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ELECTRICAL RESISTIVITY AND THERMAL CONDUCTIVITY TESTS FOR SOLAR POWER PROJECT AT DEH HALKANI, GADAP TOWN, KARACHI

Client: M/s. Renewable Resource (Pvt.) Limited

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PROJECT: ELECTRICAL RESISTIVITY TESTS & THERMAL CONDUCTIVITY TESTS FOR SOLAR POWER PROJECT AT DEH HALKANI, KARACHI

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SOIL TESTING SERVICES

Table of Contents

1.0 INTRODUCTION

Planning for Solar Power Project at Deh Halkani, Gadap Town, Karachi is underway. For this purpose, determination of the properties of subsurface deposits was essential. A program for electrical resistivity and thermal conductivity tests was, therefore, chalked out to evaluate these properties. *M/s. Soil Testing Services* were entrusted by *M/s. Renewable Resource Pvt. Limited* to carry out the tests pertaining to the determination of properties of the subsurface deposits.

Scope of fieldwork included performance of six (06) thermal conductivity tests and fifteen (15) electrical resistivity tests. This report presents a detailed account of these tests carried out at the project site.

The site conditions have been presented in Section 2 of this report. Details of thermal conductivity tests including working principle and test results have been presented in Section 3. In Section 4, working principle, details of fieldwork and test results regarding the electrical resistivity tests are discussed. Salient features of the report have been summarised in the concluding section.

2.0 SITE

The project site is located off Karachi Northen Bypass in Halkani, Gadap Town Karachi.

The topography of the area is almost plain with no major changes in elevation observed across the site. Bushes and wild plants were found at most of the site area. Figure 2.1 shows the google image of the site.

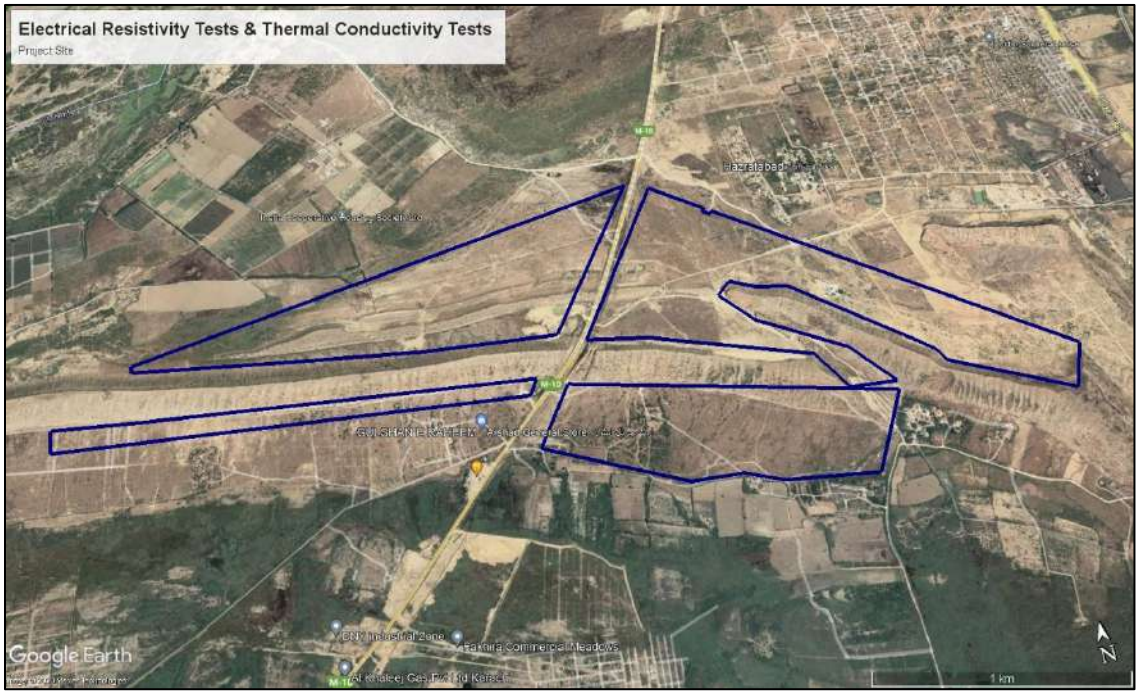


Fig 2.1: Google image of the the Neighbourhood area (Courtesy: Google Earth)

3.0 THERMAL CONDUCTIVITY TESTS

3.1 Equipment

The equipment used for thermal conductivity and thermal resistivity is KD2 Pro Thermal Property Analyser. The accessories of the equipment include KD2 pro portable unit, thermal sensor (TR-1), thermal grease, drill bits and pilot pins. The specifications of the equipment are listed in table 3.1.

Table 3.1 Specifications of the equipment

Accuracy	±5 to ±10% Thermal Conductivity/Resistivity
Measurement speed	1, 2, 5, & 10 min. read times depending on measurement type
Data storage	4,095 readings, flash memory
Compliance to Standards	ASTM Standard D5334-08 and IEEE Standard 442-1981
Operating environment	-50 to 150°C for sensors
Battery source	4 AA
Type	Ultra low-power 16-bit microcontroller w/ 24-bit A/D converter
Display	Liquid Crystal Display (LCD) 7.5 cm x 4 cm
Case dimensions	15.5 x 9.5 x 3.5 cm

3.2 Working Principle

The test method conforms to the transient line heat source theory. The thermal conductivity and thermal resistivity tests were performed in accordance with the ASTM D-5334.

Our test method is based on the theory that the rate of temperature rise of a line heat source depends on the thermal constants of the medium in which it is placed. A long, cylindrical, stainless steel needle sensor is used as a line heat source. The sensor (TR-1) is a 10 cm long thermal needle sensor. The sensor contains a heating element and a thermocouple and is inserted into the material to be tested. After the sensor is inserted, the heating element is turned on and kept on for 1-10 minutes (time is based on the sensor used). Sensor temperature variations are measured and analyzed by the Thermal Properties Analyzer Instrument to calculate the Thermal

Resistivity and Thermal Conductivity. These readings are read directly on the LCD panel of the instrument.

3.2 Test Results

Scope of work at the site included performance of tests at six (06) locations.

Table 3.1 summarizes the results collected by KD2 pro Thermal Properties Analyzer. The values of thermal conductivity, thermal resistivity and ground temperature have been presented in the table below.

Table 3.1 Thermal Conductivity and Thermal Resistivity Values

Test No.	Nearby Borehole No.	Surface Temperature (°C)	Thermal Conductivity (K)	Thermal Resistivity (rho)	Date
			W/(m·K)	(m·K)/W	
1	BH-19	23.81	0.411	2.433	11th December, 2022
2	BH-11	31.08	0.396	2.523	11th December, 2022
3	BH-30	29.89	0.502	1.993	11th December, 2022
4	BH-22	32.50	0.811	1.233	11th December, 2022
5	BH-01	30.41	0.745	1.342	11th December, 2022
6	BH-03	30.91	0.770	1.298	11th December, 2022

4.0 ELECTRICAL RESISTIVITY TESTS

4.1 Working Principle

Electrical resistivity tests are performed in accordance with ASTM-6431-99 and ASTM G-57. Electrical resistivity tests require inserting four probes into the test area. The probes are installed in a straight line spaced according to the type of configuration to be used during the testing. Following configurations was used to perform the tests at the site.

1. Wenner Configuration

The probes are installed in a straight line and equally spaced. The probes establish an electrical contact with the earth. The meter injects current through the ground via the tester and the outer two probes. The current flowing through the earth (a resistive material) develops a voltage / potential difference. This voltage drop resulting from the current flow is then measured between the two inner probes.

The meter then knows the amount of current that is flowing through the earth and the voltage drop across the two center probes. With this information the meter uses ohms law (R=V/I) to calculate and display the resistance in ohms. The product of the measured resistance and geometric factor is known as apparent resistivity.

The calculated soil resistivity is the average of the soil resistivity from the surface to a depth equivalent to the probe spacing. For example, a probe spacing of 10 meters between each probe will provide the average soil resistivity between the surface and a depth of 10 meters.

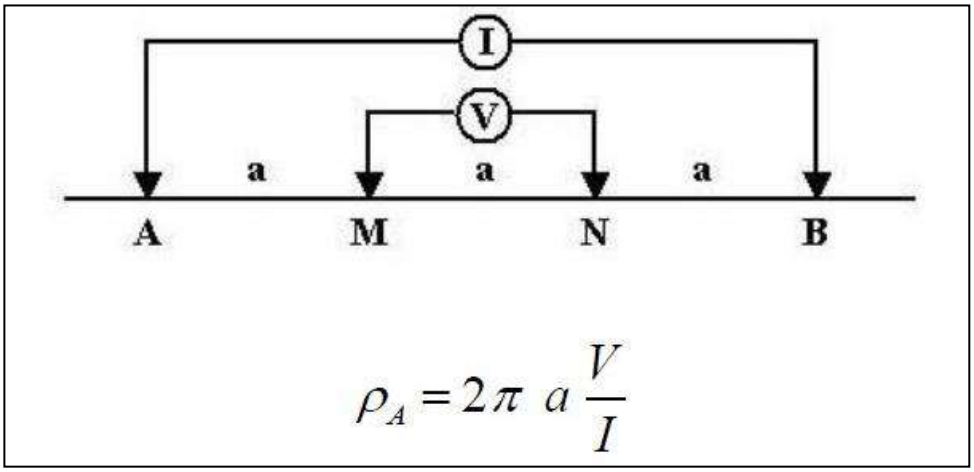


Figure 4.1 Schematic Diagram of Wenner Array

4.2 Electrical Properties of Ground

All materials, including soil and rock, have an intrinsic property, resistivity that governs the relation between the current density and the gradient of the electrical potential. Variations in the resistivity of earth materials either vertically or laterally, produce variations in the relations between the applied current and the potential distribution as measured on the surface or thereby reveal something about the composition, extent and physical properties of the subsurface materials. The various electrical geophysical techniques distinguish materials through whatever contrast exists in their electrical properties. Materials that differ geologically, such as described in a lithologic log from a drill hole, may or may not differ electrically and, therefore, may or may not be distinguished by an electrical resistivity survey. Properties that affect the resistivity of a soil or rock include porosity, water content, composition (clay mineral and metal content), salinity of the pore water, and grain size distribution.

Table 4.1 Typical electrical resistivity's of earth materials

Material	Resistivity (Ωm)
Clay	1-20
Sand, wet to moist	20-200
Shale	1-500
Porous limestone	100-1,000
Dense limestone	1,000-1,000,000
Metamorphic rocks	50-1,000,000
Igneous rocks	100-1,000,000

Table 4.1 shows some typical ranges of resistivity values for manmade materials and natural minerals and rocks, similar to numerous tables found in the literature (van Blaricon 1980; Telford et al. 1976; Keller and Frischknecht 1966). The ranges of values shown are those commonly encountered but do not represent extreme values. It may be inferred from the

values listed that the user would expect to find in a typical resistivity survey. Low resistivities for the soil layers, with underlying bedrock producing higher resistivities. Usually, this will be the case, but the particular conditions of a site may change the resistivity relationships. For example, coarse sand or gravel, if it is dry, may have a resistivity like that of igneous rocks, whereas a layer of weathered rock may be more conductive than the soil overlying it. In any attempt to interpret resistivities in terms of soil types or lithology, consideration should be given to the various factors that affect resistivity.

Table 4.2 Resistivity versus Corrosivity of Soil

Corrosivity	**Resistivity (Ω-m)**
Very Corrosive	Below 5
Corrosive	5-10
Moderately Corrosive	10-20
Mildly Corrosive	20-100
Generally not Corrosive	> 100

4.3 Electrical Resistivity Interpretation

Electrical resistivity tests were conducted at fifteen (15) different locations across the site up to the depth of 10.0 meters. The interpretation of resistivity values for each location is described in this section.

4.3.1 Soil resistivity for all lines

The resistivity values recorded at the site range from *0.87 Ω-m to 469.23 Ω-m*. The underground environment is categorized as *very corrosive to non-corrosive*. Table 4.3 corresponds to the corrosivity at various depths ranges in various line lines.

Table 4.3 Corrosivity at various depths in test lines

Test Line	Depth Range (m)	Corrosivity
ERS-1	0.0 – 3.0 3.0 – 10.0	Moderately corrosive Corrosive
ERS-2	0.0 – 10.0	Moderately corrosive
ERS-3	0.0 – 1.0 1.0 – 10.0	Mildly corrosive Non-Corrosive
ERS-4	0.0 – 3.0 3.0 – 5.0 5.0 – 10.0	Non-corrosive Mildly corrosive Moderately corrosive
ERS-5	0.0 – 1.0 1.0 – 10.0	Mildly corrosive Non-Corrosive
ERS-6	0.0 – 10.0	Non-corrosive
ERS-7	0.0 – 10.0	Non-corrosive
ERS-8	0.0 – 10.0	Non-corrosive
ERS-9	0.0 – 10.0	Non-corrosive
ERS-10	0.0 – 10.0	Non-corrosive
ERS-11	0.0 – 5.0 5.0 – 7.0 7.0 – 10.0	Corrosive Mildly corrosive Moderately corrosive
ERS-12	0.0 – 3.0 3.0 – 5.0 5.0 – 10.0	Very corrosive Corrosive Very corrosive
ERS-13	0.0 – 1.0 1.0 – 3.0 3.0 – 5.0 5.0 – 10.0	Very corrosive Corrosive Very corrosive Moderately corrosive
ERS-14	0.0 – 1.0 1.0 – 5.0 5.0 – 10.0	Mildly corrosive Moderately corrosive Corrosive
ERS-15	0.0 – 1.0 1.0 – 10.0	Moderately corrosive Mildly corrosive

Figure 4.2 Electrical resistivity Test in progress

Figure 4.3 Electrical resistivity Test in progress

5.0 RECOMMENDATIONS & CONCLUSIONS

- Electrical resistivity and thermal conductivity tests for Solar Power Project at Deh Halkani, Gadap Town, Karachi were carried out in December 2022.
- Scope of work included six (06) thermal conductivity tests and fifteen (15) electrical resistivity tests.
- The values of thermal conductivity and thermal resistivity have been presented in table 3.1.
- Appropriate measures need to be taken in order to prevent the corrosion of all metallic objects and grounding of electrical equipment.

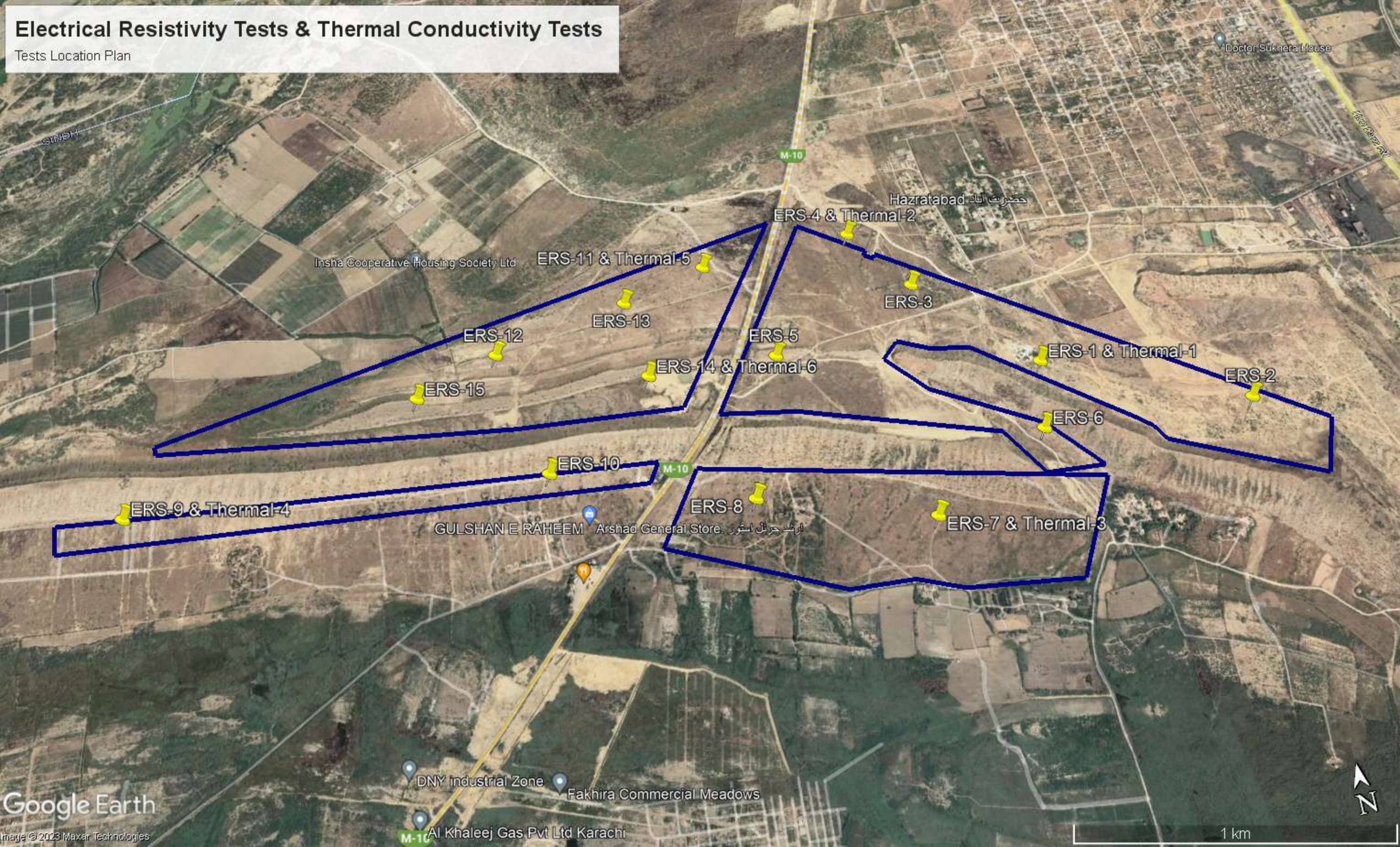
APPENDICES

APPENDIX-A

TEST LOCATION PLAN

Electrical Resistivity Tests & Thermal Conductivity Tests

Tests Location Plan



APPENDIX-B

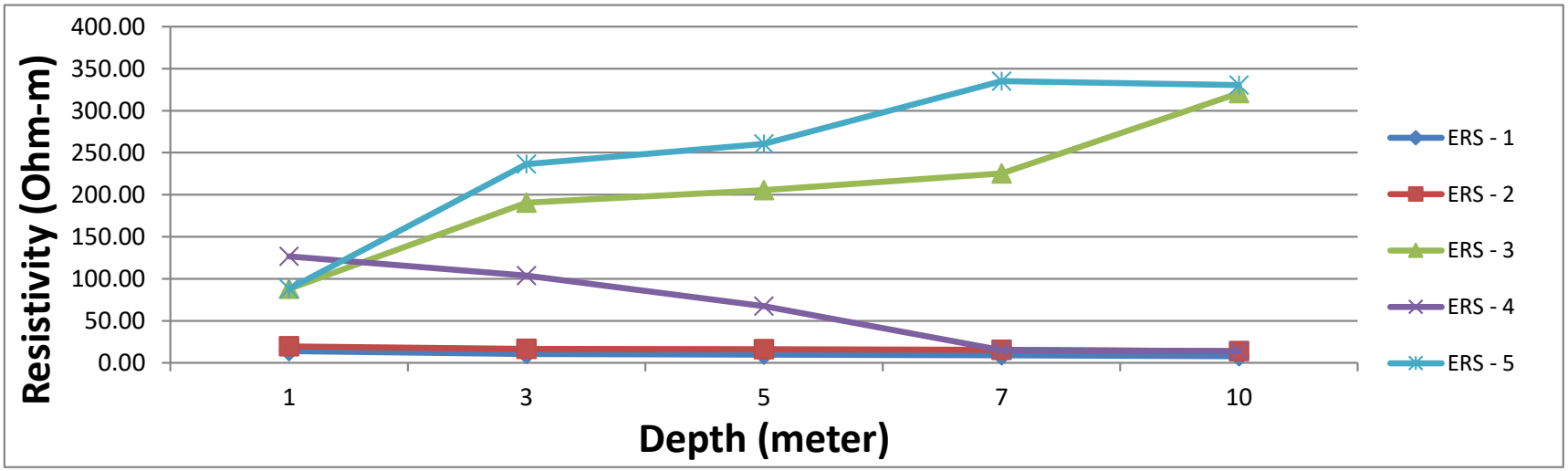
TEST RESULTS FOR ELECTRICAL RESISTIVITY TESTS

K22-1245-101

Project: Solar Power Project at Deh Halkani

Client: M/s. Renewable Resource Private Limited

Depth (meters)	ERS - 1	ERS - 2	ERS - 3	ERS - 4	ERS - 5
	Resistivity (Ohm-m)				
1	13.94	19.49	87.91	126.62	87.98
3	10.37	16.74	190.41	103.78	236.40
5	9.52	16.06	205.49	67.36	260.47
7	8.89	15.57	225.22	15.00	335.19
10	7.79	13.82	320.86	13.89	330.54



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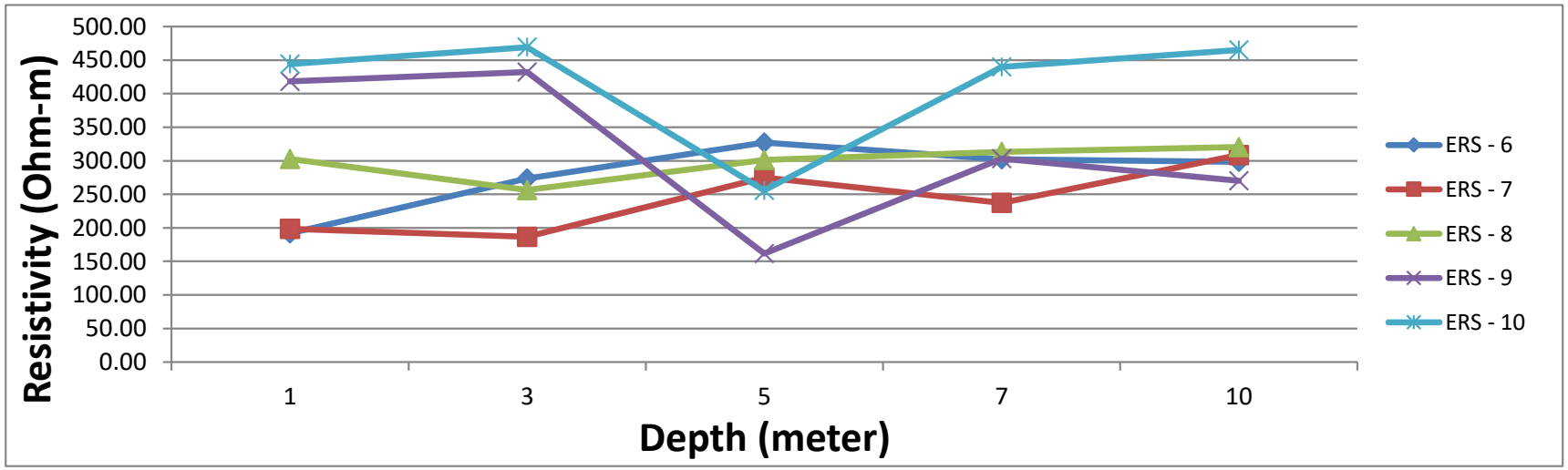
Project: Solar Power Project at Deh Halkani

Client: M/s. Renewable Resource Private Limited

Depth (meters)	ERS - 6	ERS - 7	ERS - 8	ERS - 9	ERS - 10
	Resistivity (Ohm-m)				
1	191.91	198.45	302.45	418.39	444.15
3	273.35	186.73	256.44	432.28	469.23
5	327.08	275.11	301.00	161.66	255.92
7	302.20	237.10	313.19	303.08	439.84
10	298.49	308.54	320.48	270.34	465.08



K22-1245-101

Project: Solar Power Project at Deh Halkani

Client: M/s. Renewable Resource Private Limited

Depth (meters)	ERS - 11	ERS - 12	ERS - 13	ERS - 14	ERS - 15
	Resistivity (Ohm-m)				
1	5.71	3.20	4.39	33.16	18.04
3	8.54	4.26	7.50	15.57	32.80
5	7.57	6.50	3.24	11.34	31.73
7	21.95	1.28	17.16	9.24	38.27
10	18.22	0.88	16.34	9.24	35.19