REPORT

For

ALEJANDRA ALONSO

On

Hydro-geological/Geophysical Survey for locating potential site of borehole drilling for ground water supply

At

LOSSIMINGORI VILLAGE – MONDULI DISTRICT, ARUSHA.

Carried out and prepared

By

Gasper Isaka

(Principal Hydro geologist)

And

Msafiri Rashidi

Of

Chem-Chem Drilling Company Ltd.

Survey Date: 13th to 14th April 2022

Report Date: 19th April 2022

ALEJANDRA ALONSO

ARUSHA

SUB: HYDROGEOLOGICAL AND GEOPHYSICAL SURVEY REPORT

Please find enclosed herein a report on Hydrogeological and Geophysical Survey locating a borehole drilling site for ground water supply to Alejandra Alonso at Lossimingori Village in Monduli District, Arusha Region for your action and record keeping.

Surveyed and Prepared

By

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Msafiri Rashidi: 0759609109

From

Chem Chem Drilling Company Ltd
ARUSHA

ABSTRACT

Alejandra Alonso requested Chem Chem Drilling Company Ltd to carry out comprehensive hydro geophysical survey at Lossimingori Village – Monduli District, Arusha Region.

Hydro geophysical survey concentrated more on possible potential areas of groundwater occurrence at Lossimingori Village, Monduli District.

The aim of geophysical survey was to assess the potential high yield point of borehole drilling for domestic purposes.

The investigation concentrated on the location of reoccurrence ground water as a function of storage, permeability and recharge. Storage being determined by aquifer geometry and porosity while recharge is related to parameters such rainfall on top of each other. Thickness of groundwater zone is governed by local geology, availability of pores/ openings in the rock formation, recharge and movement of water from areas of recharge toward points/ areas of discharge.

The area is underlain by volcanic rocks including basalts, tuffs, agglomerates and volcanic conglomerates overlain by brown or black clay/ pyroclastic ash soil.

Groundwater occurrence within such rocks is restricted to unconsolidated sediments and weathered/fractured/fissured volcanic rocks or in faulted zones where water can be found at medium or great depths.

Four magnetic profiles covering a total distance of 424 meters used to trace potential site as fractures or weathered zones buried underneath and 3 Vertical Electrical Sounding (VES) penetrating 160 meters deep were applied on the anomalous magneto-magnetic profile points to get respective vertical subsurface information of resistivity values with their corresponding layer thickness.

Geophysical survey come up with positive potential results of pilot borehole drilling to a minimum depth of 140 meters and maximum depth of 150 meters deep marked on magnetic profile 4 - 4', VES 4.1' GPS coordinates is 37 UTM, E 0183238 and N 9617358 and position known to a representative of the client.

ABBREVIATION AND GLOSSARY OF TERMS

GPS …… Global Positioning System

VES ……... Vertical Electrical Sounding

M …… Meter

MM……...Millimeter

AB …….. Distance between current electrodes

MN ……. Distance between potential electrodes

L/Hr ……..... Liter per hour

BH……...Borehole

GROSSARY ITEMS

Pumping test …….. A test that is conducted to determine aquifer or well characteristics

Aquifer …….A geological formation or saturated bed which store and transmit water and that may supply water to wells, boreholes or springs.

Fault ……. A fracture or a zone of fracture along which there has been displacement of the sides relative to one another parallel to the fracture.

Recharge …….. The general terms indicating the process of transport of water from surface (i.e. from river or rainfall) to the ground water.

Regolith……The loose, incoherent mantle of rock fragments, soils, brown sand, alluvium etc. which rests on solid rock.

Yield…….. Volume of water discharged from a well.

Hydro-geological…… Those factors that deal with subsurface water and related geological aspects of surface waters.

Unconfined……..Referring to an aquifer situation whereby the water table is exposed to the atmosphere through openings in the overlying materials.

Confined aquifer…….A formation in which groundwater is isolated from the surface by impermeable geologic formations. Confined water is generally at greater pressure than atmospheric, and will therefore rise above the strike level in a borehole.

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1.0 INTRODUCTION

(a) Preamble

Chemchem Drilling Company Ltd was proposed and assigned by Alejandra Alonso to conduct a hydrogeological survey work on her compound land at Lossimingori Village – Monduli District, Arusha for domestic purposes within the project area. The report describes the execution of Hydrogeological/Geophysical investigations and provides description of methodology, results, conclusion and recommendations.

(b) The Project Area

The study area covers the whole Lossimingori village at Monduli District, Arusha Region.

(c) Project Objectives

The project was to carry out Hydrogeological and Geophysical Investigations to locate potential groundwater for borehole drilling site. It is anticipated that the study area if drilled can produce successful result.

(d) Expected Outputs

- Carry out Hydrogeological and Geophysical Survey to locate exact point(s) for drilling a deep or medium depth borehole.
- Recommendations for future work

(e) Approach:

Different approaches were used in this survey in order to locate a suitable area of borehole drilling. These were a reconnaissance survey (aimed to have general overview on geomorphology, hydrogeology, water sources available and topography of the area) and geophysical survey methods (mainly Magnetic and Resistivity) were applied in this groundwater survey for the location of potential borehole drilling site.

(e) i. Reconnaissance Survey

Geophysical Survey Team under took a quick reconnaissance survey, which basically involved:

- Observation of the geomorphology of the area, focusing towards topography of the area, surface water bodies if available (streams, wetlands/swamps and spring).
- Inventory of existing groundwater sources such as boreholes and dug well
- Assessment of extent and span of catchments and similarly of the presence of vegetation that may be associated with groundwater availability.
- Assessment of the accessibility to site particularly during drilling.

(e) ii. Detailed hydro geological and geophysical sites investigation:

Detailed hydrogeological and geophysical site survey was carried out, to pin point the exact location for borehole drilling. Geophysical measurements for selected site were carried out taking into account geological conditions by using Magnetic profiling and Vertical Electrical Sounding.

(e) iii. Magnetic Profiling

Magnetic profiling was used to measure the variation of the total magnetic field in relation to geology along the profiles. The magnetic field of fractures/features, dykes system, and deeply weathered zone differs considerably from the surrounding rock. The changes are increase or decrease in the normal field of the area. Three types of conductors are target when carrying out the measurement, these are:

(a) Areas with substantial weathered thickness of weathered bedrock.

(b) Vertical zones in faulted/fractured rock

(c) Dykes intrusion

Un fractured tight dykes need to be located because they act as dams to flow of groundwater, in other cases fractures may be associated by dykes.

The magnetic intensity observation were plotted using MS excel software to determine characteristics anomalies for (a), (b) or (c) where Vertical Electrical Sounding is carried out to determine the nature of resistivity layering of the earth in the selected points along the Profile.

(e) iv. Vertical Electrical Soundings

The basis of the method is that when a current is introduced into the ground through electrodes any subsurface variation in conductivity alters the current flow within the earth, where in turn affects the distribution of electrical potential. The degree at which the electric potential at the surface is affected depends upon the thickness, the location, shape, and conductivity of the material within the ground. It is therefore possible to obtain information about the subsurface distribution of this material from measurement of the electric potential at the surface.

In the electrical resistivity method an electrical current is introduced into the earth by means of two current electrodes located at the surface, and the electrical potential difference is measured between two other electrodes. From the values of the potential difference the current applied, and the electrode separation a quantity termed "the apparent resistivity can be calculated. In a homogenous ground this is the true ground resistivity but usually it represents a weighted average of the resistivity's of all the formations through which the current passes. It is the variation of this apparent resistivity with change in electrode spacing and position that gives information about the variation in subsurface layering.

(e) v. Field Techniques and Procedures

Field technique that was used to determine the resistivity with depth is Vertical Electrical Soundings. Vertical electrical soundings were used to determine the variation of the resistivity with depth at fixed point at the surface. The schlumberger electrode configuration has been used

in this investigation. In the schlumberger electrode configuration two current electrodes and two potential electrodes are arranged in the straight line on the surface, and the distance between the current electrodes is large compared with the distance between potential electrodes. The electrodes are placed symmetrically about the centre of the spread.
In performing the Vertical Electrical Sounding the potential electrodes remain fixed while the current electrodes spacing is symmetrically about the centre of configuration. For large values of the current electrodes (AB) it becomes necessary to increase the potential electrode spacing (MN) to maintain measurable potential.

(e) vi. Interpretation Techniques

The field data for each sounding were interpreted using computer program software INTERPEX. The layered earth model is the simplification of many different layers which may be present. The program takes into account the various equivalent solutions which are generated by a computer.
In working with all vertical electrical sounding data obtained in this survey a mutual comparison between soundings in the same area is made as underground conditions normally do not change abruptly and thus the margins of equivalence are narrowed.

2.0 LOCATION OF THE SURVEY AREA

Lossimingori village is located on southern foot limb of Monduli – Makuyuni mountainous series, 2.8 km north of Arusha - Babati tarmac road at Monduli District, Arusha Region.

Geophysical survey concentrated more within Lossimingori village at Monduli District, Arusha Region. The GPS coordinates of surveyed area is 37 UTM, E 0185801 and N 9618467. For more details see attached location map of the surveyed area at Lossimingori in appendix I.

3.0 CLIMATE AND RAINFALL

The climate of the surveyed area is generally in undulating temperate terrain because of its altitude and influence of Makuyuni – Monduli mountainous series. Temperate climate of the surveyed area is dominated by high temperature about 25° C that cover almost the whole year with exception of July/ August which drops to 18° - 20°C. It receives orographical type of rainfall approximately 800-1000 mm of mean annual rainfall per year which acts as a recharge to aquifer on the area. The area receives typical two rainy seasons, one during October to December, and the other from March to May, the later being longer and heavier.

4.0 LOCAL GEOLOGY OF THE STUDY AREA

The areas investigated are occupied by Neogene Volcanic rocks, comprising of Basaltic lavas, (undifferentiated) tuffs, Agglomerates, and volcanic conglomerates overlain by brown and/or black clay soil. The out crops at surveyed areas are well porous, fractured/fissured and weathered.

5.0 HYDROGEOLOGY

The presence of water bearing layers (aquifers) and recharge of these layers in general determines groundwater occurrence. The geomorphologic, geological and climatologically condition of the surveyed area is generally favorable for groundwater storage and movement. Rainfall is orographically controlled where it falls more consistently at higher levels on the upper mountainous slopes.

The hydrogeology of the surveyed area is determined by the underlying geology, geological structures, rainfall and the prevailing recharge mechanism. Good aquifers are expected along the weathered/fractured igneous rock. The thicker the structure the more storage it can provide. In order for this storage to be recharged a catchment area of reasonable size is necessary.

The relationship between topography and ground water recharge becomes evident where the greater the topographic relief the greater the recharge. Presence of weathering and fracturing system in the area is also favorable for groundwater condition because;

a) Preferential weathering takes place along fractures and thus enhances storage.
b) The presence of fractures increases permeability which enables a single borehole/ well to draw water from a large storage area.

The two possible recharge mechanisms are direct recharge at the surface and indirect recharge via faults. Assuming that suitable storage media exist below the ground, the aquifer potential may be affected by downward percolation of rain water to the aquifer. If the infiltration is low due to presence of aquitard like clay, recharge to the aquifer is low. Percolation will depend on soil structure, vegetation cover and state of erosion of parent rock. Rocks weathering to clayey soils naturally inhibit percolation. Aquifers may be recharged laterally if the rock is permeable over a wide area. The main water bearing zones occur on the area between 40 - 160 meters below the surface and aquifer may exist in confined or semi-confined form.

6.0 GROUND WATER QUALITY

The quality of groundwater can be affected by various factors such as climate, depth and nature of the host rock. Since water is a universal solvent, it dissolves various minerals as it flows through rocks. The dissolved minerals can be of high content to the extent that can affect the quality of water for human consumption.

Various chemical substances are considered during assessing water quality. These include Total Dissolved Solids, Color, Turbidity, Iron, Manganese, Calcium, Magnesium, Sulphate, Chloride, PH, Nitrates and Fluoride (F). Every chemical substance has its allowable concentration in water.

The quality of groundwater at the surveyed area is expected to be good. However fluoride concentration in some places is bigger than WHO's (World Health Organization) limit recommended standard for drinking purposes which is 1.5 mg/l although in some places meets the Tanzanian allowable concentration of 4.0 mg/l.

7.0 GEOPHYSICAL SURVEY

a) METHODOLOGY

As mentioned above, ground water occurrence in the surveyed areas is limited to geological structures like fractured (faulted, sheared and jointed) zones of igneous or metamorphic rocks.

During this hydro-geological survey, geophysical instruments and field methodology mentioned below have been used:

Geophysical survey instruments:
Instruments used for geophysical survey work comprised of the following;

- ABEM Terrameter SAS 1000 from ABEM Nitro consult company in Sweden. This instrument was used for electrical resistivity sounding.
- Proton Magnetometer G-856 Ax Memory Mg Tm from Geometric Inc. this instrument was used for magnetic conductivity survey.

The following geophysical survey field procedures were used in locating geological structures:

b) MAGNETIC PROFILE

These profiles were constructed to perpendicularly transect the known North-South geological fault path in the area which acts as an aquifer conduit. The attempt here is to determine the boundaries of the fault.

- Magnetic profiling was carried out using a proton magnetometer/gradiometer.
- The resulting field magnetic data collected from the profile line was plotted on the linear scale graph paper in the field to get a magnetic profile graph.

Four magnetic profiles distanced 424 meters and spacing between the stations (marking) along the profile lines was 2 meter respectively. The resulting field data (conductivity) collected from the profile line was plotted on the linear scale graph paper on the field to get a profile graph.

From the interpretation of the magnetic profile graphs drawn, station with anomalous lower magnetic values noticeably below the trend line indicated locations of the sub vertical/vertical geological structures (discontinuities) such as fractured zones (faults, sheared zones, joints), contact zones of different rock in contact and litho-logical boundaries.

c) RESITIVITY: VERTICAL ELECTRICAL SOUNDING (VES)

The station with anomalous lower magnetic values was selected as the center of the VES soundings. The Schlumberger array technique was used for resistivity soundings throughout the fieldwork. The existing borehole in the area was also the subject of the VES resistivity soundings.

The spread of the current electrodes (AB/2) of this sounding was up to 160 m from the center with respective VES sounding whist spread of potential electrodes (MN/2) was up to 25 meters.

The apparent resistivity data of the VES soundings were plotted against respective spacing (distance of the current electrodes from the center of the sounding) on a double logarithmic paper to get resistivity vertical soundings vs. horizontal distance graph (curve). These graphs were further smoothened by free hand drawing in the field. Upon return to the office the data was analyzed and inputted into the ABEM recommend interpretation software Interpex. The data analysis provided a similar curve and a corresponding layer model. Reassuringly this showed consistency with the hand drawn results.

d) HYDRO GEOLOGICAL EVALUATION OF GEOPHYSICAL SURVEY

It was noted from VES curve presents in the appendix III that several geological structures have been located which could possibly be ground water bearing. The proof is through test borehole drilling at the marked site (or station)

From curve matching interpretation of resistivity data, VES sounding gave resistivity values which indicate weak zone/ fracturing of bedrock formation found between 40 to 160 meters.

e) SITE RECOMMENDED FOR TEST BOREHOLE DRILLING

The station marked by VES 4.1' is recommended for pilot borehole drilling to a minimum depth of 140 meters and maximum depth of 150 meters deep found on magnetic profile 4 - 4' respectively. The drilling site marked and position shown to a representative of the client, GPS coordinate is 37 UTM, **E 0183238** and **N 9617358.**

Station marked by VES 3.1 at magnetic profile 3 - 3', GPS coordinates E 0183095, N 9617458 selected as Alternative drilling spot.

It is very important to note that during any hydro geological survey (including geophysical survey) for borehole drilling site groundwater is not seen by a naked eye. Geophysical survey method is an indirect method used to locate ground water present in the ground through the study of the geology of the area and location of geological structures. After the survey work confirmation for presence of ground water at a particular site is through the test borehole drilling.

8.0 CONCLUSION AND RECOMMENDATIONS

Detailed geological, hydro geological, topographical and geophysical analysis has been taken into consideration to select suitable drilling site.

To confirm for presence of groundwater and quality at selected and recommended site for borehole drilling construction, test borehole (exploratory borehole) is recommended at a site given (as explained above).

- The recommended drilling depth of the exploratory (test) borehole at 150 meters deep is tentative. Actual depth will be determined from the study of the rock cuttings (samples from the borehole by the consultant site geologist or senior hydrogeology technician.VES sounding field graphs of the recommended borehole drilling site is presented in appendix III with respective magnetic profile graphs, have been included herein the report for reference use by the consultant site geologist or hydrogeology technician.

- Exploratory (test) boreholes should be of 177 or 203.2 mm in diameter, successful (productive) borehole should be converted into production boreholes by increasing the diameter of exploratory borehole from 177 or 203.2 mm to 203.2 or 254 mm. In the borehole drilling contract it should be stated openly that drilling at each site will start with test borehole drilling, then production borehole drilling only if the test borehole is successful. This implies there will be costs for drilling a test borehole at each site and costs for enlarging a successful (productive) test borehole to a production borehole. Drilling second/ alternative site is only if the first site gives unsuccessful result or client demand another borehole.

- Based on data results of geophysical investigation, there is possibility to abstract groundwater at the client's site on the points marked due to observed rock formations and presence of fracture indication which have tendency to percolate and host groundwater.

- **Air Rotary method of drilling is recommended**
- **Drilling of the borehole, design and installation of well assembly and pumping test should be carried out under supervision of a Hydro geologist/ Hydrogeology technician.**
- **Before drilling the driller/client has to apply for a drilling permit.**
- **A client /driller have to provide a construction data, drilled sample and completion form to the respective Office.**
- **After completion of borehole, the client has to apply for water use permit as required in the water Resource Management Act 2009 (Before borehole put in use).**
- **Water from different strikes/ aquifers should be chemically analyzed for quality assessment at the Water Quality Laboratory before put into use.**
- **After construction, a borehole should be fully developed by compressed air until water becomes absolutely silt free.**
- **The actual quantity and quality of water will be known only after drilling.**

- **Application of sanitary seal materials on borehole/ waste water tanks to avoid water pollution.**
- **The recommended diameters of the permanent UPVC plain and screen pipes are either 152 or 203 mm. And the slot size of screen pipes should be in the range of 1.0 mm to 2.0 mm depending on grain size of aquifer formation (for fractured rock aquifers the size may even be 10 mm). Percentage of the open areas of the slots for each screen (UPVC) should not be less than 8%.**

- **The recommended filter pack materials should be clean, well rounded quartz gravels of the diameter size range of 2 to 4 mm depending on the slot size of the screen pipes.**

- **Development of a successful borehole should be by stepwise airlift pumping method, as this is the available method in most drilling company herein Tanzania. And for determination of available quantity of water and other hydraulic parameters of each borehole, recommended pumping test procedures are:-**

(a) Multiple (variable) rate pumping tests (step – draw down test) of not less than 6 hours, the recommended minimum number of steps (pumping rates) is four.

(b) Constant rate pumping test of long duration is highly recommended as these borehole are meant for most likely submersible pumping. The recommended duration of this constant rate pumping is at least 24 hours depending on the type of aquifer (eg. Confined, unconfined or semi-confined). Normally for unconfined and semi-confined aquifer the duration of constant rate pumping test is at least 48 hours and for confined aquifer 24 hours is quite sufficient.

(c) The recommended duration of recovery test after long duration constant rate pumping test is at least one third of the duration of the constant rates pumping test.

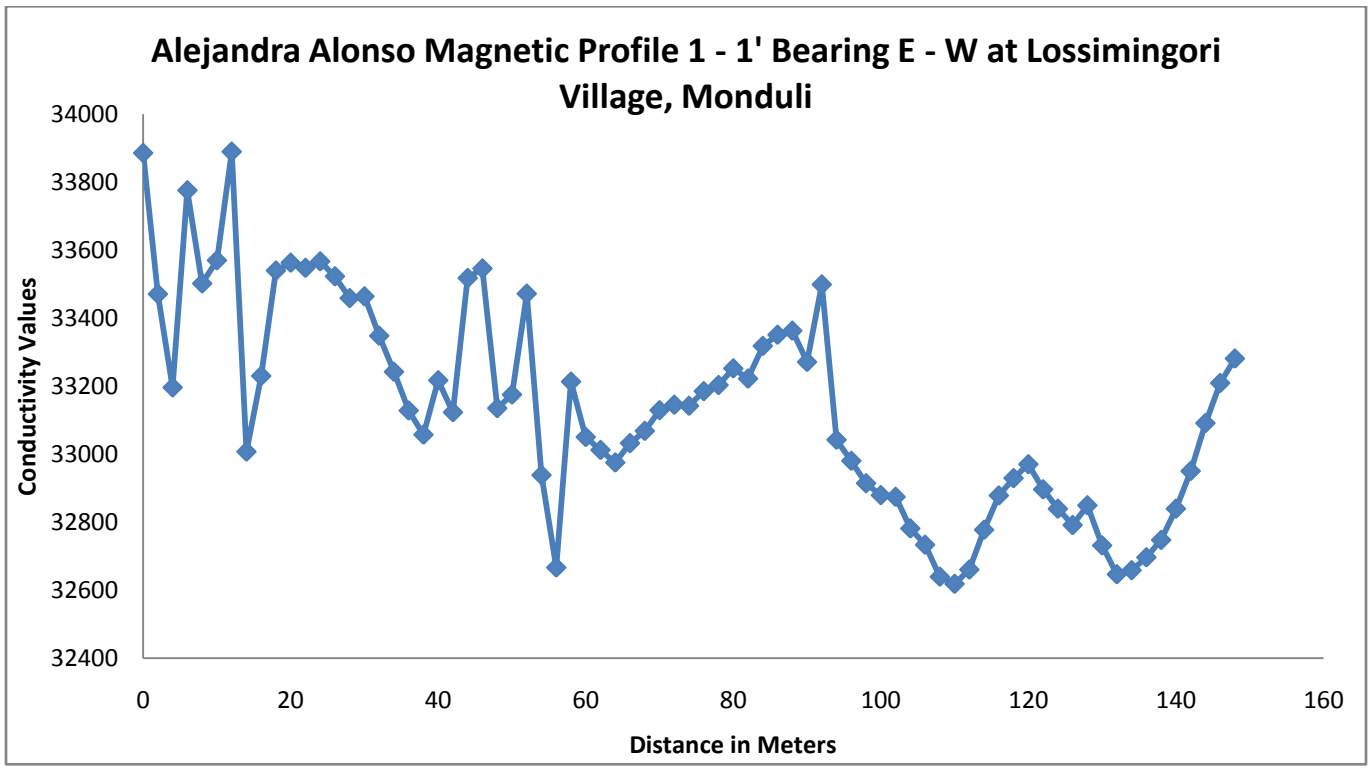
APPENDICES

Appendix I.

SATELLITE MAP OF SURVEYED AREA

Appendix II:

MAGNETIC DATA AND GRAPHS

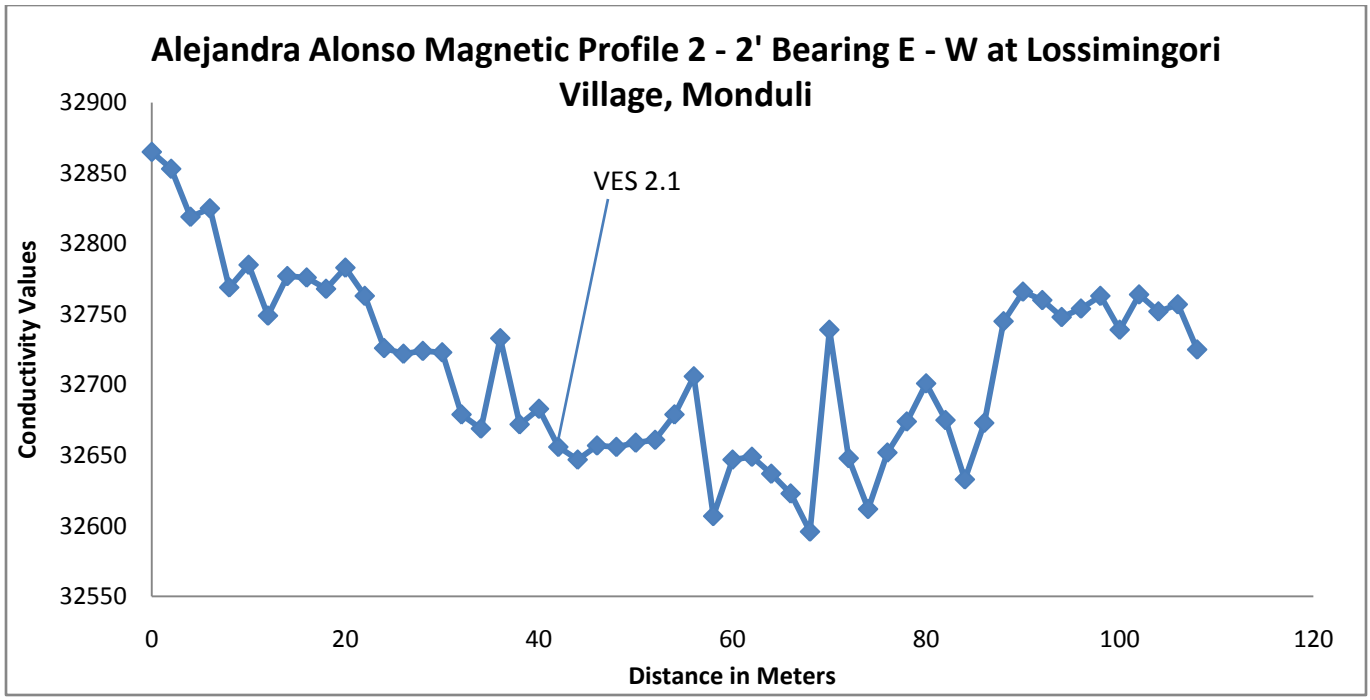


Chem Chem Drilling Company ltd.

Field Magnetic Data

Client:	**ALEJANDRA ALONSO**	**Date**	**13/4/2022**	**GPS Readings**	**Start of Profile**
Site	**ORKISIMA**	**Profile**	**1 - 1'**		**E 0185958/ N 9618673**
Village:	**LOSSIMINGORI**			**Bearing**	**End of Profile**
District:	**MONDULI**	**Altitude:**		**E - W**	**E 0185976/ N 9618522**

Station No.	Conductivity NT Values	Remarks	Station No.	Conductivity NT Values	Remarks	Station No.	Conductivity NT Values	Remarks
0	33886		68	33068		136	32696	
2	33471		70	33129		138	32747	
4	33196		72	33145		140	32839	
6	33776		74	33142		142	32950	
8	33502		76	33185		144	33091	
10	33570		78	33203		146	33209	
12	33890		80	33252		148	33281	
14	33007		82	33222				
16	33230		84	33318				
18	33540		86	33351				
20	33563		88	33363				
22	33548		90	33271				
24	33567		92	33499				
26	33523		94	33042				
28	33459		96	32980				
30	33464		98	32914				
32	33348		100	32879				
34	33242		102	32874				
36	33128		104	32781				
38	33057		106	32733				
40	33217		108	32639				
42	33123		110	32618				
44	33518		112	32660				
46	33546		114	32777				
48	33135		116	32878				
50	33175		118	32929				
52	33472		120	32970				
54	32938		122	32896				
56	32666		124	32839				
58	33213		126	32791				
60	33050		128	32849				
62	33012		130	32731				
64	32975		132	32646				
66	33032		134	32658				


Alejandra Alonso Magnetic Profile 2 - 2' Bearing E - W at Lossimingori Village, Monduli
VES 2.1
Conductivity Values
32900
32850
32800
32750
32700
32650
32600
32550
0
20
40
60
80
100
120
Distance in Meters

Chem Chem Drilling Company ltd.

Field Magnetic Data

Client:	**ALEJANDRA ALONSO**	**Date**	**13/4/2022**	**GPS Readings**	**Start of Profile**
Site	**ORKISIMA**	**Profile**	**2 - 2'**		**E 0185801/ N 9618467**
Village:	**LOSSIMINGORI**			**Bearing**	**End of Profile**
District:	**MONDULI**	**Altitude:**		**E - W**	**E 0185843/ N 9618368**

Station No.	Conductivity NT Values	Remarks	Station No.	Conductivity NT Values	Remarks	Station No.	Conductivity NT Values	Remarks
0	32865		68	32596				
2	32853		70	32739				
4	32819		72	32648				
6	32825		74	32612				
8	32769		76	32652				
10	32785		78	32674				
12	32749		80	32701				
14	32777		82	32675				
16	32776		84	32633				
18	32768		86	32673				
20	32783		88	32745				
22	32763		90	32766				
24	32726		92	32760				
26	32722		94	32748				
28	32724		96	32754				
30	32723		98	32763				
32	32679		100	32739				
34	32669		102	32764				
36	32733		104	32752				
38	32672		106	32757				
40	32683		108	32725				
42	32656	VES 2.1						
44	32647							
46	32657							
48	32656							
50	32659							
52	32661							
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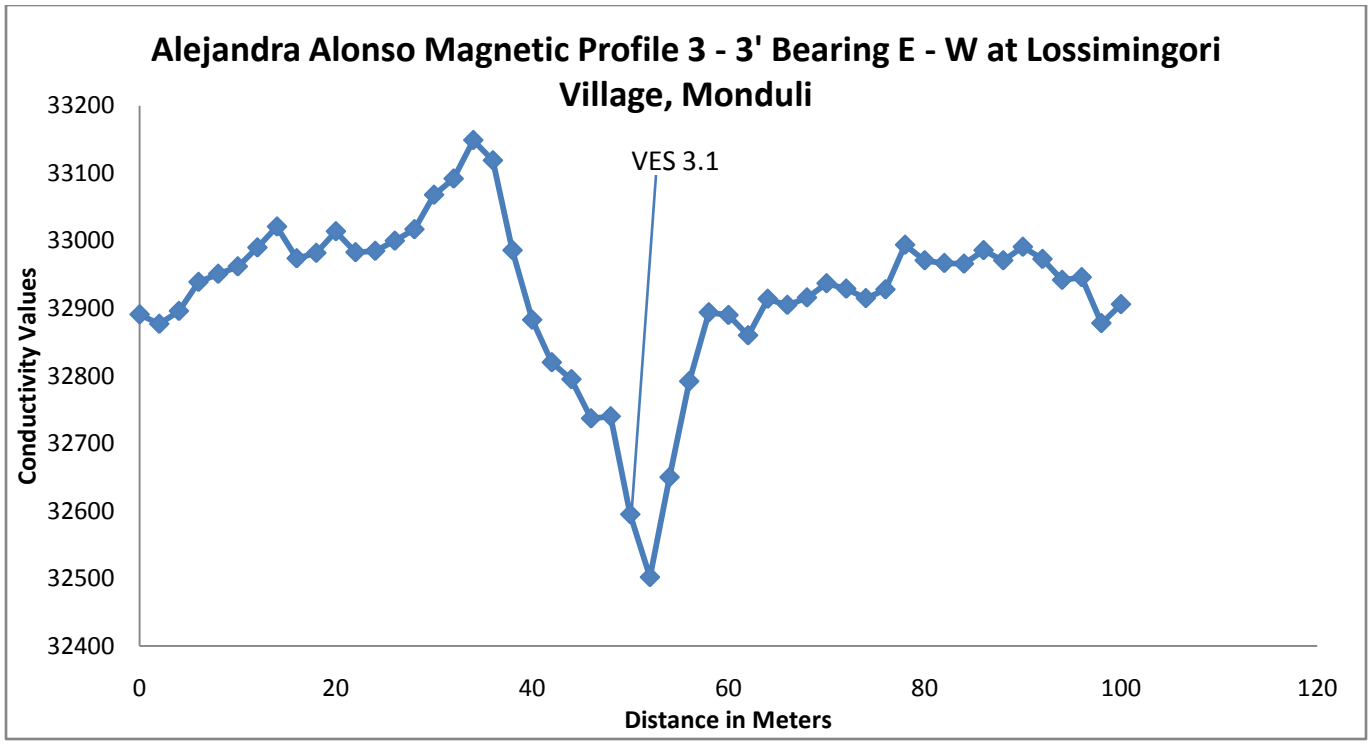
Alejandra Alonso Magnetic Profile 3 - 3' Bearing E - W at Lossimingori Village, Monduli
VES 3.1
Conductivity Values
33200
33100
33000
32900
32800
32700
32600
32500
32400
0
20
40
60
80
100
120
Distance in Meters

Chem Chem Drilling Company ltd.

Field Magnetic Data

Client:	**ALEJANDRA ALONSO**	**Date**	**13/4/2022**	**GPS Readings**	**Start of Profile**
Site	**ORKISIMA**	**Profile**	**3 - 3'**		**E 0183049/ N 9617449**
Village:	**LOSSIMINGORI**			**Bearing**	**End of Profile**
District:	**MONDULI**	**Altitude:**		**E - W**	**E 0183148/ N 9617461**

Station No.	Conductivity NT Values	Remarks	Station No.	Conductivity NT Values	Remarks	Station No.	Conductivity NT Values	Remarks
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2	32877		70	32937				
4	32896		72	32929				
6	32939		74	32915				
8	32951		76	32928				
10	32962		78	32994				
12	32990		80	32971				
14	33021		82	32967				
16	32974		84	32966				
18	32982		86	32986				
20	33014		88	32971				
22	32983		90	32991				
24	32985		92	32973				
26	33000		94	32942				
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32	33092		100	32906				
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36	33119							
38	32986							
40	32883							
42	32820							
44	32795							
46	32737							
48	32740							
50	32595	VES 3.1						
52	32502							
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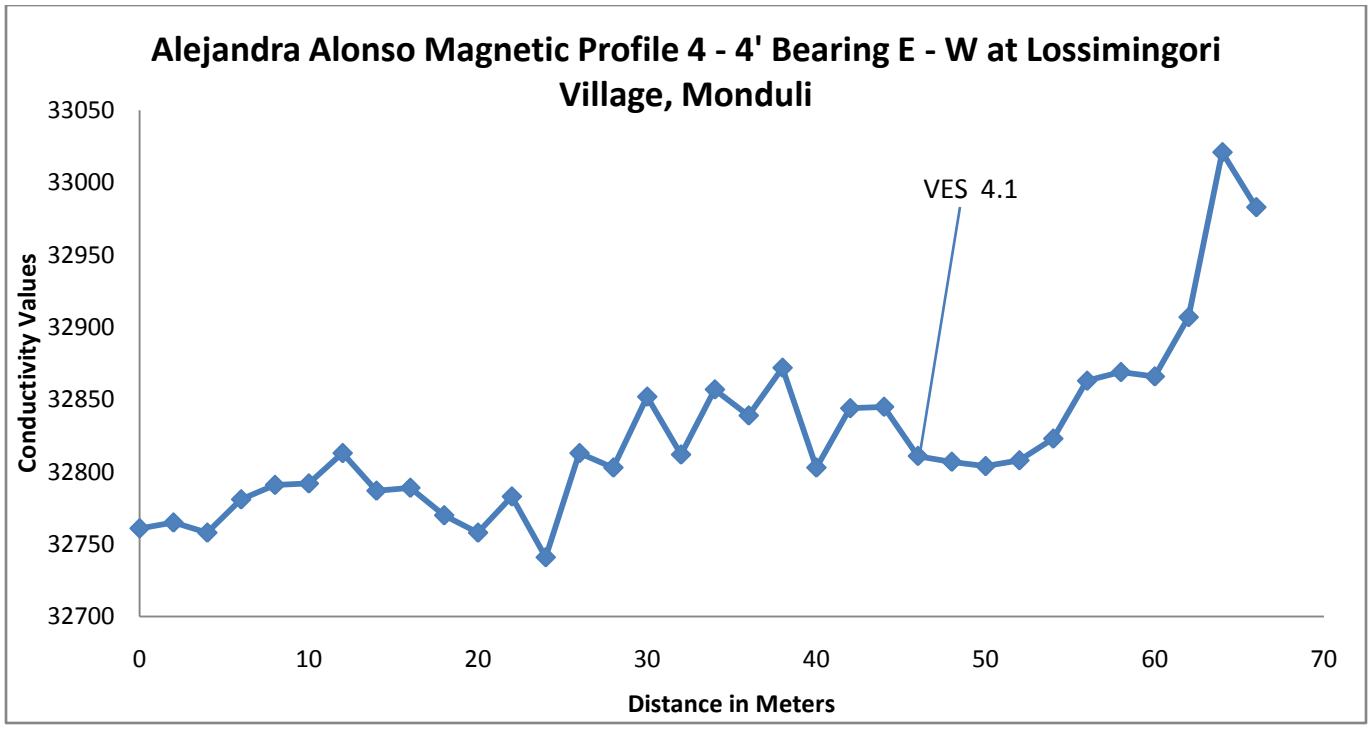
Alejandra Alonso Magnetic Profile 4 - 4' Bearing E - W at Lossimingori Village, Monduli
Conductivity Values
33050
33000
32950
32900
32850
32800
32750
32700
VES 4.1
0
10
20
30
40
50
60
70
Distance in Meters

Chem Chem Drilling Company ltd.

Field Magnetic Data

Client:	**ALEJANDRA ALONSO**	**Date**	**14/4/2022**	**GPS Readings**	**Start of Profile**
Site	**ORKISIMA**	**Profile**	**4 - 4'**		**E 0183197/ N 9617377**
Village:	**LOSSIMINGORI**			**Bearing**	**End of Profile**
District:	**MONDULI**	**Altitude:**		**E - W**	**E 0183257/ N 9617349**

Station No.	Conductivity NT Values	Remarks	Station No.	Conductivity NT Values	Remarks	Station No.	Conductivity NT Values	Remarks
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2	32765							
4	32758							
6	32781							
8	32791							
10	32792							
12	32813							
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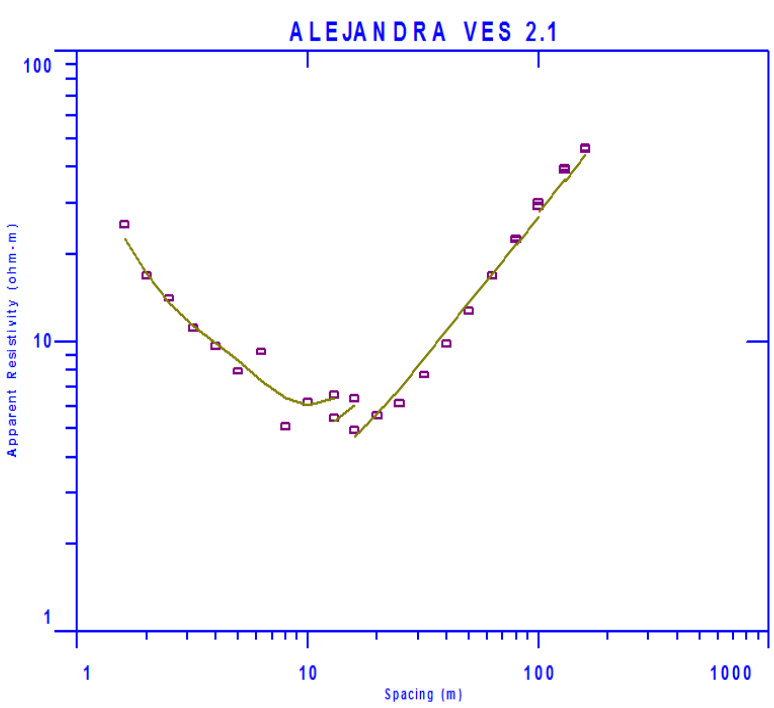
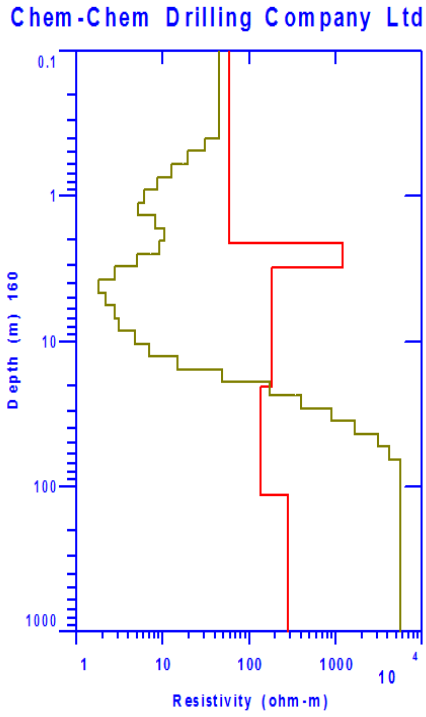
20	32758							
22	32783							
24	32741							
26	32813							
28	32803							
30	32852							
32	32812							
34	32857							
36	32839							
38	32872							
40	32803							
42	32844							
44	32845							
46	32811	VES 4.1						
48	32807							
50	32804							
52	32808							
54	32823							
56	32863							
58	32869							
60	32866							
62	32907							
64	33021							
66	33357							

Appendix III:

VERTICAL ELECTRICAL SOUNDING DATA AND CURVES





Chemchem Drilling Company Ltd.

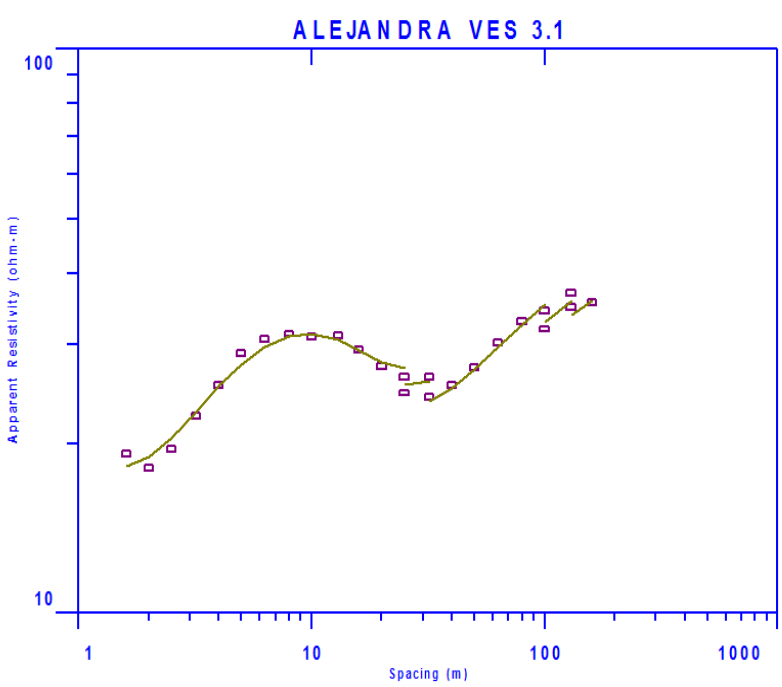
Field Data: Vertical Electrical Soundings

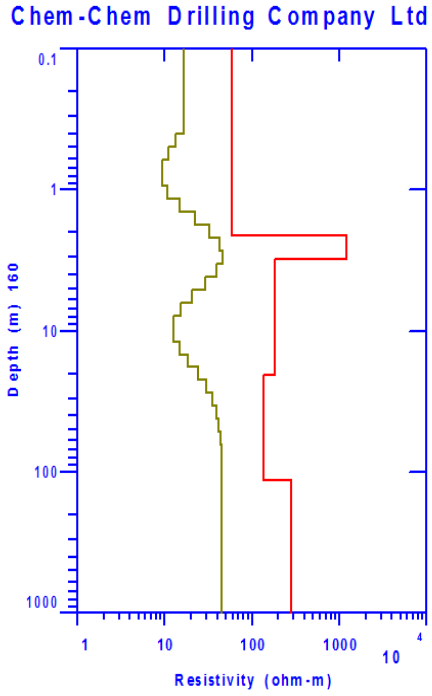
Client:	ALEJANDRA ALONSO		Date	14/4/2022	Profile	VES No.
Site:	ORKISIMA		GPS 37 UTM	E 0185817	2 - 2'	
Village:	LOSSIMINGORI		Readings:	N 9618430	station	2.1'
District	MONDULI		Altitude:		42 M	

AB/2	MN/2		K				ΔV/I		Pα	
[m]	[m]				[ohms]		[milliohms]		[ohm m]	
1	1	2	1	2	1	2	1	2	1	2
1.6	0.5		7.26		3.4928				25.36	
2			11.8		1.4314				16.89	
2.5			18.8				750.59		14.11	
3.2			31.4				354.74		11.14	
4			49.5				194.61		9.63	
5			77.8				101.73		7.91	
6.3			124				74.47		9.23	
8			200				25.43		5.09	
10			313				19.72		6.17	
13	0.5	5	530	45.2			12.34	113.87	6.54	5.47
16	0.5	5	803	72.6			7.905	68.277	6.35	4.96
20			118				44.019		5.55	
25			188				32.660		6.14	
32			314				24.469		7.68	
40			495				19.772		9.79	
50			778				16.390		12.75	
63			1240				13.648		16.92	
80	5	10	2000	990			11.319	22.64	22.64	22.42
100	5	10	3130	1560			9.309	19.377	29.14	30.23
130	5	10	2640	1020			15.003	38.28	39.61	39.04
160	5	10	4010	1570			11.456	29.544	45.94	46.38

GEOMETRIC CONSTANT (K)

AB/2	MN/2 [m]		AB/2	MN/2(K)				
[m]	0.5	5	[m]	0.5	5	10	25	50
1.6	7.26	-	20	1260	118	47.1	-	-
2	11.8	-	25	1960	188	82.43	-	-
2.5	18.8	-	32	3220	314	145	25.1	-
3.2	31.4	-	40	5030	495	236	61.23	-
4	49.5	-	50	7850	778	377	118	-
5	77.8	-	63	12500	1240	608	210	46.1
6.3	124	4.61	80	20100	2000	990	363	122
8	200	12.25	100	31400	3130	1560	589	236
10	313	23.6	130	53100	5300	2640	1020	452
13	530	45.2	160	80400	8030	4010	1570	726
16	803	72.6	200	12600	12600	6270	2470	1180
20	1260	118	250	-	19600	9800	3890	1880


ALEJANDRA VES 3.1
100
10
Apparent Resistivity (ohm-m)
1
10
100
1000
Spacing (m)


Chem-Chem Drilling Company Ltd
0.1
1
10
100
1000
Depth (m) 160
1
10
100
1000
10 4
Resistivity (ohm-m)

Chemchem Drilling Company Ltd.

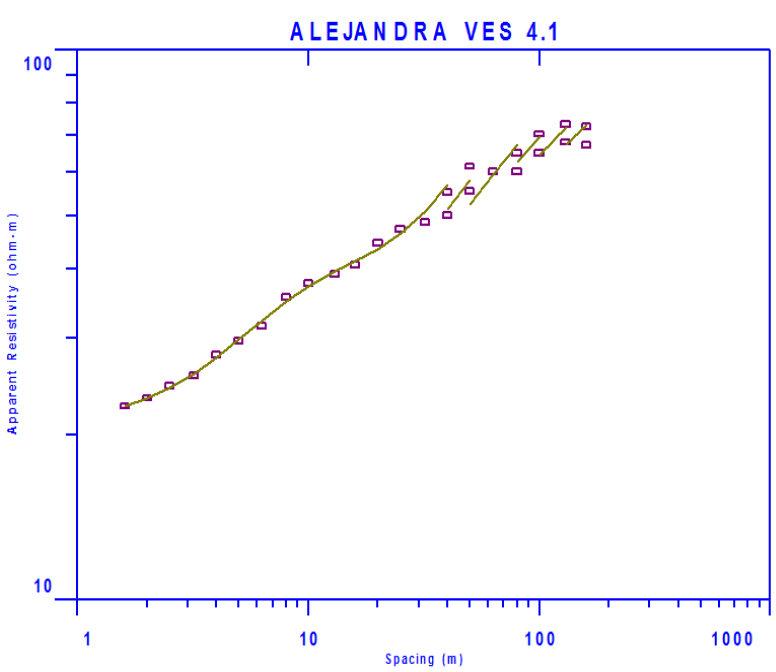
Field Data: Vertical Electrical Soundings

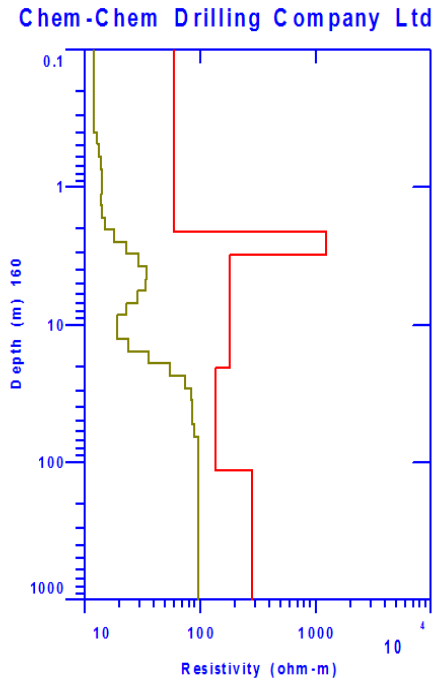
Client:	ALEJANDRA ALONSO		Date	14/4/2022	Profile	VES No.
Site:	ORKISIMA		GPS 37 UTM	E 0183095	3 - 3'	
Village:	LOSSIMINGORI		Readings:	N 9617458	station	3.1'
District	MONDULI		Altitude:		50 M	

AB/2	MN/2		K				ΔV/I		Pα	
[m]	[m]				[ohms]		[milliohms]		[ohm m]	
1	1	2	1	2	1	2	1	2	1	2
1.6	0.5		7.26		2.6401				19.17	
2			11.8		1.5335				18.10	
2.5			18.8		1.0371				19.50	
3.2			31.4				712.23		22.36	
4			49.5				512.18		25.35	
5			77.8				371.20		46.03	
6.3			124				246.93		30.62	
8			200				156.04		31.28	
10			313				98.53		30.84	
13			530				58.61		31.06	
16			803				36.537		29.34	
20			1260				21.718		27.36	
25	0.5	5	1960	188			13.374	130.67	26.21	24.57
32	0.5	5	3220	314			8.136	76.981	26.20	24.17
40			495				51.260		25.37	
50			778				35.003		27.23	
63			1240				24.003		30.13	
80			2000				16.422		32.84	
100	5	10	3130	1560			10.980	20.446	34.37	31.89
130	5	10	2640	1020			6.9764	13.80	36.97	34.82
160	5	10	4010	1570			8.846	22.636	35.47	35.54

GEOMETRIC CONSTANT (K)

AB/2	MN/2 [m]		AB/2	MN/2(K)				
[m]	0.5	5	[m]	0.5	5	10	25	50
1.6	7.26	-	20	1260	118	47.1	-	-
2	11.8	-	25	1960	188	82.43	-	-
2.5	18.8	-	32	3220	314	145	25.1	-
3.2	31.4	-	40	5030	495	236	61.23	-
4	49.5	-	50	7850	778	377	118	-
5	77.8	-	63	12500	1240	608	210	46.1
6.3	124	4.61	80	20100	2000	990	363	122
8	200	12.25	100	31400	3130	1560	589	236
10	313	23.6	130	53100	5300	2640	1020	452
13	530	45.2	160	80400	8030	4010	1570	726
16	803	72.6	200	12600	12600	6270	2470	1180
20	1260	118	250	-	19600	9800	3890	1880


ALEJANDRA VES 4.1
100
10
Apparent Resistivity (ohm-m)
1
10
100
1000
Spacing (m)


Chem-Chem Drilling Company Ltd
0.1
1
10
100
1000
Depth (m) 160
10
100
1000
10
4
Resistivity (ohm-m)

Chemchem Drilling Company Ltd.

Field Data: Vertical Electrical Soundings

Client:	ALEJANDRA ALONSO		Date		14/4/2022	Profile	VES No.
Site:	ORKISIMA		GPS	37 UTM	E 0183238	4 - 4'	
Village:	LOSSIMINGORI		Readings:		N 9617358	station	4.1'
District	MONDULI		Altitude:			46 M	

AB/2	MN/2		K				ΔV/I		Pα	
[m]	[m]				[ohms]		[milliohms]		[ohm m]	
1	1	2	1	2	1	2	1	2	1	2
1.6	0.5		7.26		3.102				22.52	
2			11.8		1.9749				23.30	
2.5			18.8		1.302				24.48	
3.2			31.4				815.15		25.60	
4			49.5				564.74		27.95	
5			77.8				379.54		29.53	
6.3			124				254.17		31.52	
8			200				177.40		35.48	
10			313				120.14		37.60	
13			530				73.87		39.15	
16			803				50.667		40.69	
20			1260				35.445		44.66	
25			1960				24.084		47.20	
32			3220				15.079		48.55	
40	0.5	5	5,030	495			10.975	101.07	55.20	50.03
50	0.5	5	7850	778			7.829	71.245	61.46	55.43
63			1240				48.523		60.17	
80	5	10	2000	990			32.418	60.70	64.84	60.09
100	5	10	3130	1560			22.471	41.568	70.33	64.85
130	5	10	2640	1020			13.803	25.77	73.16	68.02
160	5	10	4010	1570			9.0518	16.775	72.69	67.27

GEOMETRIC CONSTANT (K)

AB/2	MN/2 [m]		AB/2	MN/2(K)				
[m]	0.5	5	[m]	0.5	5	10	25	50
1.6	7.26	-	20	1260	118	47.1	-	-
2	11.8	-	25	1960	188	82.43	-	-
2.5	18.8	-	32	3220	314	145	25.1	-
3.2	31.4	-	40	5030	495	236	61.23	-
4	49.5	-	50	7850	778	377	118	-
5	77.8	-	63	12500	1240	608	210	46.1
6.3	124	4.61	80	20100	2000	990	363	122
8	200	12.25	100	31400	3130	1560	589	236
10	313	23.6	130	53100	5300	2640	1020	452
13	530	45.2	160	80400	8030	4010	1570	726
16	803	72.6	200	12600	12600	6270	2470	1180
20	1260	118	250	-	19600	9800	3890	1880