APPENDIX-8

RESULT OF VERTICAL ELECTRIC SOUDING (VES) SURVEY

GOVERNMENT OF LIBERIA / JICA

Urban Facilities Improvement Project

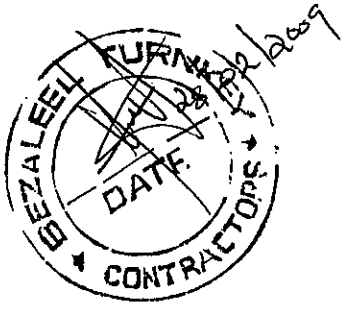
Monrovia

Liberia

GEOPHYSICAL SURVEY FOR TEN BOREHOLE POINTS

DETAILED REPORT

February, 2009



CONTRACTOR
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Monrovia

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

1.1 General Statement.

The devastating effect of the war could best be imagined on a once beautiful and blessed country called LIBERIA. This is a country that is blessed with human, natural and material resources but was destroyed by avoidable wars. No wonder that other countries of the world and well meaning organizations like the Japanese International Corporation agency (JICA) is on ground to contribute their quota to the reconstruction and reconciliation drive currently going on in Liberia in terms of provision of potable water.

An open bid was tendered for Urban Facilities Restoration and Improvement Project by Messrs BEZALEEL & TURNKEY Contractors Incorporated of No 77, Carey Street, Monrovia in January 2009. Consequent upon this, the Firm was short listed and assigned the responsibility of carrying out geological and geophysical survey, drilling, pump installation as well as the construction of overhead tanks in ten (10) locations.

Borehole is the most effective means to pure natural water demands in every part of the world which requires little or no treatment at all and it is – of course – the cheapest source of potable water obtainable nearest to the consumer.

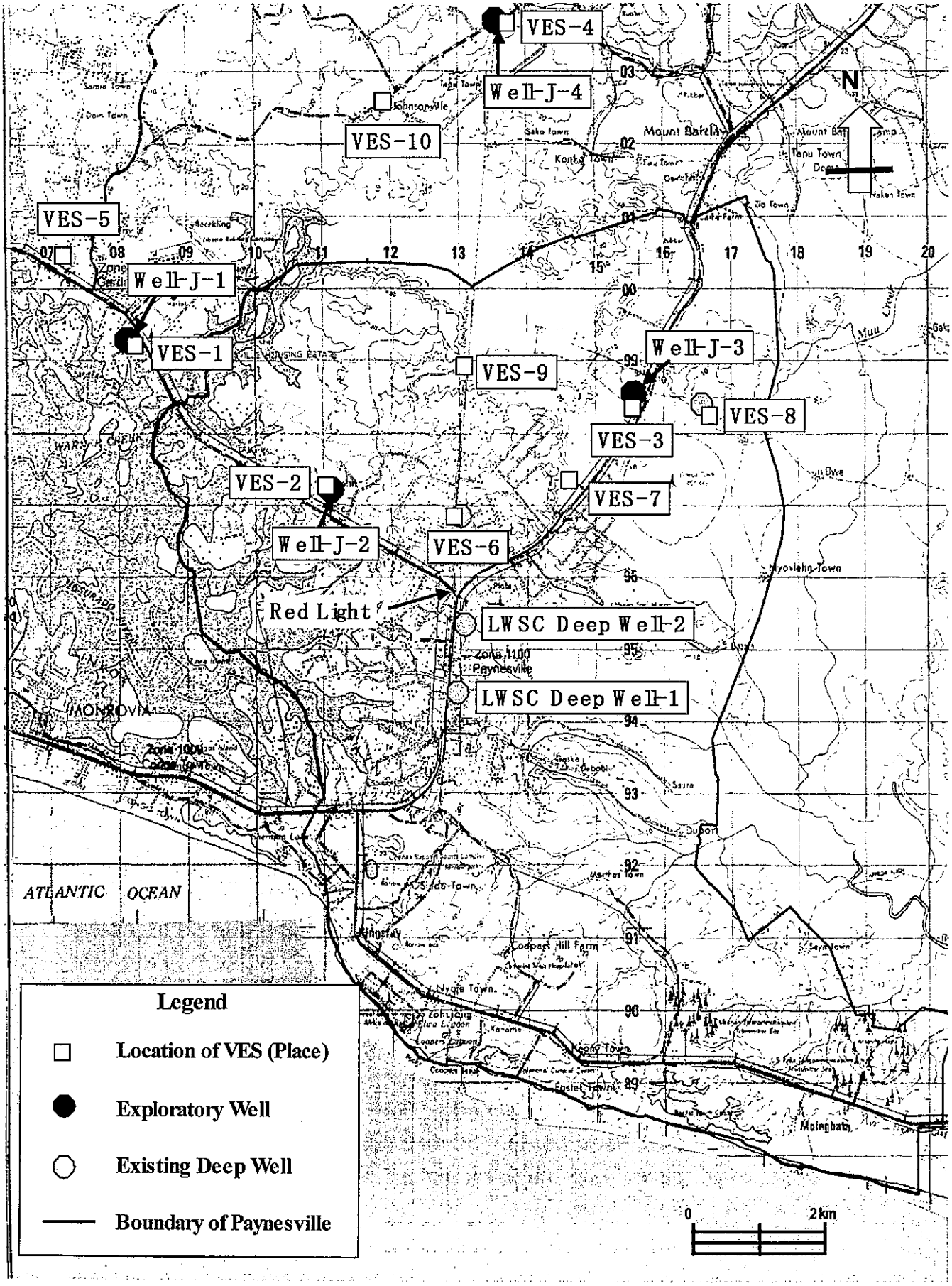
1.2 Project Scope and Objective.

The scope of work carried out by this geophysical survey is for the use of geophysical equipment (OHMEGA Resistivity Meter) to carry out 30 vertical Electrical Soundings (VES) of 3 VES each at 10 selected locations after which this comprehensive report consisting of field records, computer data interpretation logs and analysis was submitted.

The primary objective of the present geophysical and geological investigation carried out at the ten project sites is to delineate and map out regions of groundwater occurrence, while at the same time establishing the subsurface geology of the area that could be drilled and developed into productive boreholes.

1.3 Location and Access.

The project sites are located at MTA Compound, Johnsonville (Public School), Jacobs Town, Whein Town (FDA Junction), Whein Town (STD Estate), LBS Community, Upper Pipeline Community, St. Michaels Community, Pipeline Community (Daniel Junction) and Johnsonville (Down Town) in Montsserano County of Liberia (refer to **Figure 1.1**). The road networks are in moderately good conditions. There are paved roads covering almost all the project areas and they are motorable throughout the year.


VES-4
Well-J-4
VES-10
VES-5
Well-J-1
VES-1
VES-9
Well-J-3
VES-8
VES-3
VES-2
VES-7
Well-J-2
VES-6
Red Light
LWSC Deep Well-2
LWSC Deep Well-1
Johnsonville
Paynesville
MONROVIA
ATLANTIC OCEAN
N
0
2km
Legend
Location of VES (Place)
Exploratory Well
Existing Deep Well
Boundary of Paynesville

CHAPTER 2
GEOLOGICAL AND GEOPHYSICAL INVESTIGATIONS

2.1 General physiography.

Most of the project sites are located on a relatively flat terrain while few are located on undulating terrains with gentle slopes. It is evident from the geomorphologic features observed that all the areas visited coincide with the zones of structural disturbances. The weathering intensity on the rocks is suspected to be high as evident by the thick laterite capping, thick clay columns as well as sandstones observed in hand dug wells. The climate is dominated by the Inter Tropical Convergence Zone (ITCZ), the seasonal passage of which is marked by pronounced instability, frequent storms and intense precipitation characterized by two main seasons – rain and dry season. During the dry season (December to March), when the ITCZ lies in the equatorial latitudes, the climate is characterized by a warm, dry and sometimes dust laden airflow. This is when water problem is at its peak hence the need for this geological and geophysical survey to facilitate the drilling of boreholes for the people living in the project areas to enhance water supply throughout the year. The rain season is usually from March to November during which the area experience rainfall.

2.2 Geology and Hydrogeological Significance.

Despite the favourably large groundwater occurrence reported the world over, the Liberia situation appears to be restricted by the fact that hard crystalline impervious rocks underlie most part of the country. They are either igneous or metamorphic rocks that underlie many of the semi arid and even humid areas of the country where there is scarcity of potable water. In most parts of the country therefore, a serious hydrogeological situation presents itself and water has to be found to meet the needs of the people.

Recent experience has however shown that with selective siting of boreholes, adequate geological and geophysical surveys as well as improved drilling techniques, much better results have been achieved. Despite the relatively poor hydrogeological characteristics of the basement rocks, it still remains a very important source of water for more than three quarters of the population of Liberia.

The geological formation of the investigated areas range in age from Precambrian to Quaternary. Most of the sites is covered by the Cretaceous and Quaternary sediments while the remainder is covered by Precambrian rocks. MTA Compound, Jacobs Town, LBS Community and Whein Town fall within the Paynesville sandstone and Edina sediments underlain by sandy clay, sandstone as well as intercalations of clay and sandstone overlying basal conglomerate in some places.

However, Pipeline community and Johnsonville fall within the basement underlain by granite, gneiss, pegmatite and quartzite that have been intruded by a series of granitic rocks that have been variably metamorphosed and granitized through various tectono – metamorphic cycles. From hydrogeological point of view, when these rocks are differentially weathered and fractured, they are good potential sources of groundwater.

2.3 Aquifers within the Basement

2.3.1 Weathered Zone.

Basement complex weathers into clayey products, which form decomposed overburden of varying thickness. Over most of the areas underlain by basement, there is a discontinuous layer of weathered rock that varies from place to place. Groundwater occurs in the weathered mantle and fractured systems of the rocks. In the weathered zones, a lot of void spaces are created and groundwater stored therein. The highest permeability is found in the decomposed levels below the predominantly overburden.

The weathering stops or decreases rapidly where the fractures do not allow circulation of groundwater. The weathering depth is thus limited by the closing of fractures with depth. In all the sites investigated, the thicknesses of the weathered layer on crystalline rocks vary from area to the other. The nature of the weathered zone is governed by a complex interaction between bedrock lithology (mineral composition and grain size), bedrock structure, geomorphologic history and climate.

2.3.2 Fractured Zone.

Prominent fractured zones identified in the project areas, from structural map, run NE – SW with very few running NW – SE. Though they are of limited strike length, they tend to be wide in lateral extent. Quartzite and pegmatite are likely to contain more water. Where fractures are open, large yield can be obtained but the overall storage may be limited, except there is connection with the overlying weathered rocks.

2.3.3 Groundwater Quality.

There is no data available concerning the water quality in all the areas visited. Water samples taken during the course of this survey from existing boreholes and hand dug wells suggest that the water quality is generally within the World Health Organization (**WHO**) permissible standards. Apart from occasional pollution, the water samples collected are good for drinking. It has also been reported within these project areas that occasionally iron exceed desirable levels. Although this is not a danger to health, it does impact colour to household utensils and clothing washed with the affected water.

2.3.4 Site Selection.

The locations of the works are some typified places that were selected by JICA study team according to compartmentalization of hydrogeological conditions in the Greater Monrovia. Though the actual VES points shall be indicated by the Exploration geologist in the field, the VES points may be changed by JICA study team after the contract.

The selection of communities to be served with water under this project was the sole responsibility of JICA in collaboration with the Ministry of Lands, Mine and Energy. The list of the ten communities to be served with borehole points was included in the Contract agreement with BEZALEEL & TURNKEY Contractors Incorporated. However, the ten communities were subjected to site visits, geological and geophysical investigations from 23rd Jan. to 10th Feb. 2009.

2.4 Geophysical Survey

2.4.1 Introduction.

In conformity with our usual practice, the survey was planned and carried out on 23rd January to 10th February 2009 using Vertical Electrical Sounding (VES) technique with Schlumberger configuration and AB/2 of 300, 350 and 450m respectively. The **OHMEGA Resistivity Meter** is the equipment used for collection of field data. The apparent resistivity values relate to the symmetrical centre of the array, therefore expanding the array enables the Schlumberger arrangement to probe resistivity of the formation at greater depth. The depth probe allows an interpretation of depth to possible water bearing zones.

2.4.2 Data Interpretation.

The response curves, after preliminary observatory deductions were subjected to auxiliary curve matching procedure and fast iterative computer interpretation to obtain the layered parameters (resistivity and thickness). For each detail solution, layerings are constructed which are compared with the probable geological sequence and thereafter with the known geology of the area.

The response curves show a multiple combination of the bell (K) and the bowl (H) shaped auxiliary curve types with four to six geoelectric layered parameters. Some of the curves started with an initial raise in the apparent resistivity response before downward slopes while some started with high apparent resistivity response that is followed by steep downward slopes. The downward slopes are followed by wavelike gentle rise in most cases – depicting the suspected fractured zones – that lead to an upward steep gradient of the response curves (refer to **APPENDICES** for the field data).

Detailed interpretation of the response curves show that initial high resistivity responses in most of the project locations are due to the thick laterite cappings. The steep downward slopes that follow corresponds to the clayey and sandy clay formation. This is the zone where almost all the observed hand dug wells tap water. This layer is usually followed by the differentially weathered rocks. This layer is suspected to be water bearing perched aquifer with pegmatite and quartzite admix.

There are however, some antique layers within and below the differentially weathered basement suspected to be the water bearing zones that will form the major aquifers in the boreholes. The fractured zones grade into the fresh rocks with electrical resistivity ranging from 3000 to 12000 Ohm-m to infinity (refer to the **APPENDICES** for the computer interpreted data). Summary of the data interpretation is presented as **TABLE 4.1**

CHAPTER 3
BOREHOLE DESIGN

3.1 Introduction.

This is the process of specifying the physical materials and dimensions for the construction of a borehole so as to ensure optimum yield with minimum draw down consistent with the aquifer capacity, good quality water with proper protection from contamination. It is however essential to note that a poor borehole results from the use of casing and screen of inadequate sizes, or to choose materials of inferior quality, merely to cut initial cost. Any additional investment for a properly designed, efficient borehole will usually reduce operational and maintenance cost.

3.2 Casing.

It is hereby recommended that six inches nominal diameter PVC casing should be used for the construction of these boreholes, this is large enough to accommodate the pump with enough clearance for installation and efficient operation. The proposed Borehole Configuration is presented as **FIGURE 3.1**. The plastic component shall have a resistance against collapse greater than that induced by a uniform external hydrostatic pressure of 15.5Kg / cm2 for 150mm (6") diameter casing with thickness of between 6.0mm and 6.5mm.

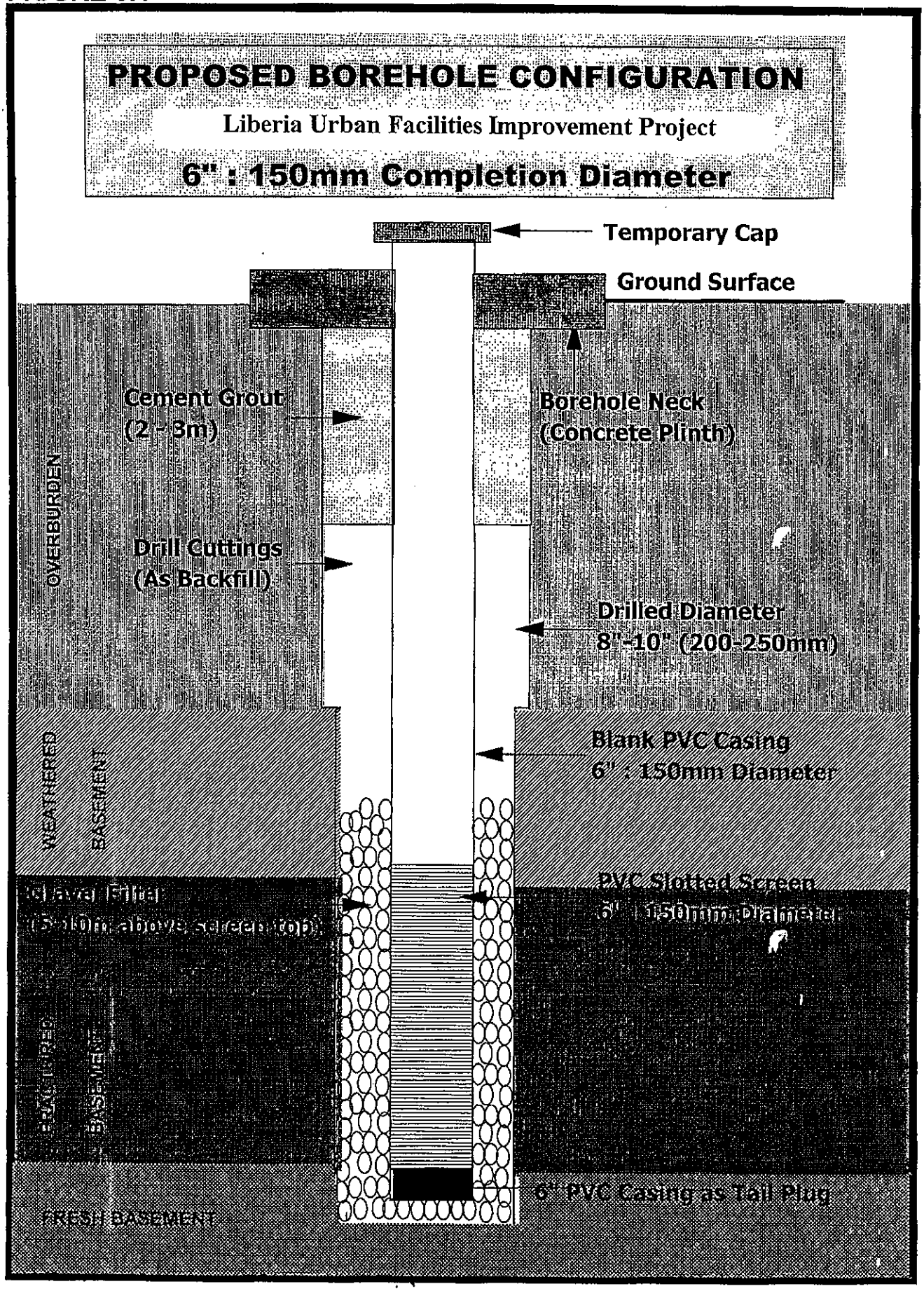
3.3 Screen.

The screen serves as the opening through which water from the aquifer flows into the borehole. The screen should allow water to flow freely with minimal losses and prevent sand and any other rock particles from the water bearing zones to enter the borehole. The screen to be installed in these boreholes must have a slot between 0.5mm and 1.0mm with ample strength to resist the forces to which it may be duly acted upon during and after installation. The slot and the position of the screen in a borehole depend on the lithological characteristics of the water bearing zones on one hand, and the discretion of the supervising Geologist on the other hand.

3.4 Gravel Pack.

Gravel packing of a borehole is the process of introducing gravel of appropriate grain size around the annular surrounding the casing and the screen to increase the specific capacity of the hole as well as to minimize sand infiltration to the hole through the screen. In any case, the gravel used should - as much as possible - be rounded, well sorted and clean.

FIGURE 3.1


PROPOSED BOREHOLE CONFIGURATION
Liberia Urban Facilities Improvement Project
6" : 150mm Completion Diameter
Temporary Cap
Ground Surface
Cement Grout
(2 - 3m)
Borehole Neck
(Concrete Plinth)
OVERBURDEN
Drill Cuttings
(As Backfill)
Drilled Diameter
8"-10" (200-250mm)
Blank PVC Casing
6" : 150mm Diameter
WEATHERED
BASEMENT
Gravel Filter
(5 - 10m above screen top)
PVC Slotted Screen
6" : 150mm Diameter
FRACTURED
BASEMENT
6" PVC Casing as Tail Plug
FRESH BASEMENT

3.5 Development.

This is the final stage in the construction of a borehole. The holes should be opened up by mud and or foam where the formations are suspected to be loose. The DTH hammer with appropriate size of button bit should be used where the formation is consolidated. An important advantage of this mode of drilling is that it is possible to monitor inflows to the boreholes thereby providing an important indication whether the yield of the boreholes, recharge and discharge rates are satisfactory.

Borehole development involves the removal of final materials in the aquifer, cleaning out and opening up of all pore spaces through which water may pass into the borehole. Borehole development is carried out in different ways such as constant flushing, surging, back washing and high velocity jetting (this is always at the discretion of the Drillers).

CHAPTER 4
CONCLUSION AND RECOMMENDATION

4.1 Conclusion.

Aerial photo and aeromagnetic data interpretation of Monrovia and its environs have unraveled the fact that the project areas are structurally disturbed though the intensity varies from one part to the other in terms of groundwater potential. Also the results of the VES data interpretation have unraveled differentially weathered and fracture zones that could be considered potential sources of potable water in all the communities visited.

4.2 Recommendation.

Based on the interpretation however, the positions of recommended points are marked on ground with iron rods with red ribbons tied to them in all the communities investigated. The recommended VES points, the suspected fractured zones and the minimum recommended drill depths are presented as **TABLE 4.1** (Summary of Data Interpretation).

SUMMARY OF DATA INTERPRETATION

TABLE 4.1

S/No	NAME	COUNTY	FORMATION	RECOMMENDED VES	SUSPECTED FRACTURE ZONE (m)	MINIMUM RECOMMENDED DRILL DEPTH (m)	REMARKS
1	MTA Compound.	Montserrado	Paynesville Sandstone.	03	21 – 53 & 68 - 85	85	Suspected plastic clay that could be well managed with mud.
2	Johnsonville (Public School).	Montserrado	Basement.	01 & 02	35 - 64	80	To avoid caving, the hole should be opened up with mud.
3	Jacobs Town (James David's Block Factory).	Montserrado	Paynesville Sandstone / Edina formation.	01 & 02	24 – 57 & 65 - 82	85	Thick overburden of clayey and sandy clay soil.
4	Whein Town (FDA Junction).	Montserrado	Paynesville Sandstone.	01 & 02	47 – 65 & 74 – 139.	85.	This hole should be opened up with mud.
5	Whein Town (SKD Estate).	Montserrado	Paynesville Sandstone.	03	29 – 46 & 60 - 76	80	Suspected stable overburden. Care should be taken to avoid caving form the fracture zone.
6	Liberia Broadcasting System (LBS Community).	Montserrado	Paynesville Sandstone.	03	25 – 44 & 61 - 93	85	This point is in a marshy area. It is liable to flooding during the rains.
7	Upper pipeline Community.	Montserrado	Basement	01 & 02	30 - 80	85	This point is too close to the road. There may be the need to shift.
8	St. Michael's Community.	Montserrado	Basement	01 & 02	25 – 50 & 60 - 72	75	Very thick laterite capping expected.
9	Pipeline Community (Daniel Junction).	Montserrado	Basement	03	34 – 65 & 78 - 143	85	There may be the need to shift this point. It is on the road.
10	Johnsonville (Down Town).	Montserrado	Basement	01 & 02	25 – 42 & 60 - 80	80	Suspected thick overburden of laterite and clayey soil.

CERTIFICATION

This is to certify that a bound copy of the DETAILED REPORT on the Geophysical survey for ten (10) borehole points under the "Government of Liberia / JICA" Urban facilities Improvement Project is submitted to BEZALLEEL & TURNKEY Incorporated of No 77, Carey Street, P. O. Box 2412, Monrovia, Liberia this 20th day of February 2009.

By: Mr. Akogun Victor O.

Signature:

02.20.09

Received by: Arc. Usar Patrick

Signature:

02.20.09

APPENDICES

APPENDIX 1

MTA Compound

- Field Data (Vertical Electrical Sounding – VES)
- Field Curves (Vertical Electrical Sounding – VES)
- Computer Interpreted Data.

VERTICAL ELECTRICAL SOUNDING FIELD DATA

LOCATION: MTA COMPOUND WATER LEVEL: —

VES NO: 01, 02 & 03 AZIMUTH:

EQUIPMENT: OHMEGA RESISTIVITY METER DATE: 23rd January, 2009.

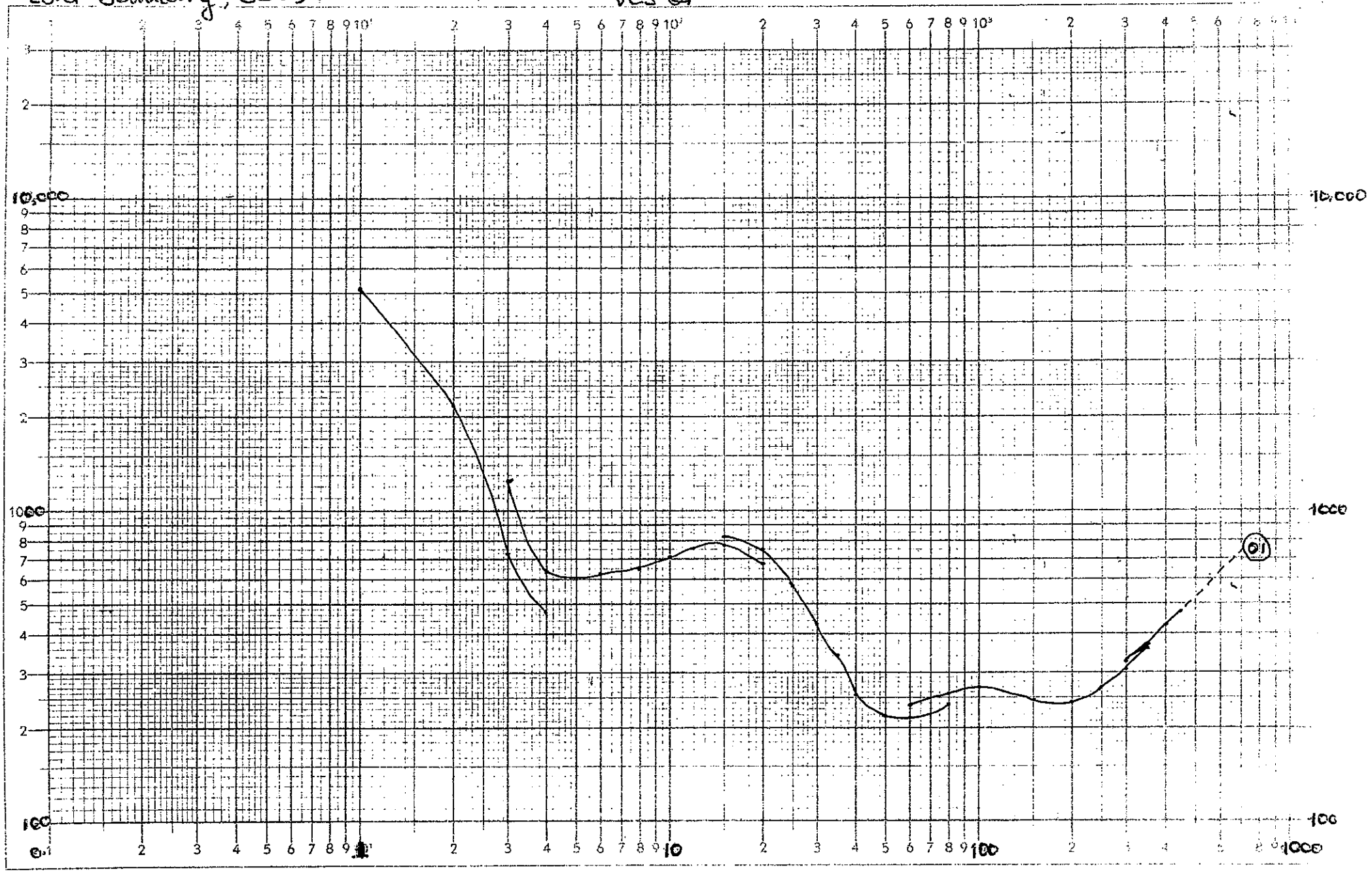
COORDINATES: Lat: 06° 19' 24.2" N Long: W010° 44' 03.4" Elevation(Masl):
06° 19' 26.8" N W010° 44' 04.9"

$= 3.142(AB/2)^2 - (MN/2)^2 / MN$

AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	1208	5074	1122	4712	666.7	2800
2	0.33	18.5	118.5	2192	139.8	2586	123.4	2282
	0.33	42.3	17.43	733	29.69	2570	40.54	1715
3	1	12.6	98.30	1239	215.2	2712	166.8	2101
4	0.33	76	6.222	473	27.62	2099	11.35	863
	1	23.6	27.06	640	94.15	2222	48.95	1155
6	1	55	11.45	630	23.93	1316	8.290	456
8	1	99	6.626	656	8.859	877	1.874	186
10	1	155	4.581	710	4.426	686	1.054	163
12	1	225	3.369	758	2.662	599	0.6845	154
15	1	352	2.207	777	1.509	531	0.3722	131
15	5	62.8	13.15	826	9.076	570	2.500	157
20	1	627	1.084	680	0.7273	456	0.2042	128
20	5	118	6.364	751	4.085	482	1.170	138
25	5	188	3.040	572	2.266	426	0.7021	132
30	5	275	1.581	435	1.564	430	0.4873	134
35	5	377	0.9121	344	1.167	440	0.3793	143
40	5	495	0.5148	255	0.8990	445	0.2990	148
50	5	777	0.2807	218	0.6152	478	0.2162	168
50	5	1123	0.1935	217	0.4381	492	0.1692	190
60	10	550	0.4297	236	0.9436	519	0.3146	173
70	5	2003	0.1368	274	0.2297	460	0.1128	226
70	10	990	0.2606	258	0.4885	483	0.2131	211
100	10	1555	0.1736	270	0.3351	521	0.1389	216
150	10	3520	0.06903	243	0.1750	616	0.05796	204
200	10	6270	0.03828	240	0.1244	780	0.03509	220
250	10	9803	0.02734	268	0.1014	994	0.02632	258
300	10	14123	0.02188	309	0.08624	1218	0.02167	306
300	15	9402	0.03489	328	—	—	0.03744	352
350	10	19229	0.01862	358	—	—	0.01872	360
350	15	12806	0.02858	366	—	—	0.03124	400
400	15	16734	0.02576	431	—	—	0.02737	458
450	15	21185	0.02228	472	—	—	0.02483	526

23rd January, 2009.

VES 01



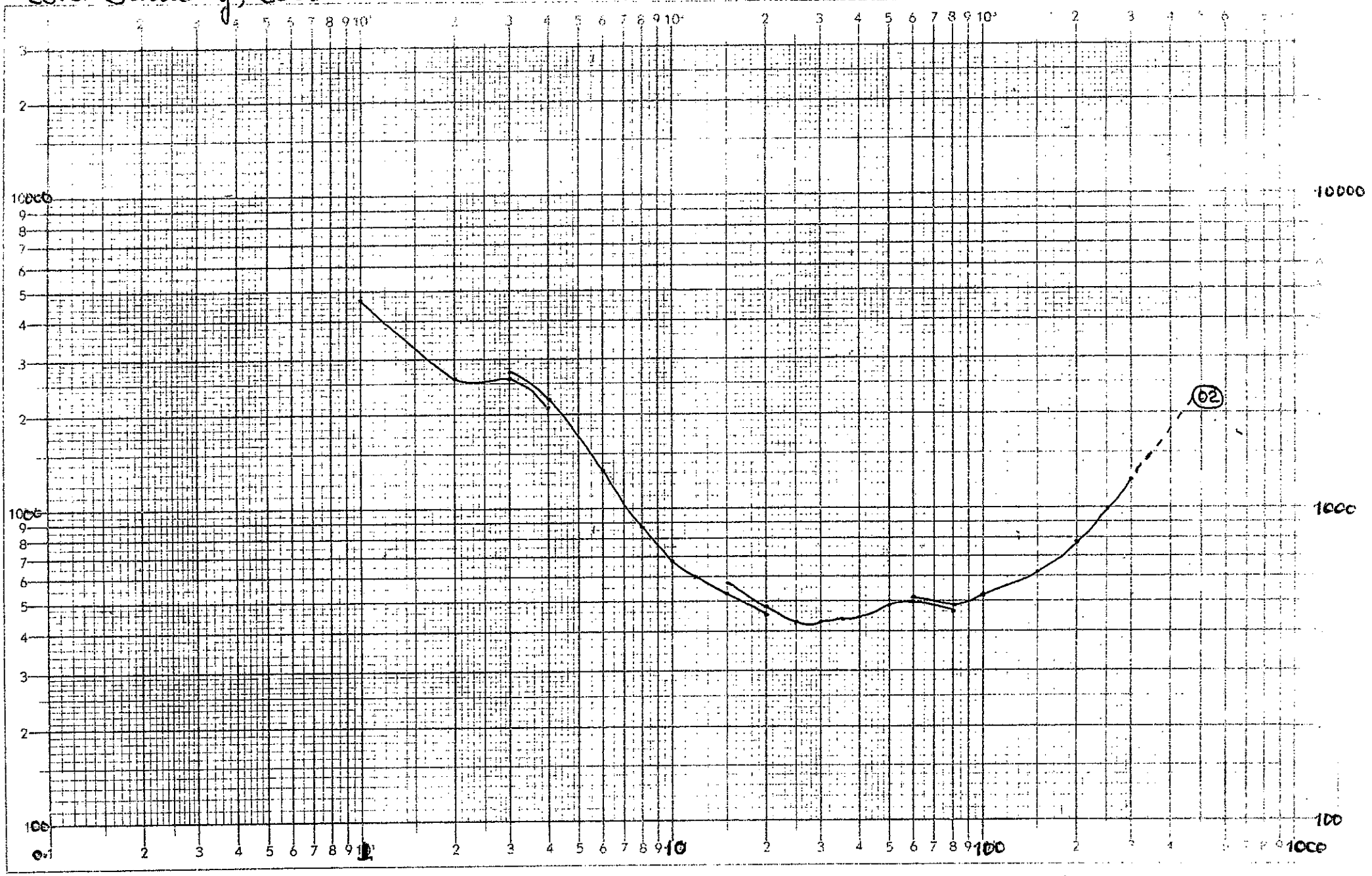
meetpapier - wormer

T 10019

X-as log. verdeeld 1-10 Y-as log. verdeeld 1-300 Eenheid 62.5 mm

23rd January, 2009.

VES 02



meetpapier · wormer

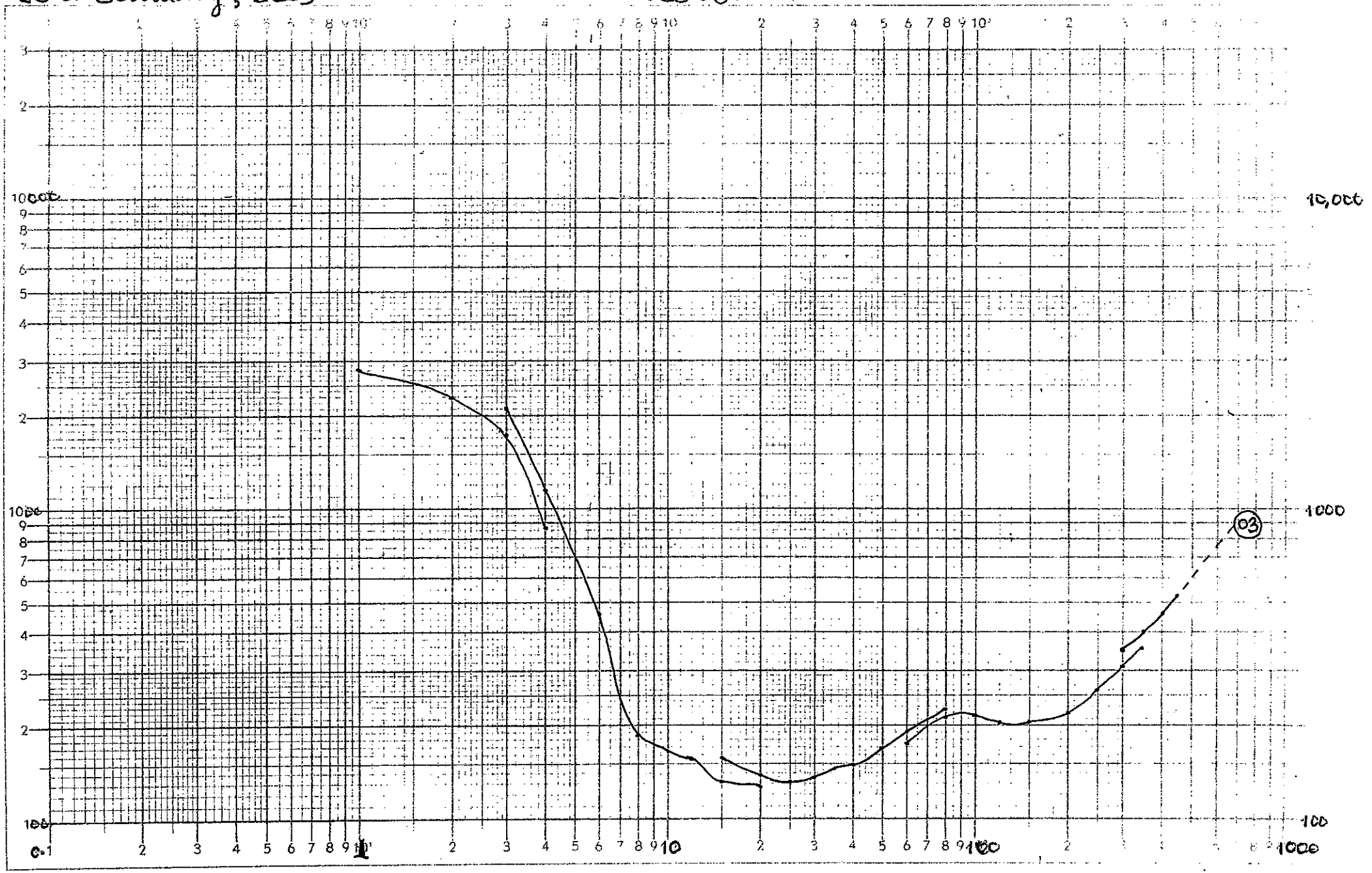
T 10019

X-as log. verdeeld 1 10 Y-as log. verdeeld 1 300 Papier 67 mm

MTA COMPOUND

23rd January, 2009

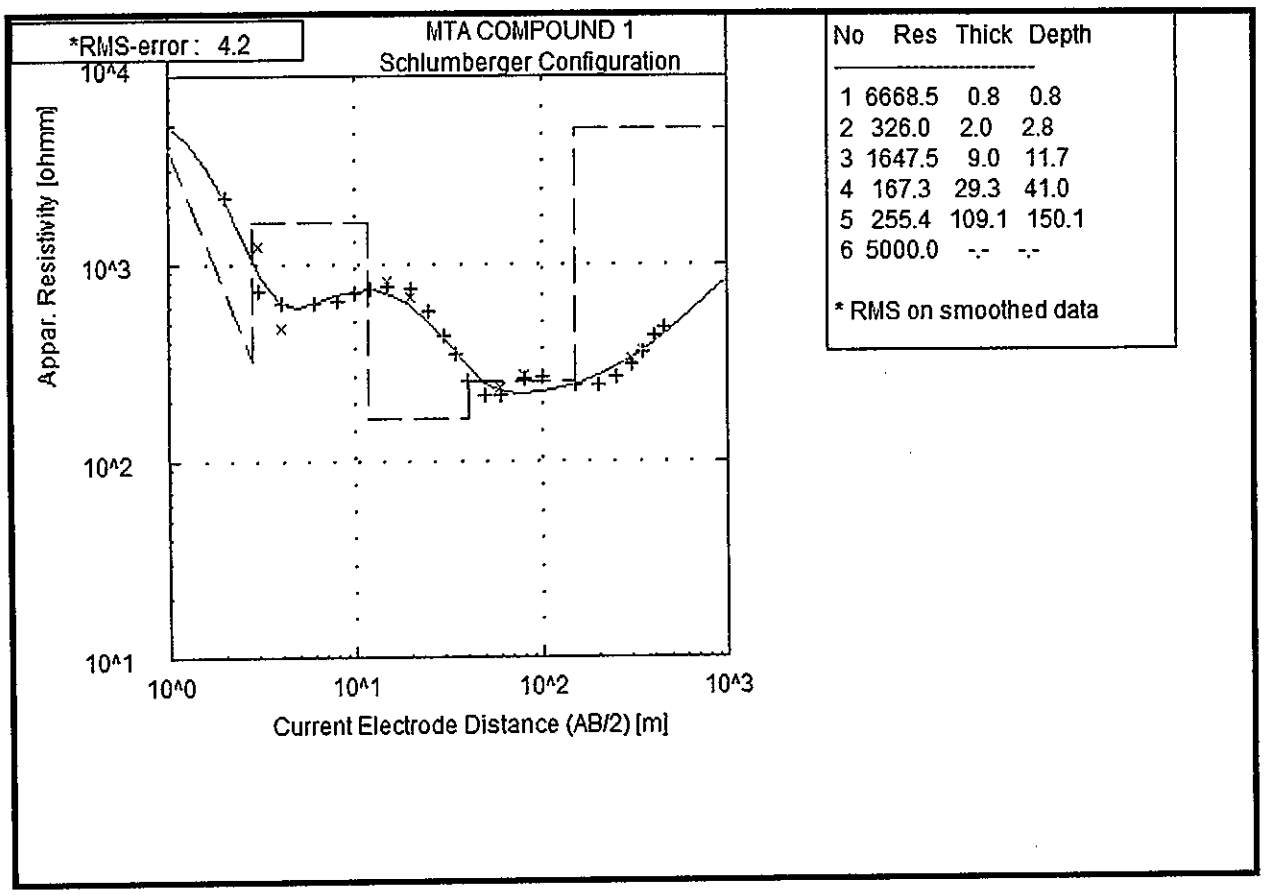
VES 03.



meetpapier - wormer

T 10019

X-as log. verdeeld 1.10 Y as log. verdeeld 300 Semiwd 67



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: MTA Compound.

DATE: 23rd January, 2009.

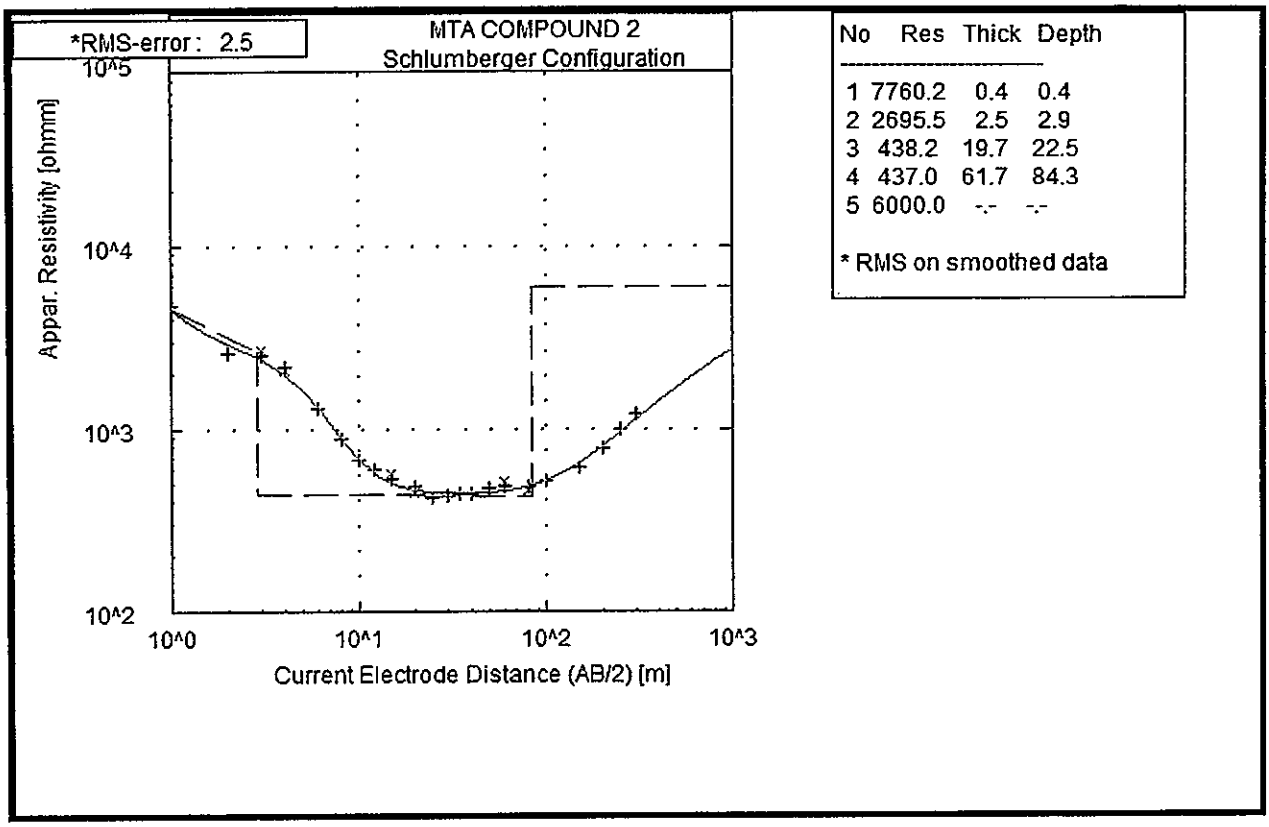
AB: 900 Meters.

AZIMUTH: 38 Degrees.

POSITION:

FILE: MTA 1

REMARK: THIS POINT THOUGH FAIR, IS NOT RECOMMENDED FOR DRILLING.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: MTA Compound.

DATE: 23rd January, 2009.

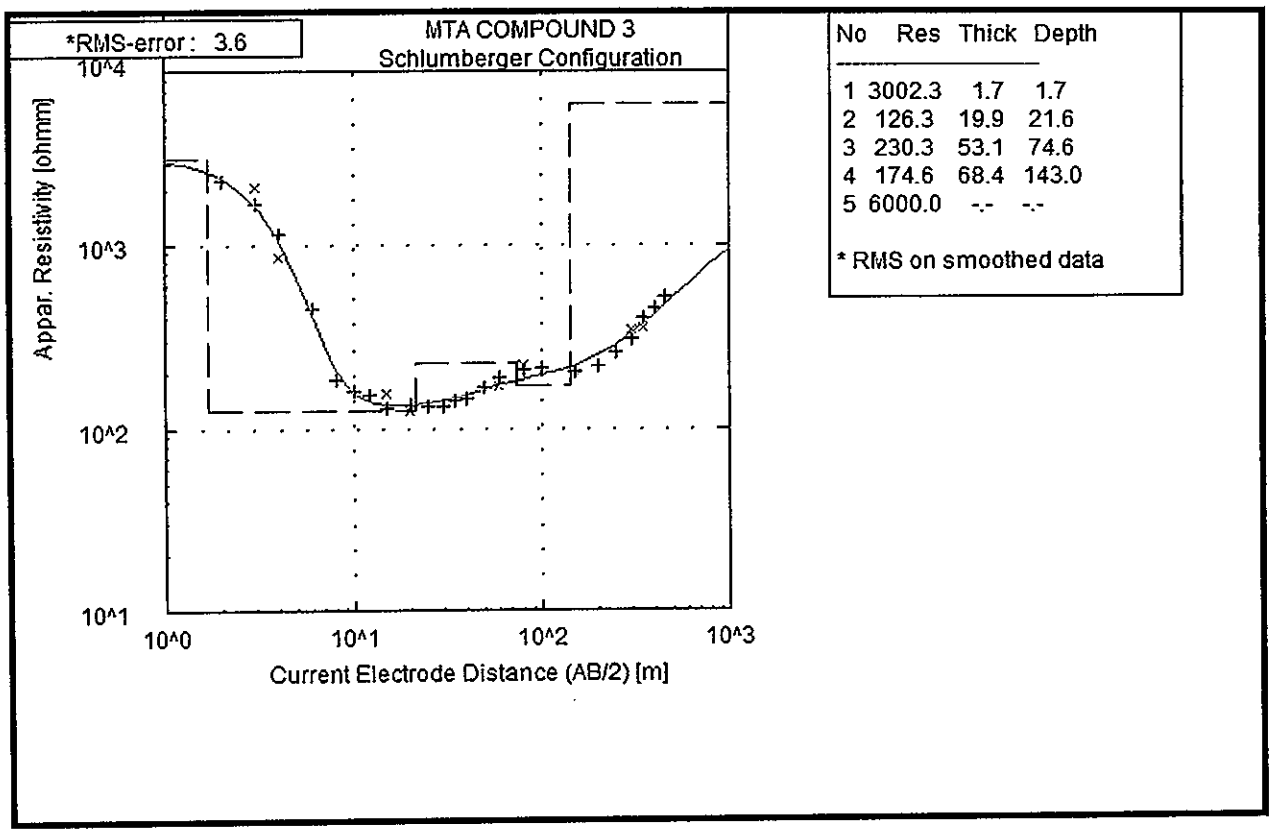
AB: 600 Meters.

AZIMUTH: 146 Degrees.

POSITION:

FILE: MTA 2

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: MTA Compound.

DATE: 23rd January, 2009.

AB: 900 Meters.

AZIMUTH: 32Degrees.

POSITION:

FILE: MTA 3

REMARK: RECOMMENDED DRILL POINT.

APPENDIX 2

Johnsonville

- Field Data (Vertical Electrical Sounding – VES)
- Field Curves (Vertical Electrical Sounding – VES)
- Computer Interpreted Data

VERTICAL ELECTRICAL SOUNDING FIELD DATA

LOCATION: JOHNSONVILLE (PUBLIC SCHOOL) WATER LEVEL: —

VES NO: 01 , 02 , 03 AZIMUTH: 07° & 160°

EQUIPMENT: OHMEGA RESISTIVITY METER. DATE: 26th – 28th January, 2009.

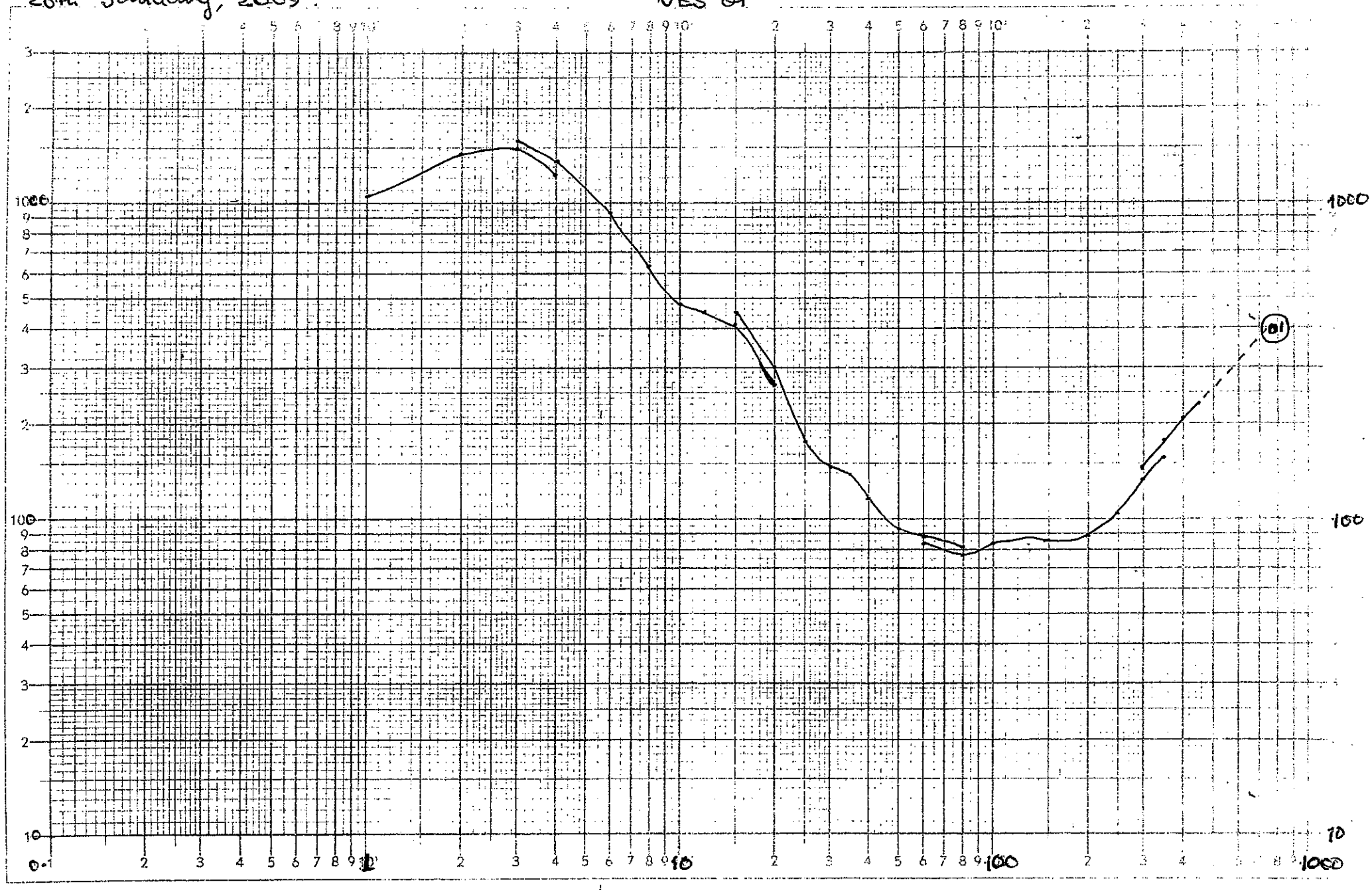
COORDINATES: Lat: 06° 21' 49.5"N Long: W010° 41' 08.3" Elevation(Masl):

$= 3.142(AB/2)^2 - (MN/2)^2 / MN$

AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	248.6	1044	359.5	1501	112.4	472
2	0.33	18.5	77.03	1425	115.3	2133	30.49	564
	0.33	42.3	35.34	1495	46.74	1977	11.02	466
3	1	12.6	125.4	1580	173.70	2189	39.65	500
4	0.33	76	16.05	1220	22.74	1728	5.000	380
	1	23.6	58.39	1378	81.74	1929	17.63	416
6	1	55	17.06	938	30.50	1676	6.050	333
8	1	99	6.445	638	15.37	1522	2.989	296
10	1	155	3.098	479	8.979	1392	1.652	256
12	1	225	2.018	454	5.665	1275	0.9466	213
15	1	352	1.168	411	3.506	1234	0.5685	200
15	5	62.8	7.134	448	17.30	1086	3.376	212
20	1	627	0.4211	264	1.611	1010	0.3435	215
20	5	118	2.542	300	7.840	925	1.905	225
25	5	188	0.9415	177	4.097	770	1.135	213
30	5	275	0.5346	147	2.610	718	0.5361	147
35	5	377	0.3687	139	1.628	614	0.3448	130
40	5	495	0.2384	118	1.072	557	0.2364	117
50	5	777	0.1197	93	0.7415	576	0.1408	109
50	5	1123	0.07836	88	0.4960	557	0.1033	116
60	10	550	0.1509	83	1.064	585	0.2255	124
70	5	2003	0.04093	82	0.2387	478	0.06740	135
70	10	990	0.07677	76	0.5128	507	0.1475	146
100	10	1555	0.05402	84	0.2249	349	0.1003	156
150	10	3520	0.02443	86	0.1088	383	0.03921	138
200	10	6270	0.01420	89	0.07257	455	0.02137	134
250	10	9803	0.01102	108	0.04866	477	0.01489	146
300	10	14123	0.009488	134	0.03838	542	0.01218	172
300	15	9402	0.01553	146	0.06148	578	0.01670	157
350	10	19229	0.008113	156	0.03100	596	0.009621	185
450	15	12806	0.01390	178	0.05045	646	0.01343	172
400	15	16734	0.01249	209	0.04285	717	0.01147	192
550	15	21185	0.01090	231.	0.03739	792.	0.01029	218.

26th January, 2009.

VES 01



meetpapier - wormer

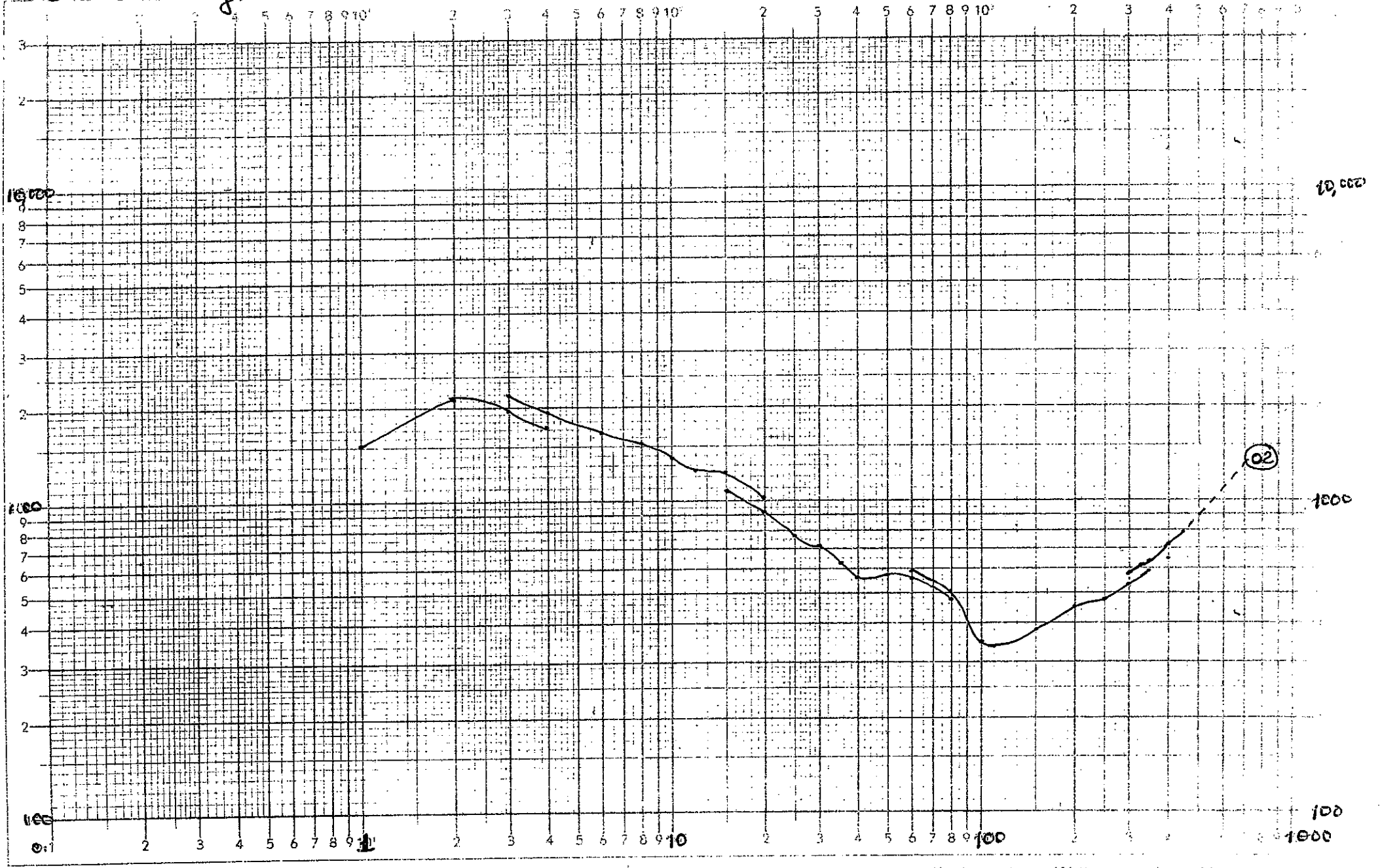
T 10019

X-as log. verdeeld 1-10 Y-as log. verdeeld 1-300 Eenheid 62.5 mm

28th January, 2009.

VES 02

07°

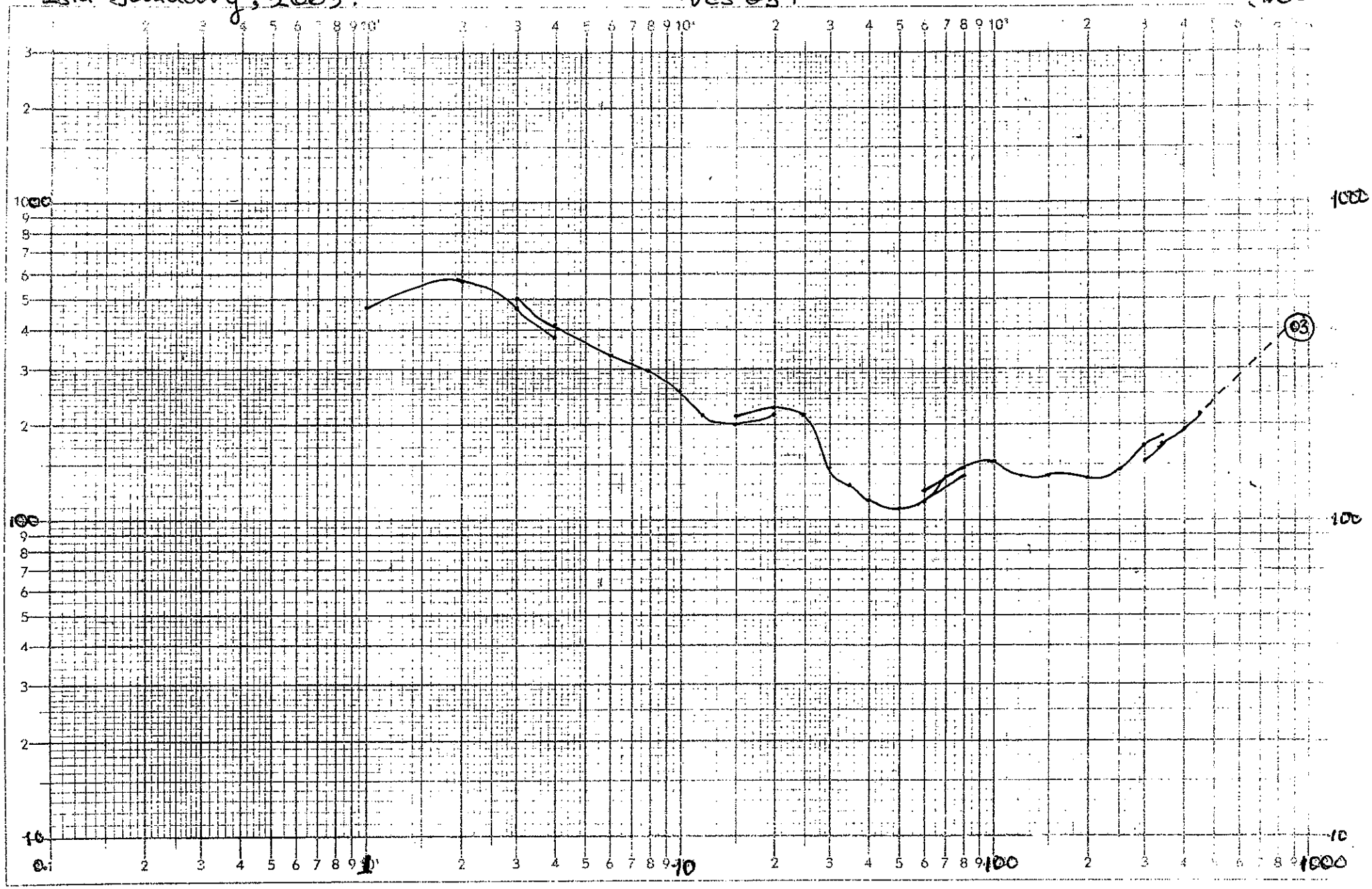


meetpapier - wormer

T 10019

X-as log. verdeeld 1-10⁴ Y-as log. verdeeld 1-300 Ω-m

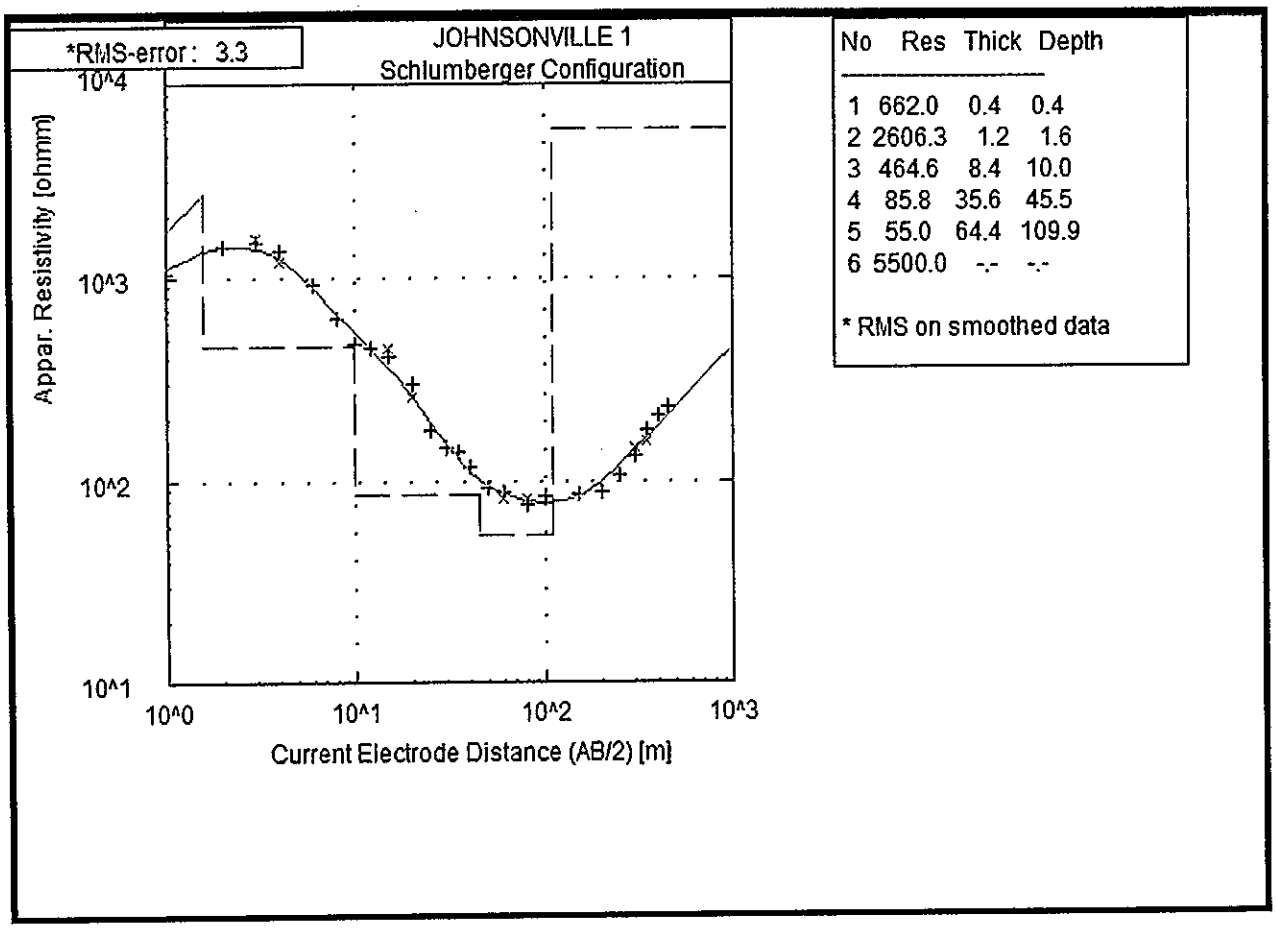
28th January, 2009. VES 03. 160°



moetpapier - wormer

T 10019

X-as log. verdeeld 1:10 Y-as log. verdeeld 1:300 Eenheid 62.5 mm



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Johnsonville.

DATE: 26th January, 2009.

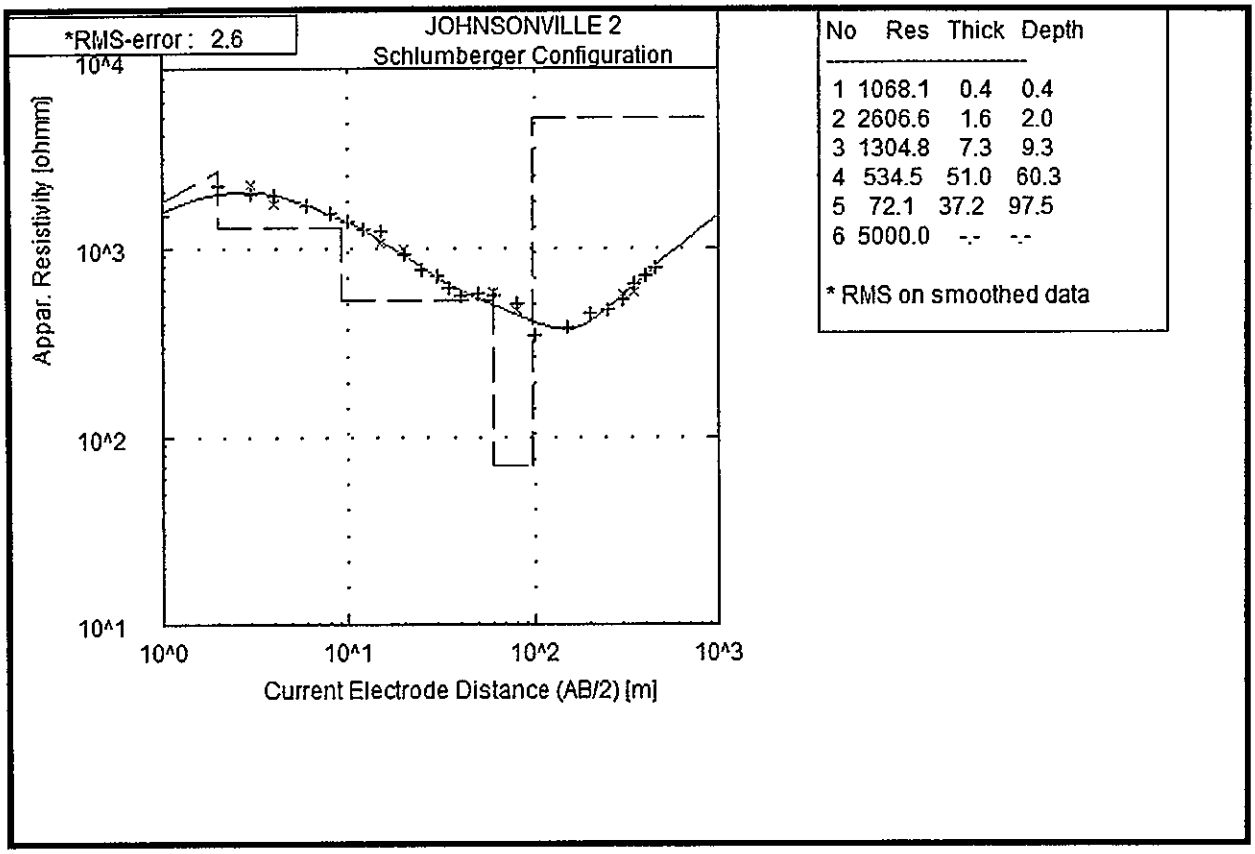
AB: 900 Meters.

AZIMUTH: 146 Degrees.

POSITION:

FILE: JOHNSONVILLE 1

REMARK: RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Johnsonville.

DATE: 28th January, 2009.

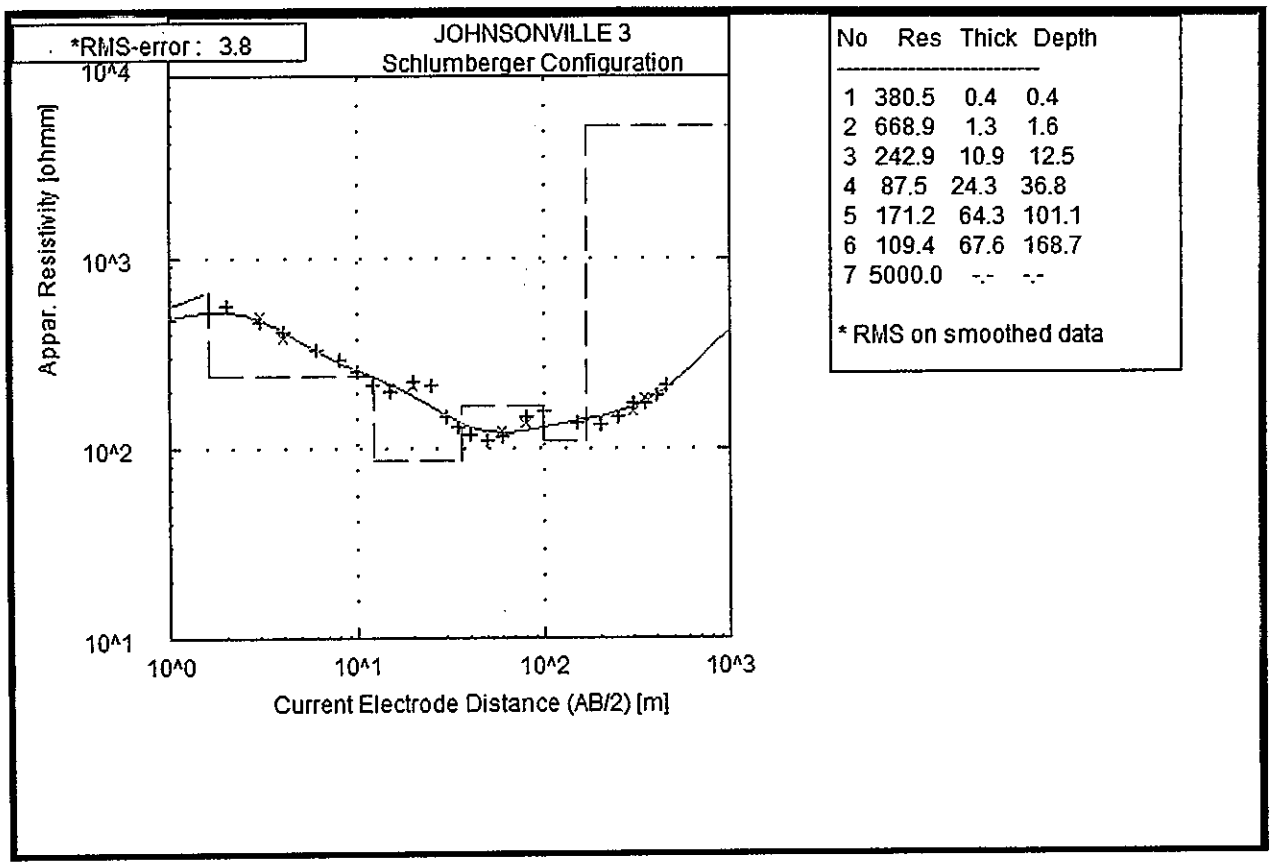
AB: 900 Meters.

AZIMUTH: 07 Degrees.

POSITION:

FILE: JOHNSONVILLE 2

REMARK: RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Johnsonville.

DATE: 28th January, 2009.

AB: 900 Meters.

AZIMUTH: 160 Degrees.

POSITION:

FILE: JOHNSONVILLE 3

REMARK: THIS POINT IS FAIR BUT NOT RECOMMENDED FOR DRILLING.

APPENDIX 3

Jacobs Town

(James David Block Factory)

- **Field Data (Vertical Electrical Sounding – VES)**
- **Field Curves (Vertical Electrical Sounding – VES)**
- **Computer Interpreted Data**

VERTICAL ELECTRICAL SOUNDING FIELD DATA

LOCATION: JACOBS TOWN WATER LEVEL: —

VES NO: 01, 02 & 03 AZIMUTH: 133°, 42° & 44°.

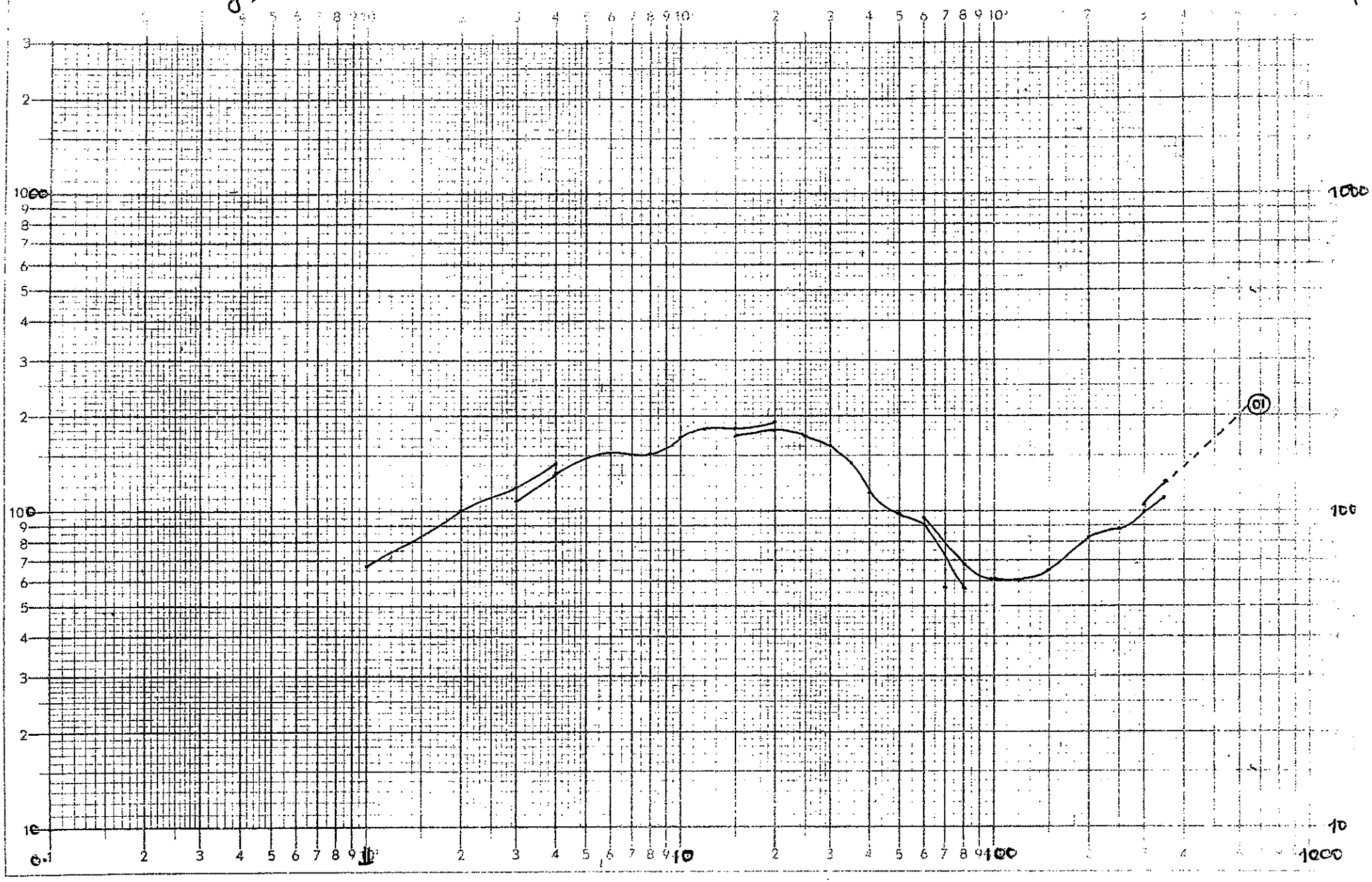
EQUIPMENT: OHMEGA RESISTIVITY METER DATE: 29th January, 2009.

COORDINATES: Lat: 06° 18′ 14·0″N Long: E10° 42′ 30″ Elevation(Masl): 25
06° 18′ 15·9″N E10° 42′ 32·5″ 24

K = 3.142(AB/2)² - (MN/2)² / MN

AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	15.98	67	23·61	99	89·33	375
2	0.33	18.5	5·452	101	5·797	107	14·49	268
	0.33	42.3	2·837	120	2·787	118	5·341	226
3	1	12.6	8·614	109	8·686	112	16·01	202
4	0.33	76	1·874	142	1·631	124	2·523	192
	1	23.6	5·604	132	4·824	114	7·023	166
6	1	55	2·756	152	2·432	134	2·949	162
8	1	99	1·540	152	1·347	133	1·682	167
10	1	155	1·104	171	0·8635	134	1·114	173
12	1	225	0·8067	182	0·6202	140	0·9151	206
15	1	352	0·5168	182	0·4013	141	0·7105	250
15	5	62.8	2·736	172	2·300	144	3·304	208
20	1	627	0·3030	190	0·1915	120	0·4540	285
20	5	118	1·520	179	1·084	128	2·118	250
25	5	188	0·9080	171	0·6273	118	1·415	266
30	5	275	0·5817	160	0·4135	114	0·9455	260
35	5	377	0·3749	141	0·3182	120	0·6578	248
40	5	495	0·2300	114	0·2209	109	0·4606	228
50	5	777	0·1266	98	0·1439	112	0·2445	190
70	5	1123	0·08097	91	0·09912	111	0·1358	153
60	10	550	0·1733	95	0·2027	111	0·2529	139
70	5	2003	0·02868	57	0·05401	108	0·04743	95
80	10	990	0·06869	68	0·1175	116	0·08528	85
100	10	1555	0·03987	62	0·08047	125	0·05338	83
150	10	3520	0·01875	66	0·04145	146	0·02863	101
200	10	6270	0·01324	83	0·03062	192	0·01831	115
250.	10	9803	0·008977	88	0·02203	216	0·01446	142
300	10	14123	0·007010	99	0·01643	232	0·01197	169
300	15	9402	0·01128	106	0·02297	216	—	—
350	10	19229	0·005772	111	0·01331	256	—	—
450	15	12806	0·009995	128	0·01820	233	—	—
400	15	16734	—	—	0·01590	266	—	—
450	15	21185	—	—	0·01459	309	—	—

29th January, 2009. VES 01. 133° 9/2

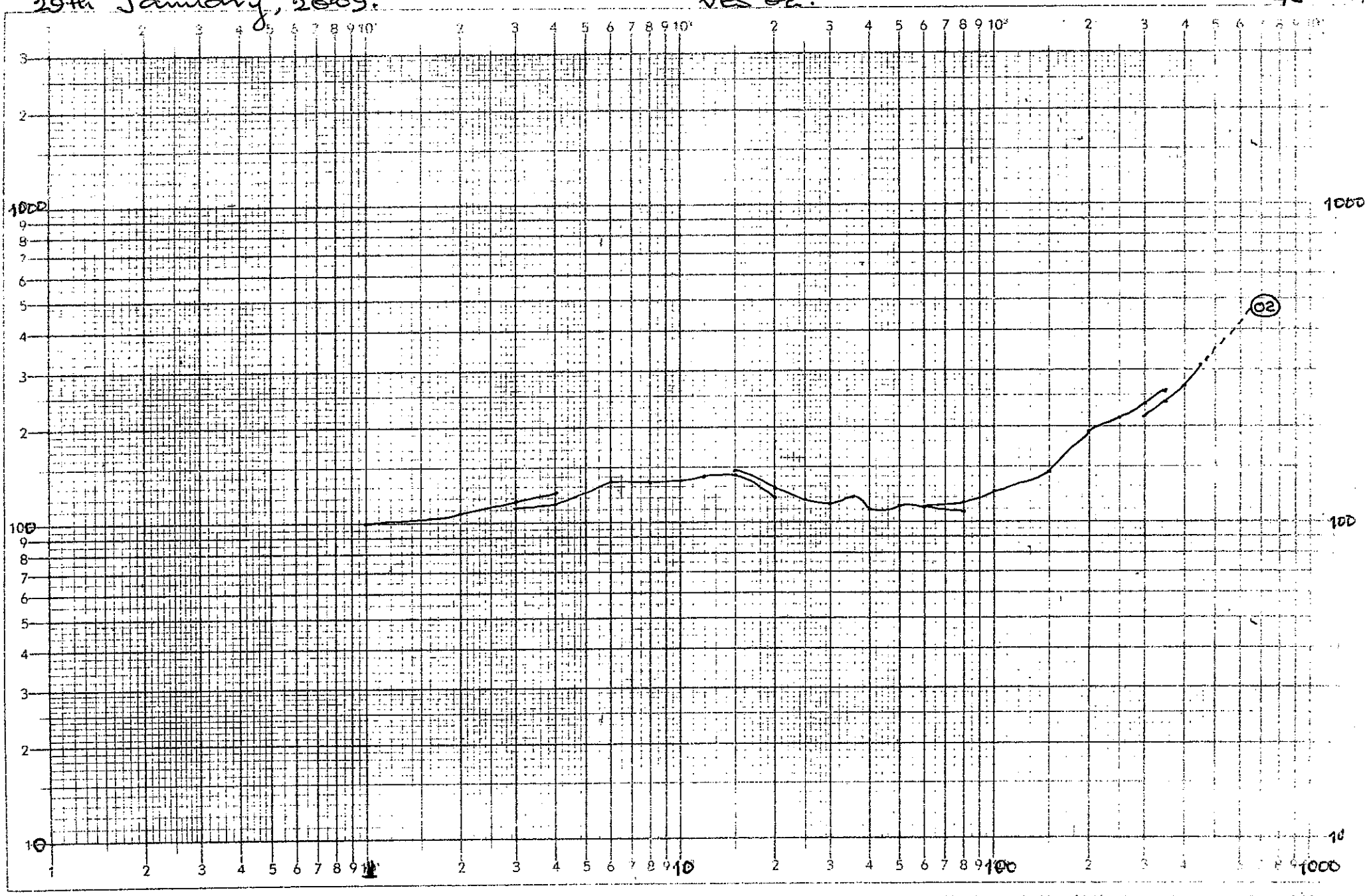


meetpapier - wormer

T 10019

X-as log. verdeeld 1 10 X-as log. verdeeld 300 Eenheid 52

29th January, 2009. VES 02.



meetpapier - wormer

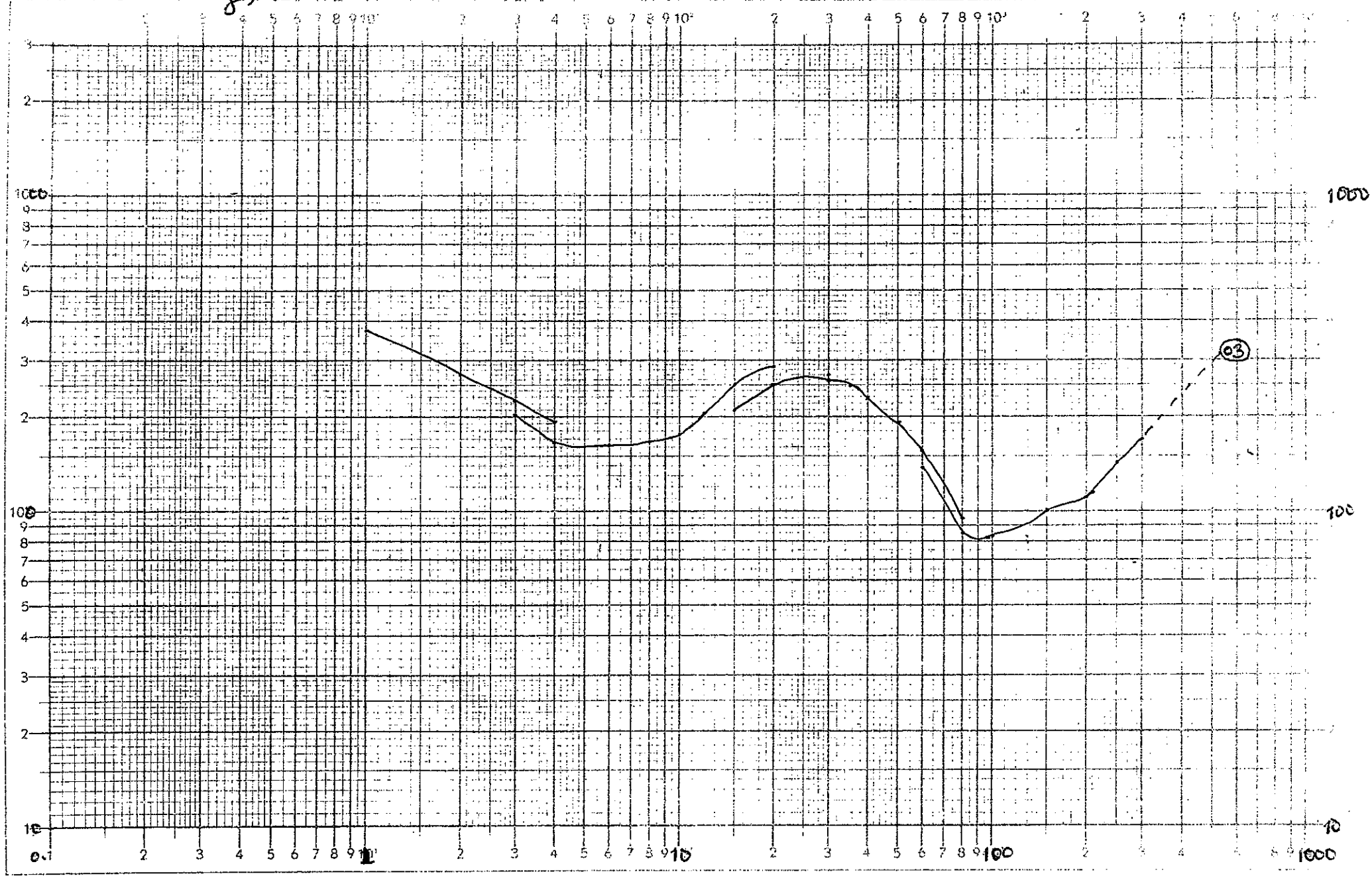
T 10019

X-as log. verdeeld 1-10⁴ Y-as log. verdeeld 1-300 Ohmeld

29th January, 2009.

VES 03

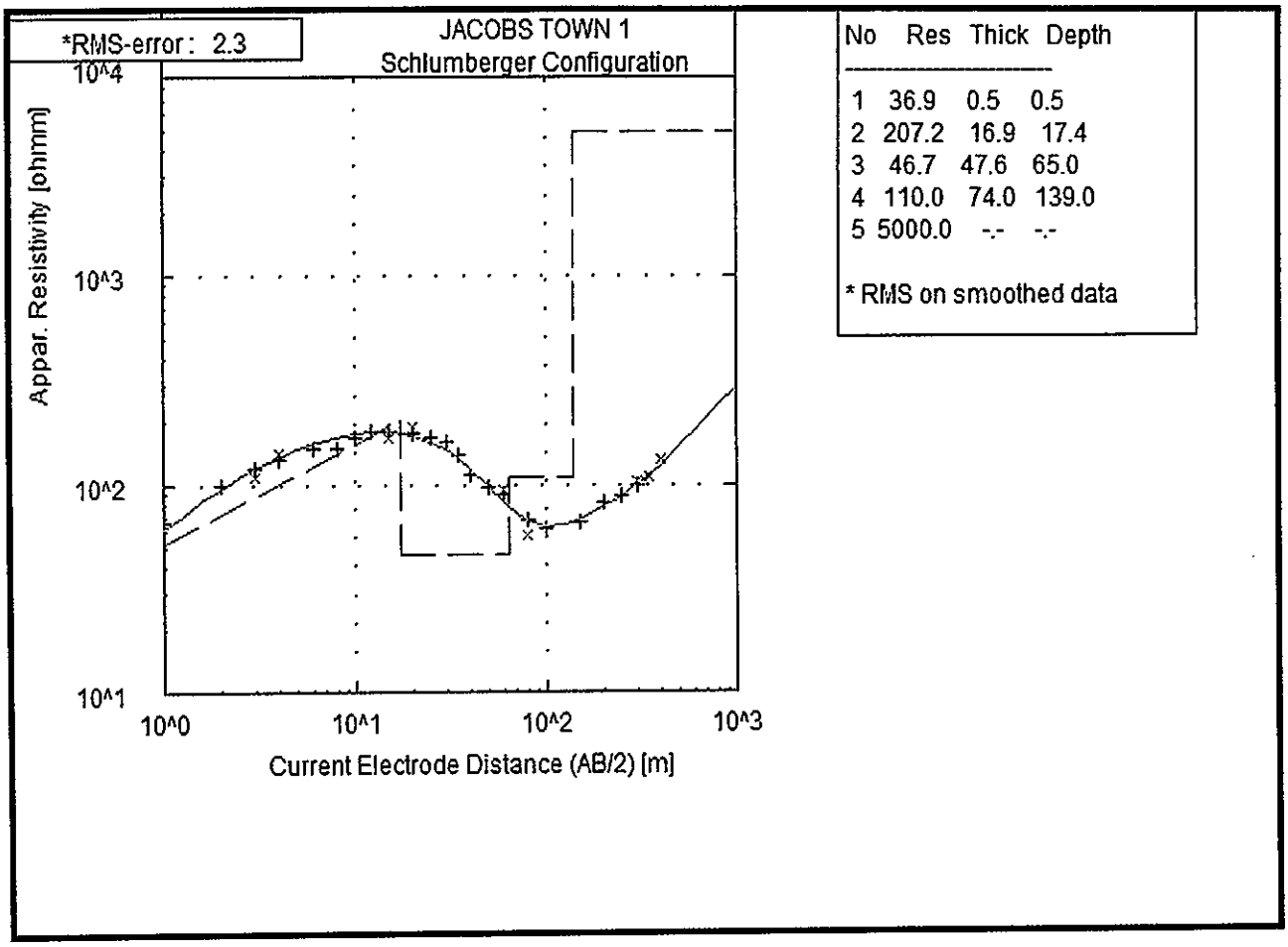
44°



meetpapier · wormer

T 10015

X-as log. verdeeld 1:10 Y-as log. verdeeld 1:300 Formaat 62



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Jacobs Town (James David's Block Factory).

DATE: 29th January, 2009.

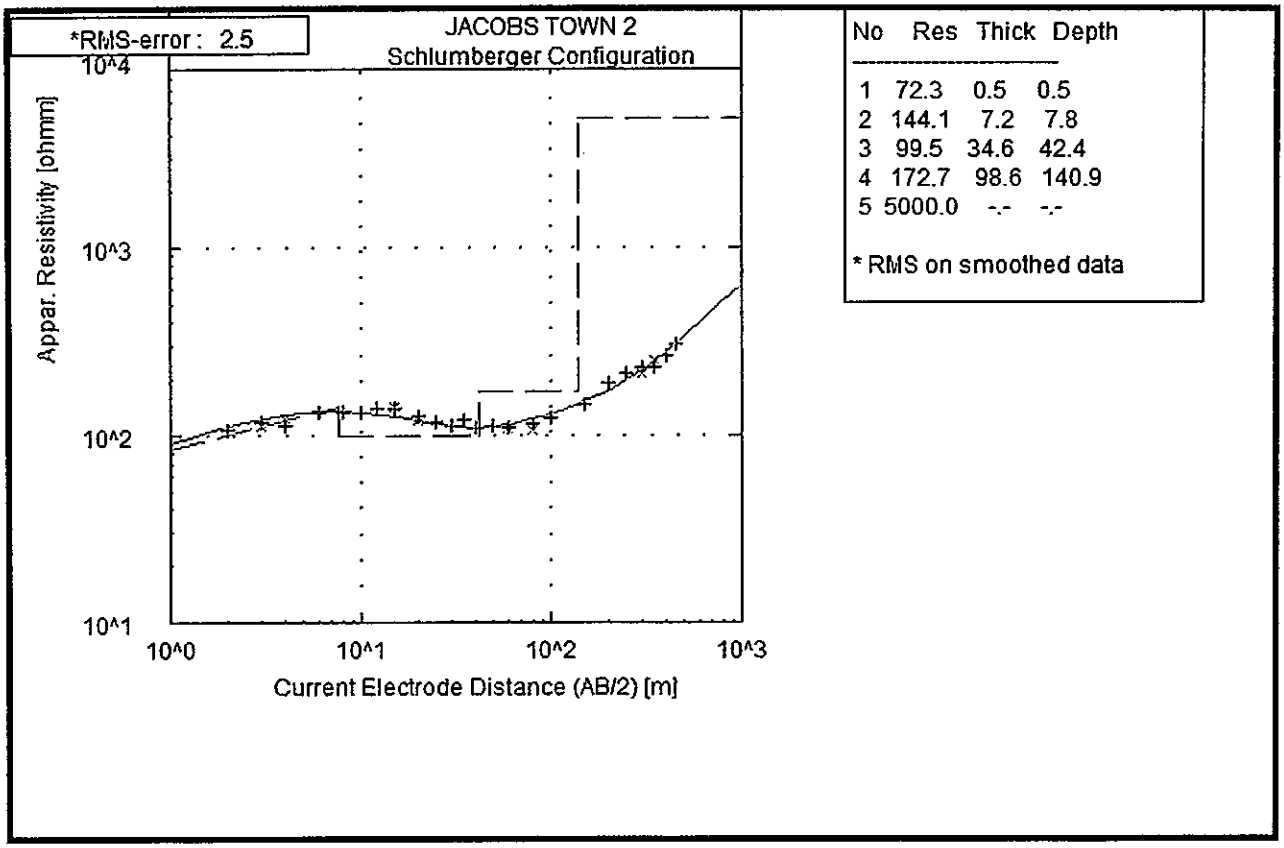
AB: 700 Meters.

AZIMUTH: 133 Degrees.

POSITION:

FILE: JACOBS TOWN 1

REMARK: RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Jacobs Town (James David's Block Factory).

DATE: 29th January, 2009.

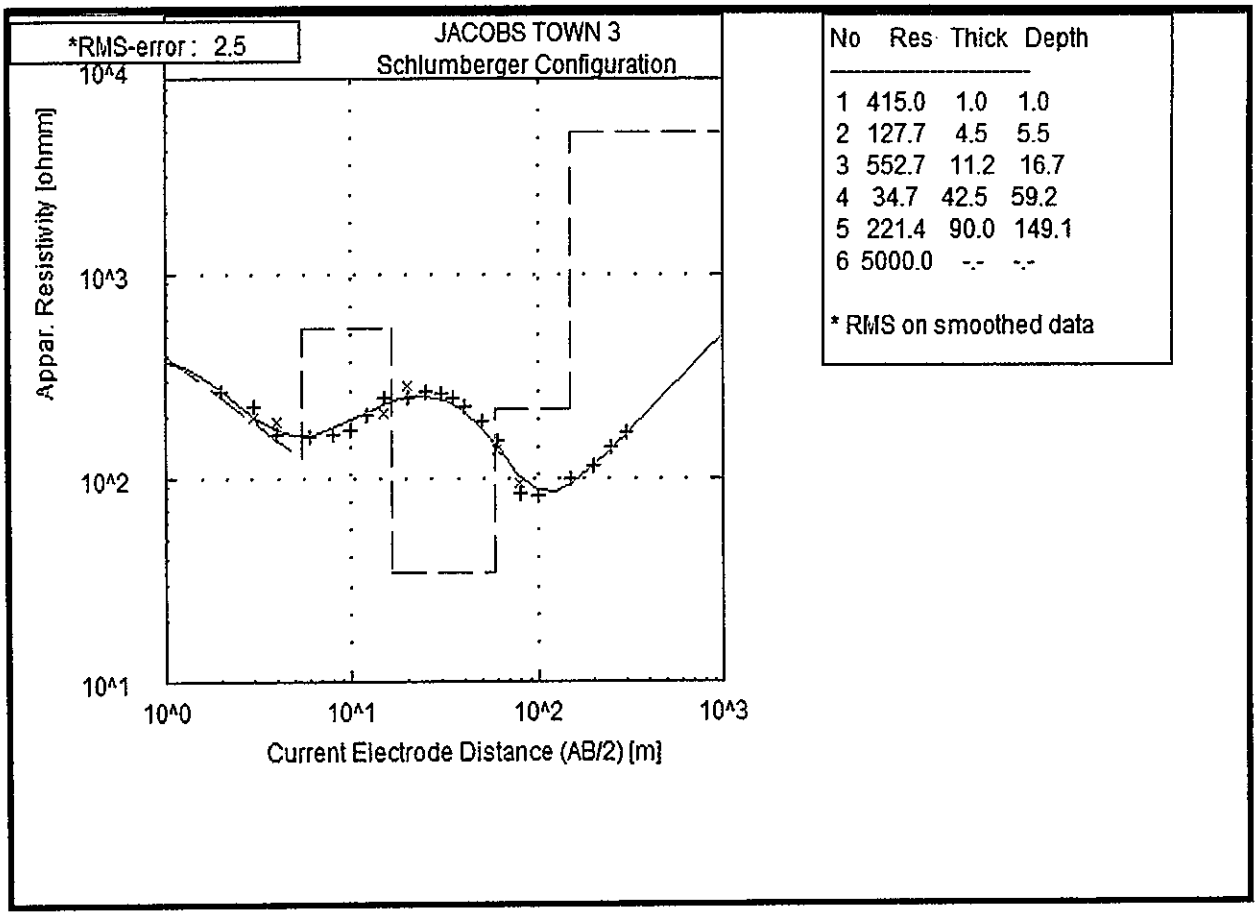
AB: 900 Meters.

AZIMUTH: 42 Degrees.

POSITION:

FILE: JACOBS TOWN 2

REMARK: RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Jacobs Town (James David's Block Factory).

DATE: 29th January, 2009.

AB: 600 Meters.

AZIMUTH: 44 Degrees.

POSITION:

FILE: JACOBS TOWN 3

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.

APPENDIX 4

Whein Town (FDA Junction)

- Field Data (Vertical Electrical Sounding – VES)
- Field Curves (Vertical Electrical Sounding – VES)
- Computer Interpreted Data.

VERTICAL ELECTRICAL SOUNDING FIELD DATA

LOCATION: WHEIN TOWN, FDA JUNCTION WATER LEVEL: —

VES NO: 01, 02 & 03. AZIMUTH: 106°, 35° & 21°

EQUIPMENT: OHMEGA RESISTIVITY METER DATE: 30th January, 2009

COORDINATES: Lat: 06° 20' 30.5" N Long: W010° 39' 45.3" Elevation(Masl): 5
06° 19' 31.6" N W010° 39' 48.4"

$= 3.142(AB/2)^2 - (MN/2)^2 / MN$

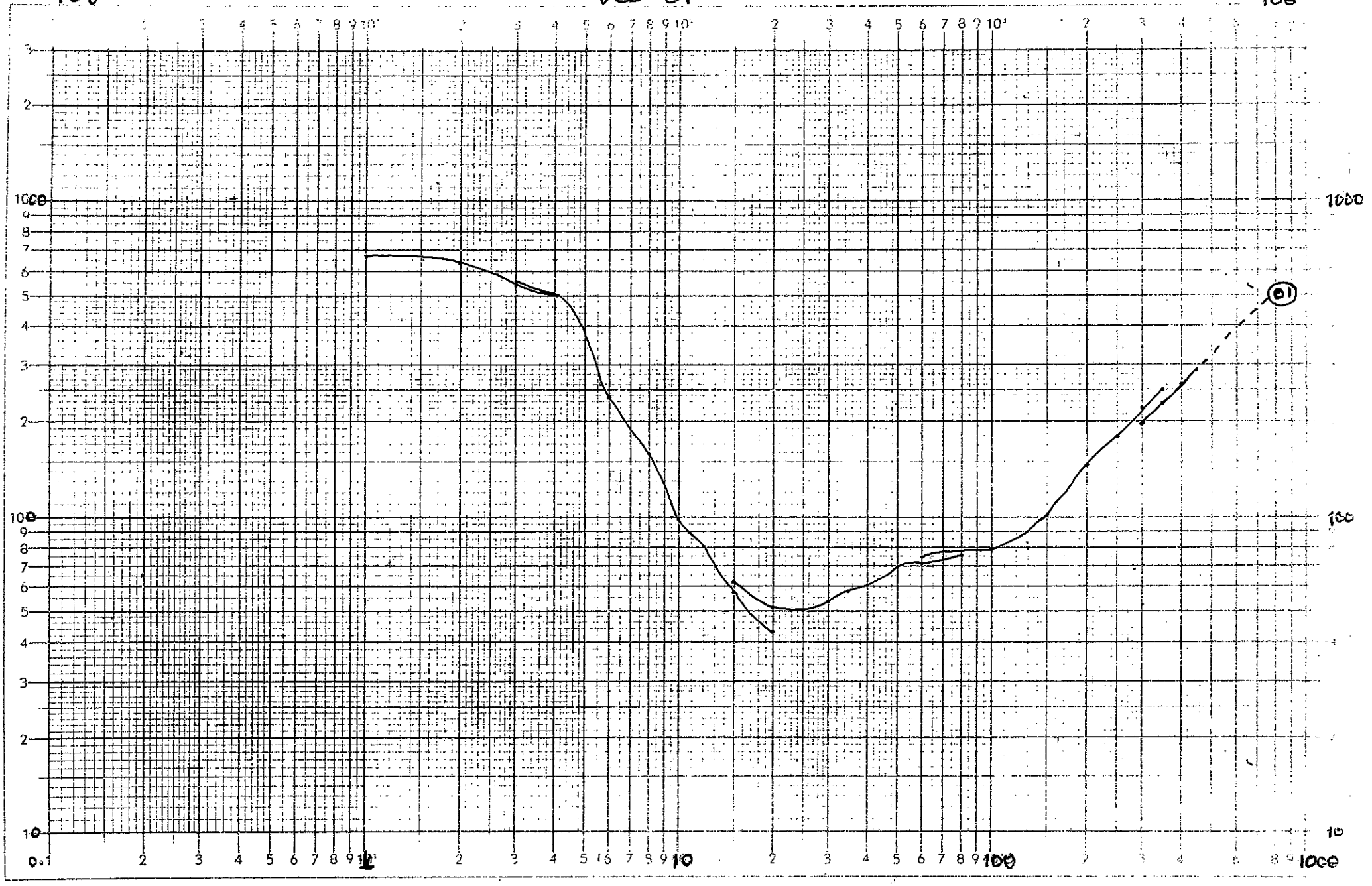
AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	161.5	678	131.5	552	86.19	362
2	0.33	18.5	34.70	642	37.43	692	13.27	245
	0.33	42.3	12.87	544	16.82	711	3.415	144
3	1	12.6	43.30	546	45.22	570	13.02	164
4	0.33	76	6.628	504	6.962	529	1.641	125
	1	23.6	21.38	505	17.93	423	5.763	136
6	1	55	4.236	233	3.901	215	2.331	128
	1	99	1.611	159	1.418	140	0.4925	49
0	1	155	0.6351	98	0.7925	123	0.1854	29
12	1	225	0.3557	80	0.5594	126	0.1175	26
5	1	352	0.1621	57	0.3466	122	0.07580	27
5	5	62.8	0.9873	62	2.198	138	0.5108	32
20	1	627	0.06891	43	0.1818	114	0.04651	29
0	5	118	0.4322	51	1.093	129	0.3040	36
25	5	188	0.2670	50	0.5746	108	0.2181	41
30	5	275	0.1922	53	0.4043	111	0.1621	45
5	5	377	0.1517	57	0.3576	133	0.1277	48
40	5	495	0.1203	60	0.2029	100	0.1023	51
0	5	777	0.08880	69	0.1682	131	0.07347	57
0	5	1123	0.06322	71	0.1078	121	0.05483	62
60	10	550	0.1346	74	0.2400	132	0.1185	65
0	5	2003	0.03723	75	0.05142	103	0.03192	64
0	10	990	0.07778	77	0.1081	107	0.06810	67
100	10	1555	0.04997	78	0.07653	119	0.04591	71
50	10	3520	0.03153	111	0.04205	148	0.02381	84
200	10	6270	0.02297	144	0.03062	192	0.01738	109
250	10	9803	0.01826	179	0.02397	235	0.01255	123
00	10	14123	0.01565	221	0.01976	279	0.01048	148
300	15	9402	0.02117	199	0.02840	267	0.01404	132
350	10	19229	0.01300	250	0.01857	356	0.009049	174
50	15	12806	0.01749	224	0.02639	338	0.01164	149
400	15	16734	0.01542	258	0.02295	384	0.01010	169
50	15	21185	0.01350	286	0.02153	456	0.009063	192

30th January 2009.

106°

VES 01

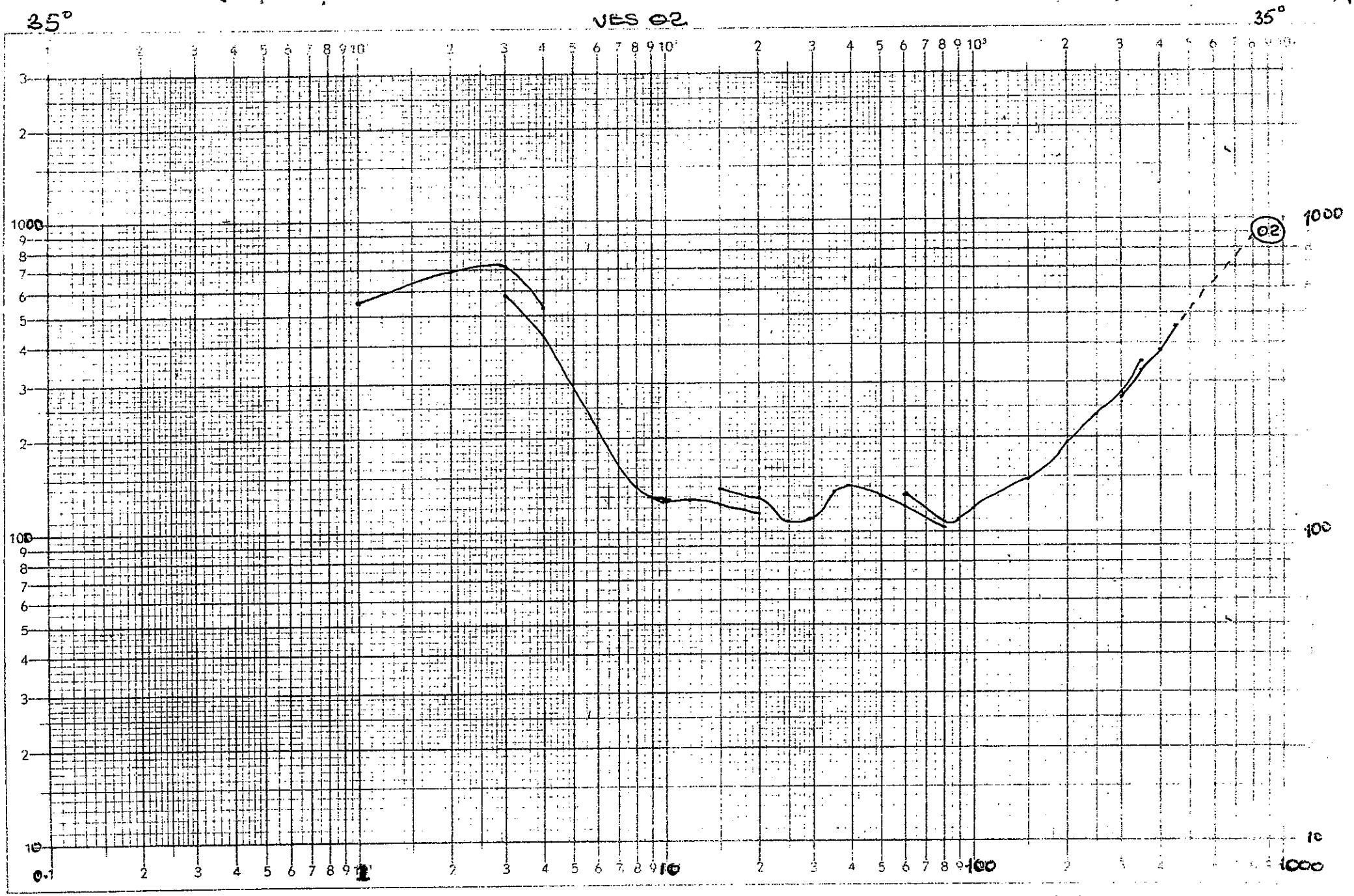
106°

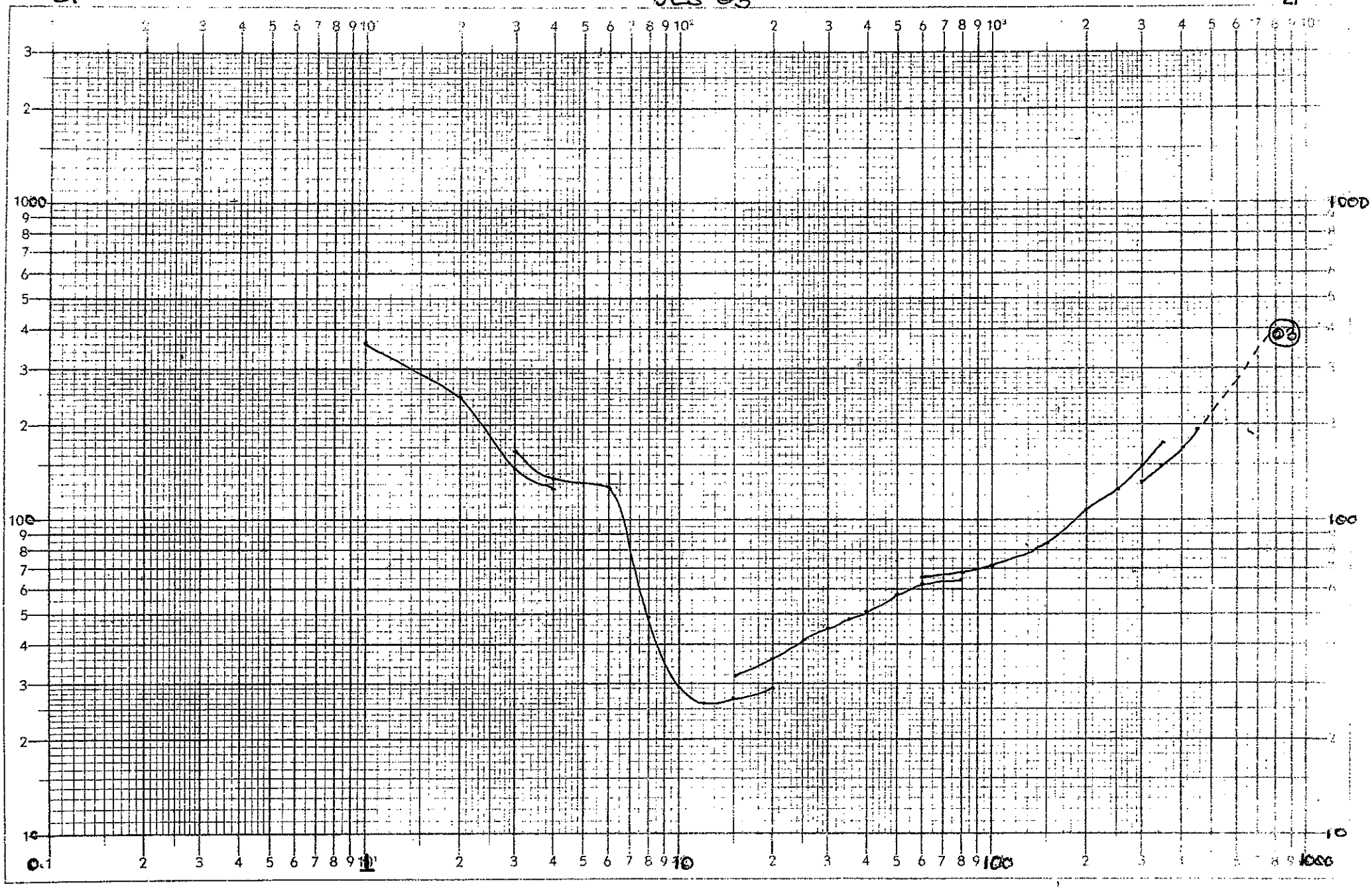


meetpapier - wormer

T 10019

X-as log. verdeeld 1:10⁴ Y-as log. verdeeld 1:300 Eenheid 62.5 mm

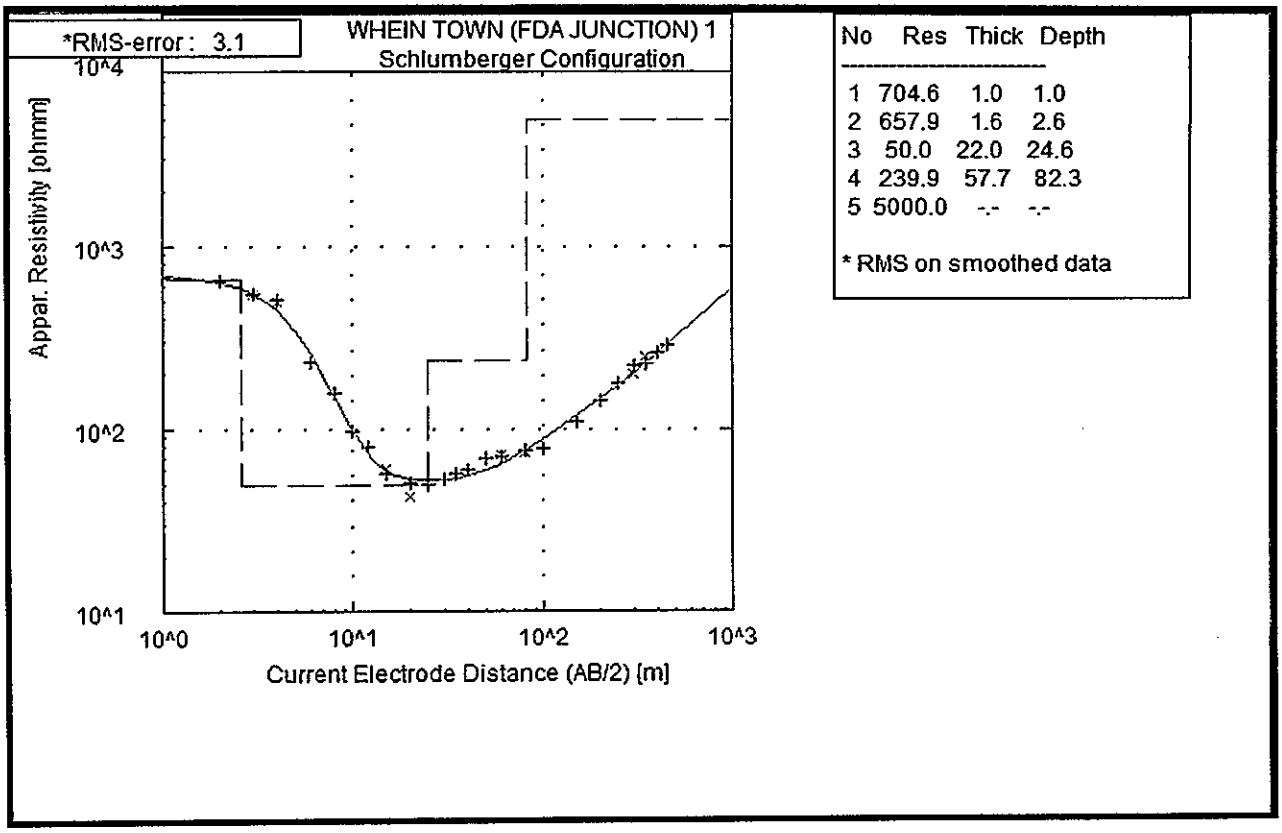

35°
VES 02
35°
02
1000
100
10
0.1
1
10
100
1000
T 10019
meetpapier - wormer



meetpapier - wormer

T 10019

X-as log. verdeeld 1·10⁴ Y-as log. verdeeld 1-300 Eenheid 62,5 mm



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Whein Town (FDA Junction).

DATE: 30th January, 2009.

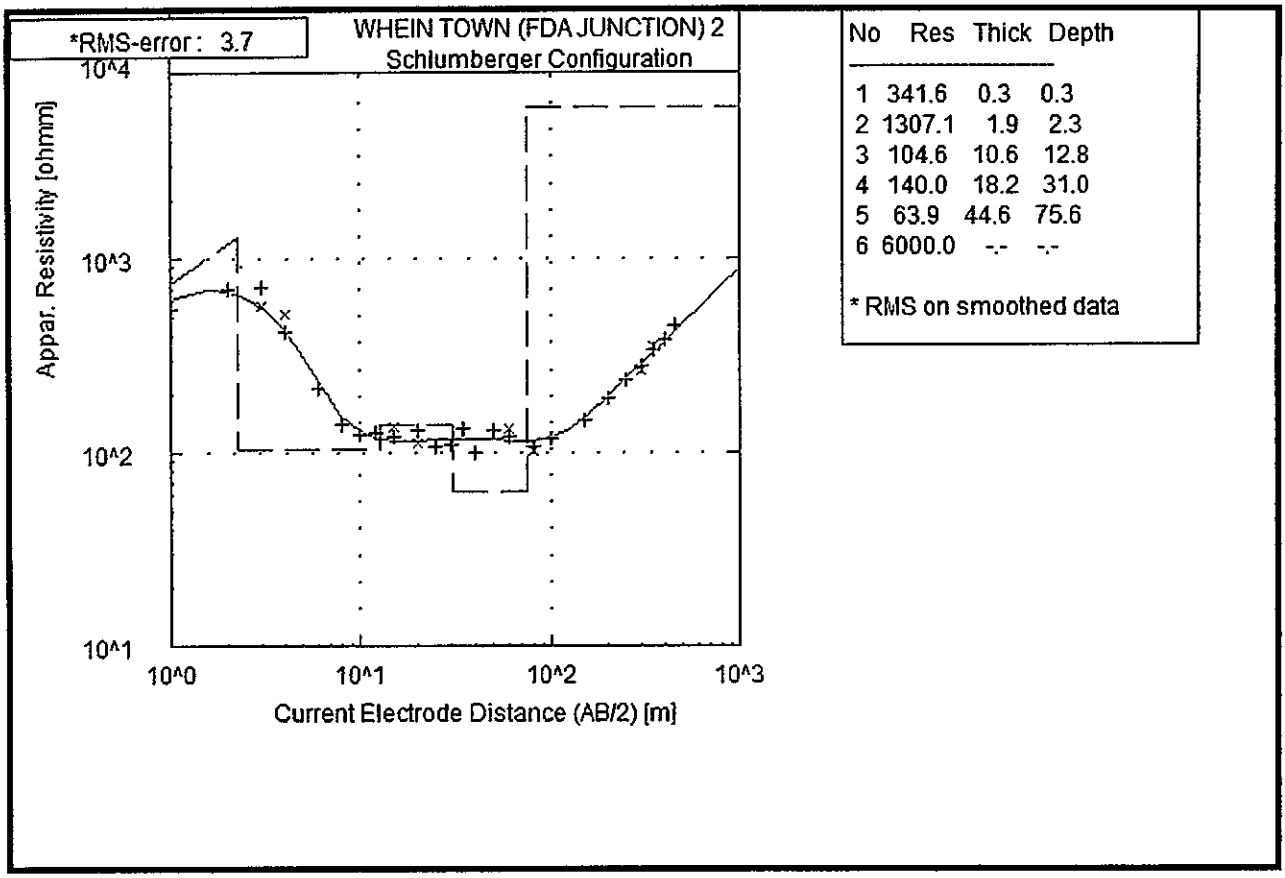
AB: 900 Meters.

AZIMUTH: 106 Degrees.

POSITION:

FILE: WHEIN TOWN 1

REMARK: RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Whein Town (FDA Junction).

DATE: 30th January, 2009.

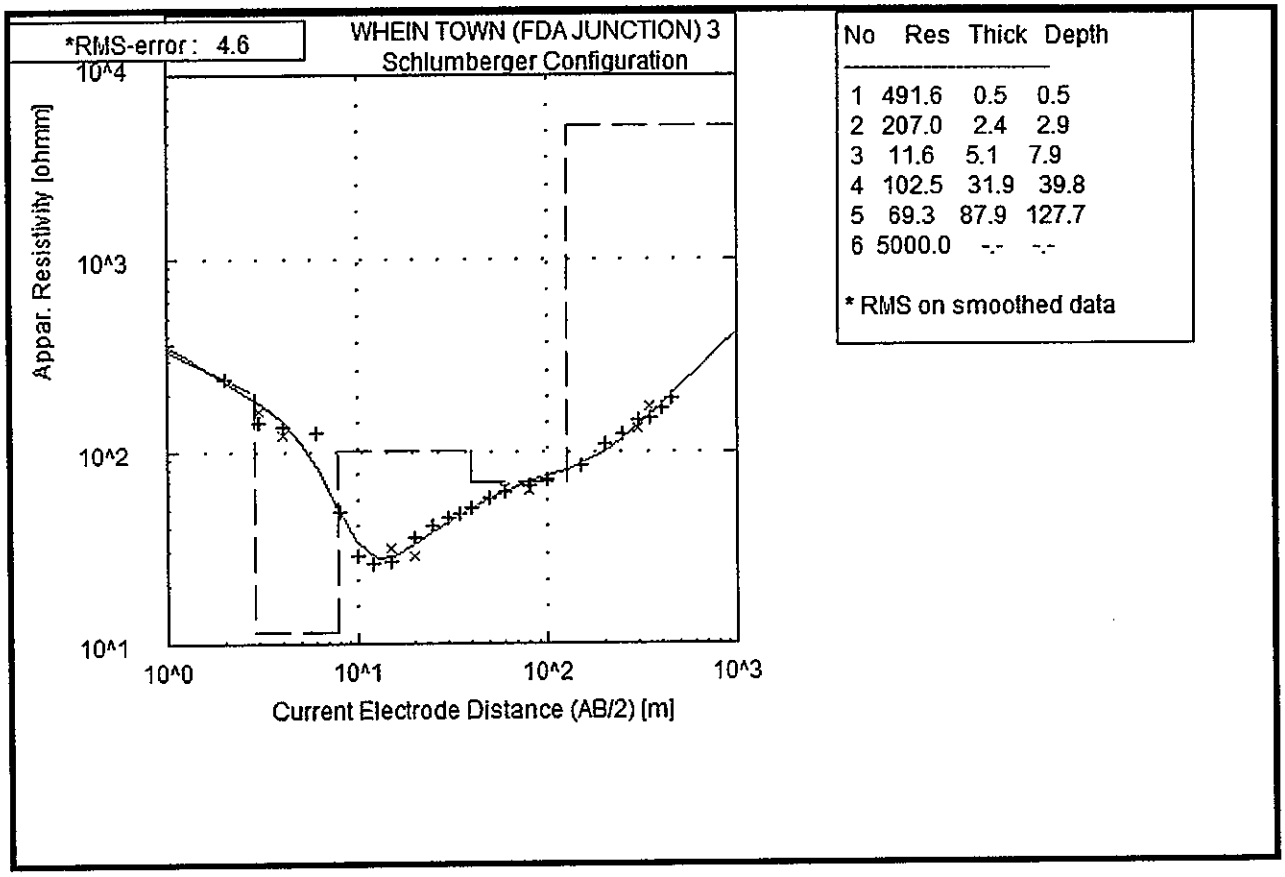
AB: 900 Meters.

AZIMUTH: 35 Degrees.

POSITION:

FILE: WHEIN TOWN 2

REMARK: RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Whein Town (FDA Junction).

DATE: 30th January, 2009.

AB: 900 Meters.

AZIMUTH: 21Degrees.

POSITION:

FILE: WHEIN TOWN 3

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.

APPENDIX 5

Whein Town (SKD Estate)

- Field Data (Vertical Electrical Sounding – VES)
- Field Curves (Vertical Electrical Sounding – VES)
- Computer Interpreted Data

VERTICAL ELECTRICAL SOUNDING FIELD DATA

LOCATION: WHEIN TOWN (SKA ESTATE) WATER LEVEL: ——

VES NO: 01, 02 & 03 AZIMUTH: 140°, 112° & 146°

EQUIPMENT: OHMEGA RESISTIVITY METER DATE: 31st January, 2009.

COORDINATES: Lat:.....Long:.....Elevation(Masl):.....

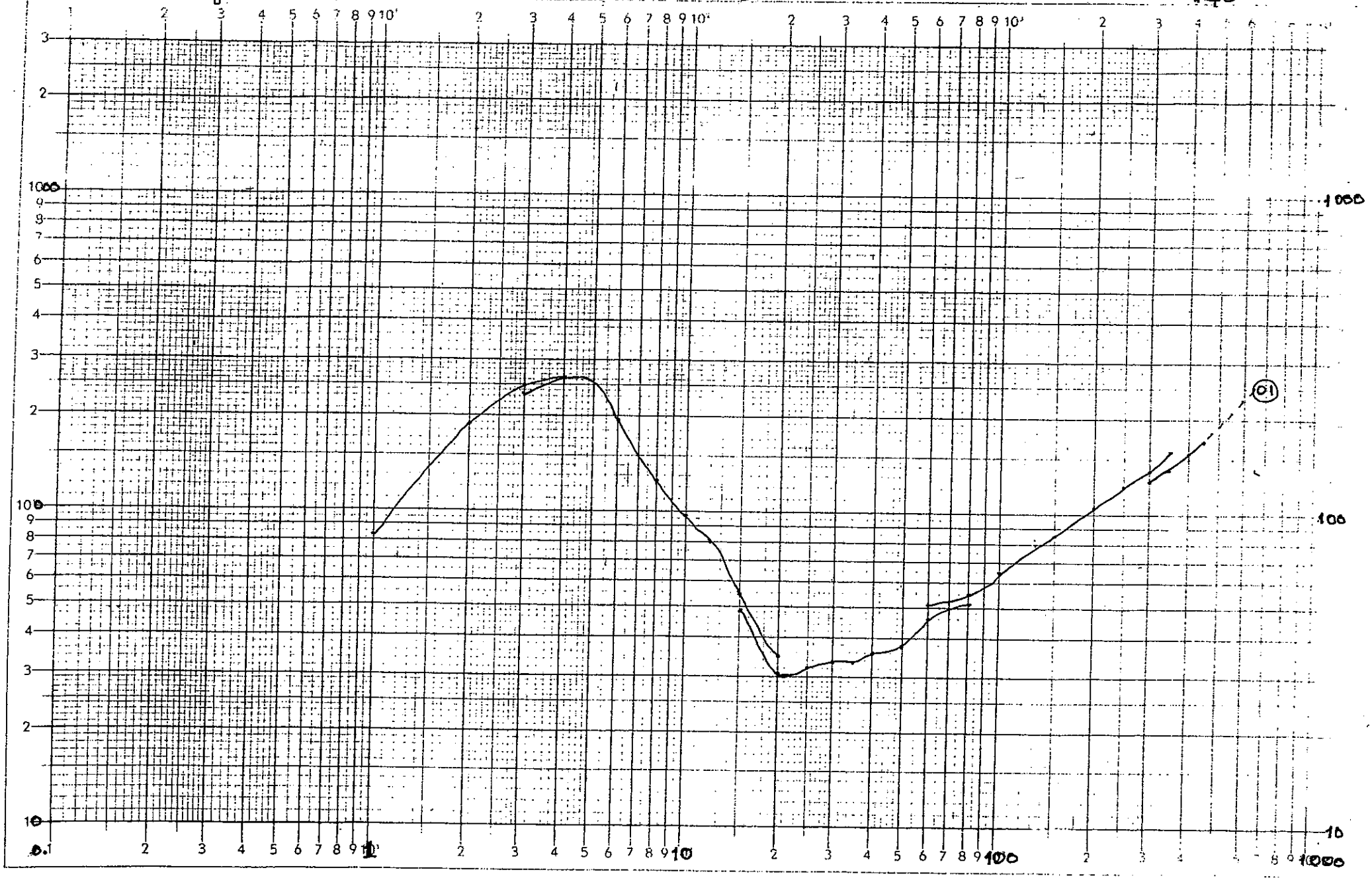
$= 3.142(AB/2)^2 - (MN/2)^2 / MN$

AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	19.76	83	20.73	87	72.43	304
2	0.33	18.5	10.22	189	9.395	174	7.124	132
	0.33	42.3	5.871	249	4.479	189	1.804	76
3	1	12.6	18.54	234	16.99	214	9.151	115
4	0.33	76	3.476	264	2.645	201	0.6729	51
	1	23.6	10.94	258	9.702	229	3.182	75
6	1	55	3.628	196	4.358	240	0.6729	37
	1	99	1.277	126	1.814	180	0.2525	25
0	1	155	0.6283	97	0.7611	118	0.1956	30
12	1	225	0.3547	80	0.2797	63	0.1002	23
5	1	352	0.1540	54	0.1094	39	0.06881	25
5	5	62.8	0.7773	49	0.9144	57	0.4299	27
20	1	627	0.05594	35	0.04625	29	0.04466	28
0	5	118	0.2624	31	0.2736	32	0.2503	30
25	5	188	0.1702	32	0.1641	31	0.1652	31
30	5	275	0.1185	33	0.1021	30	0.1277	35
5	5	377	0.08787	33	0.08614	32	0.09790	37
40	5	495	0.07175	36	0.06667	33	0.07677	38
0	5	777	0.04915	38	0.04633	36	0.04753	37
0	5	1123	0.04124	46	0.03473	39	0.02850	32
60	10	550	0.09499	52	0.06364	35	0.06495	36
0	5	2003	0.02596	52	0.02347	47	0.01398	28
0	10	990	0.05584	55	0.04317	43	0.03030	30
100	10	1555	0.04158	65	0.03222	50	0.02122	33
50	10	3520	0.02428	85	0.01905	67	0.01278	45
200	10	6270	0.01675	105	0.01292	81	0.009569	60
250	10	9803	0.01255	123	0.009589	94	0.007851	75
00	10	14123	0.009630	136	0.007718	109	0.006443	91
300	15	9402	0.01372	129	0.01021	96	—	—
350	10	19229	0.008217	158	0.006137	118	—	—
50	15	12806	0.01078	138	0.008277	106	—	—
400	15	16734	0.009322	156	0.006992	117	—	—
50	15	21185	0.008119	172	0.006184	131	—	—

31st January, 2009

VES 01

140°



meetpapier - wormer

T 10019

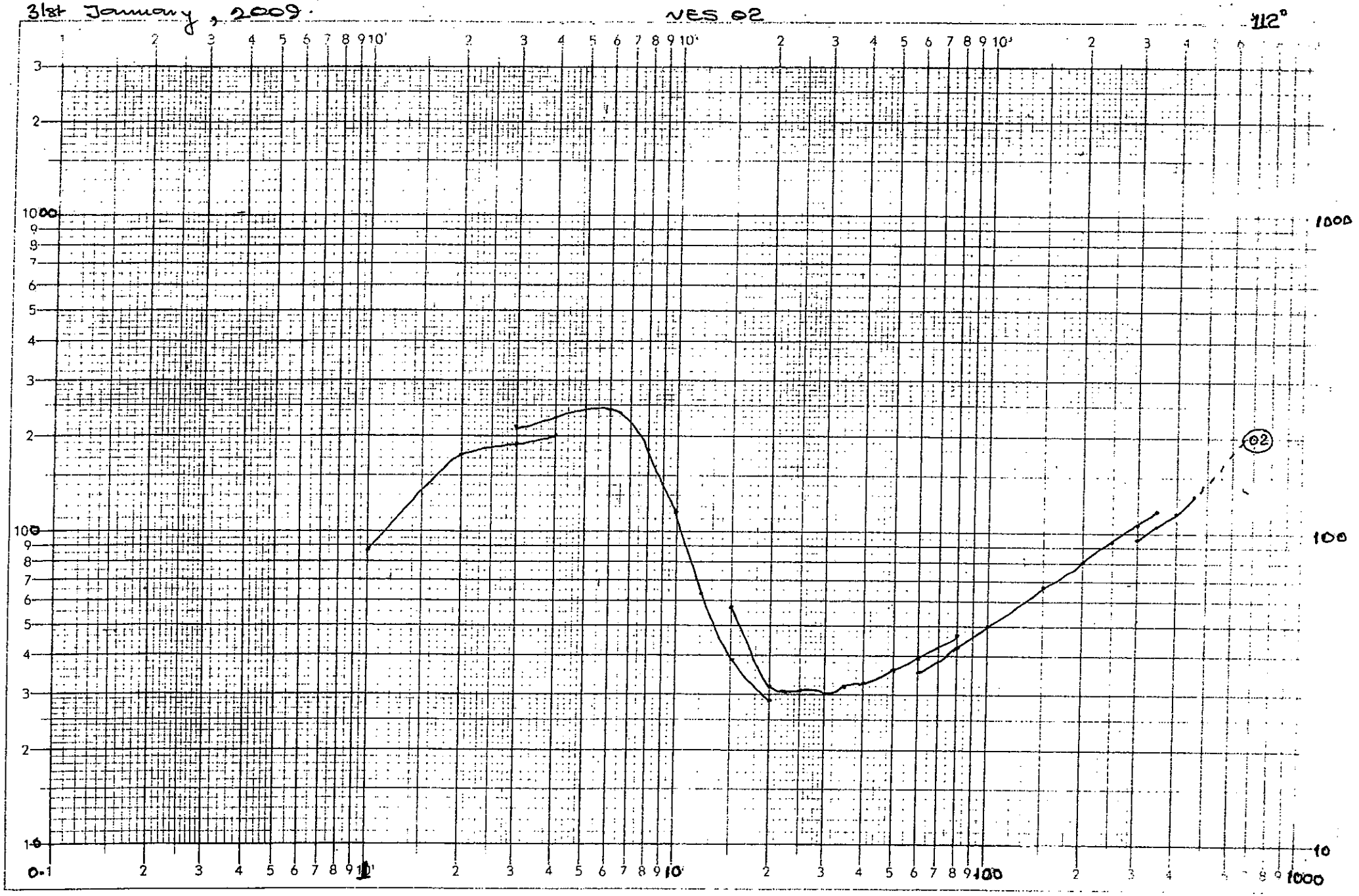
X-as log. verdeeld 1 10 x as log. verdeeld 3(0) breedte 62

WHEIN TOWN (SKD ESTATE)

31st January, 2009.

VES 02

112°



meetpapier - wormer

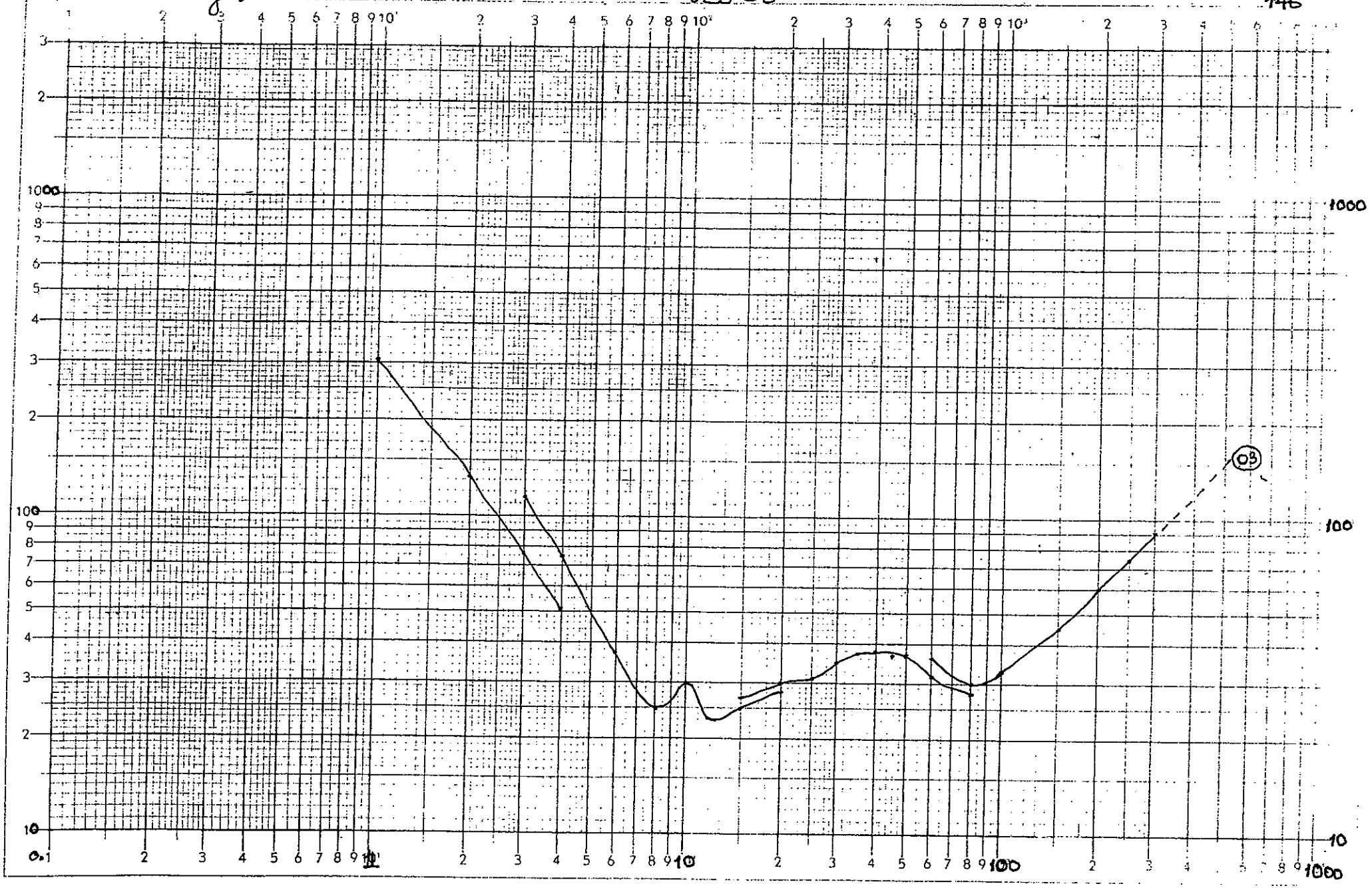
T 10019

X-as log. verdeeld 1 : 10 Y as log. verdeeld

31st January, 2009.

VES 03

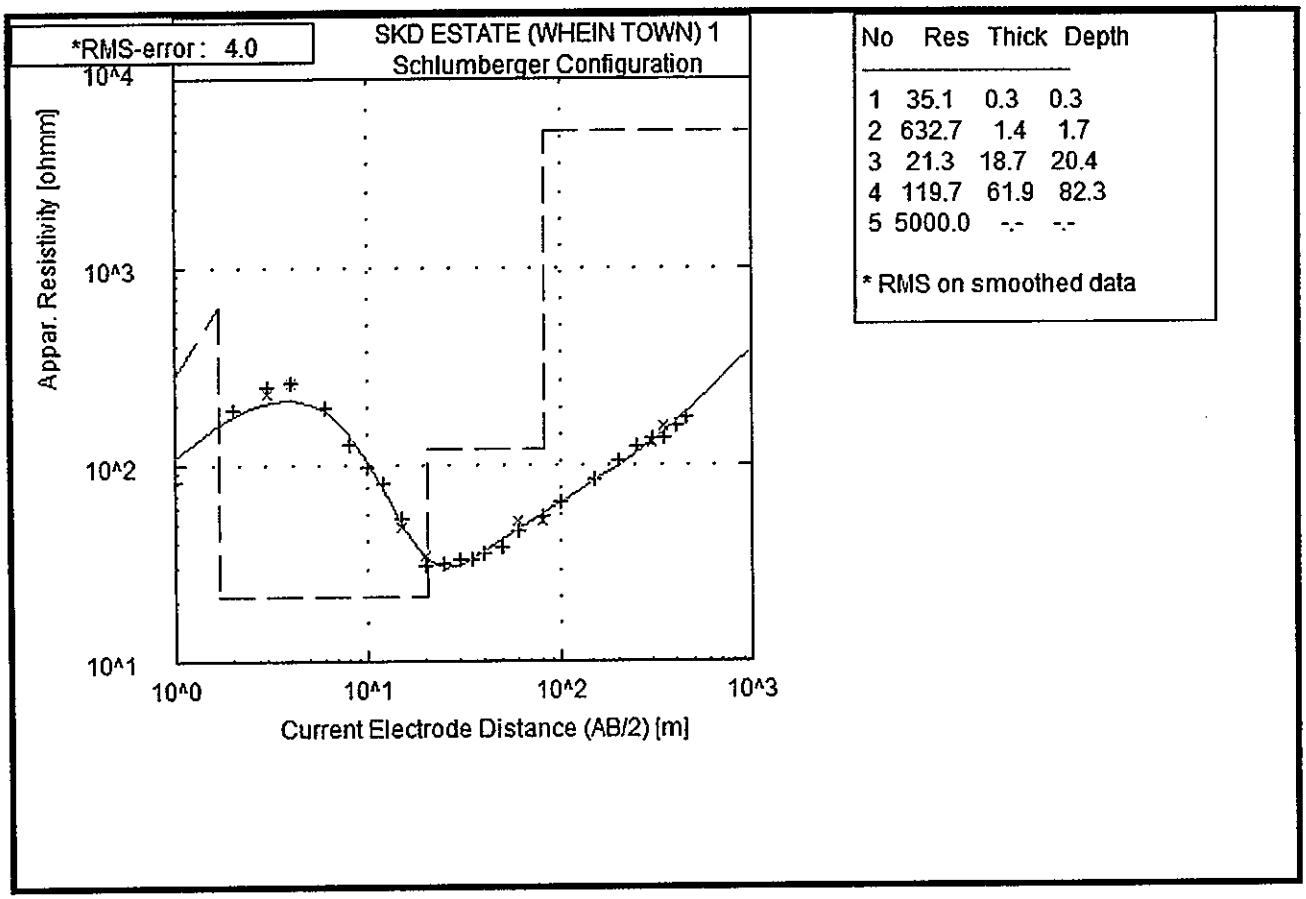
146°



meetpapier · wormer

T 10019

X-as log. verdeeld 1 10 X as log. verdeeld 100 breedte 6 /



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: SKD Estate (Whein Town).

DATE: 31st January, 2009.

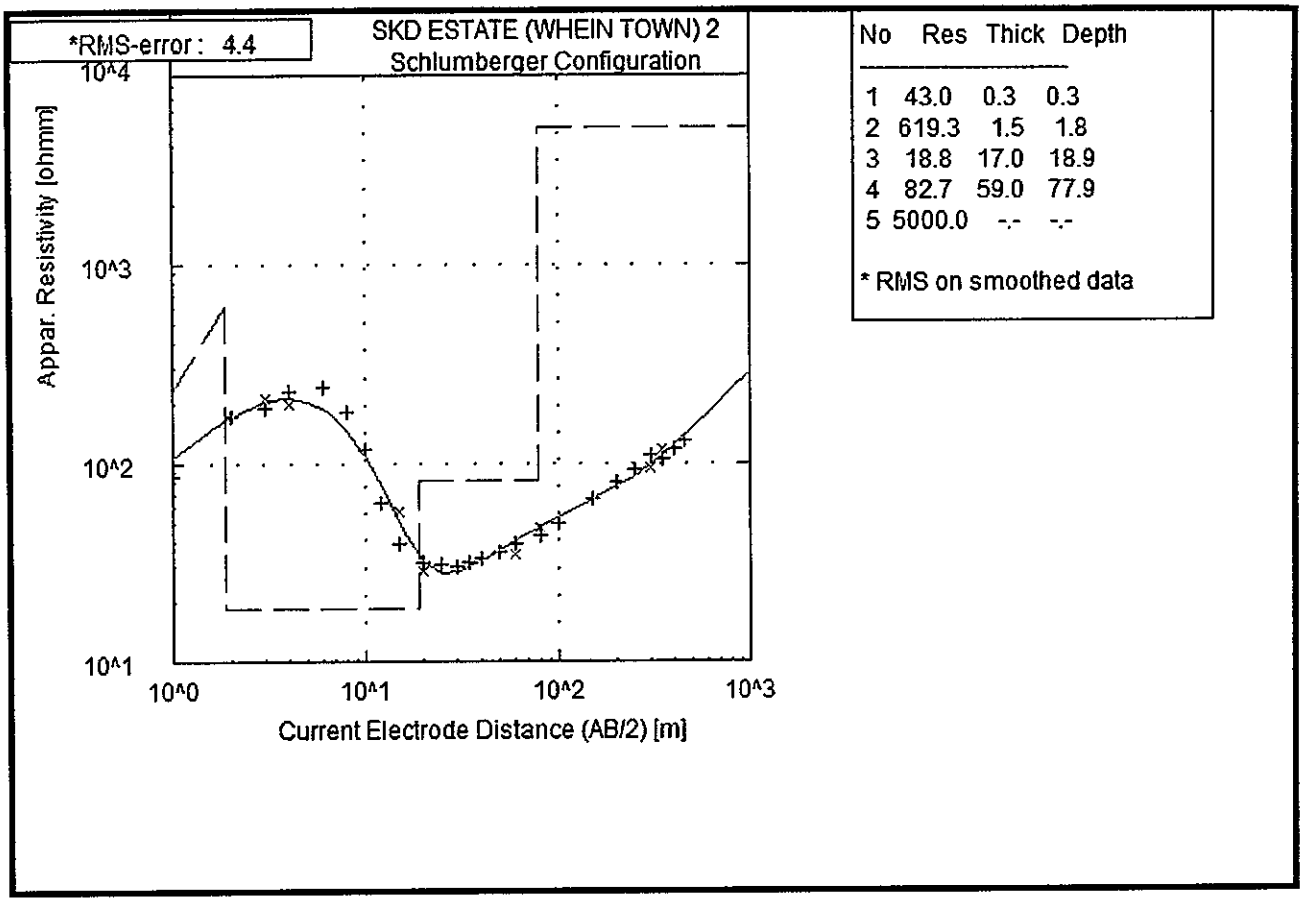
AB: 900 Meters.

AZIMUTH: 140 Degrees.

POSITION:

FILE: SKD-1

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: SKD Estate (Whein Town).

DATE: 31st January, 2009.

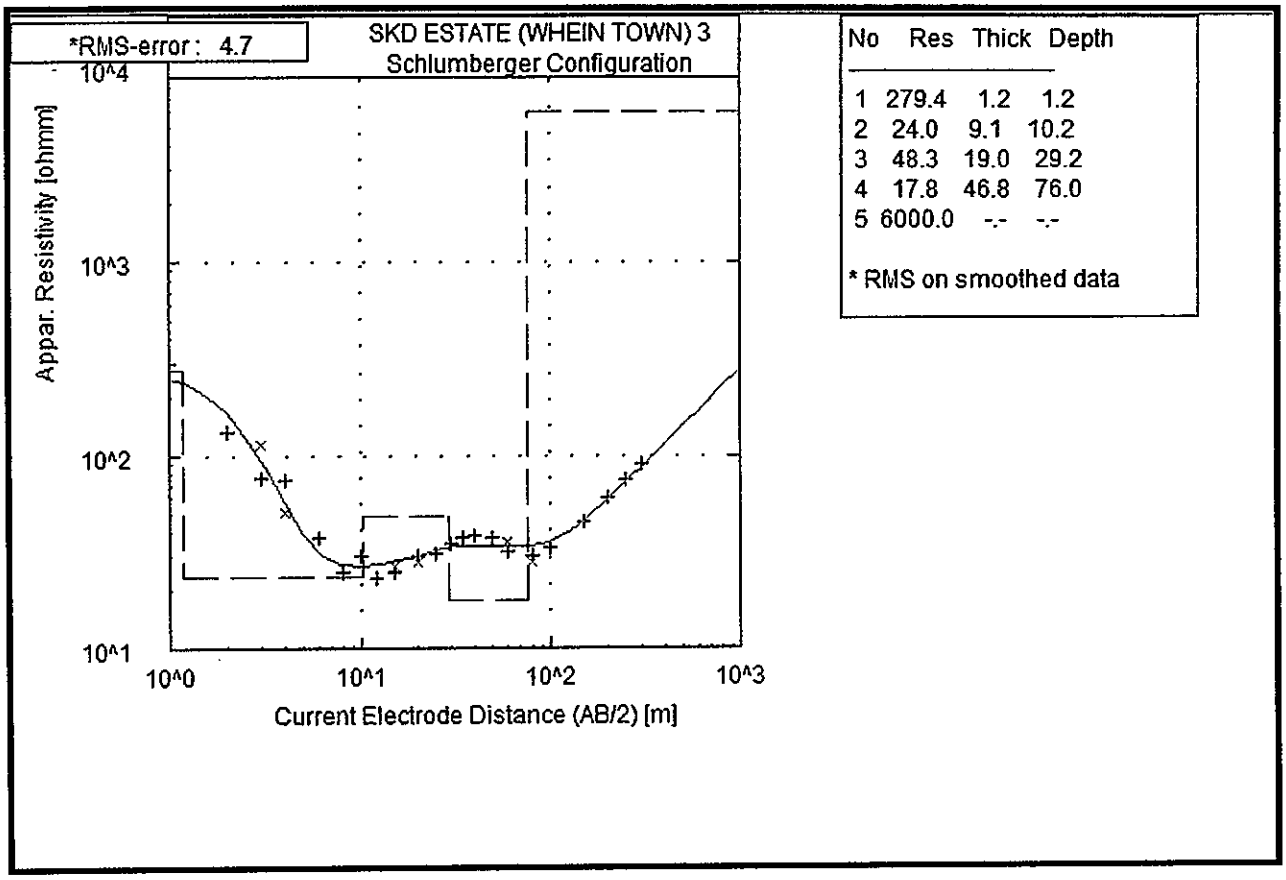
AB: 900 Meters.

AZIMUTH: 112 Degrees.

POSITION:

FILE: SKD-2

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: SKD Estate (Whein Town).

DATE: 31st January, 2009.

AB: 600 Meters.

AZIMUTH: 146 Degrees.

POSITION:

FILE: SKD-3

REMARK: THIS IS THE RECOMMENDED POINT FOR DRILLING.

APPENDIX 6

Liberia Broadcasting System
(LBS Community)

- Field Data (Vertical Electrical Sounding – VES)
- Field Curves (Vertical Electrical Sounding – VES)
- Computer Interpreted Data.

VERTICAL ELECTRICAL SOUNDING FIELD DATA

LIBERIA BROADCASTING SYSTEM

LOCATION: L.B.S. COMMUNITY ..... WATER LEVEL: —

VES NO: 01, 02 & 03 ..... AZIMUTH: 32°, 147° & 62°

EQUIPMENT: OHMEGA RESISTIVITY METER ..... DATE: 3rd January, 2009.

COORDINATES: Lat: 60°, 18', 16.5"N ..... Long: W10°, 40', 25.4" ..... Elevation(Masl): 11

60°, 18', 18.8"N W10°, 40', 27.7" 10.

I = 3.142(AB/2)² - (MN/2)² / MN

AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	47.14	198	51.19	215	67.07	282
2	0.33	18.5	15.07	279	15.37	284	8.756	162
	0.33	42.3	6.374	270	7.145	302	3.081	130
3	1	12.6	19.62	247	23.26	293	10.94	138
	0.33	76	3.253	247	3.587	273	1.165	89
	1	23.6	9.820	232	11.35	268	3.901	92
6	1	55	3.851	212	3.618	199	1.155	64
	1	99	1.621	161	1.337	132	0.4722	47
10	1	155	0.8635	134	0.6476	100	0.3091	48
12	1	225	0.4844	109	0.3749	84	0.1864	42
15	1	352	0.2442	86	0.1854	65	0.1155	41
15	5	62.8	1.426	90	1.145	72	0.6830	43
20	1	627	0.1114	70	0.09010	57	0.07226	45
20	5	118	0.5827	69	0.4915	58	0.4023	48
25	5	188	0.3516	66	0.3445	65	0.2878	54
30	5	275	0.2554	70	0.2624	72	0.2118	58
35	5	377	0.2260	85	0.1945	73	0.1773	67
40	5	495	0.1814	90	0.1601	79	0.1429	71
50	5	777	0.1165	91	0.1124	87	0.09476	74
70	5	1123	0.08989	101	0.08503	96	0.07145	80
60	10	550	0.1814	100	0.1682	93	0.1439	79
70	5	2003	0.06658	133	0.05827	117	0.04651	93
70	10	990	0.1236	122	0.1175	116	0.09526	94
100	10	1555	0.07834	122	0.08199	128	0.06922	108
150	10	3520	0.03831	135	0.03679	130	0.03537	125
200	10	6270	0.02249	141	0.02138	134	0.01986	125
250	10	9803	0.01733	170	0.01530	150	0.01489	146
300	10	14123	0.01206	170	0.01105	156	0.01168	165
300	15	9402	0.01732	163	0.01723	162		
350	10	19229	0.01097	211	0.009309	179		
350	15	12806	0.01489	191	0.01429	183		
400	15	16734	0.01363	228	0.01327	221		
450	15	21185	0.01275	270	0.01180	250		

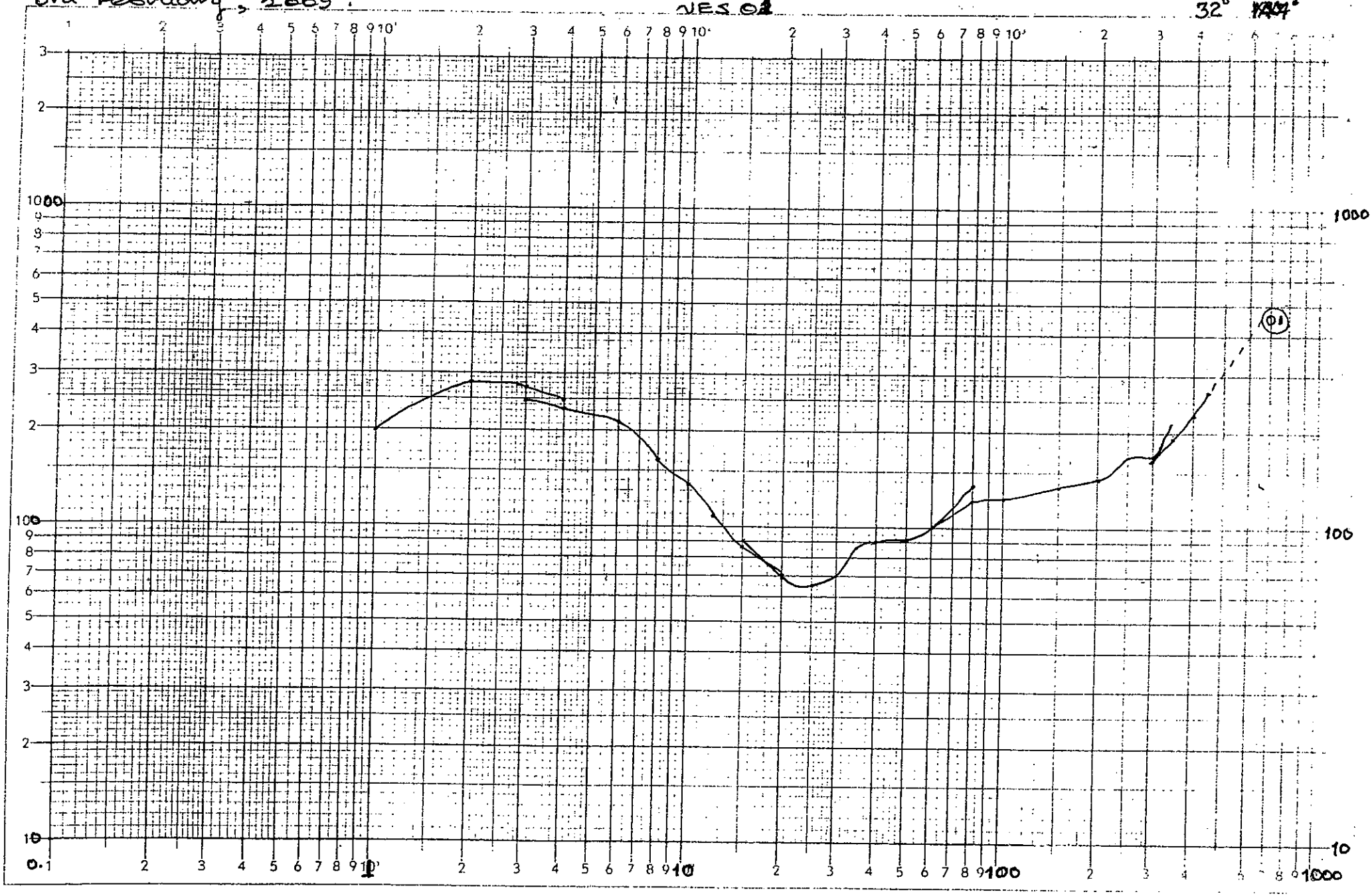
COCA COLA'S FENCE. NO ACCESS

← B.D. COMMUNITY

3rd February, 2009.

VES 01

32° NW



meetpapier - wormer

T 10019

X-as log. verdeeld 1 10¹ Y as log. verdeeld 300 Eenheid 62 mm

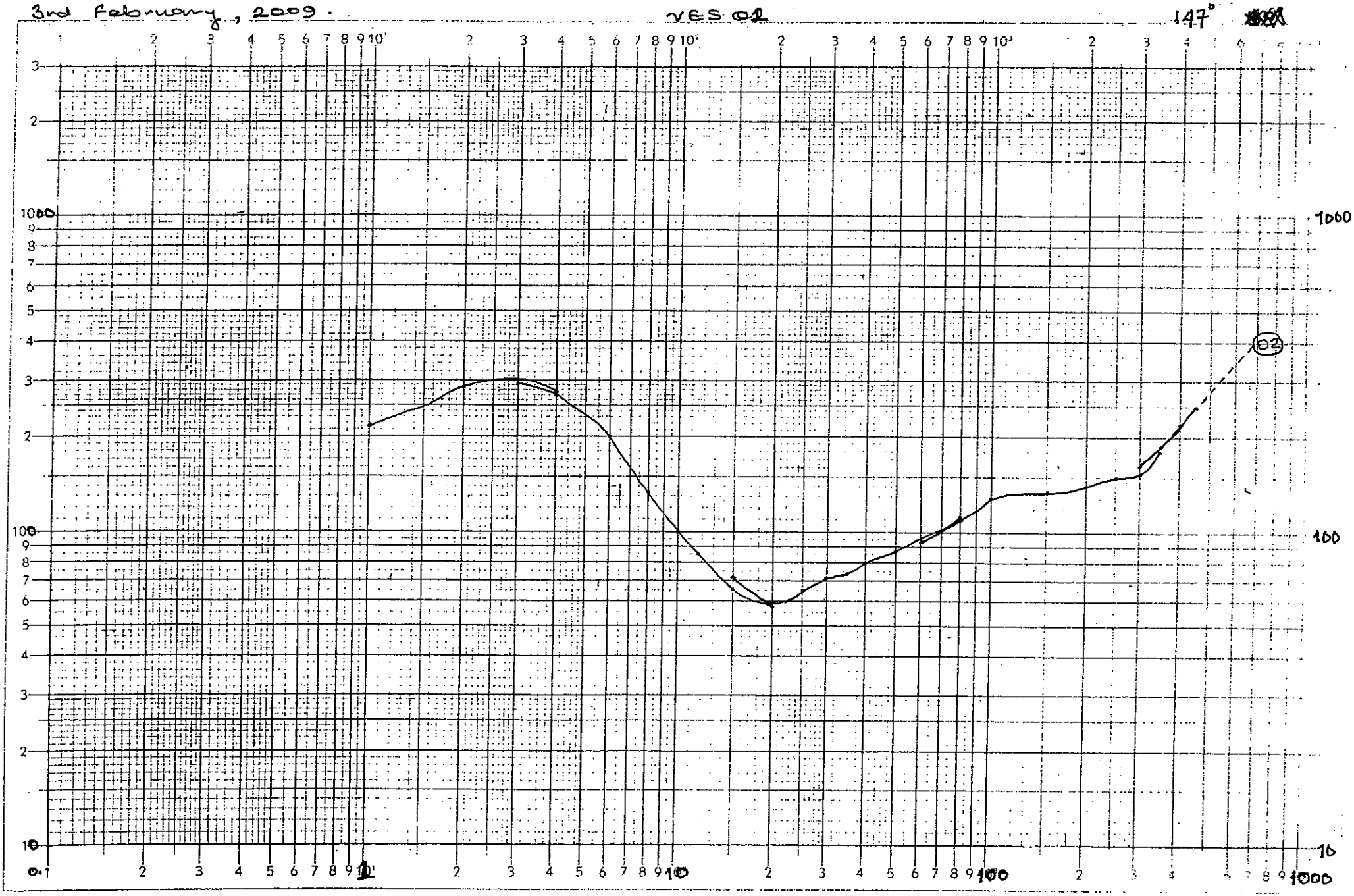
LIBERIA BROADCASTING SYSTEM

LBS COMMUNITY

3rd February, 2009.

VES 02

147°



meetpapier - wormer

T 10019

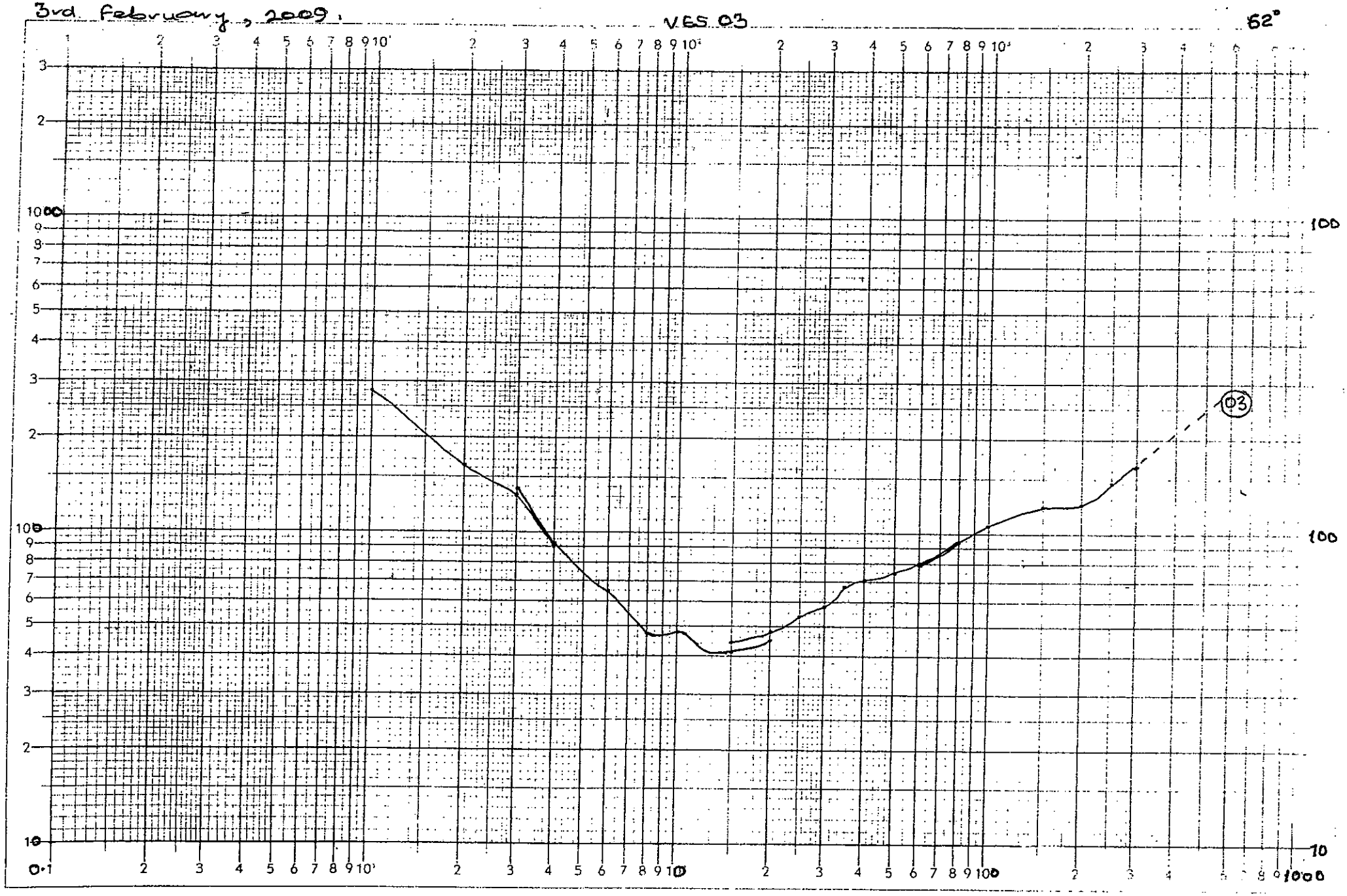
X-as log. verdeeld 1 10⁴ Y as log. verdeeld 3(0) Eenheid 62

LBS COMMUNITY

3rd February, 2009.

VES 03

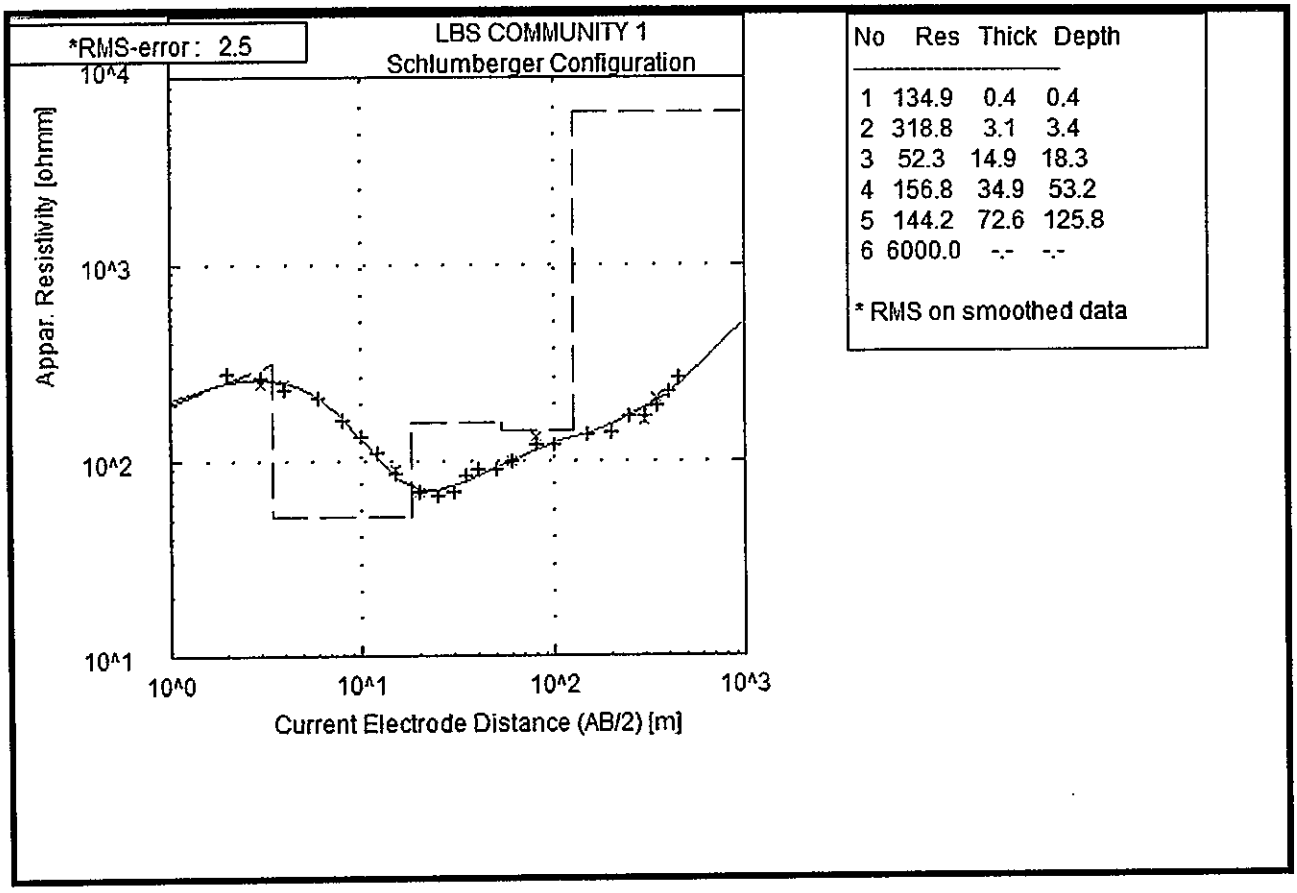
52°



meetpapier - wormer

T 10019

X-as log. verdeeld 1 10¹ Y as log. verdeeld 300 Breedte 62 mm



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Liberia Broadcasting System (LBS Community).

DATE: 3rd February, 2009.

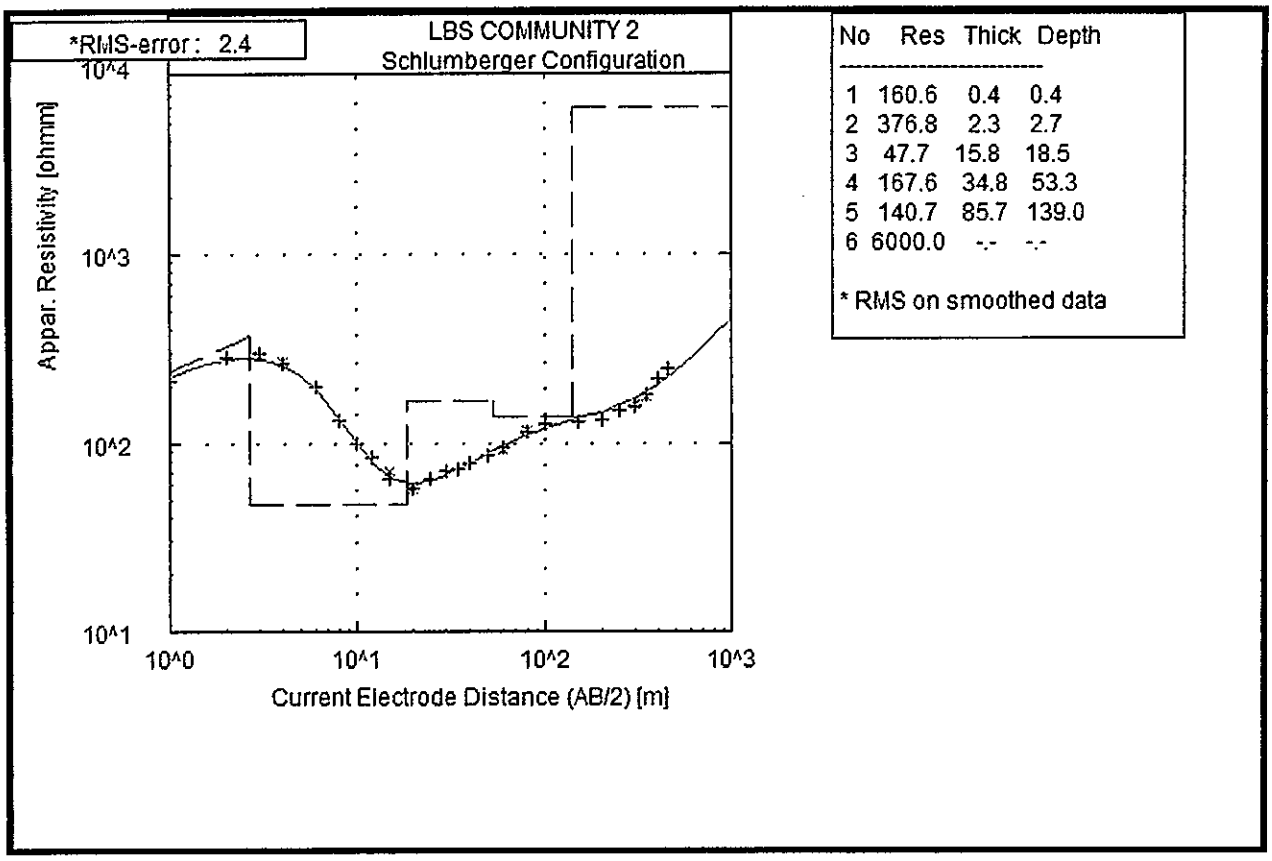
AB: 900 Meters.

AZIMUTH: 32 Degrees.

POSITION:

FILE: LBS-1

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Liberia Broadcasting System (LBS Community).

DATE: 3rd February, 2009.

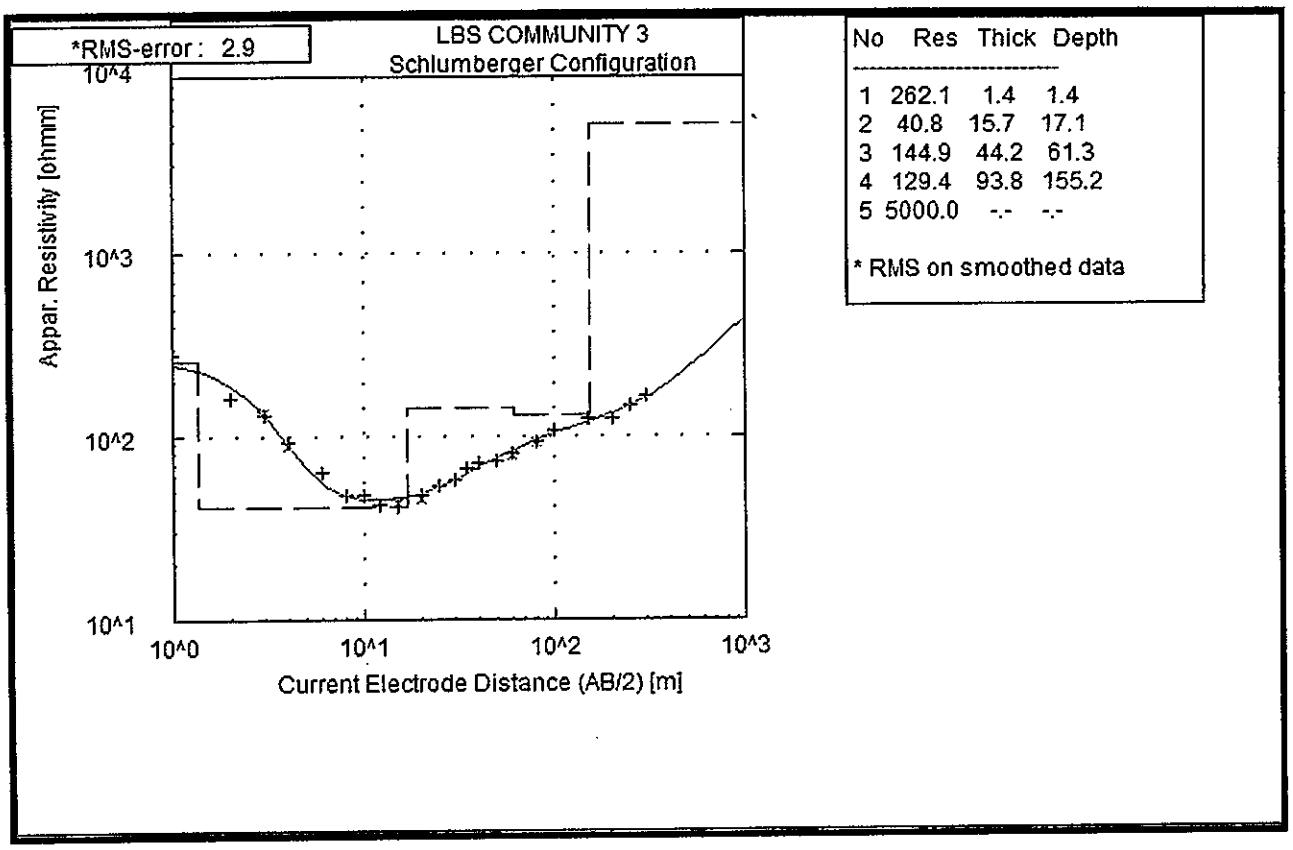
AB: 900 Meters.

AZIMUTH: 147 Degrees.

POSITION:

FILE: LBS-2

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Liberia Broadcasting System (LBS Community).

DATE: 3rd February, 2009.

AB: 600 Meters.

AZIMUTH: 62 Degrees.

POSITION:

FILE: LBS-3

REMARK: THIS IS THE RECOMMENDED DRILL POINT.

APPENDIX 7

Upper Pipeline Community

- Field Data (Vertical Electrical Sounding – VES)
- Field Curves (Vertical Electrical Sounding – VES)
- Computer Interpreted Data

VERTICAL ELECTRICAL SOUNDING FIELD DATA

OCATION: UPPER PIPELINE COMMUNITY WATER LEVEL: —

VES NO: 01, 02 & 03 AZIMUTH: 23°, 120° & 100°

QUIPMENT: OHMEGA RESISTIVITY METER DATE: 5th February, 2009.

COORDINATES: Lat:.....Long:.....Elevation(Masl):.....

$= 3.142(AB/2)^2 - (MN/2)^2 / MN$

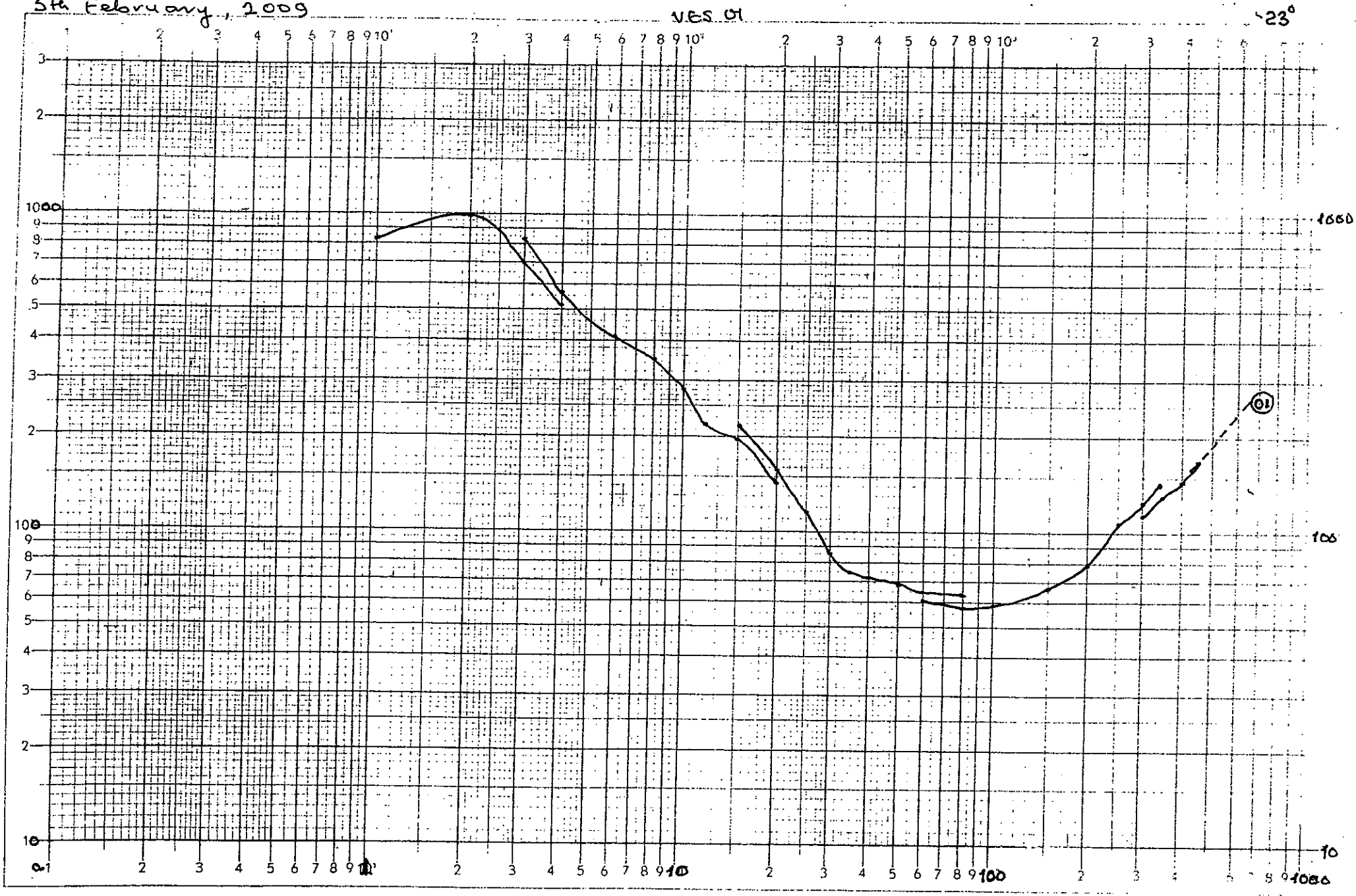
AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	194.0	815	190.9	802	230.0	965
2	0.33	18.5	53.16	982	23.67	438	78.60	1454
	0.33	42.3	16.52	699	9.716	411	33.10	1400
3	1	12.6	65.86	830	35.30	445	119.2	1502
	0.33	76	6.763	514	6.026	458	15.63	1188
	1	23.6	23.67	559	20.47	483	52.29	1234
6	1	55	7.405	407	9.993	550	13.06	718
	1	99	3.571	354	5.543	549	4.970	492
0	1	155	1.800	279	2.462	382	2.658	412
12	1	225	0.9692	218	1.429	322	1.645	370
5	1	352	0.5574	196	0.7824	275	0.8778	309
15	5	62.8	3.455	217	4.043	254	5.303	333
20	1	627	0.2266	142	0.3381	212	0.2807	176
0	5	118	1.331	157	1.652	195	1.831	216
25	5	188	0.6170	116	0.7793	147	0.6755	127
0	5	275	0.3101	85	0.3172	87	0.4218	116
5	5	377	0.1963	74	0.2229	84	0.2812	106
40	5	495	0.1455	72	0.1388	69	0.1879	93
0	5	777	0.08752	68	0.07337	57	0.1261	98
0	5	1123	0.05788	65	0.05256	59	0.09884	111
60	10	550	0.1091	60	0.1145	63	0.2236	123
0	5	2003	0.03145	63	0.03564	74	0.07589	152
0	10	990	0.05786	57	0.07966	79	0.1707	169
100	10	1555	0.03739	58	0.05706	89	0.1183	184
50	10	3520	0.01903	67	0.02727	96	0.06193	218
200	10	6270	0.01260	79	0.01659	104	0.04211	264
250	10	9803	0.01102	108	0.01194	117	0.03234	317
00	10	14123	0.008780	124	0.009630	136	0.02570	363
300	15	9402	0.01234	116	0.01340	126	0.04499	423
50	10	19229	0.007385	142	0.007853	151	0.02200	423
50	15	12806	0.01031	132	0.01085	139	0.03639	466
400	15	16734	0.008605	144	0.01038	172	0.03155	528
50	15	21185	0.007883	167.	0.008733	185.	0.02719	576.

RAYNESVILLE

5th February, 2009

VES 01

23°

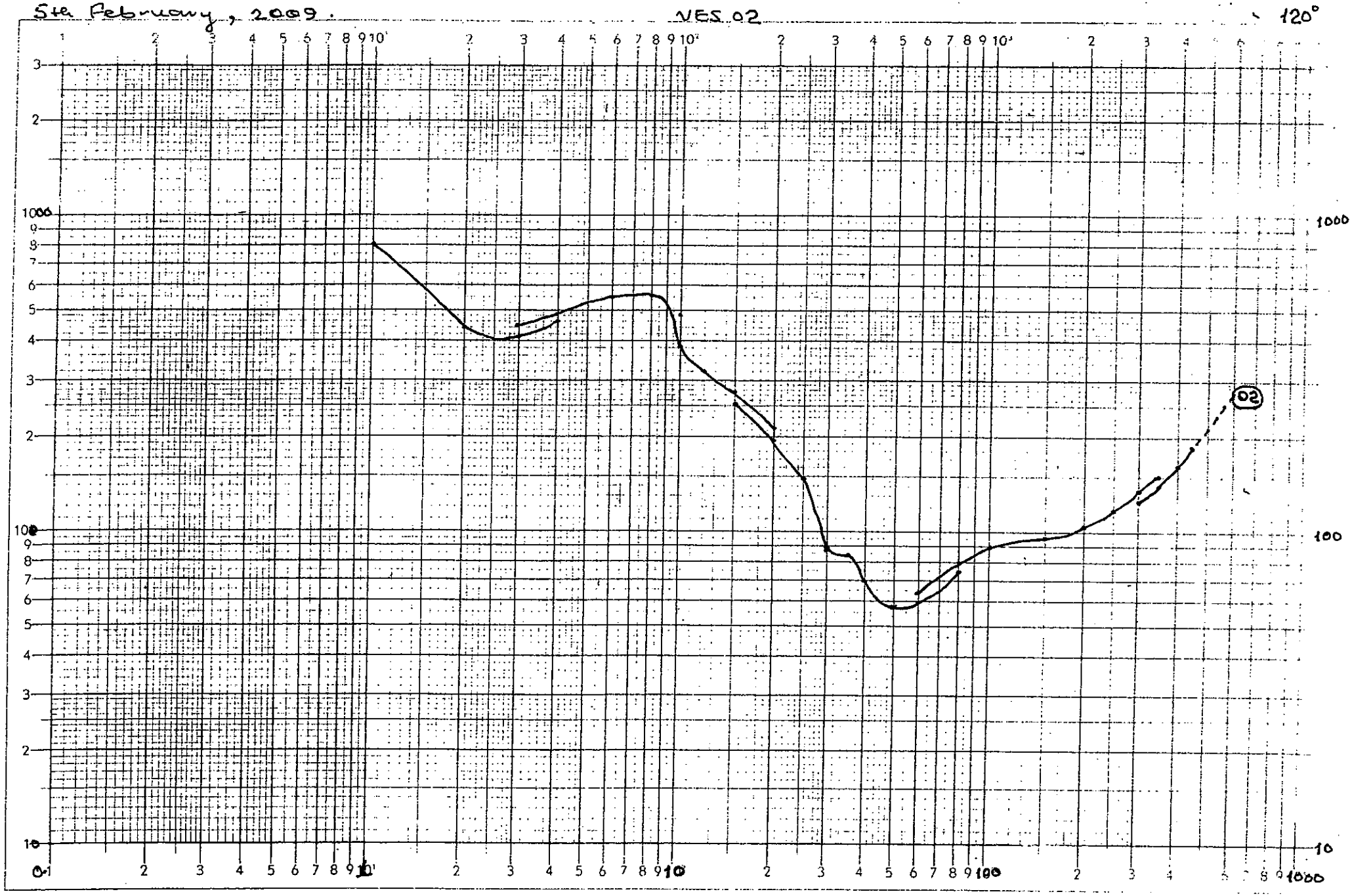


meetpapier - wormer

T 10019

X-as log. verdeeld 1 10 Y as log. verdeeld 300 mm/cm

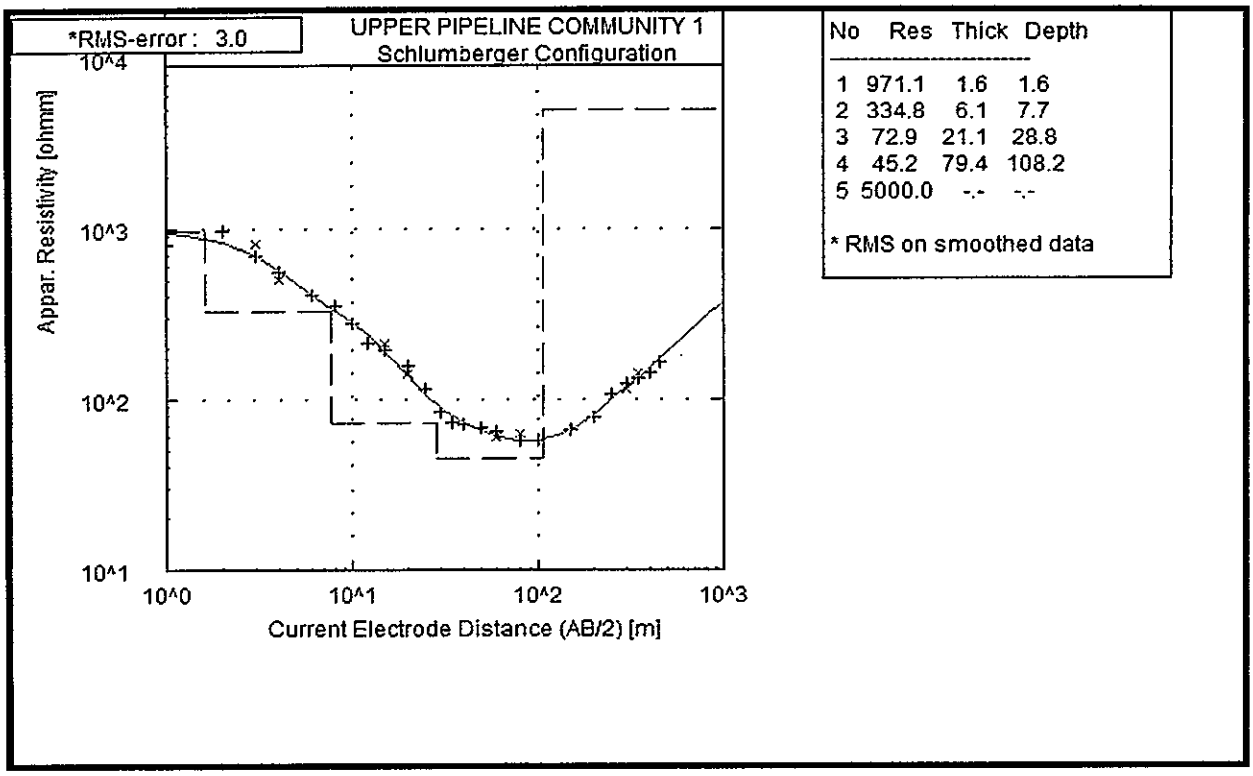
UPPER PIPELINE COMMUNITY
PATMESVILLE
5th February, 2009.



meetpapier - wormer

T 10019

X-as log. verdeeld 1.10⁴ Y as log. verdeeld 300 Eenheid 62



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Upper Pipeline Community.

DATE: 5th February, 2009.

AB: 900 Meters.

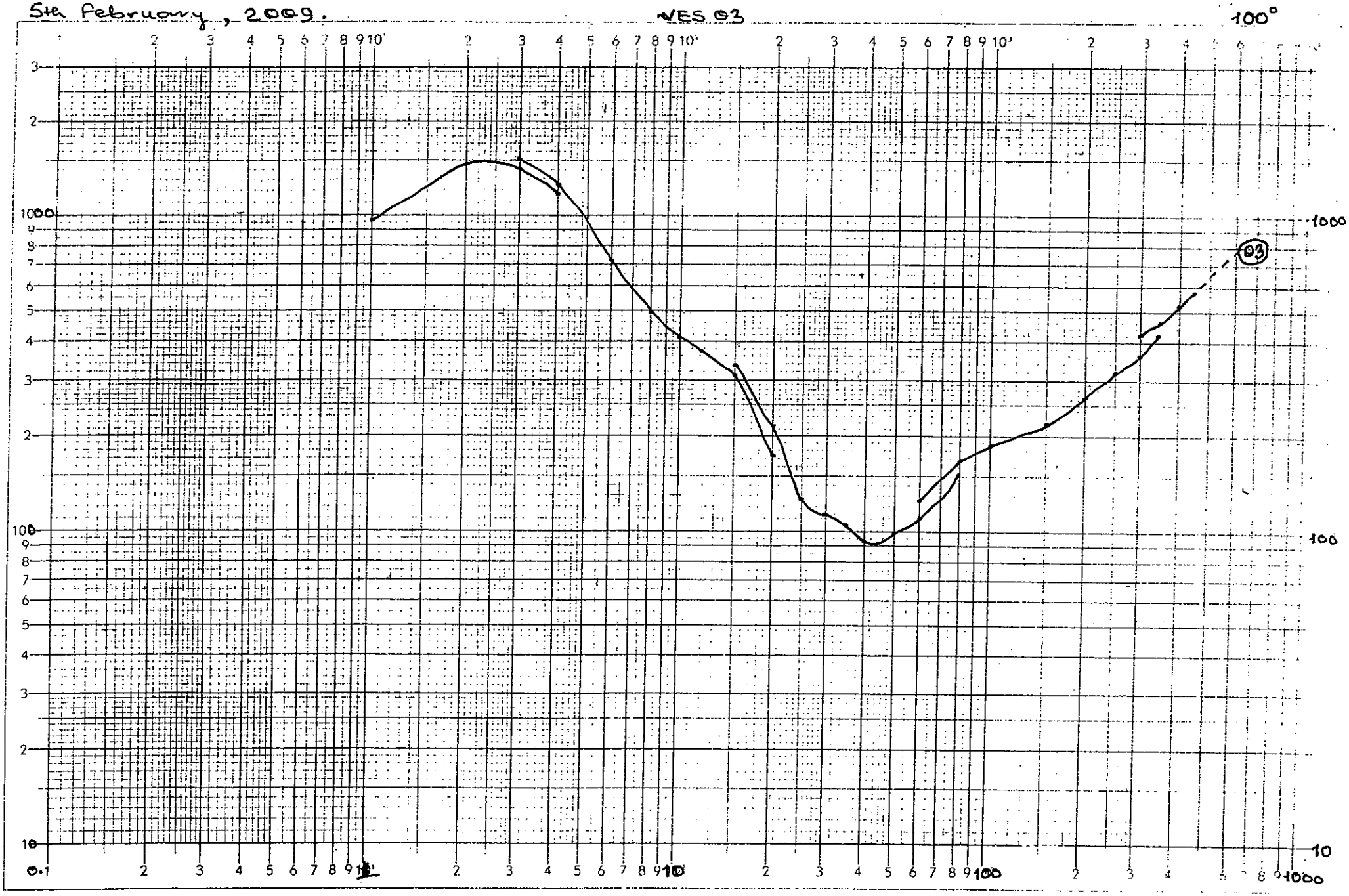
AZIMUTH: 23 Degrees.

POSITION:

FILE: UPPER-1

REMARK: THIS IS THE RECOMMENDED DRILL POINT.

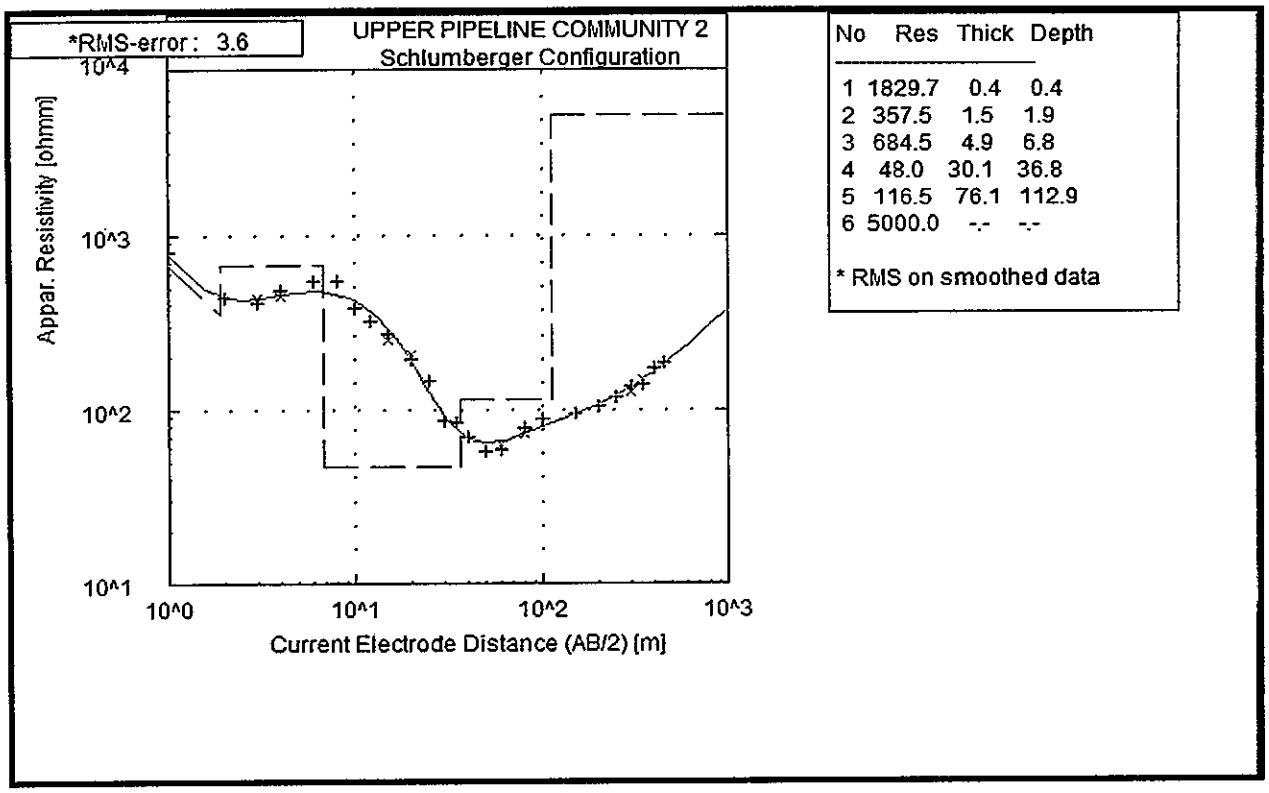
UPPER PIPELINE COMMUNITY
PATMOSVILLE
5th February, 2009.



meetpapier · wormer

T 10019

X-as log. verdeeld 1 10 Y-as log. verdeeld 300 Breedte 52



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Upper Pipeline Community.

DATE: 5th February, 2009.

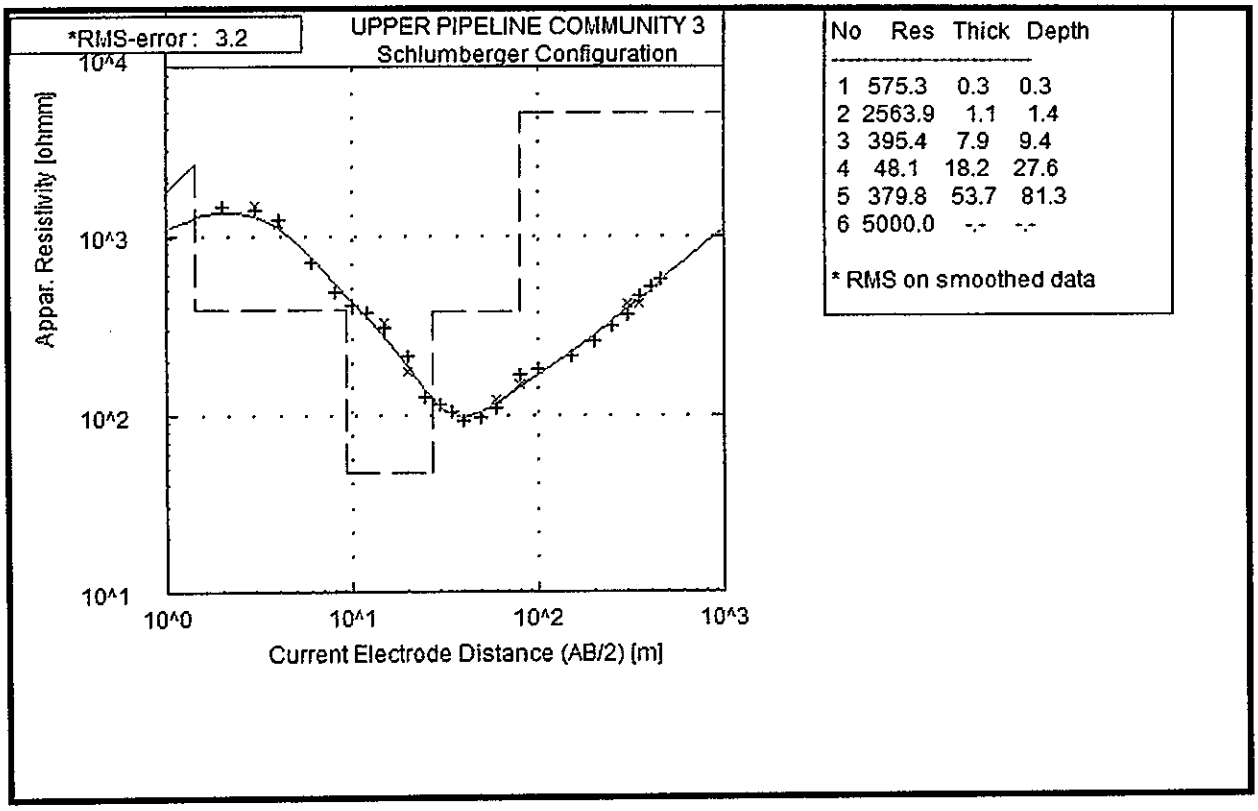
AB: 900 Meters.

AZIMUTH: 120 Degrees.

POSITION:

FILE: UPPER-2

REMARK: THIS IS THE RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Upper Pipeline Community.

DATE: 5th February, 2009.

AB: 900 Meters.

AZIMUTH: 10023 Degrees.

POSITION:

FILE: UPPER-3

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.

APPENDIX S

Saint Michael's Community

- Field Data (Vertical Electrical Sounding – VES)
- Field Curves (Vertical Electrical Sounding – VES)
- Computer Interpreted Data

VERTICAL ELECTRICAL SOUNDING FIELD DATA

LOCATION: ST. MICHAELS COMMUNITY WATER LEVEL: —

VES NO: 01, 02 & 03 AZIMUTH: 79°, 165° & 135°

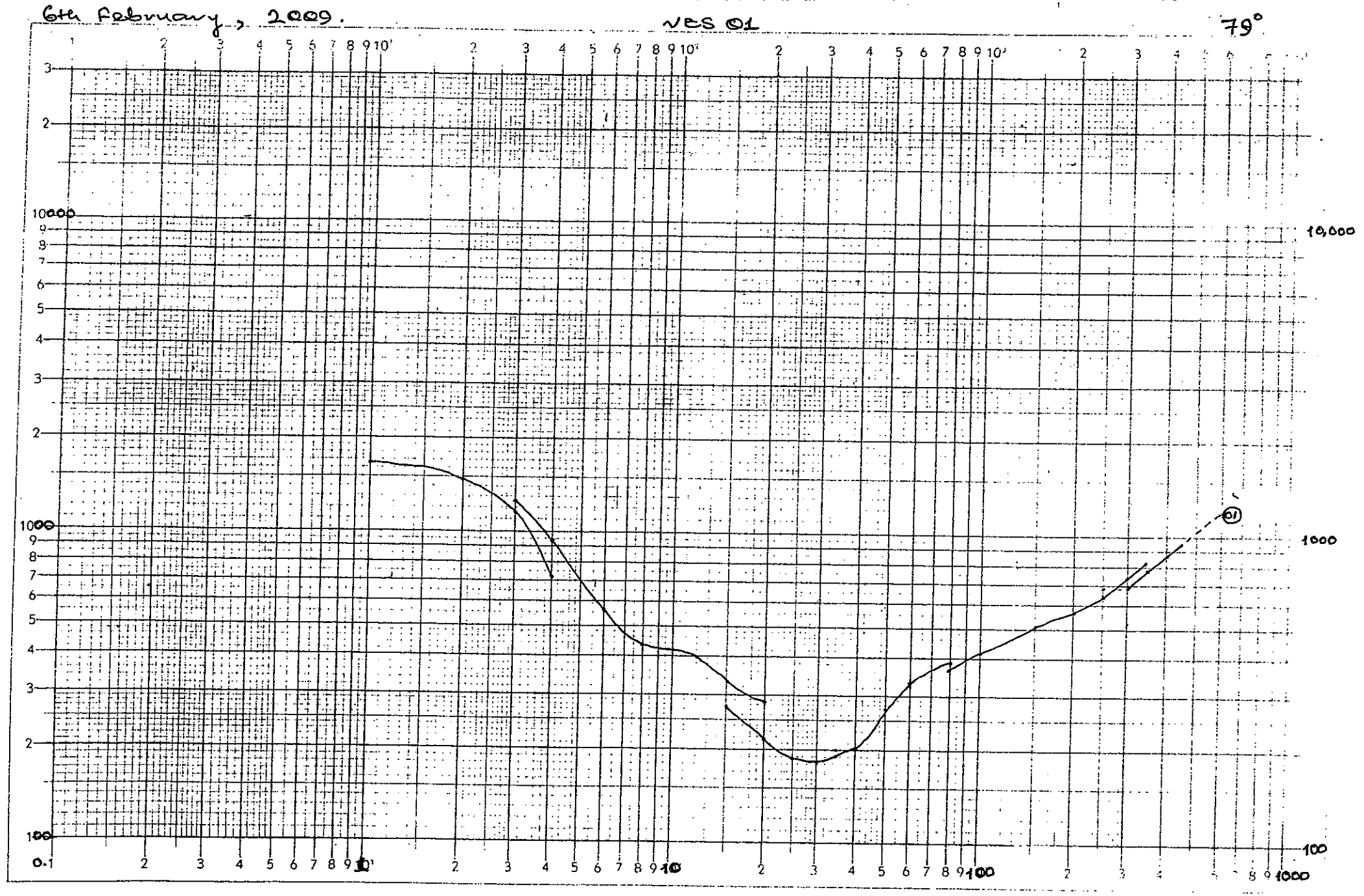
EQUIPMENT: OHMEGA RESISTIVITY METER DATE: 6th February, 2009.

COORDINATES: Lat:.....Long:.....Elevation(Masl):.....

$= 3.142(AB/2)^2 - (MN/2)^2 / MN$

AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	396·5	1665	603·9	2536	53·31	224
2	0.33	18.5	79·62	1473	62·92	1164	17·80	329
	0.33	42.3	27·01	1143	11·95	506	10·11	428
3	1	12.6	97·78	1232	47·14	594	29·44	371
	0.33	76	9·344	710	5·472	416	6·081	462
	1	23.6	39·45	931	19·76	466	19·93	470
6	1	55	10·11	556	6·455	355	9·232	513
	1	99	4·411	437	3·354	332	4·864	482
	1	155	2·736	424	1·570	243	2·817	437
12	1	225	1·763	397	1·023	230	1·591	358
	1	352	0·9506	335	0·6942	244	0·6993	246
15	5	62.8	4·276	269	4·252	267	3·820	240
20	1	627	0·4530	284	0·3700	232	0·3151	198
	5	118	1·804	213	2·195	259	1·560	184
25	5	188	0·9947	187	1·406	264	1·013	190
30	5	275	0·6618	182	0·7722	212	0·7560	208
	5	377	0·5040	190	0·5523	208	0·6212	234
40	5	495	0·4061	201	0·4424	219	0·5483	271
	5	777	0·3462	269	0·3449	268	0·4317	335
	5	1123	0·2984	335	0·3099	348	0·3719	418
60	10	550	0·6010	331	0·5891	324	0·7580	417
	5	2003	0·1891	379	0·1967	394	0·2736	548
	10	990	0·3679	364	0·3810	377	0·5513	546
100	10	1555	0·2665	414	0·3719	578	0·4124	641
150	10	3520	0·1449	510	0·2118	746	0·1976	696
200	10	6270	0·08989	564	0·1408	883	0·1388	870
250	10	9803	0·06506	638	0·1144	1121	0·1074	1053
300	10	14123	0·05240	740	0·09212	1301	0·08497	1200
300	15	9402	0·07222	679	0·1466	1378		
350	10	19229	0·04244	816	0·08144	1566		
350	15	12806	0·06021	771	0·1279	1638		
400	15	16734	0·05175	866	0·1089	1823		
450	15	21185	0·04451	943	0·08997	1906		

SWAMPY MARSHY WATER LOGGED



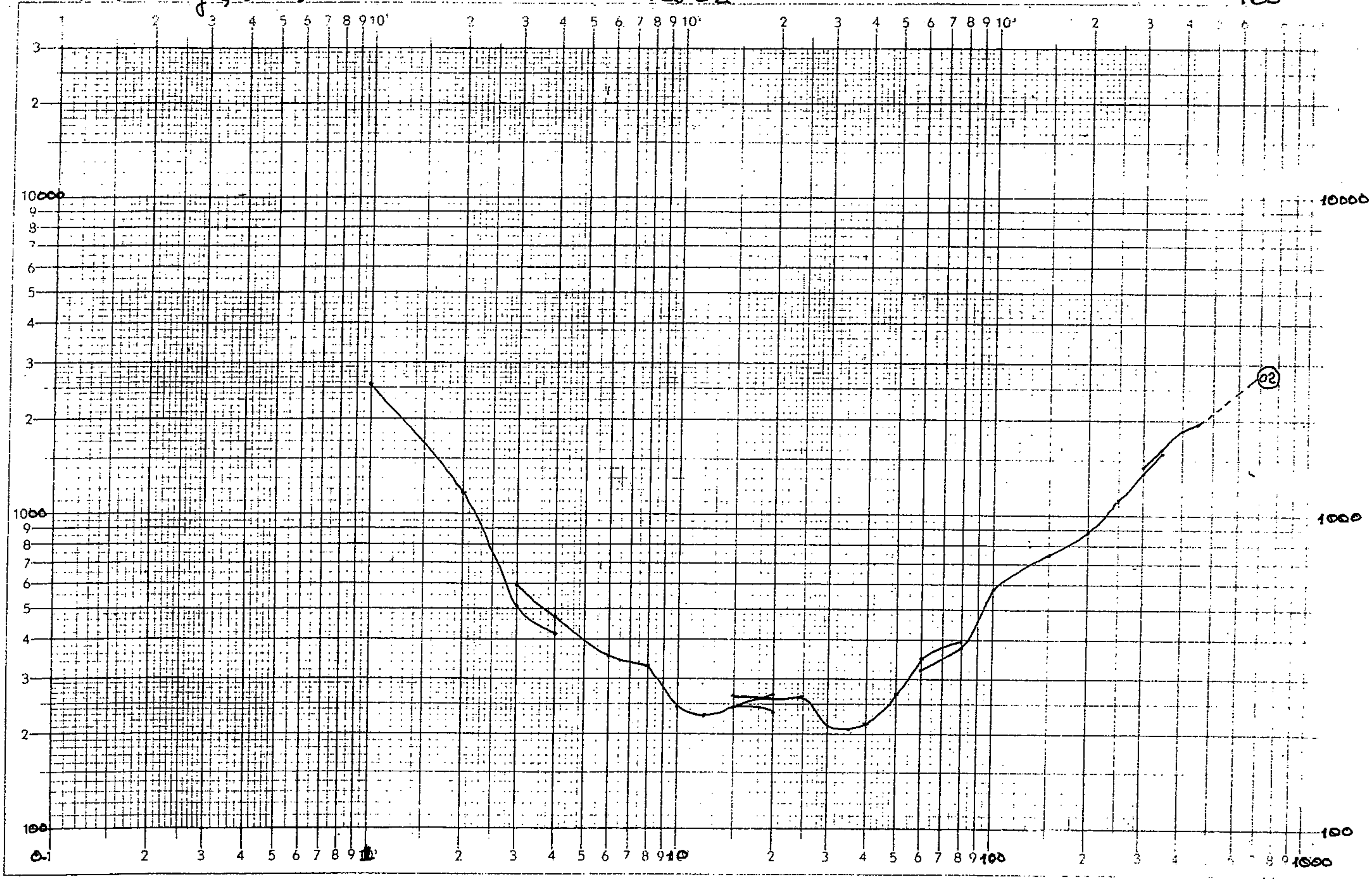
meetpapier - wormer

T 10019

X-as log. verdeeld 1 10¹ Y as log. verdeeld 1 300 millimeter 62 [illegible]

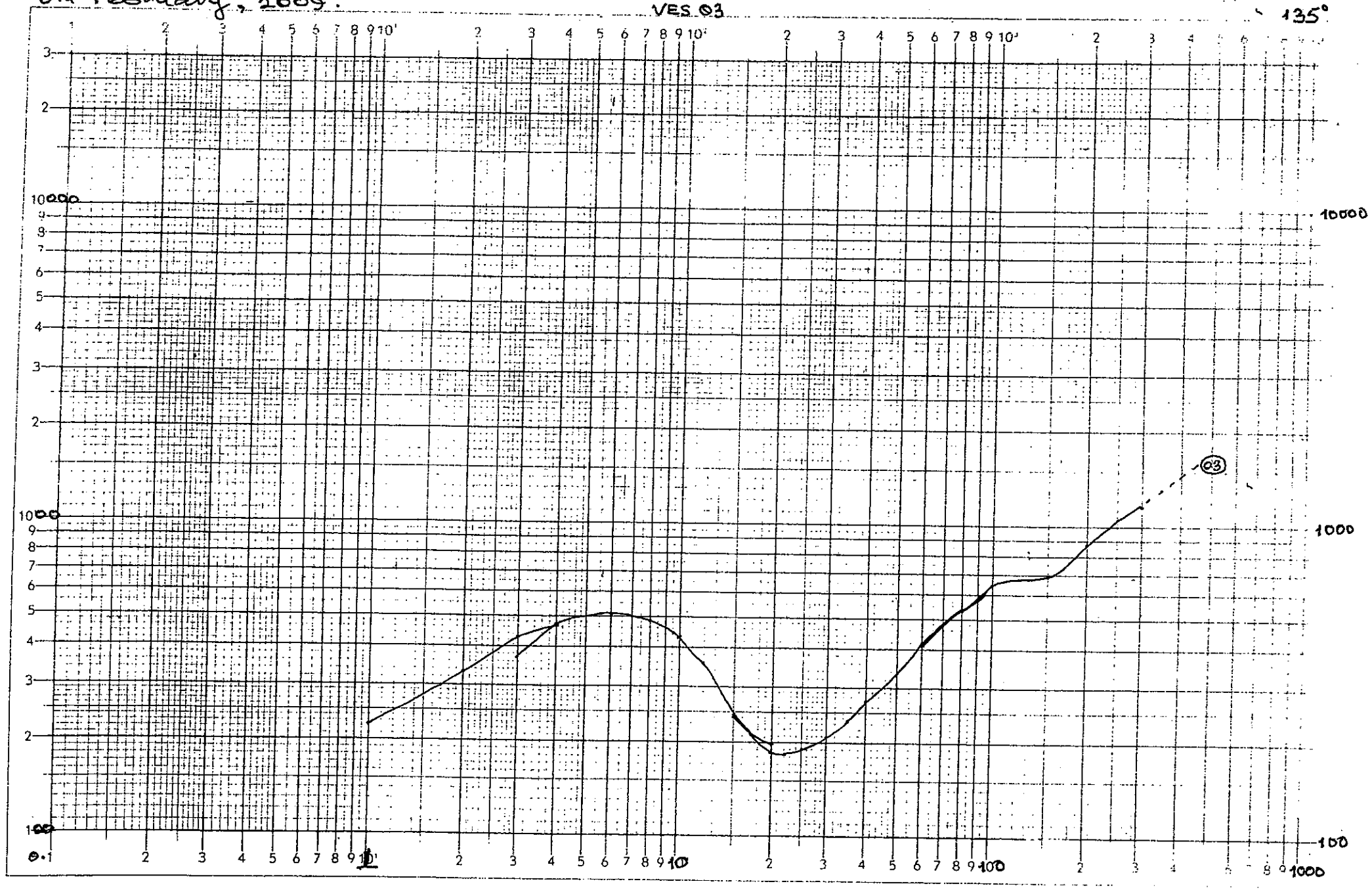
ST. MICHAEL'S COMMUNITY

6th February, 2009. VES 02 165°



meetpapier - wormer T 10019 X-as log. verdeeld 1 10⁴ Y as log verdeeld 300

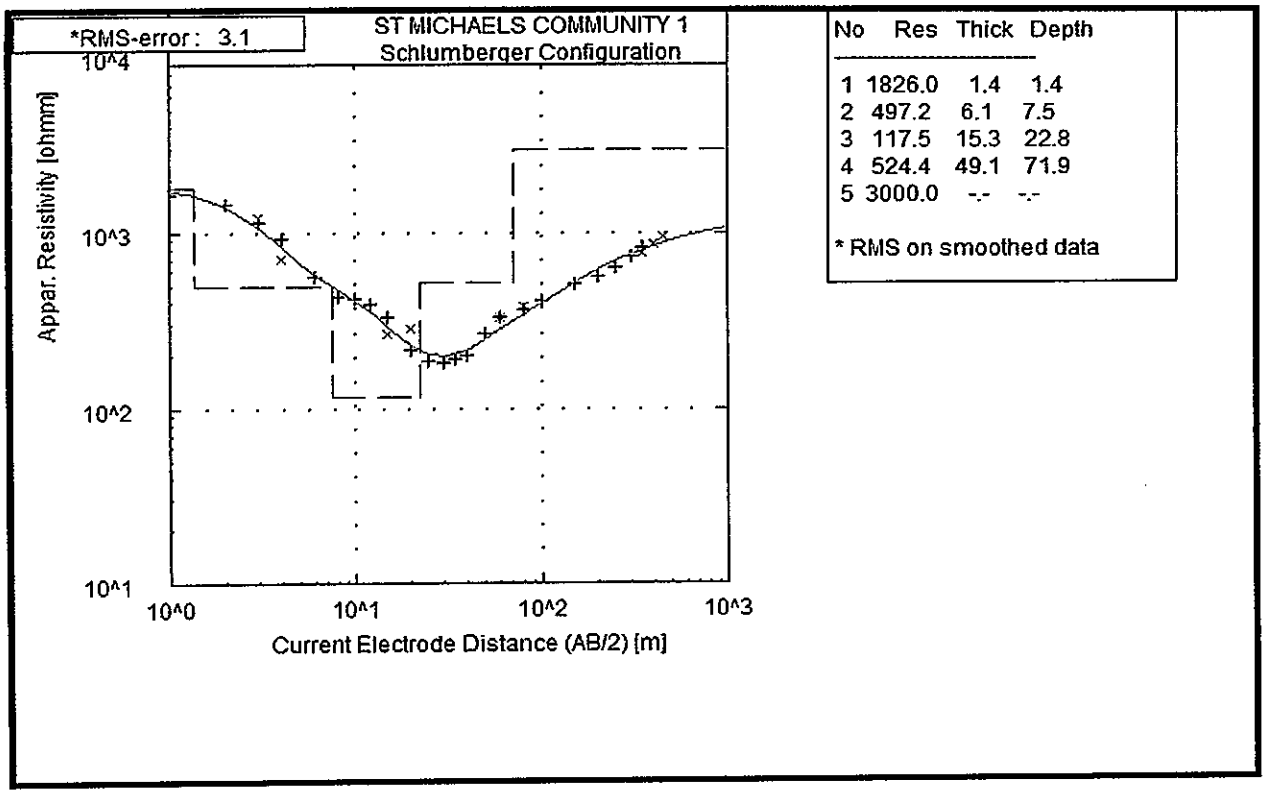
6th February, 2009.



meetpapier - wormer

T 10019

X-as log. verdeeld 1 10¹ Y as log. verdeeld 300 mm/cm 6.2 mm



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: St. Michaels Community.

DATE: 6th February, 2009.

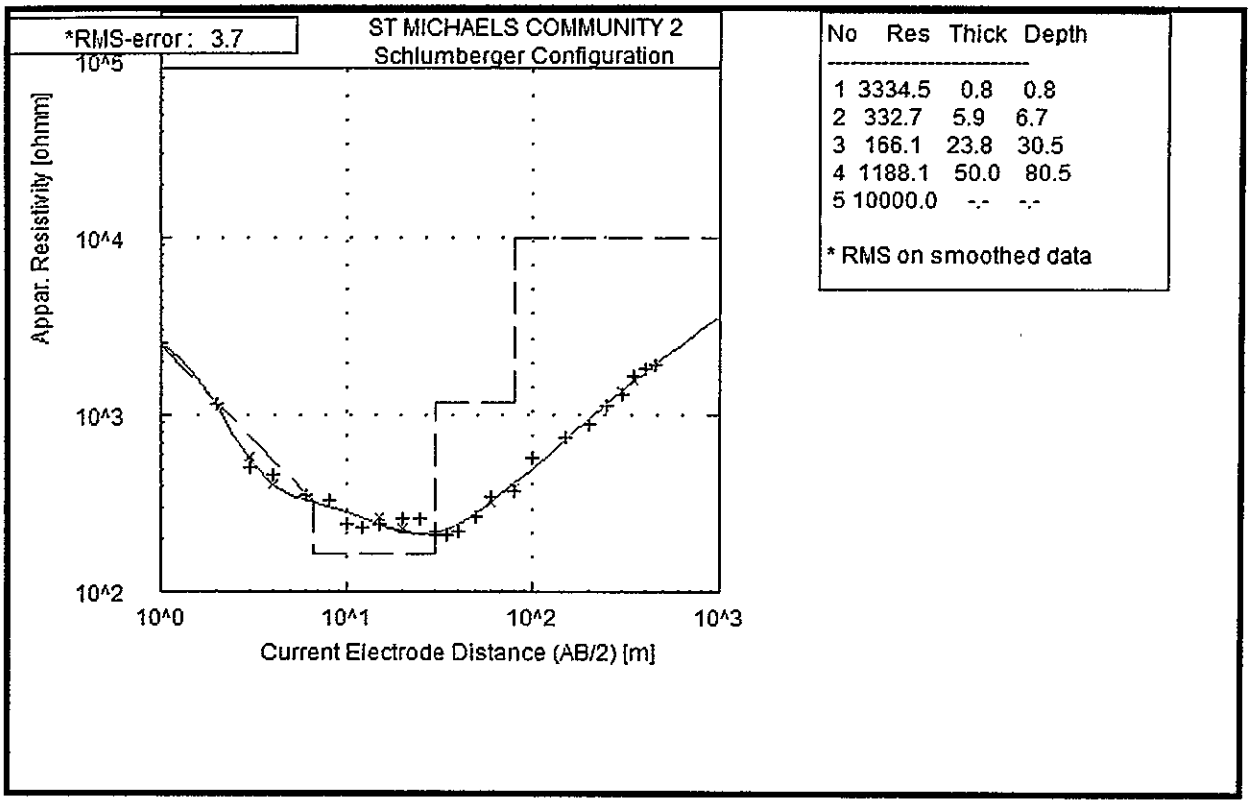
AB: 900 Meters.

AZIMUTH: 79 Degrees.

POSITION:

FILE: MICHAEL-1

REMARK: THIS IS THE RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: St. Michaels Community.

DATE: 6th February, 2009.

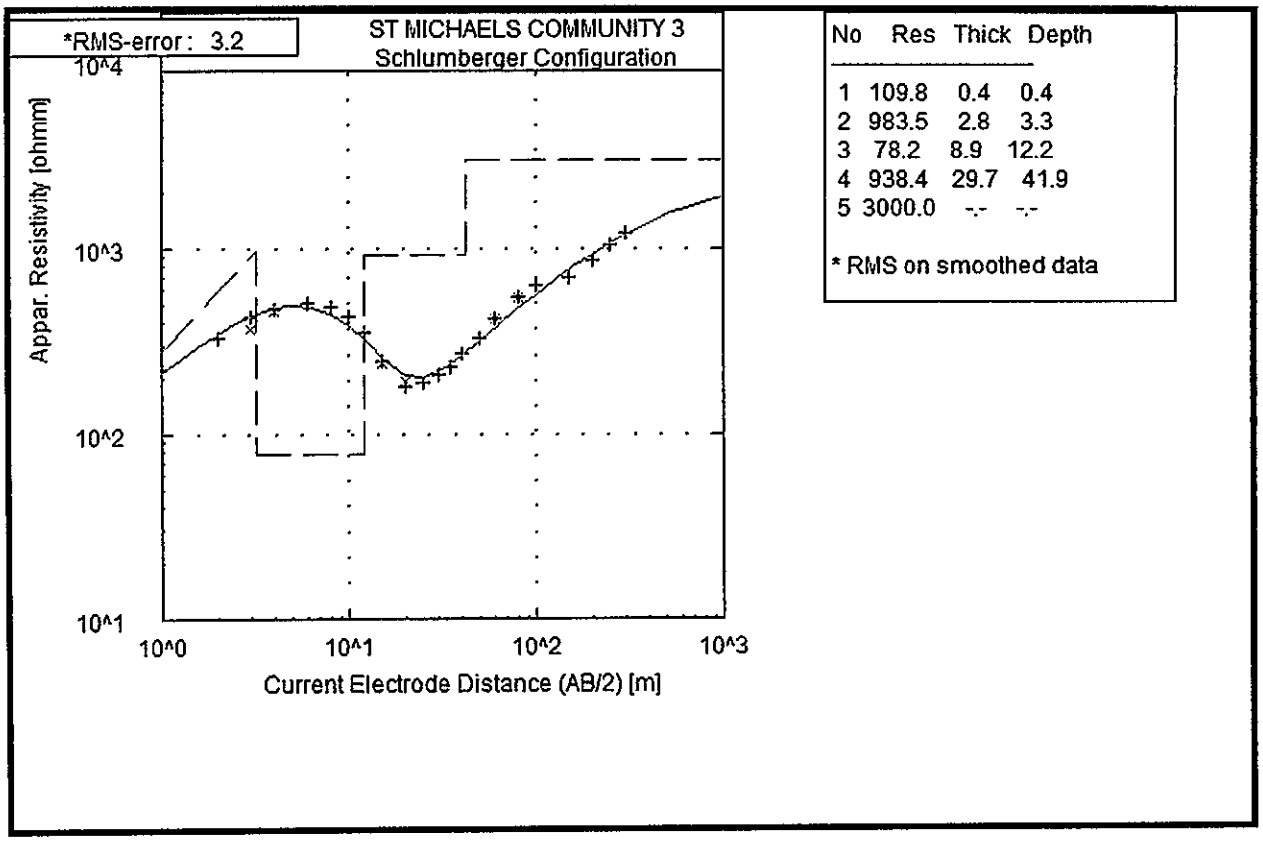
AB: 900 Meters.

AZIMUTH: 165 Degrees.

POSITION:

FILE: MICHAEL-2

REMARK: THIS IS THE RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: St. Michaels Community.

DATE: 6th February, 2009.

AB: 600 Meters.

AZIMUTH: 135 Degrees.

POSITION:

FILE: MICHAEL-3

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.

APPENDIX 9

Pipeline Community

(Daniel Junction)

- **Field Data (Vertical Electrical Sounding – VES)**
- **Field Curves (Vertical Electrical Sounding – VES)**
- **Computer Interpreted Data**

VERTICAL ELECTRICAL SOUNDING FIELD DATA

LOCATION: DANIEL JUNCTION (PIPELINE COMMUNITY) WATER LEVEL: —

VES NO: 01 , 02 & 03 AZIMUTH: 116° , 13° & 29°

EQUIPMENT: OHMEGA RESISTIVITY METER. DATE: 7th February , 2009 – 9th Feb., 2009.

COORDINATES: Lat: Long: Elevation(Masl):

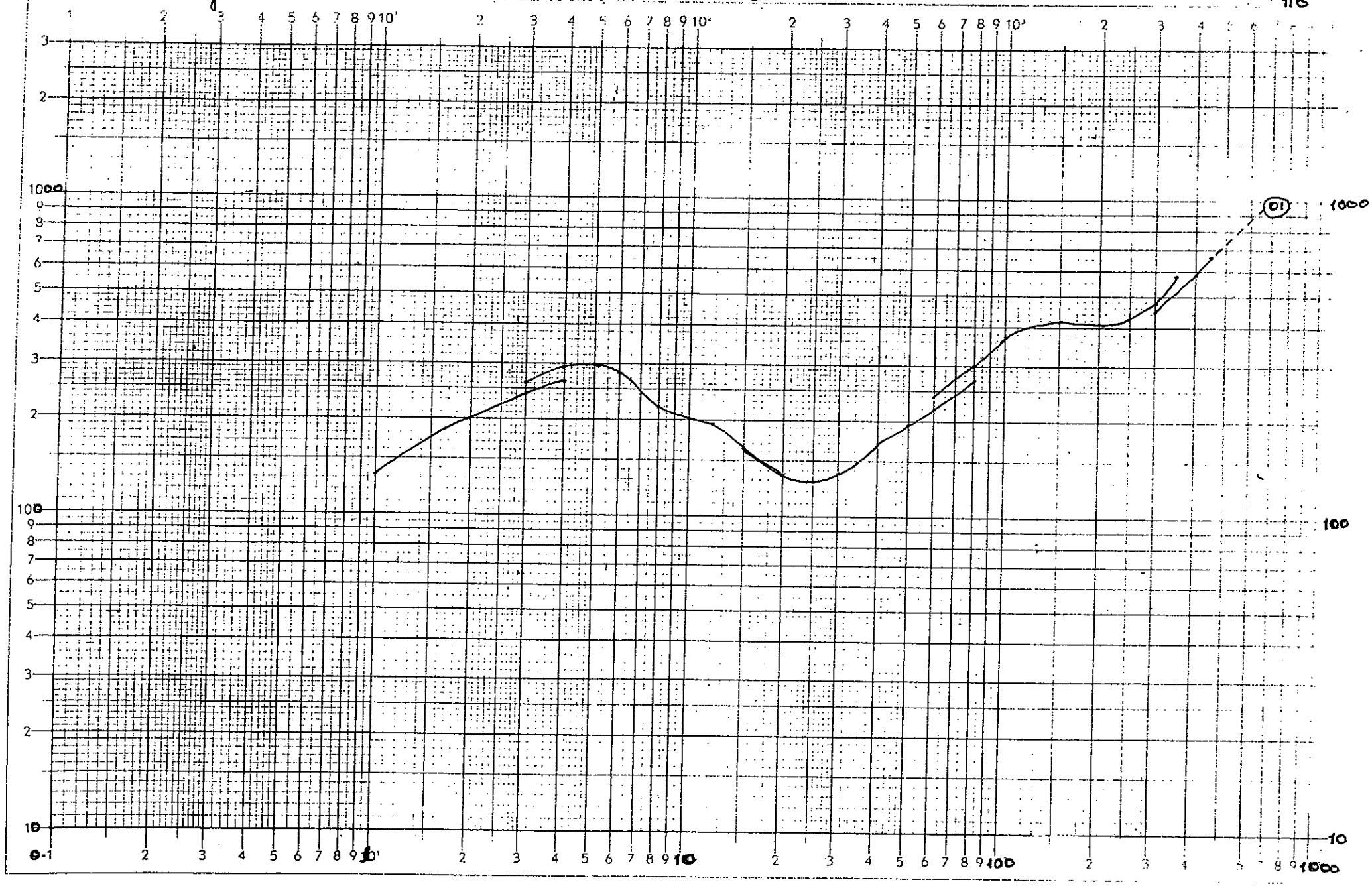
$= 3.142(AB/2)^2 - (MN/2)^2 / MN$

AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	31·43	132	25·39	107	118·2	496
2	0.33	18.5	10·81	200	8·097	150	17·90	331
	0.33	42.3	5·697	241	4·378	185	5·797	245
3	1	12.6	20·73	261	14·16	178	16·59	209
	0.33	76	3·447	262	2·371	180	2·016	153
	1	23.6	12·24	289	7·459	176	7·213	170
6	1	55	5·109	281	2·199	121	1·976	109
	1	99	2·209	219	0·8827	87	0·6922	69
0	1	155	1·297	201	0·5442	84	0·2979	46
12	1	225	0·8716	196	0·3831	86	0·1867	42
5	1	352	0·4692	165	0·2604	92	0·1108	39
5	5	62.8	2·614	164	1·561	98	0·6688	42
20	1	627	0·2108	133	0·1621	102	0·06539	41
0	5	118	1·124	132	0·9492	112	0·3814	45
25	5	188	0·6862	129	0·6489	122	0·2695	51
30	5	275	0·4982	137	0·4327	119	0·1927	53
5	5	377	0·3926	148	0·3024	114	0·1326	50
40	5	495	0·3475	172	0·2263	112	0·08485	42
0	5	777	0·2484	193	0·1266	98	0·04891	38
0	5	1123	0·1959	220	0·08330	94	0·03295	37
60	10	550	0·4327	238	0·1936	108	0·07104	39
0	5	2003	0·1348	270	0·05655	113	0·02097	42
0	10	990	0·3036	300	0·1277	126	0·05057	50
100	10	1555	0·2418	376	0·1009	157	0·03601	56
50	10	3520	0·1188	418	0·06841	241	0·01960	69
200	10	6270	0·06507	408	0·05138	322	0·01467	92
250	10	9803	0·04254	417	0·03499	343	0·01112	109
00	10	14123	0·03396	480	0·02563	362	0·008993	127
300	15	9402	0·04744	446	0·03648	343	0·01256	118
350	10	19229	0·03001	577	0·02028	390	0·007385	142
50	15	12806	0·04014	514	0·02847	365	0·01031	132
400	15	16734	0·03526	590	0·02209	370	0·008725	146
50	15	21185	0·03120	661	0·01989	421	0·007266	154

7th February 2005

VES 01

116°



meetpapier · wormer

T 10019

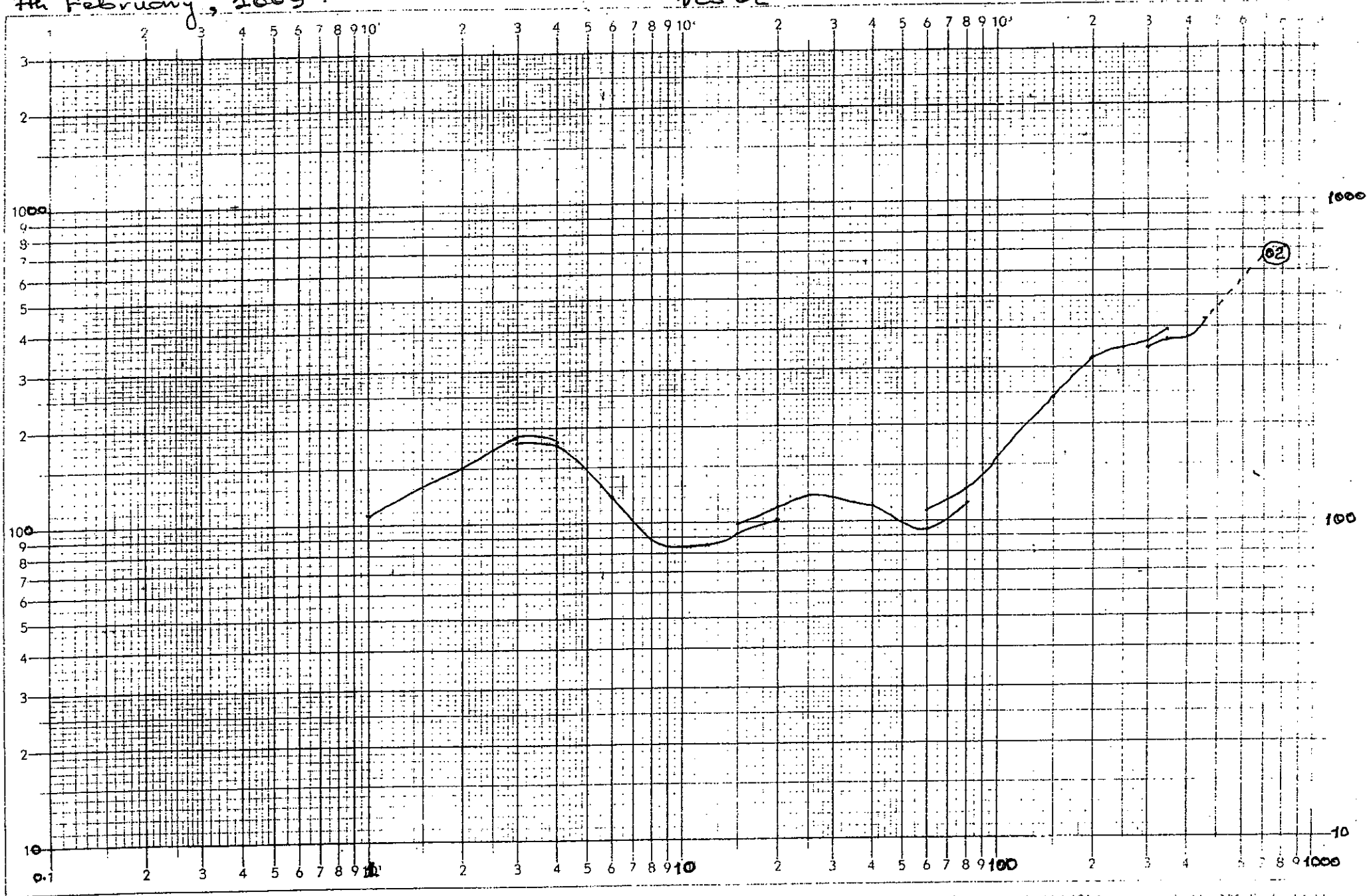
X-as log. verdeeld 1 10⁴ Y as log. verdeeld 1-300 Eenheid 5.2

DANIEL JUNCTION (PIPELINE COMMUNITY)

7th February, 2009.

VES 02

13°



T 10019

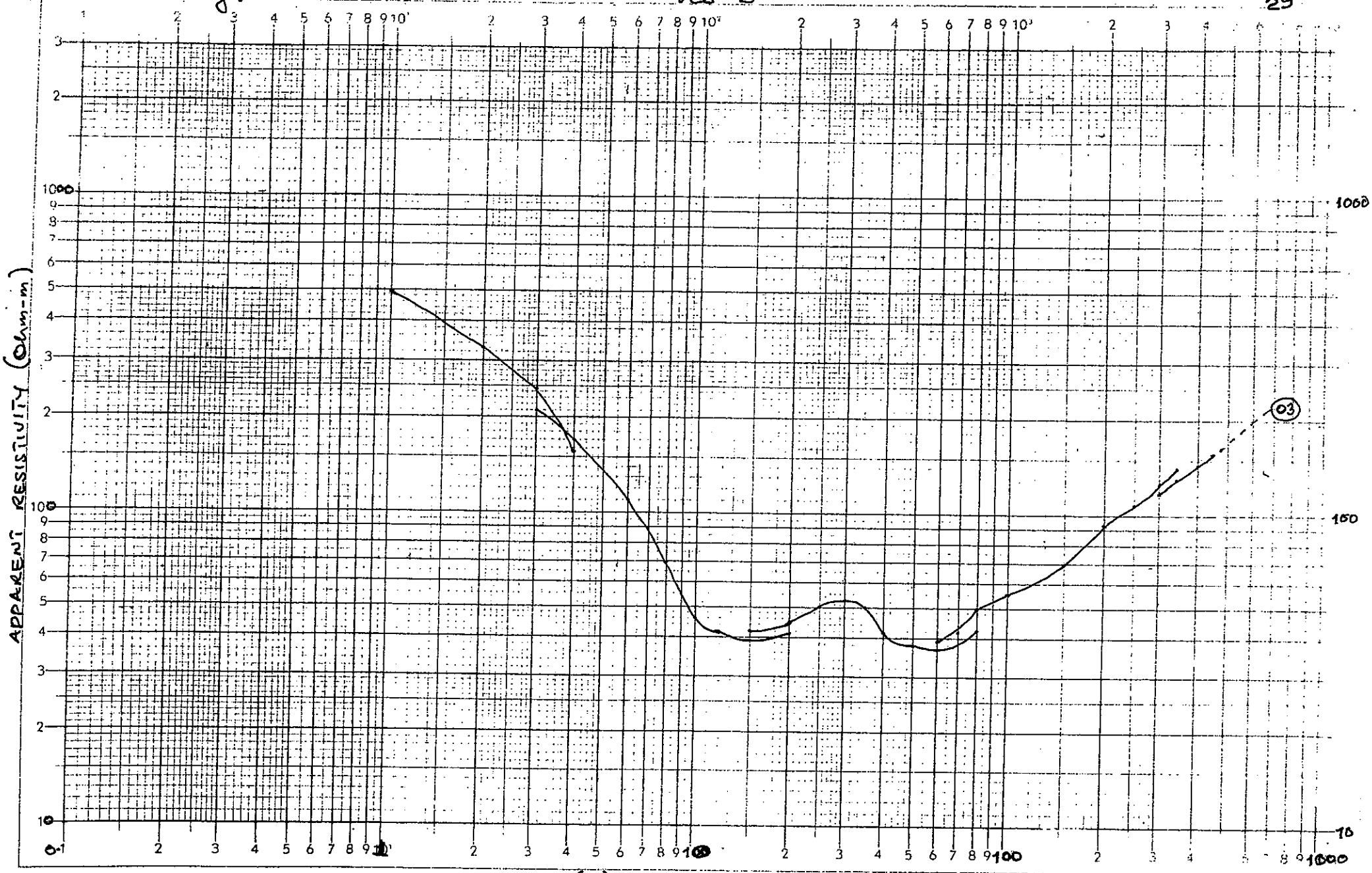
X-as log. verdeeld 1 10 Y as log verdeeld 300 Penheid 67

meetpapier · wormer

9th February, 2009.

VES 03

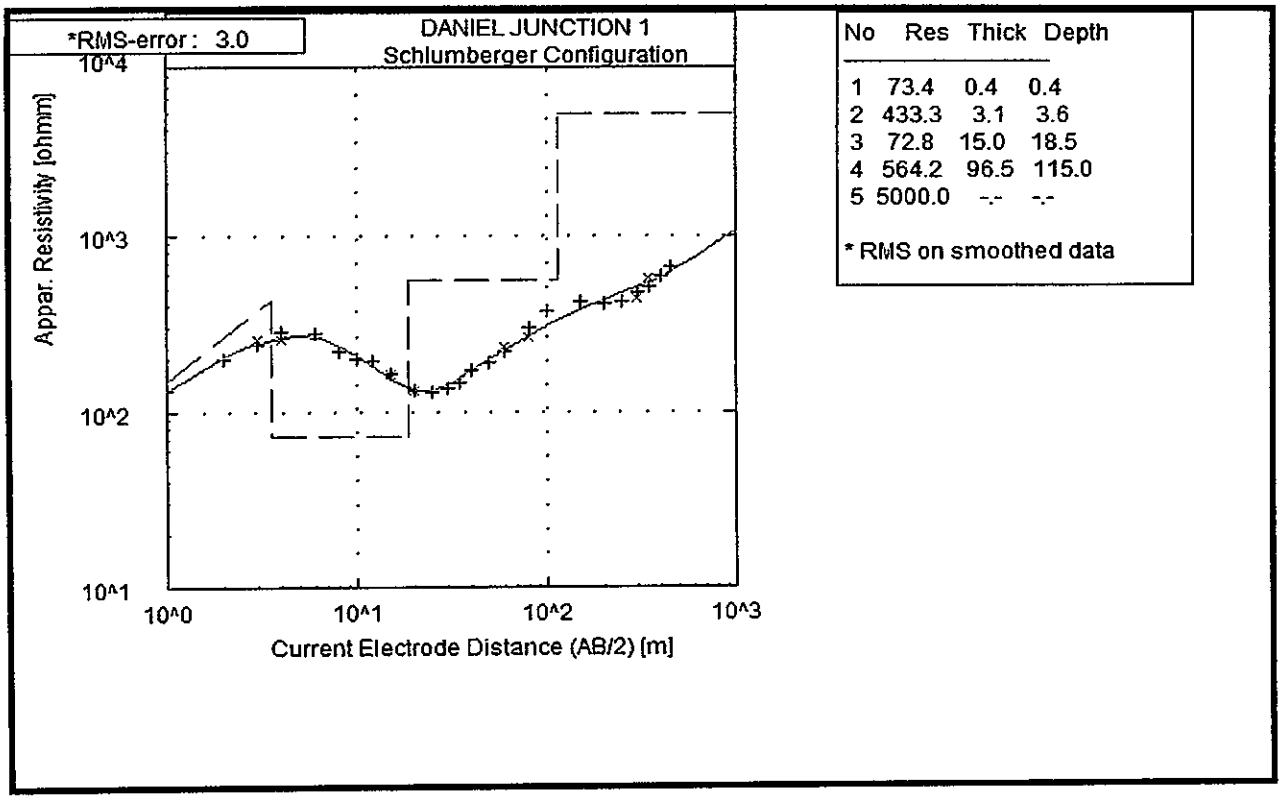
29°



meetpapier · wormer

T 10019

X-as log. verdeeld 1 10 X as log verdeeld 300 breedte 62



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Pipeline Community (Daniel Junction).

DATE: 7th February, 2009.

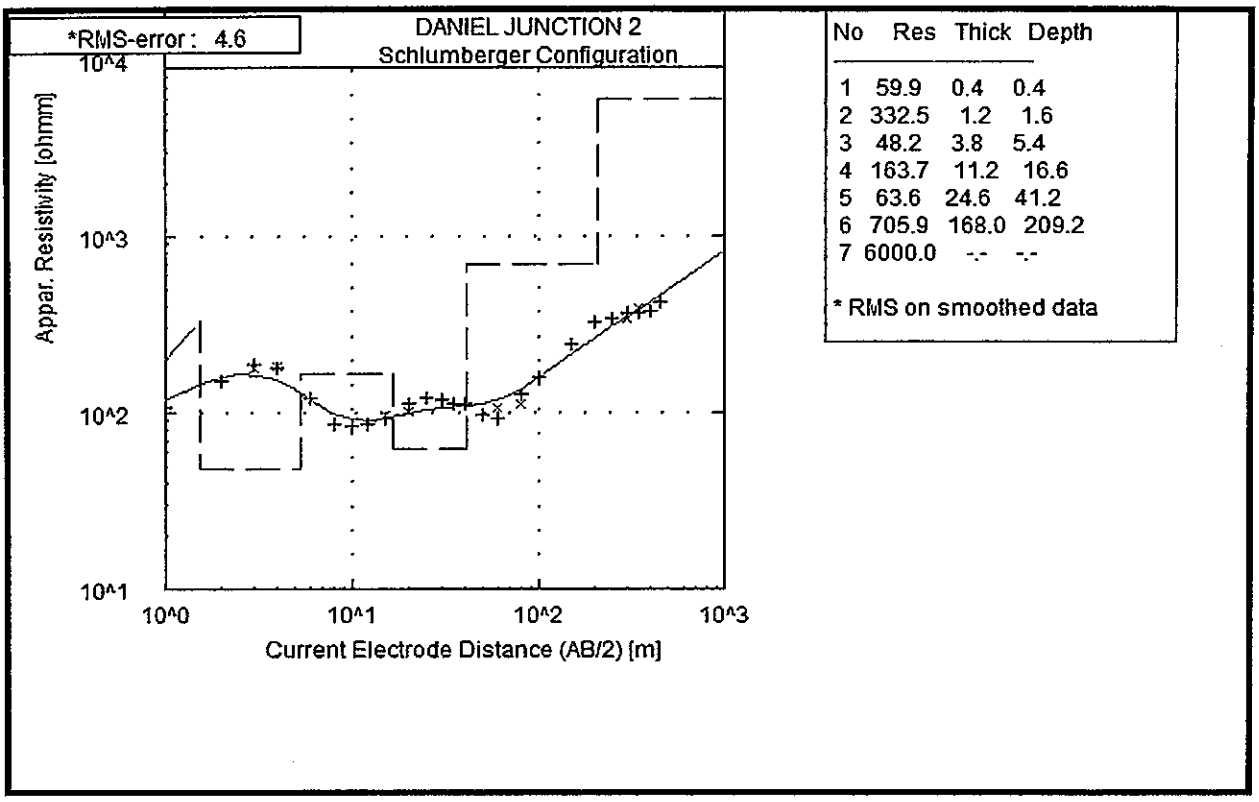
AB: 900 Meters.

AZIMUTH: 116 Degrees.

POSITION:

FILE: DANIEL-1

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Pipeline Community (Daniel Junction).

DATE: 7th February, 2009.

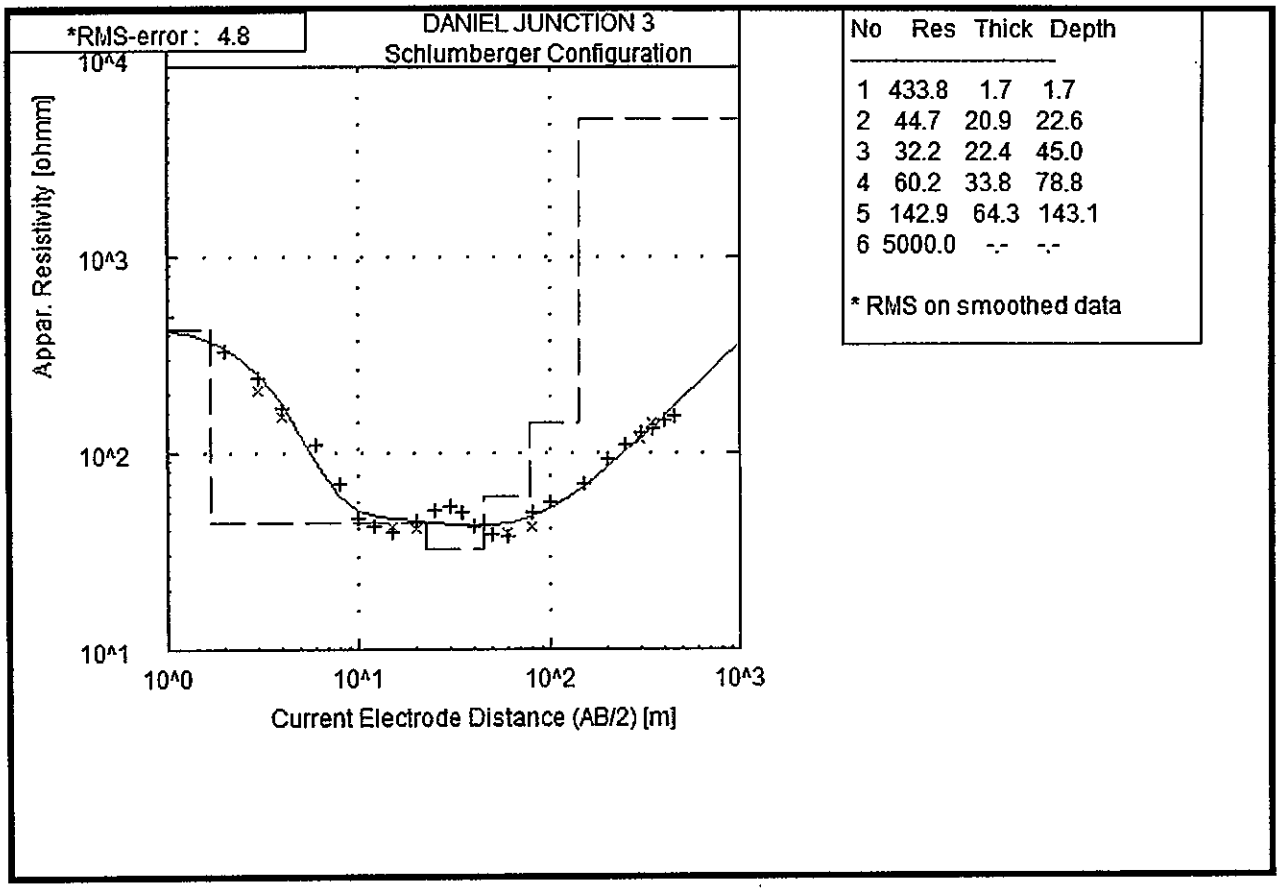
AB: 900 Meters.

AZIMUTH: 13 Degrees.

POSITION:

FILE: DANIEL-2

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Pipeline Community (Daniel Junction).

DATE: 9th February, 2009.

AB: 900 Meters.

AZIMUTH: 29 Degrees.

POSITION:

FILE: DANIEL-3

REMARK: THIS IS THE RECOMMENDED DRILL POINT.

APPENDIX C

Johnsonville (Down Town)

- Field Datas (Vertical Electrical Sounding - VES)
- Field Curves (Vertical Electrical Sounding - VES)
- Computer Interpreted Data

VERTICAL ELECTRICAL SOUNDING FIELD DATA

LOCATION: JOHNSONVILLE (DOWN TOWN) WATER LEVEL: ——

VES NO: 01 , 02 & 03 AZIMUTH: 130° , 88° & 162°

EQUIPMENT: OHMEGA RESISTIVITY METER. DATE: 10th February, 2005.

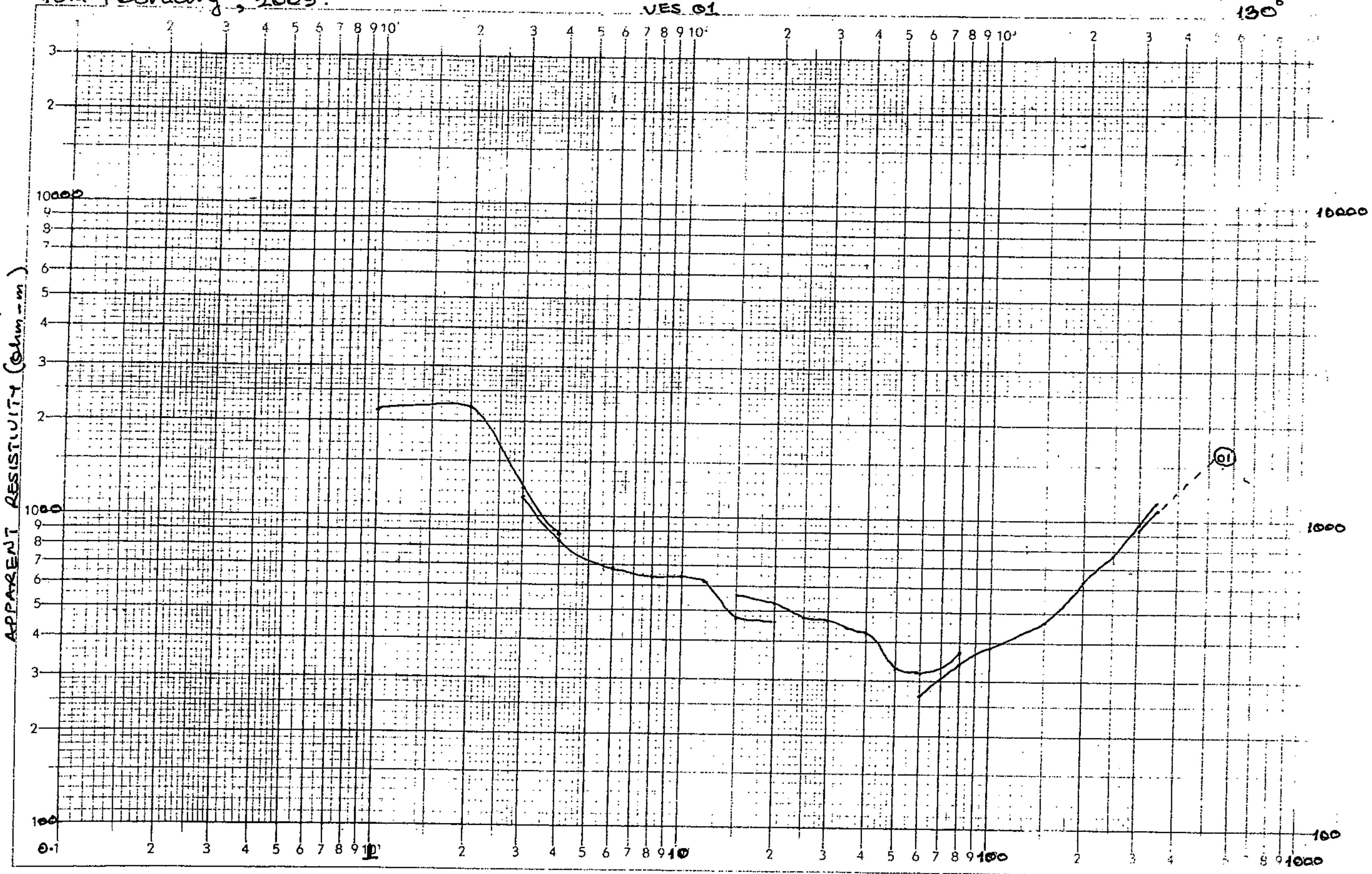
COORDINATES: Lat:.....Long:.....Elevation(Masl):.....

$= 3.142(AB/2)^2 - (MN/2)^2 / MN$

AB/2 (m)	MN/2 (m)	K	V/I	AR(Ohm-m) VES 01	V/I	AR(Ohm-m) VES 02	V/I	AR(Ohm-m) VES 03
1	0.33	4.2	509·9	2142	442·8	1860	548·3	2303
2	0.33	18.5	119·3	2207	85·99	1591	100·4	1857
	0.33	42.3	28·73	1215	31·76	1344	40·97	1733
3	1	12.6	91·66	1155	99·34	1252	147·7	1861
4	0.33	76	11·55	878	13·25	1007	17·53	1332
	1	23.6	34·90	824	42·49	1003	62·52	1476
6	1	55	12·44	684	14·49	797	17·22	947
8	1	99	6·444	638	6·800	673	7·844	777
10	1	155	4·137	641	4·155	644	4·337	672
12	1	225	2·731	615	2·533	570	2·888	650
15	1	352	1·345	473	1·779	626	1·368	482
15	5	62.8	8·888	558	9·246	581	9·283	583
20	1	627	0·7334	460	0·8999	564	0·6635	416
20	5	118	4·458	526	4·046	477	3·949	466
25	5	188	2·537	477	2·266	426	2·412	453
30	5	275	1·692	465	1·446	398	1·502	413
35	5	377	1·173	442	1·052	397	0·9912	374
40	5	495	0·8364	414	0·8154	404	0·6808	337
50	5	777	0·4276	332	0·5574	433	0·4376	340
50	5	1123	0·2850	320	0·3298	370	0·3188	358
60	10	550	0·4873	268	0·7618	419	0·6871	378
70	5	2003	0·1827	366	0·1832	367	0·1398	280
70	10	990	0·3445	341	0·3831	379	0·3364	333
100	10	1555	0·2463	383	0·2179	339	0·2309	359
150	10	3520	0·1296	456	0·1338	471	0·1225	431
200	10	6270	0·1010	633	0·1094	686	0·08724	547
250	10	9803	0·07926	777	0·08888	871	0·06587	673
300	10	14123	0·06861	969	0·07076	1070	0·05877	830
300	15	9402	0·09806	922	0·09690	911		
350	10	19229	0·06126	1178	0·06272	1206		
350	15	12806	0·08613	1103	0·08621	1104		
400	15	16734	MARSHY AREA & WATERLOGGED	—	0·07769	1300		
450	15	21185			0·06816	1444		

SWAMPY, MARSHY AND WATERLOGGED AREA.

10th February, 2009. VES 01 130°



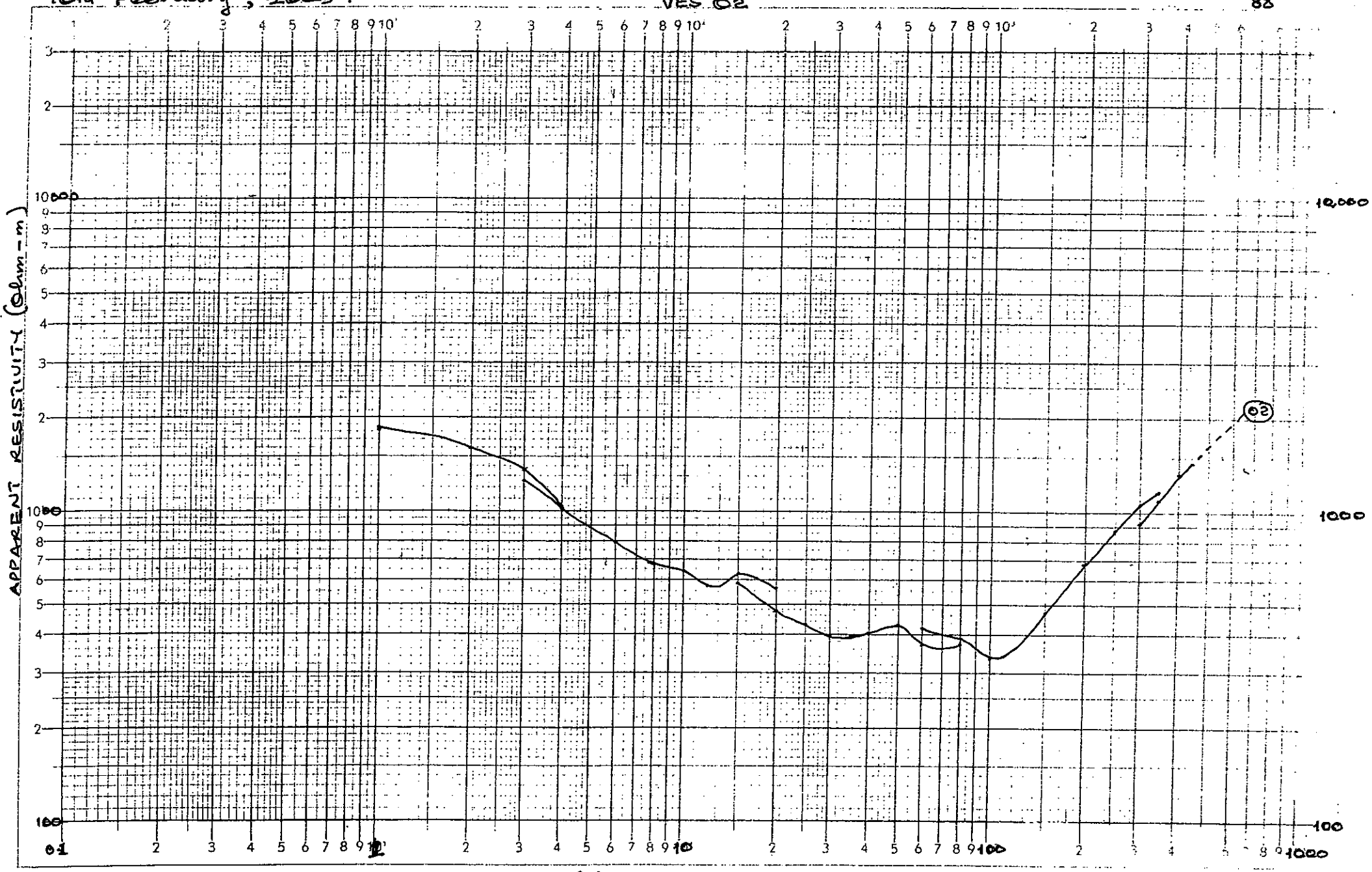
meetpapier - wormer T 10019 X-as log. verdeeld 1 10⁴ Y as log verdeeld

JOHNSONVILLE (DOHA TO...)

10th February, 2009.

VES 02

88°



meetpapier - wormer

T 10019

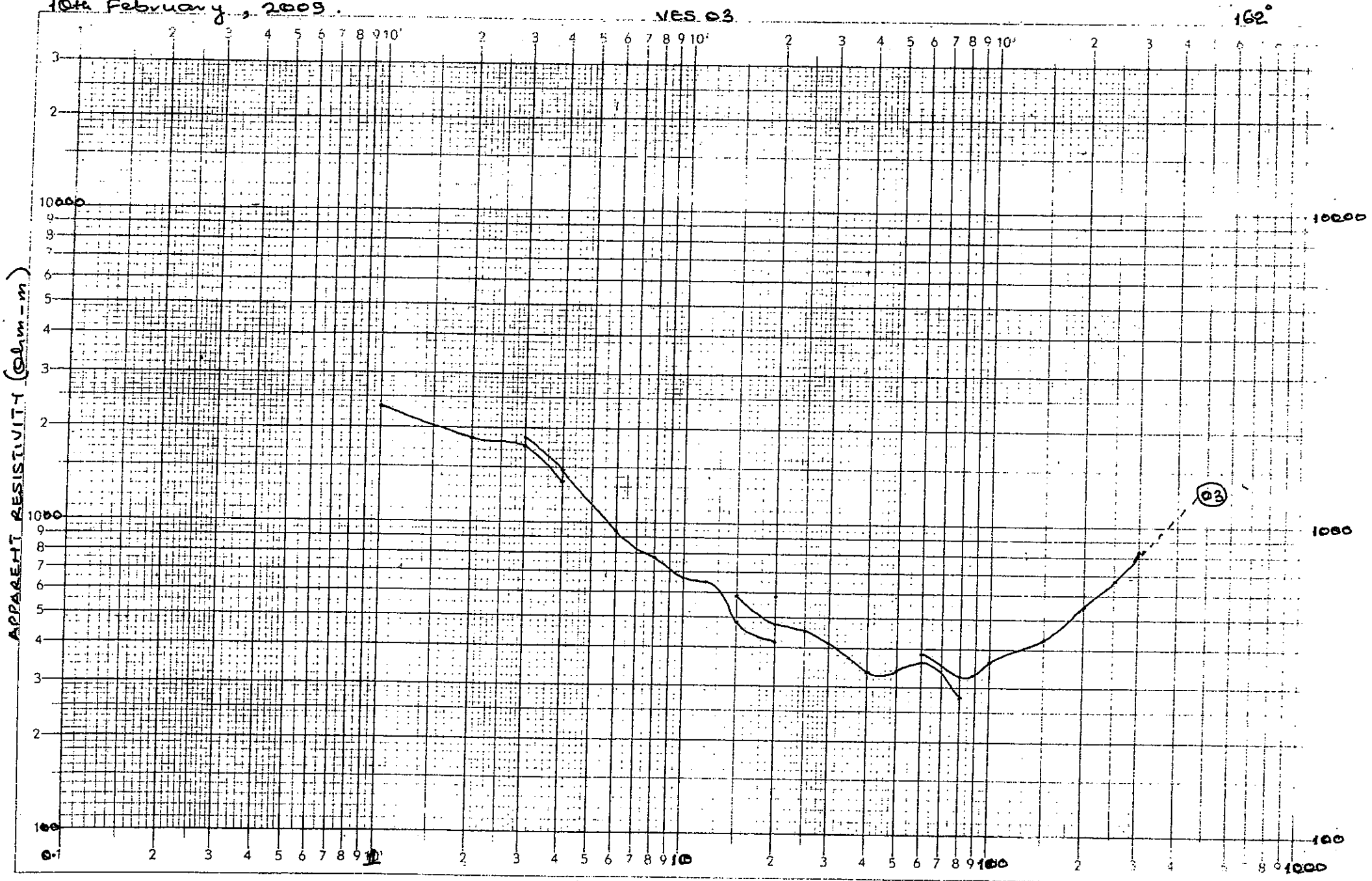
X-as log. verdeeld 1 10¹ ... as log. verdeeld ... 360 eenheid ...

JOHNSONVILLE (DOWN TOWN)

10th February, 2009.

VES 03

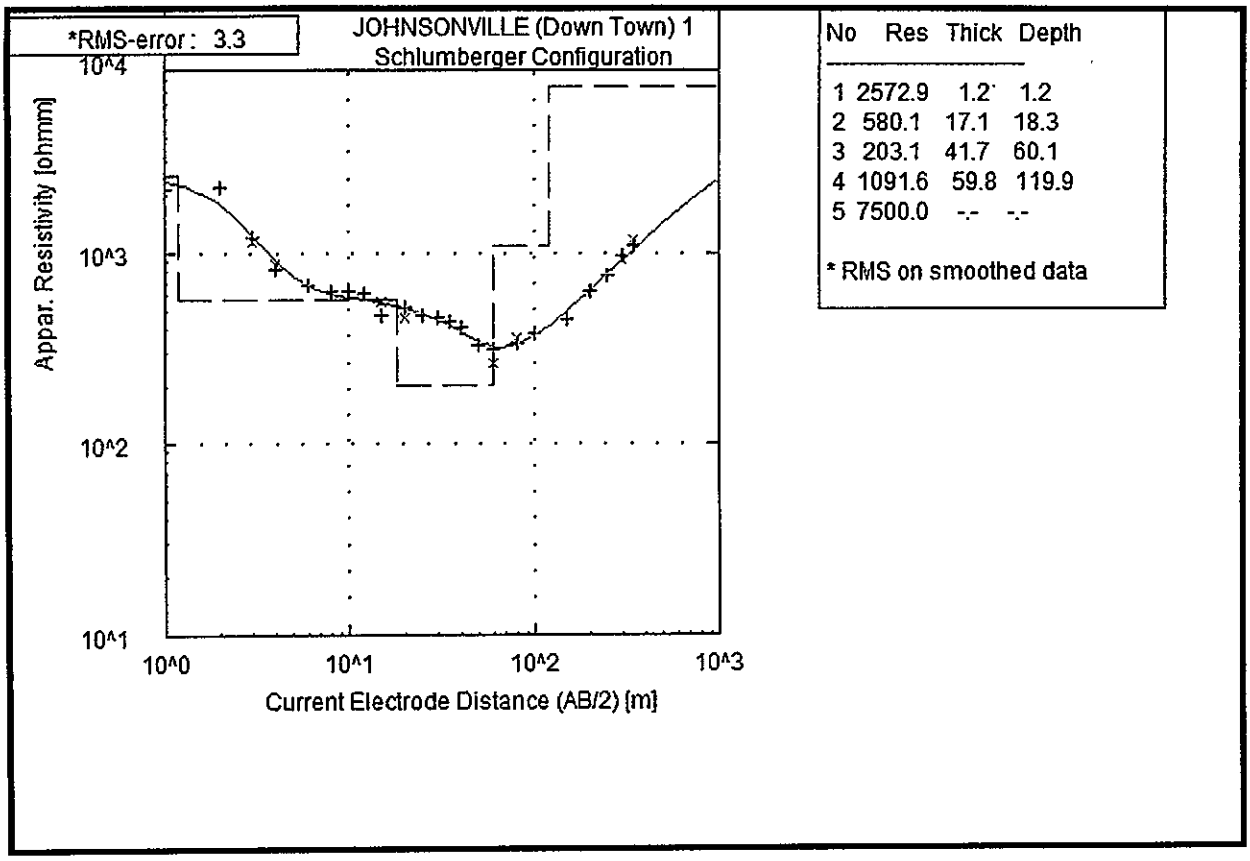
162°



meetpapier - wormer

T 10019

X-as log. verdeeld 1 10 x as log. verdeeld 3(0) hoofdverd 6 / 1 cm



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Johnsonville (Down Town).

DATE: 10th February, 2009.

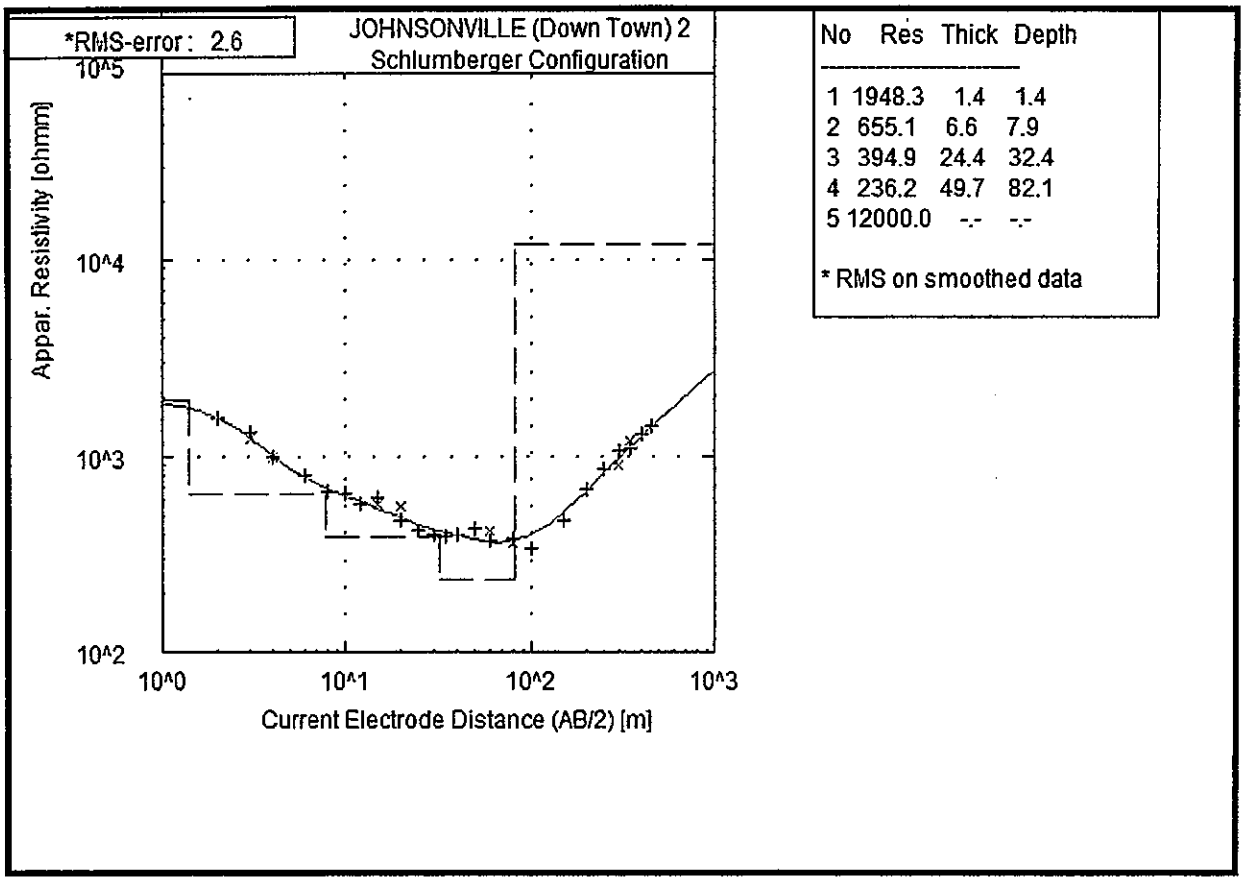
AB: 700 Meters.

AZIMUTH: 130 Degrees.

POSITION:

FILE: DOWN TOWN-1

REMARK: THIS IS THE RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Johnsonville (Down Town).

DATE: 10th February, 2009.

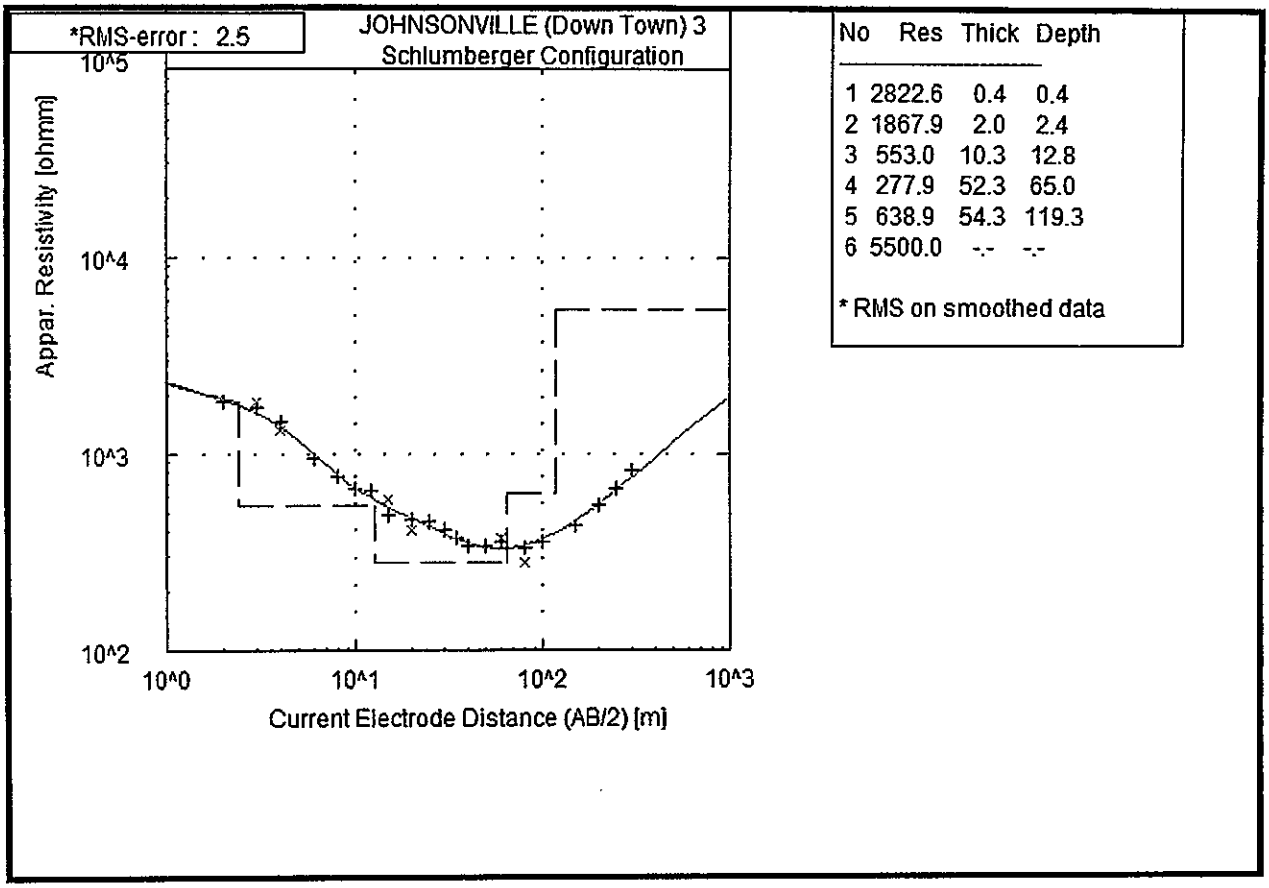
AB: 900 Meters.

AZIMUTH: 88 Degrees.

POSITION:

FILE: DOWN TOWN-2

REMARK: THIS IS THE RECOMMENDED DRILL POINT.



PROJECT: GOVERNMENT OF LIBERIA / JICA URBAN FACILITIES IMPROVEMENT PROJECT

LOCATION: Johnsonville (Down Town).

DATE: 10th February, 2009.

AB: 600 Meters.

AZIMUTH: 162 Degrees.

POSITION:

FILE: DOWN TOWN-3

REMARK: THIS POINT IS NOT RECOMMENDED FOR DRILLING.