8 Bearing Capacity of Foundation Ground

Among the proposed Project facilities, the most heavy facility is farm pond. The bearing capacity of foundation bed was calculated based on the SPT for the most heavy facility of the farm pond.

The standard design of the concrete-made farm pond is 9.6 m × 12.9 m wide, and the foundation depth is 1.4 m from the ground surface. The design load of the facilities is estimated at 5 t/sq.m

The test borings revealed that the foundation beds of the farm pond sites consist of stratum of loam having N=8 on an average. The loam layer is generally clayey, and its internal friction angle is very small. Therefore, the internal friction angle was ignored on the estimation of bearing capacity. Based on the average N-Value, the design cohesion of the foundation bed can be obtained from the following formula.

$$q_u = N/8 \qquad \text{......} \qquad (1)$$

$$C = q_u/2 \qquad \text{......} \qquad (2)$$

where, q_u: Uniaxial shear strength (kg/sq.cm)

N : Average N-Value of the foundation bed (N = 8)

C : Cohesion (kg/sq.cm)

The long term allowable bearing capacity having a safety factor of 3.0 was calculated by the following Terzaghi's formula (1963) for a rectangular type shallow foundation.

$$q_a = 1/3\{(1+0.3 \times B/L) \times C \times N_c + (0.5\text{-}0.1 \times B/L) \times B \times \gamma_1 \times N_r + \gamma_2 \times Df \times N_q\} \qquad (3)$$

where,
- q_a : Allowable bearing capacity (t/sq.m)
- C : Cohesion of foundation bed (t/sq.m)
- γ_1 : Unit weight (t/cu.m) of foundation bed below the footing bottom base, subtracting 1.0 under water level (γ_1')
- γ_2 : unit weight of overlying foundation bed (or backfill) above the footing bottom, subtracting 1.0 below groundwater level (γ_2')
- N_c, Nr, Nq : Bearing capacity factor, see following table
- B : Shorter side length of foundation base (m)
- L : Longer side length of foundation base (m)
- Df : Depth of foundation bottom (m)

ø	N_c	N_r	N_q
0°	5.3	0	3.0
5°	5.3	0	3.4
10°	5.3	0	3.9
15°	6.5	1.2	4.7

Based on the general design criteria for the proposed farm pond, the design values and allowable bearing capacities are calculated as follows:

Factor	Unit	Value	Remarks
γ_1, γ_2	t/cu.m	1.7	
N-value		8	Average value
C	t/m²	5	See formula (1) and (2)
B	m	9.6	
L	m	12.9	
Df	m	1.4	
N_c		5.3	See above table
N_r		0	See above table
N_q		3.0	See above table
qa	t/m²	13.2	See formulae (3)

As shown in the above, the calculated allowable bearing capacity of 13 t/sq.m, is more than double compared with the design load of 5 t/sq.m. Therefore, simple and economical mad foundation will be recommended as the optimum foundation type of the farm ponds.

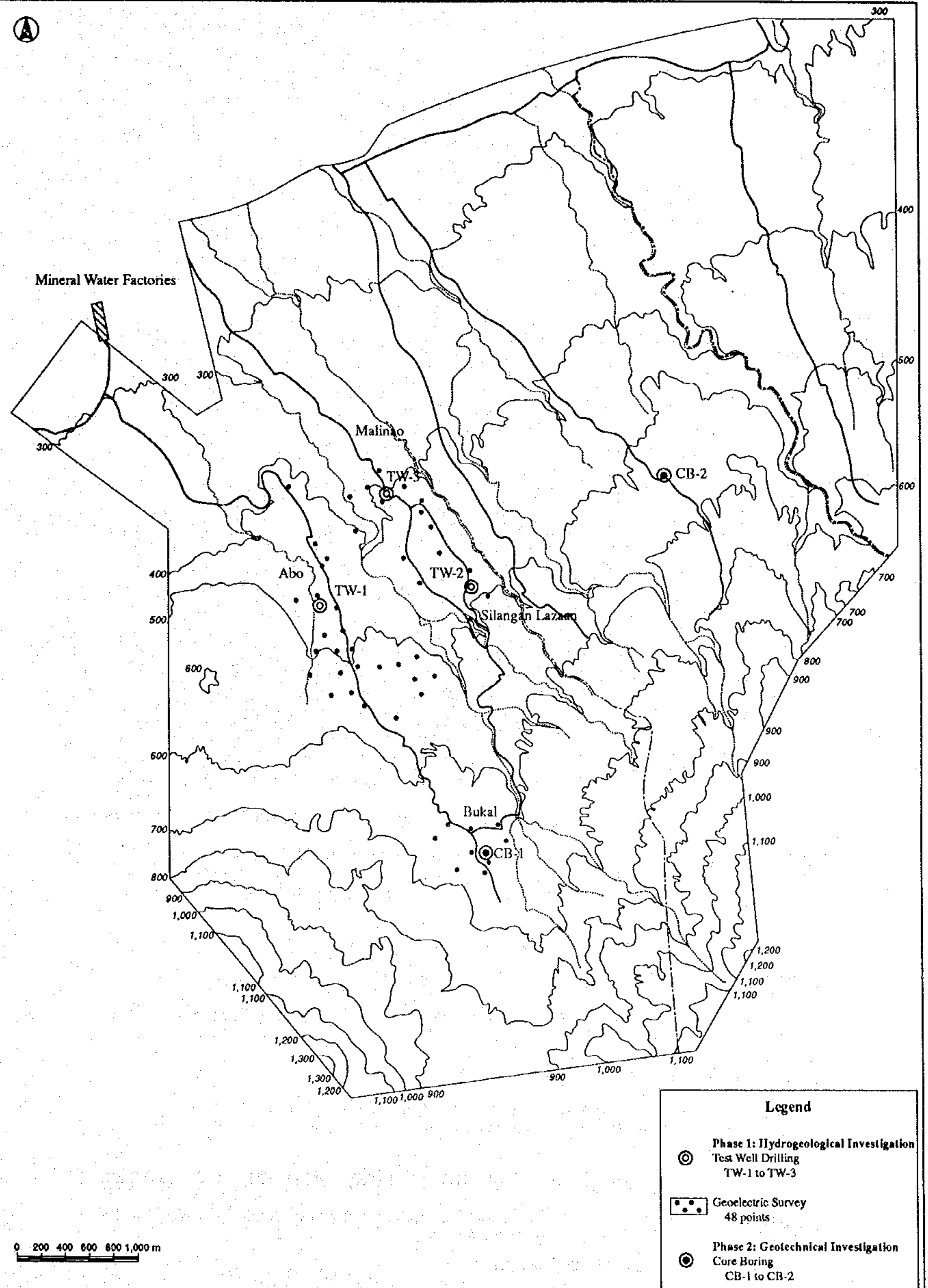
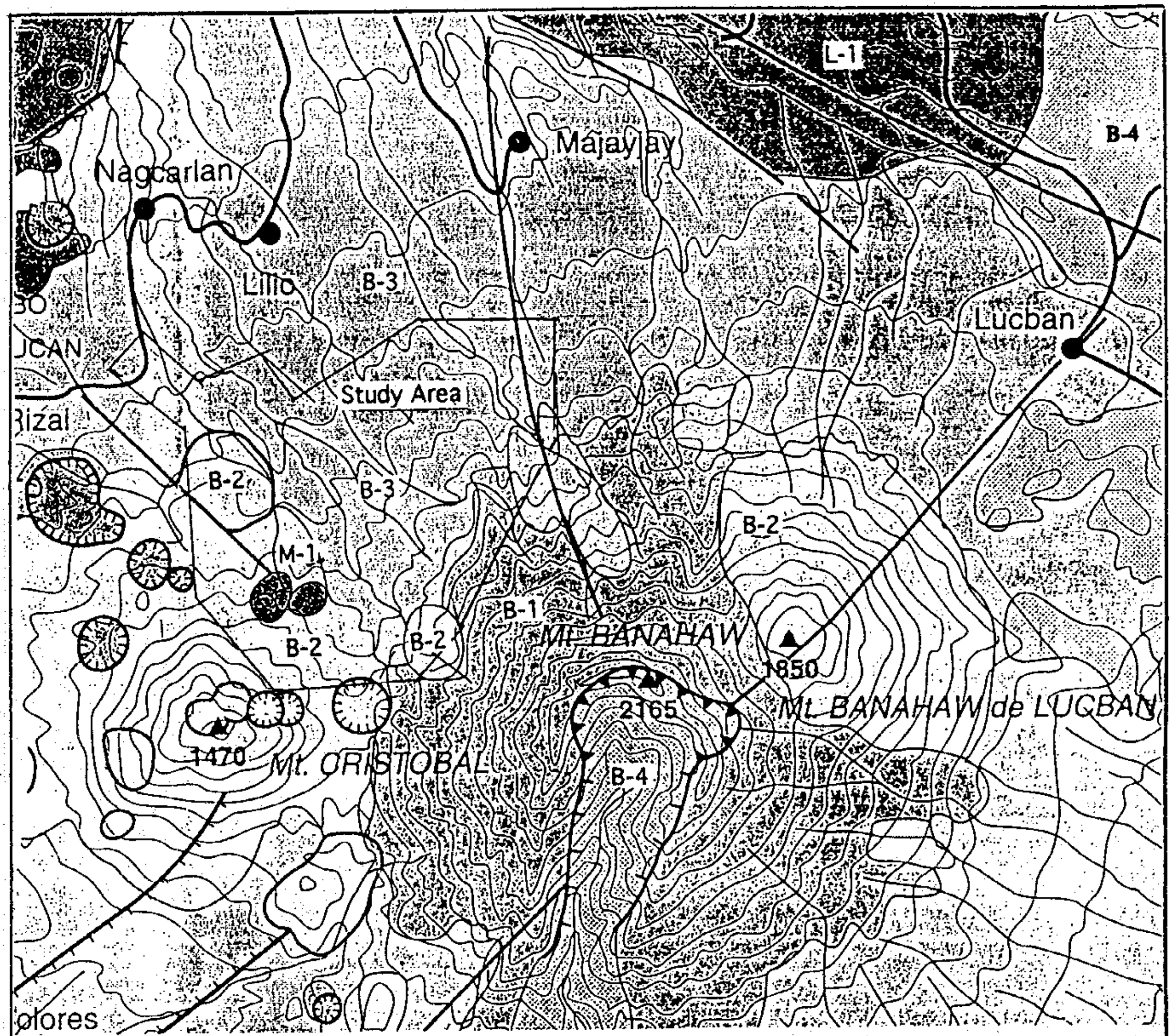


Fig. II.1.1 Location Map of Geological Investigation



Basalt Volcanoes of the Macolod Corridor (ca. 2 Ma to 1969 A.D.)

(M-1) Basalt and basaltic andesite: lava flows and tephra deposits (e.g. Mt. Macolod, Mt.Atimbia, ...), ash and scoria cones (e.g. Imoc Hill, Mt. Mayabobo, ...), on Taal area partly covered by base surge deposits

Mt. Banahaw (ca. 1.6 Ma to 1743 A.D.)

(B-1) Andesitic lava flows and tephra deposits of the main cone

(B-2) Andesitic lava domes (secondary cones, e.g. Mt. San Cristobal, Mt Banahaw de Lucban, ...)

(B-3) Ash-flow and lahar deposits

(B-4) Debris avalanche deposits (Mt. Banahaw de Lucban). Debris avalanche deposits of the central crater

Laguna de Bay Caldera – Caliraya Plateau (ca. 2.3 to 0.9 Ma.)

(L-1) Andesitic to rhyolitic tephra deposits, mainly large scale ignimbrite and lahar deposits. Andesitic lava flows

Source: Geological Map of Macolod Corridor

Fig. II.3.1 Geological Condition around the Study Area

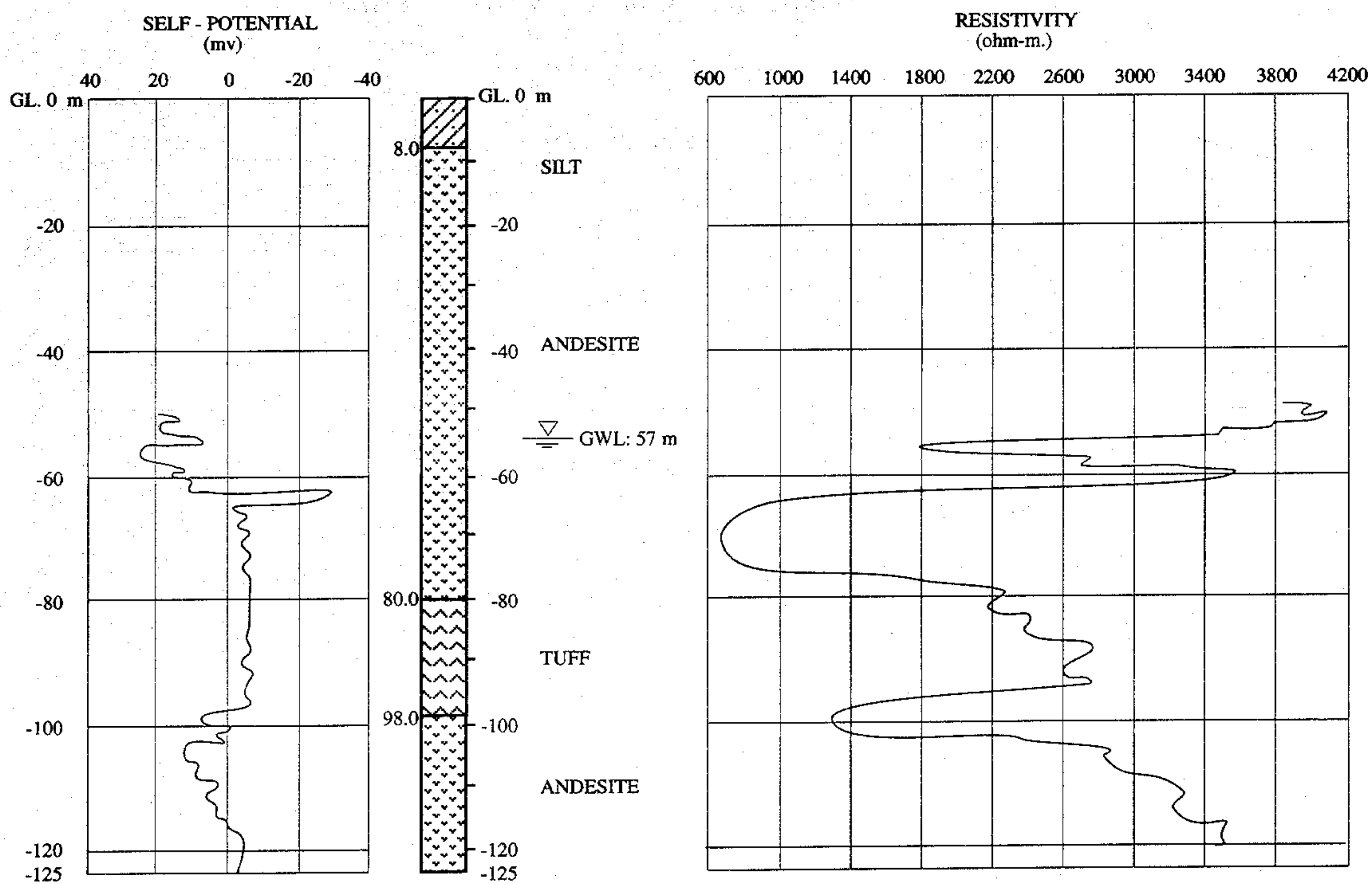


Fig. II.4.1 Lithology and Electric logging of TW-1 (Abo)

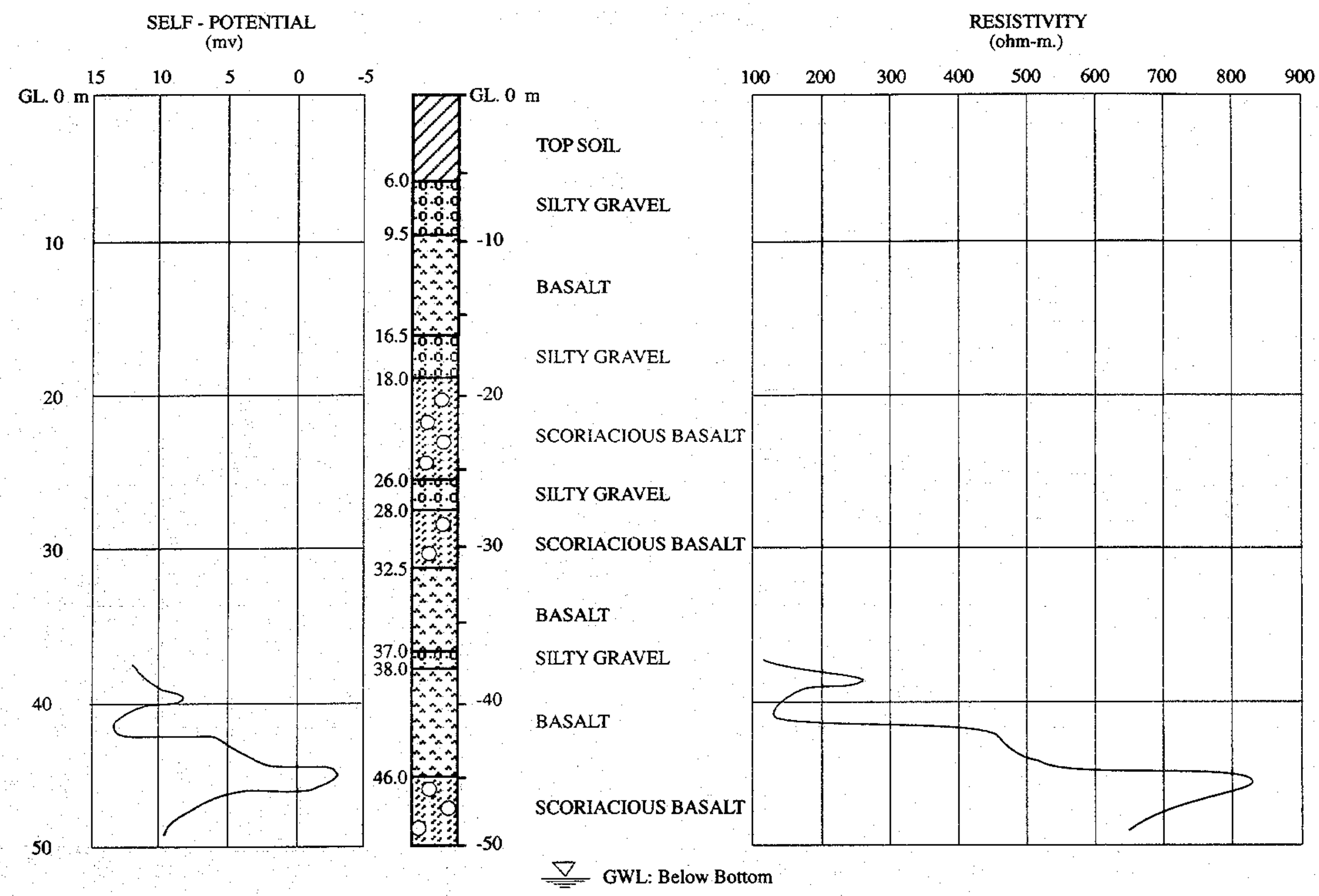


Fig. II.4.2 **Lithology and Electric logging of TW-2 (Silangan Lazzan)**

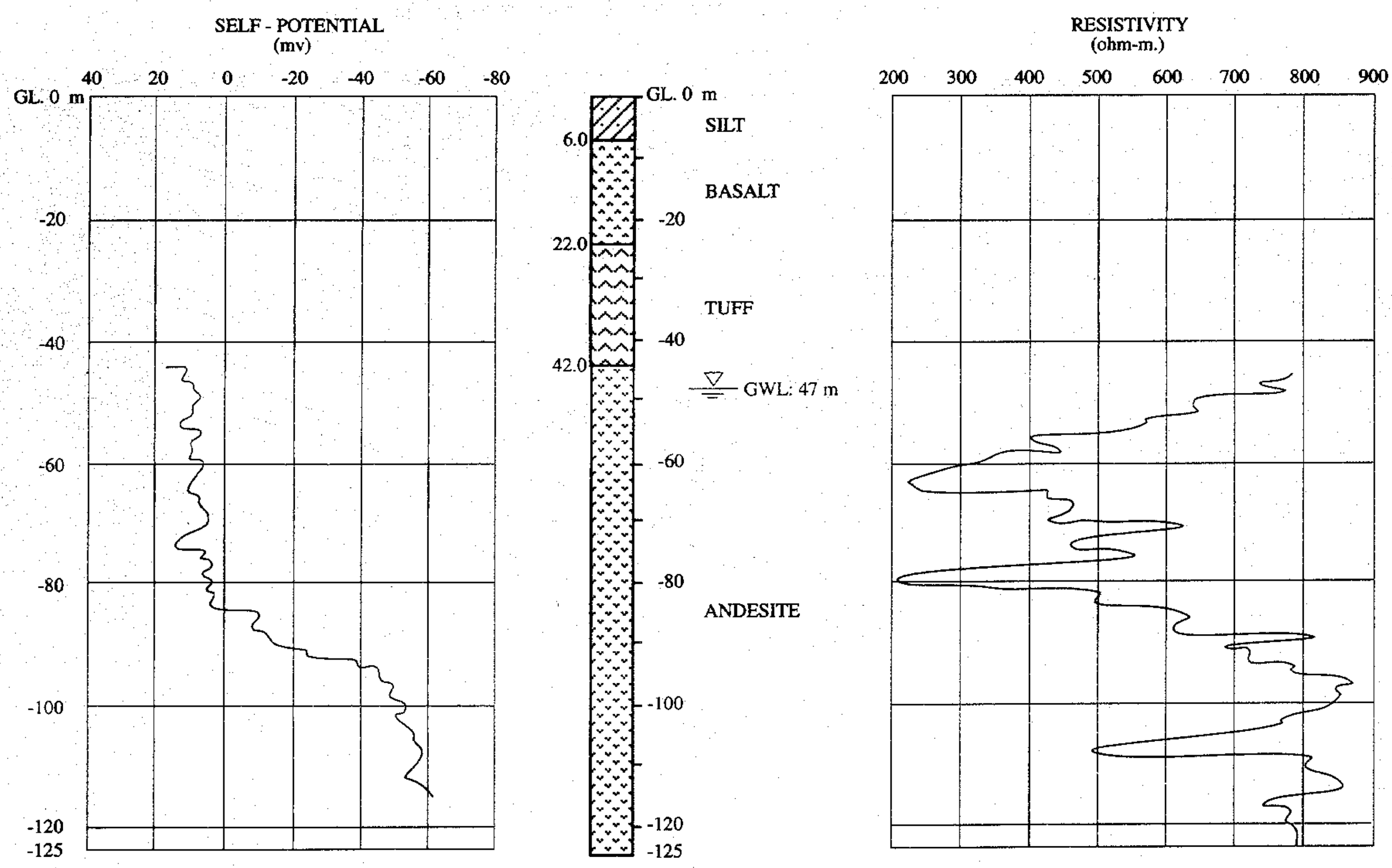


Fig. II.4.3 Lithology and Electric logging of TW-3 (Malinao)

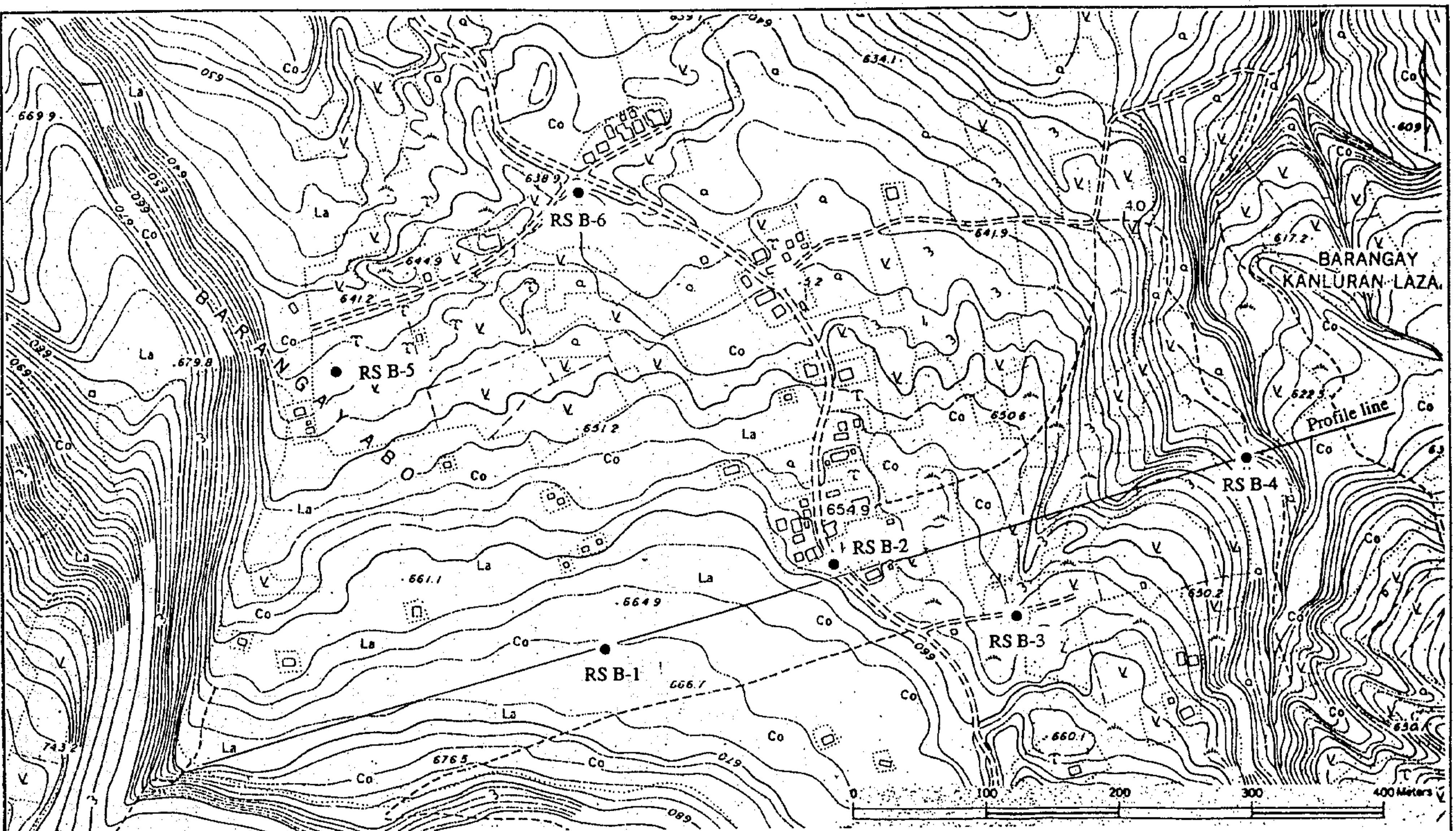


Fig. II.5.1 Location Map of Geoelectric Survey (Bukal Area)

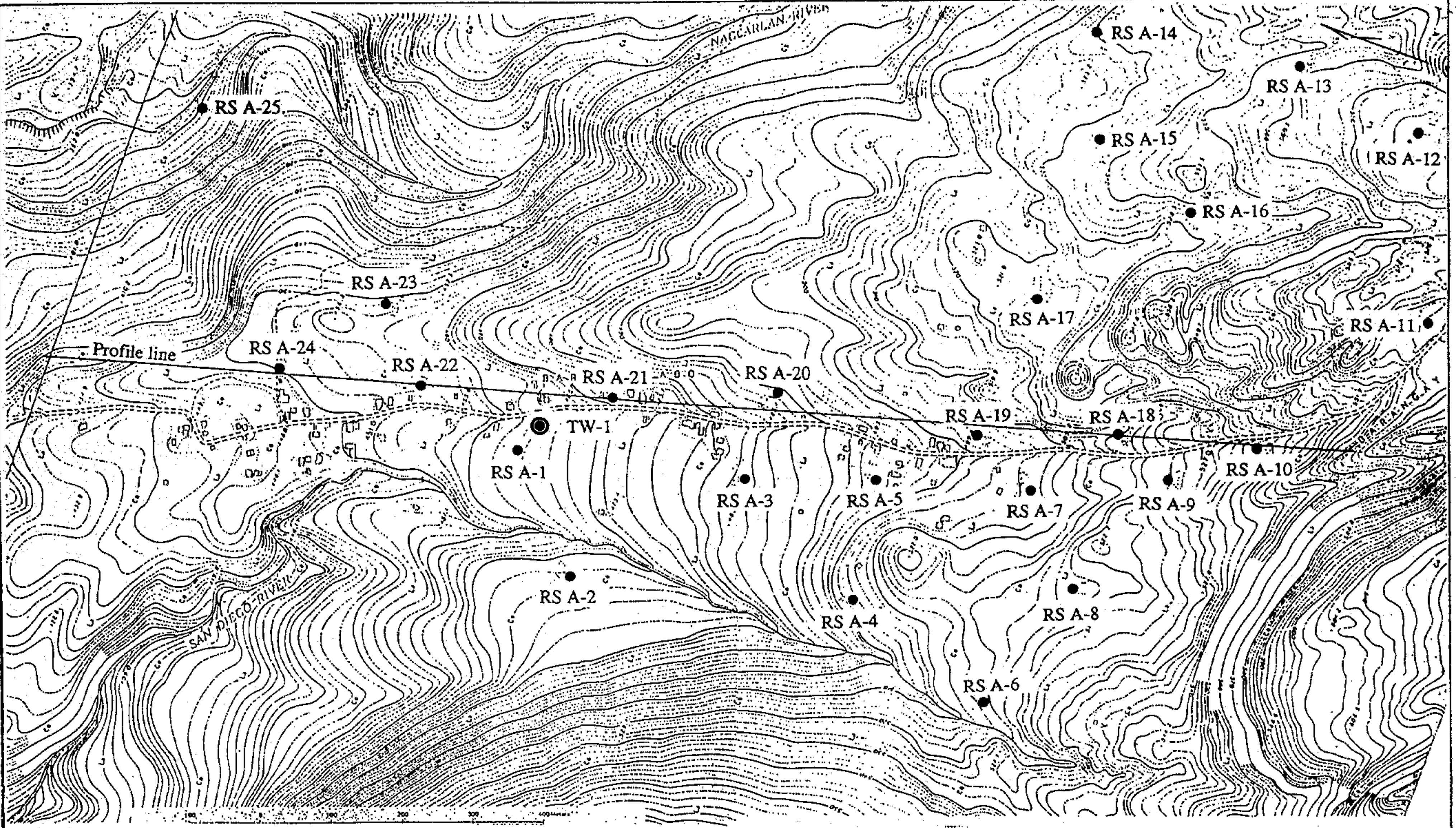


Fig. II.5.2 Location Map of Geoelectric Survey and Test Well (Abo Area)

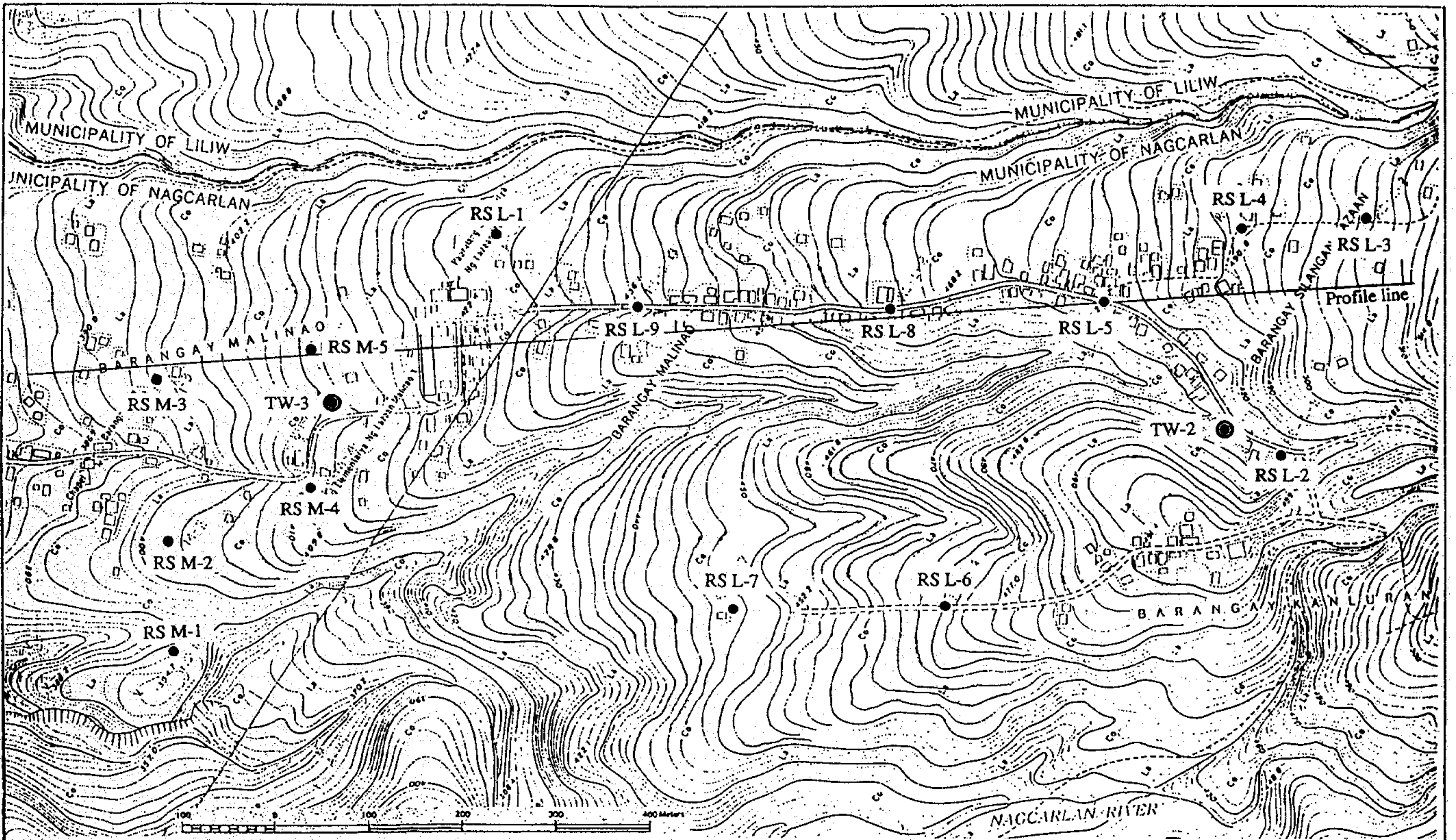


Fig. II.5.3 Location Map of Geoelectric Survey and Test Well (Silangan Lazzan and Malinao Area)

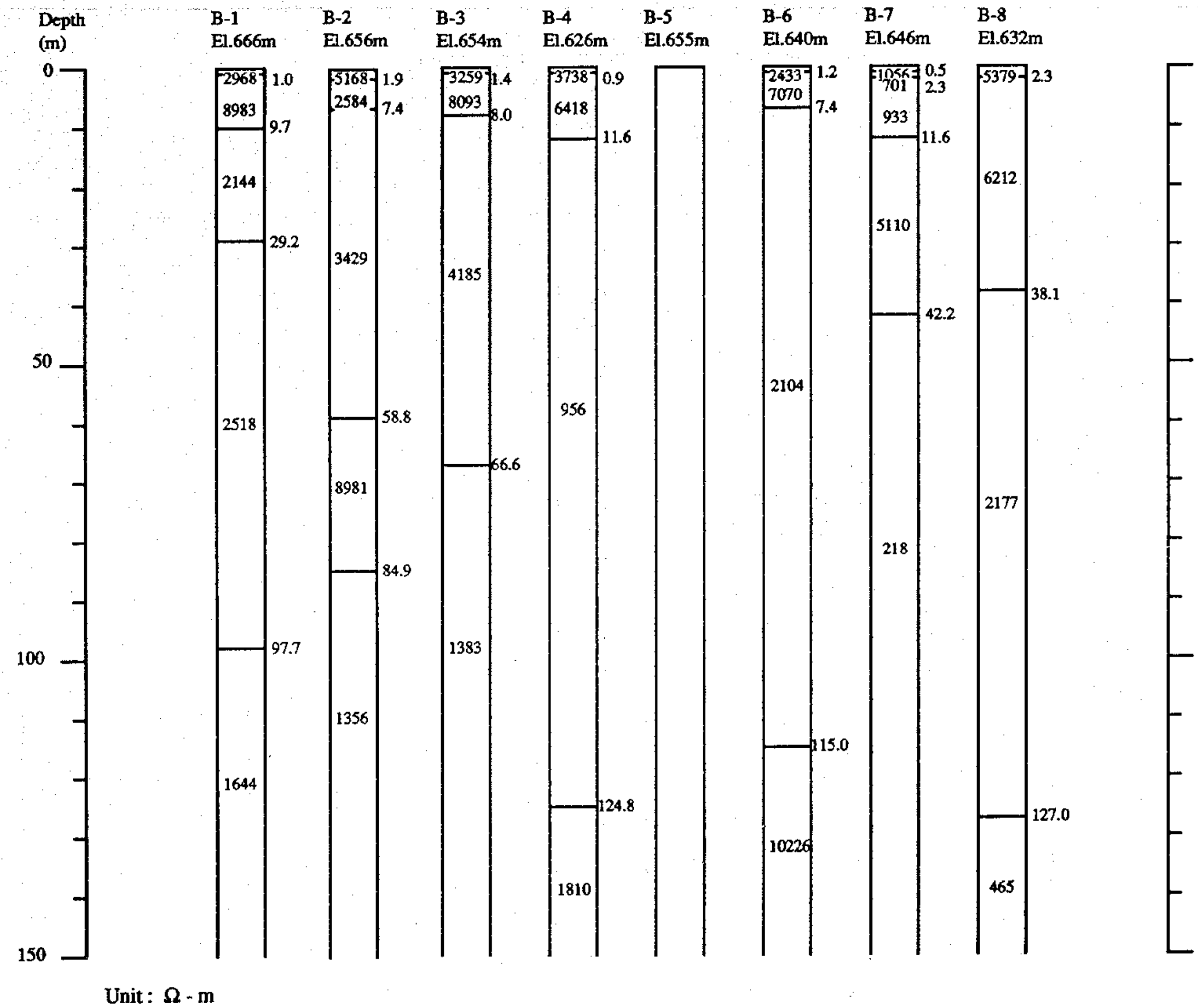


Fig. II.5.4 Resistivity Log in Bukal Area

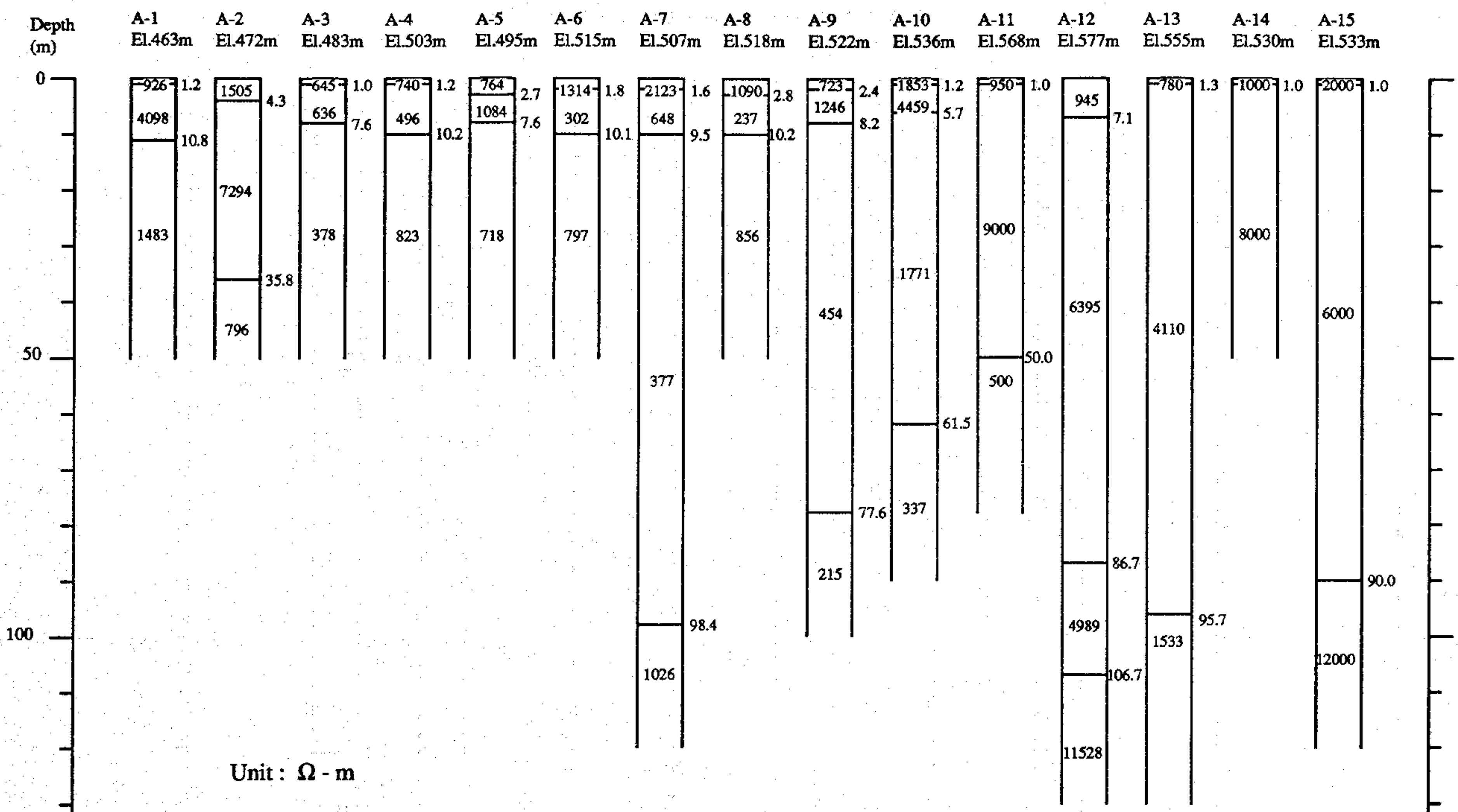


Fig. II.5.5 Resistivity Log in Abo Area (1/2)

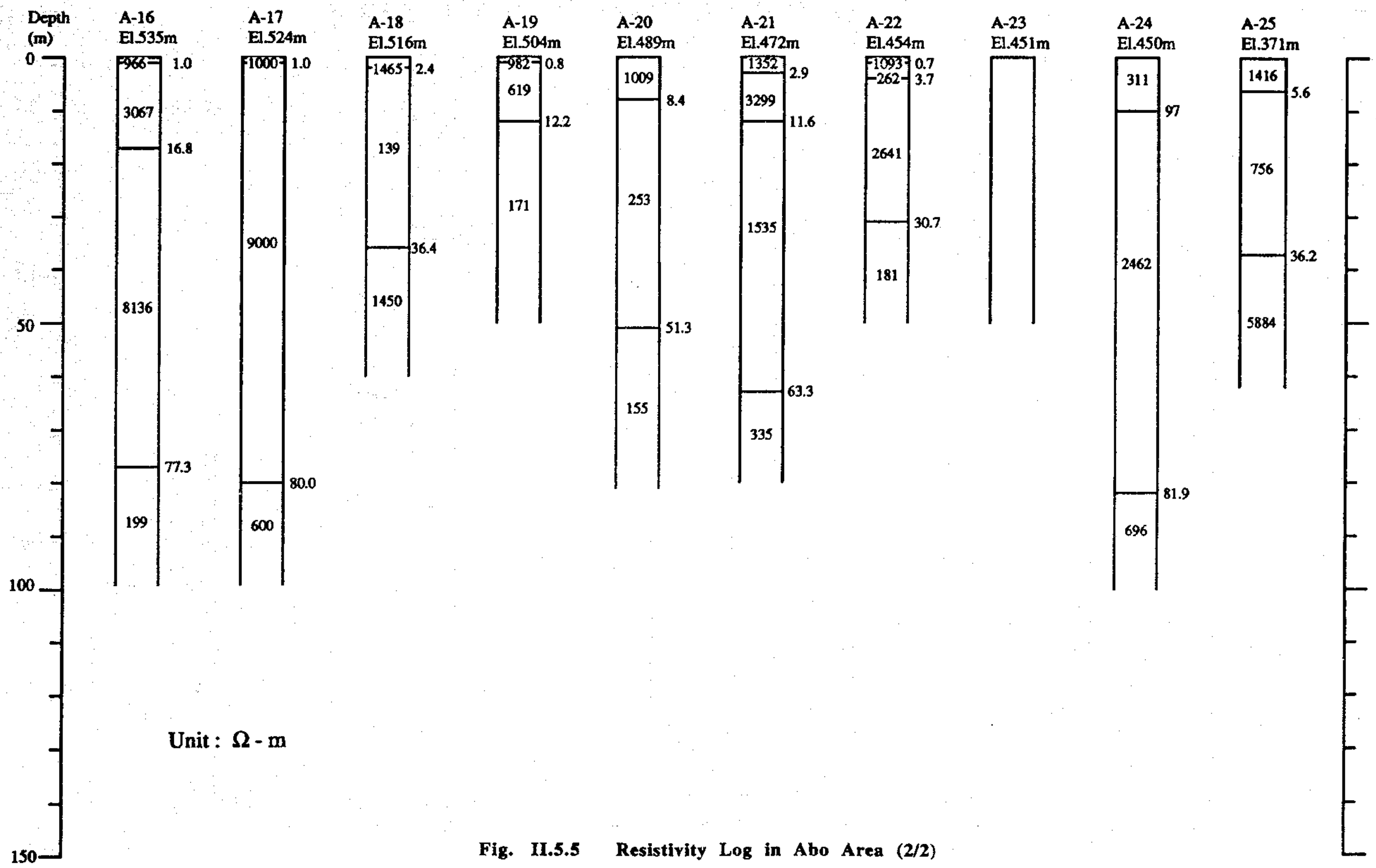


Fig. II.5.5 Resistivity Log in Abo Area (2/2)

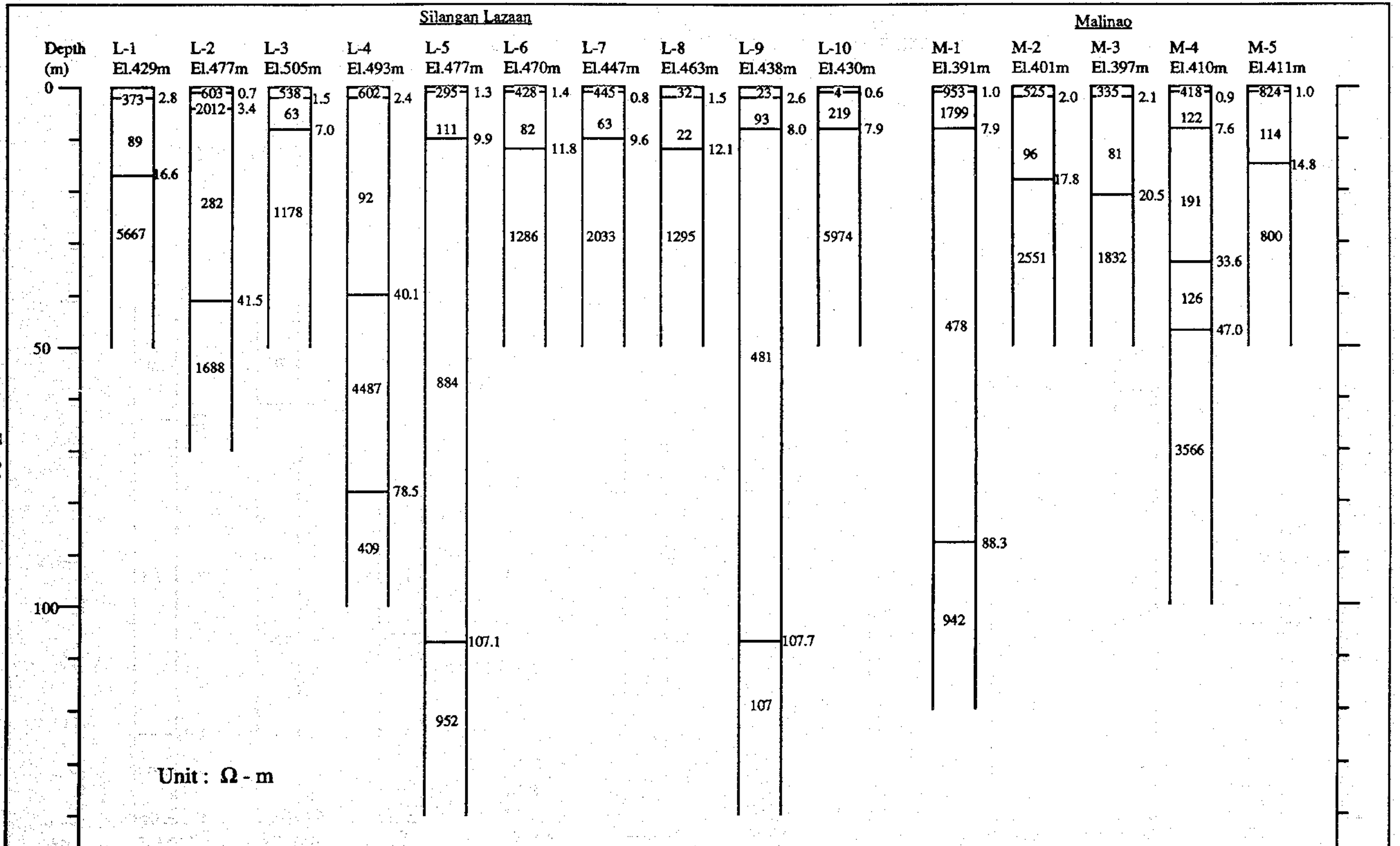


Fig. II.5.6 Resistivity Log in Silangan Lazaan and Malinao Area

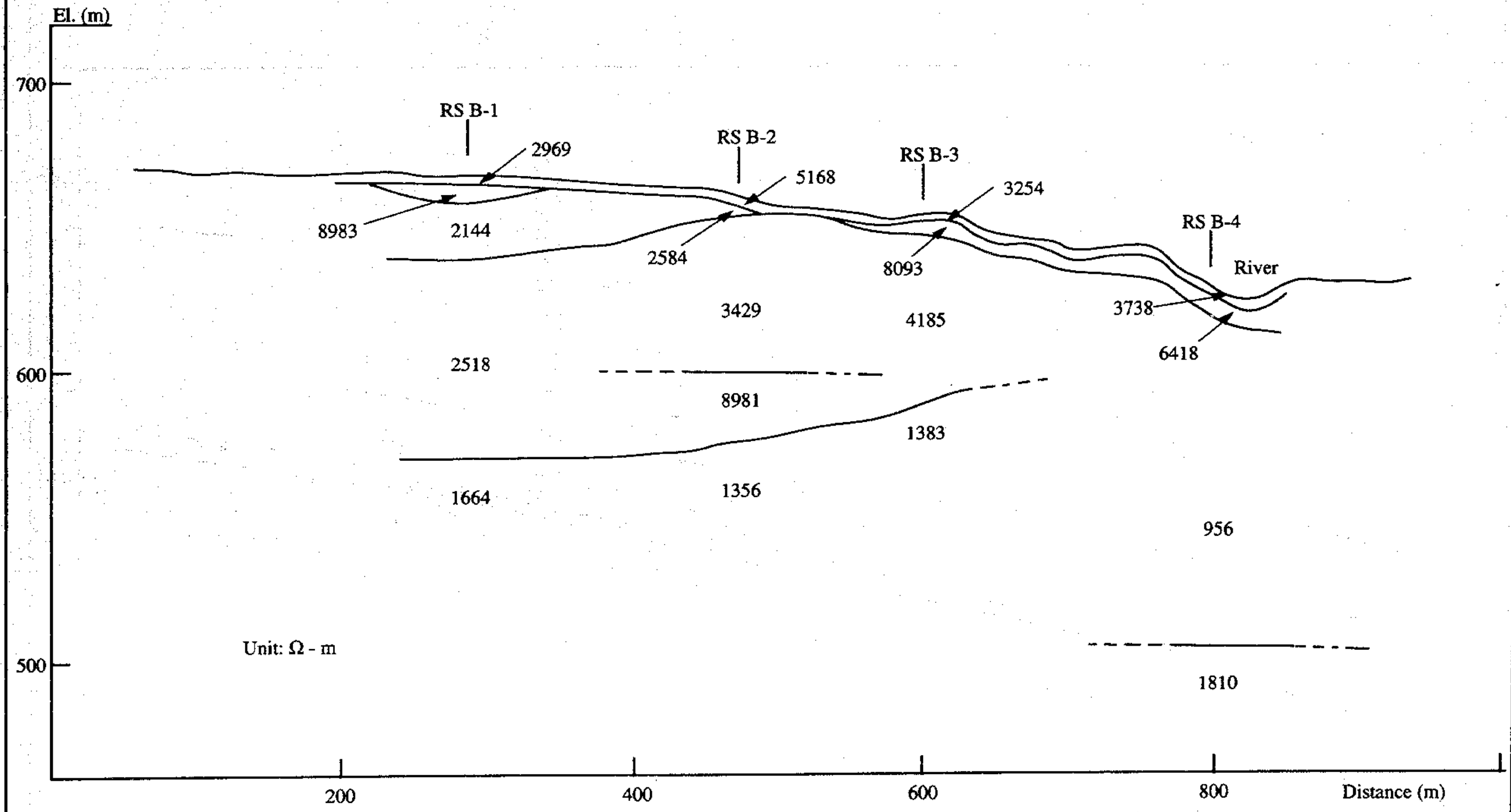


Fig. II.5.7 Typical Resistivity Profile in Bukal Area

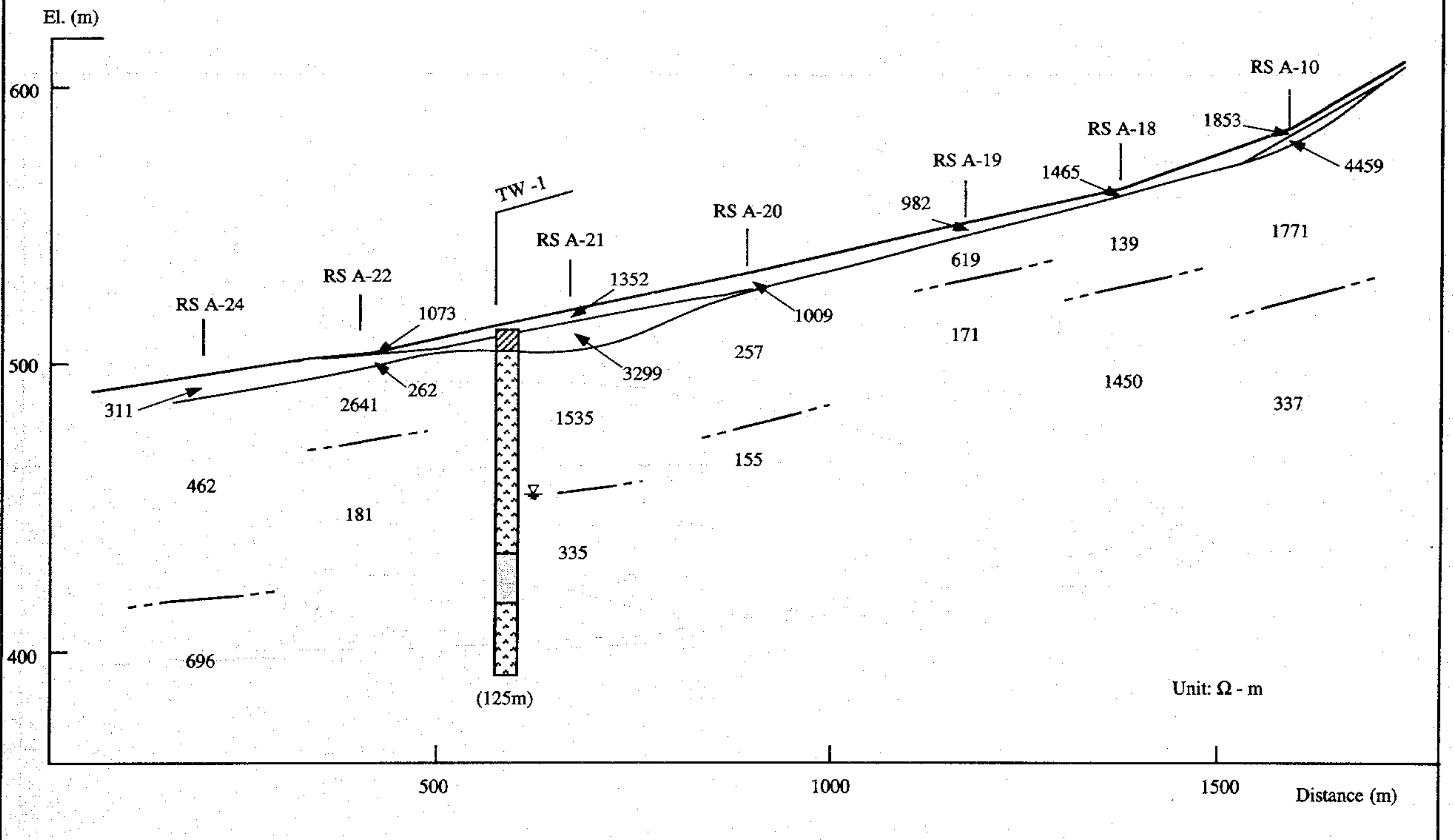


Fig. II.5.8 Typical Resistivity Profile in Abo Area

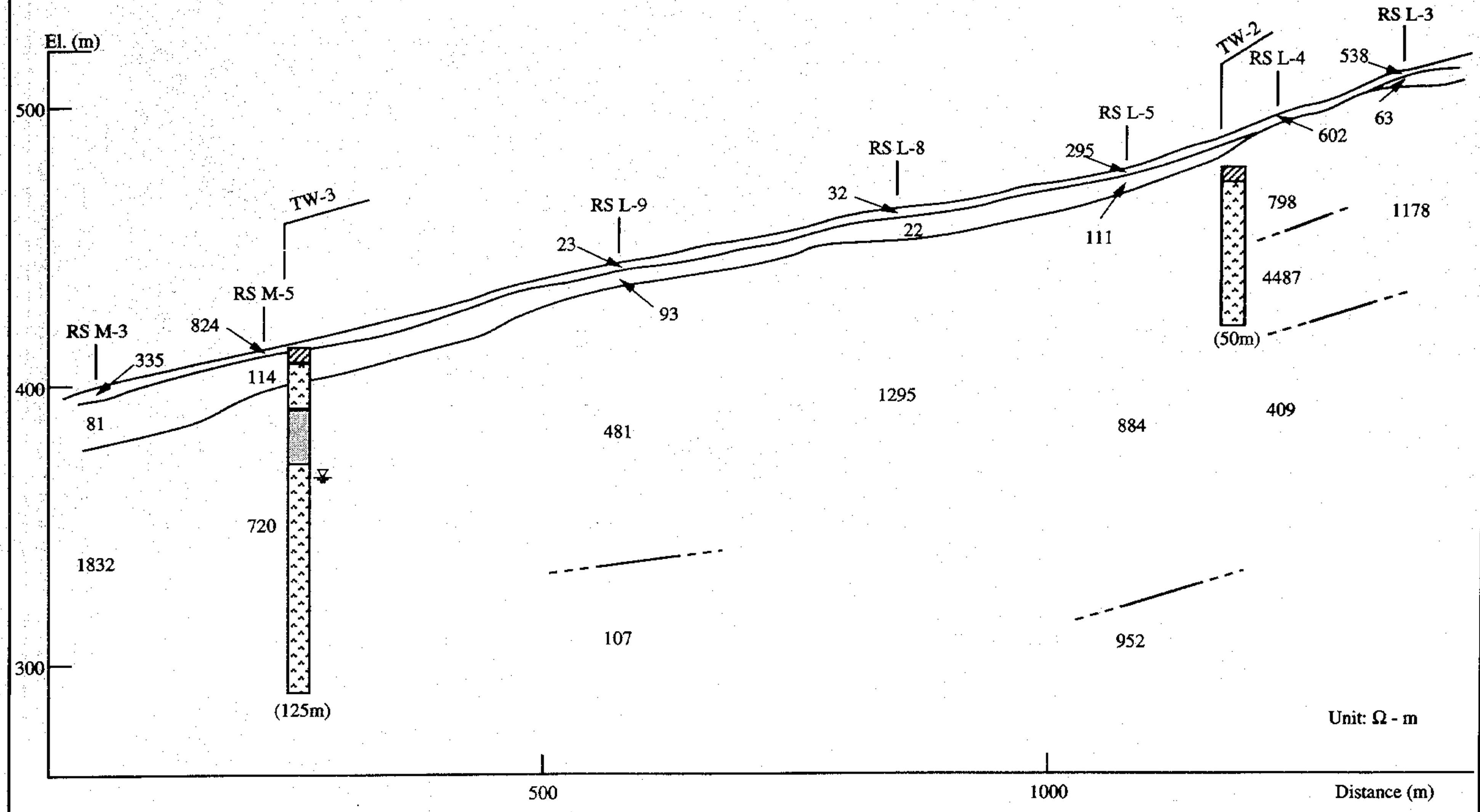


Fig. II.5.9 Typical Resistivity Profile in Silangan Lazaan and Malinao Area

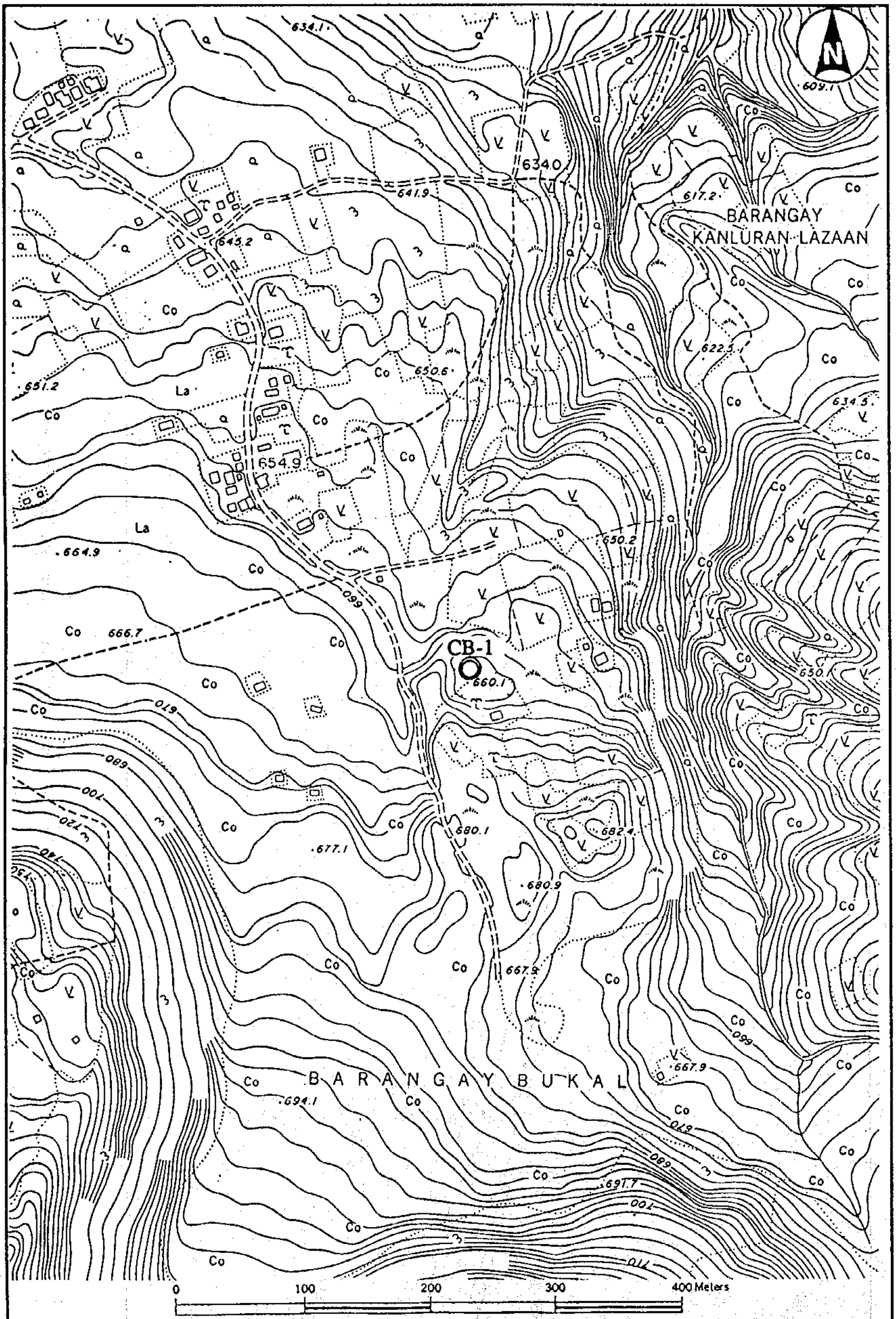


Fig. II.7.1 Location of Core Boring CB-1 in the Barangay Bukal

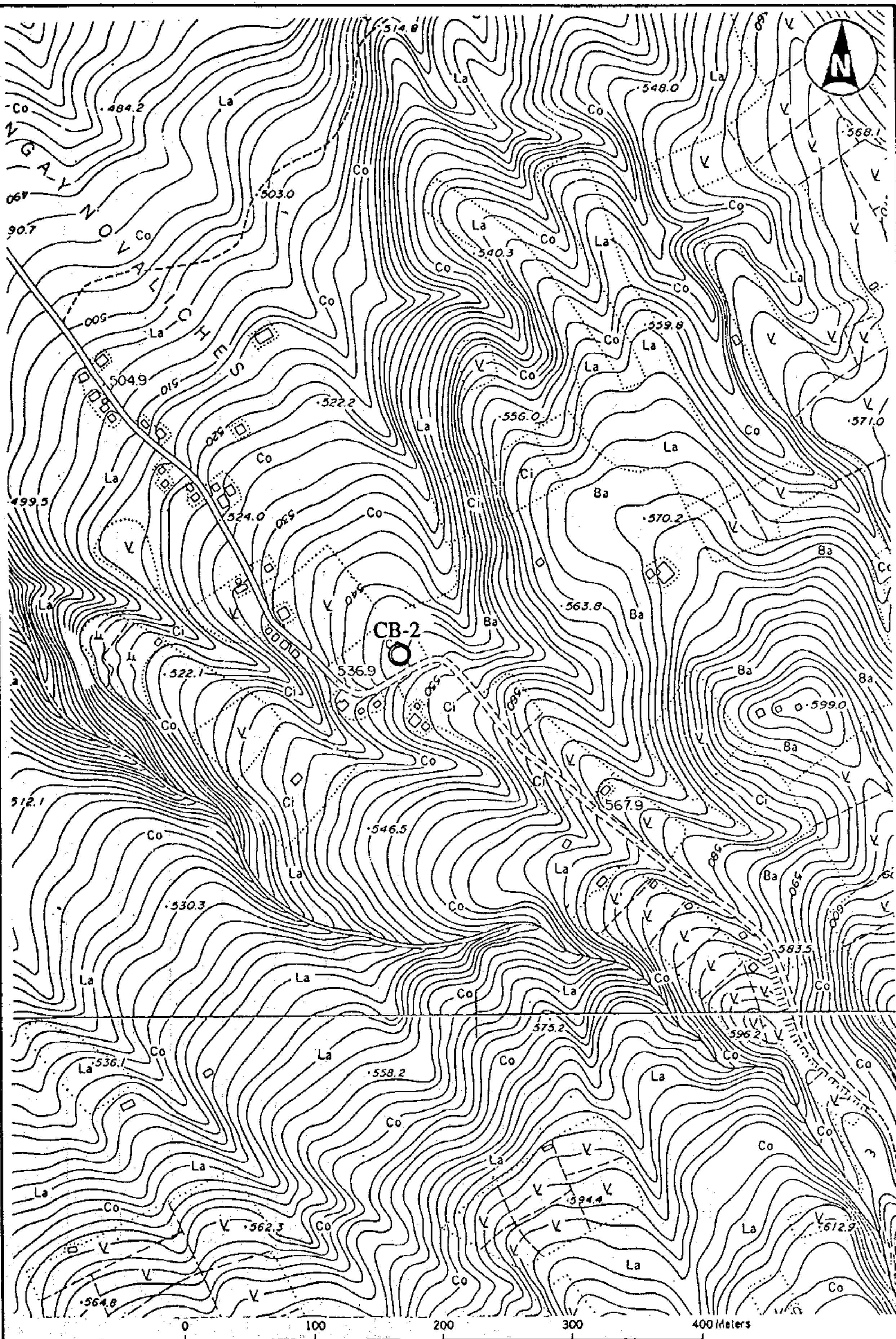


Fig. II.7.2 Location of Core Boring CB-2 in the Barangay Novaliches

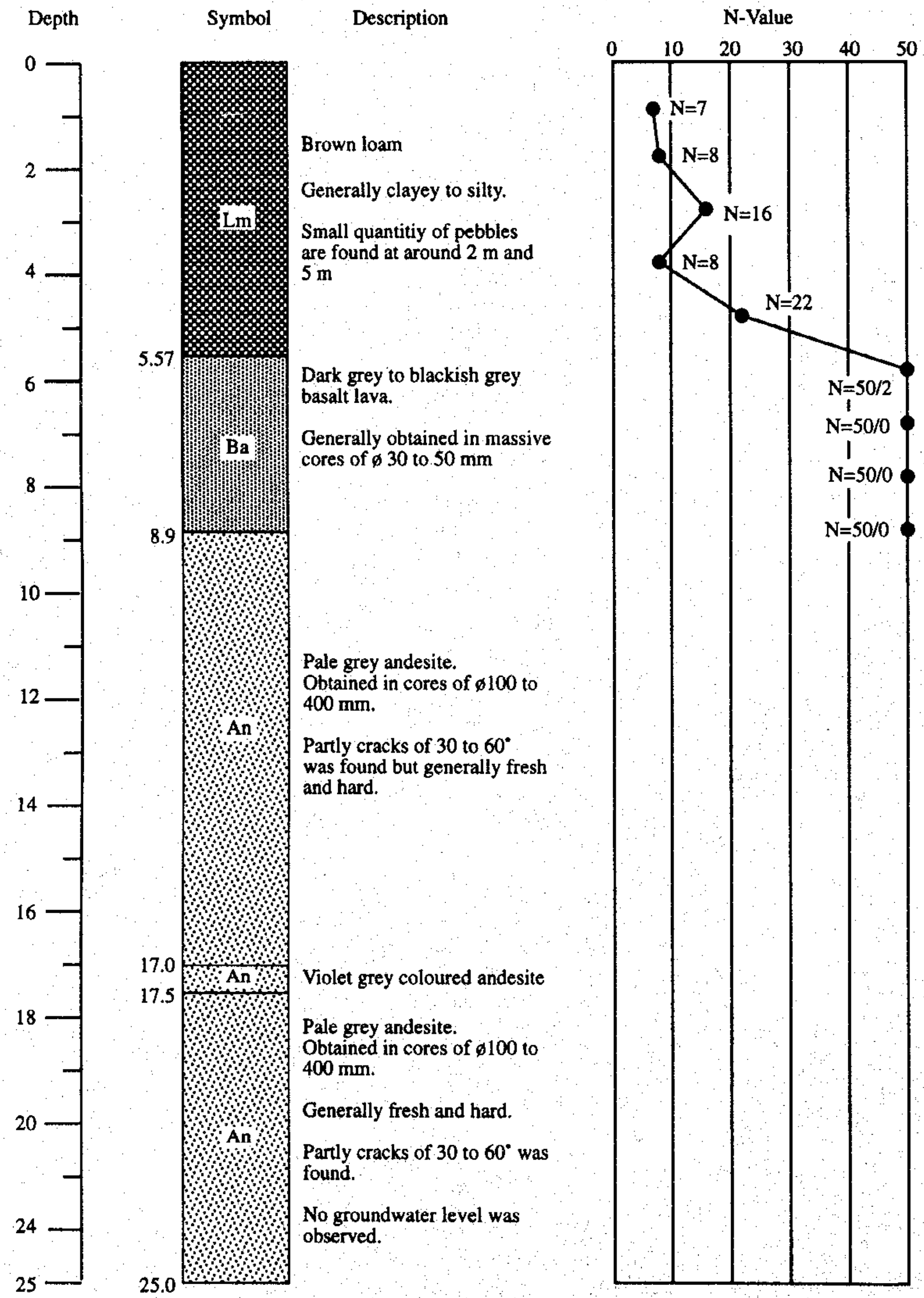


Fig. II.7.3 Boring Log and N-Values of CB-1

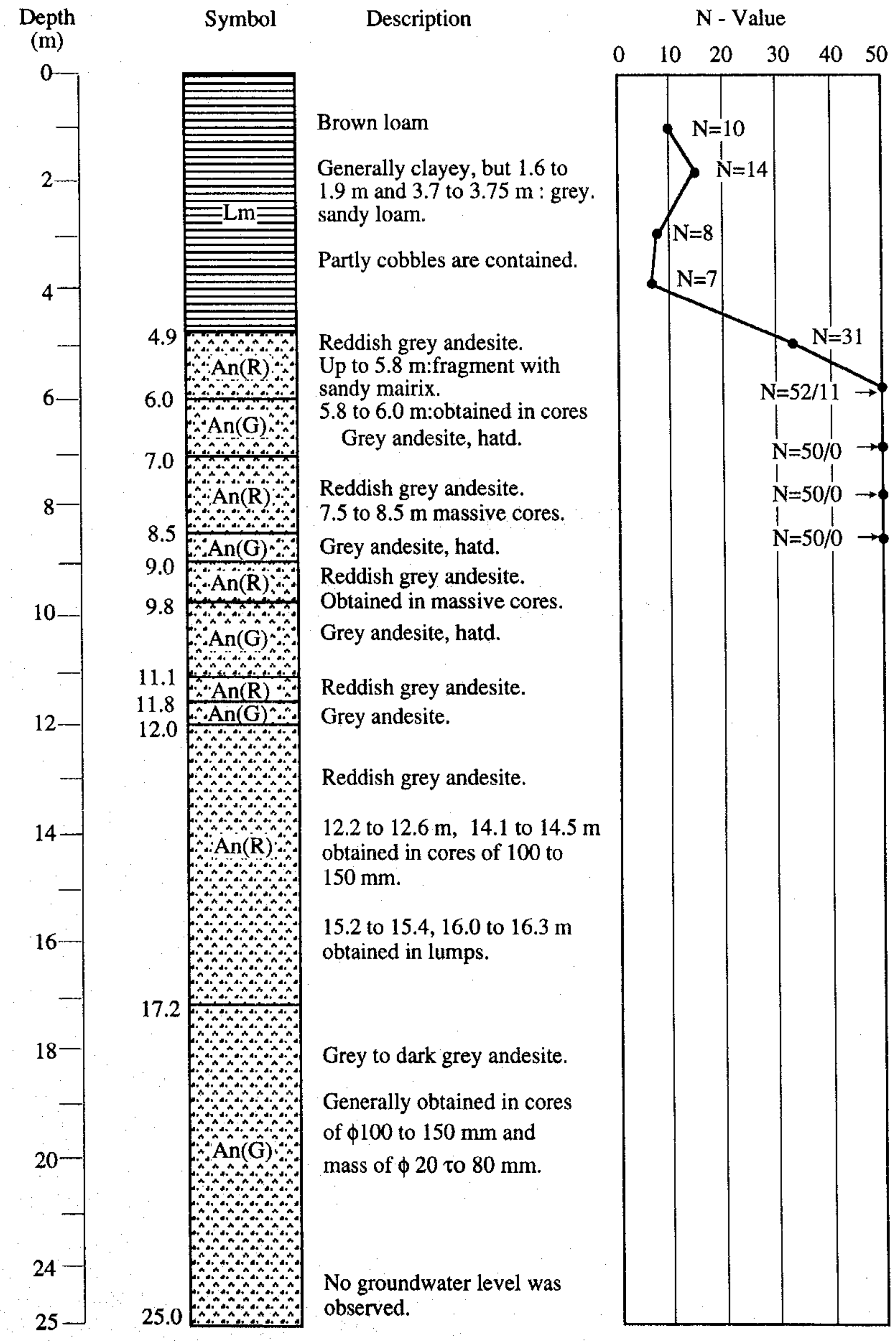


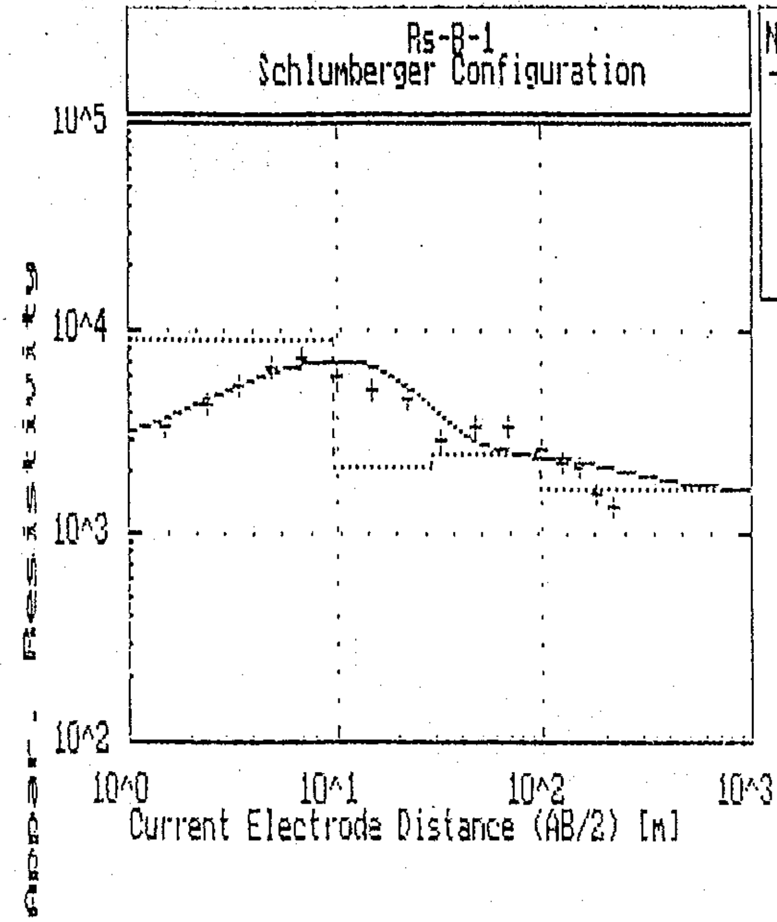
Fig. II.7.4 Boring Log and N-Values of CB-2

Attachment II.1 Resistivity-Electrode Spacing Curves
Bukal Area (B-1 to B-8, Total 8 points)

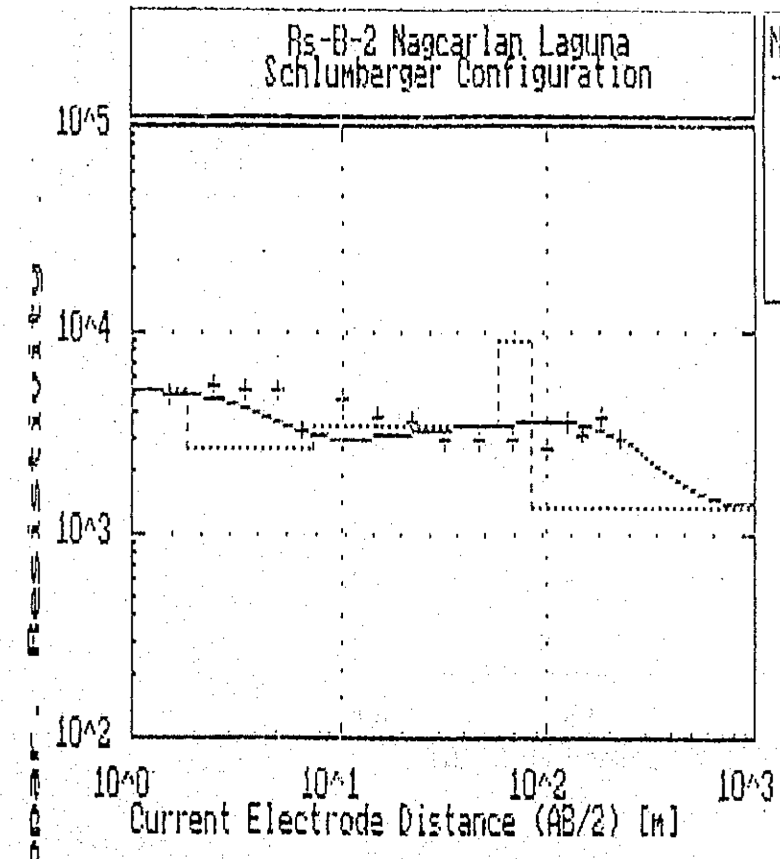
CONFIGURATION CURVES

ELECTRIC RESISTIVITY SURVEY

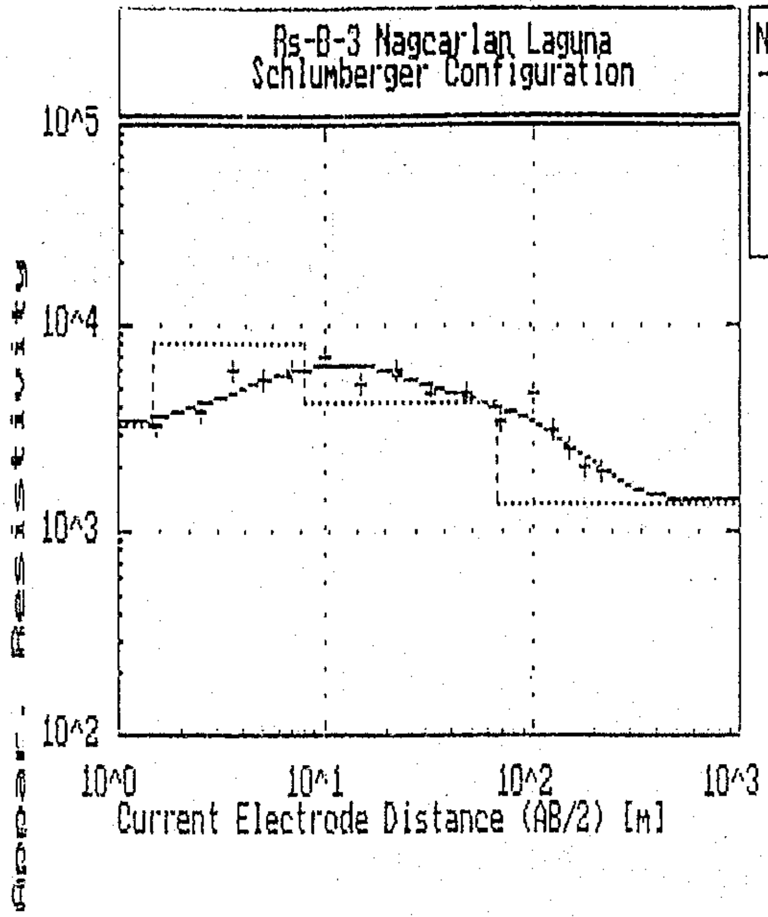
BARANGAY BUKAL, NAGCARLAN, LAGUNA



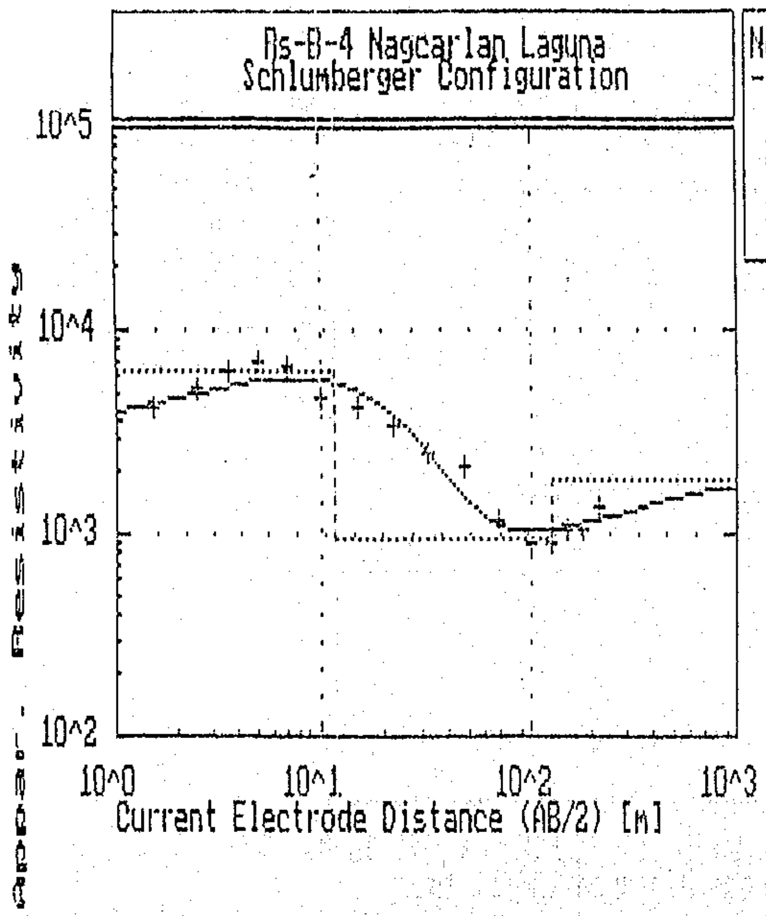
No	Res	Thick
1	2967.8	1.0
2	8983.1	8.7
3	2143.8	19.5
4	2517.6	68.5
5	1663.8	-.-



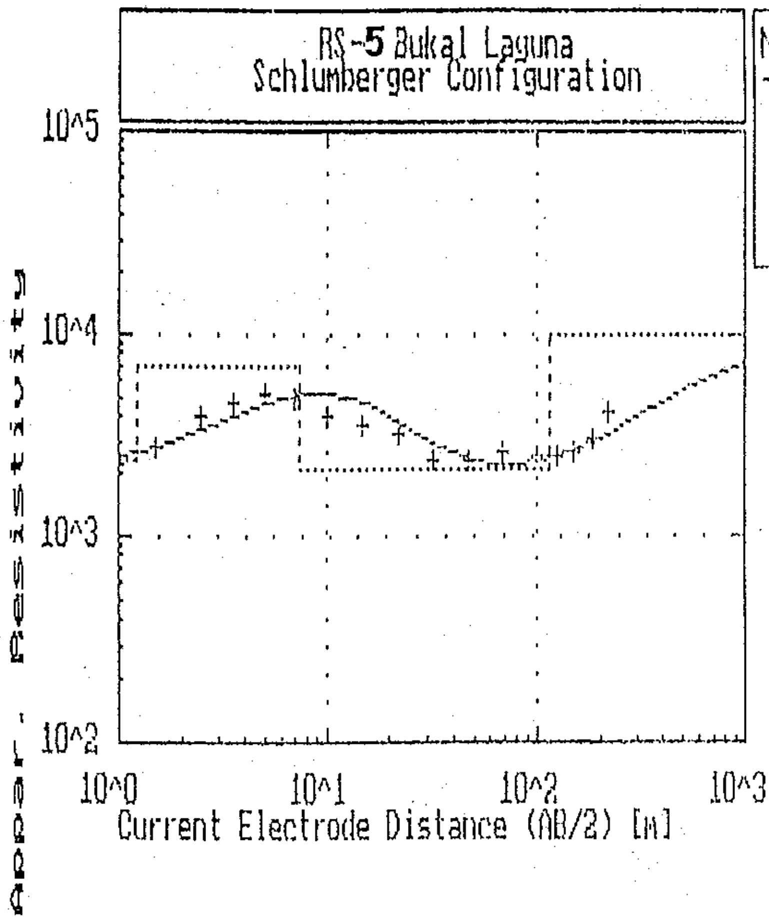
No	Res	Thick
1	5167.7	1.9
2	2583.5	5.5
3	3428.8	51.4
4	8981.0	26.1
5	1356.1	-.-



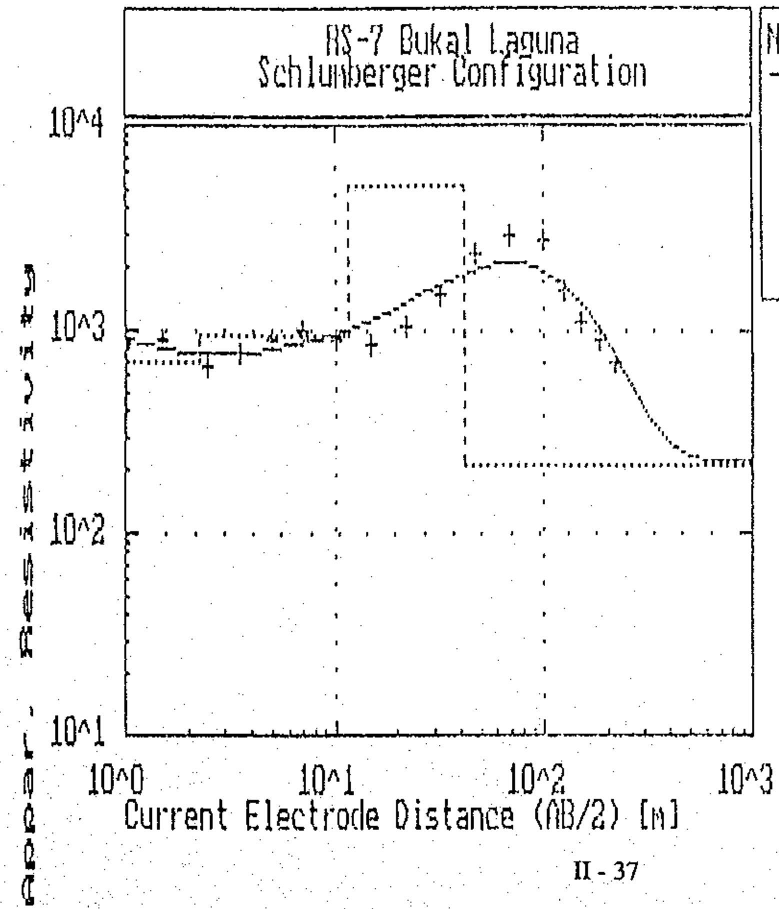
No	Res	Thick
1	3258.7	1.4
2	8092.9	6.6
3	4184.5	58.6
4	1382.7	-.-



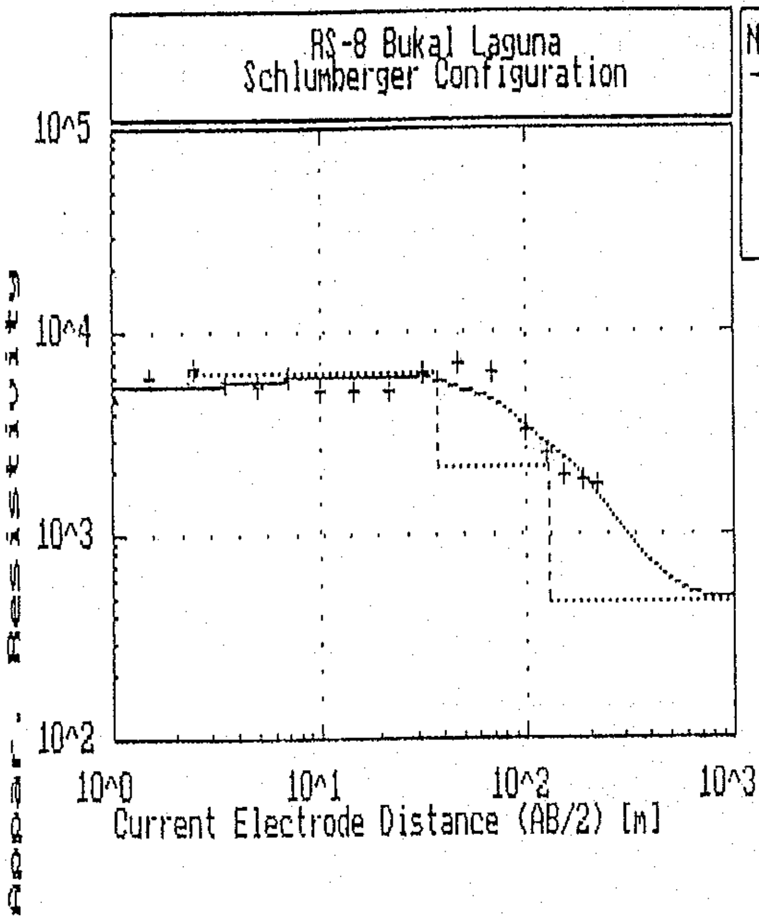
No	Res	Thick
1	3737.8	0.9
2	6417.5	10.7
3	955.5	113.2
4	1810.1	-.-



No	Res	Thick
1	2432.5	1.2
2	7090.2	6.2
3	2104.1	107.6
4	10226.2	-.-



No	Res	Thick
1	1055.6	0.5
2	700.9	1.8
3	932.8	9.3
4	5109.5	30.6
5	218.1	-.-

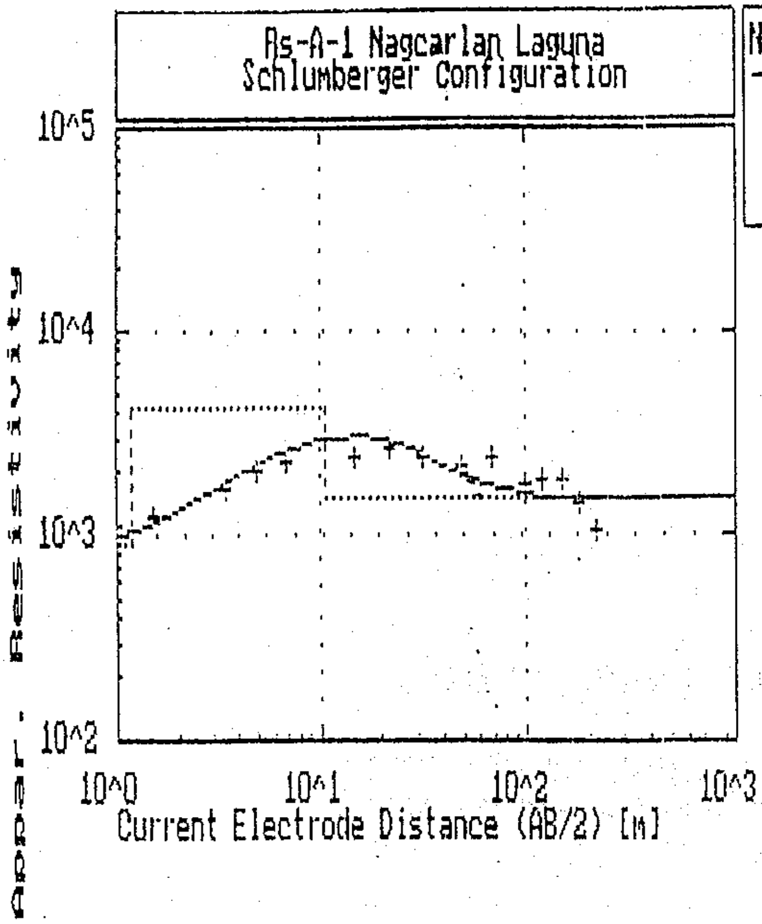


No	Res	Thick
1	5378.8	2.3
2	6212.2	35.8
3	2177.4	88.9
4	464.9	-.-

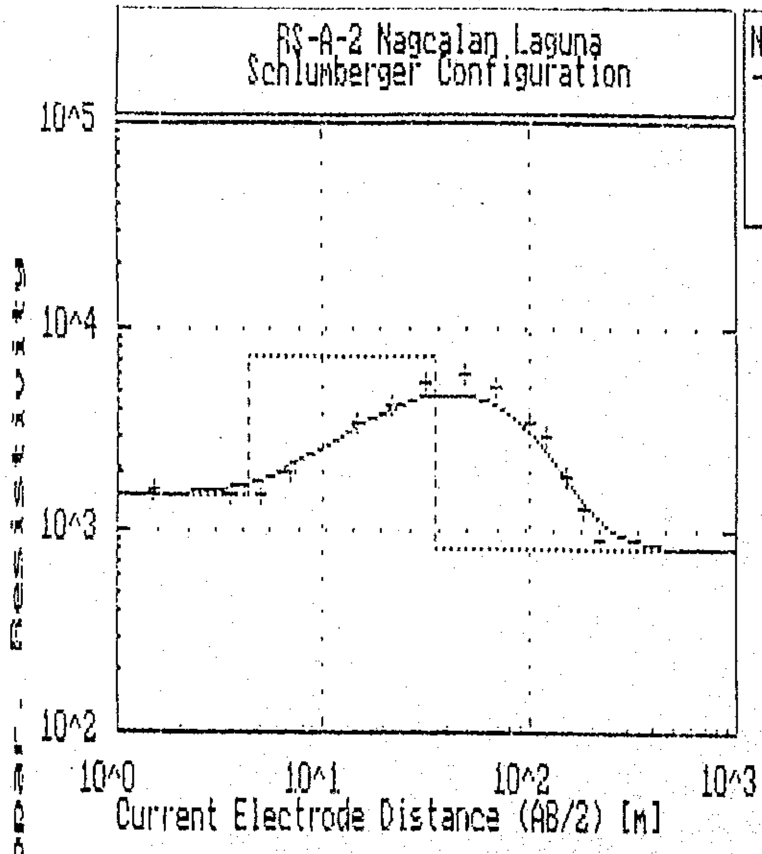
CONFIGURATION CURVES

ELECTRIC RESISTIVITY SURVEY

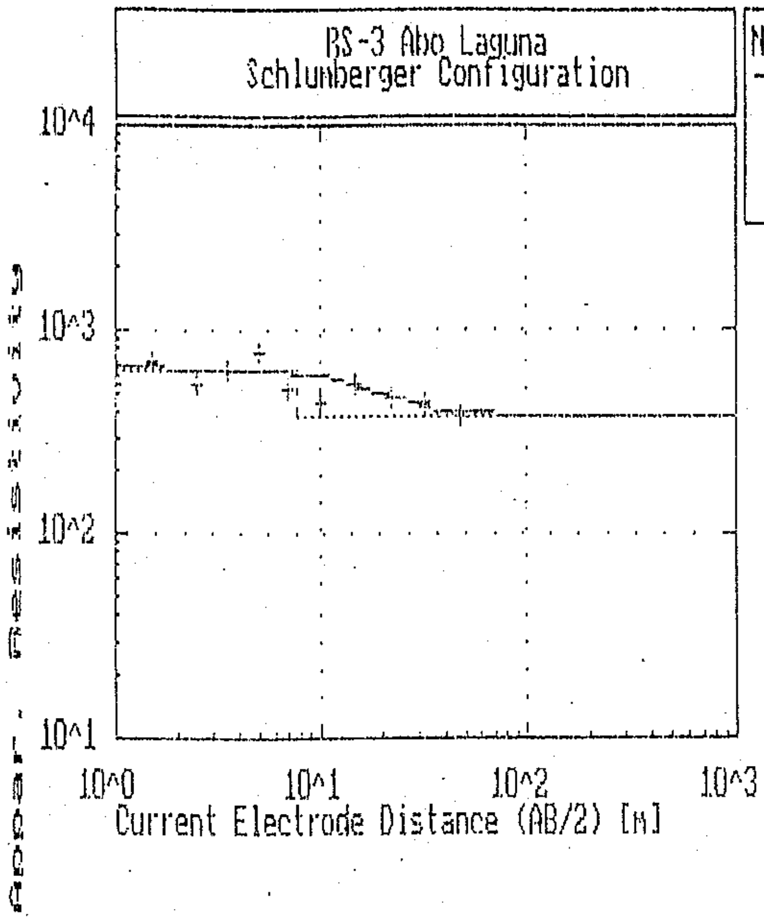
BARANGAY ABO, NAGCARLAN, LAGUNA



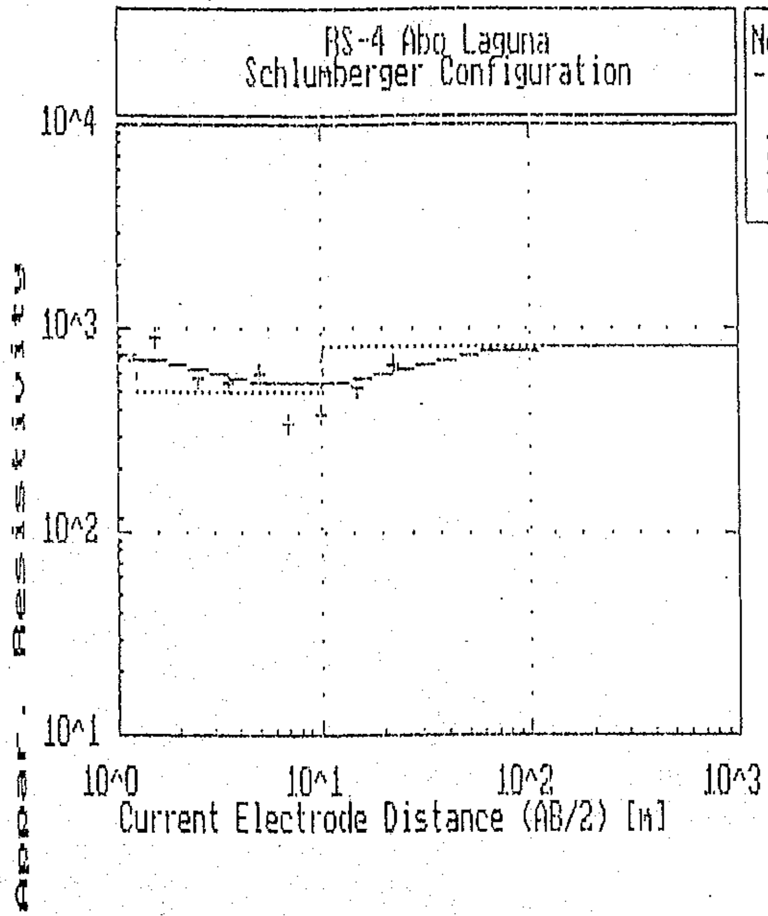
No	Res	Thick
1	925.5	1.2
2	4097.8	9.6
3	1482.6	-.-



No	Res	Thick
1	1504.5	4.3
2	7293.7	31.5
3	795.8	-.-



No	Res	Thick
1	654.3	1.0
2	635.8	6.6
3	378.0	-.-



No	Res	Thick
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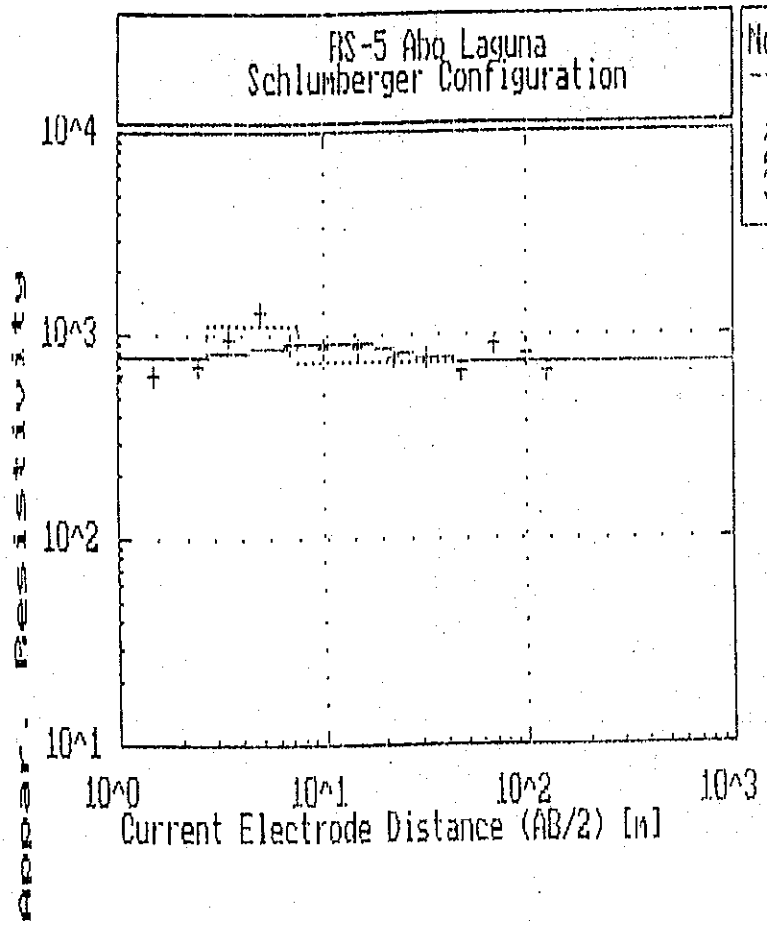
2	495.9	9.0
3	823.0	-.-



No	Res	Thick
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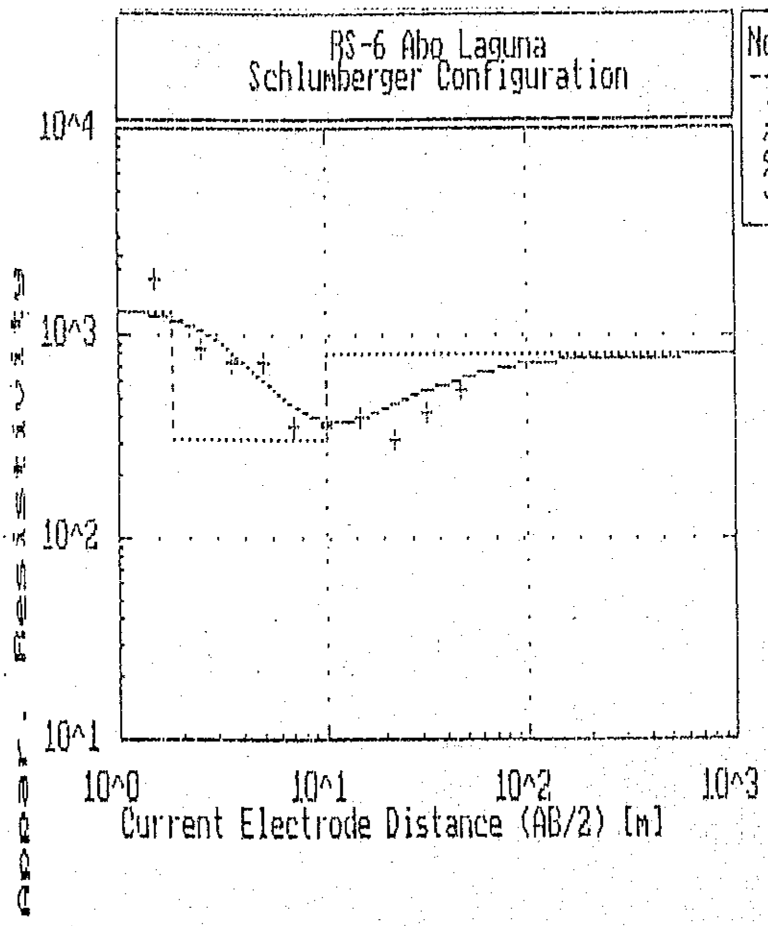
2	1084.3	4.9
3	718.4	-.-



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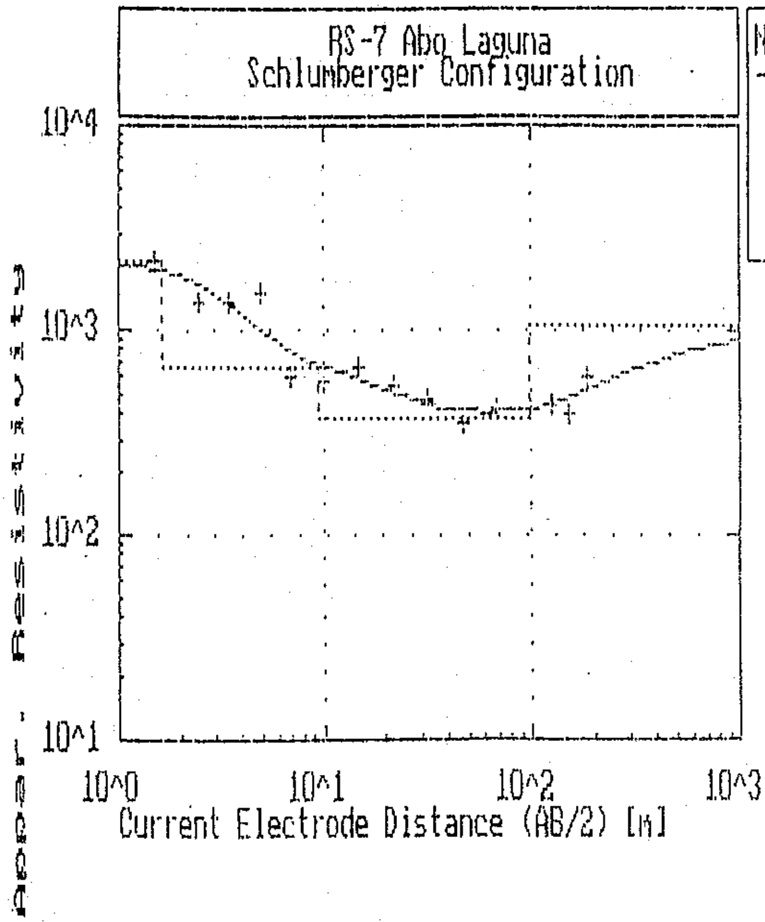
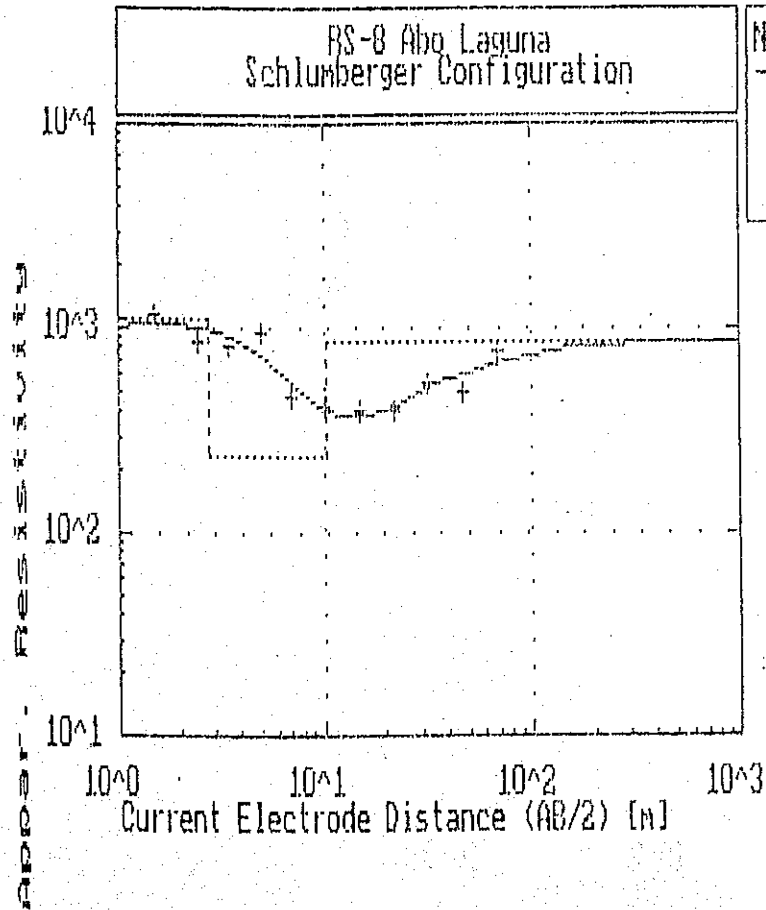
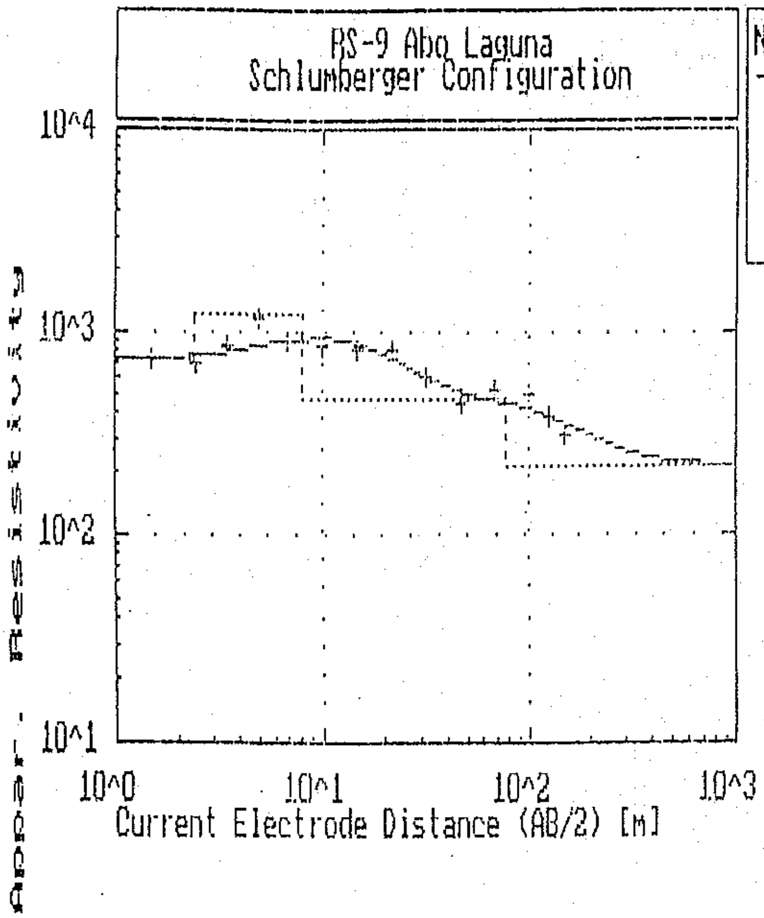
2	301.6	8.3
3	797.4	-.-



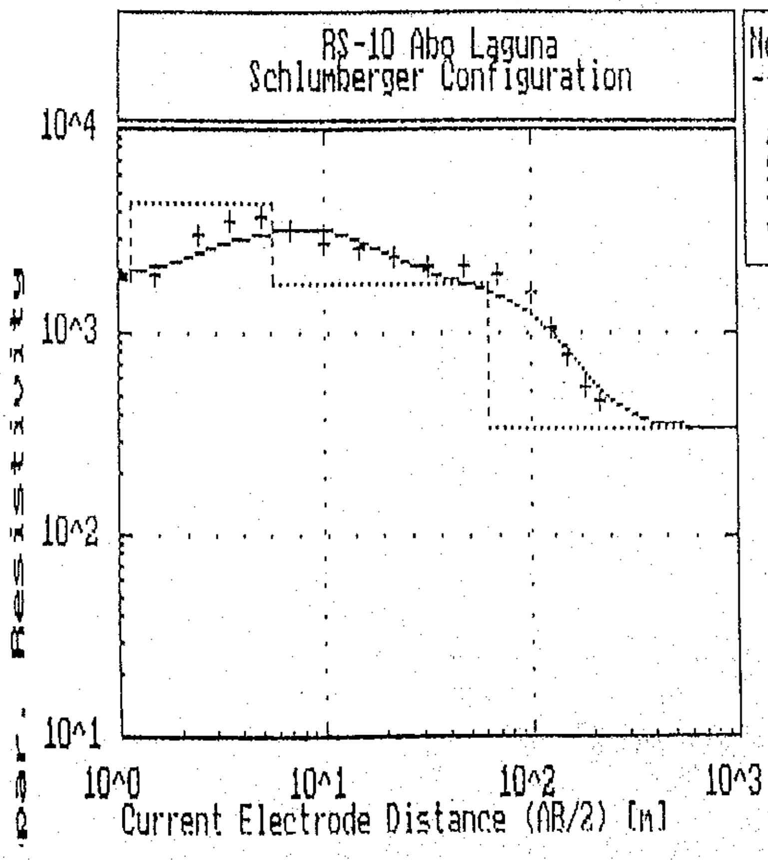
No	Res	Thick
1	2123.3	1.6
2	648.1	7.9
3	377.1	88.9
4	1026.1	-.-



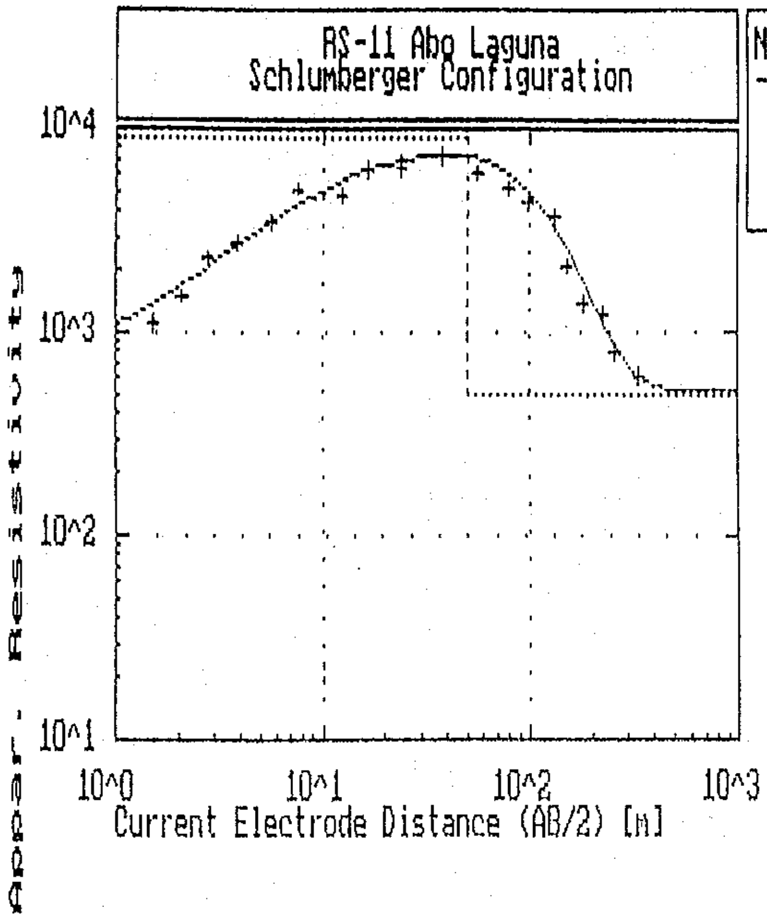
No	Res	Thick
1	1090.2	2.8
2	236.8	7.4
3	856.3	-.-



No	Res	Thick
1	722.6	2.4
2	1246.1	5.8
3	454.2	69.4
4	214.5	-.-



No	Res	Thick
1	1853.2	1.2
2	4458.8	4.5
3	1771.1	55.8
4	337.1	-.-



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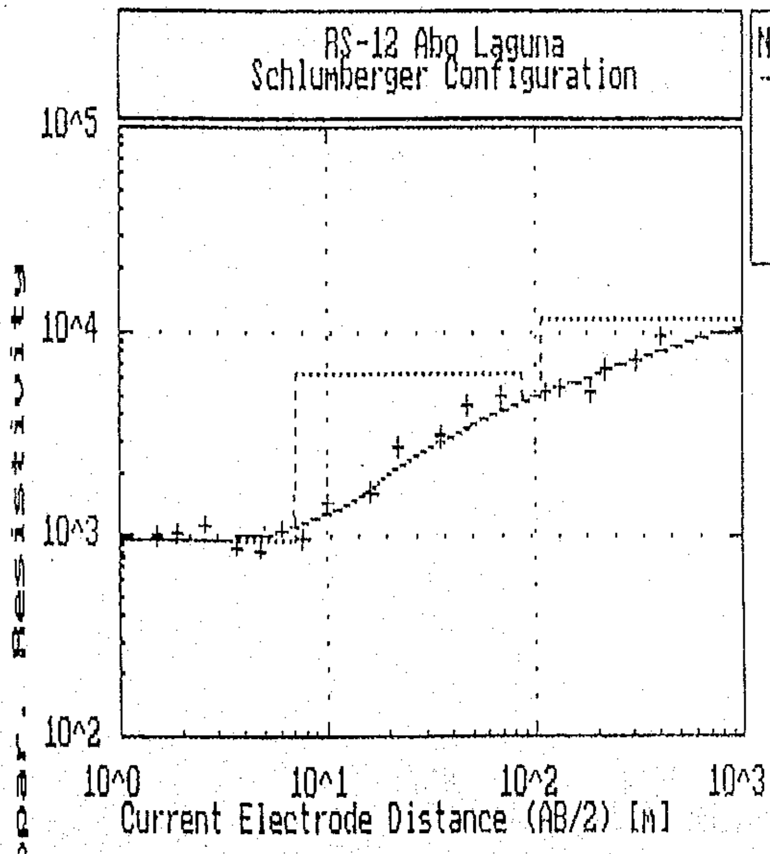
3	500.0	-.-



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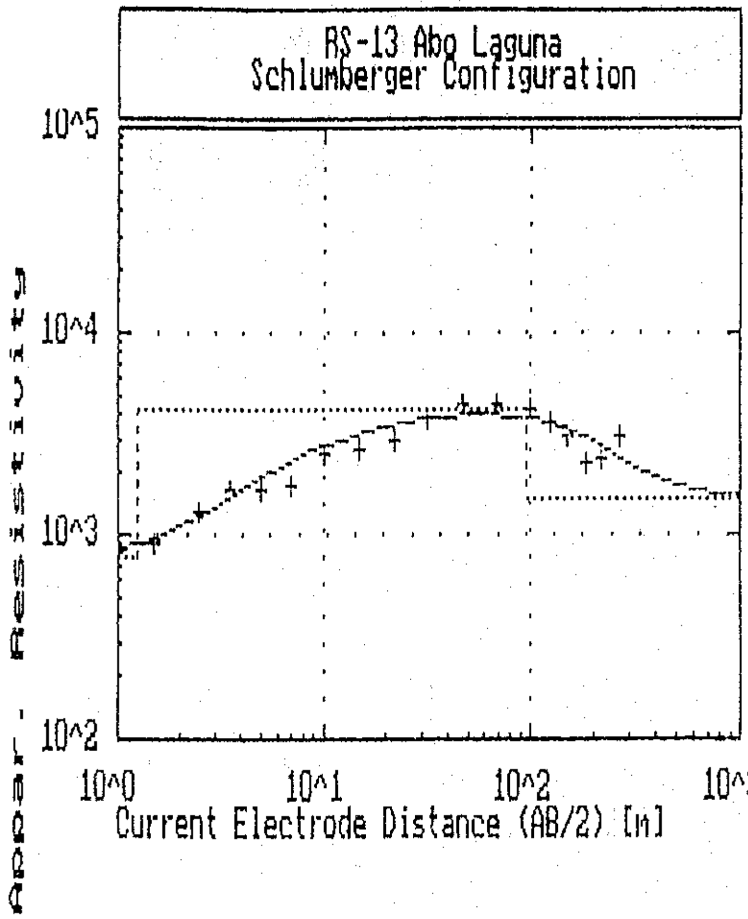
3	4988.8	20.0
4	11528.0	-.-



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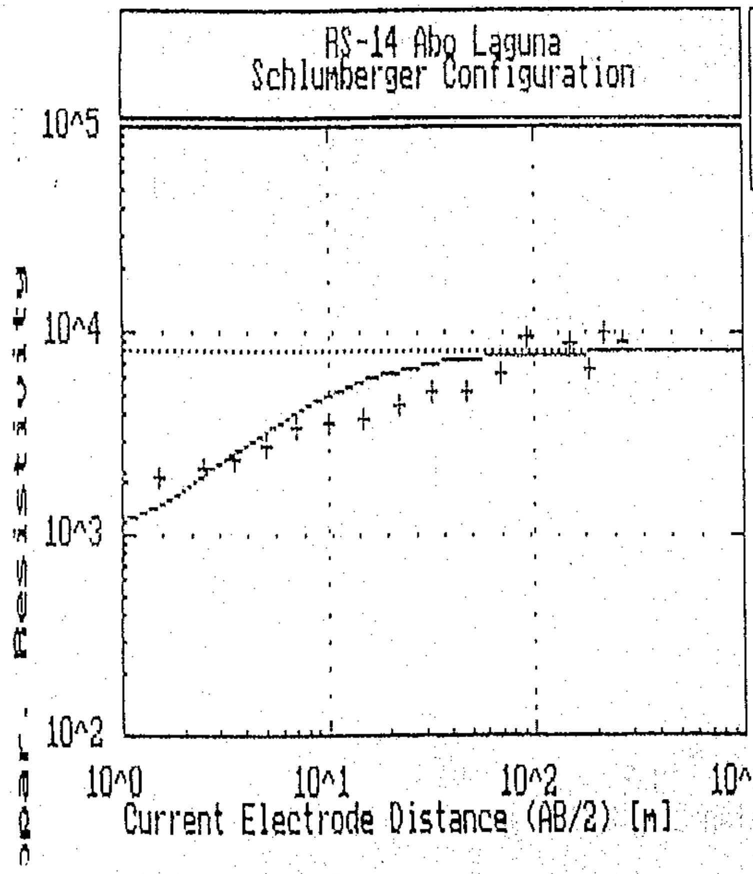
1	780.2	1.3
2	4109.6	94.4
3	1532.7	-.-



No	Res	Thick
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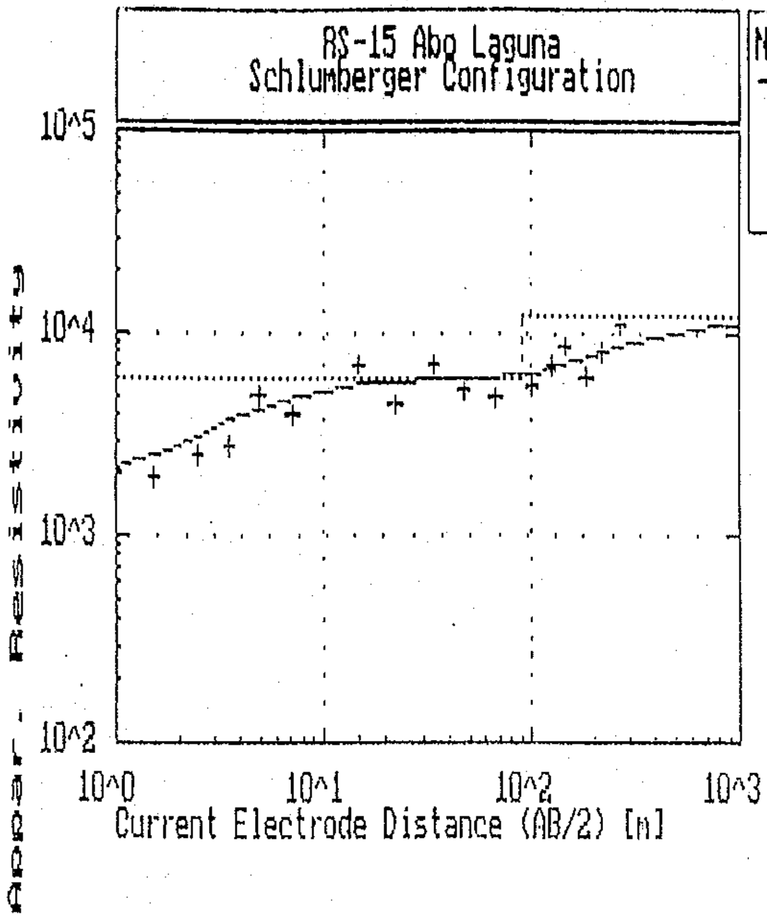
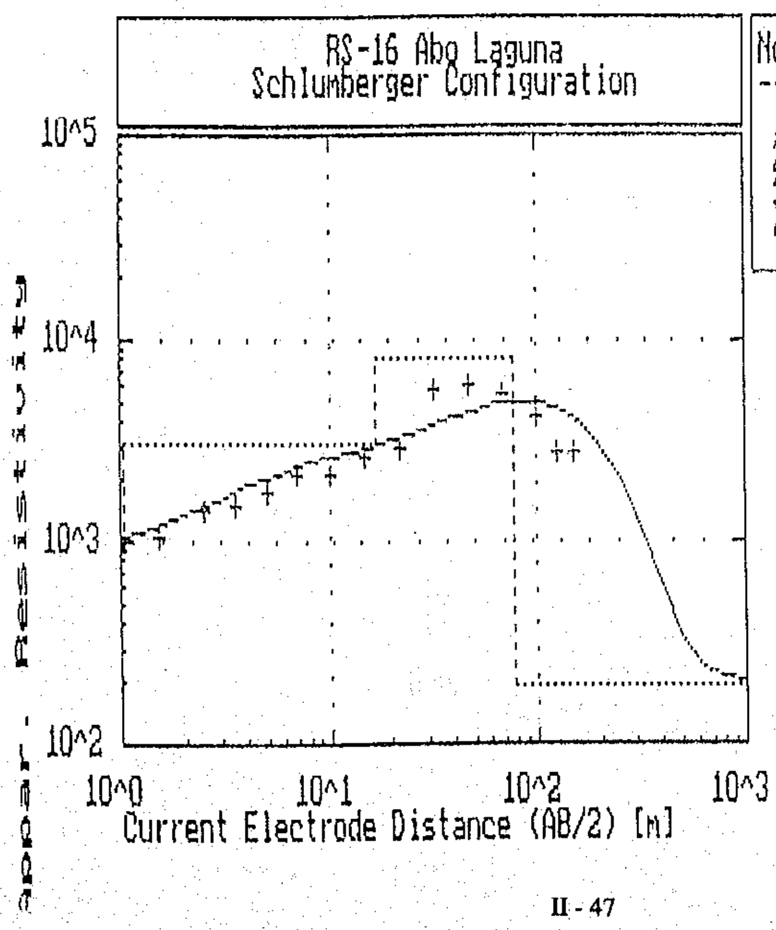
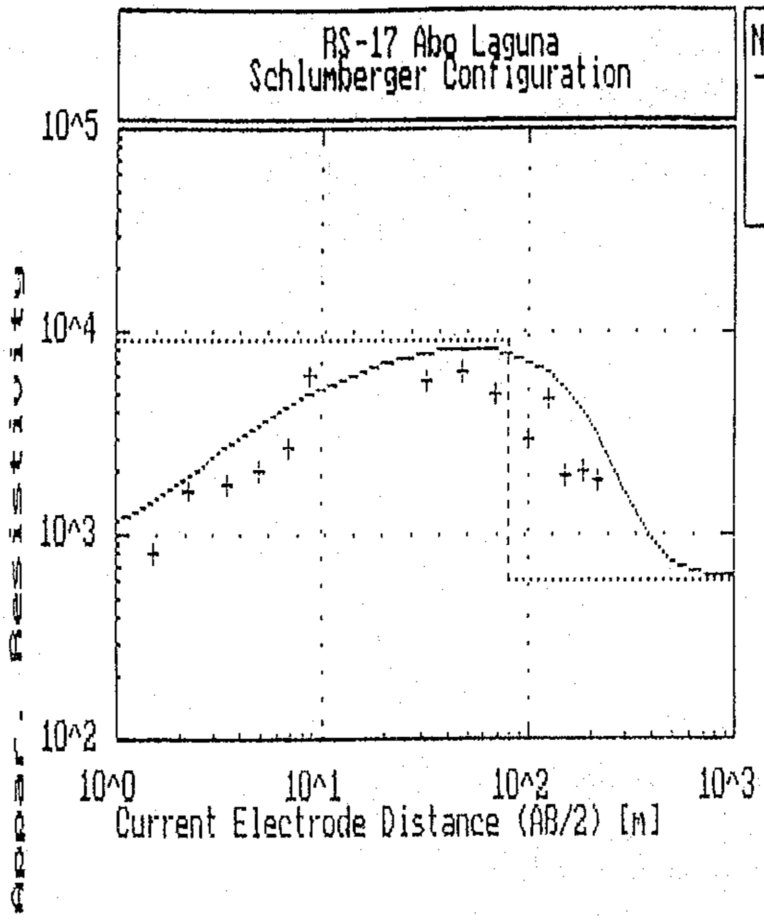
2	8000.0	-.-



No	Res	Thick
1	2000.0	1.0
2	6000.0	89.0
3	12000.0	-.-



No	Res	Thick
1	965.7	1.0
2	3067.1	15.8
3	8135.7	60.5
4	198.8	-.-



No	Res	Thick
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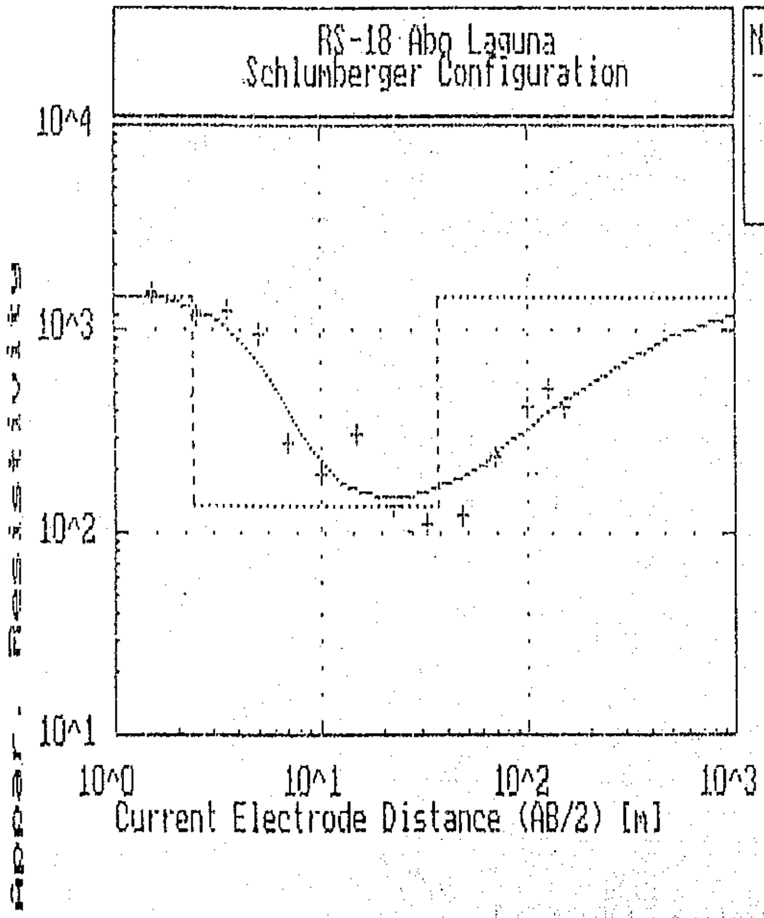
2	9000.0	79.0
3	600.0	-.-



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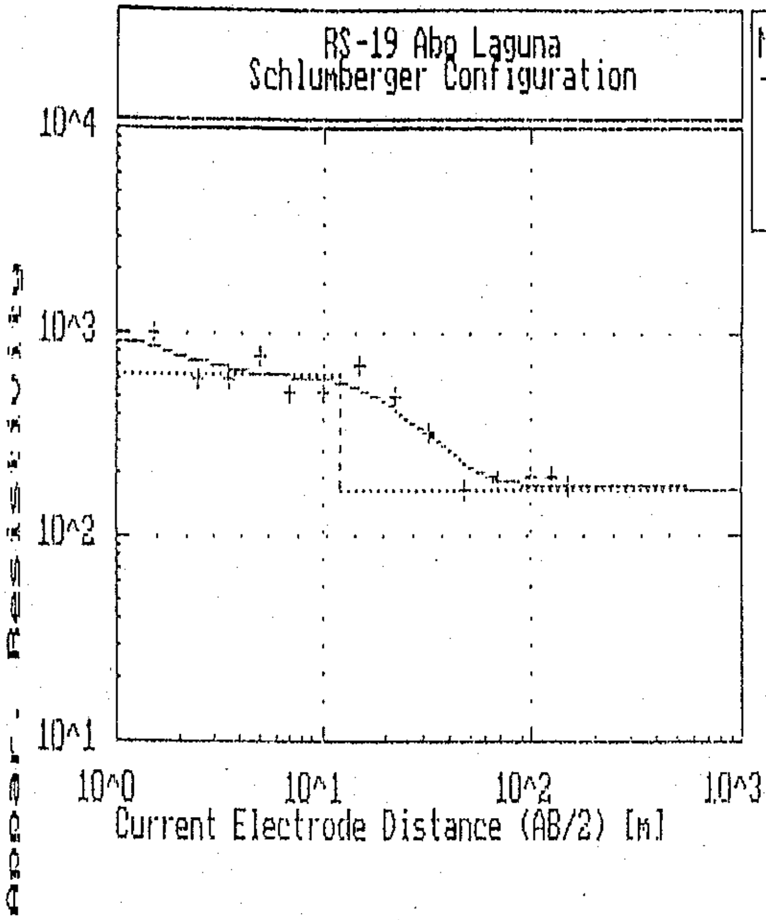
2	138.5	34.0
3	1450.1	-.-



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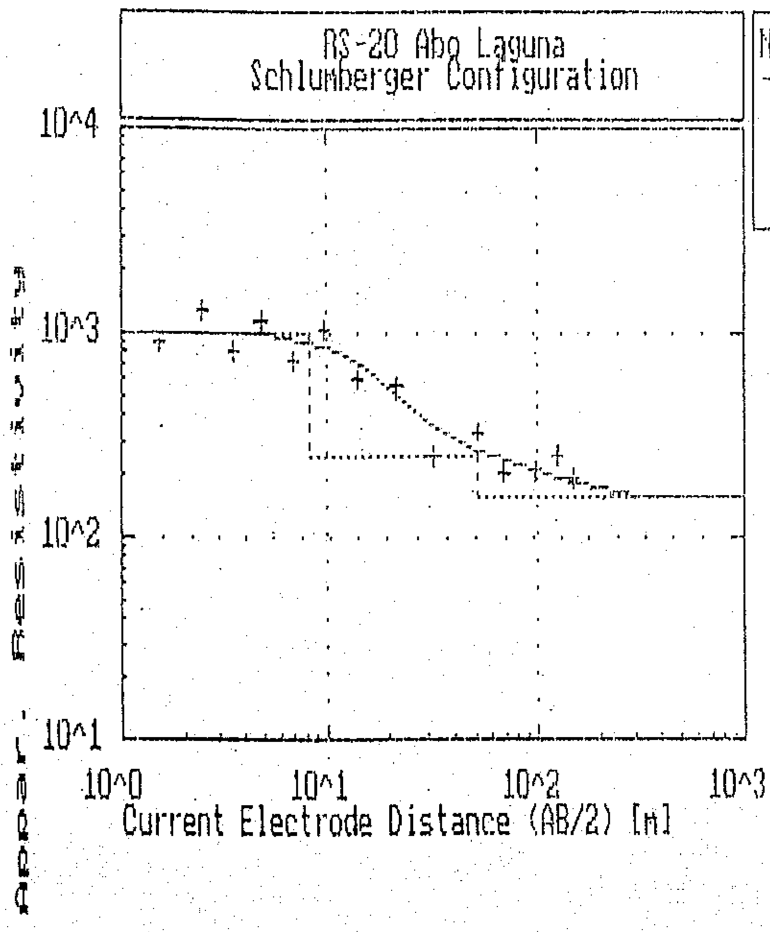
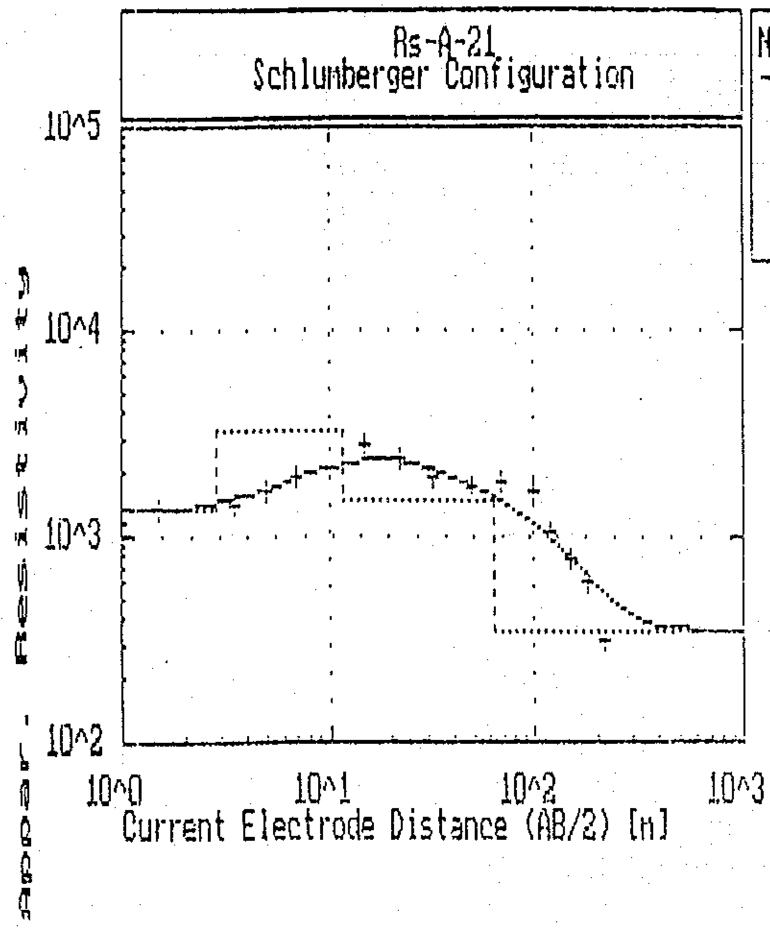
2	618.8	11.4
3	171.0	-.-



No	Res	Thick
1	1008.5	8.4
2	253.2	42.9
3	155.2	-.-



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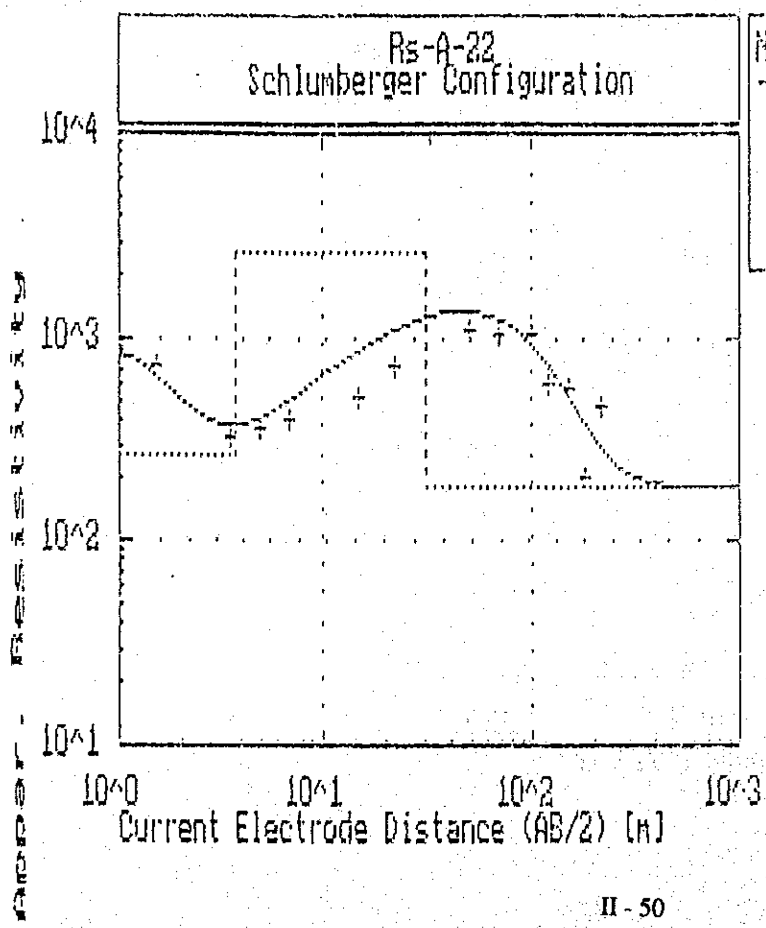
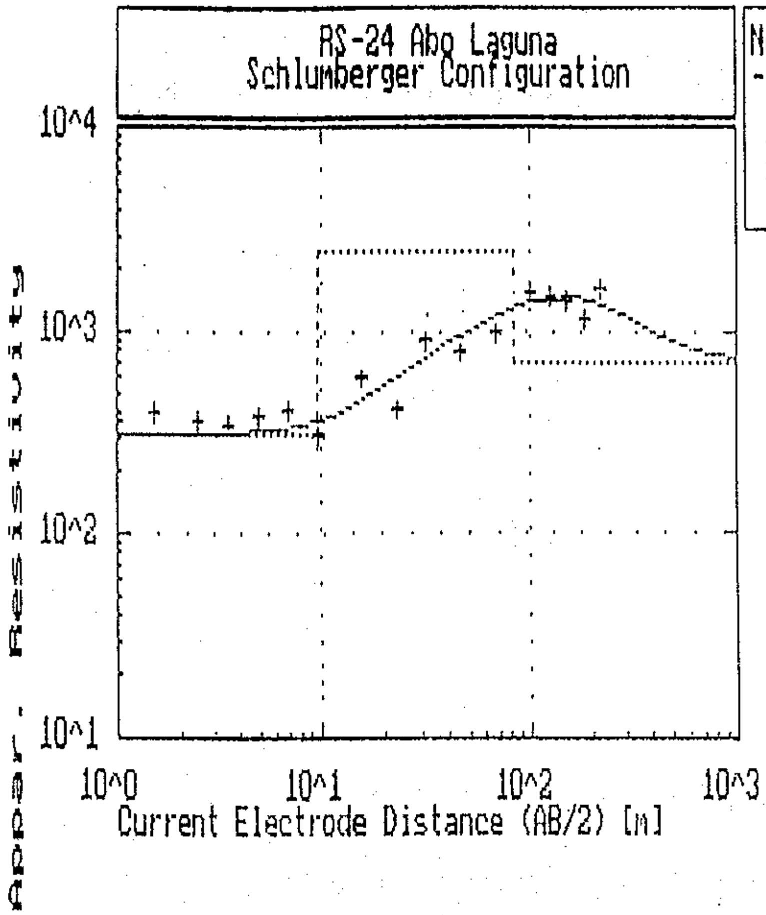
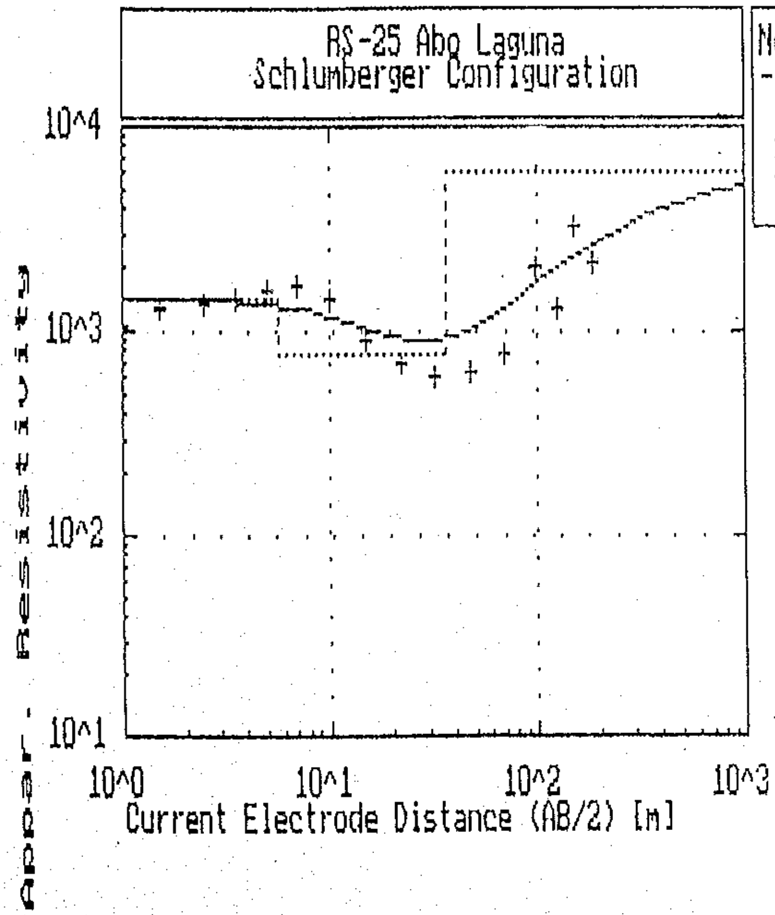
1	1351.8	2.9
2	3299.1	8.7
3	1535.1	51.7
4	335.2	-.-



No	Res	Thick
1	1093.1	0.7
2	261.9	3.0
3	2640.6	27.0
4	180.7	-.-



No	Res	Thick
1	311.2	9.7
2	2461.8	72.2
3	696.3	-.-

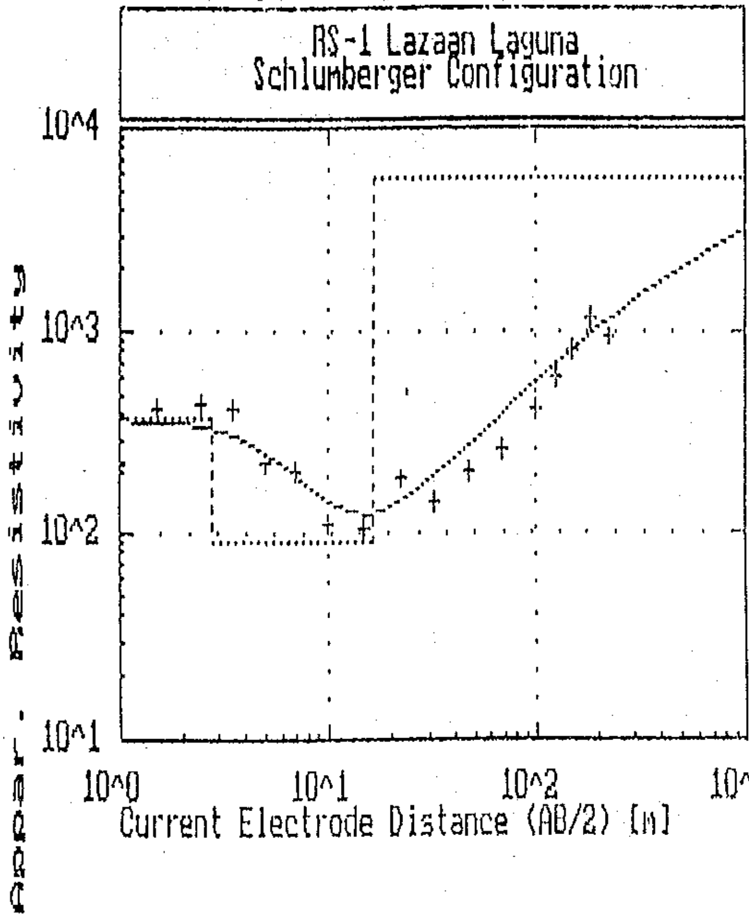


No	Res	Thick
1	1416.0	5.6
2	755.7	30.6
3	5884.0	-.-

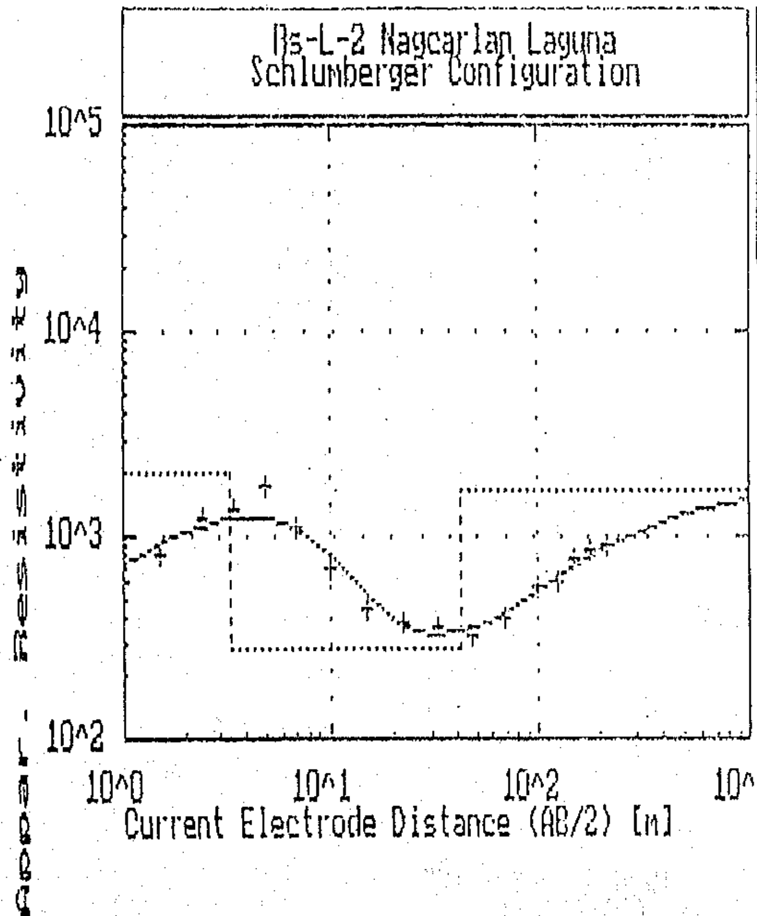
CONFIGURATION CURVES

ELECTRIC RESISTIVITY SURVEY

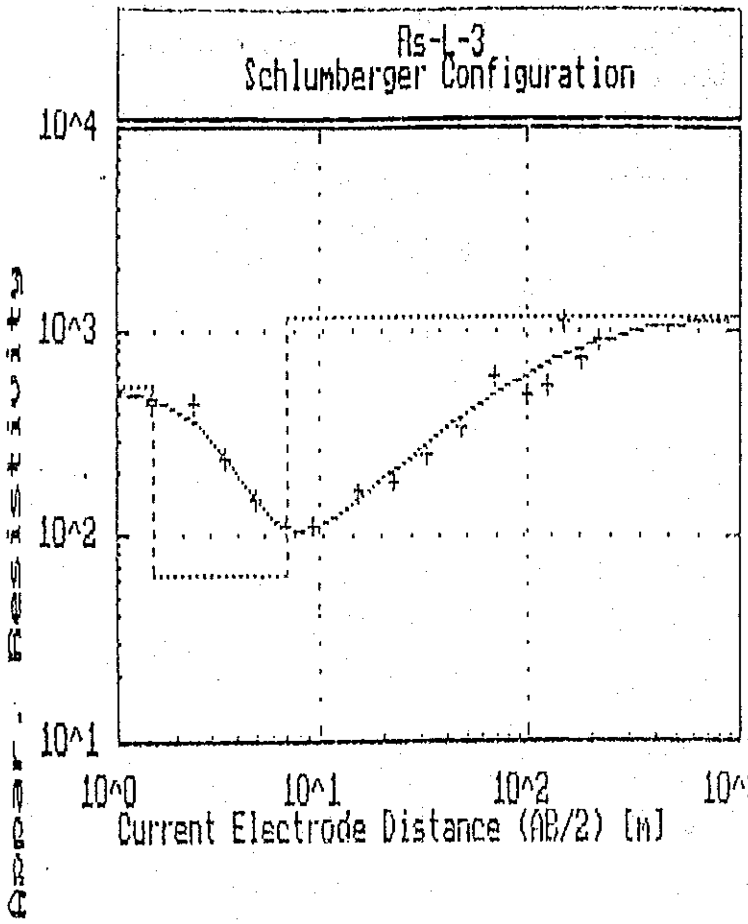
BARANGAY LAZAAN, NAGCARLAN, LAGUNA



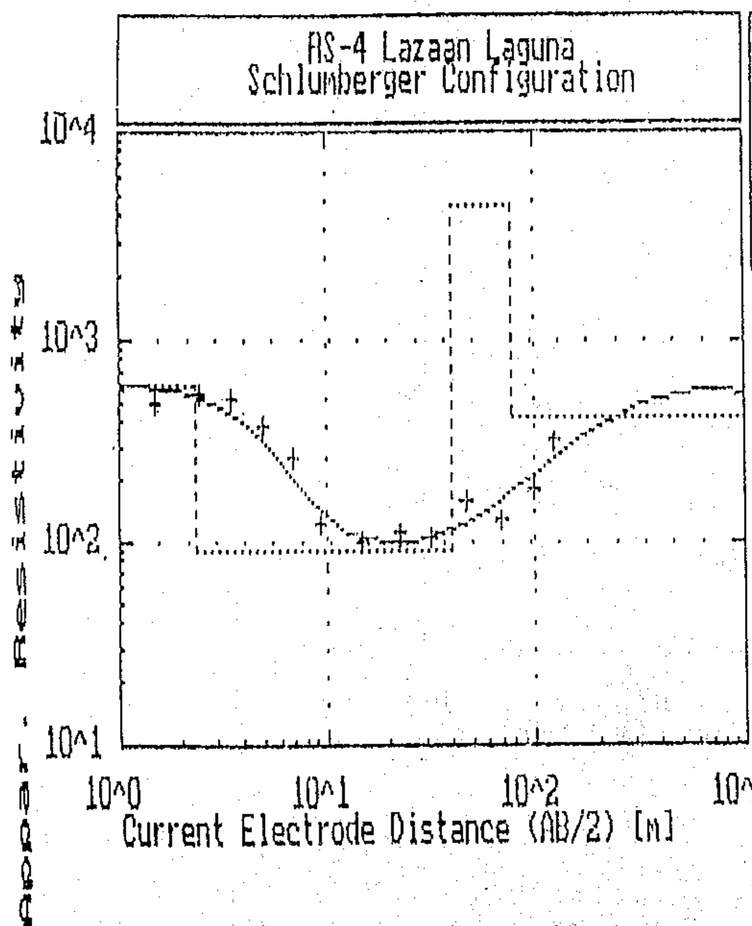
No	Res	Thick
1	372.6	2.8
2	89.2	13.8
3	5666.6	-.-



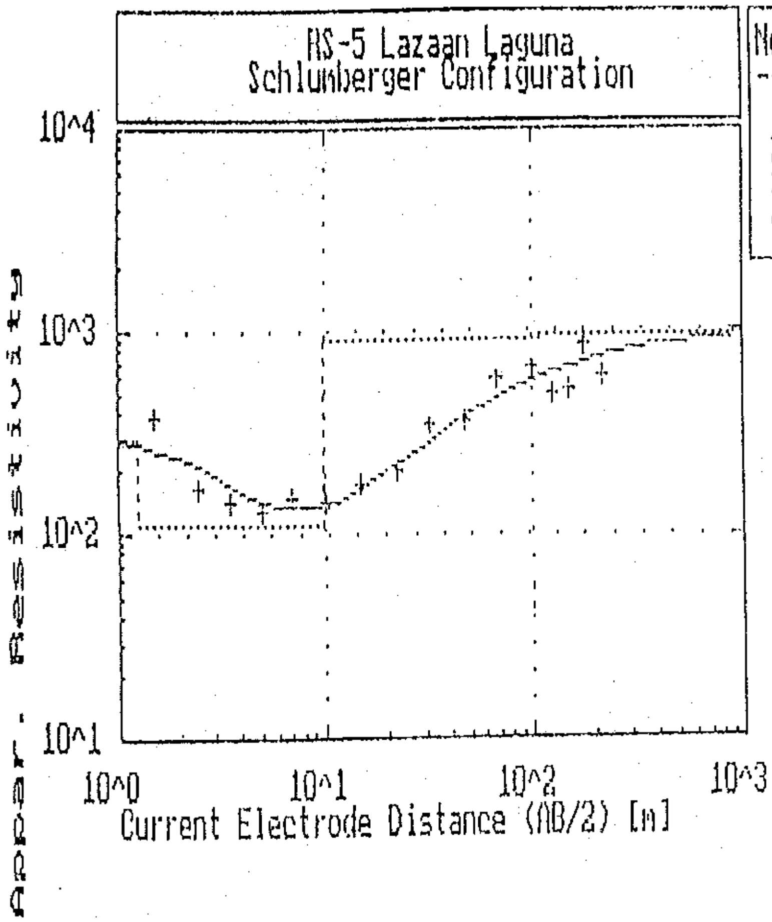
No	Res	Thick
1	603.2	0.7
2	2011.9	2.7
3	282.4	38.1
4	1668.1	-.-



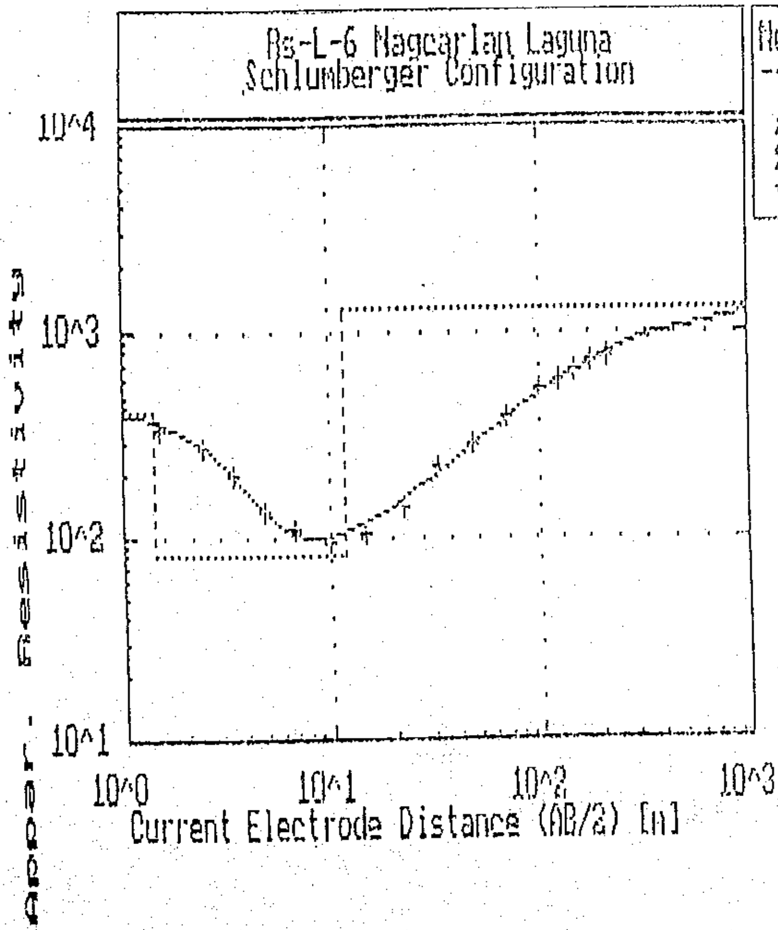
No	Res	Thick
1	538.3	1.5
2	63.1	5.5
3	1178.0	-.-



No	Res	Thick
1	601.5	2.4
2	92.3	37.7
3	4486.8	38.5
4	408.5	-.-



No	Res	Thick
1	294.6	1.3
2	110.9	8.6
3	883.9	97.2
4	952.4	-.-



No	Res	Thick
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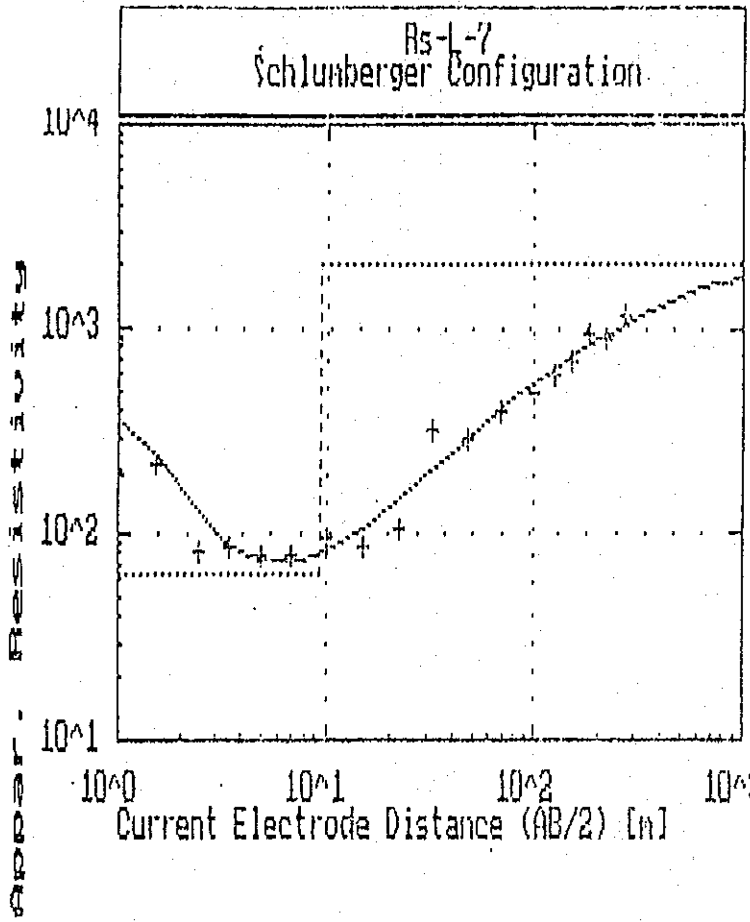
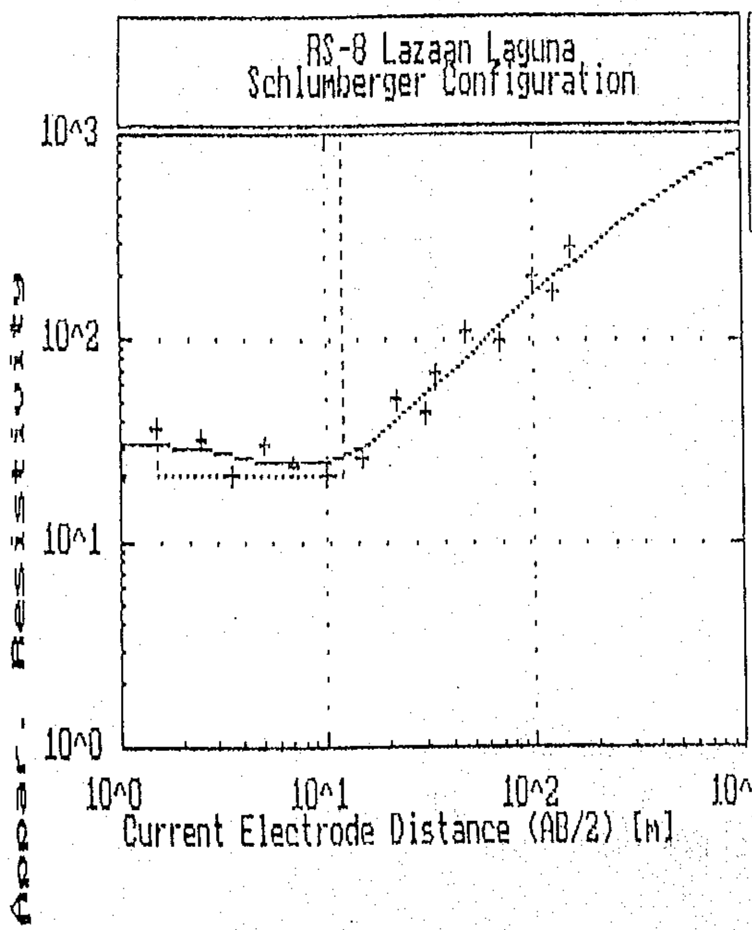
2	81.9	10.4
3	1286.3	-.-



No	Res	Thick
1	445.4	0.8
2	63.3	8.8
3	2033.0	-.-



No	Res	Thick
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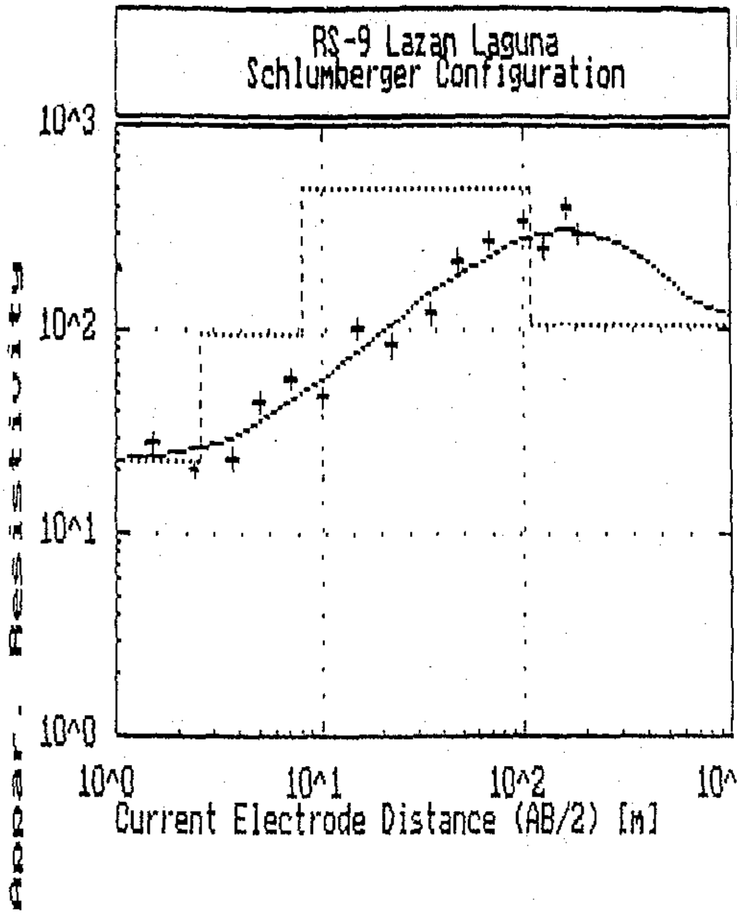
2	21.6	10.6
3	1294.9	-.-



No	Res	Thick
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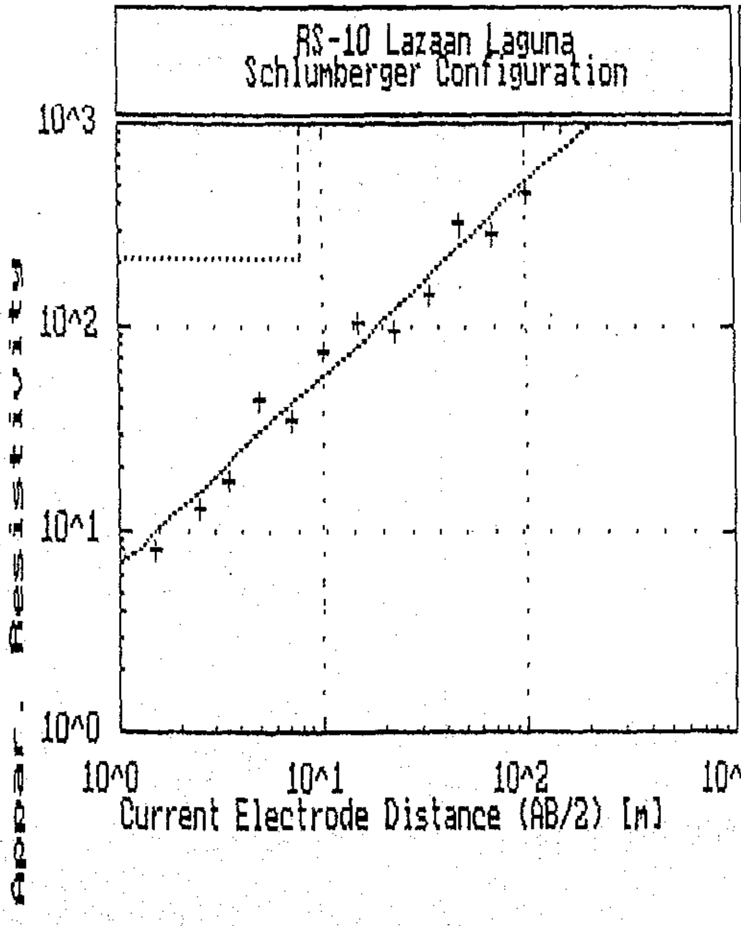
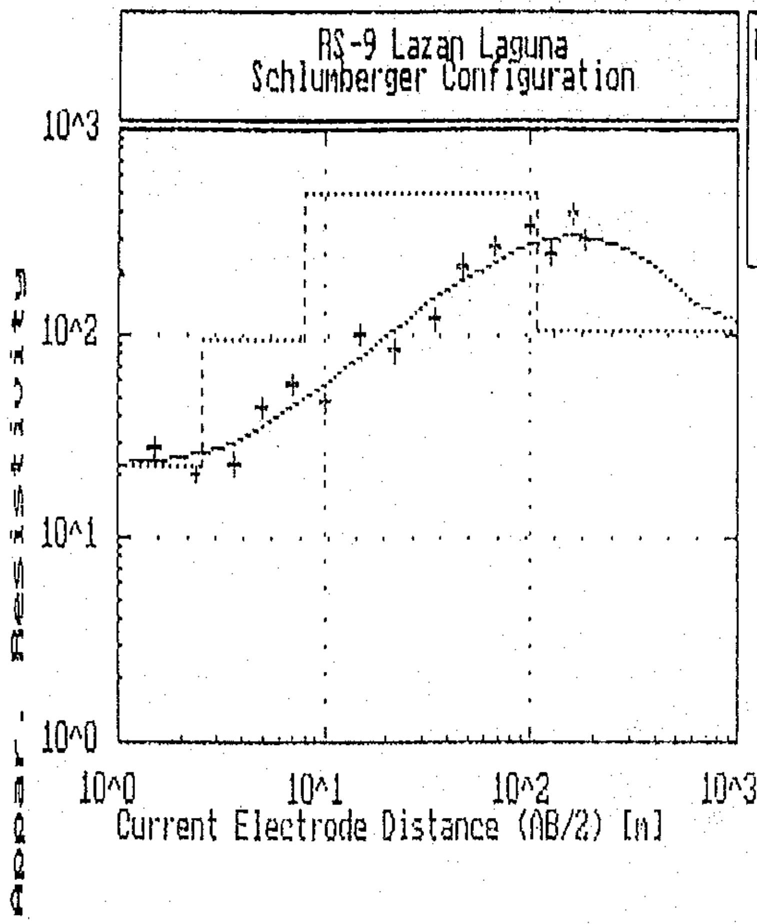
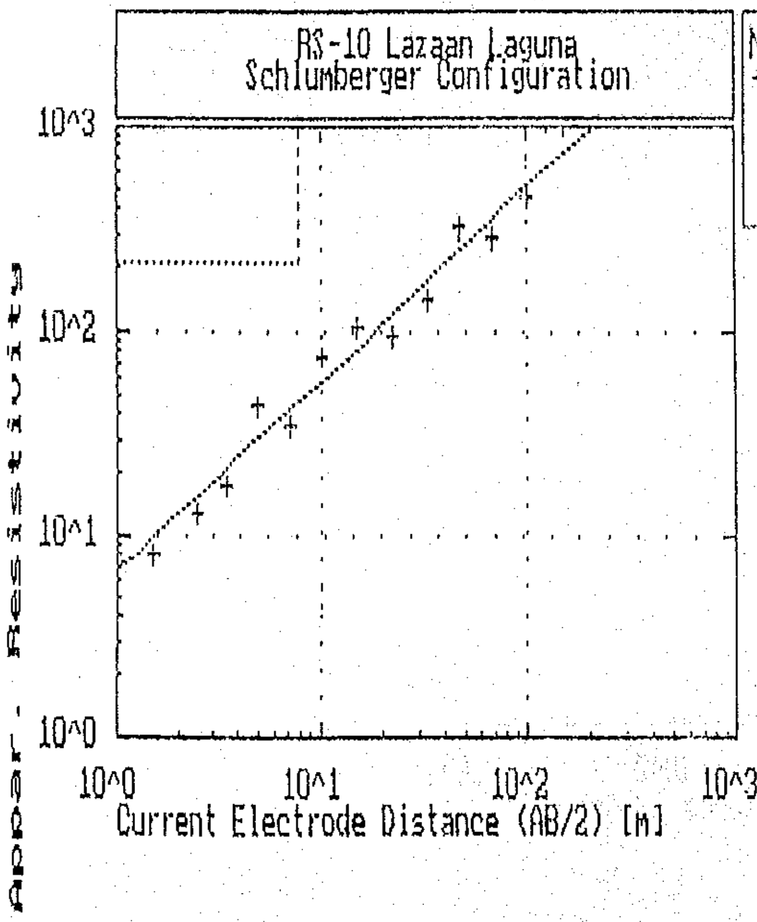
2	93.0	5.4
3	480.9	99.7
4	106.6	-.-



No	Res	Thick
1	4.1	0.6
2	218.7	7.3
3	5946.6	-.-



No	Res	Thick
1	23.0	2.6
2	93.0	5.4
3	480.9	99.7
4	106.6	-.-

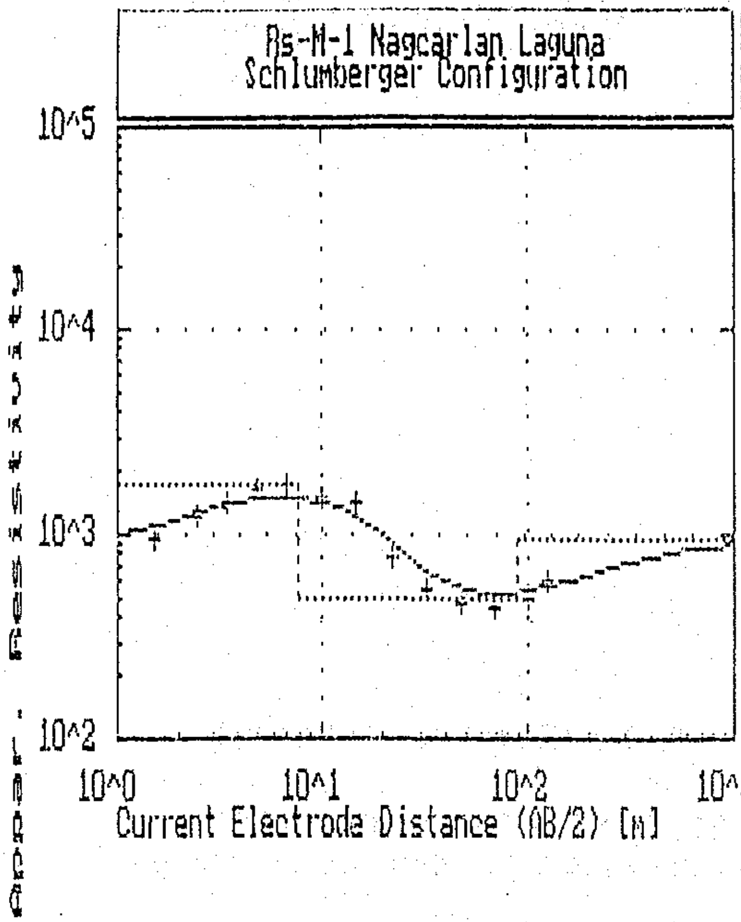


No	Res	Thick
1	4.1	0.6
2	218.7	7.3
3	5946.6	-.-

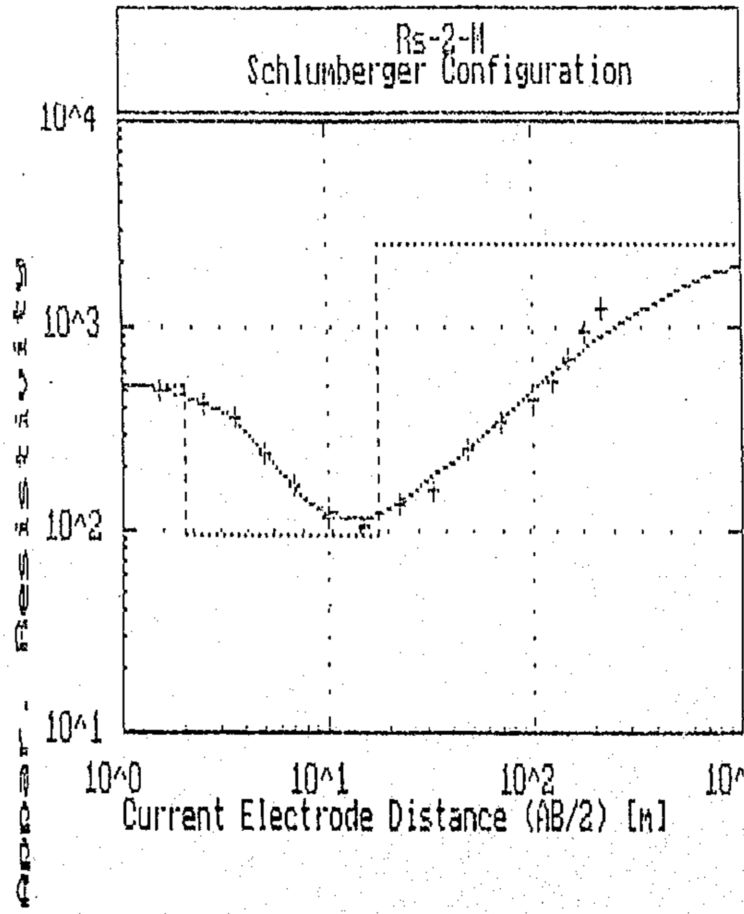
CONFIGURATION CURVES

ELECTRIC RESISTIVITY SURVEY

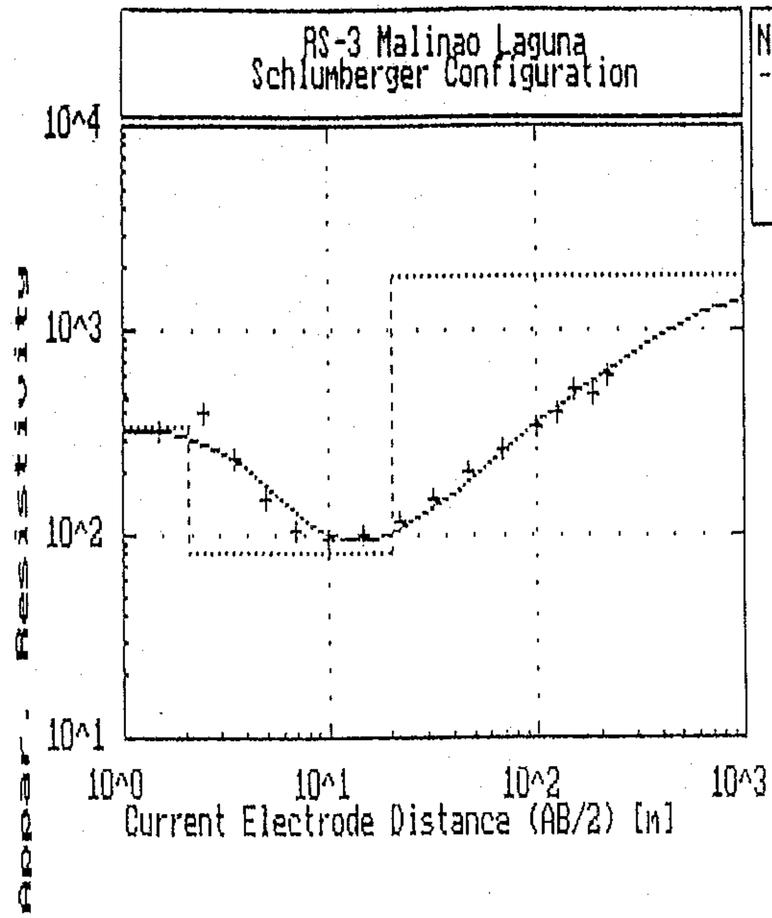
BARANGAY MALINAO, NAGCARLAN, LAGUNA



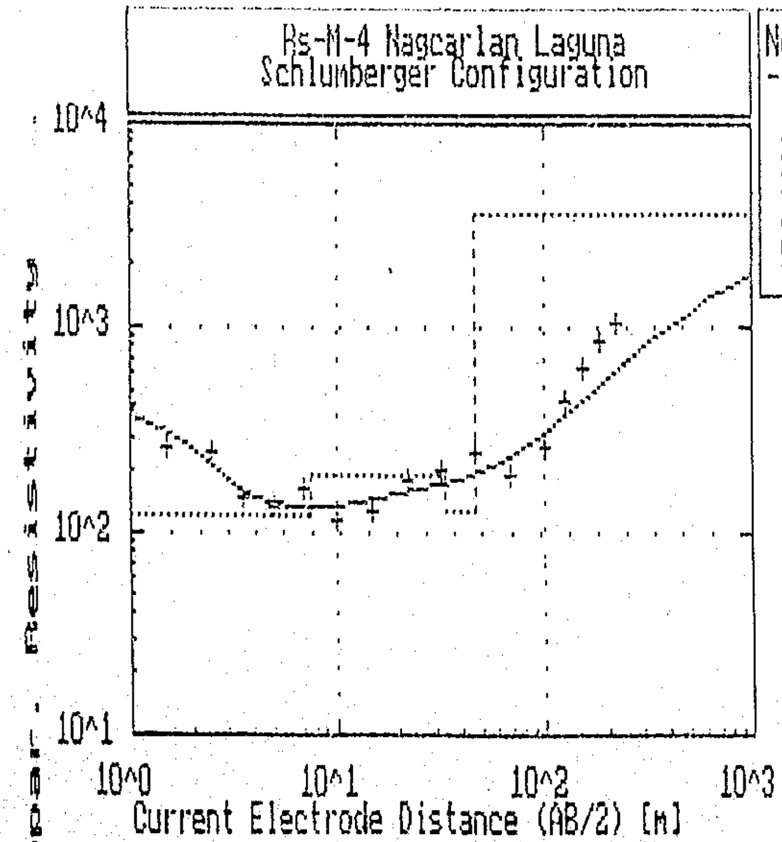
No	Res	Thick
1	953.4	1.0
2	1799.0	6.9
3	478.2	80.4
4	941.7	-.-



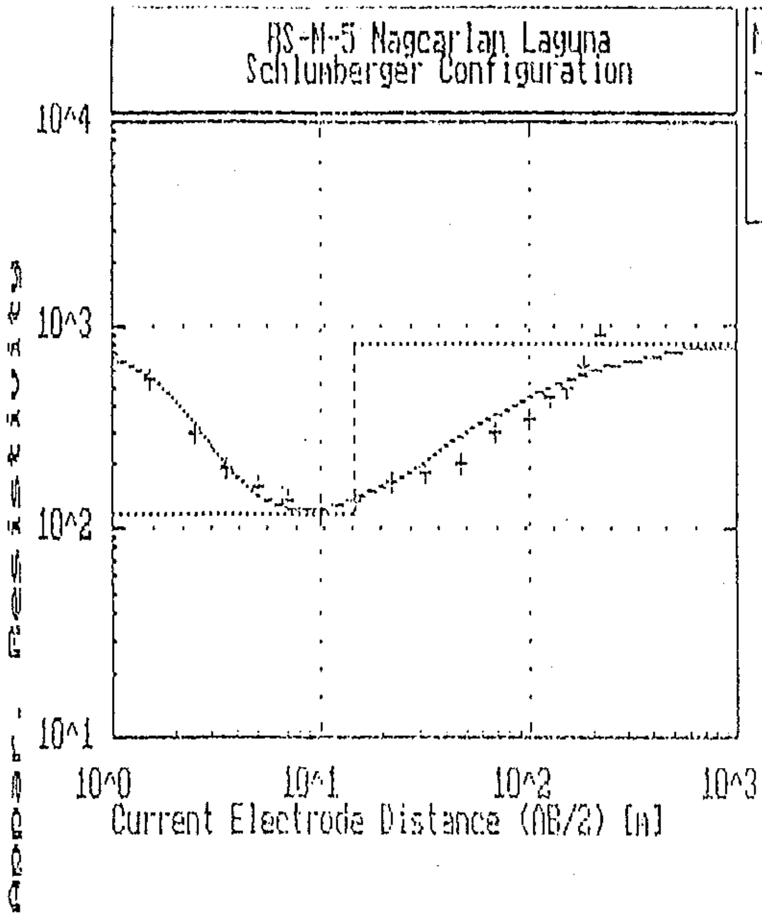
No	Res	Thick
1	525.0	2.0
2	95.8	15.8
3	2550.7	-.-



No	Res	Thick
1	335.2	2.1
2	81.3	18.4
3	1831.7	-.-



No	Res	Thick
1	417.8	0.9
2	121.8	6.7
3	191.1	26.0
4	126.0	13.4
5	3566.1	-.-



No	Res	Thick
1	834.1	1.0
2	114.3	13.8
3	799.5	-.-

FEASIBILITY STUDY ON
THE UPLAND IRRIGATION AND
RURAL DEVELOPMENT PROJECT
IN SOUTHERN LUZON

APPENDIX-III

SOIL AND LAND CLASSIFICATION

FEASIBILITY STUDY
ON
THE UPLAND IRRIGATION AND RURAL DEVELOPMENT PROJECT
IN SOUTHERN LUZON

APPENDIX-III
SOIL AND LAND CLASSIFICATION

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APPENDIX-III SOIL AND LAND CLASSIFICATION

1 Introduction

The Study area embraces the agricultural upland areas of the municipalities of Nagcarlan, Liliw and Majayjay in the slope of Mts. Banahaw and San Cristobal with a total area of 3,000 ha. The area is characterized by a slight to highly dissected nearly level to very steep volcanic footslopes and river terrace escarpment. The soils are derived from volcanic tuffacious materials. The San Diego, Nagcarlan, Rio Oples, Liliw, Maimpis and Olla rivers and their tributaries are the major drainage outlets in the area. These are oriented from south to north direction and finally drained out to the Laguna de Bay. Dominant crops in the area are mixtures of coconut, lanzones, banana and coffee intercropped with vegetables. Grassland and primary forest are found in the upper footslopes. The area has two (2) distinct seasons; the dry from November to April, and the wet during the rest of the year.

The Study area lies on the lands with the elevation of about 300 m to 1,300 m. Most of the lands are located in higher elevated area where the suitability of sub-tropical vegetable cultivation is high, as shown in the following table (also refer to Table III.1.1).

Land Elevation Classification

(Unit: ha)

Elevation (m)	Nagcarlan	Liliw	Majayjay	National Park	Total
< 300	50	0	0	0	50
300 - 400	258	105	10	0	373
400 - 500	220	234	145	0	599
500 - 600	322	205	80	0	607
600 - 700	253	103	15	90	470
700 - 800	76	106	0	140	322
800 - 900	3	19	0	245	267
900 <	0	0	0	312	312
Total	1,182	772	250	796	3,000

Remarks: Based on the topographical maps (1/4,000).

The distribution of lands by slope classes is tabulated below (also refer to Table III.1.1). The table shows more than 60 % of lands in the Study area have more than 18 % slope. Considering the present agricultural activities in the Study area, not only the lands with less than 18 % slope but also the highly slope lands are suitable for vegetable cultivation if proper soil conservation measures are applied.

Land Slope Classification

(Unit: ha)

Land Slope	Nagcarlan	Liliw	Majayjay	National Park	Total
3 - 8%	186	0	0	4	190
8 - 15%	318	178	164	55	715
15 - 18%	113	197	0	40	350
18 - 25%	170	48	3	89	310
25% <	164	84	0	577	825
Others	231	265	83	31	610
Total	1,182	772	250	796	3,000

Remarks: Based on the topographical maps (1/4,000).

The land resources of the Study area were evaluated through soil classification, land classification and present land use survey during Phase 1 and 2 periods. The soil survey was carried out by a local contractor under supervision of the JICA Study Team during Phase 1 period.

2 Soil Classification

2.1 General

The objectives of the soil classification are; a) to determine the morphological characteristics of the soils, b) to group and classify them into soil series or taxonomic units and homogeneous soil mapping units, and c) to prepare soil and land suitability maps.

Prior to the field survey, a preliminary study on the available data and maps from previous studies was done. Interpretation of topographic maps covering the Study area was done, and a provisional maps with a scale of 1:4,000 was prepared showing the predetermined sites of forty (40) master soil test pits (see Table III.2.2).

The soils were classified at the level of soil series or taxonomic units and further subdivided them into homogeneous soil mapping units based on surface texture, slope and erosion hazard. Morphological descriptions of the master soil profiles were done adapting the FAO standard for soil profile. Soil profile pits were dug to a depth of 1.0 m and soil samples from each horizon of the representative profiles were collected and submitted to the laboratory for specialized tests.

2.2 Soil Classification

The soils of the Study area were divided into two major groups based on physiographic condition, namely a) soils of the volcanic footslopes and b) miscellaneous land types. These were further classified into soil series or taxonomic name and finally subdivided them into soil mapping units. Soil series are distinguished from one another in accordance with differences in physiographic condition, parent material, texture, depth, drainage and chemical characteristics while soil mapping units are subdivisions of soil series based on the surface texture, degree of slopes and erosion, if any.

Typical soil profiles observed by *in situ* survey are presented in Attachment 1. The results of the laboratory tests are shown in Attachment 2. Those survey results define soil series and clarify general soil characteristics of the Study area.

Three soil series, namely Abo, Alipit and Bukal soil series were identified by soil characteristics and they were further classified by slope range. The areas of the identified soil series or taxonomic name are shown in Table III.2.2 and III.2.3. The soil map of the Study area is shown in Main Text.

Soil Classification of the Study area

(Unit: ha)

Soil Series	Nagcarlan	Liliw	Majayjay	National Park	Total
Abo Series	410	73	0	222	705
Alipit Series	69	434	167	40	710
Bukal Series	472	0	0	503	975
Miscellaneous Land	231	265	83	31	610
Total	1,182	772	250	796	3,000

Source: Soil survey carried out under Phase 1 period.

The characteristics of the three soil series are briefly described as follows.

Abo soil series: The Abo soil series belongs to fine loamy mixed isohyperthermic family of moderately deep and well drained soils of Typic Eutropepts with udic moisture regime. The soils occur on highly dissected gently sloping to steep slopes associated with a dentritic drainage pattern, derived from pyroclastic, volcanic tuffaceous materials. This soil series is concentrated along the Nagcarlan river on upper footslopes of Mt. Banahaw.

Alipit soil series: The Alipit soil series is a number of the fine clayey mixed isohyperthrmic family of Typic Hapludalfs. The soils are moderately deep and well drained, and occur on moderately dissected, nearly level to very steep volcanic footslopes. This soil series is characterized by an orchric epipedon and argillic B horizon with udic moisture regime.

Bukal soil series: The Bukal soil series is a number of the coarse loamy mixed isohyperthermic family of Typic Udorthents. The soils are moderately deep and well drained, and formed on slightly dissected and nearly level to very steep volcanic footslopes on the middle and upper portion of Mt. Banahaw. The soils are derived from volcanic tuff that have udic moisture regime.

The soils in the Study area generally shows preferable characteristics for agricultural use. The all soils have enough depth of more than 50 cm and well drained condition. Soil reaction varies from 5.0 to 6.5. Organic matter content is noted as medium. Available Phosphate is medium to high. Exchangeable Potassium content is also high. While, total Nitrogen is medium and Cation Exchange Capacity (CEC) varies low to high (see Table III.2.4).

3 Land Classification

3.1 General

Land suitability classification is a system of grouping soil units together having similar characteristics, degree of limitations and requirements. The FAO Framework for Land Evaluation (1976) was basically adopted to assess the suitability of the land in the Study area. The land qualities and soil characteristics used in the assessment of suitability classes and subclasses are the following; slope, erosion hazard, texture, effective soil depth, drainage condition, presence of coarse fragments or rock outcrops, soil pH, total Nitrogen, available Phosphorous, and cation exchange capacity. Some of these limitations are correctable by adding fertilizer and soil amendments and some are more or less difficult or uneconomical to correct. Upland rice, diversified crops and tree crops were assessed of their performance in each soil mapping units considering their soil characteristics and limitations and the soil requirements for each land utilization types.

Soil suitability order indicates whether the land is suitable (S) or not suitable (N) for the use under consideration. Suitability classes reflect degrees of suitability of soil units within the orders. The classes are numbers consecutively by Arabic numbers which are affixed to the suitability order S to indicate the suitability class.

Suitable (S):	Soils on which sustainable use of the kind under consideration is expected to yield benefits which justify the inputs without risk or damage of land resources.
Highly suitable (S1):	Soils having no significant limitation to sustainable application of a given use.
Moderately suitable (S2):	Soils having limitation which together are moderately severe for sustainable application of a given use; production will be significantly lower and/or inputs significantly higher than S1 land.
Marginally suitable (S3):	Soils with limitations that, in total are severe for sustainable application of a given use, production will be so reduced and/or the needed inputs will be so high that the use of this land will only be marginally justified.
Not Suitable (N):	Soils which have the qualities that appear to preclude sustained use of the kind under consideration. The value of expected benefits does not justify the expected cost of inputs that would be required.

The subclasses for the suitability reflect the kind of limitations or improvement measures required within the classes. Appended to the class symbols are subscript letters that indicate constraints in land use by the representative soils. These subclasses letters are grouped in the descending order of their limiting influence. Major limiting factors of the soils are as follows:

Slope (t):	Land slope influences soil erosion because runoff velocity and removal materials increase as slope increases. Level to nearly level topography has minimal erosion hazard and can be easily adopted to many uses.

Erosion (e): The degree and amount of soil erosion are dependent on steep and length of slope, soil texture and structure, climate, and vegetation including cultural and management practices. The erosion class limits and their descriptions are as follows.

Erosion class	Description
1	Sheet erosion - Less than 1/4 eroded
2	Sheet - rill erosion - 1/4 to 3/4 eroded

Soil Texture (s): Soil texture has considerable effect on plant growth and farming practices. Diversified crops are more adopted to light textured soils while paddy is more appropriated in clayey soils. In terms of water and nutrient retaining capacity, fine loamy and clayey soils have higher capacity than sandy soils.

Soil Depth (k): Effective soil depth refers to the thickness of the soil to layers of sand, gravel, stones or to impermeable layer or depth of water table. Soil depth is a measure of the available rooting zone and amount of soil nutrient. Shallow soil layers over restrictive subsoil materials will impede depth of root penetration and may also contribute to a water deficit for plant growth.

Internal Drainage (d): Drainage is basically important in the choice of crops. The indicative factors of soil drainage are slope, soil color, structure and consistence, depth of water table, infiltration and permeability, land use and amount of rainfall. Drainage condition of the soil influences the root system development.

Soil Fertility (x): The level of soil fertility directly affect to plant growth or requirement of fertilizer. The indicative factors of fertility are soil pH, Nitrogen, Phosphorous, Potassium, Cation Exchange Capacity (CEC) and so on.

The land suitability criteria for the diversified crops are summarized in the following table (also refer to Table III.3.1).

Land Suitability Criteria for Diversified Crops

Factors	S1	S2	S3	N
Drainage (d)	Well	Not used	Imperfect drained	Poor or Excessive
Soil Depth (cm) (k)	> 75	75 - 50	50 - 25	< 25
Soil Texture (t)	Fine-Medium	Not used	Coarse	Very Coarse
Slope (%) (s)	0-5	5 - 15	15 - 25	> 25
Fertility (x) - CEC (me/100g)	> 24	24 - 16	< 16	Not used

Source: FAO Framework for land Evaluation, 1976. Modified by the JICA Study Team.

3.2 Land Classification

The soil units of the Study area were categorized into four groups by suitability for upland paddy, diversified crops and tree crops. The areas and distribution of the suitability groups are shown in Table III.3.2 and III.3.3 (soil suitability map is shown in Main Text). For vegetable cultivation, the suitability groups are briefly mentioned as follows.

Land Suitability Groups for Vegetables

Group	Suitability for vegetable	Soil unit	Area (ha)
Group A	Moderately suitable	AbB, AbC1, AtB, AtC1, BuB, BuC1	905
Group B	Marginally suitable	AbD1, AtD1, BuD1	350
Group C	Marginally suitable	AbA1, AtE1, BuE2	310
Group N	Not suitable	AbF1, AtF1, BuF2	825

Source: The JICA Study Team.

The identified suitability groups have the following characteristics of soil and land.

Group A: The lands under suitability group A are classified moderately suitable (S2) for diversified crops. Subclasses of S2tx was recognized under this group due to its topographic limitation and low fertility level. The recommended mitigation measures are provision of soil conservation techniques such as contour planting, buffer strip cropping and cover crops, and practice crop rotation with legume crops including regular application of organic and inorganic fertilizers every cropping season.

Group B: The suitability group B consists of marginally suitable lands (S3) for diversified crops. The lands are rated subclass of S3t owing to its major topographic limitation. The soils under this group are similar to the soil characteristics of suitability group B except for its slope ranging from 15 to 18 %. This group needs a special conservation management techniques to control soil erosion. These are bench terraces, buffer strip cropping, contour planting and cover crops. Dosage of organic and inorganic (NPK) fertilizers is also recommended.

Group C: The suitability group C is also recognized as marginally suitable lands (S3t) for vegetable cultivation. The lands of the group C has similar soil characteristics to group C and steeper slope of 18 to 25 %. The lands of more than 20 % slope are classified into not suitable by FAO because of soil erosion problem. However, such lands are included in marginal suitable in this Study because soil erosion control measures shall be introduced as a major component of the project.

Group N: The suitability group N embraces the steep to very steep ridges and hilly areas in the Study area. It concludes the soil mapping units AbF1, AtF1 and BuF2 with slopes of more than 25 %. The soils are slightly to moderately eroded. The limitations of this group are considered uneconomical or very difficult to correct owing to its slope and rock outcrops.

4 Land Resources

4.1 General

The vegetable cropped area in the Study area is still expanding especially in Nagcarlan area. The land potential for the further expansion of vegetable cultivation was evaluated, and future land use plan was discussed in the Study.

The soil and land suitability discussed above was a basic data for the assessment. In addition, the land status and present land use were key information in the evaluation of possible area to be developed for vegetable production.

4.2 Land Status

The land of the Study area are classified into three categories; Alienable & Disposable (A&D) land, Public Forest land, and a part of Mts. Banahaw-San Cristobal National Park. Those lands were briefly describes as below.

A&D land:	1,820 ha in lower portion of the Study area. The ownership of farmers has been recognized by the municipalities by means of free patent, titles or tax declaration. Most A&D land areas in the Study area are subject to land redistribution under the CARP.
Public Forest land:	390 ha in middle portion. Extensive development and logging are not allowed unless special permission is issued by DENR. Major land use is grassland and shrubs, and vegetable and tree crops in same part of the slope of Mt. Banahaw.
National Park:	790 ha in upper portion. Development is strictly prohibited.

The future extensive development on the vegetable cultivation should be within A&D land because of environmental preservation. The land of Public Forest and National Park should remain from the development and their natural vegetation should be preserved.

4.3 Present Land Use

The almost all suitable lands for vegetable cropping are used as farm lands, where vegetables, tree crops and some paddy are planted by the farmers. The areas of agricultural land use are vegetables of 720 ha, tree crops of 1,220 ha and paddy of 40 ha in the whole area. The most dominant crop of them is coconut. The vegetables are sometimes planted under coconut tree and/or other fruit trees, as known as a multi-story cropping. The vegetables are also planted in some considerably steep lands of the upper portion, as known as a shifting cultivation.

4.4 Land Potential

Land potential for agricultural land use focusing on vegetable cultivation and nature preservation are assessed. The potential area for extension of vegetable cropping is considered to be the difference between suitable lands for vegetable cropping and present vegetable cropped area, as follows (also refer to Table III.4.1).

Land Potential to be Transformed to Vegetable (Physical Factors only)

	Area
Suitable area for vegetable (a):	1,565 ha
Vegetable cropped area (b):	720 ha
Potential area to be transformed to vegetable (c) = (a) - (b):	845 ha

Source: The JICA Study Team