CHAPTER VI GEOPHYSICAL SURVEY

6.1 Purpose of Survey

Pre-Quaternary formations are widely developed on the El Tih Plateau and Quaternary deposits distribute in many wadis and El Qaa Plain. However, no geophysical survey has been made on the Pre-Quaternary formations. So far as the Quaternary deposits, WRRI conducted the geophysical survey in the northern area of El Qaa Plain and some wadis such as Wadi Sudr, Wadi Kid and so on.

Main prospective aquifers are occurred in both Pre-Quaternary formations and Quaternary deposits. Therefore, it is indispensable to clear the hydrogeological conditions of each formation.

Taking the characteristics of each formation into consideration, Transient Elector Magnetic (TEM) survey method was applied to the Quaternary deposits as shallow geophysical survey and Schlumberger method to the Pre-Quaternary formations as deep geophysical survey.

As the results of these surveys, geoelectrical sections and profiles were prepared in each area.

6.2 Electro-Magnetic Survey (TEM Method)

6.2.1 Survey Area

Surveyed areas by this method were W. Feiran (1) Area, W. Feiran (2) Area, Tarfa Area, Oasis Feiran Area, W. Gharandal Area, W. Dahab Area, W. Zaghara Area, W. Watir Area, Umm Ahmed Spring and El Sawana Spring.

The location of the electro-magnetic survey (TEM) is shown Fig. 6.2.1-1. Surveyed area, number of profile and number of survey point are as follows:

Location	Profile	No. of Profile	No. of Survey Point
El Qaa Plain	A,B,C,S,T,U,V	7	202
Wadi Feiran		5	44
-Tarfa	D	(1)	(7)
-Oasis Feiran	E,F	(2)	(16)
-Mokattab	G	(1)	(11)
-Downstream-El Qaa	H	(1)	(10)
Wadi Gharandal	I,J	2	20
Wadi Zaghara	K,L	2	10
Wadi Dahab	M	1	20
Wadi Watir		3	12
-Wadi Khareiza	N	(1)	(4)
-Wadi El Hathy	O	(1)	(4)
-Sheikh Attia	P	(1)	(4)
Wadi Zalaga		2	9
-Ain Umm Ahmed	Q	(1)	(4)
-El Sawana	R	(1)	(5)
Total		22	317

6.2.2 Survey Method

Electro-Magnetic Survey was performed applying transient electro-magnetic method (vertical sounding), using a Canadian equipment of type TEM57 transmitter and PROTEM57 digital receiver (Geonics Limited, Canada).

The TEM method (Transient electro-magnetic method) is a type of electrical prospecting based on resistivity, similar to the Schlumberger method generally used. With the TEM method apparent resistivity is measured as a function of time.

Basically the TEM method allows calculation of resistivity from the transient decay waveform of eddy current induced secondary magnetic fields, produced by the negative part of a pulsed transmitter current. The Central loop configuration (Transmitter Loop size is 100m square) is used in the survey.

The result of electro-magnetic survey were presented as resistivity-structure section. The optimum resistivity-structure model is obtained by applying inversion analysis to the curve matching method by INTERPEX TEMIXXL computer program for resistivity interpretation.

The parameters are supposed to satisfy a solution representing the geoelectric condition prevailing, but due to equivalency it may be possible that other solutions can be found because there is no geological information available.

Equipment used;

Transmitter	: GEONICS TEM57 With Generator
Motor Generator	: HONDA EX650
Transmitting Loop	: GEONICS 300 m x 300 m Loop
Receiver	: GEONICS Protem 57 Digital Receiver
Sensor	: GEONICS Low Frequency Coil, Horizontal Stand
Transceiver	: KENWOOD TH-42
GPS receiver	: MAGELLAN Meridian XL

6.2.3 Survey Results

1) El Qaa Plain

The northern area of the plain from El Tur were surveyed by WRRI. The survey revealed the hydrogeological condition and the eventual sea water intrusion in the coastal aquifer in the El Tur area. As the results of these surveys, geoelectrical sections and profiles were prepared.

In addition to this survey, the electro-magnetic survey (TEM) was conducted by the Study Team. The main purpose of the survey is to clear the geological and hydrogeological conditions of Quaternary Deposits in the eastern and the southern part of the plain. The survey line were allocated in NW-SE direction to supplement and to combine both data, while the survey lines by WRRI were placed in NE-SW direction, traversing the plain. Location map of electro-magnetic survey at El Qaa Plain is shown in Fig. 6.2.3-1.

Existing Data of geophysical study at El Qaa Plain Area can be summarized in Table 6.2.3-1 and is used for classification in the resistivity structure.

Summary of electro-magnetic survey result is shown in Table 6.2.3-2. Available Well Data around electro-magnetic survey line at El Qaa Plain is summarized in Table 6.2.3-3. Summary of Resistivity Logging Data is summarized in Table 6.2.3-4.

The examination of the resistivity structure section due to quantitative interpretation of TEM curve measured along Line A, B, C, S, T, U and V are summarized as follows.

(1) Line A (Fig. 6.2.3-2)

i) From A003 to A013

- An upper layer with high resistivity values ranging from 67 to 180 ohm-m.
- An intermediate layer with a value of ranging from 30 to 123 ohm-m. It is supposed

that the lower values of this layer corresponds to an aquifer of low salinity.

- At depth, a layer with resistivity values ranging from 7.4 to 16 ohm-m. It is supposed that this layer contains water of high salinity.
- In well RIWR7 (37-EB-P1), the water level at 24.17 mASL, which can correspond to the limit between the upper and intermediate layer.

ii) From A014 to A018

- An upper layer with high resistivity values ranging from 45 to 86 ohm-m. This layer contains some small part of low resistivity zone (6.4 to 29 ohm-m) at A014, 015.
- An second layer with medium resistivity ranging from 11 to 30 ohm-m which is supposed to be an aquifer of low salinity.
- An third layer with low resistivity values ranging from 3.7 to 7.0 ohm-m which is supposed to be an aquifer of high salinity.
- At depth, a layer with medium resistivity values ranging from 11 to 44 ohm-m.

iii) From A018 to A020

- An upper layer with high resistivity values ranging from 80 to 132 ohm-m.
- The second layer with medium resistivity values ranging from 28 to 83 ohm-m which is supposed to be an aquifer of low salinity.
- The third layer with low resistivity values ranging from 2.8 to 5.4 ohm-m which is supposed to be an aquifer of high salinity.

iv) From A021 to A027

- An upper layer with high resistivity values ranging from 77 to 366 ohm-m.
- The second layer with medium resistivity values ranging from 6.6 to 34 ohm-m. It seems that this layer corresponds to an aquifer of low salinity or transition zone of the salt water intrusion.
- An layer with high resistivity values ranging from 76 to 176 ohm-m at depth from A025 to A027.

v) From A028 to A029

- An upper layer with high resistivity values ranging from 84 to 152 ohm-m.
- An intermediate layer with low resistivity values ranging from 9.3 to 27 ohm-m which is supposed to be an aquifer of high salinity.

(2) Line B (Fig. 6.2.3-3)

i) From B001 to B009

- An upper layer with high resistivity values ranging from 34 to 115 ohm-m.
- An intermediate layer with medium resistivity values ranging from 11 to 25 ohm-m which is supposed to be an aquifer of low salinity.
- At depth, a layer with low resistivity values ranging from 5.2 to 7.6 ohm-m and this layer is supposed to be an aquifer of high salinity.
- In well QAA18 (37-EA-11), the water level at about 48 mASL, which can correspond to the limit between the upper and intermediate layer.

ii) From B010 to B019

- An upper layer with high resistivity values ranging from 37 to 205 ohm-m.
- An intermediate layer with medium resistivity values ranging from 8.6 to 18 ohm-m is supposed to be an aquifer of low salinity.
- At depth, a layer with low resistivity values ranging from 4.2 to 6.4 ohm-m is supposed to be an aquifer of high salinity.
- At deeper part from B016 to B020, a layer with medium resistivity values ranging from 12 to 70 ohm-m.
- In well QAA17 (37-EA-17), the water level at 29 mASL, the level can correspond to the limit between the upper and intermediate layer.

iii) From B020 to B029

- An upper layer with high resistivity values ranging from 62 to 130 ohm-m.
- An intermediate layer with medium resistivity values ranging from 11 to 42 ohm-m is supposed to be an aquifer of low salinity.
- At depth, a layer with low resistivity values ranging from 2.6 to 12 ohm-m is supposed to be an aquifer of high salinity.
- There is no intermediate layer with medium resistivity values between B022 and B023.
- According to the resistivity logging data of RIWR6/1(48-AB-P2) which is located at 900m southwest from B021, the water level at 19 mASL may correspond to the limit between the upper and intermediate layer.

iv) From B030 to B039

- An upper layer with high resistivity values ranging from 37 to 124 ohm-m.
- An intermediate layer with medium resistivity values ranging from 11 to 32 ohm-m supposed to be an aquifer of low salinity.
- At depth, a layer with low resistivity values ranging from 4.5 to 9.8 ohm-m is supposed to be an aquifer of high salinity.
- There is no intermediate layer with medium resistivity values between B034 and B035.

v) From B040 to B057

- An resistivity discontinuity was recognized between B051 and B052.
- From B040 to B051,

  An upper layer with high resistivity values ranging from 43 to 191 ohm-m.

  An intermediate layer with medium resistivity values ranging from 12 to 24 ohm-m and this layer is supposed to be an aquifer of low salinity.

  At depth, a layer with low resistivity values ranging from 4.7 to 9.8 ohm-m is supposed to be an aquifer of high salinity.

- From B051 to B057

  This region is dominated by high resistivity ranging from 42 to 140 ohm-m. No layer with low resistivity values are found in this region.

vi) From B058 to B077

- This region is dominated by high resistivity values ranging from 50 to 425 ohm-m. An layer with midge resistivity values ranging from 25 to 36 ohm-m is found at depth of B058, 059, 060. An intermediate layer with midge resistivity values ranging from 14 to 21 ohm-m is found at depth of B076, 077.

vii) From B078 to B097

- An upper layer with high resistivity values ranging from 49 to 153 ohm-m.
- An intermediate layer with midge resistivity values ranging from 22 to 74 ohm-m.
- At depth, a layer with high resistivity values ranging from 50 to 1309 ohm-m.

viii) From B098 to B099

- This region is dominated by high resistivity values ranging from 48 to 558 ohm-m.

No layer with low resistivity values are found in this region.

(3) Line C (Fig. 6.2.3-4)

i) From C001 to C009

- An upper layer with midge resistivity values ranging from 13 to 64 ohm-m.
- An intermediate layer with low resistivity values ranging from 5.1 to 9.4 ohm-m is supposed to be an aquifer of high salinity.
- At depth, a layer with midge resistivity values ranging from 11 to 21 ohm-m.

ii) From C010 to C019

- An upper layer with relatively high resistivity values ranging from 21 to 66 ohm-m.
- An intermediate layer with midge resistivity values ranging from 12 to 33 ohm-m which is supposed to be an aquifer of low salinity is found between C011 and C014.
- An intermediate layer with low resistivity values ranging from 6.7 to 9.98 ohm-m which is supposed to be an aquifer of high salinity between C015 and C019.
- A layer with low resistivity values ranging from 4.2 to 8.2 ohm-m is found at depth between C010 to C012.
- A layer with high resistivity values ranging from 23 to 291 ohm-m is found at depth between C013 and C020.

iii) From C020 to C029

- An upper layer with relatively high resistivity values ranging from 18 to 51 ohm-m.
- The second layer with midge resistivity values ranging from 11 to 29 ohm-m is supposed to be an aquifer of low salinity.
- The third layer with low resistivity values ranging from 2.9 to 9.4 ohm-m is supposed to be an aquifer of high salinity.
- At depth, a layer with high resistivity values ranging from 23 to 265 ohm-m.

iv) From C030 to C034

- An upper layer with relatively high resistivity values ranging from 45 to 112 ohm-m.
- An intermediate layer with low resistivity values ranging 5.1 to 13 ohm-m is supposed to be an aquifer of high salinity.
- At depth, a layer with high resistivity values ranging from 205 to 411 ohm-m.

(4) Line S (Fig. 6.2.3-4)

- A relatively high resistivity layer ranging from 4 to 58 ohm-m is lied from S001 to S012.
- Under them lower resistivity layers are situated.
- A layer of low resistivity ranging from 1 to 9 ohm-m is situated from S001 to S011.
- This layer is supposed to be an aquifer of high salinity.

(5) Line T (Fig. 6.2.3-4)

- A intermediate or high resistivity layer ranging from 67 to 141 ohm-m covers on the surface from T001 to T008.
- Low resistivity layer ranging from 3 to 7 ohm-m is situated below near sea level from T001 to T006.
- This low resistivity layer is probably supposed to be an aquifer of high salinity.
- Low resistivity layer ranging from 10 to 15 ohm-m are situated from T004 and T005, from T007 to T008 above the sea level.
- These low resistivity layers are possibly supposed to be an aquifer of low salinity.

(6) Line U (Fig. 6.2.3-4)

- A intermediate or high resistivity layer ranging from 34 to 154 ohm-m covers on the surface from U001 to U012.
- Low resistivity layer ranging from 3 to 7 ohm-m is situated near below the sea level from U001 to U008.
- This low resistivity layer is probably supposed to be an aquifer of high salinity.
- Low resistivity layer ranging from 12 to 14 ohm-m is situated above the sea level from U006 and U009.
- These low resistivity layers are possibly supposed to be an aquifer of low salinity.

(7) Line V (Fig. 6.2.3-4)

- A intermediate or high resistivity layer ranging from 14 to 106 ohm-m covers on the surface from V001 to V008.
- Low resistivity layer ranging from 0.8 to 6 ohm-m is situated near below the sea level from V001 to V005.
- This low resistivity layer is probably supposed to be an aquifer of high salinity.

- Low resistivity layer ranging from 7 to 17 ohm-m is situated above the sea level from V006 and V008.
- These low resistivity layers are possibly supposed to be an aquifer of low salinity.

(8) Resistivity Contour Map

Based on the results, resistivity contour maps were prepared at depths of 0 mASL,

- 50 mASL and -100 mASL (Fig. 6.2.3-5, 6 and 7).

2) Wadi Feiran Area

Five (5) survey lines were allocated in the wadi: Line D is at Tarfa, Line E, F and G at Oasis Feiran, Line G at Mokattab and Line H at the downstream of the wadi. Location of survey lines are shown in Fig. 6.2.3-8.

(1) Tarfa (Line D: Fig. 6.2.3-9)

- A high resistivity layer ranging from 173 to 870 ohm-m covers on the surface from D001 to D007.
- A low resistivity layer ranging 9 to 48.72 ohm-m is situated at deeper part from D003 to D005.

This low resistivity layer is possibly supposed to be an aquifer of low salinity.

- A high resistivity layer ranging 111 to 4201 ohm-m is situated at deeper part from D001 to D002 and D6 to D7.
- A clear boundary between high resistivity layer and low resistivity layer which is possibly supposed to be an fissure zone is situated between D005 and D006.

(2) Oasis Feiran

i) Line E (Fig. 6.2.3-9)

In this line received signal was decayed very early because Quaternary deposits were very thin and underlain by very high resistivity layer (Basement Rocks).

- A low resistivity layer ranging from 17 to 54 ohm-m covers on the surface from E002 to E007.
- A high resistivity layer ranging 462 to 18604 ohm-m is situated at deeper part from E003 to E007.
- A low resistivity layer ranging 13 to 42 ohm-m is situated at E2 from upper to deeper part.

- A low resistivity layer of 13 ohm-m is situated at deeper part of E002.
- This low resistivity layer is possibly supposed to be an aquifer of low salinity.
- A high resistivity layer ranging 111 to 561 ohm-m is situated at E1 from upper to deeper part.
- Clear vertical boundaries between high resistivity layer and low resistivity layer which are possibly supposed to be fissure zones are situated between E1 and E002, and between E002 and E003.

ii) Line F (Fig. 6.2.3-9)

In this line received signal was decayed very early because Quaternary deposits were very thin and underlain by very high resistivity layer (Basement Rocks).

- A intermediate resistivity layer ranging from 97 to 303 ohm-m covers on the surface from F004 to F9.
- A high resistivity layer ranging from 819 to 1062 ohm-m covers oh the surface from to F001 to F003.
- A higher resistivity layer ranging 3956 to 9389 ohm-m is situated at deeper part from F001 to F002.
- A higher resistivity layer ranging 1697 to 650654 ohm-m is situated at deeper part from F004 to F009.
- A high resistivity layer of 1062 ohm-m is situated at F003 from surface to at level of 100 mASL.
- Clear horizontal boundaries between 1-st layer and 2-nd layer with higher resistivity which are possibly supposed to contain groundwater are situated between F1 and F002, and between F004 and F009.

(3) W. Feiran (1) (Line G: Fig. 6.2.3-10)

Location of electro-magnetic survey line at W. Feiran (1) Area is shown in Fig.6.2.3-14.

- A intermediate resistivity layer ranging from 31 to 155 ohm-m covers on the surface from G001 to G011.
- 2-nd or 3-rd layers of low resistivity ranging from 6 to 9 ohm-m are situated from G008 to G011.
- These low resistivity layers are probably supposed to be an aquifer of low salinity.

- A low or intermediate resistivity layer ranging from 8 to 36 ohm-m is situated at deeper part from G6 to G7.
- This low or intermediate resistivity layer is possibly supposed to be an aquifer of low salinity.
- A higher resistivity layer ranging 2182 to 44614 ohm-m is situated at deeper part from G001 to G006.
- A clear horizontal boundaries between 1-st layer and 2-nd layer with higher resistivity which is possibly supposed to contain groundwater is situated between G001 and G005.
- Clear vertical boundaries between high resistivity layer and low resistivity layer which are possibly supposed to be fissure zones are situated between G005 and G006, and between G007 and G008.

(4) Wadi Feiran (2) (Line H : Fig. 6.2.3-10)

Location of electro-magnetic survey line at W. Feiran (2) Area is shown in Fig.6.2.3-16.

- A intermediate resistivity layer ranging from 14 to 78 ohm-m covers on the surface from H001 to H005.
- A low resistivity layer ranging 2 to 9 ohm-m is situated at deeper part from H001 to H005.
- These low resistivity layer is probably supposed to be an aquifer.
- A low or intermediate resistivity layer ranging from 8 to 22 ohm-m covers on the surface from H006 to H010.
- 1-st layer of low resistivity ranging from 12 to 22 ohm-m is situated above 2-nd higher resistivity ranging from 61 to 89 ohm-m from H006 to H007.
- There is a clear horizontal boundary between 1-st layer of lower resistivity and 2-nd layer of higher resistivity, and this boundary is possibly supposed to contain groundwater.
- 2-nd or 3-rd layers of low resistivity ranging from 5 to 8 ohm-m are situated from H008 to H010.
- Clear horizontal boundaries between lower 2-nd layer and higher 3-rd layer or between lower 3-rd layer and higher 4-th layer, and these boundaries which are possibly supposed to contain groundwater are situated between H008 and H010.
- Clear vertical boundaries between high resistivity layer and low resistivity layer are

possibly supposed to be fissure zones, are situated between H002 and H003, and between H001 and H006, and between H007 and H008.

3) Wadi Gharandal Area

Location of electro-magnetic survey line at W. Gharandal Area is shown in Fig.6.2.3-11. Two (2) survey lines were allocated in the wadi.

(1) Line I (Fig. 6.2.3-12)

- A low or intermediate resistivity layer ranging from 13 to 49 ohm-m covers on the surface from I001 to I011.
- Under them lower resistivity layer ranging from 1 to 17 ohm-m is situated.
- This low resistivity layer is probably supposed to be an aquifer of high salinity.

(2) Line J (Fig. 6.2.3-12)

- A intermediate or high resistivity layer ranging from 20 to 187 ohm-m covers on the surface from J001 to J009.
- A low resistivity layer ranging 2 to 9 ohm-m is situated at deeper part from J001 to J005.
- These low resistivity layer is probably supposed to be an aquifer.

4) Wadi Watir Area

Location of electro-magnetic survey line at W. Watir Area is shown in Fig.6.2.3-13.

(1) Line N (Fig. 6.2.3-14)

- A low or intermediate resistivity layer ranging from 11 to 39 ohm-m covers on the surface from N001 to N004.
- Under them a low resistivity layer ranging 4 to 7 ohm-m is situated at deeper part from N001 to N004.
- These low resistivity layer is probably supposed to be an aquifer.

(2) Line O (Fig. 6.2.3-14)

- A low or intermediate resistivity layer ranging from 20 to 56 ohm-m covers on the surface from O001 to O004.
- Under them low resistivity layers of 5 and 9 ohm-m are situated at the O002 and O004 respectively.

- A low resistivity layer ranging 5 to 9 ohm-m is situated at deeper part from O001 to O004.
- These low resistivity layers are probably supposed to be an aquifer.

(3) Line P (Fig. 6.2.3-14)

- A intermediate or high resistivity layer ranging from 15 to 114 ohm-m covers on the surface from P001 to P004.
- Under them low or intermediate resistivity layers ranging from 3 to 41 ohm-m are situated.
- Low resistivity layers of 3 and 7 ohm-m are situated at deeper part of P001 and P003 respectively.
- These low resistivity layers are probably supposed to be an aquifer.

5) Wadi Zalaga Area

Electro-magnetic survey lines in the wadi were allocated at Umm Ahmed Spring and El Sawana Spring Area as shown in Fig.6.2.3-13.

(1) Line Q (Fig. 6.2.3-15)

In this line received signal was decayed very early because Quaternary deposits were very thin and underlain by very high resistivity layer (Basement Rocks).

- A intermediate or high resistivity layer ranging from 31 to 124 ohm-m covers on the surface from Q001 to Q004.
- Under them high resistivity layers ranging from 396 to 8787 ohm-m are situated except Q002.
- At Q002 relatively low resistivity layer of 36 ohm-m is situated between higher resistivity layers.
- This low resistivity layer is possibly supposed to be an aquifer.
- Clear horizontal boundaries are situated between lower 1-st layer and higher 2-nd layer or between lower 2-nd layer and higher 3-rd layer and these boundaries which are possibly supposed to contain groundwater are situated between Q001 and Q004.

(2) Line R (Fig. 6.2.3-15)

In this line received signal was decayed very early because Quaternary deposits were very thin and underlain by very high resistivity layer (Basement Rocks).

- A high resistivity 1-st layer ranging from 81 to 145 ohm-m covers on the surface from R001 to R005 on a higher resistivity 2-nd layer more than 483 ohm-m.
- It is possibly supposed that there is an aquifer near a clear horizontal boundary between 1-st layer and 2-nd layer.

6) Wadi Zaghara and Wadi Dahab Area

Location of electro-magnetic survey line at W. Zaghara and Wadi Dahab Area is shown in Fig. 6.2.3-16.

(1) Line K (Fig. 6.2.3-17)

In this line received signal was decayed very early because Quaternary deposits were very thin and underlain by very high resistivity layer (Basement Rocks).

- A high resistivity layer ranging from 179 to 553 ohm-m covers on the surface from K003 to K004 on a higher resistivity layer more than 16017 ohm-m.
- A high resistivity layer more than 1044 ohm-m is lied thick over 200 m on the surface from K001 to K002 and K005 from H1 to H005.
- There is a clear boundary between the layer lower resistivity less than 1000 ohm-m and higher resistivity more than 1000 ohm-m, and this boundary is possibly supposed to be fissure zones which contain groundwater.

(2) Line L (Fig. 6.2.3-17)

In this line received signal was decayed very early because Quaternary deposits were very thin and underlain by very high resistivity layer (Basement Rocks).

- A high resistivity 1-st layer ranging from 89 to 349 ohm-m covers on the surface from L001 to L005 on a higher resistivity 2-nd layer more than 20789 ohm-m.
- It is possibly supposed that there is an aquifer near a clear horizontal boundary between 1-st layer and 2-nd layer.

(2) Line M (Fig. 6.2.3-17)

Location of electro-magnetic survey line at W. Dahab Area is shown in Fig.6.2.3-24.

- A intermediate or high resistivity layer ranging from 58 to 452 ohm-m covers on the surface from M001 to M020.
- 5 low resistivity layers ranging from 10 to 70 ohm-m are situated at M005, at point from M006 to M0010, at 0M012, at point from M013 to M015 and at point from

M017 to M018 down to at the depth of 200 m.

- These low resistivity layers are possibly supposed to be an aquifer of low salinity.

6.3 Deep Resistivity Survey (Schlumberger Method)

6.3.1 Survey Area

Deep Resistivity Survey was performed in the area where the Lower Cretaceous Sandstone underlay. Location of survey station is shown in Fig. 6.3.1-1.

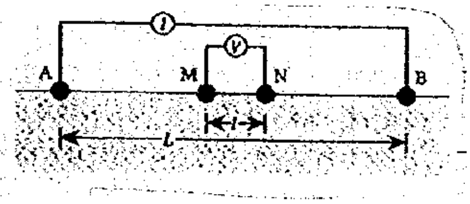
6.3.2 Survey Method

The survey was performed applying vertical electric sounding(V.E.S) technique, using a Japanese equipment of type CH-8708A transmitter and EPR-121A recorder.

The distance between the electrode(AB/2) begins with 5 meters and expands till it up to 3000 meters aiming to explore a resistivity thick section to clarify the geoelectric and hydrogeological conditions prevailing within the studied area. Allocation and spacing of electrodes is as shown below.

Schlumberger Method

$$\rho_a = \pi \frac{L^2 - l^2}{4l} \frac{V}{I}$$



AB/2(m)	5	7	10	15	20	30	50	70	100	150	200	300	500	700	1000	1500	2000	3000
MN/2(m)	1	1	1	1	1	1	1											
						5	5	5	5	5	5							
										30	30	30	30	30	30	30		
															50	50	50	50

Equipment used;

Transmitter	: DOWA CH-8708A Max Output 1200V, 15A
Motor Generator	: ZMG-30, MODEL V465D, 400Hz, 115V, 30kVA
Voltage Regulator	: VR-1
Pen Recorder	: TOA EPR-121A, 2 pen, 0.5mV/7.5cm
Transceiver	: KENWOOD TH-42
GPS receiver	: MAGELLAN meridian XL

The optimum strata-structure model was inferred by repeating the curve matching method (forward analysis) in which the theoretical value of apparent resistivity calculated on an assumed strata model was compared with the measured value. The analysis program by Ushijima et al (1987) was used for the analysis. The calculation of theoretical value of apparent resistivity was based on the linear filter method.

6.3.3 Survey Results

The electric survey was performed at 61 stations.

Location of survey station was determined GPS receiver.

Results of analysis in Schlumberger method are shown Table 6.3.3-1.

The data present resistivity structure of high- low-high strata in the study area.

Electric logging data of existing wells in the study area are not able to compare with observed data. Because the resistivity of well logging data showed very low resistivity less than 10 ohm-m and there was no resistivity difference from well head to the bottom from well head to the bottom.

It was inferred that electric logging has been carried out in porous or fractured formations filled with very low resistivity mud.

Resistivity of formation varies with water content of formation and salinity of formation water.

The survey area is very wide and water content of each formations and salinity of formation water varies in very wide range. Therefore resistivity of formations are not constant. Also resistivity of basement is not constant.

Resistivity of each formations can take very wide range. Then it is very difficult to identify formations arbitrarily by resistivity value.

But there is distinctive difference of resistivity between Lower Cretaceous sandstone regarded as an aquifer and under layers which includes Pre-Cretaceous basement rocks.

The former has low resistivity whereas the latter has relatively high resistivity.

Assuming that the deepest high resistivity layer presents sustaining layer which includes. Pre-Cretaceous basement rocks and low resistivity layer on the deepest high resistivity layer presents Lower Cretaceous aquifer, an elevation contour map was provided to present the top of the Precambrian Basement Rocks (Fig. 6.3.3-1).

Table 6.2.3-1 Summary of Existing Data (El Qaa Plain)

Section	Layer	Resistivity (ohm-m)	estimation
Profile A	upper layer	443 - 4800	loose sand and eroder surface layer
	intermediate layer	34 - 78	lower part of intermediate layer contains water of low salinity
	at depth	7 - 12	clay or an aquifer of fairly high salinity
Profile B	upper layer	465 - 1950	loose sand and eroder surface layer
	second layer	90 - 300	limit between the second and third layer correspond to the water level
	third layer	28 - 35	lower part of third layer contains water
	at depth	2 - 10	
Profile C	upper layer	239-918	eroded surface layer
	second layer	120 - 147	
	third layer	23 - 40	lower part of the third layer contains water
	at depth	2 - 15	
Profile D	upper layer	120 - 534	eroded surface layer (from 4 to 10m thick)
	second layer	10 - 142	
	third layer	7 - 37	limit between the third and fourth layer correspond to the water level
	fourth layer	17 - 100	contains water
	at depth	5 - 10	
Profile E	upper layer	100 - 1800	eroded surface layer
	intermediate layer	42 - 84	lower part of intermediate layer contains water of low salinity
	at depth	9 - 19	
Profile F	upper layer	340 - 1400	eroded surface layer
	intermediate layer	60 - 192	
	at depth	3 - 23	cray or an aquifer of fairly high salinity
Profile G	upper layer	80 - 205	
	intermediate layer in the west	2	low resistivity values correspond to an aquifer of high salinity affected by sea
	intermediate layer in the east	16 - 70	correspond to an aquifer of low salinity
	at depth	38 - 170	

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Table6.2.3-2 Summary of TEM Survey Result (El Qaa Plain)

Section	Station No.	Layer	Resistivity (ohm-m)	Estimation
Line A	3 - 13	upper	67 - 180	
		intermediate	30 - 123	lower values of this layer is supposed to be an aquifer of low salinity
		at depth	7.4 - 16	contains water of high salinity
	14 - 18	upper	45 - 86	
		second	11 - 30	supposed to be an aquifer of low salinity
		third	3.7 - 7.0	supposed to be an aquifer of high salinity
		at depth	11 - 44	
	18 - 20	upper	80 - 132	
		second	28 - 83	supposed to be an aquifer of low salinity
		third	2.8 - 5.4	supposed to be an aquifer of high salinity
	21 - 27	upper	77 - 366	
		second	(6.6) 12 - 34	supposed to be an aquifer of low salinity or transition
		third	25 - 27	at No.25 - 27
	28 - 29	upper	84 - 152	
		intermediate	9.3 - 27	higher part of this layer is supposed to be an aquifer of low salinity
		at depth	41 - 95	
Line B	1 - 9	upper	34 - 115	
		intermediate	11 - 25	supposed to be an aquifer of low salinity
		at depth	5.2 - 7.6	supposed to be an aquifer of high salinity
	10 - 19	upper	37 - 205	
		intermediate	(8.6) 10 - 18	supposed to be an aquifer of low salinity
		at depth	4.2 - 6.4	supposed to be an aquifer of high salinity
	20 - 29	upper	62 - 130	
		intermediate	11 - 42	supposed to be an aquifer of low salinity
		at depth	2.6 - 12	supposed to be an aquifer of high salinity
	30 - 39	upper	37 - 124	
		intermediate	11 - 32	supposed to be an aquifer of low salinity
		at depth	4.5 - 9.8	supposed to be an aquifer of high salinity
	40 - 51	upper	43 - 191	
		intermediate	12 - 24	supposed to be an aquifer of low salinity
		at depth	4.7 - 9.8	supposed to be an aquifer of high salinity
	51 - 77	-	42 - 425	this region is dominated by high resistivity values
	78 - 97	upper	49 - 153	
		intermediate	22 - 74	
		at depth	50 - 1309	
	98 - 99	-	48 - 558	this region is dominated by high resistivity values
Line C	1 - 9	upper	13 - 64	
		intermediate	5.1 - 9.4	supposed to be an aquifer of high salinity
		at depth	11 - 21	
	10 - 19	upper	21 - 66	
		intermediate	12 - 33	supposed to be an aquifer of low salinity between No.11 and No. 14
		intermediate	6.7 - 9.98	supposed to be an aquifer of high salinity between No.15 and No. 19
		at depth between No.10 and No.12	4.2 - 8.2	
		at depth between No.13 and No.19	23 - 291	
	20 - 29	upper	18 - 51	
		second	11 - 29	supposed to be an aquifer of low salinity
		third	2.9 - 9.4	supposed to be an aquifer of high salinity
		at depth	23 - 265	
	30 - 34	upper	45 - 112	
		intermediate	5.1 - 13	supposed to be an aquifer of high salinity
		at depth	205 - 411	

Table 6.2.3-3 Available Well Data (El Qaa Plain)

Ser. No.	Reformed Well Code No. (by JICA)	Well Name	Cordination Lat.	Cordination Long.	Elevation (m)	Drilled Depth BGL(m)	Static Water Level BGL(m)	Rem.
1	37-EA-I1	QAA18	283306	333035	100	200	66.23	1250m SW from TEM station B 2
2	37-EA-I7	QAA17	282902	333407	95	200	68.5	750m SW from TEM station B11
3	37-EA-P1	RIWR7	283136	333501	126.29	300	102.12	750m SW from TEM station A 8
4	37-EA-P2	RIWR6/1	282429	333749	98.17	500	79.35	900m SW from TEM station B22
5	37-EA-I6	RIWR6	282429	333745	98.975	360	-	900m SW from TEM station B22
6	47-AB-010	SP EL QAA2	282352	333734	84	350	63.06	2000m SW from TEM station B23
7	47-AB-012	SP EL QAA4	282255	333824	78	150	56.59	1800m SW from TEM station B25

Table6.2.3-4 Summary of Available Resistivity Logging Data (El Qaa Plain)

Reformed Well Code (by JICA)	Well Name	Depth (m)	Short Normal (ohm-m)	Long Normal (ohm-m)	Description
47-AB-12	SP EL QAA4	0 - 20			wadi deposites
		20 - 26	60	>100	gravels
		26 - 55			sand, gravels
		55 - 70	20 - 60	50 - 100	sand
		70 - 115	10 - 20	30 - 50	sand
		115 - 150	<10	25	sand
48-AB-J6	RIWR6	0 - 7	-		clay with little sand
		7 - 29	180		fine sand
		29 - 48	280		medium to coarse sand
		48 - 82	150		sand - clay interclation
		82 - 358	25 - 55		clay with sand

Table 6.2.3-5 Result of Analysis (TEM Method) (1/3)

Line	Station No.	Latitude	Longitude	Elevation (m)	Depth of boundary 1 (m)	Depth of boundary 2 (m)	Depth of boundary 3 (m)	Depth of boundary 4 (m)	Depth of boundary 5 (m)	Elevation of boundary 1 (m)	Elevation of boundary 2 (m)	Elevation of boundary 3 (m)	Elevation of boundary 4 (m)	Elevation of boundary 5 (m)	Resistivity of #1 Layer (ohm-m)	Resistivity of #2 Layer (ohm-m)	Resistivity of #3 Layer (ohm-m)	Resistivity of #4 Layer (ohm-m)	Resistivity of #5 Layer (ohm-m)	Resistivity of #6 Layer (ohm-m)
A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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Line	Station No.	Latitude	Longitude	Elevation (m)	Depth of boundary 1 (m)	Depth of boundary 2 (m)	Depth of boundary 3 (m)	Depth of boundary 4 (m)	Depth of boundary 5 (m)	Elevation of boundary 1 (m)	Elevation of boundary 2 (m)	Elevation of boundary 3 (m)	Elevation of boundary 4 (m)	Elevation of boundary 5 (m)	Resistivity of #1 Layer (ohm-m)	Resistivity of #2 Layer (ohm-m)	Resistivity of #3 Layer (ohm-m)	Resistivity of #4 Layer (ohm-m)	Resistivity of #5 Layer (ohm-m)	Resistivity of #6 Layer (ohm-m)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 6.2.3-5 Result of Analysis (TEM Method) (2/3)

Line	Station No.	Latitude	Longitude	Elevation (m)	Depth of Boundary 1 (m)	Depth of Boundary 2 (m)	Depth of Boundary 3 (m)	Depth of Boundary 4 (m)	Depth of Boundary 5 (m)	Elevation of Boundary 1 (m)	Elevation of Boundary 2 (m)	Elevation of Boundary 3 (m)	Elevation of Boundary 4 (m)	Elevation of Boundary 5 (m)	Resistivity of 1st Layer (ohm-m)	Resistivity of 2nd Layer (ohm-m)	Resistivity of 3rd Layer (ohm-m)	Resistivity of 4th Layer (ohm-m)	Resistivity of 5th Layer (ohm-m)	Resistivity of 6th Layer (ohm-m)
B	86	28° 6.11' N	33° 53.60' E	176	75.42	147.6				345.18	113.4				85.60	25.59	659.8			
B	87	28° 5.87' N	33° 53.89' E	179	85.44	159.7				195.56	126.5				92.30	50.35	343.6			
B	88	28° 5.62' N	33° 53.95' E	180	94.03	161.8				125.98	178.3				79.3	57.98	350.8			
B	89	28° 5.49' N	33° 54.12' E	270	94.21	170.2	347.5	264.5	404.1	175.79	169.8	129.5	25.5	144.5	1.0	67.45	181.5	42.39	165.7	30.1
B	90	28° 5.22' N	33° 54.33' E	270	159.2	254	754.8			110.8	-14	454.8			153.6	98.26	352.7	92.36		
B	91	28° 4.96' N	33° 54.52' E	272	93.64	145	390.5	451.1		179.56	129	41.5	-11.5		67.6	36.76	212.2	73.93	145.3	
B	92	28° 4.64' N	33° 54.45' E	281	83.05	105.3	754.8			149.95	175.9	473.8			138	9.28	262.6	69.3		
B	93	28° 4.36' N	33° 54.75' E	283	42.25	147.7	467.6			240.95	111.9	-384.6			92.36	92.15	652.5	42.05		
B	94	28° 4.21' N	33° 54.91' E	179	75.6	166.2	474.7			199.4	112.8	-195.6			103.3	50.36	269.8	71.36		
B	95	28° 3.97' N	33° 55.06' E	280	78.94	161.5	692.9			84.26	114.5	-362.9			67.80	49.10	198.2	87.54		
B	96	28° 3.69' N	33° 55.14' E	279	37.17	167.1	464.5			221.83	111.0	-125.5			55.16	35.54	1569.5	352.4		
B	97	28° 3.41' N	33° 55.28' E	270	76.77	165.7	289.0	264.1		195.23	104.9	19.0	294.1		49.16	171.5	51.63	235.5	79.65	
B	98	28° 3.13' N	33° 55.38' E	269	99.02	182.9	342.5			169.98	86.5	-73.5			72.66	129.5	6.39	34.85		
B	99	28° 2.88' N	33° 55.49' E	269	96.17	159.5	379			172.47	109.5	-130			48.37	175.8	158.3	56.54		
C	1	28° 16.57' N	33° 40.62' E	79	45.06	90.33	349.2			32.94	-11.33	-270.2			96.16	8.14	1.5	12.92		
C	2	28° 16.16' N	33° 41.02' E	42	41.27	114.5	421.8			30.73	-34.5	-359.8			12.28	1.43	5.08	17.7		
C	3	28° 15.70' N	33° 41.42' E	62	38.86	75.42	299.8	243.7	515.3	41.14	6.58	-217.8	119.7	453.9	26.45	20.35	5.48	18.45		
C	4	28° 15.22' N	33° 41.82' E	64	28.29	42.08	250.7			61.71	29.42	-190.1			25.56	13.72	4.14	12.96		
C	5	28° 14.78' N	33° 42.23' E	95	59.6	206.4				37.4	-111.4				30.75	6.71	14.25			
C	6	28° 14.36' N	33° 43.58' E	145	43.37	210.2				96.63	-109.2				36.56	6.56	11.52			
C	7	28° 13.90' N	33° 43.02' E	112	37.05	62.56	241.2			74.92	66.16	-129.2			96	64.27	6.87	20.75		
C	8	28° 13.45' N	33° 43.41' E	114	36.96	69.05	189.6			79.42	47.17	-75.6			42.72	57.91	4.45	10.29		
C	9	28° 13.00' N	33° 43.75' E	121	56.09	365.6				64.11	277.6				31.98	8.45	16.44			
C	10	28° 12.58' N	33° 44.17' E	121	42.92	464.7				37.36	-343.7				27.12	8.3	27.65			
C	11	28° 12.18' N	33° 44.49' E	127	60.73	96.63	130.6	264.3		66.35	21.35	-3.6	-137.3		42.95	20.62	12.1	4.77	3.82	
C	12	28° 11.77' N	33° 44.83' E	130	33.54	59.79	114.5	292.6		96.46	70.71	15.5	-152.6		36.15	45.09	14.07	4.18	18.46	
C	13	28° 11.32' N	33° 45.25' E	140	64.25	123	231.6			75.75	17	-91.6			49.25	13.28	45.72	25.54		
C	14	28° 10.88' N	33° 45.62' E	145	75.85	152.5	301.8			69.17	-7.5	-156.8			40.71	12.72	290.7	46.93		
C	15	28° 10.41' N	33° 46.00' E	140	39.75	83.21	118.1			100.25	56.77	21.9			25.98	7.78	125.8	301.7		
C	16	28° 10.00' N	33° 46.38' E	140	41.10	85.93	216.6			98.45	54.07	93.6			57.71	25.75	6.15	99.26		
C	17	28° 9.58' N	33° 46.75' E	147	49.79	249.7				97.25	96.7				59.74	6.67	90.47			
C	18	28° 9.06' N	33° 47.27' E	147	44.88	88.99	170.6			102.12	58.01	-24.6			65.74	22.6	6.56	65.84		
C	19	28° 8.75' N	33° 47.52' E	150	51.81	72.38	137.4			94.19	77.92	12.6			47.38	16.4	9.76	35.82		
C	20	28° 8.32' N	33° 47.86' E	155	37.49	91.71	143			117.51	63.49	12			35.4	14.92	6.5	22.81		
C	21	28° 7.85' N	33° 48.25' E	150	44.18	76.52	139.2	157.3		105.82	80.48	10.8	2.7		34.62	50.63	31.4	4.92	38.2	
C	22	28° 7.49' N	33° 48.61' E	150	41.83	77.71	80.21	127.8	174.9	108.37	72.29	79.78	32.5	5.0	26.75	17.94	7.1	26.78	2.41	42.30
C	23	28° 6.92' N	33° 49.06' E	143	12.56	83.31	113.4			130.44	59.69	29.6			41.31	13.56	8.25	92.82		
C	24	28° 6.45' N	33° 49.47' E	160	41.5	72.72	144.6			118.5	87.28	15.4			30.51	16.56	9.15	159.5		
C	25	28° 6.05' N	33° 49.80' E	162	49.81	90.08	155.9			112.19	71.92	6.1			44.34	36.9	10.98	264.9		
C	26	28° 5.60' N	33° 50.25' E	163	51.79	79.81	116.1	181		111.21	83.19	46.9	-18		36.39	16.86	30.36	10.51	159.2	
C	27	28° 5.13' N	33° 50.62' E	163	110.9	201.3				52.1	-38.3				45.86	11.45	83.31			
C	28	28° 4.68' N	33° 51.00' E	170	43.15	211.3				126.85	-41.3				56.86	36.3	44.92			
C	29	28° 4.29' N	33° 51.49' E	170	91.72	137				78.28	33				36.39	7.68	196.9			
C	30	28° 3.86' N	33° 51.77' E	142	100.8	171				41.2	-21				44.34	13.34	284.7			
C	31	28° 3.36' N	33° 52.15' E	163	119.8	179.6	468.8			43.2	3.4	-305.8			45.64	10.18	420.7	36.15		
C	32	28° 2.94' N	33° 52.56' E	170	35.09	60.33	311.1			134.91	109.67	-141.1			88.25	5.18	410.6	18.2		
C	33	28° 2.50' N	33° 52.94' E	148	42.6	126	141.3	279.1		105.4	47	6.7	-131.3		61.07	112.4	9.54	106.7	60.11	
C	34	28° 2.05' N	33° 53.33' E	151	112.5	255				42.5	-100				56.17	99.37	39.85			
D	1	28° 41.98' N	33° 56.98' E	1130	149.1	261.5				1040.9	878.5				870.3	546.9	3.6			
D	2	28° 41.61' N	33° 56.69' E	1190	176.8	678.5				1013.2	371.9				296.4	662.9	142.6			
D	3	28° 41.70' N	33° 55.53' E	1130	85.48	153.2	267.8			1044.52	974.8	862.2			575.5	92.71	9.62	48.72		
D	4	28° 41.74' N	33° 55.24' E	1120	129.8	215.6	392.1			990.2	904.4	727.9			224.3	511.1	21.10	102.6		
D	5	28° 41.79' N	33° 54.91' E	1090	48.33	110.7	238.1			1041.67	979.3	851.9			456.1	37.76	13.52	39.1		
D	6	28° 41.61' N	33° 54.69' E	1105	110.5	751.2				994.5	353.8				561.6	111.9	253.8			
D	7	28° 42.16' N	33° 54.39' E	1090	118.8	125.1	129.8	132.7		971.2	964.9	960.2	957.3		124.3	371.9	873.7	186.5	4271.8	
E	1	28° 42.66' N	33° 39.56' E	710	110.5	371.2				599.5	343.8				561.8	311.9	153.8			
E	2	28° 42.59' N	33° 39.95' E	700	23.42	38.46				676.58	661.54				25.73	11.35	42.46			

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Line	Station No.	Latitude	Longitude	Elevation (m)	Depth of Boundary 1 (m)	Depth of Boundary 2 (m)	Depth of Boundary 3 (m)	Depth of Boundary 4 (m)	Depth of Boundary 5 (m)	Elevation of Boundary 1 (m)	Elevation of Boundary 2 (m)	Elevation of Boundary 3 (m)	Elevation of Boundary 4 (m)	Elevation of Boundary 5 (m)	Resistivity of 1st Layer (ohm-m)	Resistivity of 2nd Layer (ohm-m)	Resistivity of 3rd Layer (ohm-m)	Resistivity of 4th Layer (ohm-m)	Resistivity of 5th Layer (ohm-m)	Resistivity of 6th Layer (ohm-m)
E	3	28° 42.29' N	33° 40.07' E	706	23.38	311.2				681.62	393.8				54.36	1314.3	11422.2			
E	4	28° 42.05' N	33° 40.35' E	710	9.15	108.8				700.85	601.16				37.6	464.6	5324.4			
E	5	28° 42.04' N	33° 40.78' E	710	30.31	27.78				679.69	682.22				24.68	847.3	7413.6			
E	6	28° 42.04' N	33° 41.21' E	730	9.77	22.49				720.23	707.51				36.72	799	19604.7			
E	7	28° 41.76' N	33° 41.54' E	720	6.6	36.31				713.4	683.69				37	462	12743.5			
F	1	28° 43.46' N	33° 35.90' E	570	180.4	431.8	951.4			389.6	139.4	-381.4			6.93	9658.3	130	39.1		
F	2	28° 43.54' N	33° 35.57' E	570	133.9	431.2				436.1	138.9				3115.7	9189.8	123			
F	3	28° 43.39' N	33° 35.36' E	540	437.4	930.8				102.6	-390.8				8462.1	476	2074.6			
F	4	28° 43.22' N	33° 35.12' E	530	34.76					495.24					422.7	1677.6				
F	5	28° 43.17' N	33° 34.79' E	520	108.7					411.3					9.3	65634.5				
F	6	28° 43.43' N	33° 34.39' E	510	187.6	598.8	405.5			322.4	312.2	96.4			304.8	3480.4	2.49	2549.6		
F	7	28° 43.54' N	33° 34.35' E	500	42.36	70.71				457.64	429.29				47.41	99706.4	10470.0			
F	8	28° 43.83' N	33° 34.05' E	500	70.98	84.3	109.7	129.8		429.02	415.7	390.3	370.2		455.6	2221.6	5134.5	14672.9	56264.1	
F	9	28° 46.03' N	33° 33.89' E	500	93.29					406.71					245.5	4749.3				
G	1	28° 46.76' N	33° 31.21' E	390	37.4	375.6				352.6	15.4				112.9	3441.8	1764.5			
G	2	28° 47.10' N	33° 30.79' E	390	117.1	371.5				272.9	18.9				155.7	2192.5	426.2			
G	3	28° 47.57' N	33° 30.22' E	390	63.91	225.5				326.09	161.9				67.75	2124.7	1139.9			
G	4	28° 47.62' N	33° 29.65' E	380	47.36	158.5				332.64	221.5				410.2	3308.2	19721.9			
G	5	28° 47.84' N	33° 29.11' E	380	101.9	245.1				278.1	134.9				110	4461.4	20.1			
G	6	28° 47.85' N	33° 28.26' E	370	91.52	193.2	347.6			278.48	136.9	22.4			106.5	36.15	19.54	121.6		
G	7	28° 47.90' N	33° 27.80' E	370	31.57	167.6	215.6			338.43	202.7	154.6			67.39	27.41	8.15	496.1		
G	8	28° 47.81' N	33° 27.23' E	370	32.72	110.8				337.28	270.9				30.79	9.54	493.9			
G	9	28° 47.79' N	33° 26.59' E	360	34.61	125.2				325.39	236.8				31.09	6.24	161.6			
G	10	28° 47.48' N	33° 26.04' E	360	48.67	81.99	131.9			311.33	278.01	228.5			36.67	27.85	8.79	7.41		
G	11	28° 47.24' N	33° 25.41' E	360	42.6	76.15	171.2			317.4	283.45	158.9			49.27	17.30	6.38	15.28		
H	1	28° 43.15' N	33° 19.92' E	140	64.91	64.96	147.6			75.91	75.96	-6.6			64.42	25.71	9.35	27.68		
H	2	28° 42.05' N	33° 19.34' E	140	33.34	69.63	134.6	193.2		106.96	70.37	5.4	-53.2		75.79	11.38	46.92	5.42	40.77	
H	3	28° 42.51' N	33° 18.68' E	140	33.7	69.52	111.6	198		106.3	71.49	28.4	-58		48.17	5.19	6.38	4.41	6.17	
H	4	28° 42.32' N	33° 19.05' E	135	28.13	70.83	124.7			106.87	64.17	10.3			78.39	2.96	5.16	2.24		
H	5	28° 42.08' N	33° 17.41' E	130	21.07	47.6	164.3			108.93	82.4	-34.3								
H	6	28° 41.95' N	33° 20.56' E	140	52.14	82.44				87.86	57.56				22.55	35.79	17.4			
H	7	28° 41.42' N	33° 21.11' E	150	35.97	75.46	120.8	179.2		114.09	75.34	29.2	-29.2		12.90	60.55	11.64	11.12	5.41	
H	8	28° 40.44' N	33° 21.81' E	160	22.99	40.99	96.71			154.15	114.72	63.62			30.98	6.22	6.2	18		
H	9	28° 39.21' N	33° 22.57' E	150	20.61	39.66	103.7	167.6		129.39	110.34	46.3	-15.6		6.83	5.45	12.96	4.72	43.07	
H	10	28° 38.51' N	33° 23.71' E	150	24.9	48.12	99.09			103.1	81.99	50.56			20.69	6.27	27.46	8.18		
I	1	29° 19.26' N	32° 59.65' E		17.8	27.5	42.42	241.1							13.38	6.96	2.71	3.92	6.67	
I	2	29° 19.47' N	32° 59.88' E		15.99	31.8	34.47								37.79	14.41	4.95	3.85		
I	3	29° 19.62' N	33° 0.11' E		54.09	28.17									17.22	9.41	2.14			
I	4	29° 19.84' N	33° 0.40' E		16.90	34.67	62.95								24.32	6.78	3.96	2.3		
I	5	29° 20.03' N	33° 0.57' E		36.72	37.45	49.76								39.38	7.8	4.53	2.36		
I	6	29° 20.15' N	33° 0.84' E		36.33	38.78	59.96								34.3	8.11	5.72	3.98		
I	7	29° 20.27' N	33° 1.06' E		46.39	37.74	49.38								49.56	13.21	9.95	3.23		
I	8	29° 20.47' N	33° 1.26' E		47.29	39.54	41.72								48.18	11.44	2.19	2.71		
I	9	29° 20.62' N	33° 1.56' E		30.39	39.21	47.48	130.8							37.15	10.72	4.22	3.18	2.4	
I	10	29° 20.84' N	33° 1.79' E		29.3	28.34	49.36								46.07	17.15	4.79	2.91		
I	11	29° 21.06' N	33° 2.01' E		30.27	30.22	56.42								41.93	19.34	5.49	4.74		
J	1	29° 21.10' N	33° 7.19' E		12.96	59.38	163.9	272.9							42.25	19.6	5.89	29.12	34.79	
J	2	29° 21.05' N	33° 6.95' E		19.39	41.98	71.76	116.3							48.74	19.16	10.25	19.19	8.83	
J	3	29° 20.98' N	33° 6.87' E		25.56	49.51	36.31								20.65	5.96	7.63	12.91		
J	4	29° 20.98' N	33° 6.35' E		26.71	42.42	66.11	120	284.9						157.4	47.4	9.92	2.1	2.56	29.87
J	5	29° 21.05' N	33° 6.04' E		40.25	30.15	97.28	143.5							50.76	36.98	26.71	13.47	4.26	
J	6	29° 20.97' N	33° 5.71' E		42.09	68.46	101.4	141.2	238.6						20.34	29.71	[illegible]	11.82	5.79	11.17
J	7	29° 20.95' N	33° 5.42' E		36.72	32.41	106.5	147.9							30.87	30.19	25.18	16.15	10.19	
J	8	29° 20.99' N	33° 5.06' E		36.31	47.47	62.18	111.1	203.3						37.27	25.51	30.36	17.16	25.57	5.8
J	9	29° 21.11' N	33° 4.76' E		40.38	28.57	114.3								49.67	30.41	17.48	12.29		
K	1	29° 28.95' N	34° 22.93' E		550.1										3610.6	3.02				
K	2	29° 28.88' N	34° 22.38' E		512.4	353.3									3424.7	3115.2	2214.1			

Table 6.2.3-5 Result of Analysis (TEM Method) (3/3)

Line	Station No.	Latitude	Longitude	Elevation (m)	Depth of boundary 1 (m)	Depth of boundary 2 (m)	Depth of boundary 3 (m)	Depth of boundary 4 (m)	Depth of boundary 5 (m)	Elevation of boundary 1 (m)	Elevation of boundary 2 (m)	Elevation of boundary 3 (m)	Elevation of boundary 4 (m)	Elevation of boundary 5 (m)	Resistivity of #1 Layer (ohm-m)	Resistivity of #2 Layer (ohm-m)	Resistivity of #3 Layer (ohm-m)	Resistivity of #4 Layer (ohm-m)	Resistivity of #5 Layer (ohm-m)	Resistivity of #6 Layer (ohm-m)
K	3	28° 33.38'N	34° 22.05'E		871.1	168.8	397	572							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
K	4	28° 29.61'N	34° 21.69'E		23.79	39.6									[illegible]	[illegible]	[illegible]			
K	5	28° 29.89'N	34° 21.10'E		213.1	264.9									[illegible]	[illegible]	[illegible]			
L	4	28° 37.59'N	34° 19.05'E		60.71										[illegible]	[illegible]				
L	2	28° 37.07'N	34° 19.03'E		87.3										[illegible]	[illegible]				
L	1	28° 36.66'N	34° 18.71'E		92.3										[illegible]	[illegible]				
L	4	28° 35.50'N	34° 19.24'E		164.9										[illegible]	[illegible]				
L	4	28° 35.74'N	34° 18.26'E		140.9										[illegible]	[illegible]				
M	1	28° 30.45'N	34° 29.94'E		62.22	172.6	229.6	451							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
M	2	28° 30.78'N	34° 28.81'E		61.36	163.2	149.1	207.2	312.9						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
M	3	28° 30.91'N	34° 28.62'E		99.45	154.4	194.4	274.5							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
M	4	28° 31.16'N	34° 28.39'E		212.2	202.1	303.9								[illegible]	[illegible]	[illegible]	[illegible]		
M	5	28° 31.47'N	34° 28.49'E		101	135	248	279.9							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
M	6	28° 31.68'N	34° 28.93'E		77.59	176.1	140.1	475.0							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
M	7	28° 31.88'N	34° 28.04'E		149.9	254.0									[illegible]	[illegible]	[illegible]			
M	8	28° 32.22'N	34° 28.06'E		53.37	80.13	175.0								[illegible]	[illegible]	[illegible]	[illegible]		
M	9	28° 32.49'N	34° 28.64'E		59.61	120.4	259.1								[illegible]	[illegible]	[illegible]	[illegible]		
M	10	28° 32.73'N	34° 27.91'E		57.76	49.36	133.4	176.1	271.8						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
M	11	28° 34.23'N	34° 28.21'E		103.9	259.9									[illegible]	[illegible]	[illegible]			
M	12	28° 33.04'N	34° 28.01'E		45.99	82.80	113.3	145.0							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
M	13	28° 33.37'N	34° 28.30'E		45.42	141.9	254.1								[illegible]	[illegible]	[illegible]	[illegible]		
M	14	28° 33.76'N	34° 28.34'E		170.8	207.9									[illegible]	[illegible]	[illegible]			
M	15	28° 33.91'N	34° 28.13'E		135.1	219	254.9								[illegible]	[illegible]	[illegible]	[illegible]		
M	16	28° 34.55'N	34° 28.19'E		126.1	169.3	304.6								[illegible]	[illegible]	[illegible]	[illegible]		
M	17	28° 34.76'N	34° 28.00'E		41.43	122.1	176.8								[illegible]	[illegible]	[illegible]	[illegible]		
M	18	28° 35.72'N	34° 27.77'E		47.31	179.9	197.4								[illegible]	[illegible]	[illegible]	[illegible]		
M	19	28° 36.00'N	34° 27.67'E		195.8	196.5	268.8								[illegible]	[illegible]	[illegible]	[illegible]		
M	20	28° 35.26'N	34° 27.96'E		159.9	209.0	319								[illegible]	[illegible]	[illegible]	[illegible]		
N	1	29° 18.62'N	34° 26.39'E		19.82	52.9	64.1	109.9							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
N	2	29° 18.31'N	34° 26.76'E		25.9	144.2									[illegible]	[illegible]	[illegible]			
N	3	29° 18.15'N	34° 27.38'E		20.46	57.85	78.5	109.5							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
N	4	29° 18.12'N	34° 27.73'E		39.8	195.9									[illegible]	[illegible]	[illegible]			
O	1	29° 19.78'N	34° 31.24'E		36.76	88.20	142.2								[illegible]	[illegible]	[illegible]	[illegible]		
O	2	29° 19.59'N	34° 30.58'E		24.42	38.72	29.75								[illegible]	[illegible]	[illegible]	[illegible]		
O	3	29° 19.07'N	34° 30.38'E		55.91	54.92	307.4	155.5							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
O	4	29° 15.58'N	34° 30.28'E		20.41	44.53	85.6	437							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
P	1	29° 16.50'N	34° 30.31'E		66.85	161.8	361.0	227.4							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
P	2	29° 16.00'N	34° 29.96'E		52.45	51.29	71.46	124.8	159.9						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
P	3	29° 15.50'N	34° 30.00'E		25.86	61.19	115.0								[illegible]	[illegible]	[illegible]	[illegible]		
P	4	29° 14.54'N	34° 30.06'E		66.51	67.4									[illegible]	[illegible]	[illegible]			
Q	1	29° 2.04'N	34° 23.91'E		39.45										[illegible]	[illegible]				
Q	2	29° 2.49'N	34° 24.08'E		76.96	91.67	113.6								[illegible]	[illegible]	[illegible]	[illegible]		
Q	3	29° 2.96'N	34° 24.30'E		109.6	129.6	178.5								[illegible]	[illegible]	[illegible]	[illegible]		
Q	4	29° 3.49'N	34° 24.55'E		27.47	280.9									[illegible]	[illegible]	[illegible]			
Q	6	29° 7.25'N	34° 25.95'E		60.76	179.4									[illegible]	[illegible]	[illegible]			
Q	3	29° 7.34'N	34° 25.65'E		87.64	92.20									[illegible]	[illegible]	[illegible]			
R	1	29° 6.88'N	34° 25.53'E		56.22	99.98	126.9								[illegible]	[illegible]	[illegible]	[illegible]		
R	4	29° 6.62'N	34° 25.37'E		107.9	159.7	202.6								[illegible]	[illegible]	[illegible]	[illegible]		
R	5	29° 6.35'N	34° 25.28'E		39.66										[illegible]	[illegible]				
S	1	28° 14.05'N	33° 36.85'E	18	25.53	30.92	170.5	292.6		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
S	2	28° 18.56'N	33° 37.04'E	20	20.15	36.90	47.85	76.59	120.49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S	3	28° 17.21'N	33° 37.30'E	25	19.75	30.92	41.86	76.10	97.95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S	4	28° 17.74'N	33° 37.51'E	30	20.51	38.14	44.15	77.26		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
S	5	28° 18.28'N	33° 37.78'E	35	21.42	40.22	71.35	246.9		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
S	6	28° 18.72'N	33° 38.05'E	35	27.46	64.52	152.46	391.5		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
S	7	28° 19.23'N	33° 38.31'E	37	16.27	61.56	126.43			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
S	8	28° 19.73'N	33° 38.59'E	39	44.67	77.58	117.2			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		

SOUTH SINAI GROUNDWATER RESOURCES STUDY
IN THE ARAB REPUBLIC OF EGYPT

JULY, 1998 JIC

Line	Station No.	Latitude	Longitude	Elevation (m)	Depth of boundary 1 (m)	Depth of boundary 2 (m)	Depth of boundary 3 (m)	Depth of boundary 4 (m)	Depth of boundary 5 (m)	Elevation of boundary 1 (m)	Elevation of boundary 2 (m)	Elevation of boundary 3 (m)	Elevation of boundary 4 (m)	Elevation of boundary 5 (m)	Resistivity of #1 Layer (ohm-m)	Resistivity of #2 Layer (ohm-m)	Resistivity of #3 Layer (ohm-m)	Resistivity of #4 Layer (ohm-m)	Resistivity of #5 Layer (ohm-m)	Resistivity of #6 Layer (ohm-m)
S	9	28° 20.25'N	33° 38.83'E	45	53.56	85.28	169.9			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
S	10	28° 20.60'N	33° 39.32'E	50	63.59	89.98	174.9			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
S	11	28° 21.08'N	33° 39.73'E	56	46.36	89.25	190.56	172.9		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
S	12	28° 21.47'N	33° 40.11'E	60	72.5	108.5	172.5			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
T	1	28° 14.92'N	33° 45.09'E	160	45	58	47.59	142.45	67.95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
T	2	28° 14.47'N	33° 45.49'E	175	49.7	93.35	172.29			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
T	3	28° 14.00'N	33° 45.83'E	180	44.7	96.10	142.98	172.08		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
T	4	28° 13.63'N	33° 46.12'E	165	42.4	67.4	307.75	160.98		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
T	5	28° 13.15'N	33° 46.52'E	170	67.1	167.64	226.29			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
T	6	28° 12.72'N	33° 46.87'E	170	59.5	84.5	153.4	207.14	267.39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T	7	28° 12.32'N	33° 47.22'E	190	45.7	66.8	114.58	176.54		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
T	8	28° 11.87'N	33° 47.60'E	195	52.8	75.3	159.38	214.76		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
U	1	28° 6.47'N	33° 43.14'E	30	16.59	37.12	49.58			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
U	2	28° 6.77'N	33° 43.80'E	45	21.56	42.14	64.91			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
U	3	28° 7.07'N	33° 44.32'E	60	25.90	51.96	81.5			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
U	4	28° 7.36'N	33° 44.89'E	75	26.97	53.62	62.46			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
U	5	28° 7.65'N	33° 45.63'E	90	32.66	61.07	172.04			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
U	6	28° 7.95'N	33° 45.02'E	110	38.95	64.34	106.939	216.5		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
U	7	28° 8.27'N	33° 45.55'E	120	35.61	38.49	155.57	212.51		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
U	8	28° 8.51'N	33° 47.09'E	135	31.8	49.25	105.75	257.4		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
U	9	28° 8.91'N	33° 48.07'E	140	41.3	78.32	194.62	159.95		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
U	10	28° 9.20'N	33° 48.52'E	180	75.1	445.97	229.38			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
U	11	28° 9.67'N	33° 49.01'E	195	39.7	76.9	101.25	158.9		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
U	12	28° 9.83'N	33° 49.69'E	210	45.4	58.1	95.3	317.72		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
V	1	28° 2.22'N	33° 47.05'E	15	11.64	22.42	39.71	118.1		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
V	2	28° 2.40'N	33° 47.56'E	30	17.54	29.6	38.92			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
V	3	28° 2.65'N	33° 48.05'E	40	25.42	39.05	61.05			[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
V	4	28° 2.74'N	33° 48.72'E	45	15.4	38.96				[illegible]	[illegible]				[illegible]	[illegible]	[illegible]			
V	5	28° 2.91'N	33° 49.32'E	85	29.36	45	90.75	150.38		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
V	6	28° 3.26'N	33° 49.96'E	130	36.32	45.97	78.59	173.71		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
V	7	28° 3.52'N	33° 50.41'E	150	34.1	66.72	92.68	168.92		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
V	8	28° 4.02'N	33° 50.66'E	170	29.2	42.9	71.19	111.35		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Table 6.3.3-1 Result of Analysis (Schlumberger Method) (1/3)

No	LOCATION LONGITUDE deg	'	"	LATITUDE deg	'	"	ELEVATION (m)	Depth of Boundary #1 (m)	#2 (m)	#3 (m)	#4 (m)	#5 (m)	#6 (m)	#7 (m)	Resistivity of Layor #1 (ohm-m)	#2 (ohm-m)	#3 (ohm-m)	#4 (ohm-m)	#5 (ohm-m)	#6 (ohm-m)	#7 (ohm-m)	#8 (ohm-m)
1	33	20	55	29	6	34	500	1.38	5.26	44.05	362.45	655.05			81.95	284.00	72.48	228.00	234.40	3014.90		
2	33	32	17	29	5	30	618	1.33	2.60	32.54	85.67	188.37	702.77		138.20	477.00	189.90	764.60	204.00	4314.70	273.90	
3	33	44	14	28	57	22	802	1.47	5.03	28.51	172.41				148.10	19.43	852.00	156.80	47353.00			
4	33	25	26	28	47	14	270	27.07	518.87						532.90	22.76	224.60					
5	33	33	16	28	58	49	615	6.46	41.56	556.26					123.90	256.10	9209.10	1812.60				
6	33	43	1	28	48	41	1125	8.92	39.86	583.06					92.03	135.30	5817.70	7902.50				
7	33	56	26	28	49	20	1230	1.78	4.32	31.66					321.70	10.04	36601.00	1559.00				
8	34	20	58	28	51	18	835	1.91	6.28	11.39	32.21	106.26			68.57	1115.50	152.10	1388.90	29.94	5208.50		
9	34	10	51	28	49	20	930	4.87	59.45						350.30	75.92	8837.00					
10	34	1	15	29	34	13	745	6.26	14.75	90.91	993.41				135.30	10.37	50.68	12.42	71.36			
11	34	26	0	29	5	34	620	17.55	32.02	2119.02	2485.92				90.32	6.64	222076.10	31910.30	69846.90			
12	34	17	6	29	0	21	770	16.17	40.27	845.67	1351.17				91.49	11.03	460633.20	3628.30	78762.60			
13	34	7	35	28	55	40	940	13.66	24.80	58.48	102.12	2517.82			2006.80	519.60	1086.20	444.80	1660.10	2554.50		
16	34	30	48	29	19	25	650	1.71	5.05	18.91	125.01				109.10	18.59	423.00	12.42	99.55			
17	34	34	52	29	29	39	776	2.62	12.23	137.13	574.53				234.20	57.90	19.34	37.02	174.80			
18	34	35	22	29	33	1	798	5.73	23.96	50.93	110.12	232.52	531.82	891.42	241.30	175.90	43.43	211.90	31.18	157.70	68.12	3998.50
19	34	41	7	29	36	38	710	6.24	74.59	1215.09					515.30	51.27	152.10	12157.50				
20	34	30	49	29	41	21	760	8.11	28.74	239.14					54.85	70.05	10.71	121.20				
21	34	26	29	29	32	21	895	1.00	18.15	89.30	327.30	614.10			850.80	29.71	59.85	134.80	25.83	35486.80		
22	34	17	44	29	23	37	885	1.92	15.01	47.47	569.27				207.30	6.82	49.43	25.12	789.70			
23	34	15	12	29	31	42	700	3.58	26.36	323.06					19.43	47.53	11.88	2133.50				
24	34	17	31	29	40	9	730	1.91	20.65	477.05					792.60	71.20	37.72	505.80				
25	34	7	46	29	43	8	555	1.44	69.00	663.30					638.00	26.09	11.02	46.59				
26	34	9	52	29	34	32	636	3.55	54.39	129.77	309.17				57.77	7.67	24.78	6.40	136.80			
27	34	2	36	29	24	8	822	0.79	40.26	446.66	558.66	1022.06			1342.90	1421.40	44.32	92.40	4.68	432.00		
28	34	4	25	29	15	31	1025	2.57	9.73	44.38	526.18				122.90	30.73	84.92	18.08	39.93			
29	34	2	5	29	9	14	1250	6.14	34.68	538.48	1036.18				409.30	589.20	12.16	38.91	1873.00			
30	33	59	47	29	40	18	565	2.51	12.54	380.54	1015.84				253.90	77.19	34.41	8.04	89.93			
31	33	56	33	29	48	32	475	1.18	27.43	432.73	986.83				20.64	4.86	23.64	12.25	39.94			
32	33	54	42	29	35	59	603	10.24	103.87	168.96	840.86				132.70	11.25	164.40	5.46	293.60			
33	33	57	18	29	30	37	681	3.46	125.06	298.36	571.96				7042.00	85.16	236.50	46.55	19.05			
34	33	56	53	29	26	31	759	5.00	10.01	68.71	608.31				7.52	2.90	27.73	15.79	35.50			
35	33	47	56	29	43	44	515	2.38	9.79	32.03	113.92	875.92			302.40	619.20	24.20	40.53	9.22	180.70		
36	33	44	30	29	37	53	590	2.54	60.50	875.90					50.35	71.10	8.81	22.33				
37	33	47	49	29	29	59	740	1.29	2.43	5.48	132.98	1481.48			314.90	9.22	283.70	14.24	8.74	20.04		
38	33	48	10	29	22	31	830	28.19	70.75	427.35					67.05	119.50	5.02	249.80				
39	33	46	46	29	17	5	940	2.48	13.00	28.59	228.39	1051.49			687.20	69.62	134.40	20.06	12.66	106.00		
40	33	37	3	29	11	9	942	3.14	13.28	33.68	79.67	321.27	719.87		121.50	8.18	157.30	27.32	108.80	41.05	274.60	
41	34	21	35	29	20	54	880	3.72	7.77	25.95	569.85				51.49	3.73	255.00	39.82	530.30			
42	33	45	56	29	53	5	425	17.82	180.62	379.02	967.82				5.17	2.72	37.92	10.00	264.40			
43	33	37	30	29	47	57	455	5.20	54.93	113.18	258.38				90.65	7.81	9.83	4.26	99.28			
44	33	39	28	29	42	54	520	4.01	16.72	42.32	99.04	235.44			20.64	50.41	3.58	36.70	3.83	4340.90		
45	33	28	49	29	36	12	540	1.49	3.64	13.51	58.17	211.97	447.77	784.47	64.24	216.00	5.99	35.28	4.58	37.67	15.62	397.40
46	33	31	53	29	31	6	570	2.38	8.39	25.22	35.86	218.96	437.26		67.21	109.90	13.73	58.05	4.31	97.77	4093.40	
47	33	34	59	29	18	4	725	3.55	134.15	1493.95					283.00	13.03	49.68	1851.40				
48	33	33	14	29	56	26	435	2.31	4.87	14.15	166.25	458.65	1393.65		89.43	12.02	73.78	12.41	64.04	16.90	494.00	
49	33	30	54	29	45	38	505	2.19	8.26	285.56					9.95	23.23	3.06	24785.30				
50	33	21	17	29	59	19	425	3.26	5.61	174.41					55.71	180.10	5.10	110.30				
51	33	21	4	29	51	9	430	4.29	52.56	127.09	252.99				50.01	9.39	6.98	15.73	64.19			
52	33	22	40	29	42	33	618	7.57	379.17						18.86	10.17	1647.30					
53	33	14	43	29	42	5	660	1.47	9.82	499.52					67.85	164.49	10.71	665.10				
54	33	13	12	29	34	6	620	1.08	24.76	86.98	314.68				214.30	6.05	123.20	7.91	332.20			
55	33	19	7	29	27	55	685	4.45	14.24	43.02	98.71	1227.51			96.71	25.17	131.50	24.87	64.94	246.20		
56	33	25	18	29	24	17	705	4.30	20.22	76.86	407.96				26.71	4.49	22.95	18.04	601.40			
57	33	27	7	29	19	59	800	3.70	13.79	33.14	90.64	1241.14			111.70	166.70	45.97	101.10	52.35	724.70		
58	33	33	44	29	25	2	630	3.46	14.77	60.13	206.93				97.18	4.22	20.05	4.33	178.70			
59	33	11	20	29	56	6	490	2.32	10.58	49.87	246.77				483.30	30.38	15.08	41.90	444.80			
60	33	8	10	29	48	24	440	9.25	27.70	61.68	253.08	853.18			12.87	17.98	11.34	140.60	37.47	475.10		
61	34	9	53	29	12	23	1115	2.45	8.74	25.59	371.99	2139.49			405.40	130.10	311.80	135.60	15.35	56.70		
62	34	9	55	29	1	25	892	3.69	33.04	125.08	503.58				244.60	143.00	8.48	126.30	366.60			
63	34	21	57	29	9	9	690	2.11	22.43	53.34	115.71	583.91			535.00	139.70	168.10	70.71	1404.30	5608.60		

Table 6.3.3-1 Result of Analysis
(Schlumberger Method)) (2/3)

No	LOCATION LONGITUDE			LATTITUDE			ELEVATION	Elevation of Boundary							Resistivity of Layor							
	deg	'	"	deg	'	"	(m)	#1 (m)	#2 (m)	#3 (m)	#4 (m)	#5 (m)	#6 (m)	#7 (m)	#1 (ohm-m)	#2 (ohm-m)	#3 (ohm-m)	#4 (ohm-m)	#5 (ohm-m)	#6 (ohm-m)	#7 (ohm-m)	#8 (ohm-m)
1	33	20	35	29	6	34	500	498.62	494.74	455.95	157.55	-155.05			81.95	284.00	72.48	228.00	234.40	3014.90		
2	33	32	17	29	5	30	618	616.67	615.40	585.46	532.33	429.63	-84.77		138.20	477.00	189.90	764.60	204.00	4314.70	273.90	
3	33	44	14	28	57	22	802	800.53	796.97	773.49	629.59				148.10	19.43	852.00	156.80	47353.00			
4	33	25	26	28	47	14	270	242.93	-248.87						532.90	22.76	224.60					
5	33	33	16	28	58	49	615	608.54	573.44	58.74					123.90	256.10	9209.10	1812.60				
6	33	43	1	28	48	41	1125	1116.08	1085.14	541.94					92.03	135.30	5817.70	7902.50				
7	33	56	26	28	49	20	1230	1228.22	1225.68	1198.34					321.70	10.04	36601.00	1559.00				
8	34	20	58	28	51	18	835	833.09	828.72	823.61	802.79	728.74			68.57	1115.50	152.10	1388.90	29.94	5208.50		
9	34	10	51	28	49	20	930	925.13	870.55						350.30	75.92	8837.00					
10	34	1	15	29	34	13	745	738.74	730.25	654.09	-248.41				135.30	10.37	50.68	12.42	71.36			
11	34	26	0	29	5	34	620	602.45	587.98	-1499.02	-1865.92				90.32	6.64	222076.10	31910.30	69846.90			
12	34	17	6	29	0	21	770	753.83	729.73	-75.67	-581.17				91.49	11.03	460633.20	3628.30	78762.60			
13	34	7	35	28	55	40	940	926.34	915.20	881.52	837.88	-1577.82			2006.80	519.60	1086.20	444.80	1660.10	2554.50		
16	34	30	48	29	19	25	650	648.29	644.95	631.09	524.99				109.10	18.59	423.00	12.42	99.55			
17	34	34	52	29	29	39	776	773.38	763.77	638.87	201.47				234.20	57.90	19.34	37.02	174.80			
18	34	35	22	29	33	1	798	792.27	774.04	747.07	687.88	565.48	266.18	-93.42	241.30	175.90	43.43	211.90	31.18	157.70	68.12	3998.50
19	34	41	7	29	36	38	710	703.76	635.41	-505.09	-505.09				515.30	51.27	152.10	12157.50				
20	34	30	49	29	41	21	760	751.89	731.26	520.86					54.85	70.05	10.71	121.20				
21	34	26	29	29	32	21	895	894.00	876.85	805.70	567.70	280.90			850.80	29.71	59.85	134.80	25.83	35486.80		
22	34	17	44	29	23	37	885	883.08	869.99	837.53	315.73				207.30	6.82	49.43	25.12	789.70			
23	34	15	12	29	31	42	700	696.42	673.64	376.94	376.94	376.94	376.94		19.43	47.53	11.88	2133.50				
24	34	17	31	29	40	9	730	728.09	709.35	252.95					792.60	71.20	37.72	505.80				
25	34	7	46	29	43	8	555	553.56	486.00	-108.30					638.00	26.09	11.02	46.59				
26	34	9	32	29	34	32	636	632.45	581.61	506.23	326.83				57.77	7.67	24.78	6.40	136.80			
27	34	2	36	29	24	8	822	821.21	781.74	375.34	263.34	-200.06			1342.90	1421.40	44.32	92.40	4.68	432.00		
28	34	4	25	29	15	31	1025	1022.43	1015.27	980.62	498.82				122.90	30.73	84.92	18.08	39.93			
29	34	2	5	29	9	14	1250	1243.86	1215.32	711.52	213.82				409.30	589.20	12.16	38.91	1873.00			
30	33	59	47	29	40	18	565	562.49	552.46	184.46	-450.84				253.90	77.19	34.41	8.04	89.93			
31	33	56	33	29	48	32	475	473.82	447.57	42.27	-511.83				20.64	4.86	23.64	12.25	39.94			
32	33	54	42	29	35	59	603	592.76	499.13	434.04	-237.86				132.70	11.25	164.40	5.46	293.60			
33	33	57	18	29	30	37	681	677.54	555.94	382.64	109.04				7042.00	85.16	236.50	46.55	19.05			
34	33	56	53	29	26	31	759	754.00	748.99	690.29	150.69				7.52	2.90	27.73	15.79	35.50			
35	33	47	56	29	43	44	515	512.62	505.21	482.97	401.08	-360.92			302.40	619.20	24.20	40.53	9.22	180.70		
36	33	44	30	29	37	53	590	587.46	529.50	-285.90					50.35	71.10	8.81	22.33				
37	33	47	49	29	29	59	740	738.71	737.57	734.52	607.02	-741.48			314.90	9.22	283.70	14.24	8.74	20.04		
38	33	48	10	29	22	31	830	801.81	759.25	402.65					67.05	119.50	5.02	249.80				
39	33	46	46	29	17	5	940	937.52	927.00	901.41	711.61	-111.49			687.20	69.62	134.40	20.06	12.66	106.00		
40	33	37	3	29	11	9	942	938.86	928.72	908.32	862.33	620.73	222.13		121.50	8.18	157.30	27.32	108.80	41.05	274.60	
41	34	21	35	29	20	54	880	876.28	872.23	854.05	310.15				51.49	3.73	255.00	39.82	530.30			
42	33	45	56	29	53	5	425	407.18	244.38	45.98	-542.87				5.17	2.72	37.92	10.00	264.40			
43	33	37	30	29	47	57	455	449.80	400.07	341.82	196.62				90.65	7.81	9.83	4.26	99.28			
44	33	39	28	29	42	54	520	515.99	503.28	477.68	420.96	284.56			20.64	50.41	3.58	36.20	3.83	4340.90		
45	33	28	49	29	36	12	540	538.51	536.36	526.49	481.83	328.03	92.23	-244.47	64.24	216.00	5.99	35.28	4.58	37.67	15.62	397.40
46	33	31	53	29	31	6	570	567.62	561.61	544.78	534.14	351.04	132.74		67.21	109.90	13.73	58.05	4.31	97.77	4093.40	
47	33	34	59	29	18	4	725	721.45	590.85	-768.95					283.00	13.03	49.68	1851.40				
48	33	33	14	29	56	26	435	432.69	430.13	420.85	268.75	-23.65	-958.65		89.43	12.02	73.78	12.41	64.04	16.90	494.00	
49	33	30	54	29	45	38	505	502.81	496.74	219.44					9.95	23.23	3.06	24785.30				
50	33	21	17	29	59	19	425	421.74	419.39	250.59					55.71	180.10	5.10	110.30				
51	33	21	4	29	51	9	430	425.71	377.44	302.91	177.01				50.01	9.39	6.98	15.73	64.19			
52	33	22	40	29	42	33	618	610.43	238.83						18.86	10.17	1647.30					
53	33	14	43	29	42	5	660	658.53	650.18	160.48					67.85	164.40	10.71	665.10				
54	33	13	12	29	34	6	620	618.92	595.24	533.02	305.32				214.30	6.05	123.20	7.91	332.20			
55	33	19	7	29	27	55	685	680.55	670.76	641.98	586.29	-542.51			96.71	25.17	131.50	24.87	64.94	246.20		
56	33	25	18	29	24	17	705	700.70	684.78	628.14	297.04				26.71	4.49	22.95	18.04	601.40			
57	33	27	7	29	19	59	800	796.30	786.21	766.86	709.36	-441.14			111.70	166.70	45.97	101.10	52.35	724.70		
58	33	33	44	29	25	2	630	626.54	615.23	569.87	423.07				97.18	4.22	20.05	4.33	178.70			
59	33	11	20	29	56	6	490	487.68	479.42	440.13	243.23				483.30	30.38	15.08	41.90	444.80			
60	33	8	10	29	48	24	440	430.75	412.30	378.32	186.92				12.87	17.98	11.34	140.60	37.47	475.10		
61	34	9	53	29	12	23	1115	1112.55	1106.26	1089.41	743.01	-1024.49			405.40	130.10	311.80	135.60	15.35	56.70		
62	34	9	55	29	1	25	892	888.31	858.96	766.92	388.42				244.60	143.00	8.48	126.30	366.60			
63	34	21	57	29	9	9	690	687.89	667.57	636.66	574.29	106.09			535.00	139.70	168.10	70.71	1404.30	5608.60		

Table 6.3.3-1 Result of Analysis (Schlumberger Method)) (3/3)

No.	LOCATION LONGITUDE deg	'	"	LATITUDE deg	'	"	ELEVATION (m)	Thickness of Layer #1 (m)	#2 (m)	#3 (m)	#4 (m)	#5 (m)	#6 (m)	#7 (m)	Resistivity of Layer #1 (ohm-m)	#2 (ohm-m)	#3 (ohm-m)	#4 (ohm-m)	#5 (ohm-m)	#6 (ohm-m)	#7 (ohm-m)	#8 (ohm-m)
1	33	20	55	29	6	34	500	1.38	3.88	38.79	318.4	292.6			81.95	284	72.48	228	234.4	3014.9		
2	33	32	17	29	5	30	618	1.33	1.27	29.94	53.13	102.7	514.4		138.2	477	189.9	764.6	204	4314.7	273.9	
3	33	44	14	28	57	22	802	1.47	3.56	23.48	143.9				148.1	19.43	852	156.8	47353			
4	33	25	26	28	47	14	270	27.07	491.8						532.9	22.76	224.6					
5	33	33	16	28	58	49	615	6.46	35.1	514.7					123.9	256.1	9209.1	1812.6				
6	33	43	1	28	48	41	1125	8.92	30.94	543.2					92.03	135.3	5817.7	7902.5				
7	33	56	26	28	49	20	1230	1.78	2.54	27.34					321.7	10.04	36601	1559				
8	34	20	58	28	51	18	835	1.91	4.37	5.11	20.82	74.05			68.57	1115.5	152.1	1388.9	29.94	5208.5		
9	34	10	51	28	49	20	930	4.87	54.58						350.3	75.92	8837					
10	34	1	15	29	34	13	745	6.26	8.49	76.16	902.5				135.3	10.37	50.68	12.42	71.36			
11	34	26	0	29	5	34	620	17.55	14.47	2087	366.9				90.32	6.64	222076.1	31910.3	69846.9			
12	34	17	6	29	0	21	770	16.17	24.1	805.6	505.5				91.49	11.03	460633.2	3628.3	78762.6			
13	34	7	35	28	55	40	940	13.66	11.14	33.68	43.64	2415.7			2006.8	519.6	1086.2	444.8	1660.1	2554.5		
16	34	30	48	29	19	25	650	1.71	3.34	13.86	106.1				109.1	18.59	423	12.42	99.55			
17	34	34	52	29	29	39	776	2.62	9.61	124.9	437.4				234.2	57.9	19.34	37.02	174.8			
18	34	35	22	29	33	1	798	5.73	18.23	26.97	59.19	122.4	299.3	359.6	241.3	175.9	43.43	211.9	31.18	157.7	68.12	3998.5
19	34	41	7	29	36	38	710	6.24	68.35	1140.5					515.3	51.27	152.1	12157.5				
20	34	30	49	29	41	21	760	8.11	20.63	210.4					54.85	70.05	10.71	121.2				
21	34	26	29	29	32	21	895	1	17.15	71.15	238	286.8			850.8	29.71	59.85	134.8	25.83	35486.8		
22	34	17	44	29	23	37	885	1.92	13.09	32.46	521.8				207.3	6.82	49.43	25.12	789.7			
23	34	15	12	29	31	42	700	3.58	22.78	296.7					19.43	47.53	11.88	2133.5				
24	34	17	31	29	40	9	730	1.91	18.74	456.4					792.6	71.2	37.72	505.8				
25	34	7	46	29	43	8	555	1.44	67.56	594.3					638	26.09	11.02	46.59				
26	34	9	52	29	34	32	636	3.55	50.84	75.38	179.4				57.77	7.67	24.78	6.4	136.8			
27	34	2	36	29	24	8	822	0.791	39.47	406.4	112	463.4			1342.9	1421.4	44.32	92.4	4.68	432		
28	34	4	25	29	15	31	1025	2.57	7.16	34.65	481.8				122.9	30.73	84.92	18.08	39.93			
29	34	2	5	29	9	14	1250	6.14	28.54	503.8	497.7				409.3	589.2	12.16	38.91	1873			
30	33	59	47	29	40	18	565	2.51	10.03	368	635.3				253.9	77.19	34.41	8.04	89.93			
31	33	56	33	29	48	32	475	1.18	26.25	405.3	554.1				20.64	4.86	23.64	12.25	39.94			
32	33	54	42	29	35	59	603	10.24	93.63	65.09	671.9				132.7	11.25	164.4	5.46	293.6			
33	33	57	18	29	30	37	681	3.46	121.6	173.3	273.6				7042	85.16	236.5	46.55	19.05			
34	33	56	53	29	26	31	759	5	5.01	58.7	539.6				7.52	2.9	27.73	15.79	35.5			
35	33	47	56	29	43	44	515	2.38	7.41	22.24	81.89	762			302.4	619.2	24.2	40.53	9.22	180.7		
36	33	44	30	29	37	53	590	2.54	57.96	815.4					50.35	71.1	8.81	22.33				
37	33	47	49	29	29	59	740	1.29	1.14	3.05	127.5	1348.5			314.9	9.22	283.7	14.24	8.74	20.04		
38	33	48	10	29	22	31	830	28.19	42.56	356.6					67.05	119.5	5.02	249.8				
39	33	46	46	29	17	5	940	2.48	10.52	25.59	189.8	823.1			687.2	69.62	134.4	20.06	12.66	106		
40	33	37	3	29	11	9	942	3.14	10.14	20.4	45.99	241.6	398.6		121.5	8.18	157.3	27.32	108.8	41.05	274.6	
41	34	21	35	29	20	54	880	3.72	4.05	18.18	543.9				51.49	3.73	255	39.82	530.3			
42	33	45	56	29	53	5	425	17.82	162.8	198.4	588.8				5.17	2.72	37.92	10	264.4			
43	33	37	30	29	47	57	455	5.2	49.73	58.25	145.2				90.65	7.81	9.83	4.26	99.28			
44	33	39	28	29	42	54	520	4.01	12.71	25.6	56.72	136.4			20.64	50.41	3.58	36.2	3.83	4340.9		
45	33	28	49	29	36	12	540	1.49	2.15	9.87	44.66	153.8	235.8	336.7	64.24	216	5.99	35.28	4.58	37.67	15.62	397.4
46	33	31	53	29	31	6	570	2.38	6.01	16.83	10.64	183.1	218.3		67.21	109.9	13.73	58.05	4.31	97.77	4093.4	
47	33	34	59	29	18	4	725	3.55	130.6	1359.8					283	13.03	49.68	1851.4				
48	33	33	14	29	56	26	435	2.31	2.56	9.28	152.1	292.4	935		89.43	12.02	73.78	12.41	64.04	16.9	494	
49	33	30	54	29	45	38	505	2.19	6.07	277.3					9.95	23.23	3.06	24785.3				
50	33	21	17	29	59	19	425	3.26	2.35	168.8					55.71	180.1	5.1	110.3				
51	33	21	4	29	51	9	430	4.29	48.27	74.53	125.9				50.01	9.39	6.98	15.73	64.19			
52	33	22	40	29	42	33	618	7.57	371.6						18.86	10.17	1647.3					
53	33	14	43	29	42	5	660	1.47	8.35	489.7					67.85	164.4	10.71	665.1				
54	33	13	12	29	34	6	620	1.08	23.68	62.22	277.7				214.3	6.05	123.2	7.91	332.2			
55	33	19	7	29	27	55	685	4.45	9.79	28.78	55.69	1128.8			96.71	25.17	131.5	24.87	64.94	246.2		
56	33	25	18	29	24	17	705	4.3	15.92	56.64	331.1				26.71	4.49	22.95	18.04	601.4			
57	33	27	7	29	19	59	800	3.7	10.09	19.35	57.5	1150.5			111.7	166.7	45.97	101.1	52.35	724.7		
58	33	33	44	29	25	2	630	3.46	11.31	45.36	146.8				97.18	4.22	20.05	4.33	178.7			
59	33	11	20	29	36	6	490	2.32	8.26	39.29	196.9				483.3	30.38	15.08	41.9	444.8			
60	33	8	10	29	48	24	440	9.25	18.45	33.98	191.4	600.1			12.87	17.98	11.34	140.6	37.47	475.1		
61	34	9	53	29	12	23	1115	2.45	6.29	16.85	346.4	1767.5			405.4	130.1	311.8	135.6	15.35	56.7		
62	34	9	55	29	1	25	892	3.69	29.35	92.04	378.5				244.6	143	8.48	126.3	366.6			
63	34	21	57	29	9	9	690	2.11	20.32	30.91	62.37	468.2			535	139.7	168.1	70.71	1404.3	5608.6		

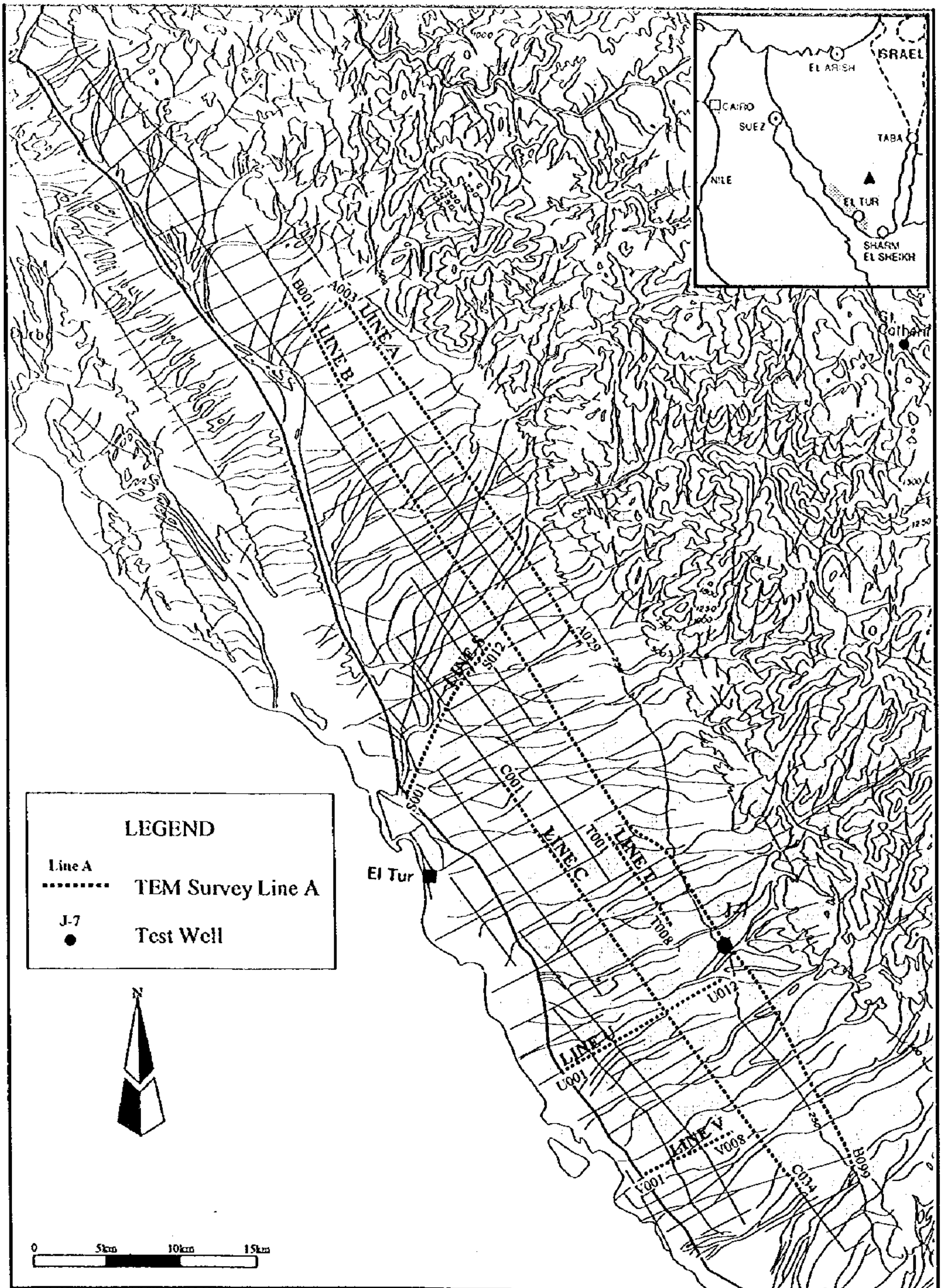

Fig. 6.2.3-1 TEM Survey Location (El Qaa Plain)

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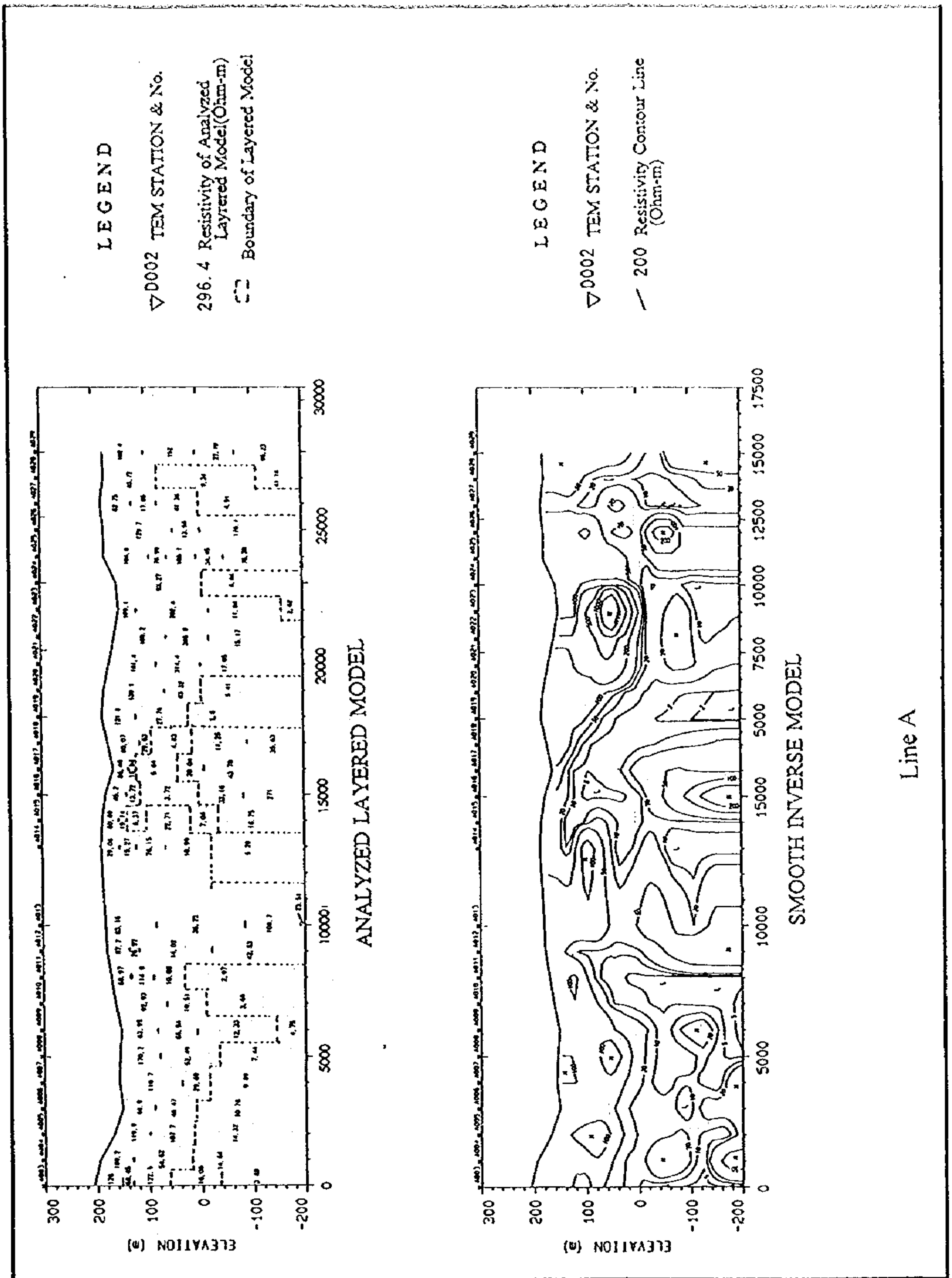

Fig. 6.2.3-2(1) Geoelectric Profile (Line A : El Qaa Plain)

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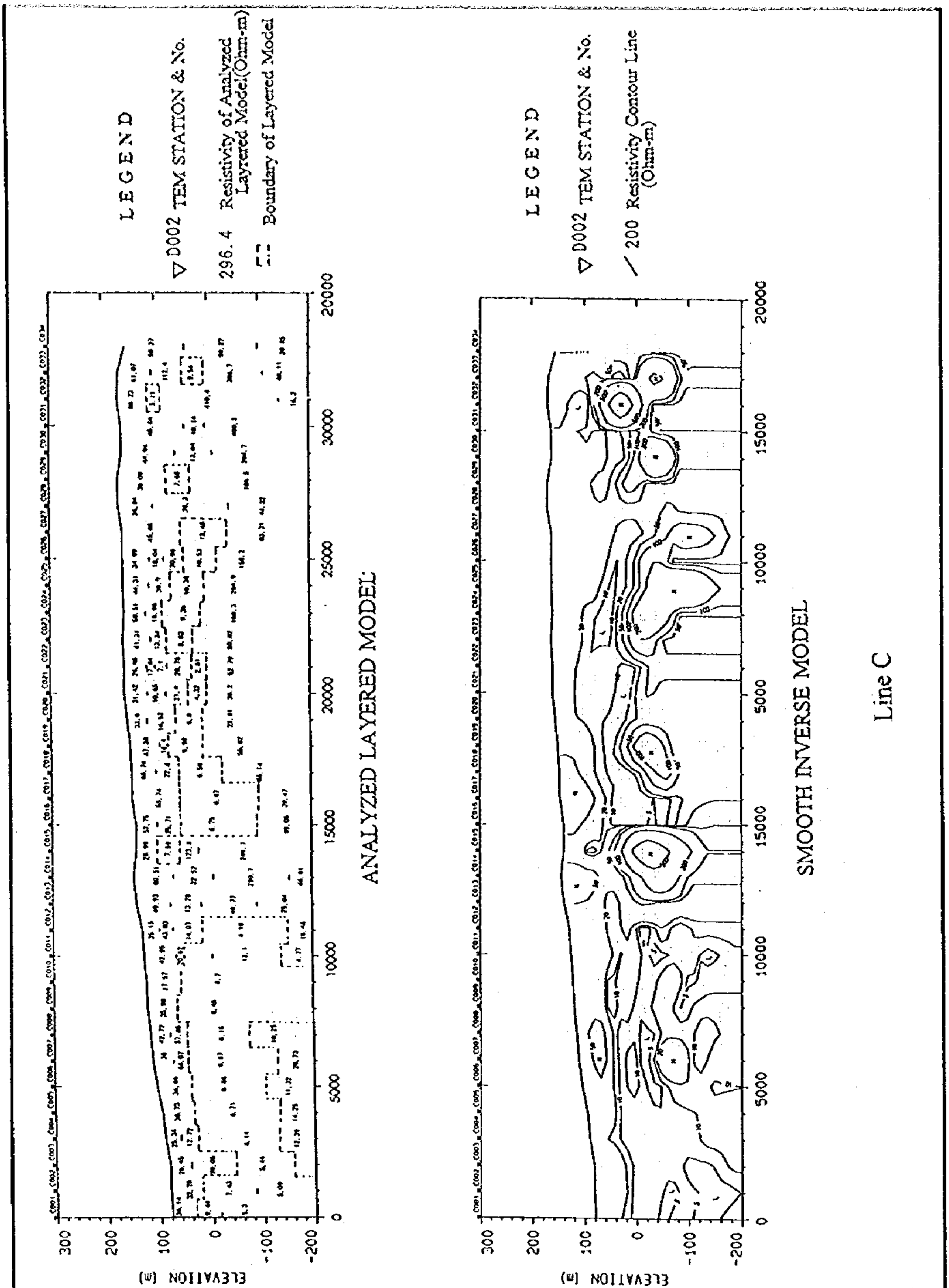

Fig. 6.2.3-2(2) Geoelectric Profile (Line C : El Qaa Plain)

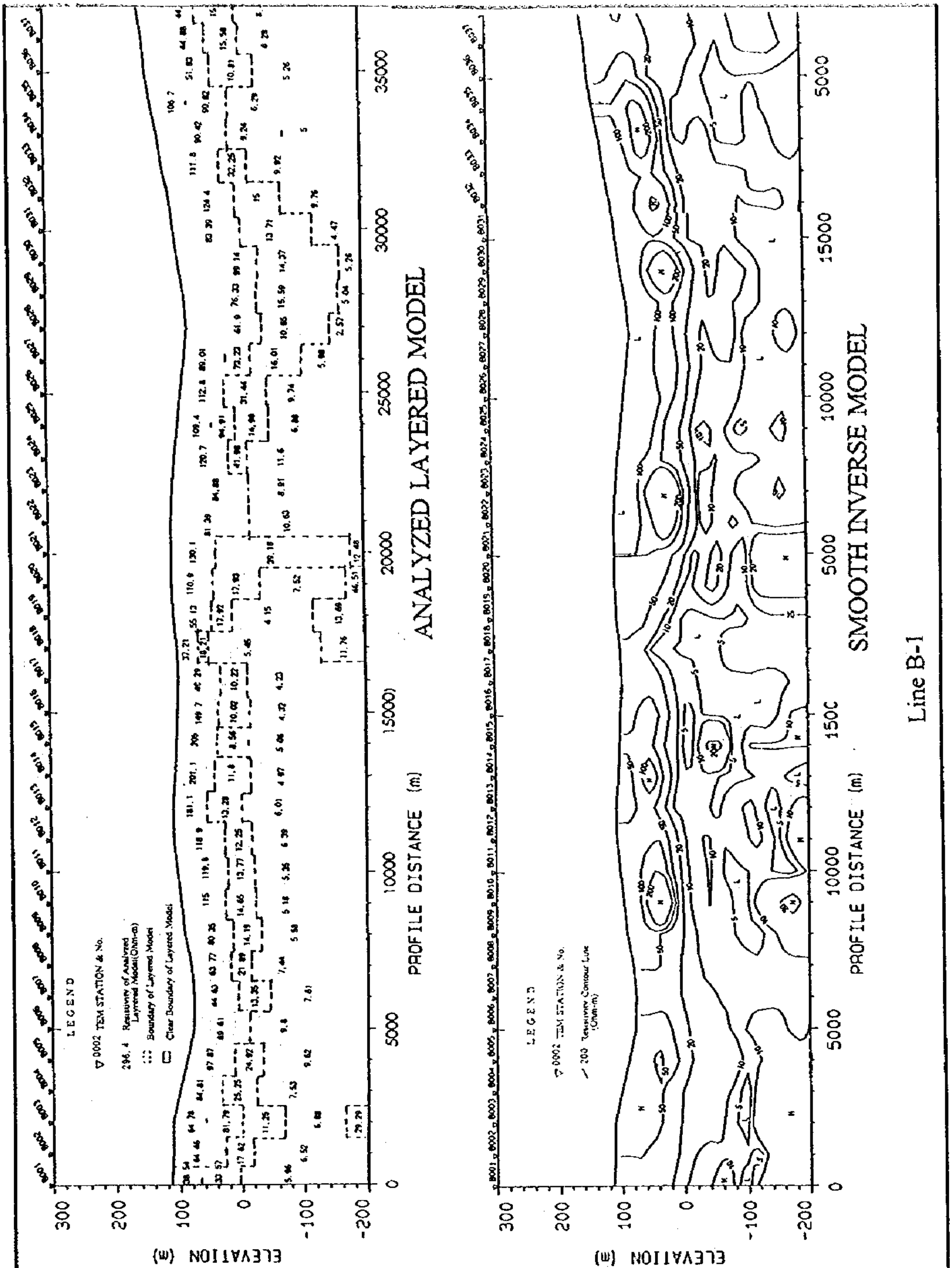

Fig. 6.2.3-3 Geoelectric Profile (Line B : El Qaa Plain)(1/2)

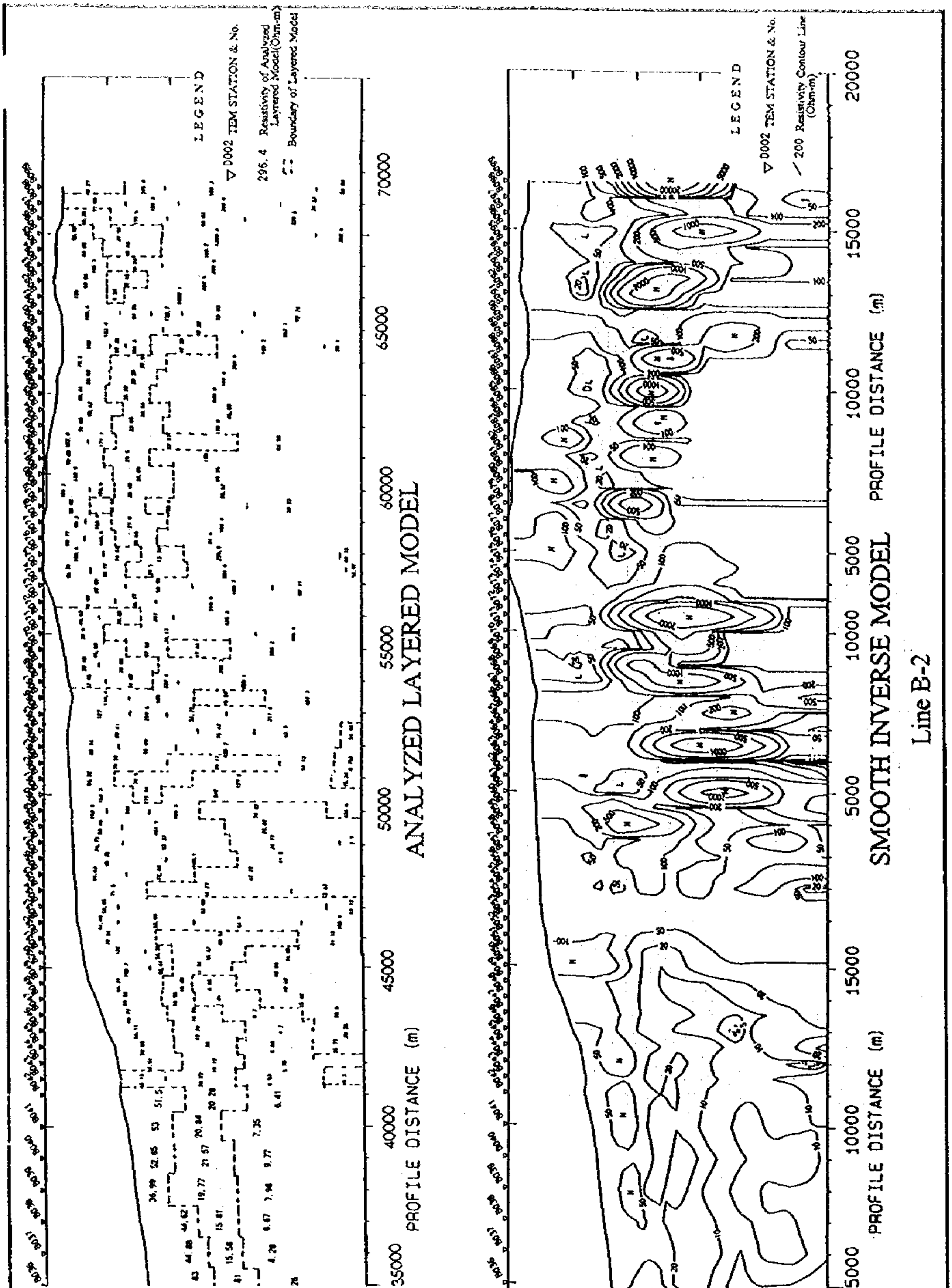

Fig. 6.2.3-3 Geoelectric Profile (Line B : El Qaa Plain) (2/2)

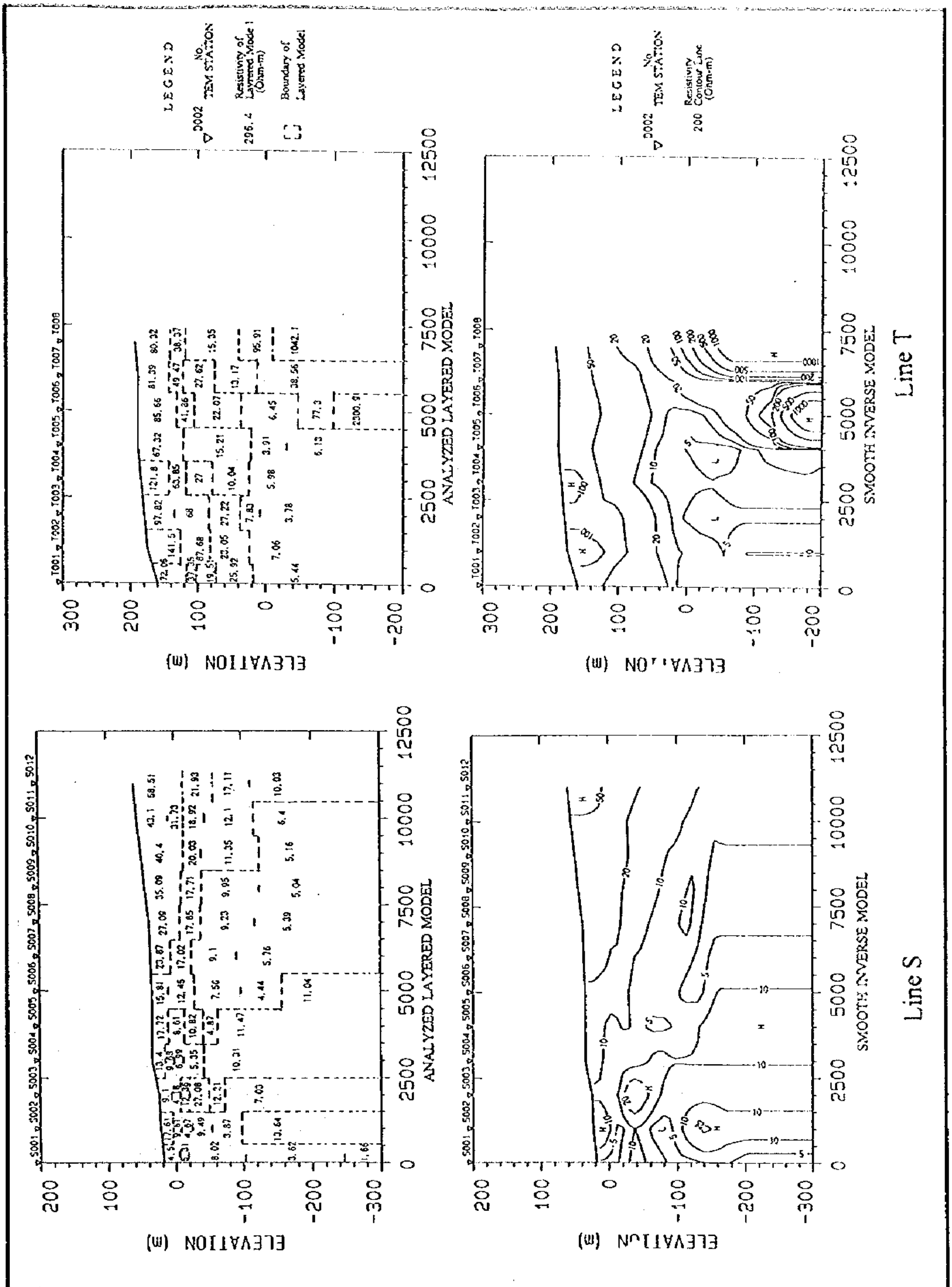

Fig. 6.2.3-4 (1) Geoelectric Profile (Line S and T : El Qaa Plain)

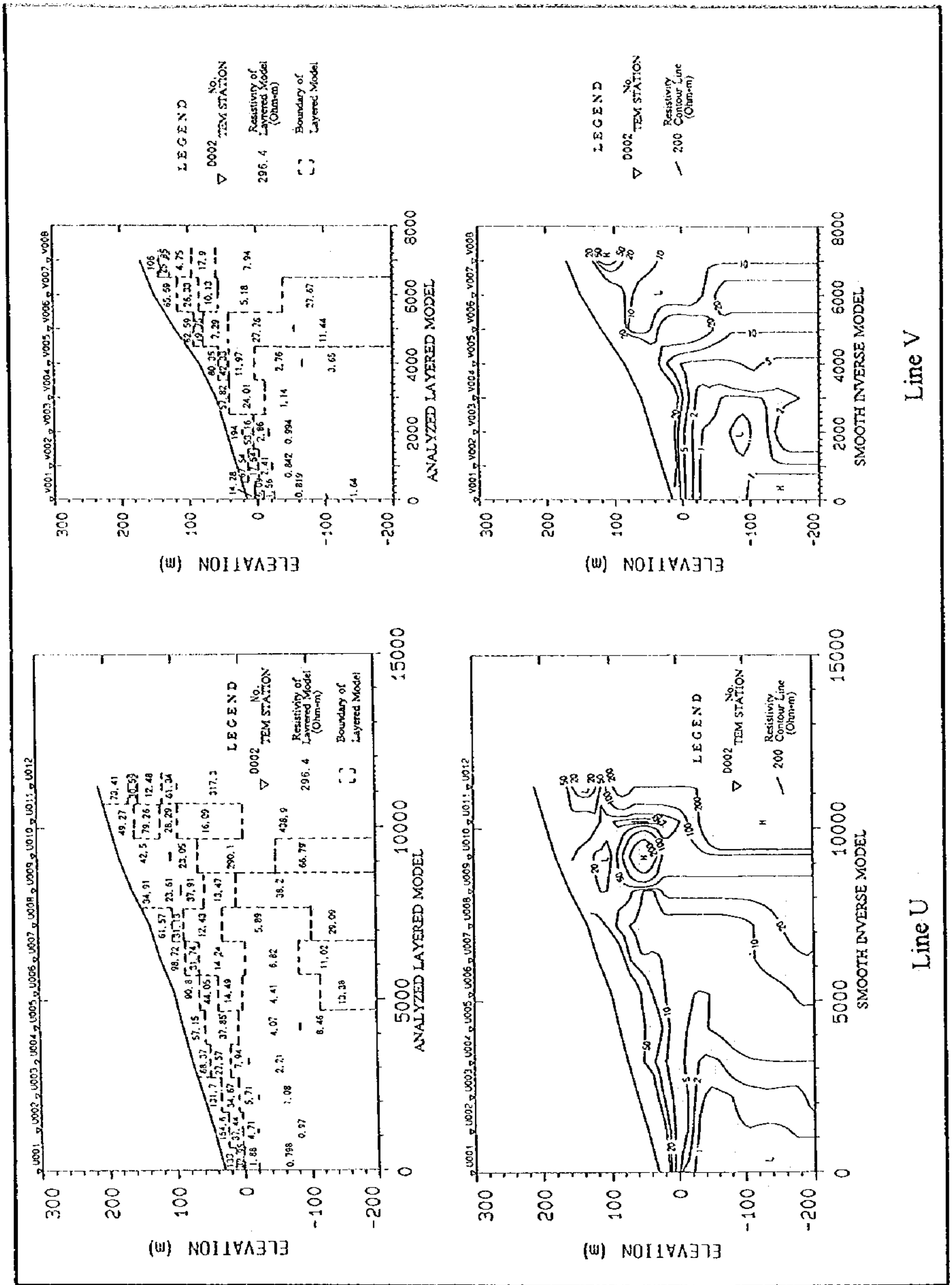

Fig. 6.2.3-4 (2) Geoelectric Profile (Line U and V : El Qaa Plain)

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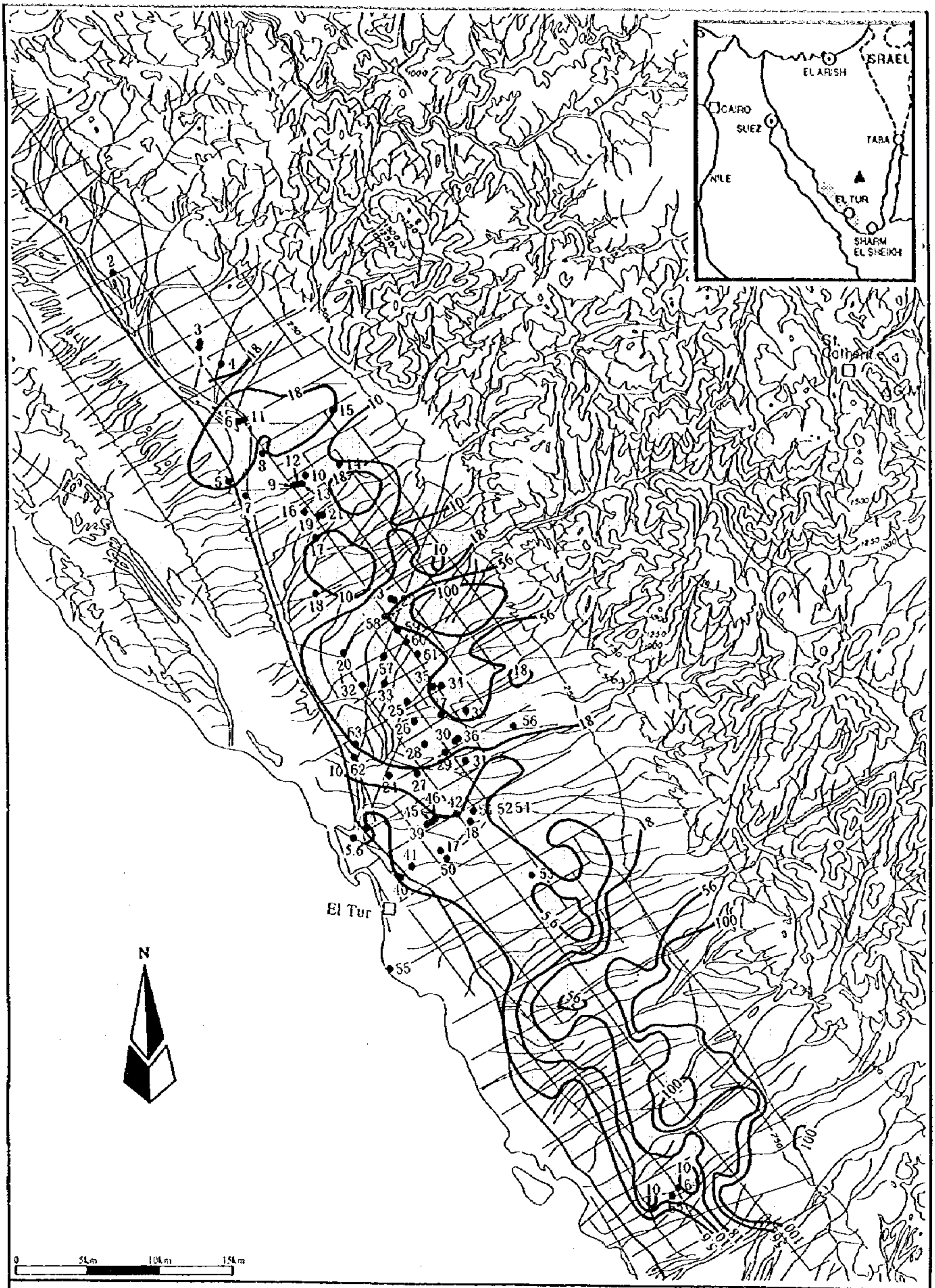

Fig. 6.2.3-5 Resistivity Contour at Sea Level (El Qaa Plain)

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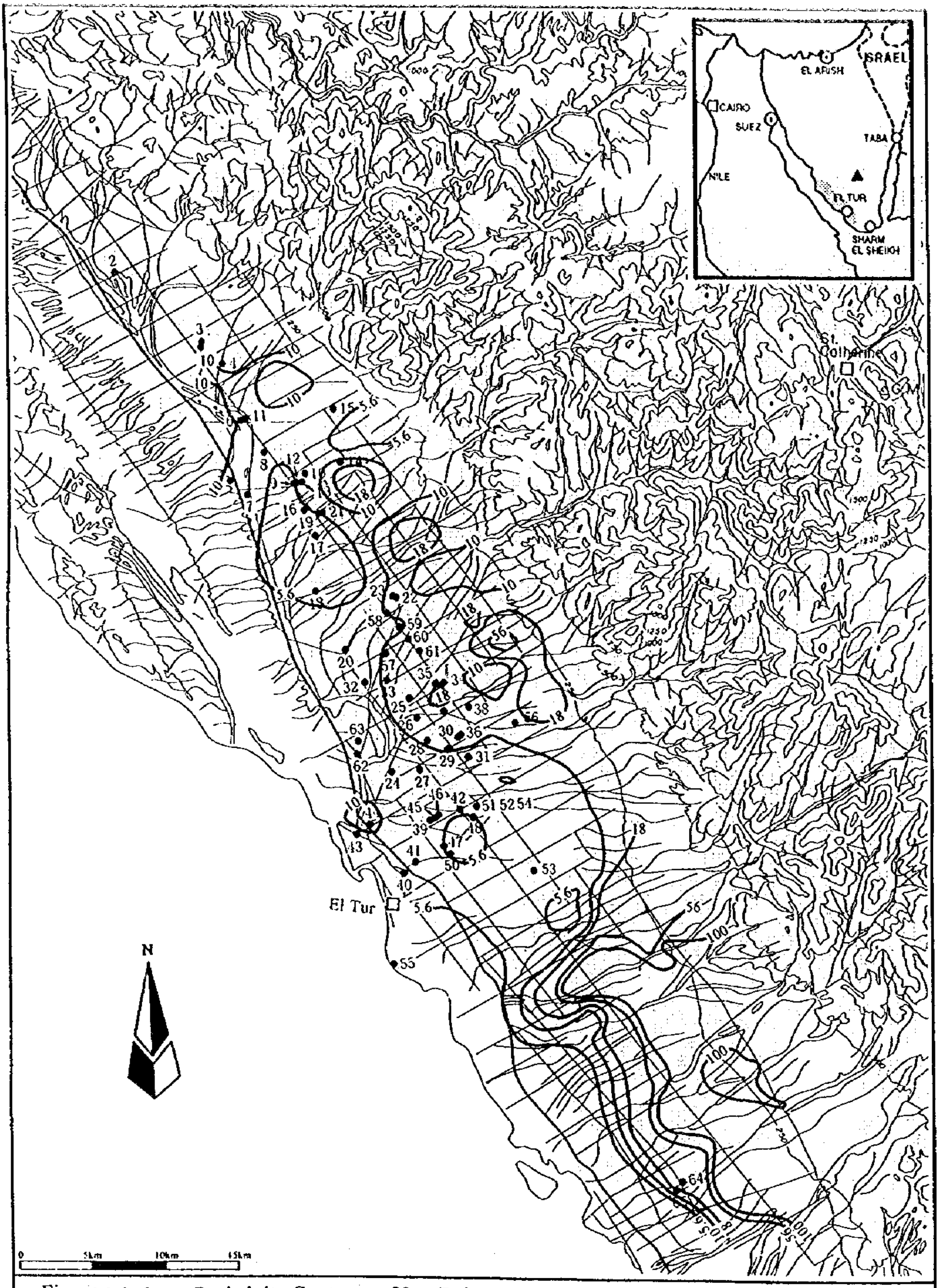

Fig. 6.2.3-6 Resistivity Contour at 50 m Below Sea Level (El Qaa Plain)

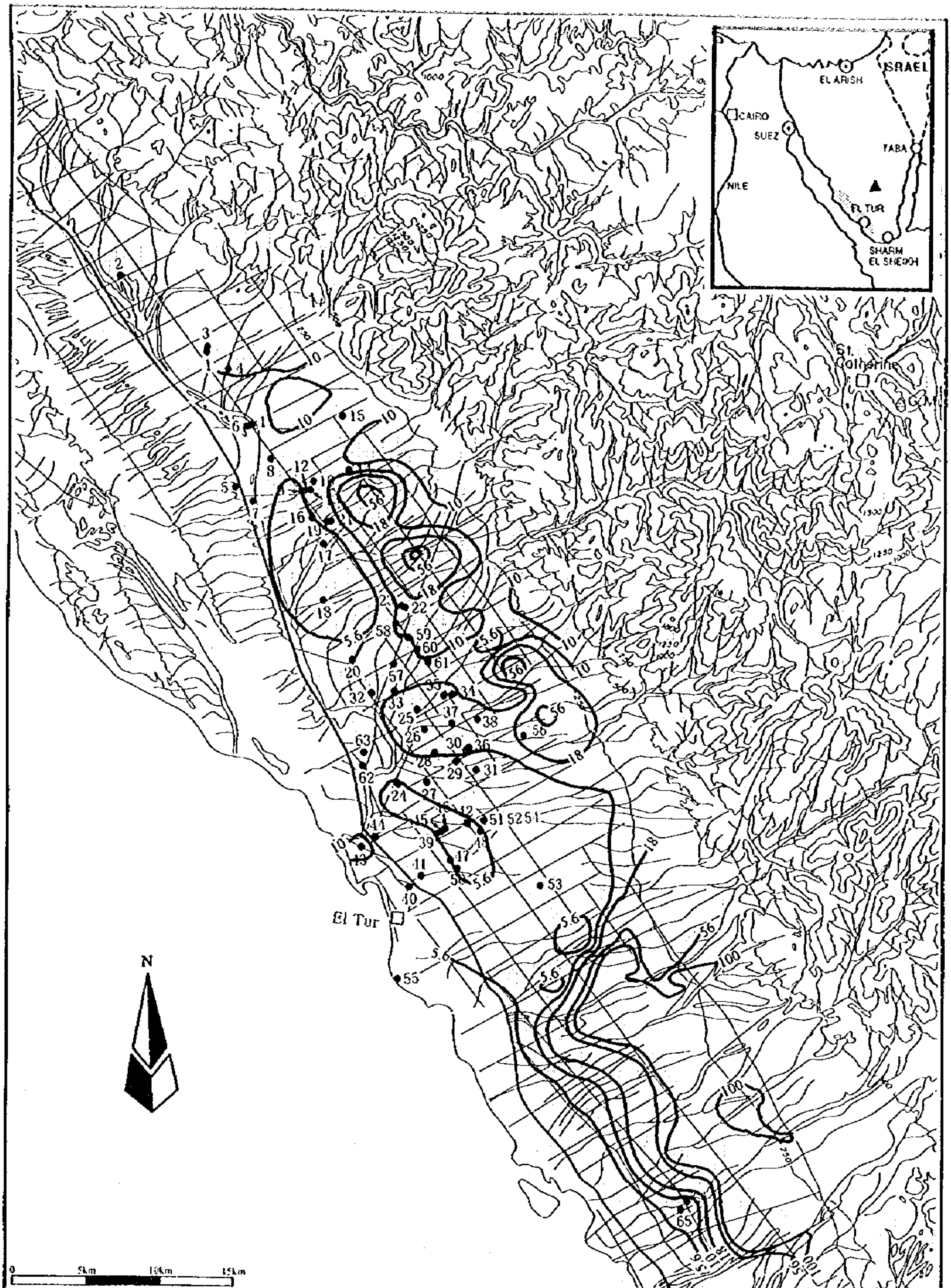

Fig. 6.2.3-7 Resistivity Contour at 100 m Below Sea Level (El Qaa Plain)

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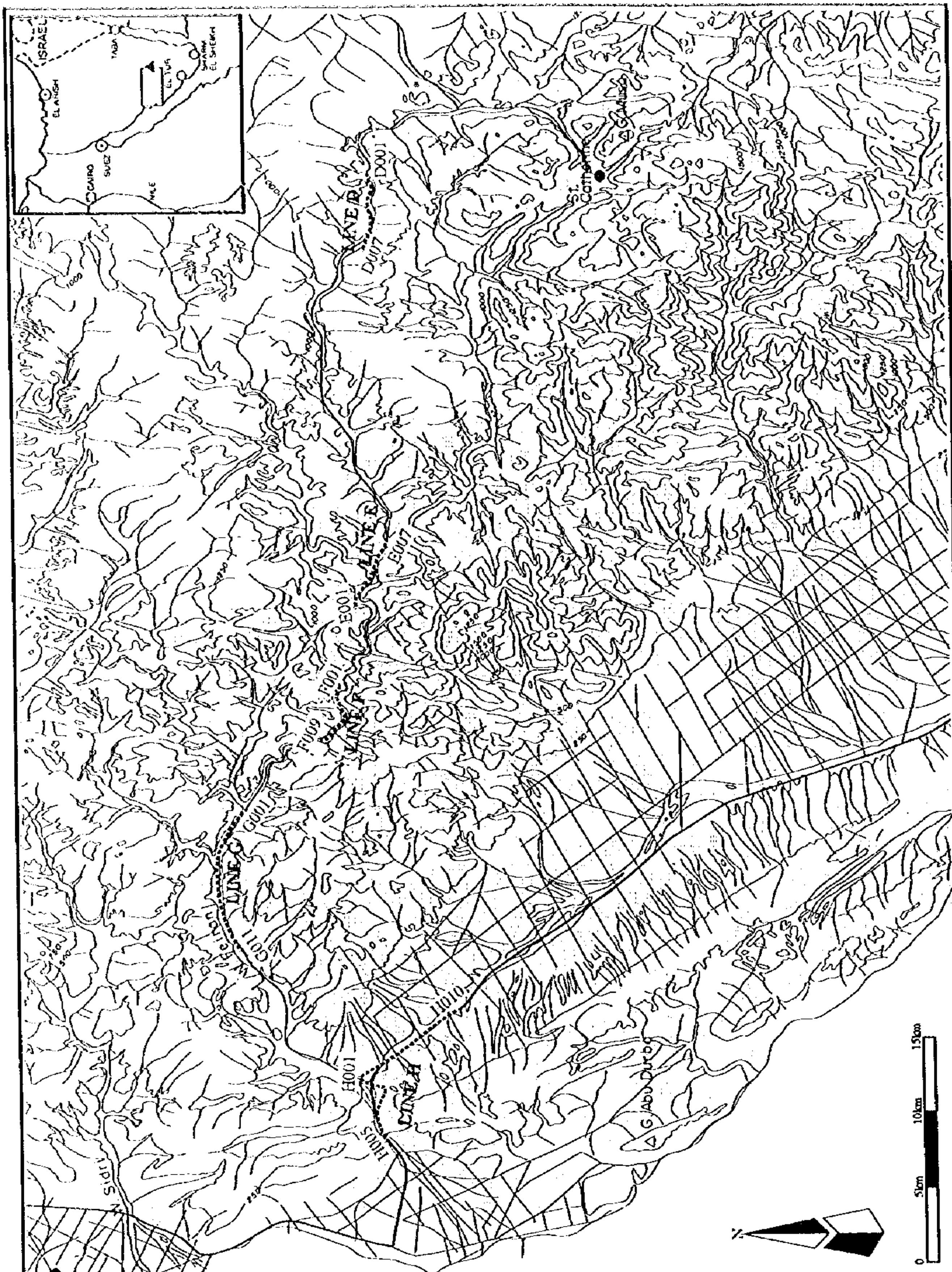

Fig. 6.2.3-8 TEM Survey Location (Wadi Feiran)

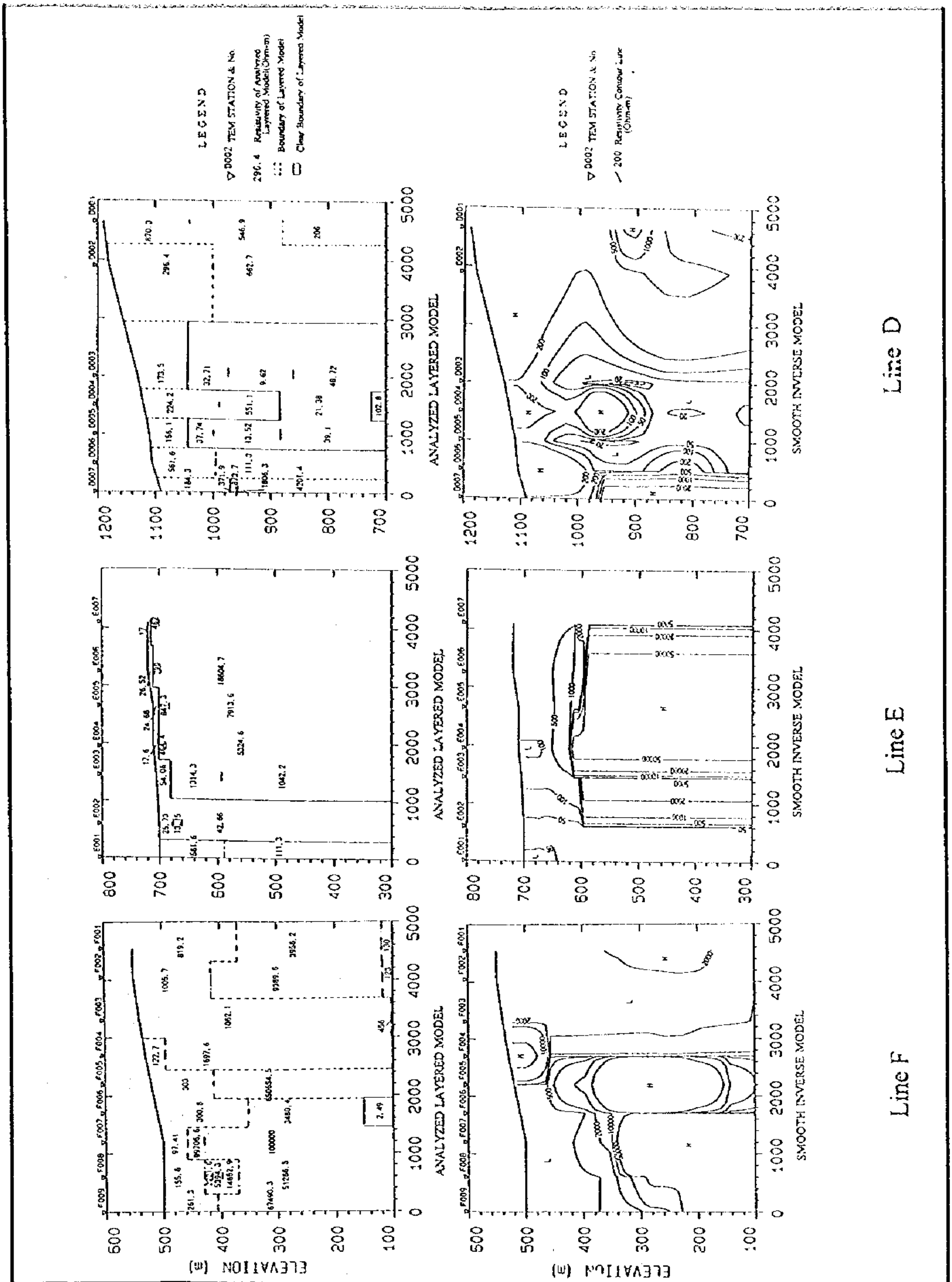

Fig. 6.2.3-9 Geoelectric Profile (Line D, E and F : Wadi Feiran)

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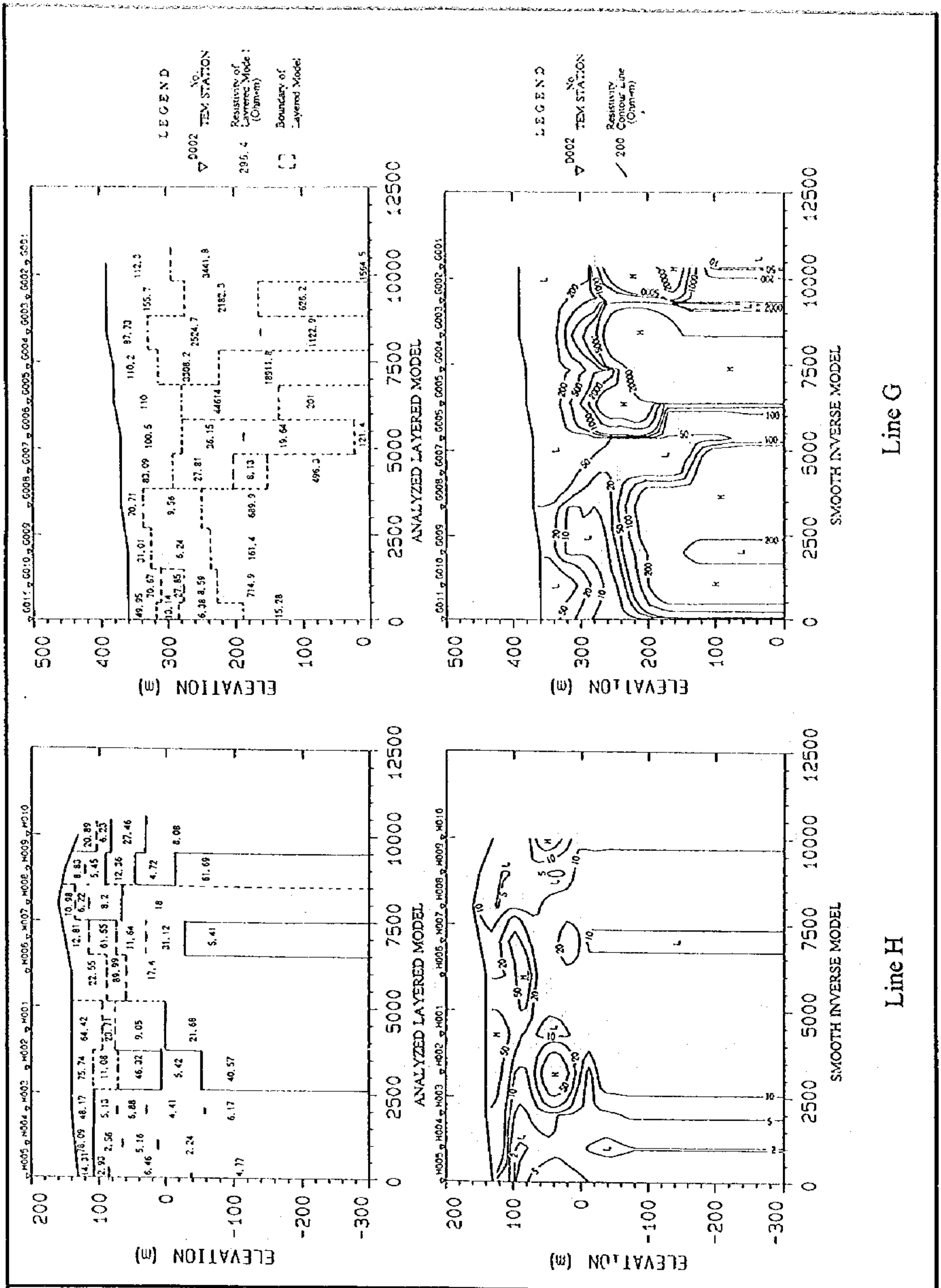

Fig. 6.2.3-10 Geoelectric Profile (Line G and H : Wadi Feiran)

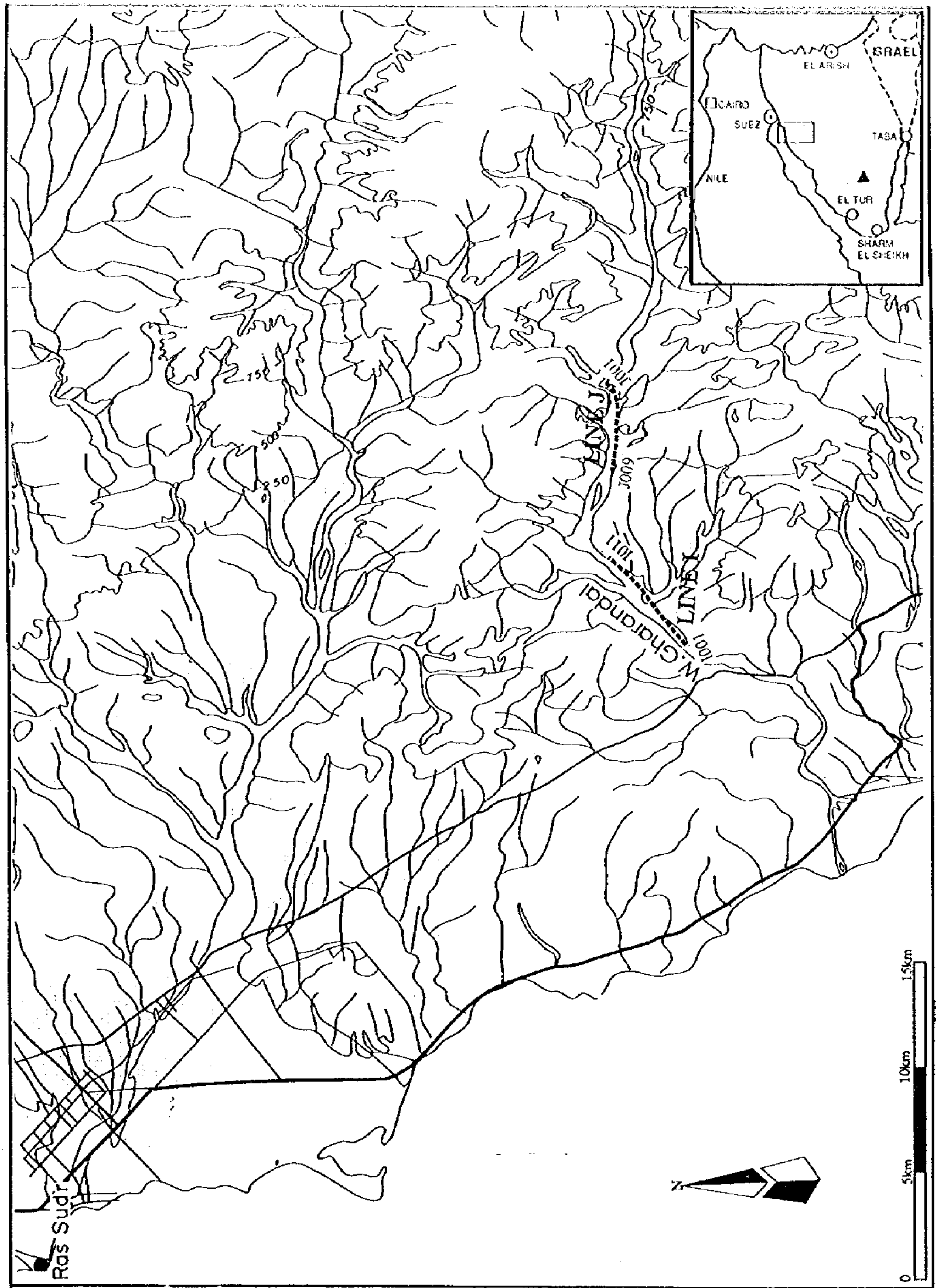

Fig. 6.2.3-11 TEM Survey Location (W. Gharandal)

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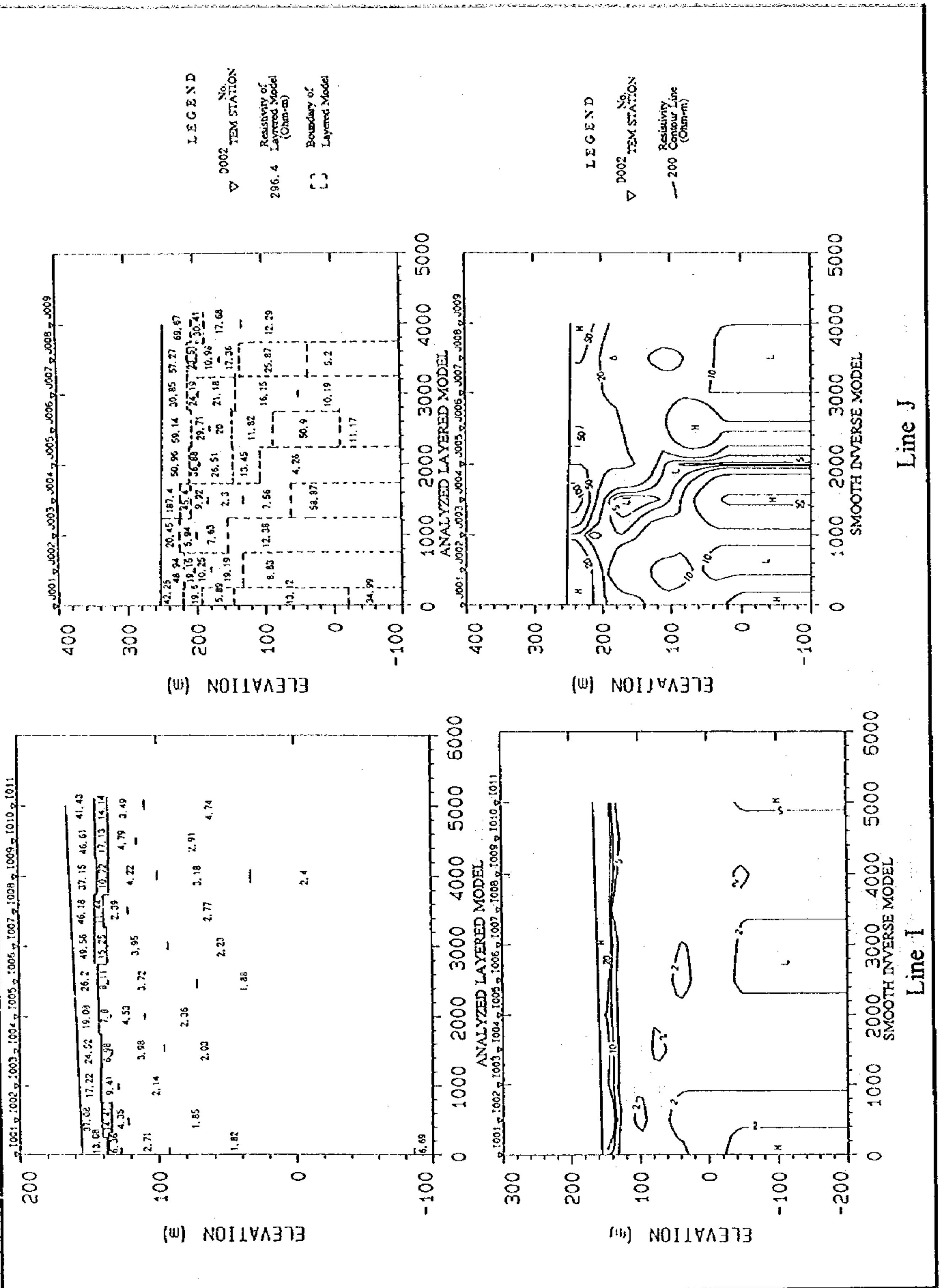

Fig. 6.2.3-12 Geoelectric Profile (Line I and J : W. Gharandal)

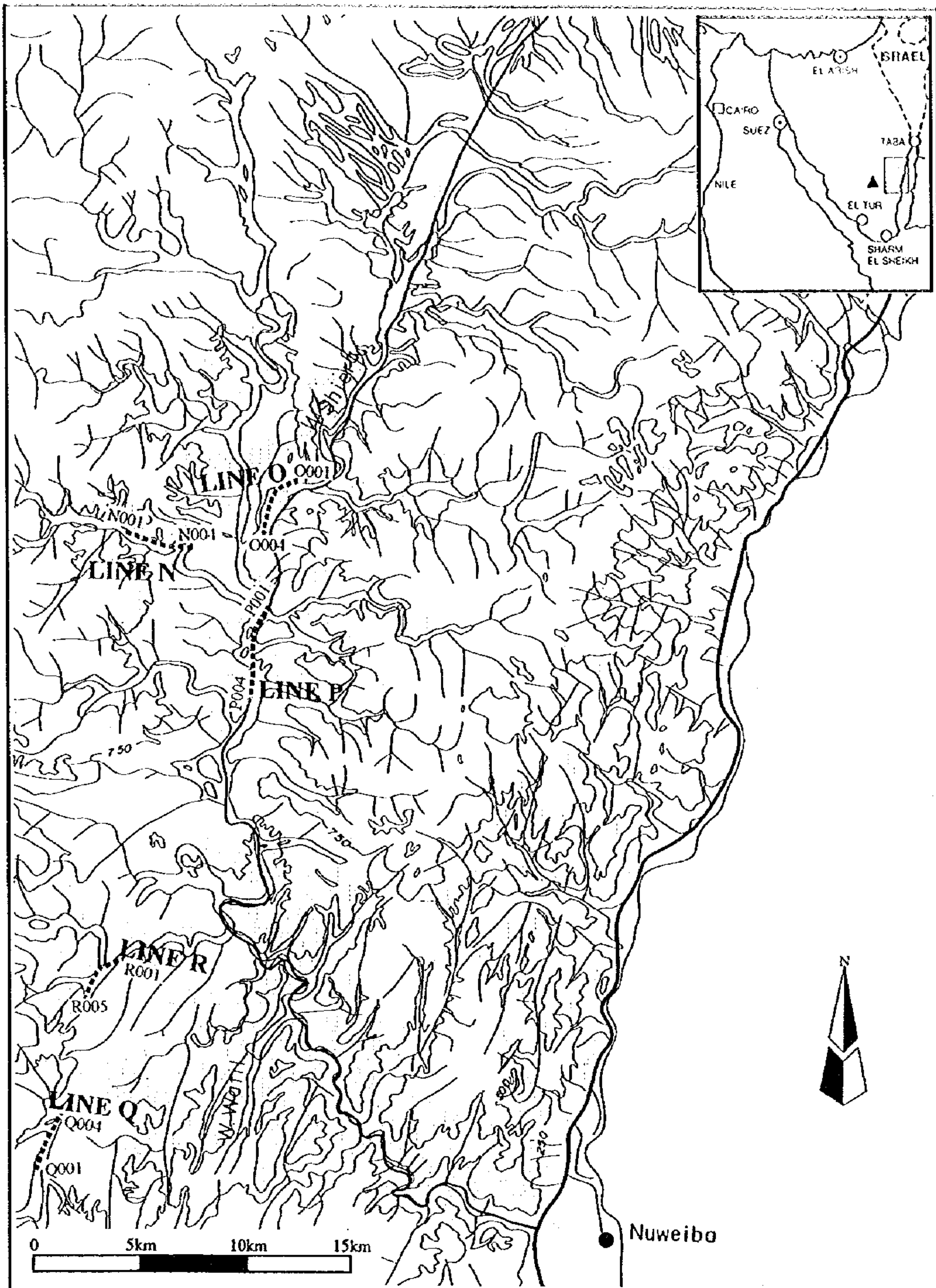

Fig. 6.2.3-13 TEM Survey Location (W. Watir, W. Zalaga)

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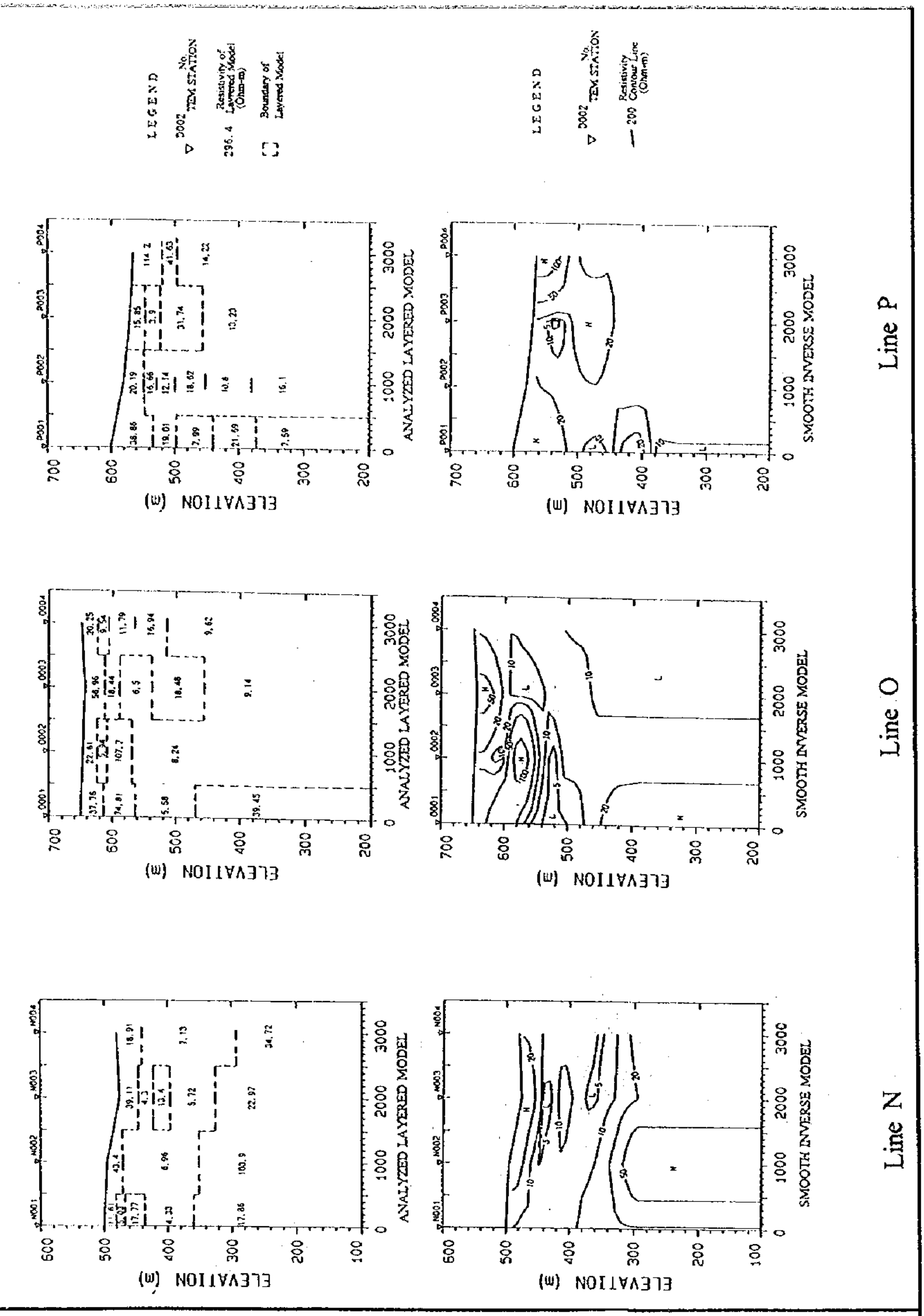

Fig. 6.2.3-14 Geoelectic Profile (Line N, O and P : W. Watir)

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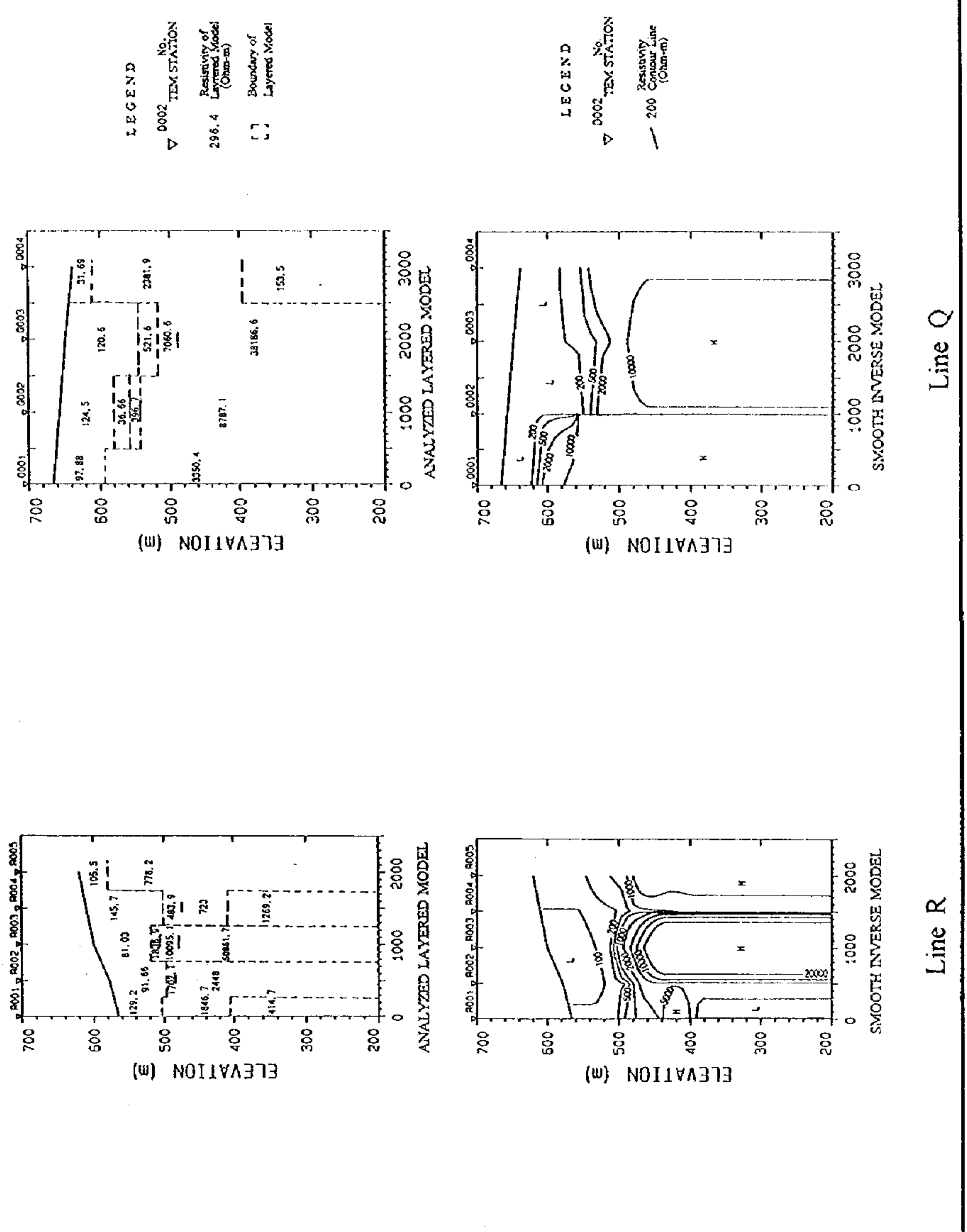

Fig. 6.2.3-15 Geoelectic Profile (Line Q and R : W. Zalaga)

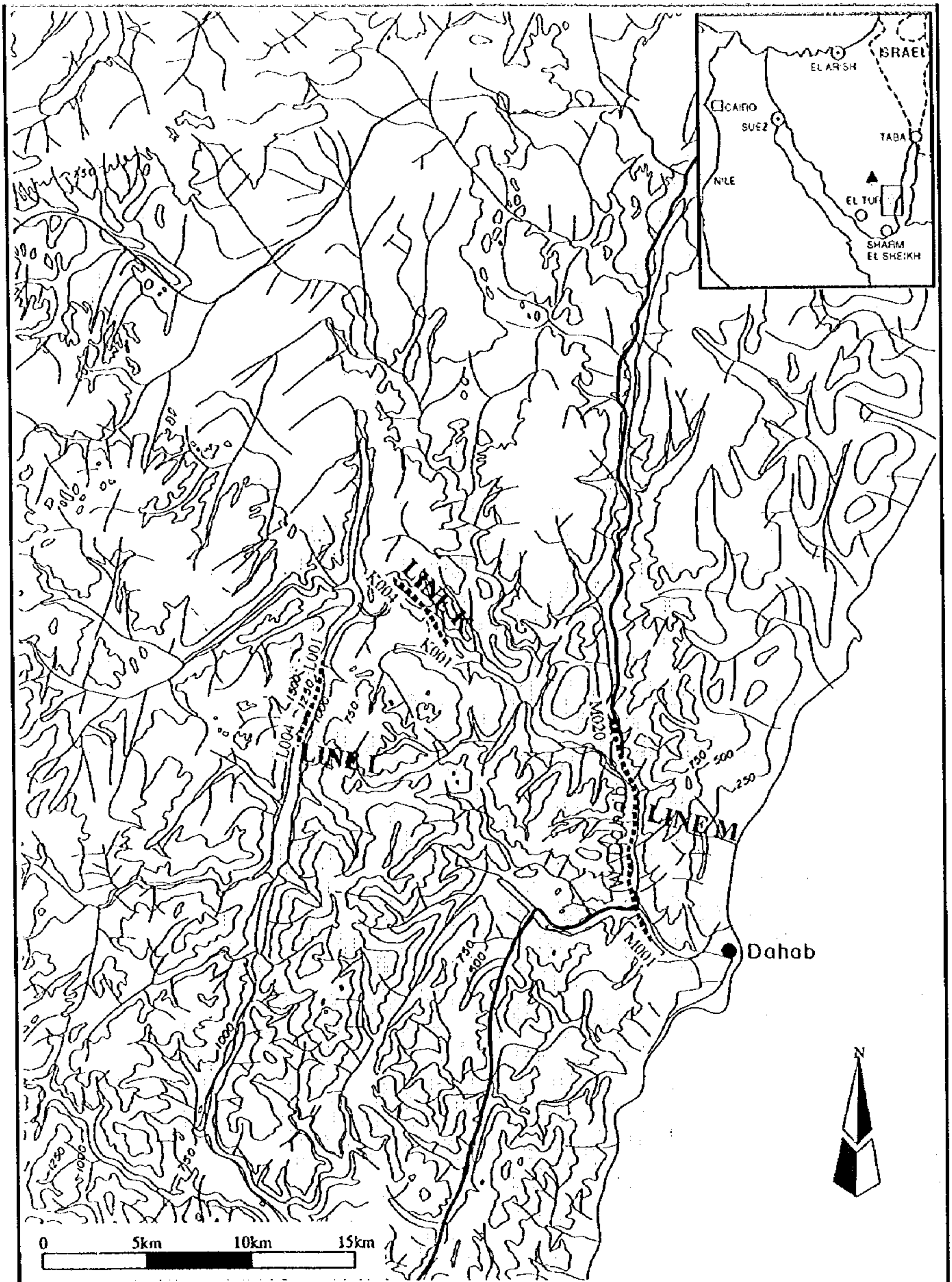

Fig. 6.2.3-16 TEM Survey Location (W. Zaghara and W. Dahab)

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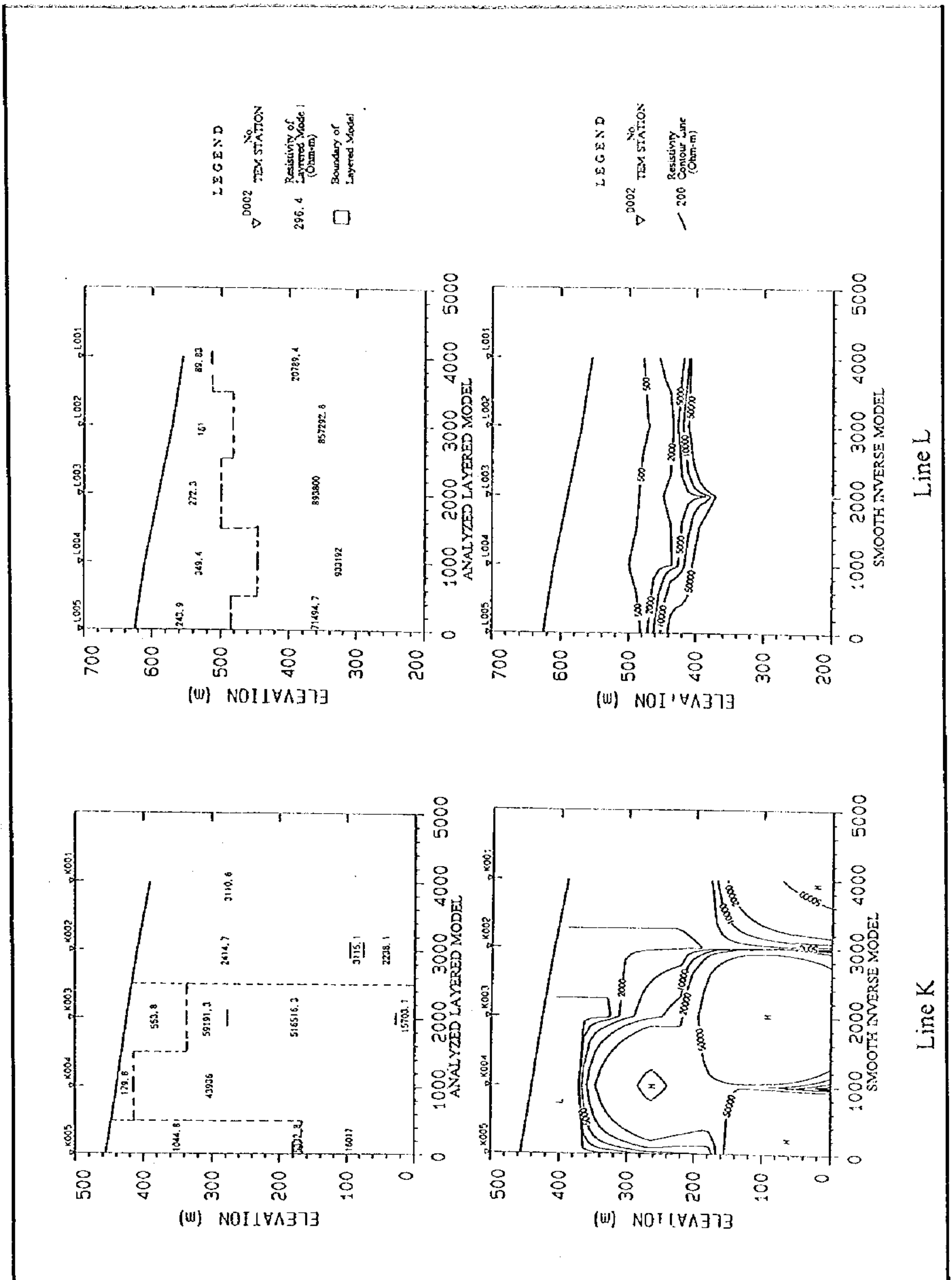

Fig. 6.2.3-17 Geoelectric Profile (Line K and L : W.Zaghara)

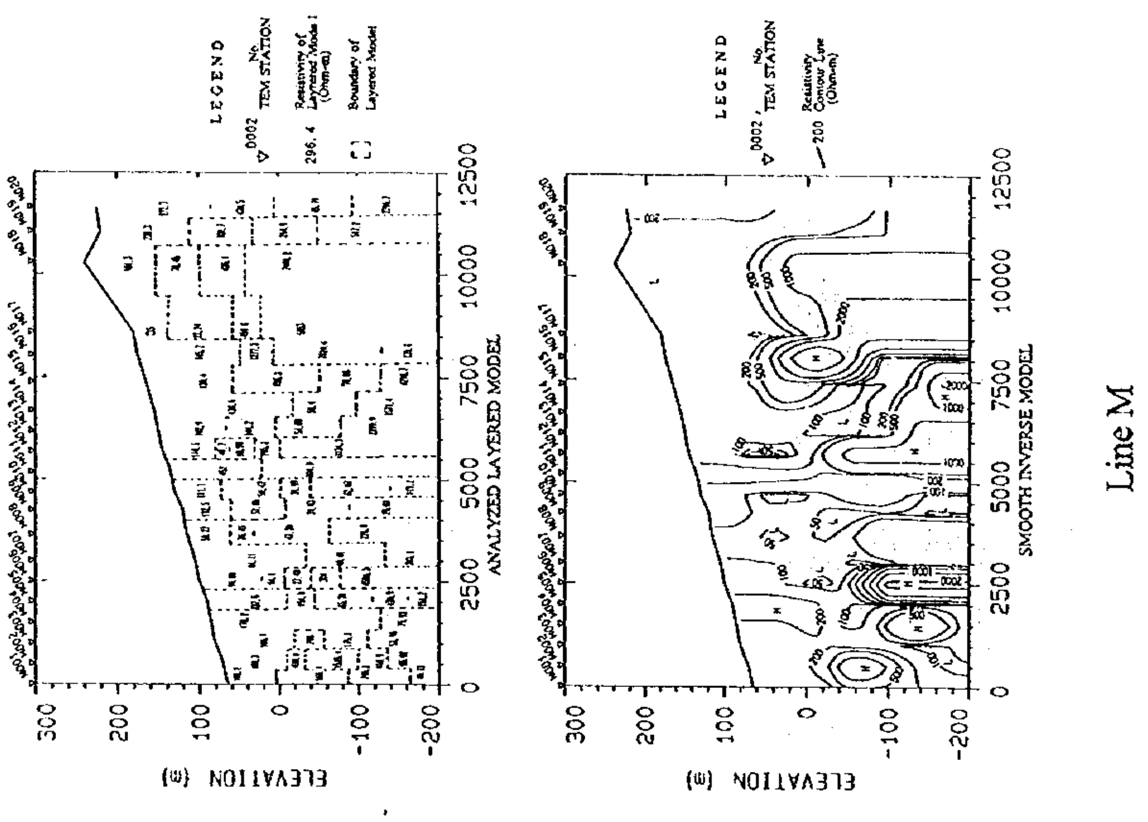

Fig. 6.2.3-18 Geoelectric Profile (Line M : W. Dahab)

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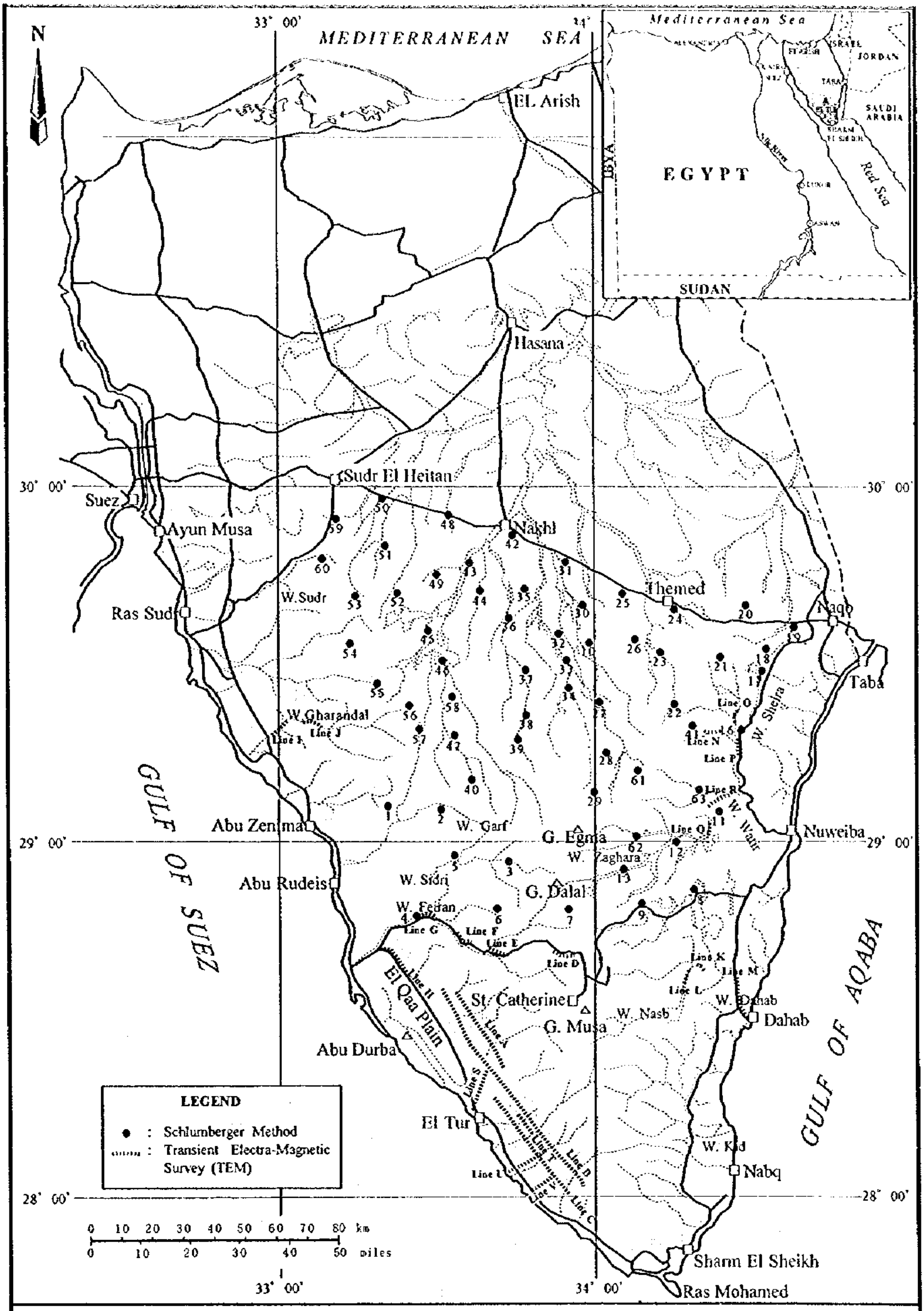

Fig. 6.3.1-1 Location of Geophysical Survey Point

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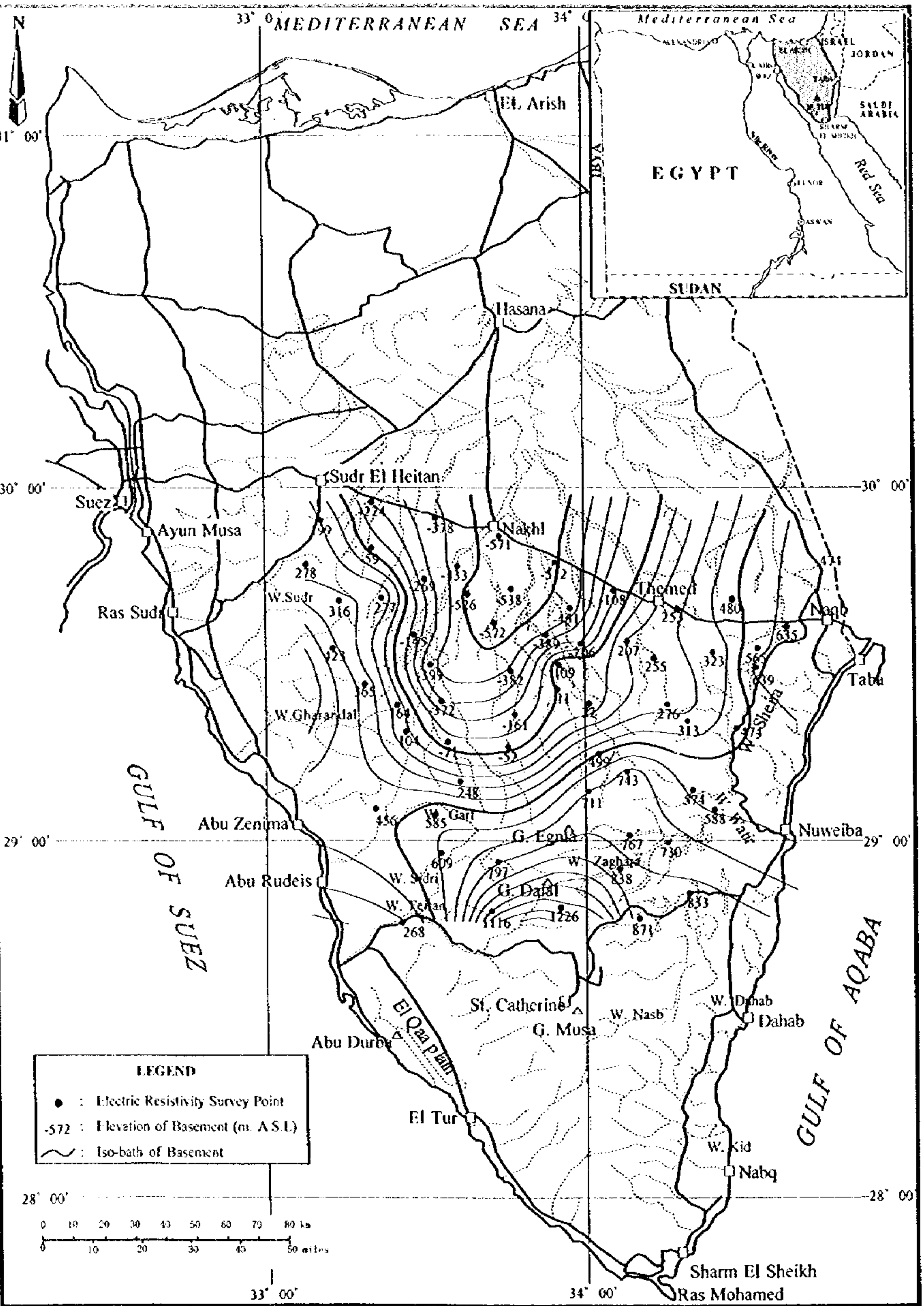

Fig. 6.3.3-1 Basement of Lower Cretaceous

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CHAPTER VII TEST WELL DRILLING AND PUMPING TEST

7.1 Location of Test Well

A total of seven (7) test wells have been drilled during a series of study. These wells include six (6) wells for Lower Cretaceous aquifer placed in El Tih Plateau and one (1) well for Quaternary aquifer in El Qaa Plain. Location map of these wells is shown in Fig.7.1-1. Other information, such as coordination and altitude are summarized as follows.

Well No. (location)	Drilled Depth	Coordination (Lat./Long.)	Altitude (m:asl)
J-1 (South Nakhl)	1,254m	29°42'31"N 33°39'08"E	520m
J-2 (South Themed)	1,260m	29°34'35"N 34°01'43"E	657m
J-3 (North Malha)	1,000m	29°33'53"N 33°32'15"E	544m
J-4 (South Themed)	1,130m	29°26'21"N 34°02'56"E	775m
J-5 (Wadi Khareiza)	557m	29°20'18"N 34°22'41"E	740m
J-6 (South Malha)	900m	29°19'40"N 33°36'48"E	710m
J-7 (South El Qaa)	250m	28°08'29"N 33°52'18"E	285m

7.2 Methodology of Test Well Drilling

7.2.1 Drilling Method and Procedure

Test wells were drilled by the rotary drilling method with a direct mud circulation system. The test wells were designed as a 9-5/8" x 6-5/8" for the Lower Cretaceous aquifer wells of J-1, 2, 3, 4, 5 and 6, and 12" x 10" for a Quaternary aquifer well of J-7. Therefore, following procedures and specifications were applied.

1) Drilling Procedure and Specification for the Well No. J-1, 2, 3, 4, 5 and 6

Step No.	Work Description	Specific Requirements
1	Drill a conductor hole to a depth of approximately 30m	Hole size: 26" (660.40 mm)
2	Install a conductor pipe to the drilled depth.	Pipe size: 20" (508.00 mm OD)
3	Seal the annular space between the wall of a drilled bore and the conductor pipe by cementing.	
4	Resume drilling of the borehole to the required depth.	Bit size: 8-1/2" (215.9 mm)
5	Perform Well logging through the drilled borehole.	Resistivity, SP, Temperature, Gammer Ray, Neutron, Caliper
6	Reaming the hole from 8-1/2" to 12-1/4" to the required depth	Bit size : 12-1/4" (311.2 mm)
7	Install casing pipe to the drilled depth (750m and 950m as planned)	Casing size : 9-5/8" (244.5 mm ID)
8	Make cement grout packing for the annular space between the borehole and casing pipe	
9	Resume drilling of the borehole to the required depth (up to the bottom of lower cretaceous sandstone : 1,000 m and 1,200 m as planned)	
10	Perform Well Logging through the drilled borehole	Resistivity, SP, Temperature, Gammer Ray, Neutron, Caliper
11	Determine the position(s) of well screen through the instruction of the Engineer.	Will be imformed by the Engineer
12	Install casing and screens pipe as determined.	Casing size: 6-5/8" (168.3 mm OD) Screen size: 6-5/8" (168.3 mm OD)
13	Perform the development of a well by airlifting and/or surging, bailing etc.	
14	Carry out the pumping test by submersible pump.	Step draw down test, constant discharge test and time recovery test.
15	Construct the well head facilities and install the water level recorder.	

2) Drilling Procedure and Specification for the Well No. J-7

Step. No.	Work Description	Specific Requirements
1	Drill a conductor hole to a depth of approximately 30m	Hole size: 26" (660.40 mm)
2	Install a conductor pipe to the drilled depth.	Pipe size: 20" (508.00 mm OD)
3	Seal the annular space between the wall of a drilled bore and the conductor pipe by cementing.	
4	Resume drilling of the borehole to the required depth. (up to the bottom of Quaternary deposit)	Bit size: 8-1/2" (215.9 mm)
5	Perform Well logging through the drilled borehole.	Resistivity, SP, Temperature, Gammer Ray, Neutron, Caliper
6	Reaming the hole from 8-1/2" to 17-1/2" to the required depth	Bit size : 17-1/2"
7	Determine the position(s) of well screen through the instruction of the Engineer.	
8	Install casing pipe to the drilled depth	Casing size : 12" x 10" Screen size : 10"
9	Perform the development of a well by airlifting and/or surging, bailing etc.	
10	Carry out the pumping test by submersible pump.	Step draw down test, constant discharge test and time recovery test.
11	Construct the well head facilities	

7.2.2 Structural Design of Wells

The structure of borehole was determined considering the size of the permanent casing and screen pipes, and planned drilling depth. The standard design is shown in Fig.7.2.1-1. The borehole size was designed as 9-5/8" x 6-5/8" for the wells of J-1, 2,3,4,5 and 6, 12" x 10" for a well of J-7.

For future pumping use and periodical water level measurement, the well head and well cap were constructed as shown in Fig.7.2.1-2. The fence was built up around the well head as shown in Fig.7.2.1-3. After the construction of wellhead facilities, the water level recorders donated by JICA were installed as shown in Fig.7.2.1-2.

7.2.3 Materials Used.

Particular materials were selected for test wells. The specifications of major materials are described hereunder.

1) Pipes

(1) Conductor Pipe

Outside Diameter	Wall Thickness	Use for
508.0 mm (20")	8.0 mm	Surface Conductor

(2) Casing Pipe

Outside Diameter	Joint	Use for
a) 9-5/8" (244.50mm)	S.R.T 8rd	Pump House (J-1, 2, 3, 4, 5 and 6)
b) 6-5/8" (168.30mm)	S.R.T 8rd	Borehole (J-1, 2, 3, 4, 5 and 6)
c) 12" (304.8mm)	S.R.T 8rd	Pump House (J-7)
d) 10" (254.00mm)	S.R.T 8rd	Borehole (J-7)

(3) Screen Pipe

Following 2 kinds of casing pipe were provided.

i) for Lower Cretaceous Aquifer wells

Nominal size (inch)	:	6-5/8"
Screen outside diameter (mm)	:	160.3mm
Effective unit length (mm)	:	5,400
Overall unit length (mm)	:	6,300
Materials	:	SUS304, stainless steel (AISI)
Opening ratio (%)	:	Not less than 12%
Joint	:	S.R.T 8rd

ii) for Quaternary Aquifer wells

Nominal size (inch)	:	10"
Materials	:	Local material

2) Casing Materials

(1) Centralisers

i) Sizes for suit: 20" API casing to 26" hole (for Conductor hole)
ii) Sizes for suit: 9-5/8" API casing to 12-1/4" hole (for Pump House)

(2) Casing Cementing Shoes

i) Sizes for suit: 20" API casing round thread (for Conductor hole)
ii) Sizes for suit: 9-5/8" API casing round thread (for Pump House)

(3) Cement Baskets

i) Sizes for suit : 20" API casing (for Conductor hole)
ii) Sizes for suit : 9-5/8" API casing (for Pump House)

7.2.4 Sampling and Analysis

1) Micro Fossil Analysis

The cutting samples of each test wells have been collected every 4 meters basically and/or every change in the Upper Cretaceous formation. The washed residues of the samples were microscopically examined to define the fauna so that the ages have been determined.

2) Grain Size Analysis

The cutting samples of each test wells have been collected from the Lower Cretaceous Sandstone. The collected samples were tested sieve analysis based on the ASTM standard to obtain the grain size distribution.

Based on the grain size analysis, permeability was estimated by D_{20} (Effective particle diameter at 20 % passing) which is Creager's method. The relationship between D_{20} and permeability shows bellows;

D_{20}(mm)	Permeability(K) (cm/sec)	Soil Classification
0.005	3.00×10^{-6}	Clay
0.01	1.05×10^{-5}	Silt
0.02	4.00×10^{-5}	
0.03	8.50×10^{-5}	
0.04	1.75×10^{-4}	
0.05	2.80×10^{-4}	
0.06	4.60×10^{-4}	Very Fine Sand
0.07	6.50×10^{-4}	
0.08	9.00×10^{-4}	
0.09	1.40×10^{-3}	
0.10	1.75×10^{-3}	
0.12	2.60×10^{-3}	Fine Sand
0.14	3.80×10^{-3}	
0.16	5.10×10^{-3}	
0.18	6.85×10^{-3}	
0.20	8.90×10^{-3}	
0.25	1.40×10^{-2}	
0.30	2.20×10^{-2}	Medium Sand
0.35	3.20×10^{-2}	
0.40	4.50×10^{-2}	
0.45	5.80×10^{-2}	
0.50	7.50×10^{-2}	
0.60	1.10×10^{-1}	Coarse Sand
0.70	1.60×10^{-1}	
0.80	2.15×10^{-1}	
0.90	2.80×10^{-1}	
1.00	3.60×10^{-1}	
2.00	1.80	Very Coarse Sand

3) Radio-active Isotope Analysis

The purpose of the analysis is to estimate the age of groundwater. A total of 6 samples from the test wells drilled were collected and analyzed. The most commonly used tracer isotopes are those which are a constituent of the water molecules (O-18 Deuterium and Tritium), and other isotopes (C-13 and C-14), which from dissolved compounds.

4) Water Quality

The purpose of the analysis is to obtain the groundwater quality. A total of 6 samples from the test wells drilled were collected and analyzed. The water samples taken from the test wells analyzed on the following items adopting Egyptian Standard for Drinking Water.

A Concentration of Anion and Cation (mg/l)
Anion (4 items): HCO_3^-, CO_3^{2-}, Cl^-, SO_4^{2-}
Cation (4 items): Ca^{2+}, Mg^{2+}, Na^+, K^+

B Drinking water Standards Parameter

(i) Physical Properties
- Color (Platinum-Cobalt Units)
- Turbidity (NTU)
- Total Dissolved Solids (TDS: mg/l)

(ii) Chemical Properties
- Nitrite (NO_2)
- Iron (Fe)
- Manganese (Mn)
- Total Hardness ($CaCO_3$)
- pH

(iii)Bacterial Test
- Total Coliform (group/100ml)
- Bacteria (pcs./ml)

7.2.5 Pumping Test

1) Upper Cretaceous Limestone Aquifer (Aquifer Test)

After drilling of pump house which is planned up to the bottom of Upper Cretaceous Limestone Layer, if the existence of fissure water have confirmed, the aquifer test was conducted.

The test was conduct by the airlifting method using 14 bar capacity of high-pressure compressor. Before start the aquifer test, static water level was measured. The test flow rate was measured as longer as possible. Recovery of the water level also measured immediately after completion of the air lifting.

2) Lower Cretaceous Sandstone Aquifer (Pumping Test)

Three (3) different kinds of pumping test; step draw down test, constant discharge test and recovery test were conducted for each wells.

(1) Pumping

Based on the casing size installed, following submersible pump was used for pumping.

1,500 lit./min. x 390m head

A pump was installed in the casing pipes through rising main and delivery pipes. A valve and flow meter were installed on the delivery pipe works.

(2) Method of Test

The each test was carried out by the standard method as mentioned below.

Item 1: Step draw down test

At least 3 steps, and each step was measured 120 minutes duration.

Item 2: Constant discharge test

24 hours' measurement was conducted as soon as the water levels have recovered its original static water level after the completion of the step draw down test.

Item 3: Time recovery test

The test starts immediately after completion of the Constant Discharge Test and carry out for a minimum period of 24 hours or until the water level recover the original static water level.

However, in order to meet the hydrogeological conditions at each well, discharge rate, test duration, the Hydrogeologist of the Study Team altered number of steps and time interval.

(3) Measurement

The static water level was measured just before the commencement of the any pumping test. Throughout the duration of each test, the water level was measured and recorded following observation time schedule listed below;

Time from start of pumping or pumping rate increase (minutes)	Time interval between observations (minutes)
0 - 5	1/2
5 - 10	1
10 - 20	2
20 - 30	3
30 - 60	5
60 - 120	10
120 - 240	20
240 - 360	40
360 and longer	60

The flow of all water pumped from the well during pumping test was measured by both an Oriphis meter in the delivering pipe works and triangular weir. Discharge rate was recorded during the pumping test at intervals mentioned above.

(4) Method of Analysis

i) Aquifer Constants

Aquifer constants necessary for the hydrogeological evaluation are transmissibility, storage coefficient and permeability. These aquifer constants were analyzed by using the results of constant discharge and recovery tests. Theis and Jacob's methods are applied for the analysis. The aquifer constants are given by the following formulas;

(i) Theis's Equation

Transmissibility (T) = Q x $W_{(u)}$ /4p x s

Where Q = pumping rate (m^3/day)
$W_{(u)}$ = well function of "u"
s = draw down (m) at matching point

Permeability (K) = T /L

Where T = transmissibility (m^3/day/m)
L = thickness of aquifer (m: total length of screen pipes)

(ii) Jacob's Equation

Transmissibility (T) = 0.183 x Q / Δ s

Where Q = pumping rate (m^3/day)
Δ s = draw down on one "log cycle" (m)

Permeability (K) = T /L

Where T = transmissibility (m^3/day/m)
L = thickness of aquifer (m: total length of screen pipes)

ii) Well Efficiency

Well efficiency are given by the following formula;

Well Efficiency (%) $E_w = BQ/(BQ + CQ^2)$

Where B = aquifer loss
C = well loss
Q = discharge rate (l/s)

iii) Radius of Influence

The Radius of Influence is given by the following formula after Theis Equation;

Radius of Influence (m) $R = (4Ttu/S)^{0.5}$

$$s = (Q/4\pi T)W(u)$$

Where Q = Discharge rate(m^3/h)
T = Transmissivity (m^2/h)
s = draw down(m)(0.001)
S = Effective porosity(0.3)
W(u) =Well function of Theis
t =Time of pumping operation(h)

7.3 Result of Drilling and Test

The test well data for each well, lithological column, casing design and well logging are shown in Fig.7.3-1 to 7.3-7.

7.3.1 J-1 (Fig.7.3-1)

1) Lithology

The well was drilled up to 1,254m depth. Wadi deposit was observed at the depth from surface to 10 m. Based on the results of micro fossil analysis and lithology observed, following eight (8) major formations were classified.

Layer	Depth(m)	Lithology	Formation (age)
1	10-40	Limestone	Paleocene
2	40-180	Limestone, Limestone intercalated with Claystone	Maastrichtian
3	180-290	Claystone	Campanian
4	290-385	Limestone intercalated with Claystone	Coniacian-Santonian
5	385-520	Limestone, Chalky Limestone., Limestone intercalated with Shale	Turonian
6	520-865	Alternation of Limestone and Shale	Cenomanian
7	865-1,110	Sandstone, Shale	Lower Cretaceous
8	1,110-1,254	Sandstone, Shale	Jurassic

2) Well Logging

Results of well logging are as follows

Layer	Resistivity (Ω-m)		Gamma Ray(cps)	Spontaneous Potential(mv)	Temperature (°C)
	Short	Long			
1	2-5	1-2	-	-	25.2-25.9
2	1-10	1-3	2-51	906-992	25.9-26.6
3	6-23	1-12	17-109	949-1012	26.6-28.0
4	1-18	1-7	8-47	771-1018	28.0-28.4
5	5-133	2-297	2-45	882-1411	28.4-30.6
6	2-97	2-178	5-62	981-1089	30.6-37.1
7	27-99	45-96	3-56	1002-1190	37.1-48.2
8	31-69	51-109	5-112	-	47.7-52.4

3) Determination of Casing Design

Casing design is determined as shown in Fig.7.3-8. Lower Cretaceous formation is composed mostly of sandstone, and minor intercalation of shale is observed in upper and lower part. The geophysical data indicate that the layer is promising aquifer, except shale intercalation which Gamma Ray shows high value. The length of screen and casing pipes including sand trap are 161.72 m and 43.45 m respectively.

4) Micro Fossil Analysis

A total of 50 subsurface samples of Upper Cretaceous formation were collected. These samples composed of chalky limestone, limestone, shale, clay, chalky limestone, and sandy shale. The results of fossil analysis are presented in Table 7.3.1-1. Based on the results of fossil analysis, following eight (8) Epoch/Age were confirmed.

Depth(m)	Thickness(m)	Epoch/Age
10-40	30	Paleocene
40-180	140	Maastrichtian
180-290	110	Campanian
290-385	95	Coniacian-Santonian
385-520	135	Turonian
520-865	345	Cenomanian
865-1110	245	Lower Cretaceous
1110-1254	>144	Cambrian

5) Grain Size Analysis

A total of 14 ditch samples were collected from the Lower Cretaceous formation. Collected samples are classified as fine sand. The distributions of permeability coefficient are shown in Table.7.3.1-2. The permeability coefficient estimated by D20 is 2.9x10-3 cm/sec. The samples collected from upper and lower part, however, no effective particle size at 20% passing was found. This is due cohesive soil condition of the samples.

6) Pumping Test

(1) Upper Cretaceous Limestone

An aquifer test was conducted by the airlifting. The tested depth of the formation is from 402m to 500m. The maximum discharge by the airlifting was 5.5 m^3/h. Static water level was observed as 71.08m below the ground level. After discharge by airlifting, recovery test was conducted (see Fig.7.3.1). Transmissibility and Permeability were calculated as $1.8x10^{-2}$ m^2/min and$1.3x10^{-4}$cm/sec respectively.

(2) Lower Cretaceous Sandstone

Three (3) different kinds of pumping test method; four (4) steps draw down test, constant discharge and recovery test were conducted by submersible pump. The results of analysis are shown in Fig.7.3.1-2.

The aquifer constants calculated are summarized as follows;

Method	Transmissibility T:(m^2/min)	Storage S	Permeability k(cm/sec)
Jacob	2.72×10^{-1}	1.77×10^{-8}	2.8×10^{-2}
Recovery	-	-	-
Theis	1.48×10^{-1}	-	1.52×10^{-2}

The average of the transmissibility was calculated as 2.07×10^{-1} m^2/min.

The formation loss and well loss are calculated as 5.3×10^{-2} day/m^2 and 3×10^{-7} day/m^2, respectively. Well efficiency at a discharge rate of 800 m^3/day is calculated as 95 %. No critical discharge was observed by the step draw down test.

Radius of Influence was given as follows;

$R(m)=24.932t^{0.5}$ ($Q=30m^3/h$) t: time of pumping operation(hour)