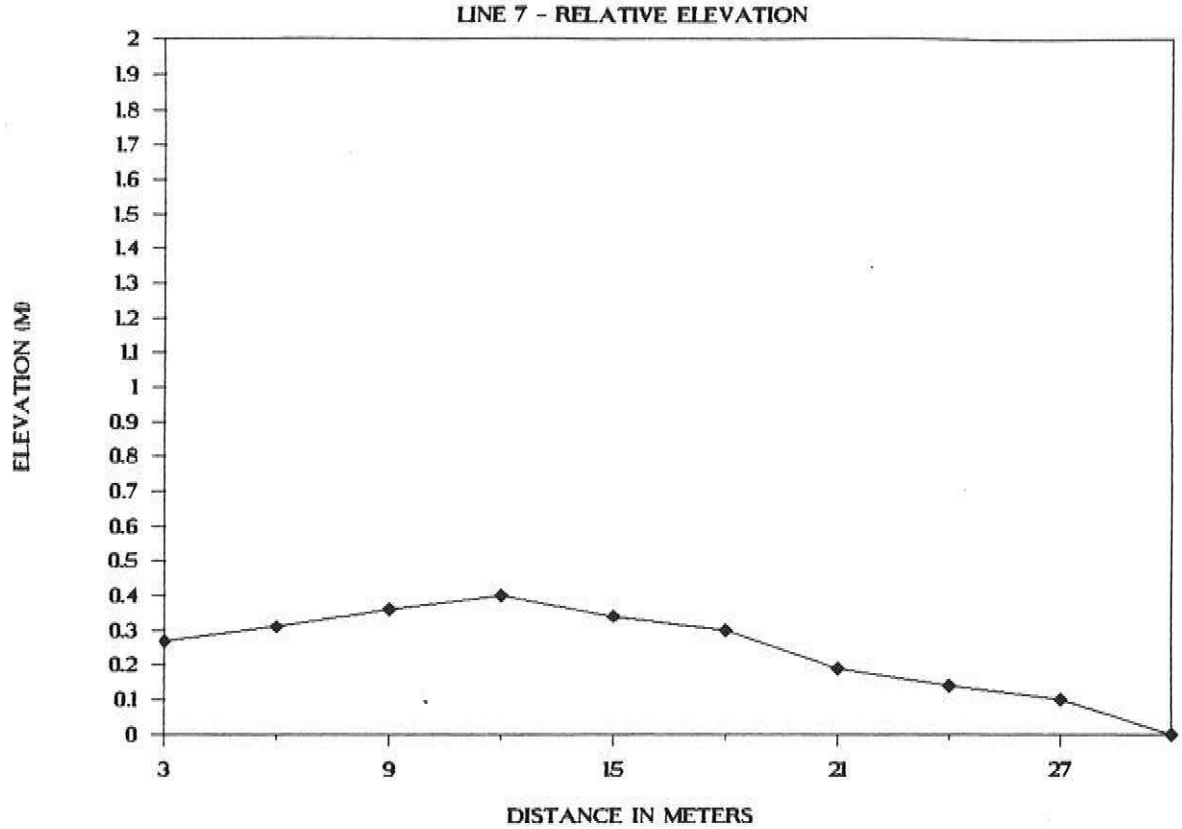

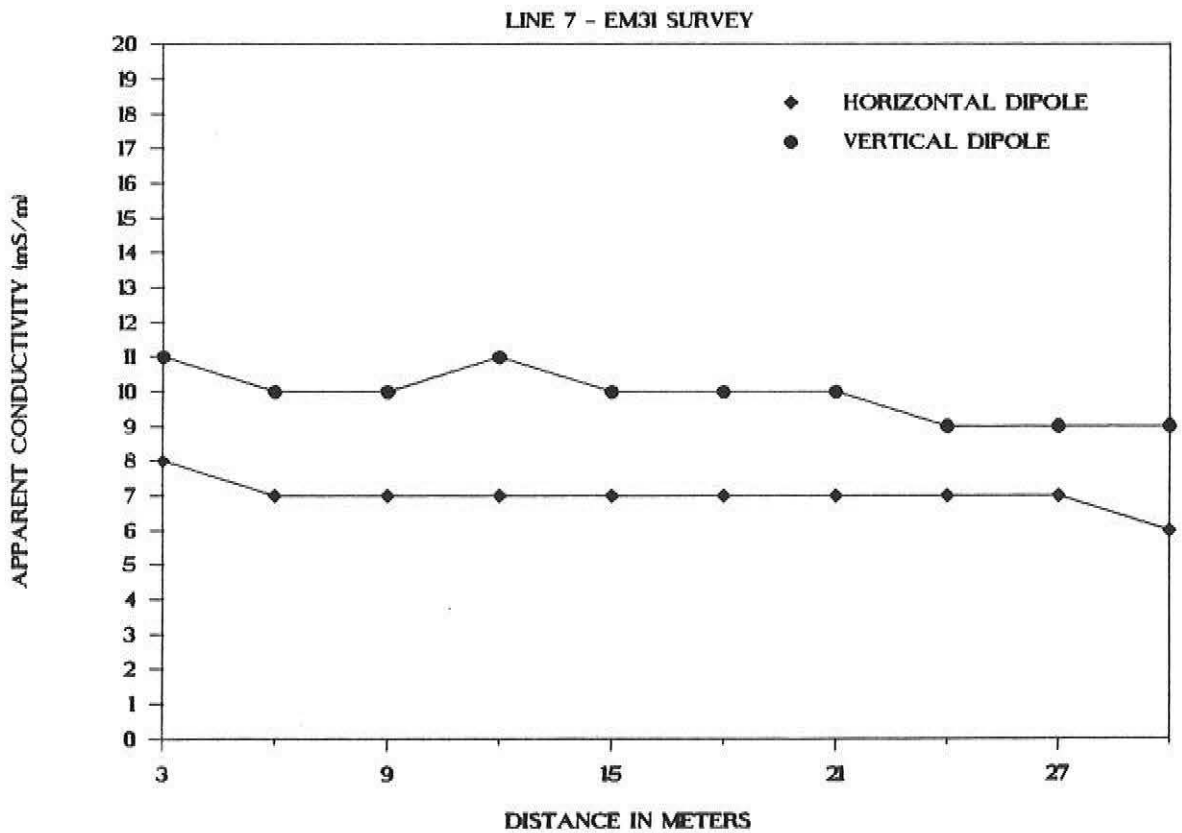

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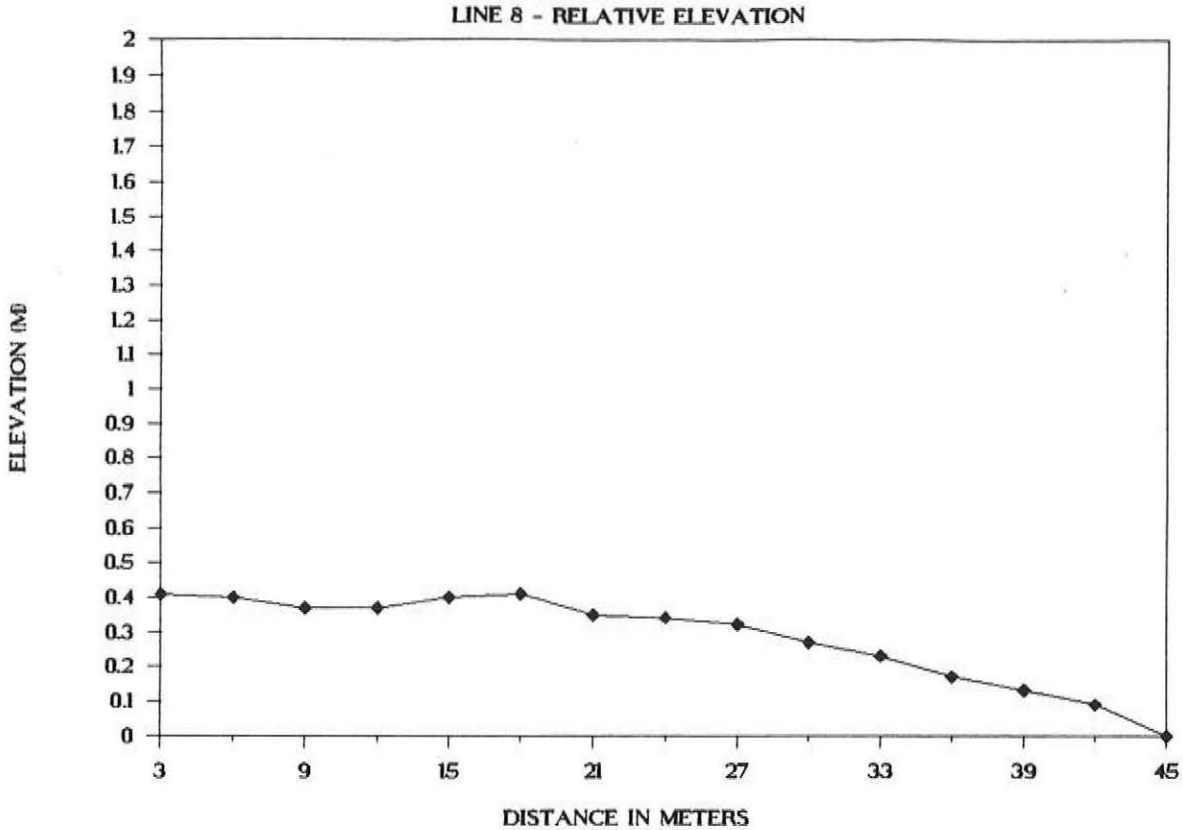

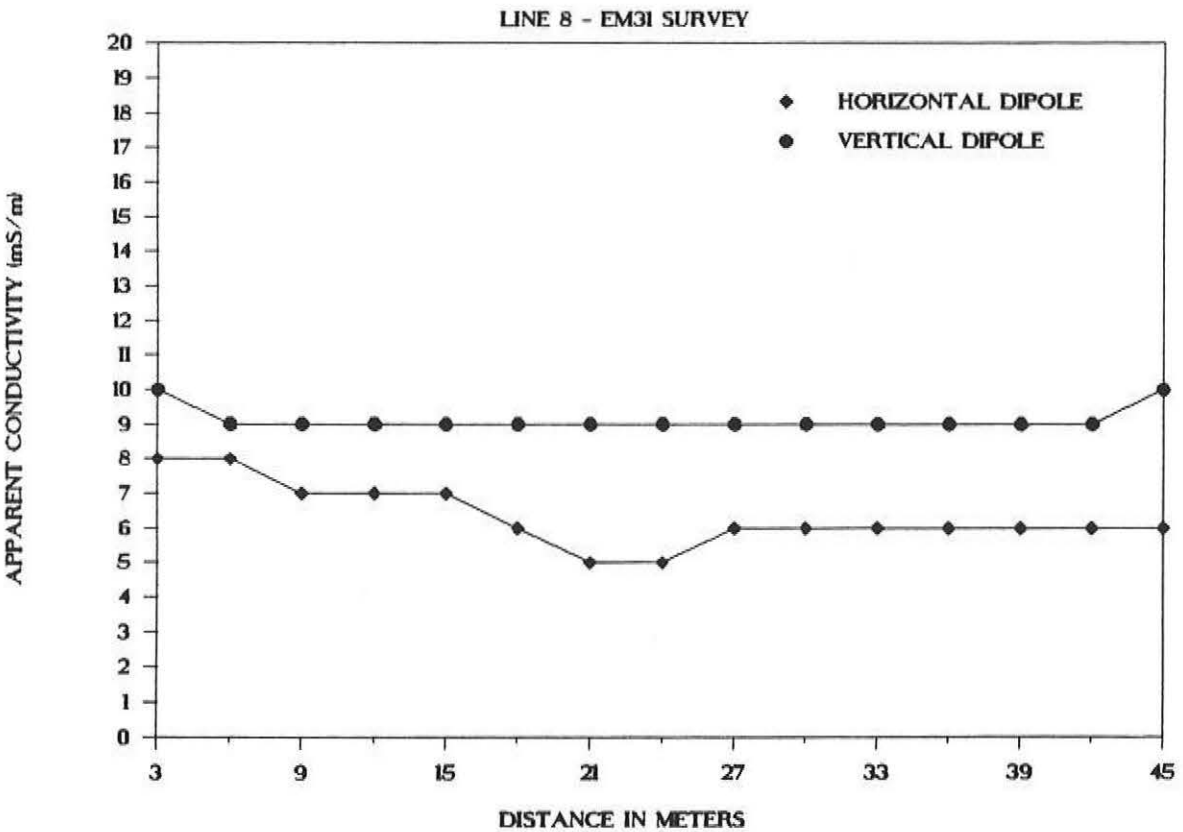

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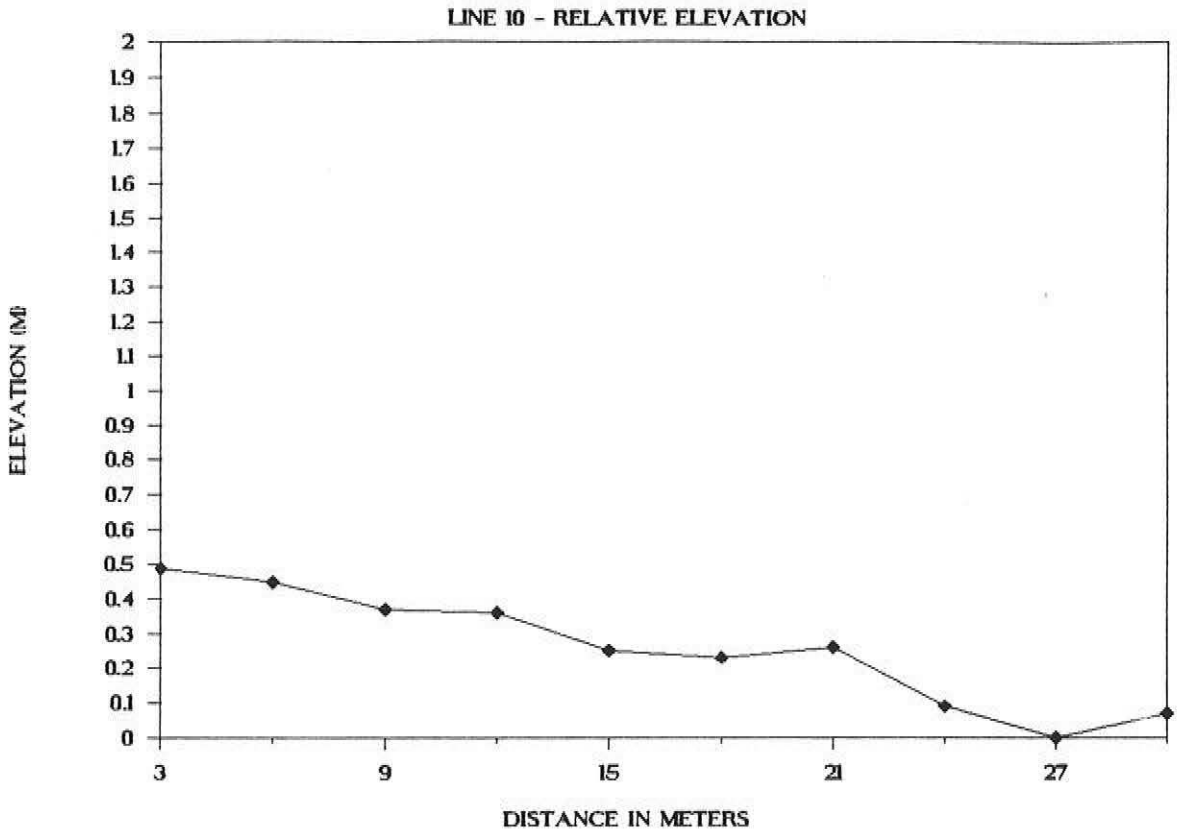
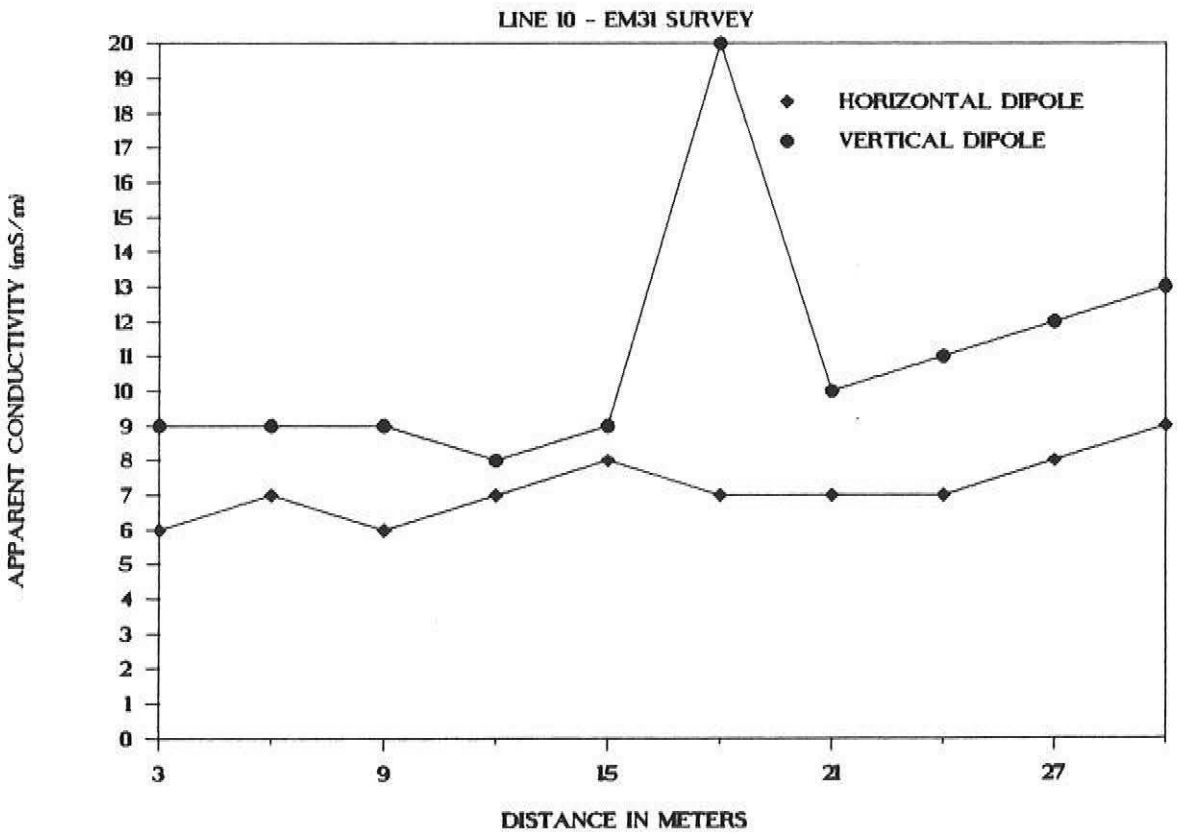
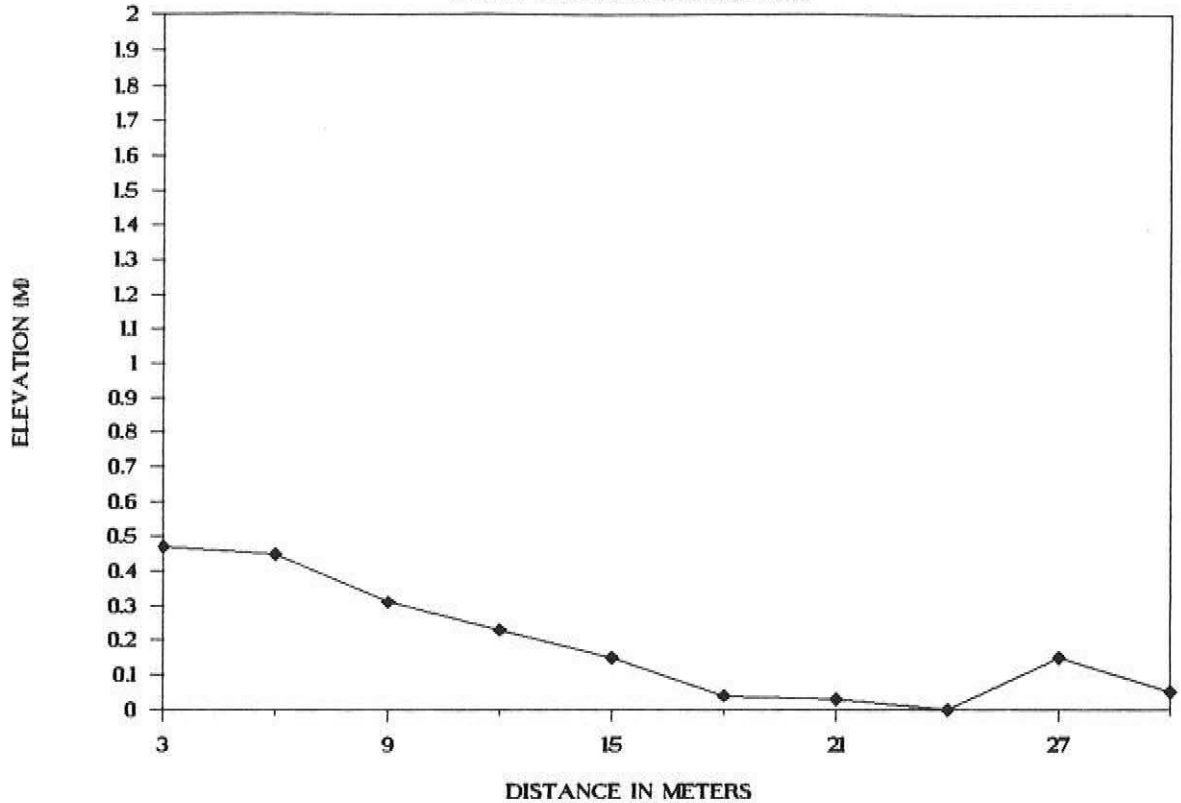


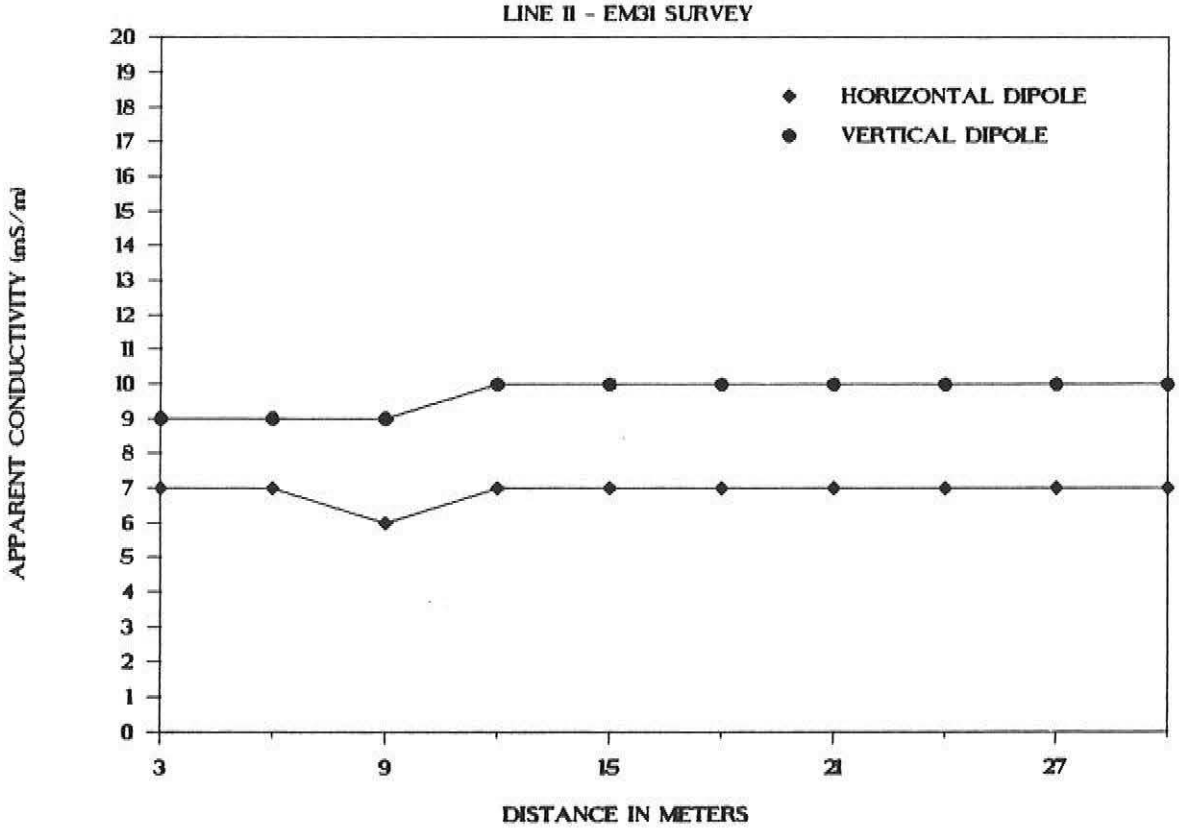


HEDGEPETH SITE

LINE II - RELATIVE ELEVATION



LINE II - EM31 SURVEY



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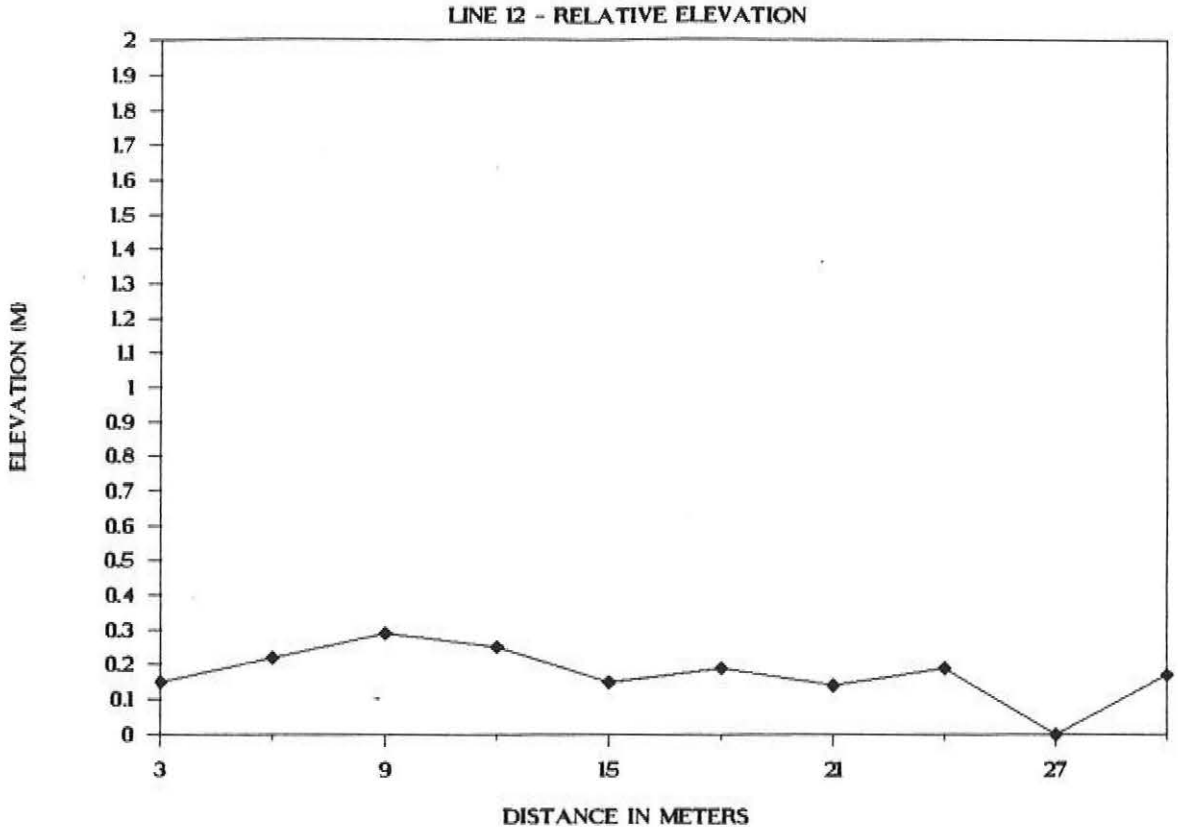

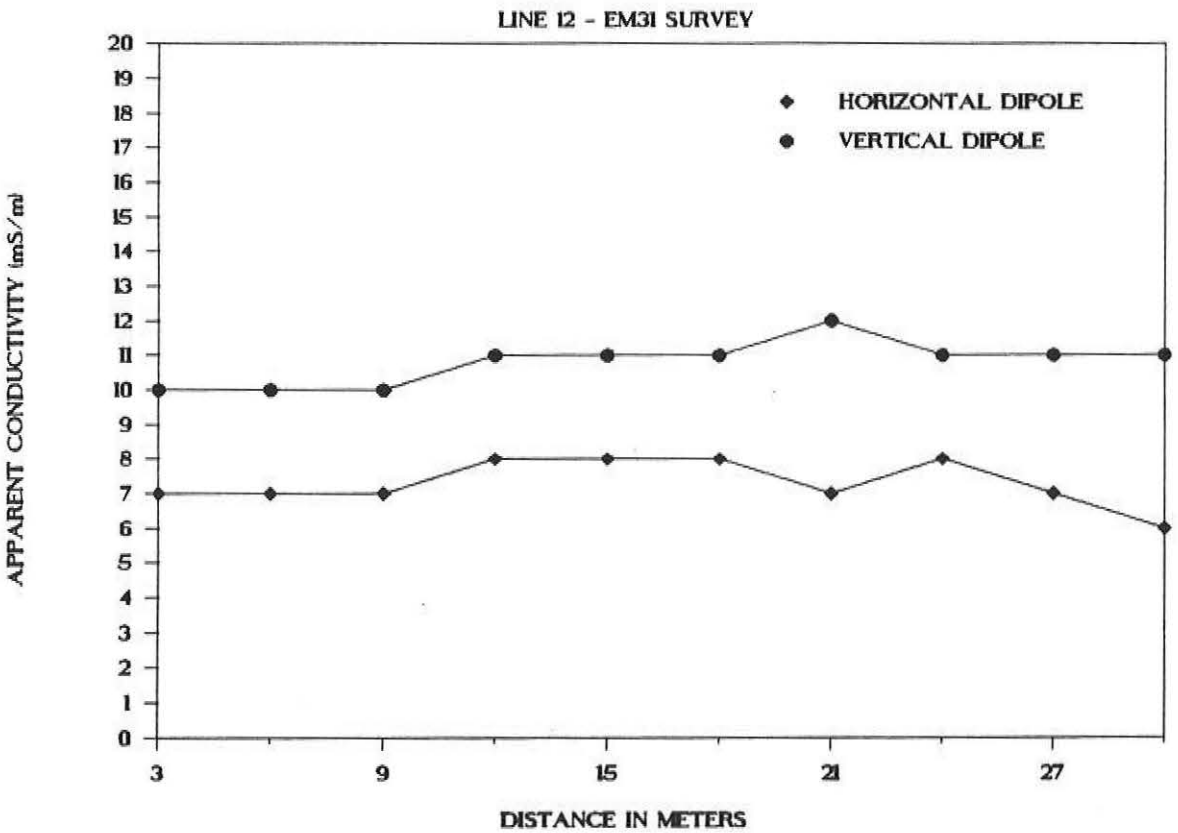

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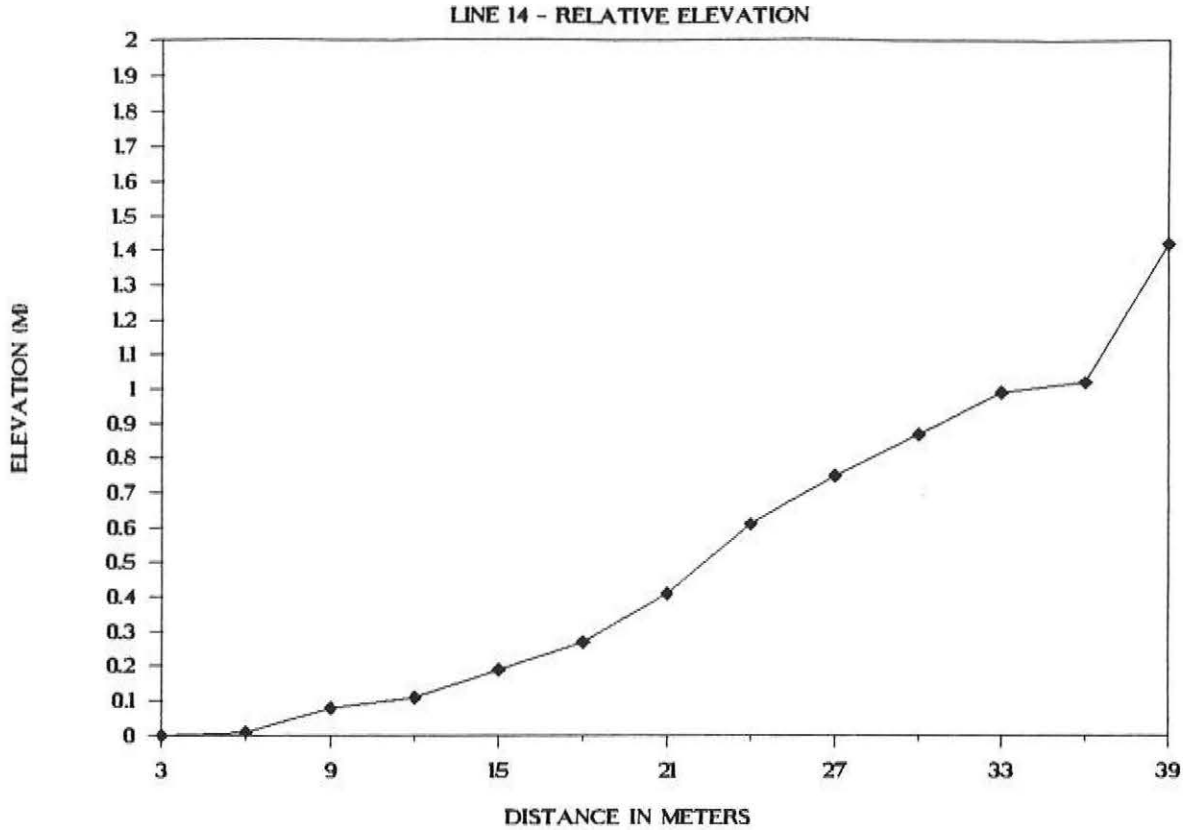
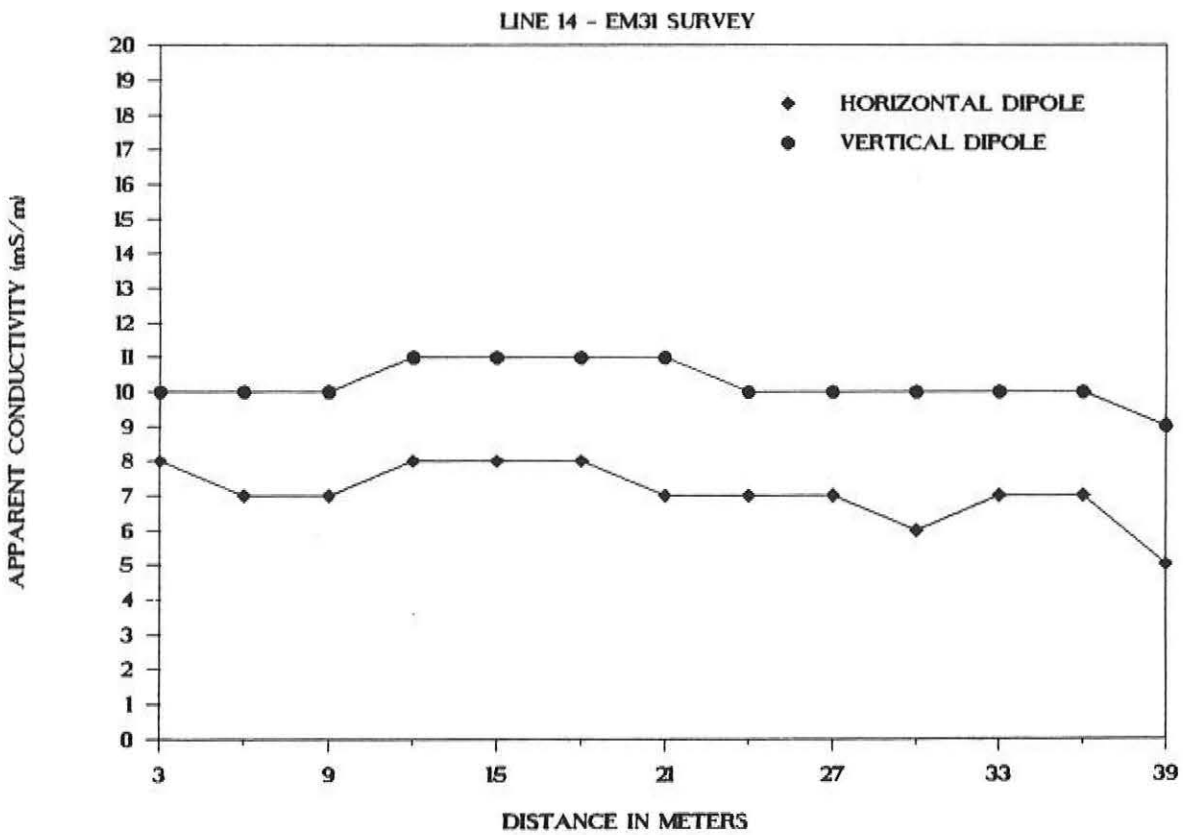
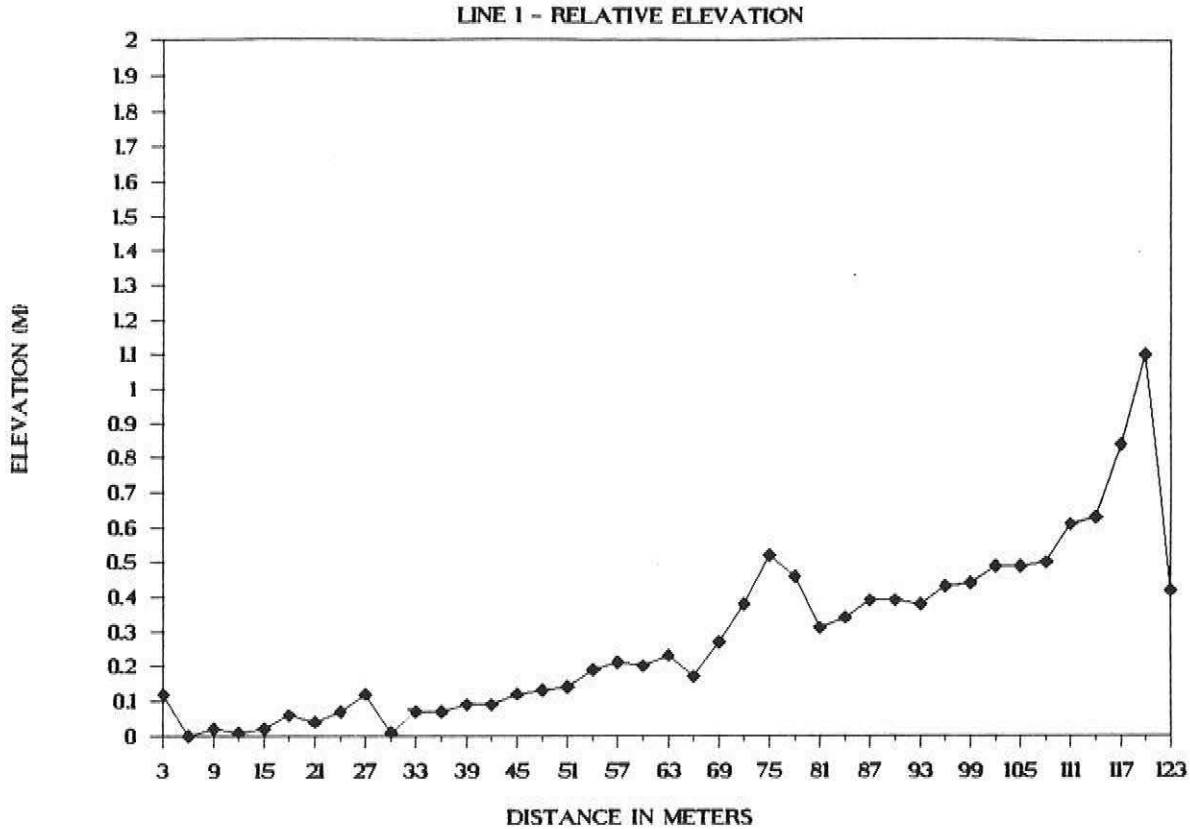
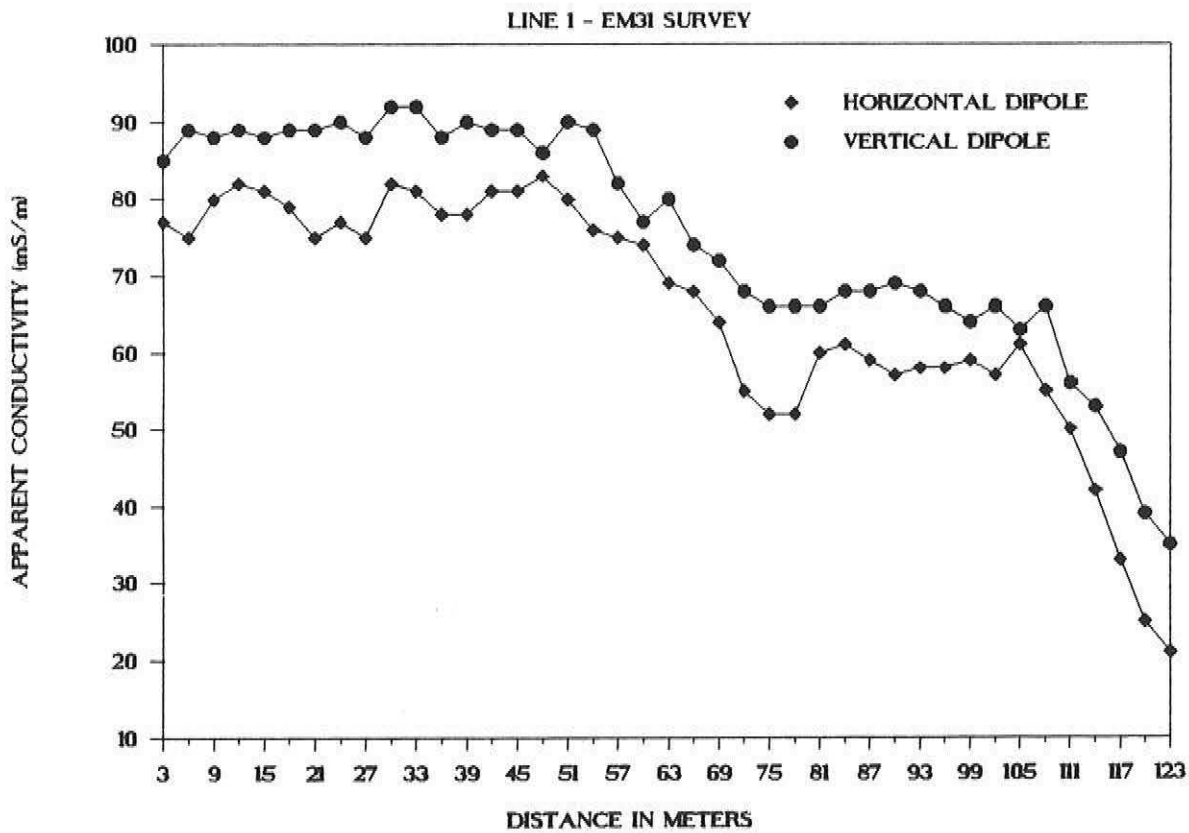




WATSON BREAK SITE





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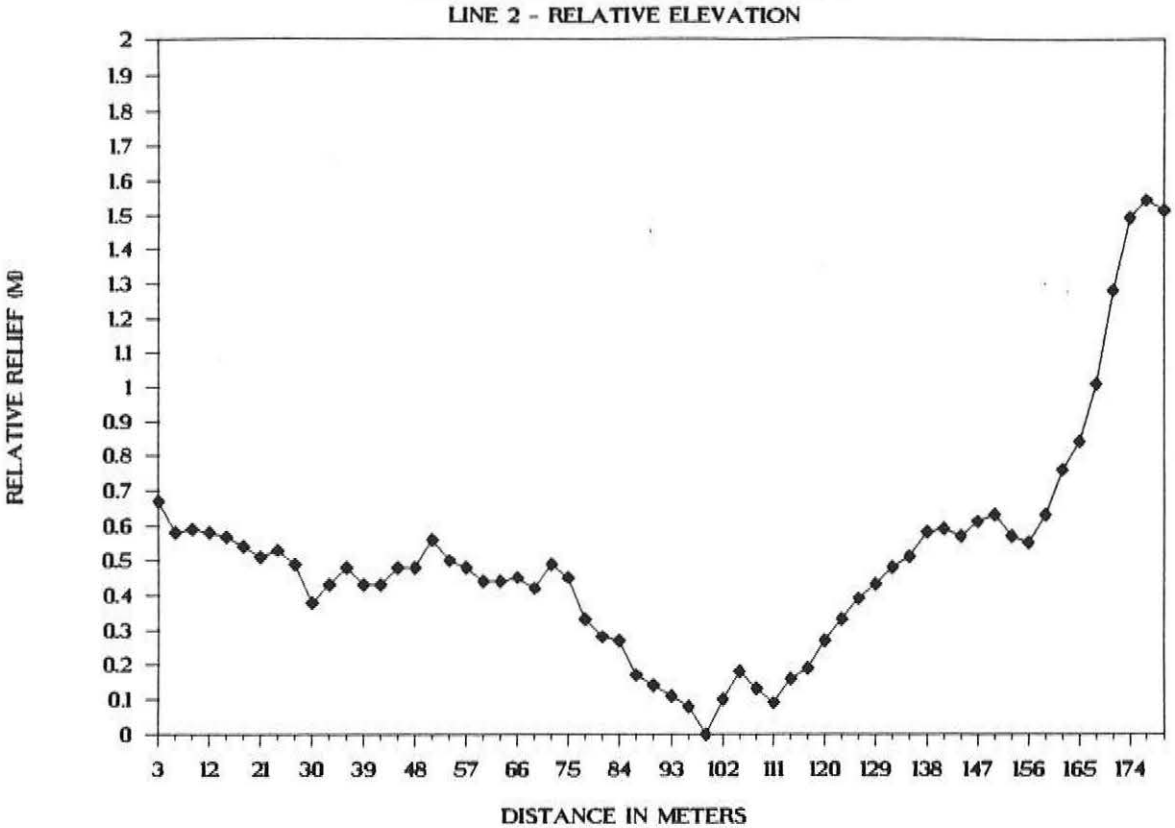

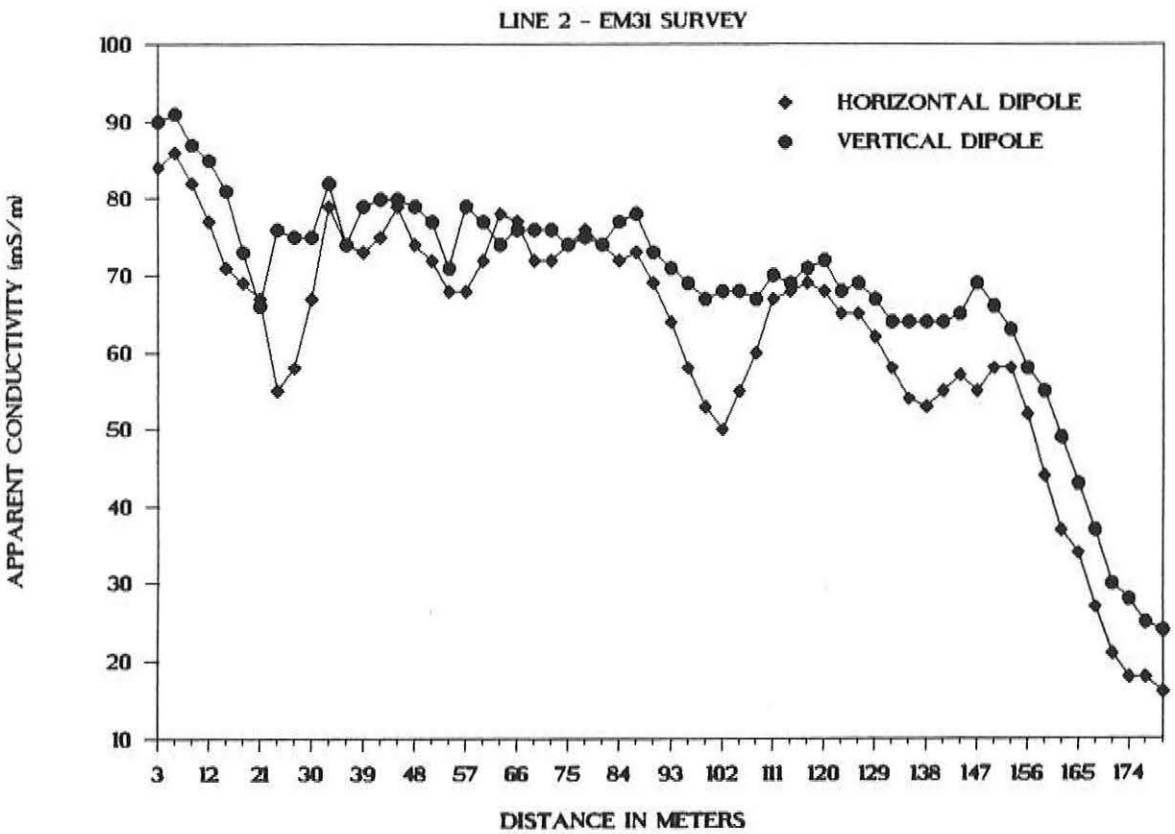

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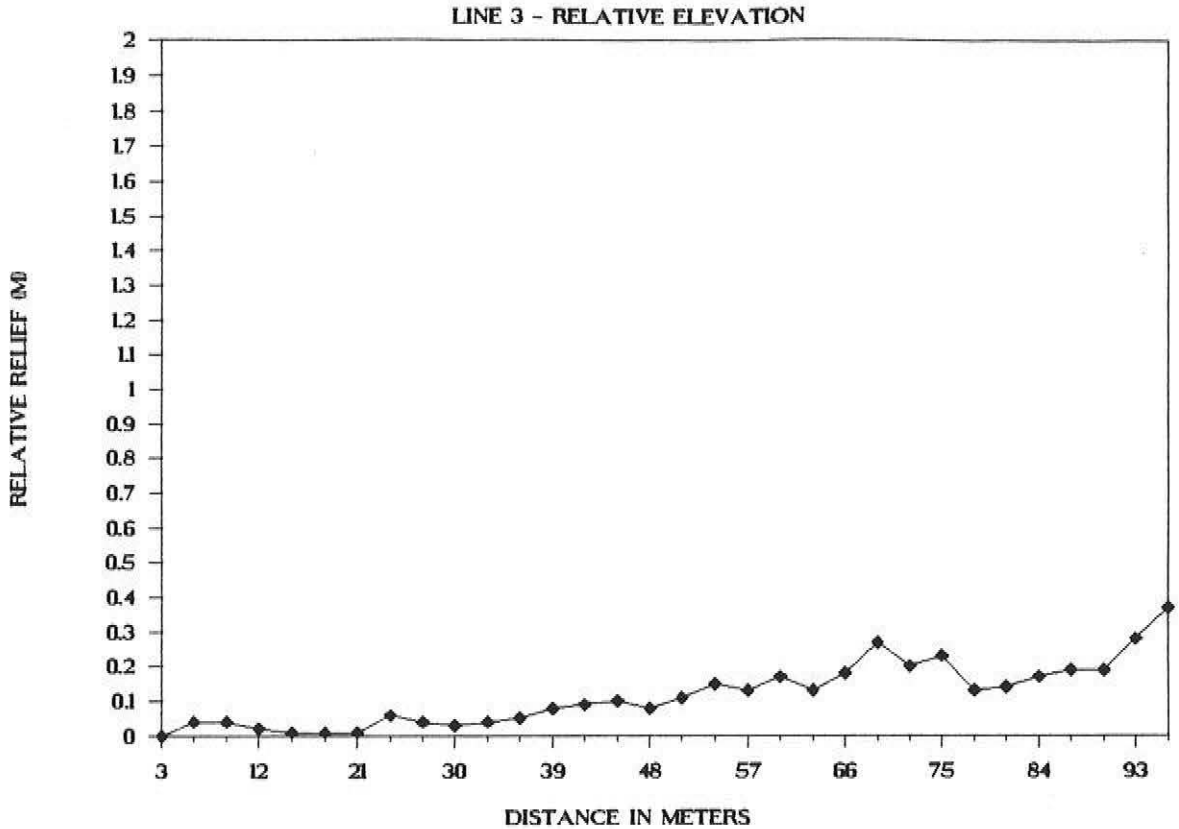

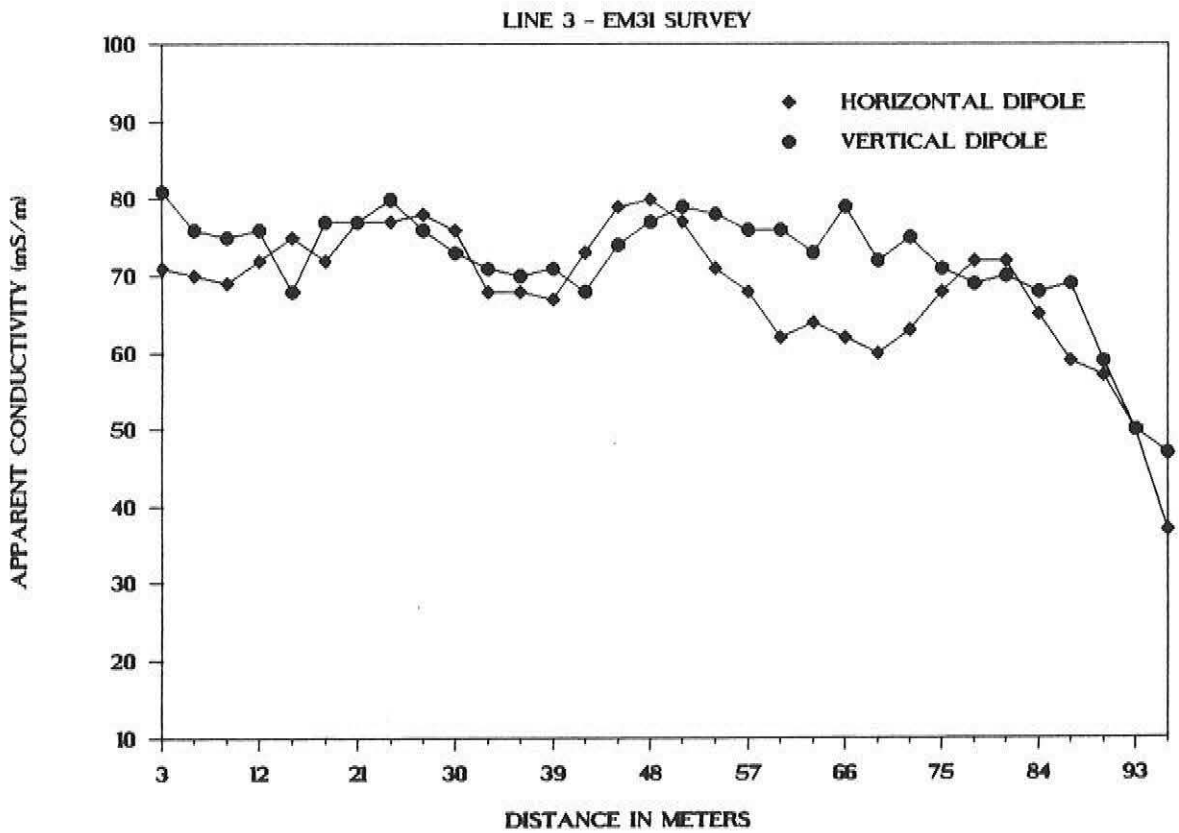

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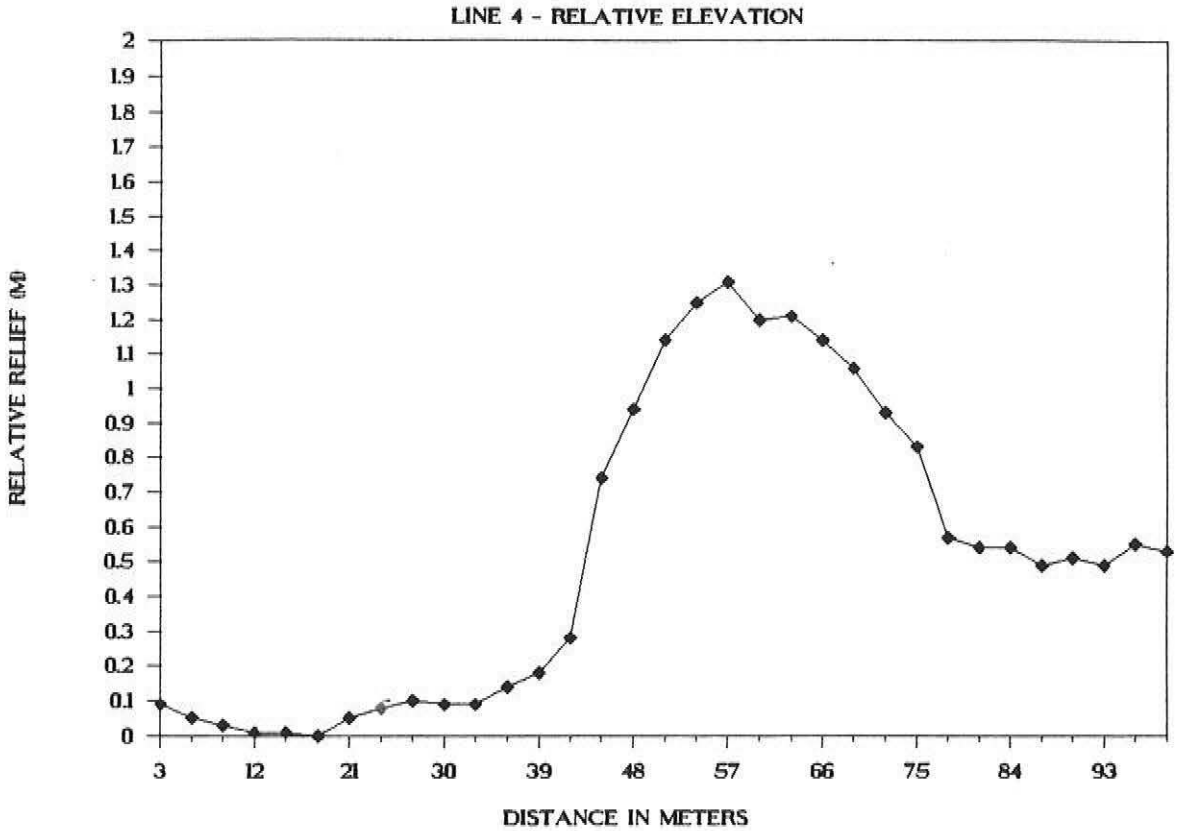
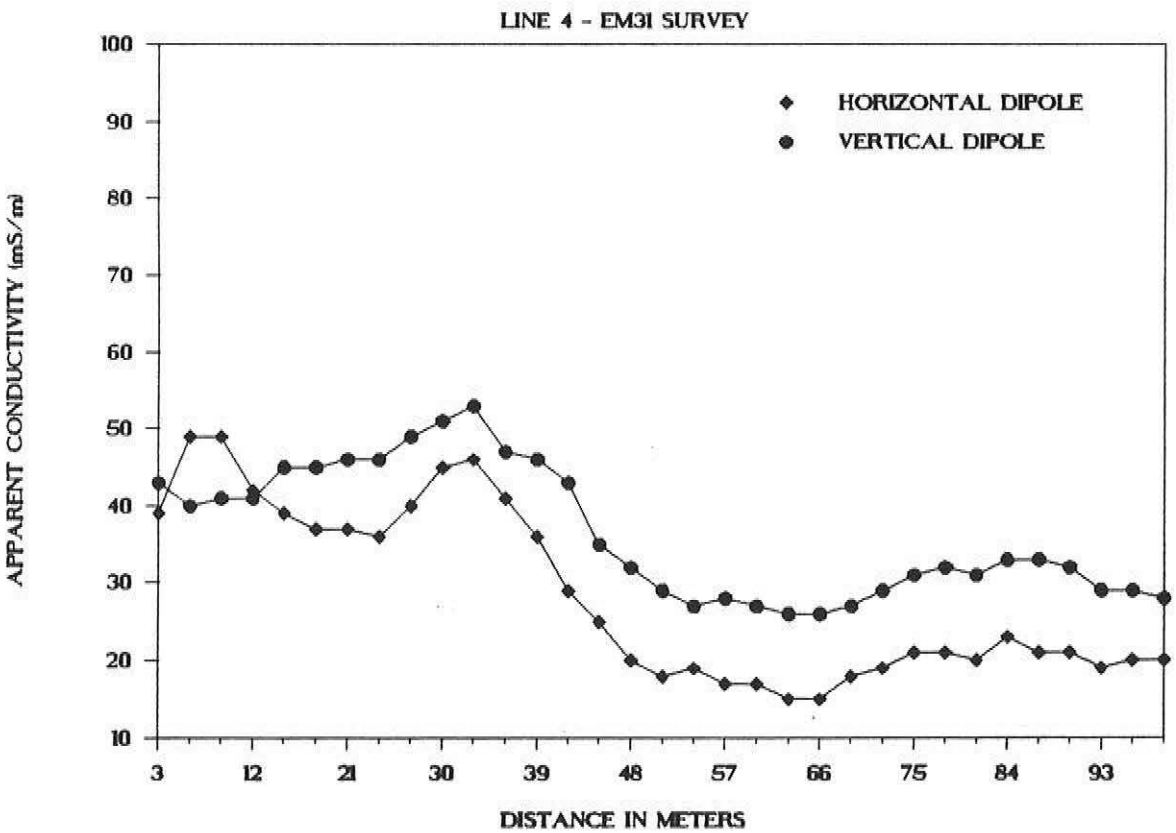
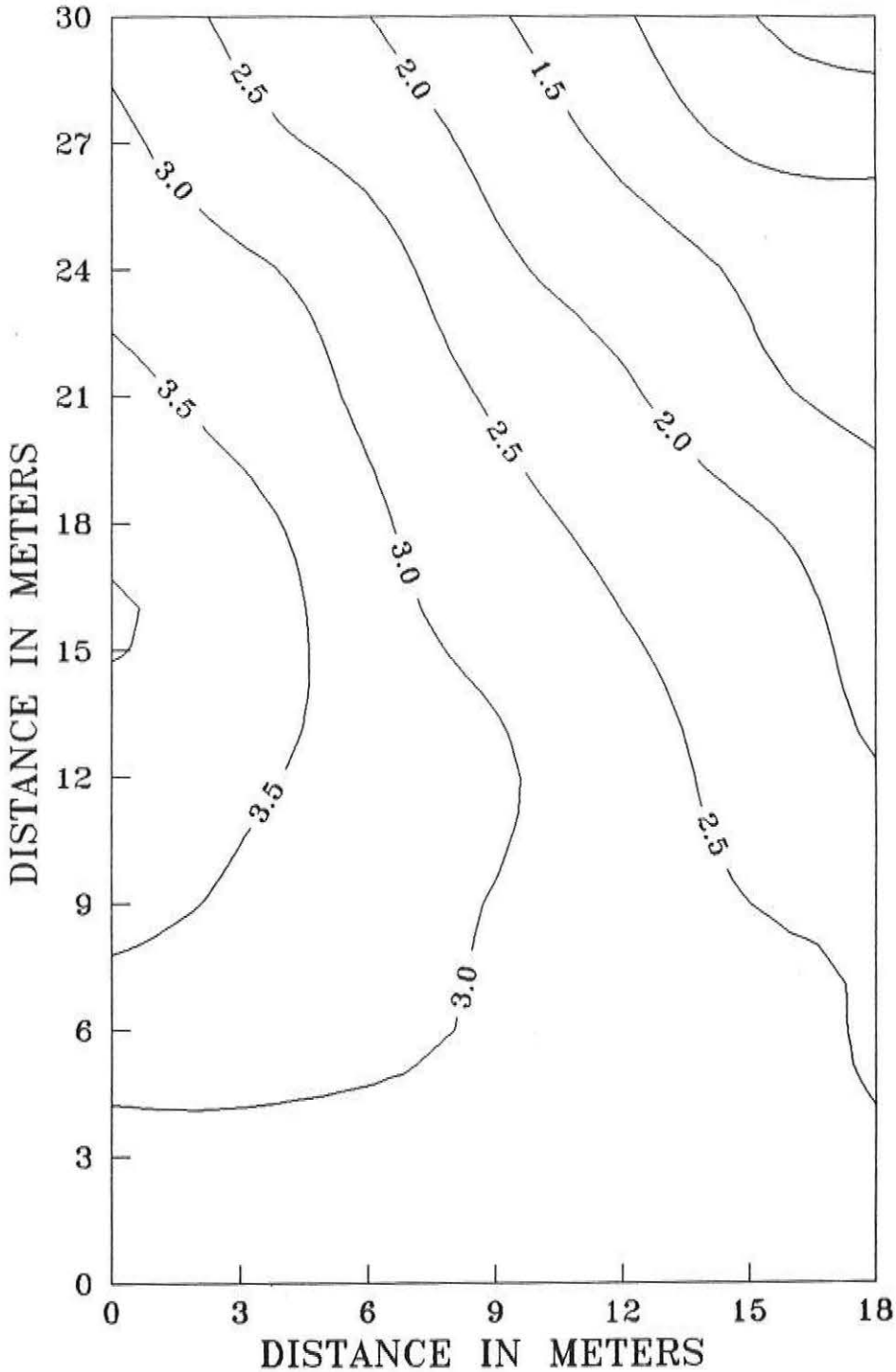




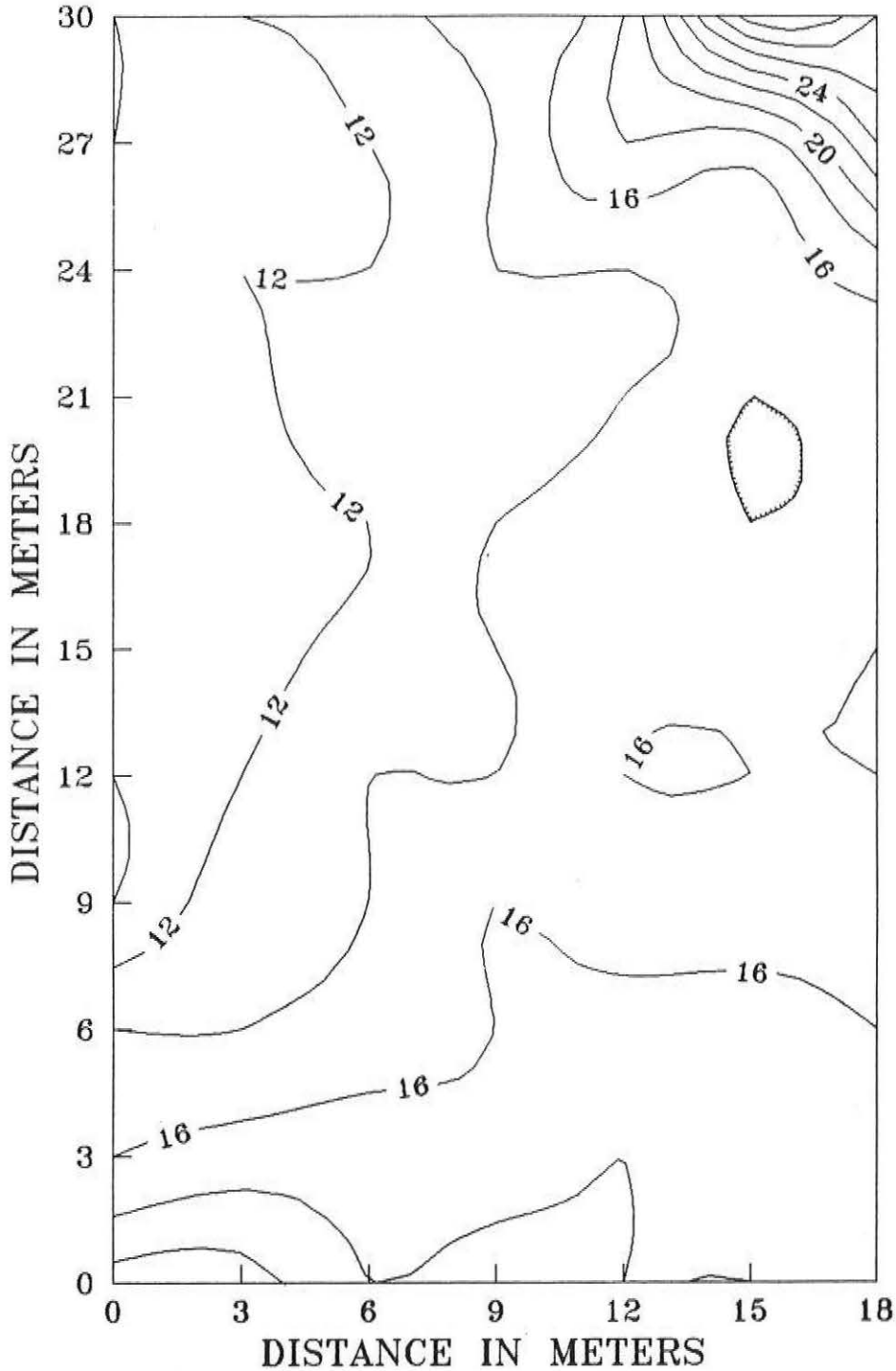
RELATIVE ELEVATION OF WATSON BREAK SITE

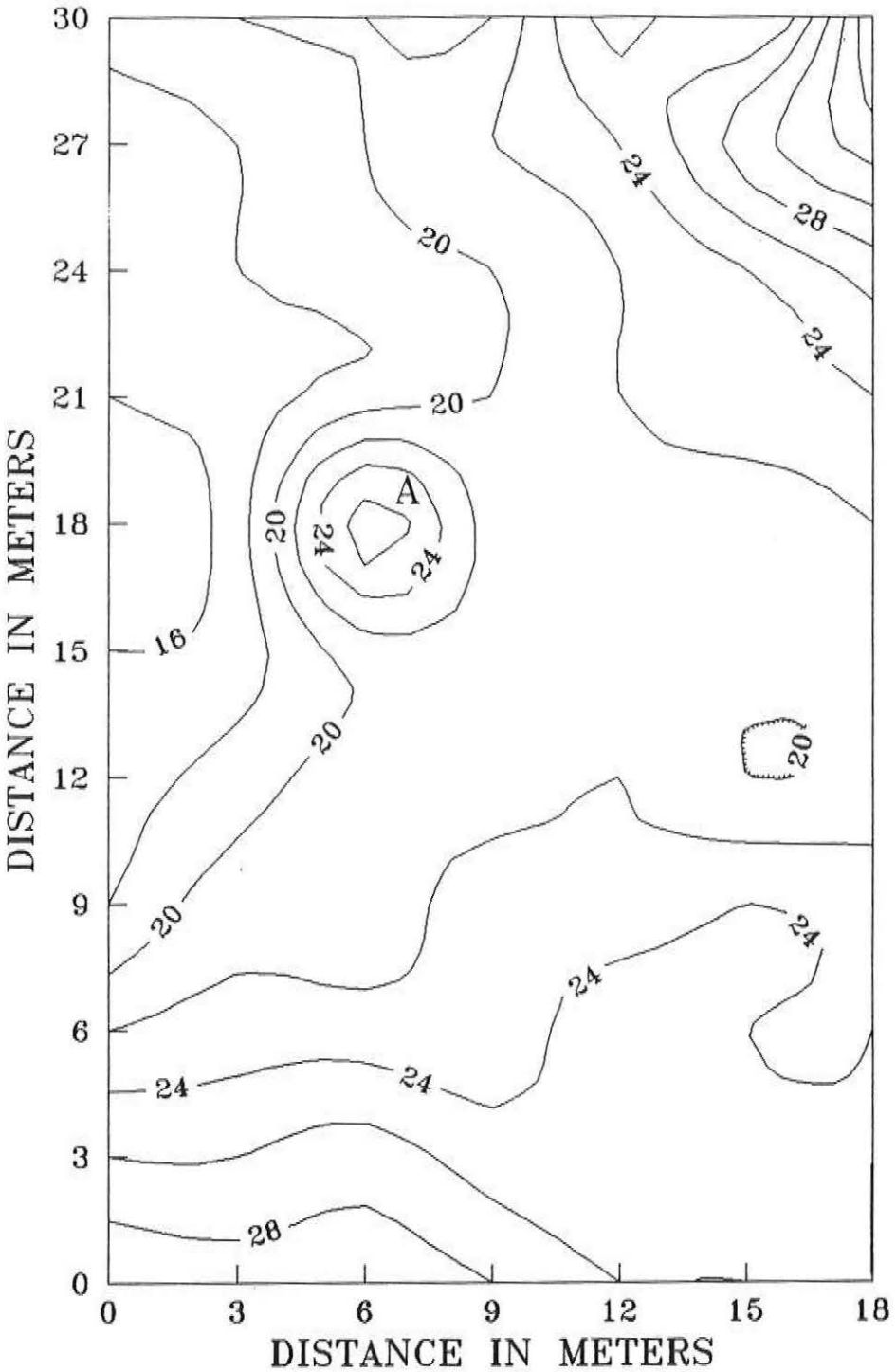
CONTOUR INTERVAL = 0.5 M



EM31 SURVEY OF WATSON BREAK

HORIZONTAL DIPOLE ORIENTATION



EM31 SURVEY OF WATSON BREAK

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