Report on Conductivity Measurement of Soil around Jaliardwip at Teknaf

BUREAU OF RESEARCH, TESTING & CONSULTATION
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
CHITTAGONG UNIVERSITY OF ENGINEERING & TECHNOLOGY
CHATTOGRAM-4349, BANGLADESH

1.0. Introduction

Prof. Mahmood Omar Imam, Team Leader, Naf project, Consultancy Services for Construction of Cable Car in Naf Tourism Park, issued Work Order (Ref. No.: CUET/BRTC-Naf/21/21/89(1) Date: 22.03.2021) for **'Conductivity Measurement of Soil around Jaliardwip at Teknaf'** in 32 locations to BRTC, Department of EEE, CUET.

In response, BRTC, EEE, CUET carried out Conductivity Tests of Soil at **29 locations** around the Jaliardwip at Teknaf. The tests report is enclosed here.

Test Apparatus:

Instrument Name	Model/Asset number	Serial Number
Earth Resistance & Resistivity Tester	KEW 4106	E0107639

Environmental Conditions:

Weather Conditions		Soil Conditions	Soil Type
Sunny		Wet	Loam
Partly Overcast		Moist	Clay
Overcast		Dry	Sand
Raining		Very Dry/Arid	Stone/Granite
Temperature: (Oct"21)	34°C	Humidity: (Oct"21)	89%
Temperature: (Dec'21)	28°C	Humidity: (Dec'21)	55%

Test Points/Locations:

SL	Test Points	SL	Test Points	SL	Test Points
1	Station-A	11	Station-B, Additional Point	21	T-2B7C (Ex-3)
2	Station-A	12	Station-B	22	T-2B7C (Ex-4)
3	T-1B7A	13	2B	23	Station-A, Additional Point-1
4	T-1B6A	14	T-2B1C	24	Station-A, Additional Point-2
5	T-1B5A	25	T-2B2C	25	Station-A, Additional Point-3
6	T-1B4A	16	T-2B5C	26	Station-A, Additional Point-4
7	T-1B3A	17	T-2B6C	27	Station-A, Additional Point-5
8	T-1B2A	18	T-2B7C	28	Station-A, Additional 1 (Right side)
9	T-1B1A	19	T-2B7C (Ex-1)	29	Station-A, Additional -2 (Left side)
10	1B	20	T-2B7C (Ex-2)		

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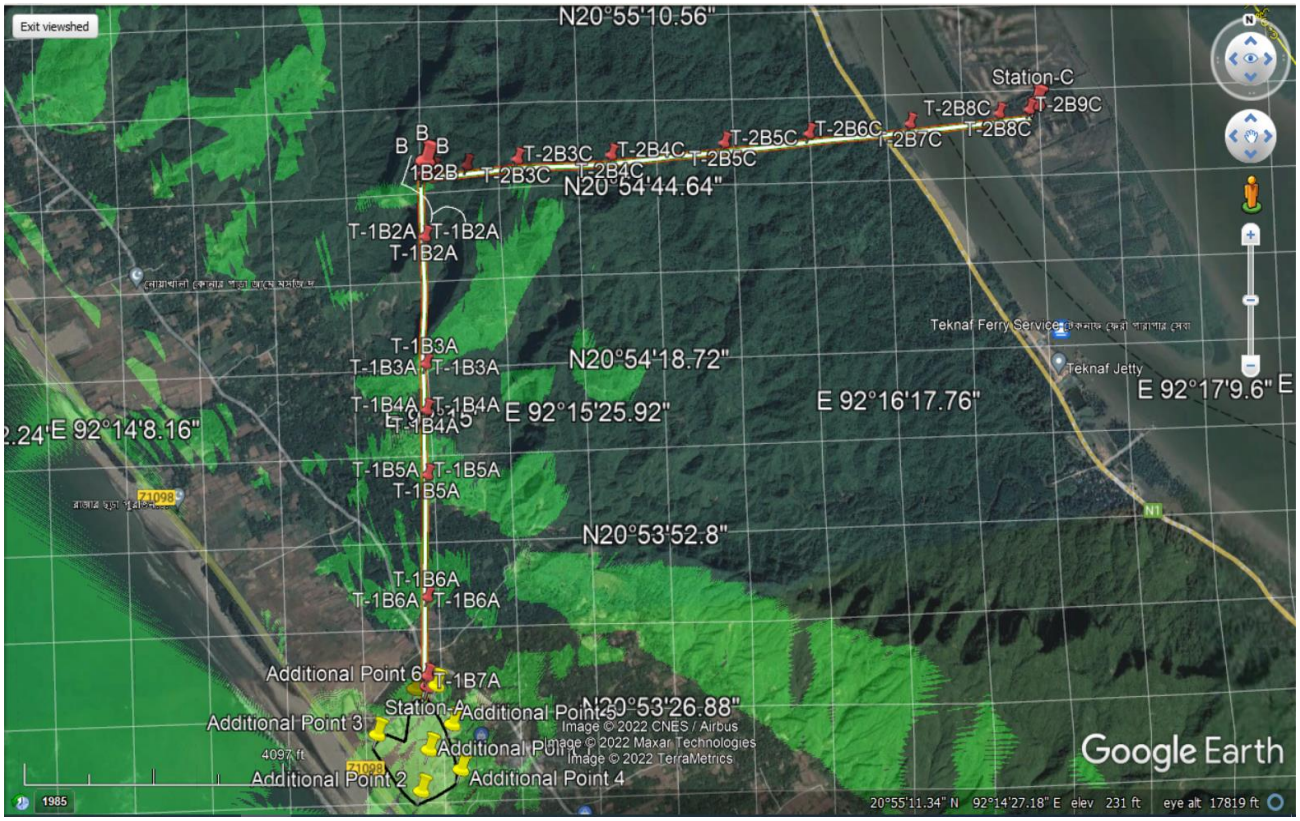

Figure: Google Earth View of the site

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Figure: Some snapshots during testing

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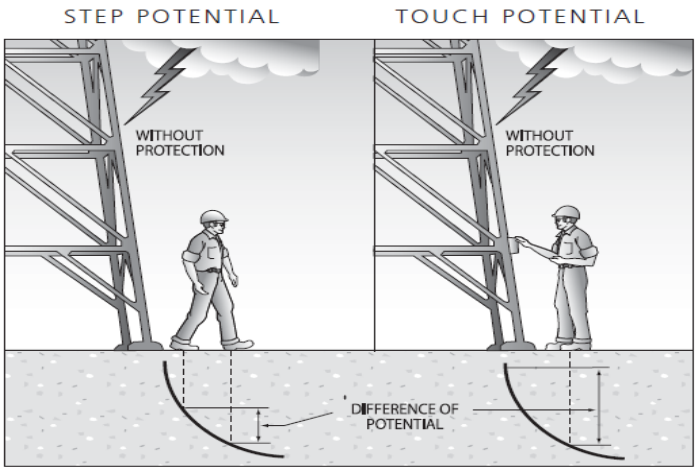
1.1 Objectives of a grounding system

1.1.1 To Ensure Personal Safety to personnel during normal and fault conditions by limiting step and touch potential.

1.1.1.1 Grounding of Electrical Systems. Electrical systems that are required to be grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher voltage lines and that will stabilize the voltage to earth during normal operation.

1.1.1.2 Grounding of Electrical Equipment. Conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth so as to limit the voltage to ground on these materials. Where the electrical system is required to be grounded, these materials shall be connected together. Where the electrical system is not solidly grounded, these materials shall be connected together in a manner that establishes an effective path for fault current.



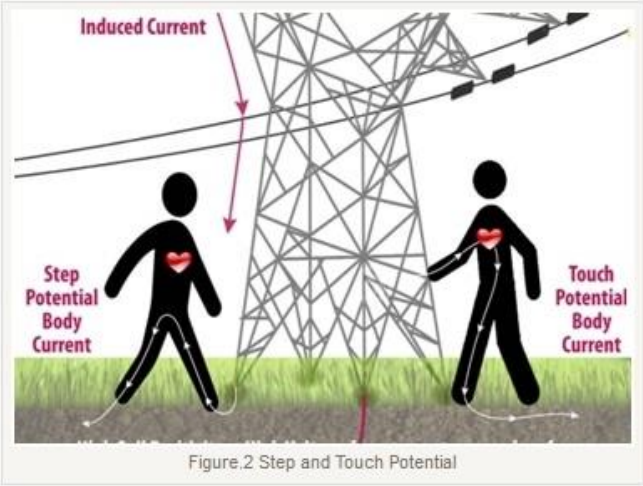


Figure.2 Step and Touch Potential

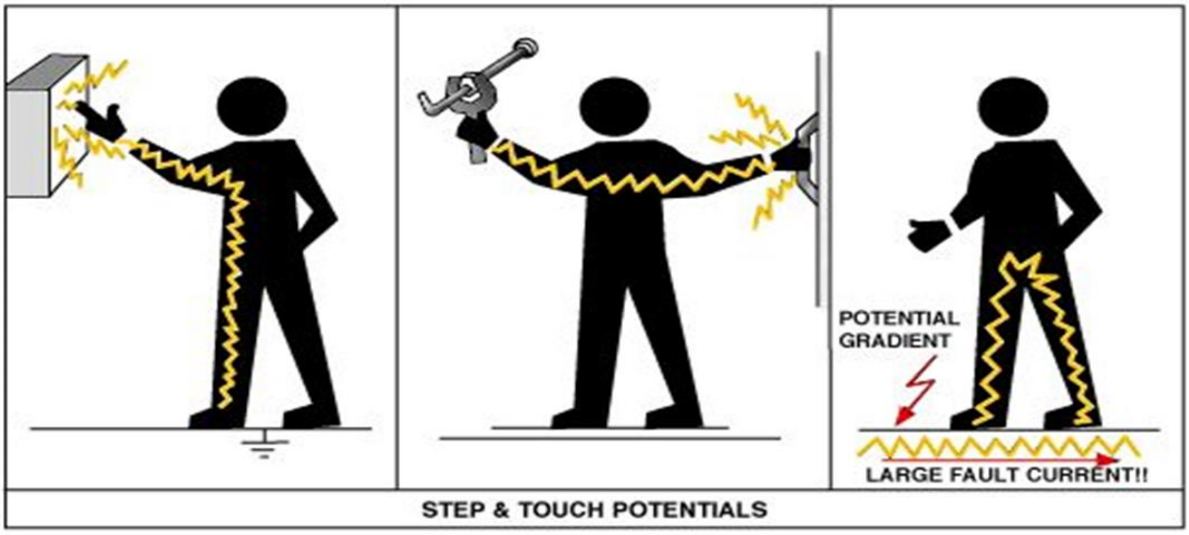


Figure: Eart current flowing

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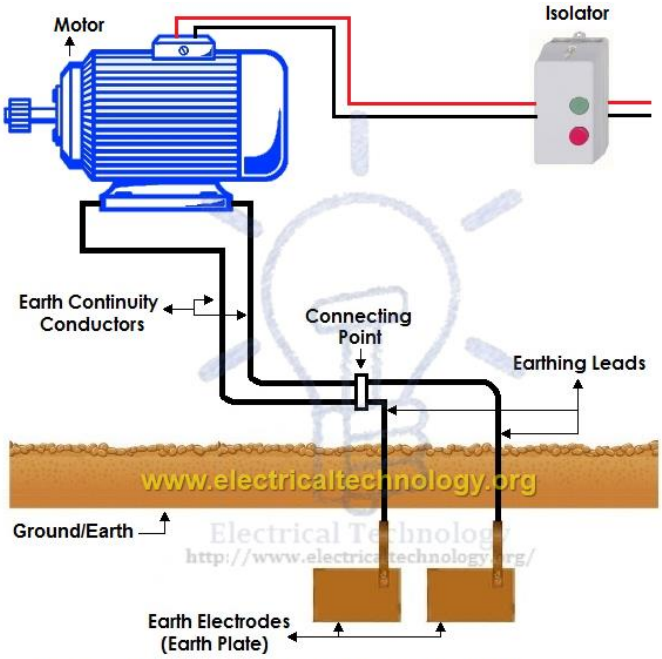
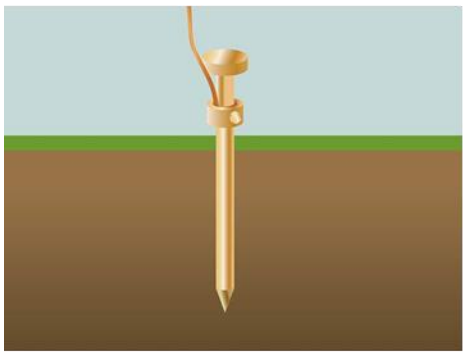
1.1.2 Prevent damage to electrical/electronic apparatus.

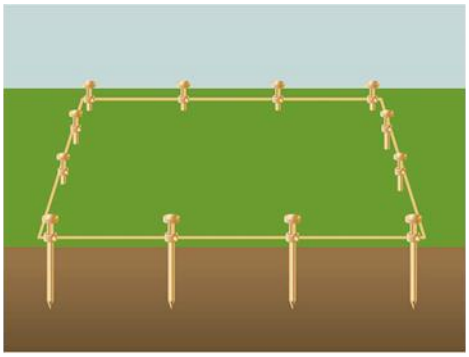


Earthing of Single Motor From Two Places

1.2 Types of Grounding Systems



Ground rod



Ground rod group

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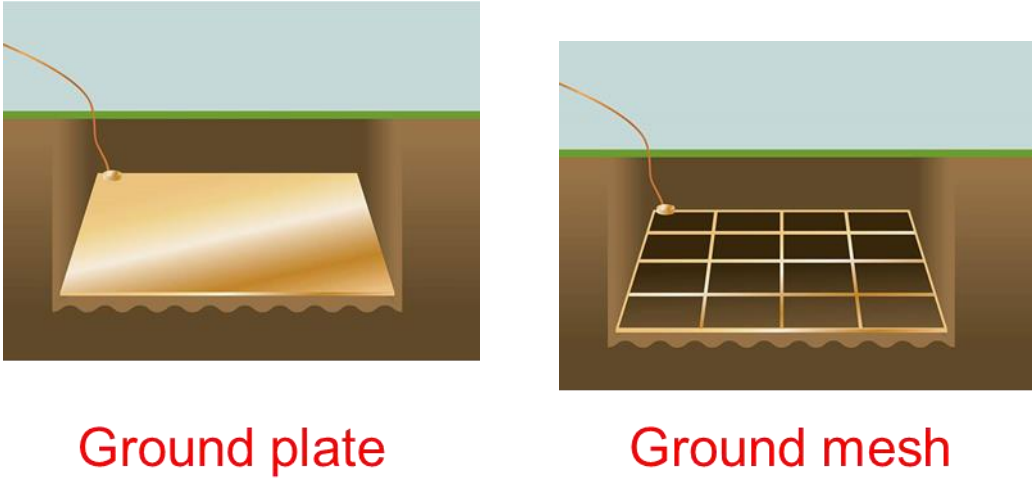

Figure: Schematic drawings of typical earthing systems

1.3 Soil Resistivity

Soil resistivity is another name for the specific resistance of the soil. It is measured in ohm-meters or ohm-centimeters. An ohm-meter is that resistivity of the soil when it has a resistance of 1 ohm between opposite faces of a cube with one meter sides.

Resistance is directly proportional to soil resistivity. This relationship is not as easy to compute in real life as it may sound, because soil resistivity will inevitably vary with depth. The second difficulty in dealing with different locations is that the resistivity varies greatly with sites. Factors that will affect the resistivity of the soil are the soil type, compactness, chemical composition, temperature and water content.

The tables below give an idea of the resistivity of several mediums that are of interest for the design of grounding system.

Material	Typical Resistivity
Copper	1.72 x 10-8 ohm.m
GEM, Material	0.12 ohm.m
Bentonite	2.5 ohm.m
Concrete	30 to 90 ohm.m

1.4 Grounding System Design & Planning

- ✓ Establish the need: Resistance-to-ground < 25 ohm/3 or 5 ohm/1 ohm
- ✓ Site analysis and collection of geological data
- ✓ Soil resistivity testing.
- ✓ Data Analysis: sophisticated computer programs can begin to provide a soil model showing the soil resistivity in ohm-meters and at various layer depths.
- ✓ Grounding Design

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1.5 Ground Testing Methods

1.4.1 Resistivity Measurement (Wenner method)

Resistivity measurements are performed by using a four-wire method. Used to determine which kind of earthing should be used shown in the following figure.

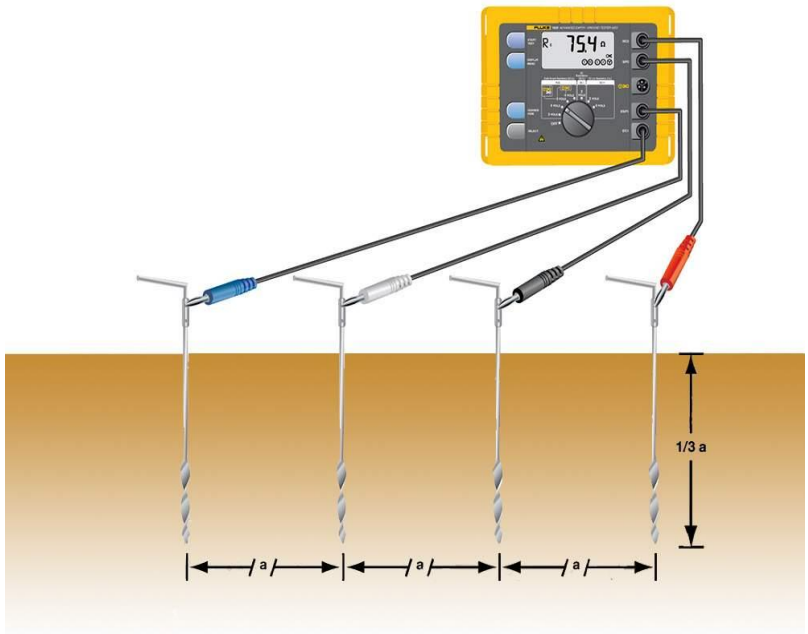

Figure: Ground resistivity measurement by using Wenner method.

Using the Wenner Array method, four small electrodes (auxiliary probes) are placed in a straight line at intervals of a and the depth of b. A current is passed through the outer two probes, and the potential voltage is then measured between the two inner probes. A simple Ohm's Law equation determines the resistance. From this information, it is now possible to calculate the resistivity of the local soil. For most practical circumstances, "a" is 20 times larger than "b", where we can then make the assumption that b=0.

Then the Resistivity, ρ, is determined by:

$$\rho = 2 \pi S R$$

where,

ρ = Resistivity of the local soil (Ω-m)

S = distance between probes (m)

b = depth of probes into the ground (m)

R = resistance value measured by the testing device (Ω)

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1.4.2 Test Procedure:

The Wenner method, for soil resistivity testing shall be used. All four electrodes are moved for each test with the spacing between each adjacent pair remaining exactly the same. In each method the depth penetration of the electrodes is less than five percent of the separation to ensure that the approximation of point sources, required by the simplified formulae, remains valid.

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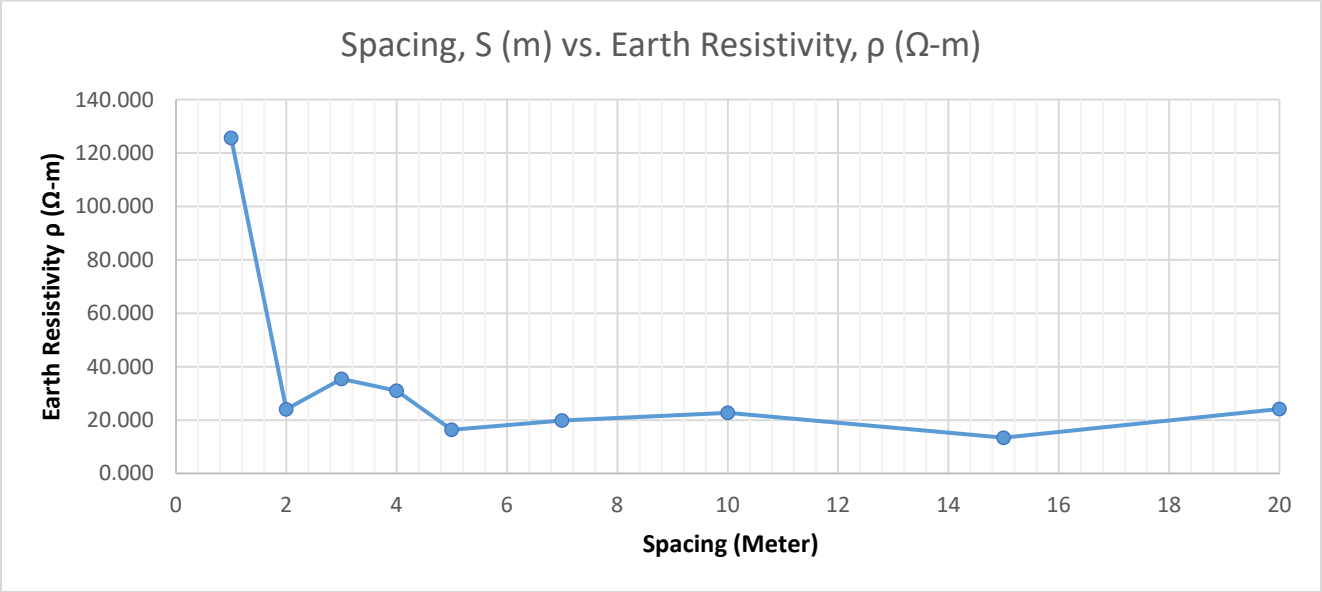
Test No 1: Station A

Test Point:	1. Station A, Marine drive side (X=421908.00 m, Y=2310316.00 m, Z = 3.605 m), Soil type: sandy clay (paddy field)
Date:	6-Oct-21

** This soil was tested again on 01-Dec-21 during dry season to check the results
(please see the result in Test No.: 02)

Test Results:

Sl.No.	S (m)	ρ (Ω-m)	ρt (Ω-m) Calculated (2*Pi*S*R)	R (Ω)
1	1	125.600	6.283	1.000
2	2	24.000	16.035	1.276
3	3	35.400	70.874	3.760
4	4	31.000	27.571	1.097
5	5	16.300	13.635	0.434
6	7	19.800	18.561	0.422
7	10	22.700	25.321	0.403
8	15	13.400	13.477	0.143
9	20	24.100	24.127	0.192



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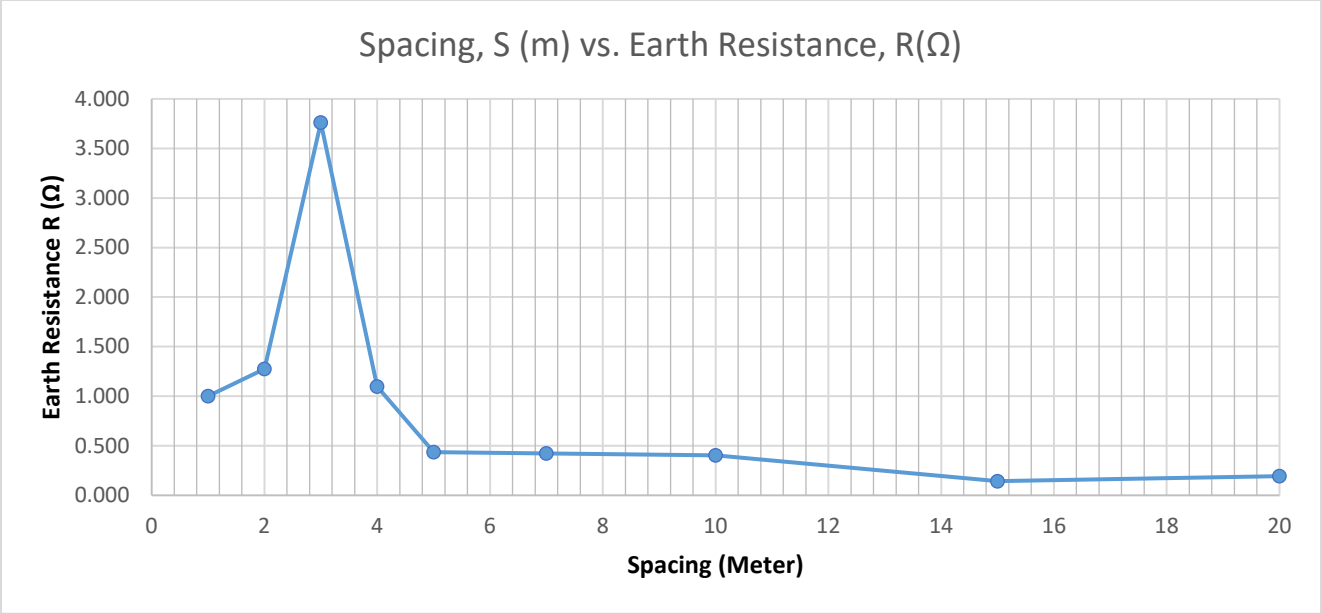

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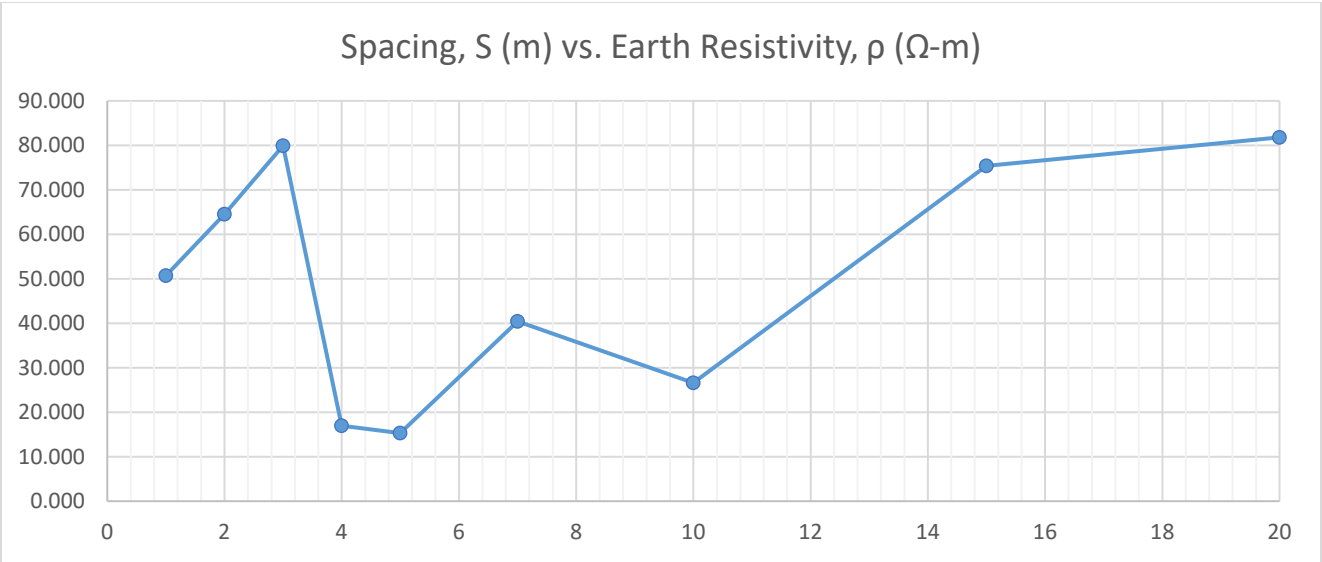
Test No 2: Station A

Test Point:	**Station-A, Again (X=421908.00 m, Y=2310316.00 m, Z = 3.605 m), Soil type: sandy clay (paddy field)**
Date:	**1-Dec-21**

Test Results:

Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	1	50.700	50.705	8.070
2	2	64.500	64.591	5.140
3	3	79.900	79.922	4.240
4	4	17.000	17.090	0.680
5	5	15.300	15.394	0.490
6	7	40.400	40.464	0.920
7	10	26.600	26.641	0.424
8	15	75.400	75.493	0.801
9	20	81.800	81.807	0.651



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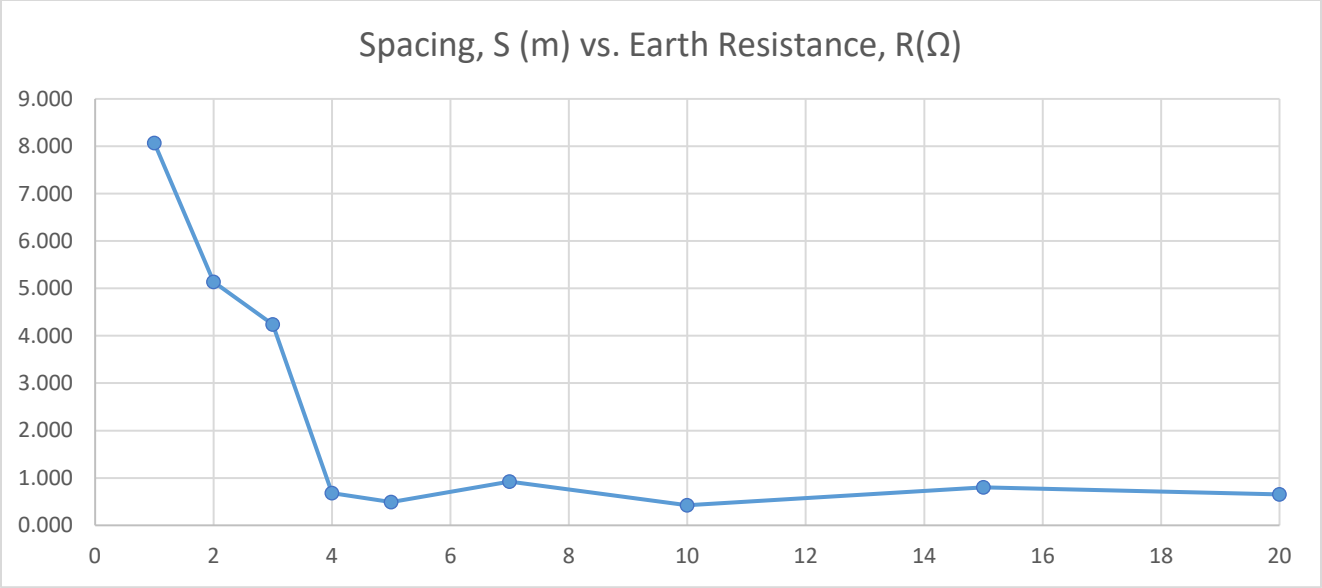

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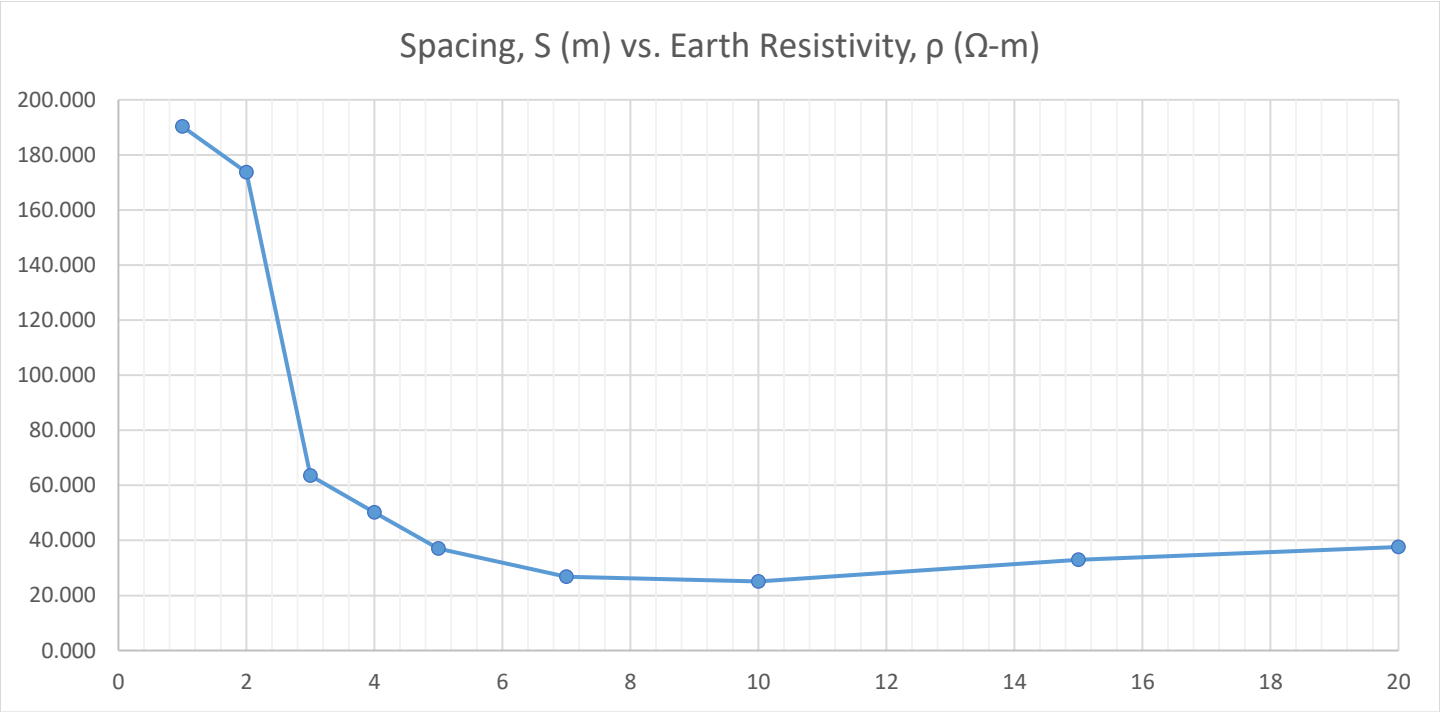
Test No. 3:

Test Point:	**3. T-1B7A (X=421911.00 m, Y=2310380.00 m, Z = 4.541 m), Soil type: Slit soil (Mixed soil)**
Date:	**7-Oct-21**

Test Results

Sl.No.	S (m)	ρ (Ω-m)	ρt (Ω-m) Calculated (2*Pi*S*R)	R (Ω)
1	1	190.300	190.381	30.300
2	2	173.700	173.793	13.830
3	3	63.500	63.523	3.370
4	4	50.200	50.266	2.000
5	5	37.000	37.071	1.180
6	7	26.800	26.829	0.610
7	10	25.100	25.133	0.400
8	15	32.980	3.299	0.035
9	20	37.600	37.699	0.300



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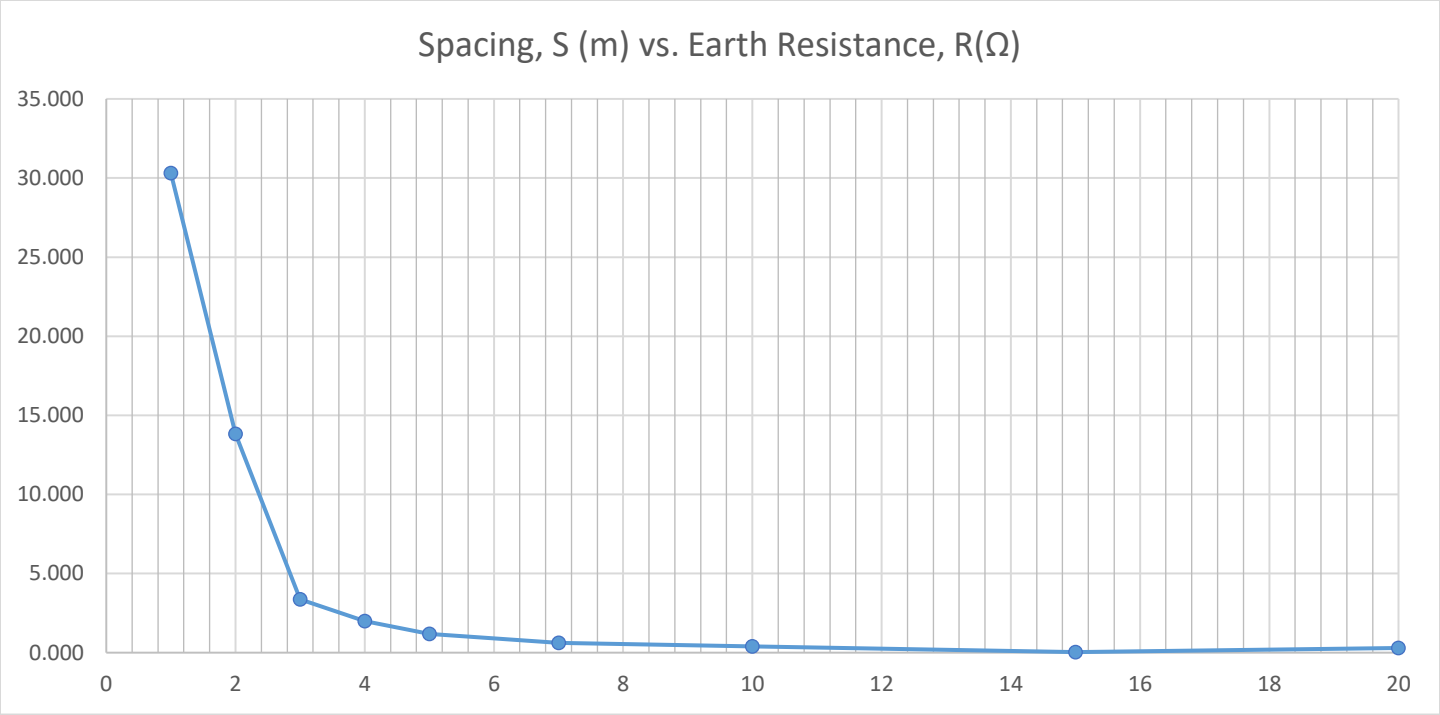

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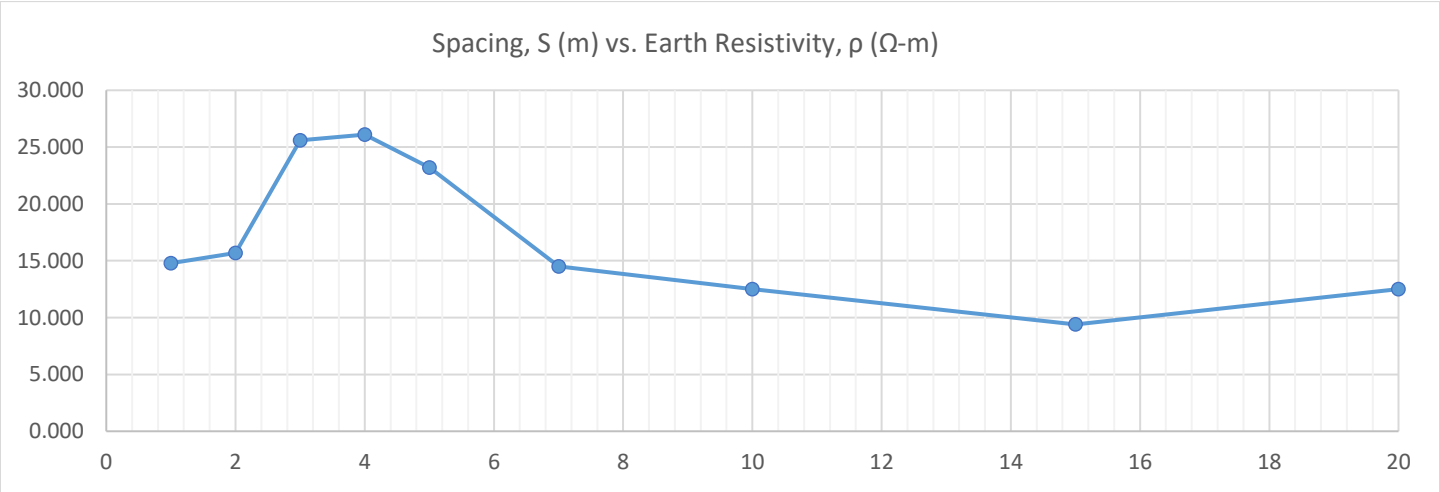
Test No. 4:

Test Point:	**4. T-1B6A (X=421929.00 m, Y=2310748.00 m, Z = 7.236 m), Soil type: clay-sand mixture (down side of hill)**			
Date:	**7-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**14.800**	**14.828**	**2.360**
2	**2**	**15.700**	**15.708**	**1.250**
3	**3**	**25.600**	**25.635**	**1.360**
4	**4**	**26.100**	**26.138**	**1.040**
5	**5**	**23.200**	**23.248**	**0.740**
6	**7**	**14.500**	**14.514**	**0.330**
7	**10**	**12.500**	**12.566**	**0.200**
8	**15**	**9.400**	**9.425**	**0.100**
9	**20**	**12.500**	**12.566**	**0.100**



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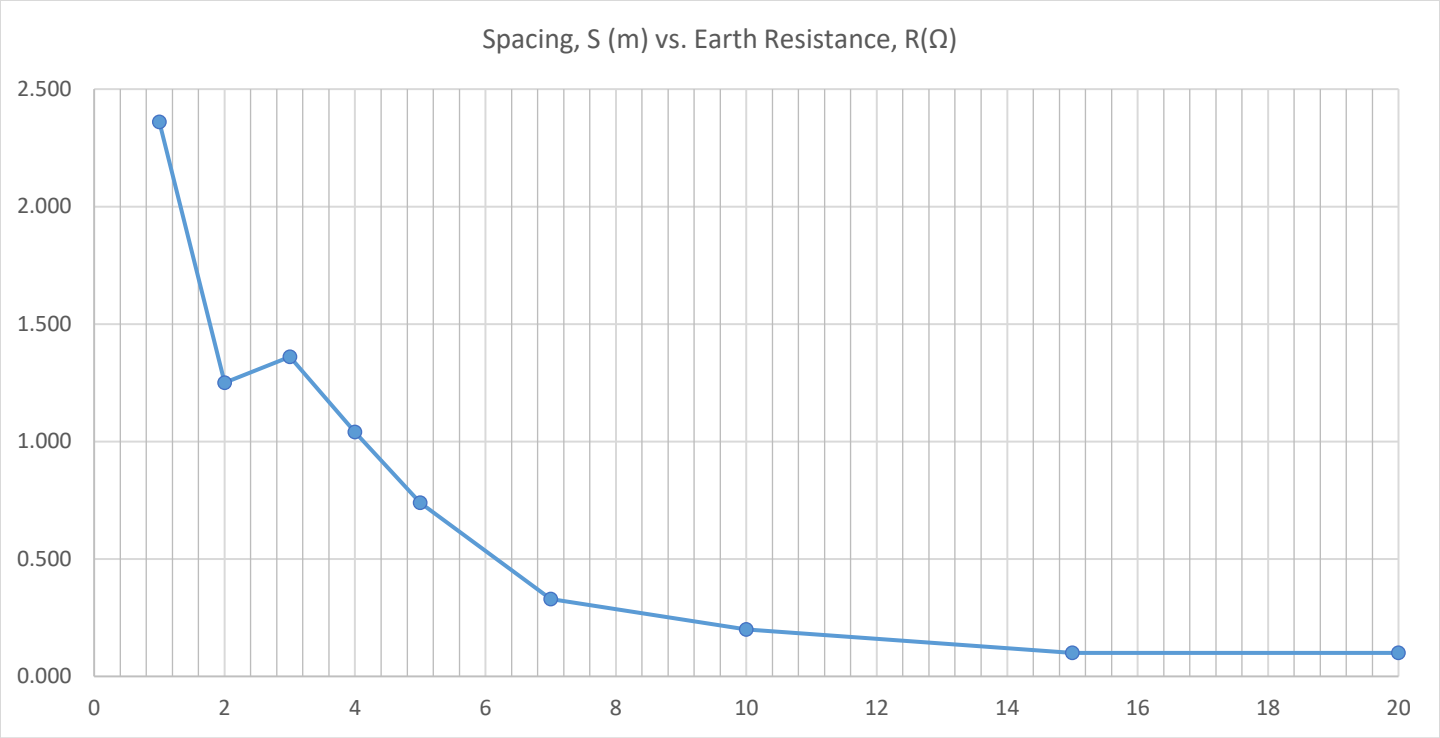

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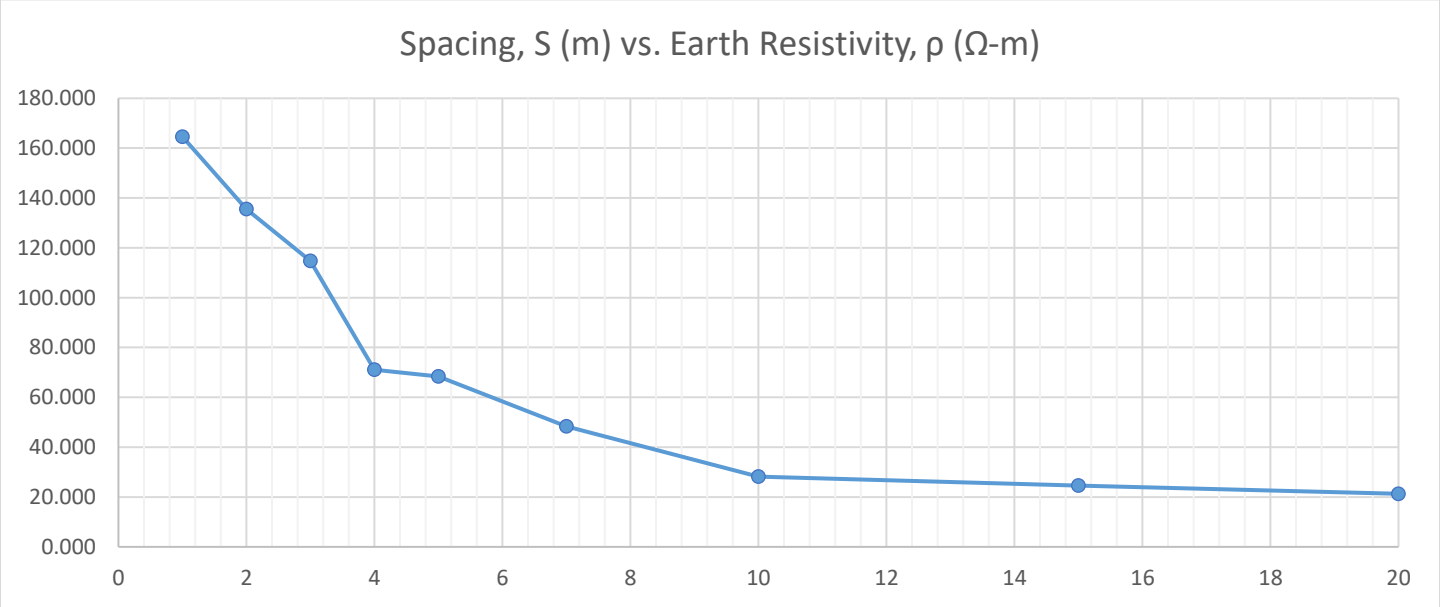
Test Point 5:

Test Point:	**5. T-1B5A (X=421954.00 m, Y=2311310.00 m, Z = 21.673 m), Soil type: clay-sand mixture (down side of hill)**			
Date:	**8-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**164.600**	**164.620**	**26.200**
2	**2**	**135.500**	**135.591**	**10.790**
3	**3**	**114.700**	**114.794**	**6.090**
4	**4**	**71.100**	**71.126**	**2.830**
5	**5**	**68.400**	**68.487**	**2.180**
6	**7**	**48.300**	**48.381**	**1.100**
7	**10**	**28.200**	**28.274**	**0.450**
8	**15**	**24.600**	**24.693**	**0.262**
9	**20**	**21.300**	**21.363**	**0.170**



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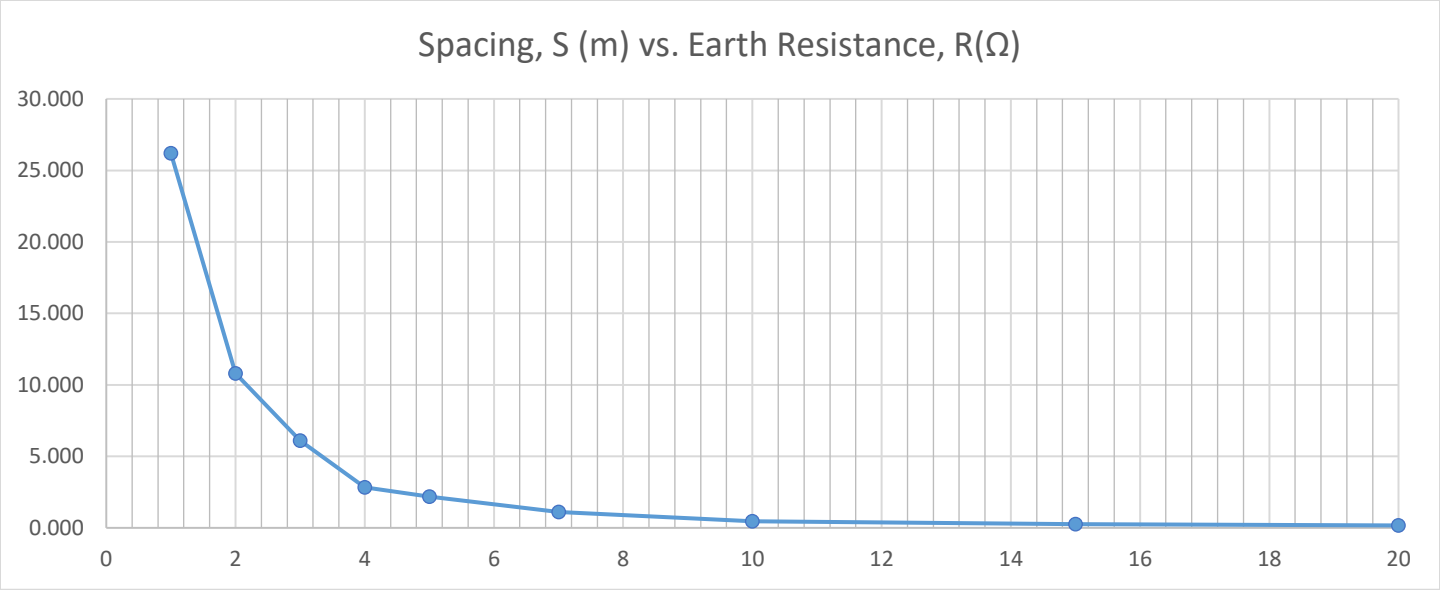

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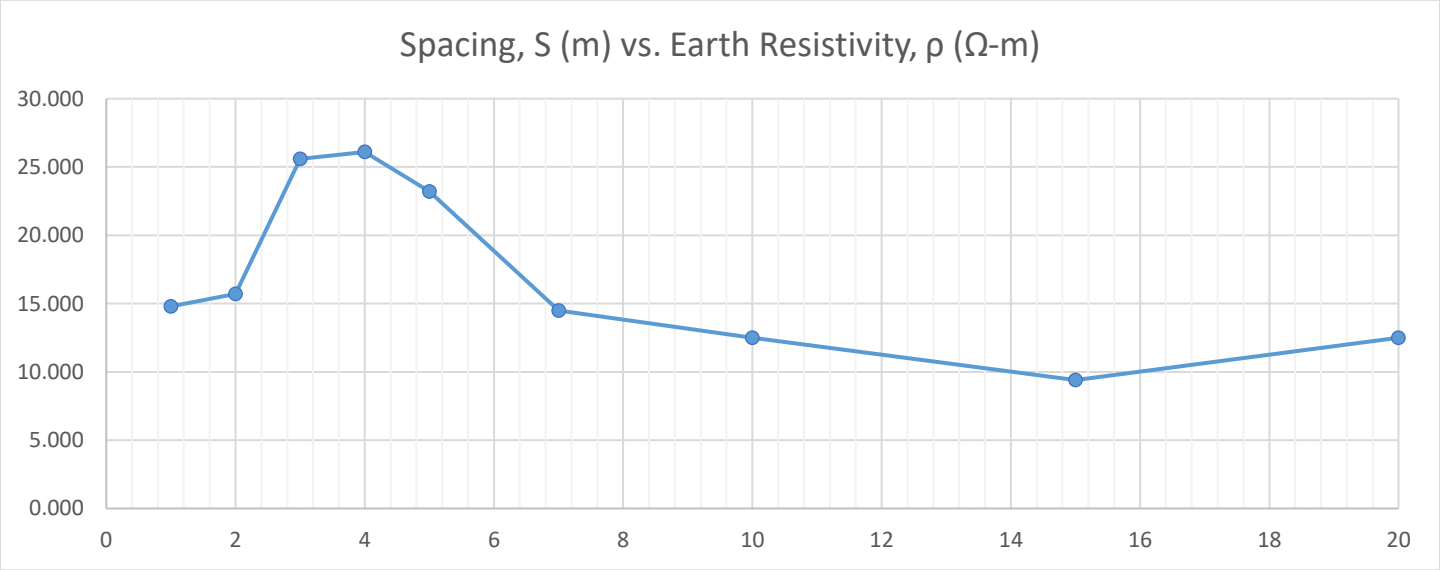
Test No.: 06

Test Point:	**6. T-1B4A (X=421969.00 m, Y=231608.00 m, Z = 85.930 m), Soil type: clay-sand mixture (down side of hill)**			
Date:	**7-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**14.800**	**14.828**	**2.360**
2	**2**	**15.700**	**15.708**	**1.250**
3	**3**	**25.600**	**25.635**	**1.360**
4	**4**	**26.100**	**26.138**	**1.040**
5	**5**	**23.200**	**23.248**	**0.740**
6	**7**	**14.500**	**16.713**	**0.380**
7	**10**	**12.500**	**12.566**	**0.200**
8	**15**	**9.400**	**9.425**	**0.100**
9	**20**	**12.500**	**12.566**	**0.100**



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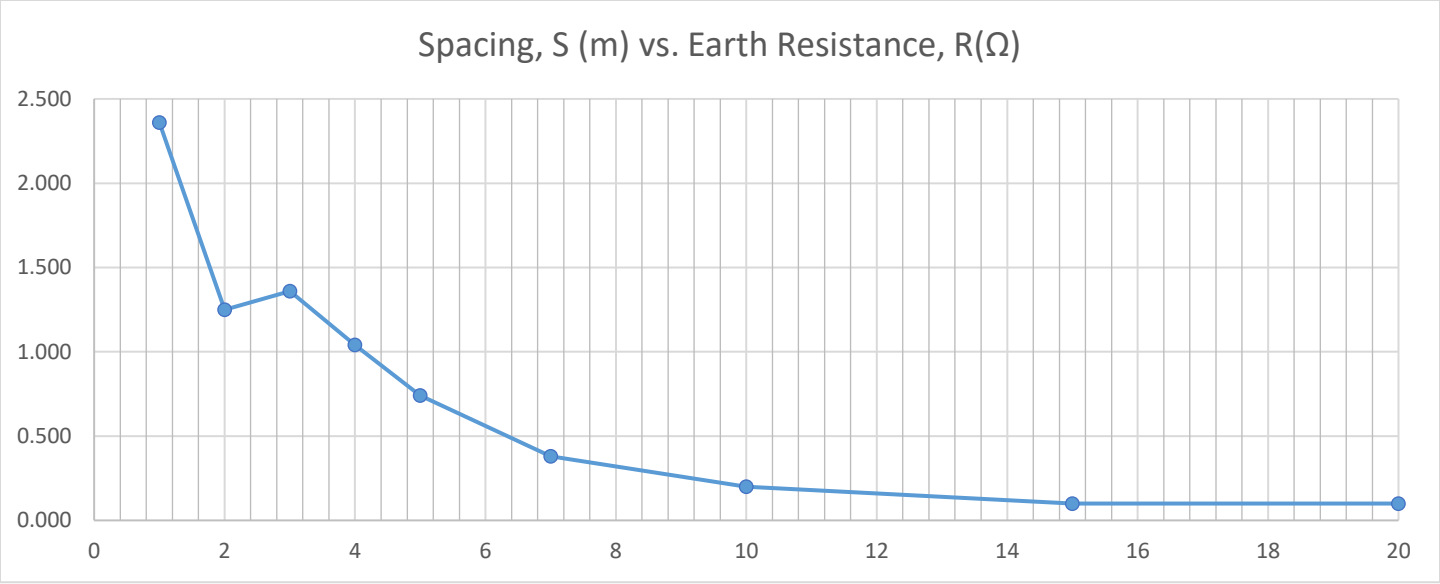

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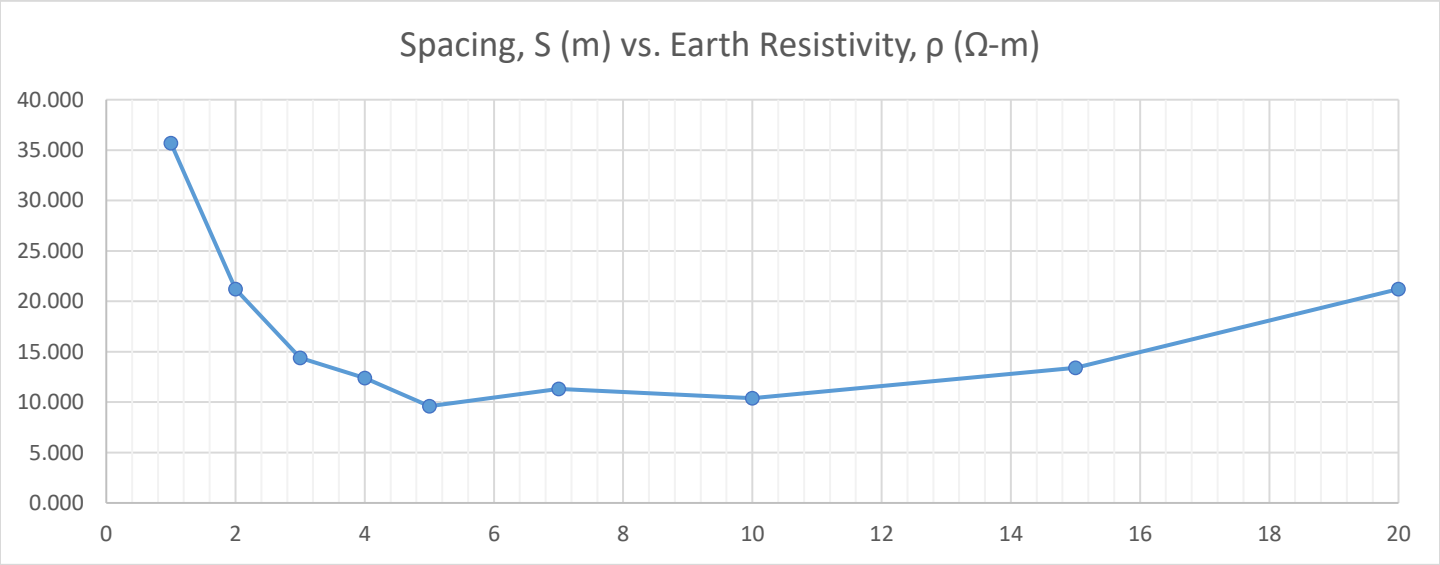
Test No.: 07

Test Point:	**7. T-1B3A (X=421978.00 m, Y=2311816.00 m, Z = 98.305 m), Soil type: clay-sand mixture (middle of hill)**			
Date:	**8-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**35.700**	**35.751**	**5.690**
2	**2**	**21.200**	**21.137**	**1.682**
3	**3**	**14.400**	**14.476**	**0.768**
4	**4**	**12.400**	**12.416**	**0.494**
5	**5**	**9.600**	**9.613**	**0.306**
6	**7**	**11.300**	**11.391**	**0.259**
7	**10**	**10.400**	**10.493**	**0.167**
8	**15**	**13.400**	**13.477**	**0.143**
9	**20**	**21.200**	**21.237**	**0.169**



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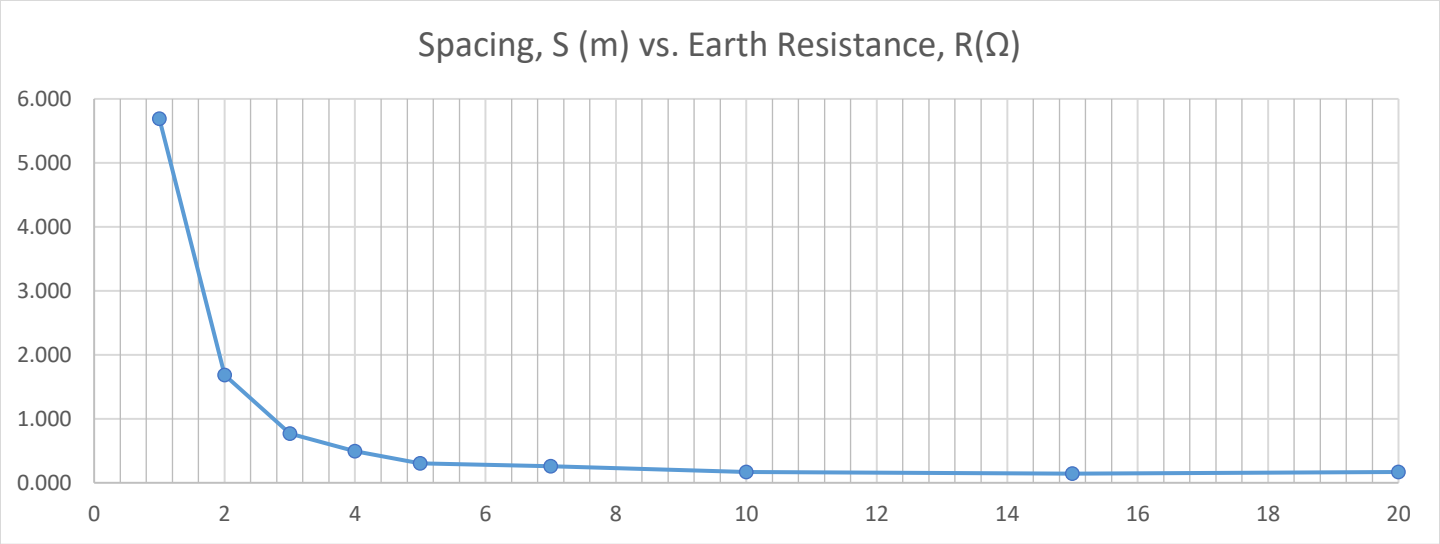

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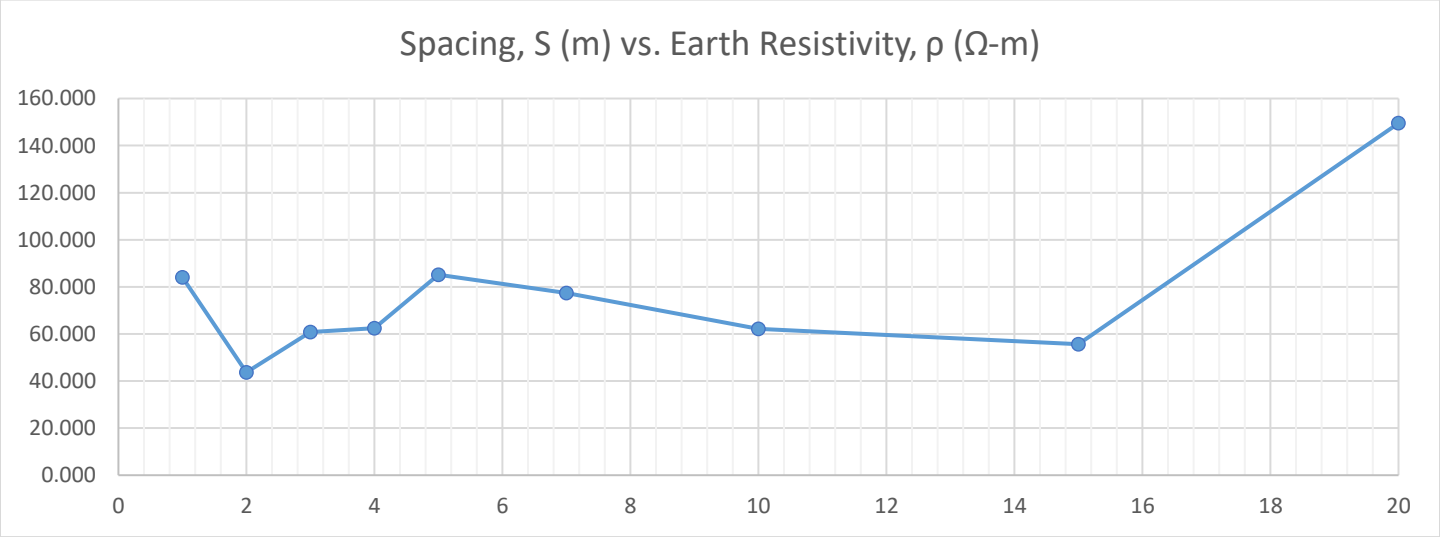
Test No. 8:

Test Point:	**8. T-1B2A (X=422005.00 m, Y=2312388.00 m, Z = 152.621 m), Soil type: sand-rock mixture (Hill)**			
Date:	**9-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**84.100**	**84.132**	**13.390**
2	**2**	**43.700**	**43.731**	**3.480**
3	**3**	**60.800**	**60.884**	**3.230**
4	**4**	**62.500**	**62.581**	**2.490**
5	**5**	**85.100**	**85.137**	**2.710**
6	**7**	**77.400**	**77.409**	**1.760**
7	**10**	**62.200**	**62.204**	**0.990**
8	**15**	**55.600**	**55.606**	**0.590**
9	**20**	**149.500**	**149.540**	**1.190**



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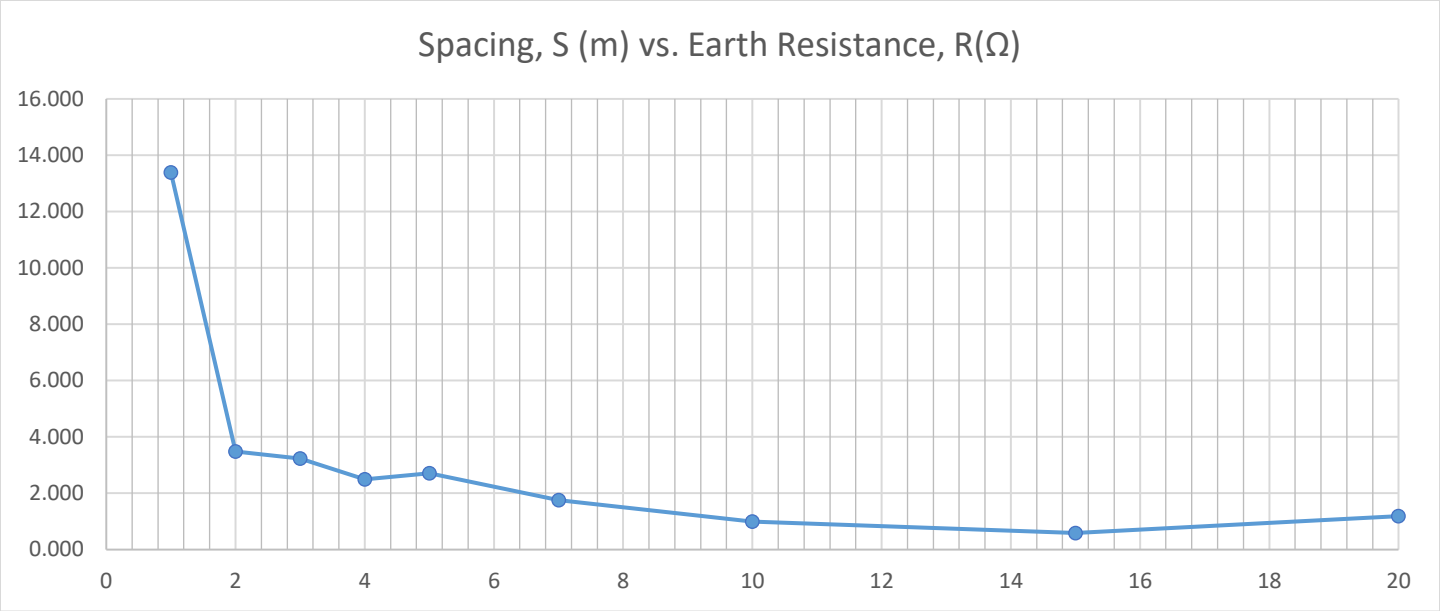

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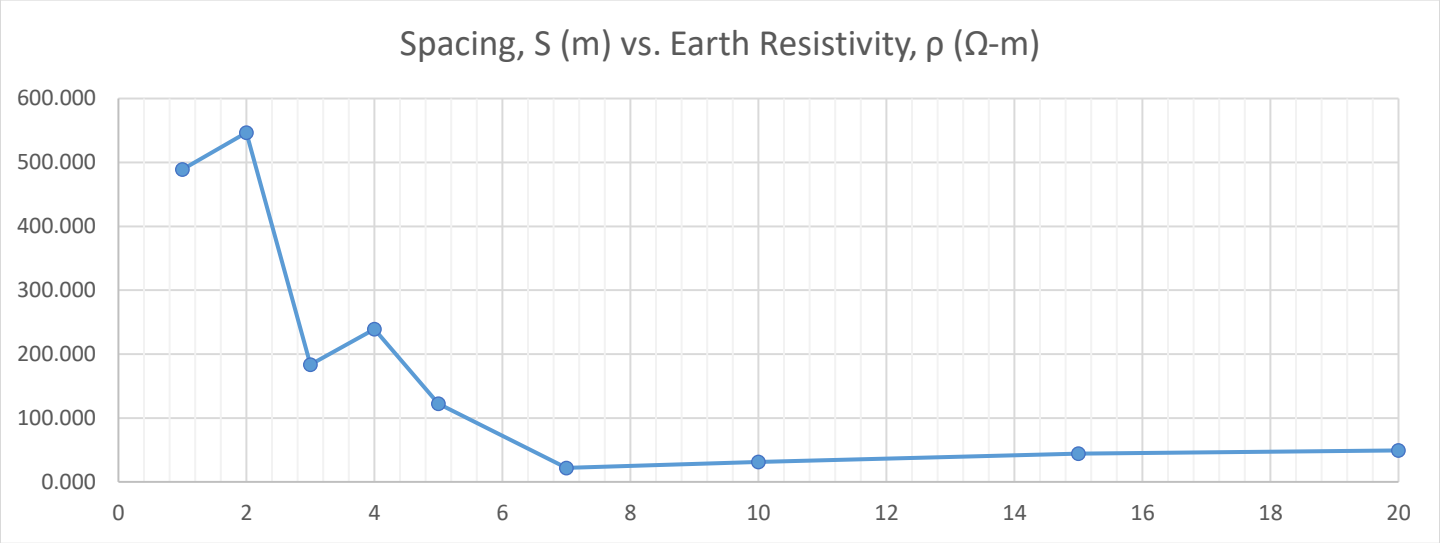
Test No. 9

Test Point:	**9. T-1B1A (X=422017.00 m, Y=2312644.00 m, Z = 204.777 m), Soil type: sand-rock mixture (Hill top)**			
Date:	**12-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**488.800**	**488.833**	**77.800**
2	**2**	**546.600**	**546.638**	**43.500**
3	**3**	**183.400**	**183.407**	**9.730**
4	**4**	**239.200**	**239.264**	**9.520**
5	**5**	**122.500**	**122.522**	**3.900**
6	**7**	**21.900**	**21.991**	**0.500**
7	**10**	**31.400**	**31.416**	**0.500**
8	**15**	**44.200**	**44.297**	**0.470**
9	**20**	**49.000**	**49.009**	**0.390**



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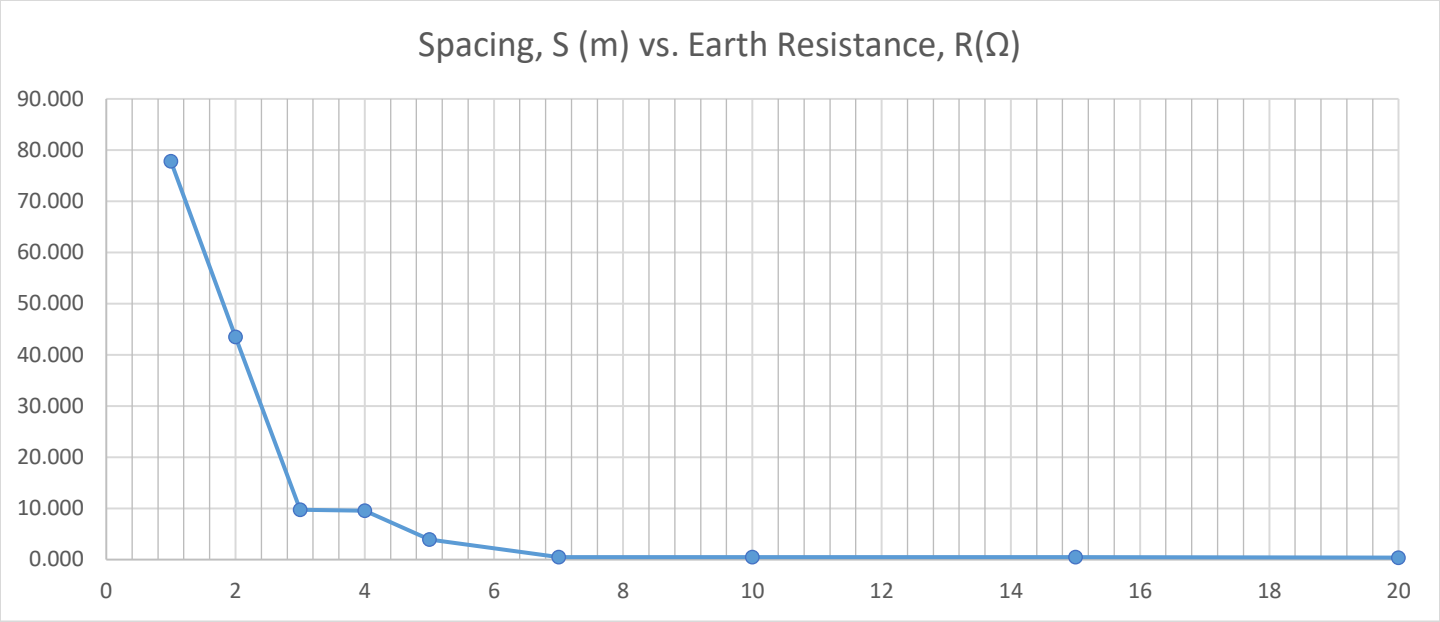

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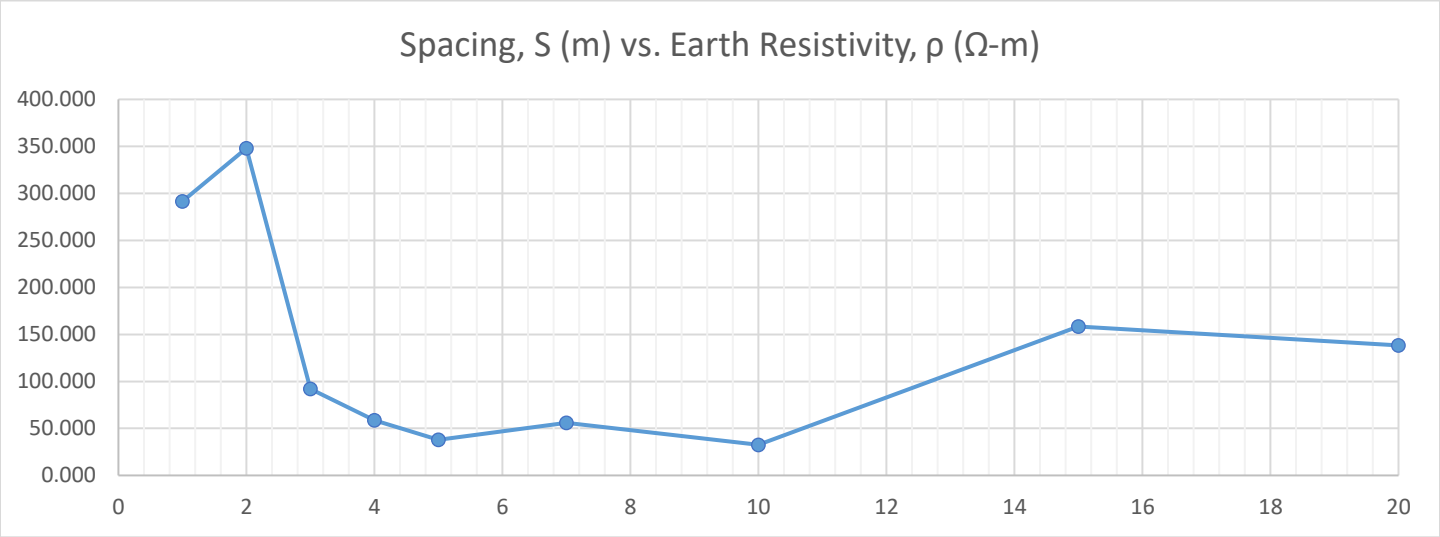
Test No 10.:

Test Point:	**10. 1B (X=422017.00 m, Y=2312660.00 m, Z = 205.061 m), Soil type: sand-rock mixture (Hill top)**			
Date:	**12-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**291.500**	**291.540**	**46.400**
2	**2**	**348.000**	**348.089**	**27.700**
3	**3**	**91.900**	**91.986**	**4.880**
4	**4**	**58.800**	**58.811**	**2.340**
5	**5**	**38.000**	**38.013**	**1.210**
6	**7**	**55.800**	**55.858**	**1.270**
7	**10**	**32.600**	**32.673**	**0.520**
8	**15**	**158.300**	**158.337**	**1.680**
9	**20**	**138.200**	**138.230**	**1.100**



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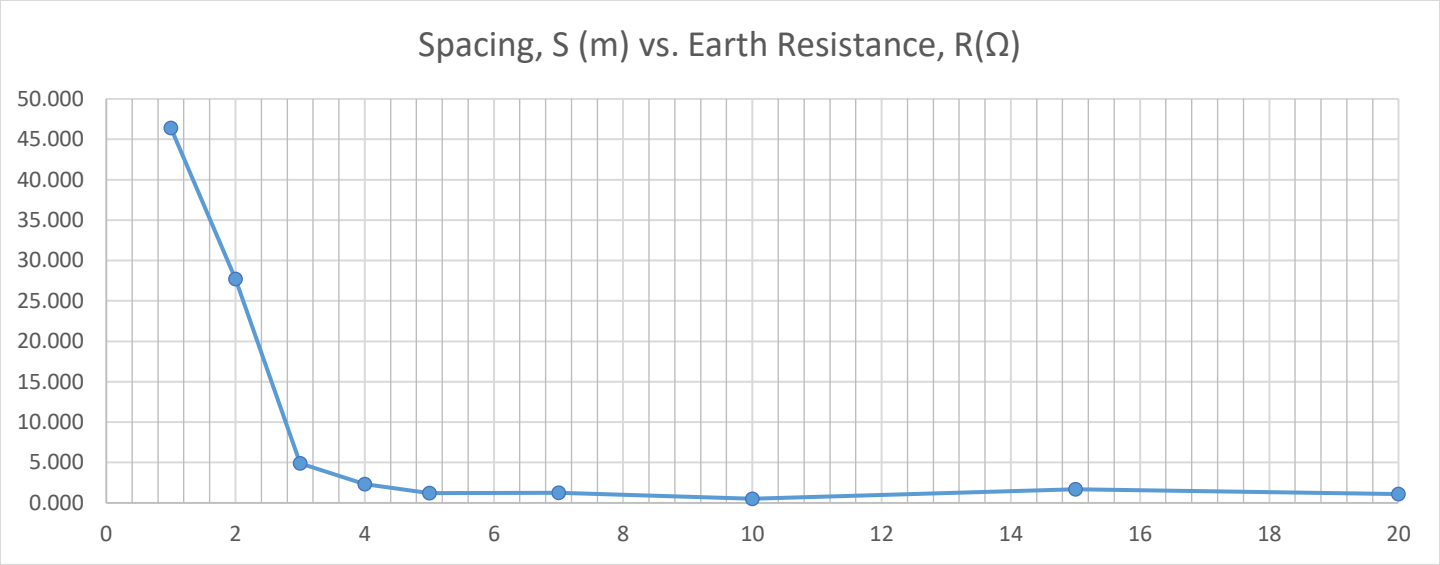

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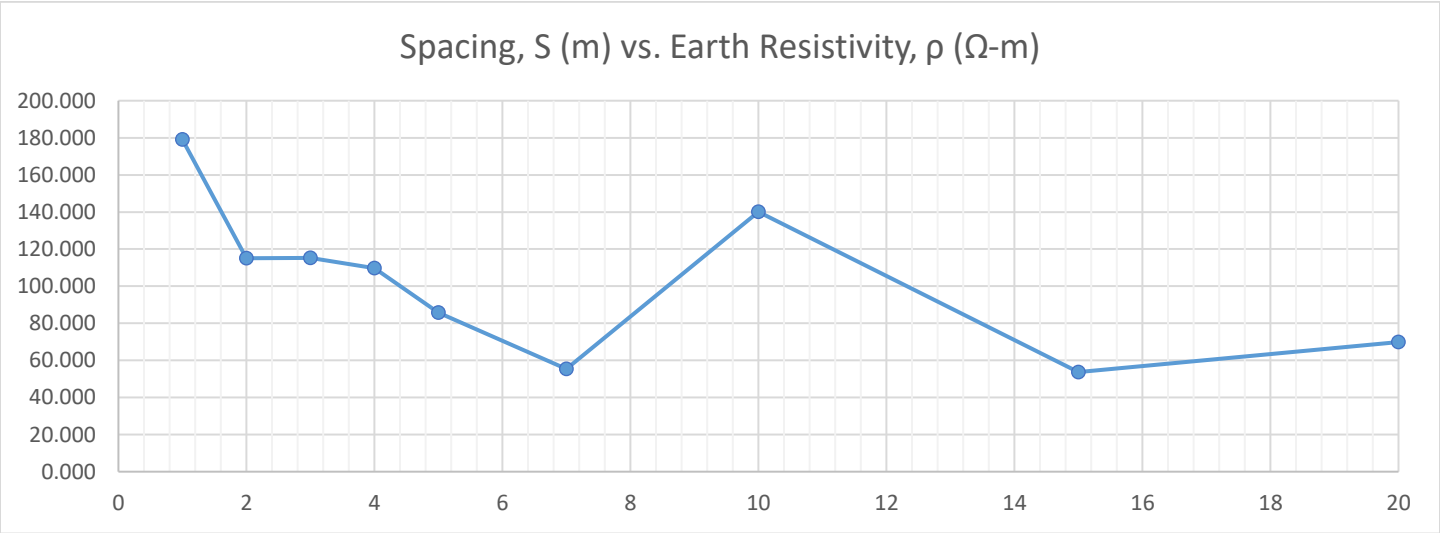
Test No. 11

Test Point:	**11. Station-B Additional Point 1 (X=422017.00 m, Y=2312655.00 m, Z = 204.707 m), Soil type: clay-sand-rock mixture (Hill top)**			
Date:	**12-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**179.000**	**179.071**	**28.500**
2	**2**	**115.100**	**115.108**	**9.160**
3	**3**	**115.300**	**115.360**	**6.120**
4	**4**	**109.800**	**109.830**	**4.370**
5	**5**	**85.700**	**85.766**	**2.730**
6	**7**	**55.400**	**55.418**	**1.260**
7	**10**	**140.100**	**140.115**	**2.230**
8	**15**	**53.700**	**53.721**	**0.570**
9	**20**	**69.900**	**69.995**	**0.557**



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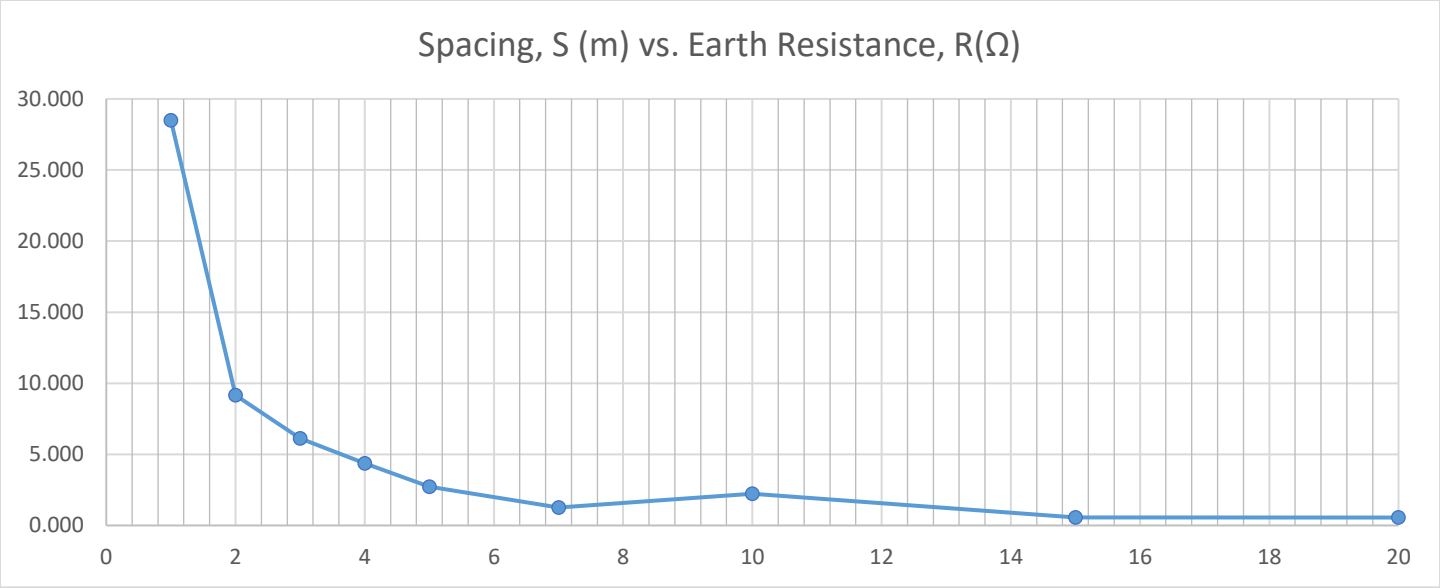

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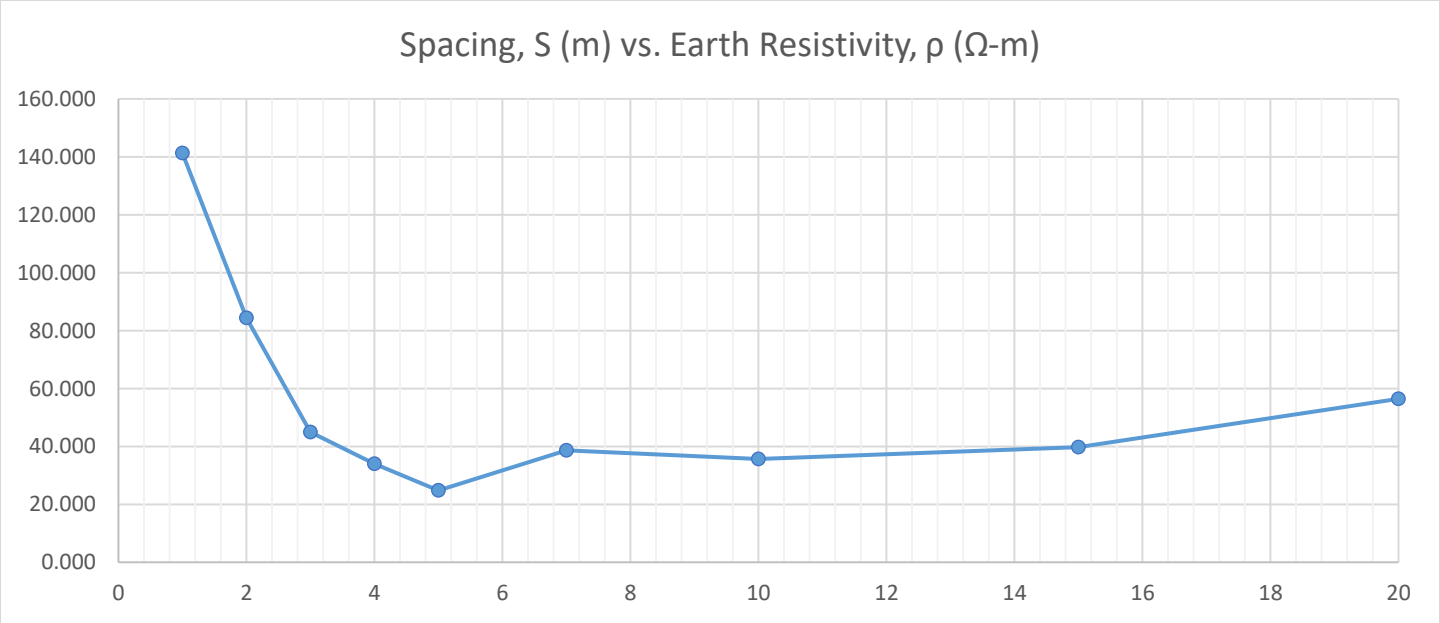
Test No 12:

Test Point:	**11. Station-B (X=422019.00 m, Y=2312680.00 m, Z = 203.325 m), Soil type: clay-sand-rock mixture (Hill top)**			
Date:	**12-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**141.300**	**141.372**	**22.500**
2	**2**	**84.400**	**84.446**	**6.720**
3	**3**	**45.000**	**45.051**	**2.390**
4	**4**	**34.000**	**34.005**	**1.353**
5	**5**	**24.800**	**24.881**	**0.792**
6	**7**	**38.700**	**38.705**	**0.880**
7	**10**	**35.700**	**35.751**	**0.569**
8	**15**	**39.700**	**39.773**	**0.422**
9	**20**	**56.400**	**56.423**	**0.449**



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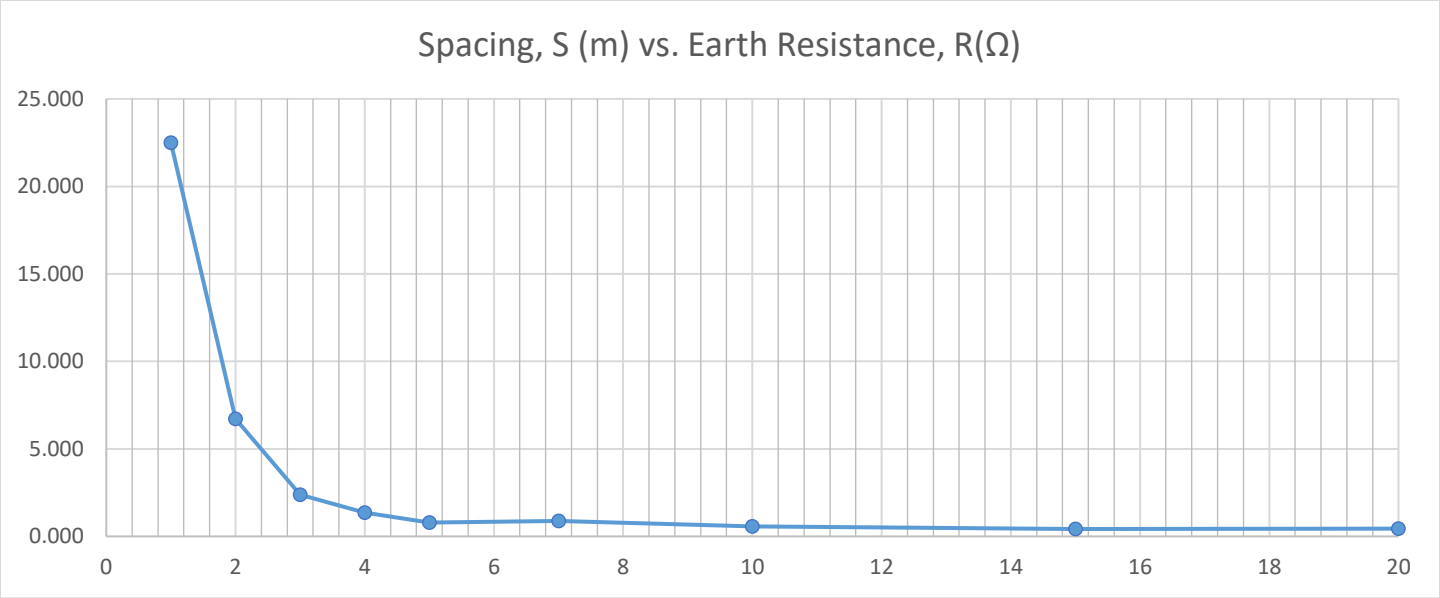

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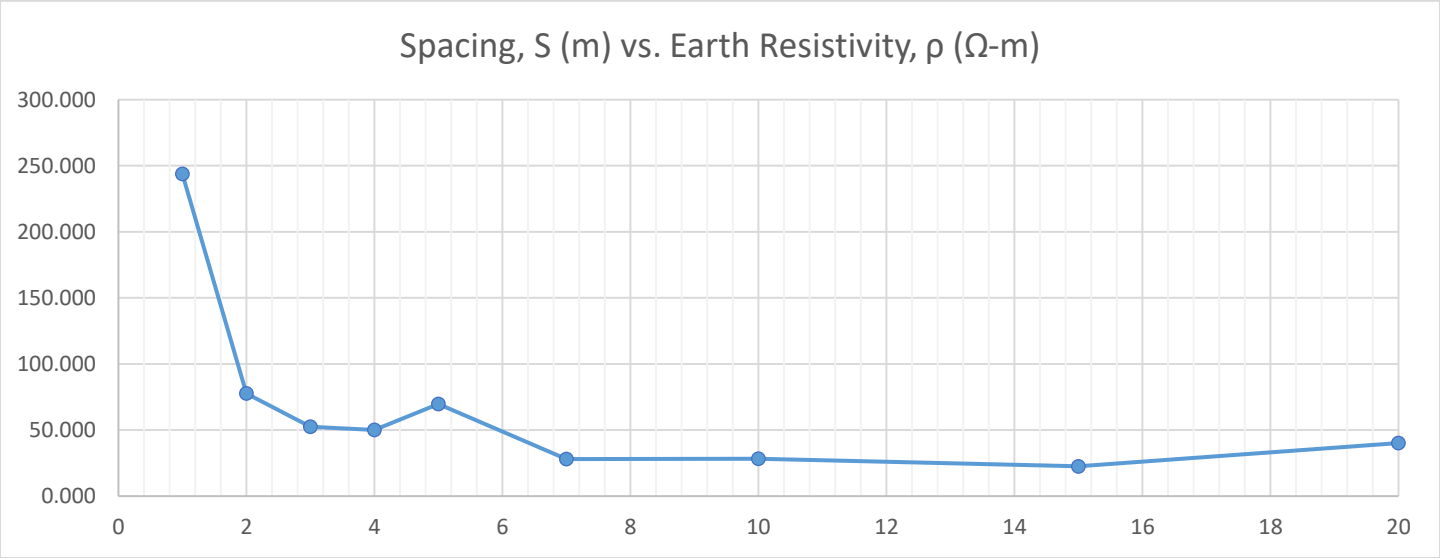
Test No. 13:

Test Point:	**13. 2B (X=422039.00 m, Y=2312681.00 m, Z = 201.695 m), Soil type: clay-sand-rock mixture (Hill top)**			
Date:	**12-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**243.700**	**243.788**	**38.800**
2	**2**	**77.700**	**77.786**	**6.190**
3	**3**	**52.500**	**52.590**	**2.790**
4	**4**	**50.000**	**50.014**	**1.990**
5	**5**	**69.700**	**69.744**	**2.220**
6	**7**	**28.100**	**28.149**	**0.640**
7	**10**	**28.200**	**28.274**	**0.450**
8	**15**	**22.600**	**22.620**	**0.240**
9	**20**	**40.200**	**40.212**	**0.320**



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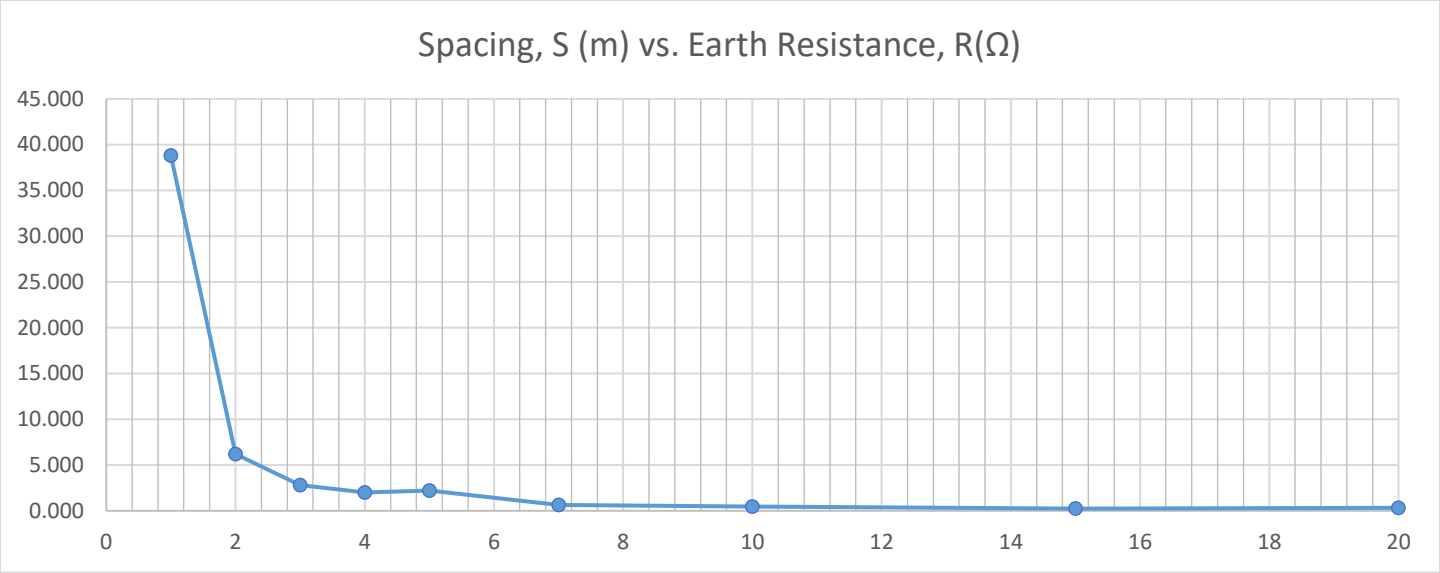

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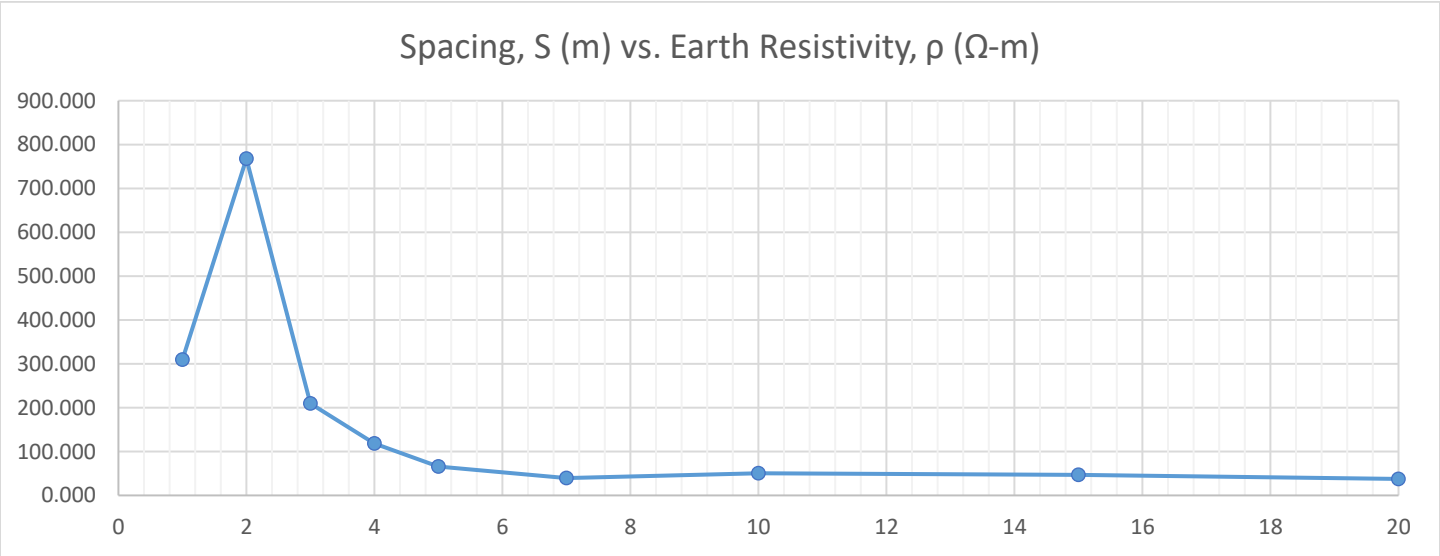
Test No. 14:

Test Point:	**14. T-2B1C (X=422068.00 m, Y=2312683.00 m, Z = 199.020 m), Soil type: clay-sand-rock mixture (Hill top)**			
Date:	**12-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**309.700**	**309.762**	**49.300**
2	**2**	**767.800**	**767.807**	**61.100**
3	**3**	**209.200**	**209.231**	**11.100**
4	**4**	**118.100**	**118.124**	**4.700**
5	**5**	**65.900**	**65.974**	**2.100**
6	**7**	**39.500**	**39.584**	**0.900**
7	**10**	**50.200**	**50.266**	**0.800**
8	**15**	**47.100**	**47.124**	**0.500**
9	**20**	**37.600**	**37.699**	**0.300**



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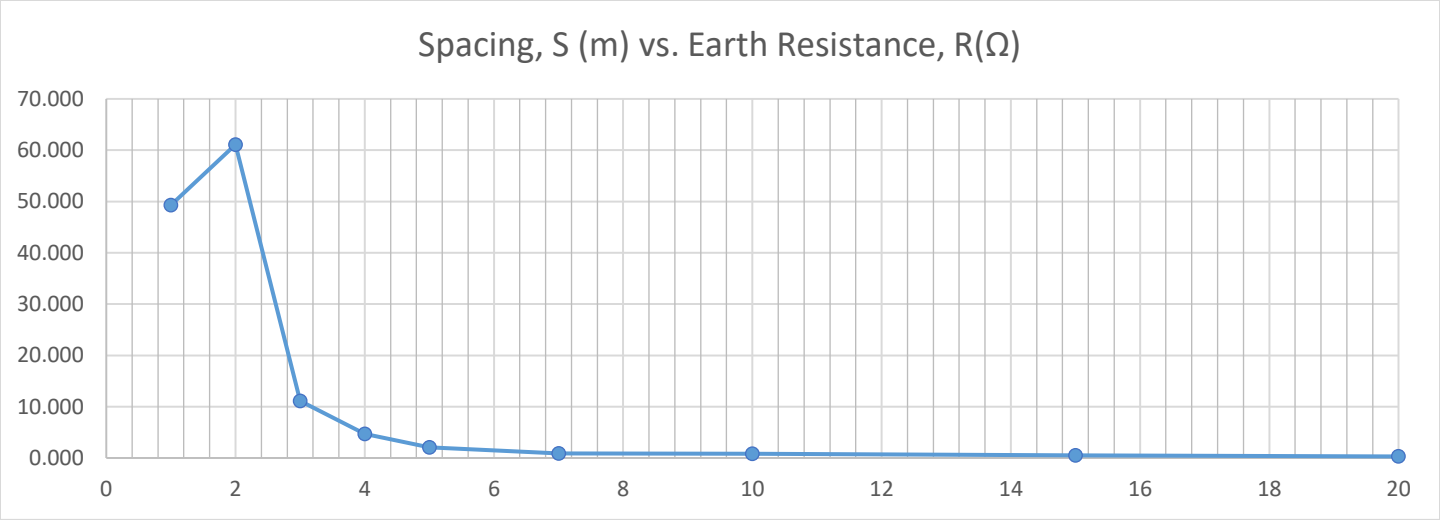

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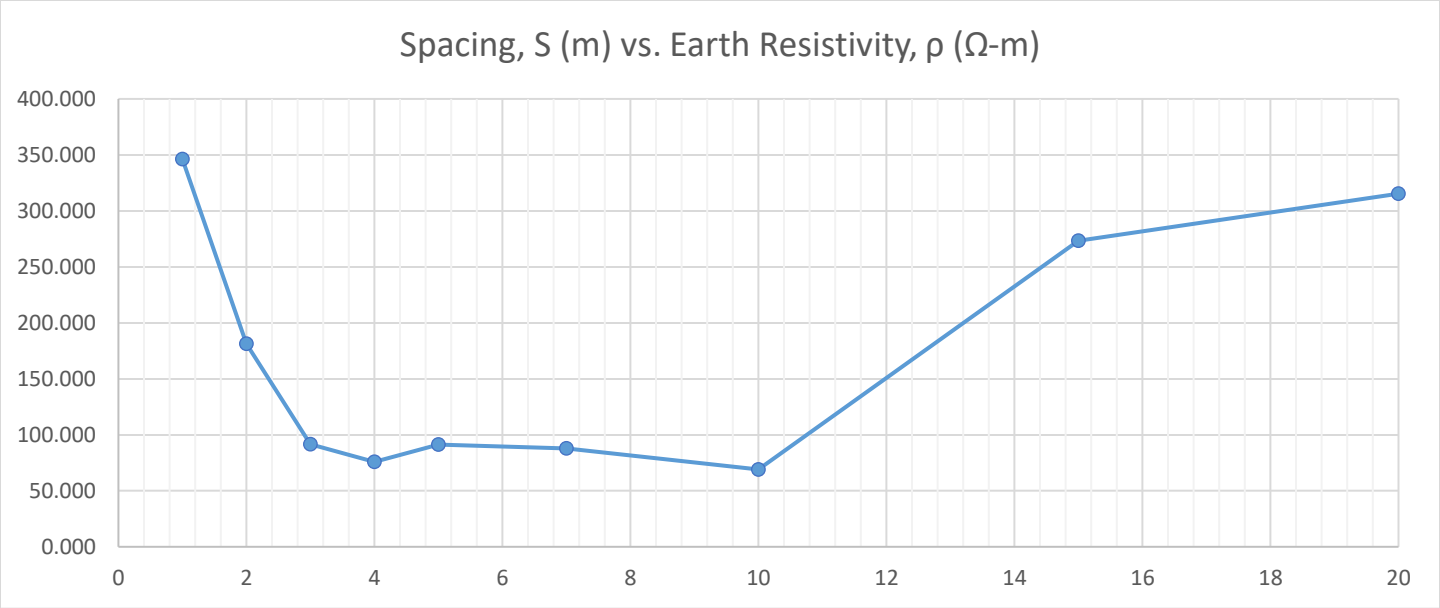
Test No. 15:

Test Point:	**15. T-2B2C (X=422221.00 m, Y=2312694.00 m, Z = 185.127 m), Soil type: sand-rock mixture (Hill top)**			
Date:	**10-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**346.200**	**346.204**	**55.100**
2	**2**	**181.300**	**181.333**	**14.430**
3	**3**	**91.600**	**91.609**	**4.860**
4	**4**	**75.900**	**75.901**	**3.020**
5	**5**	**91.400**	**91.421**	**2.910**
6	**7**	**87.900**	**87.965**	**2.000**
7	**10**	**69.100**	**69.115**	**1.100**
8	**15**	**273.300**	**273.319**	**2.900**
9	**20**	**315.400**	**314.160**	**2.500**



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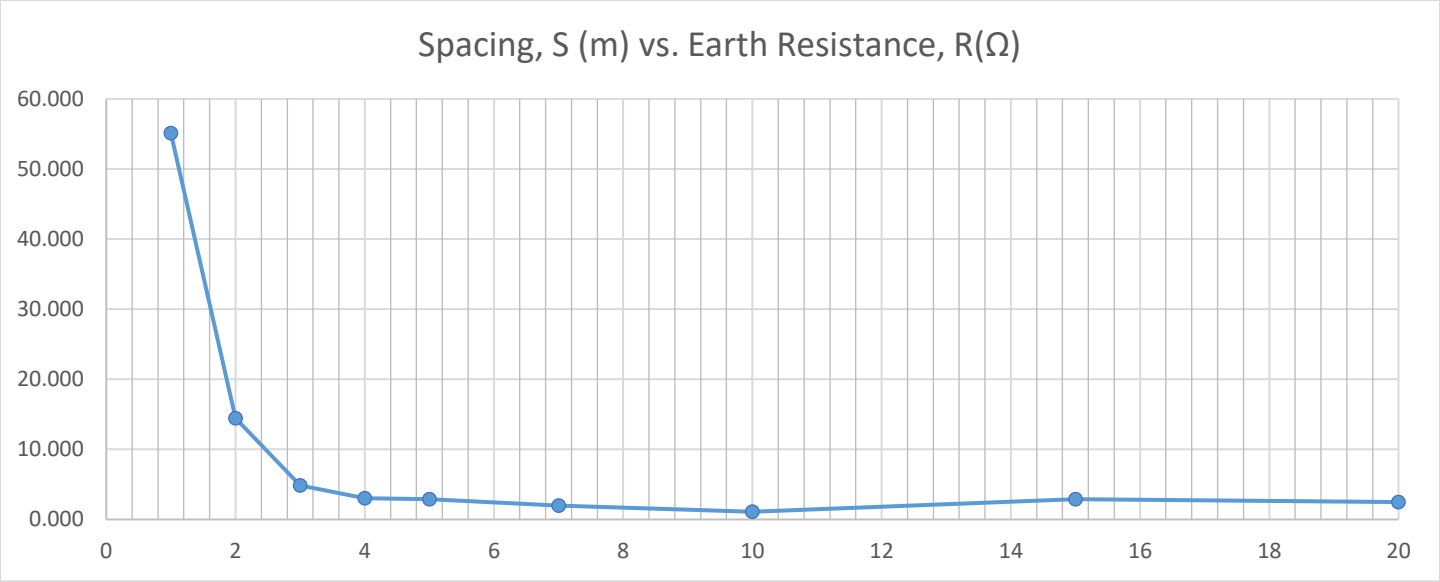

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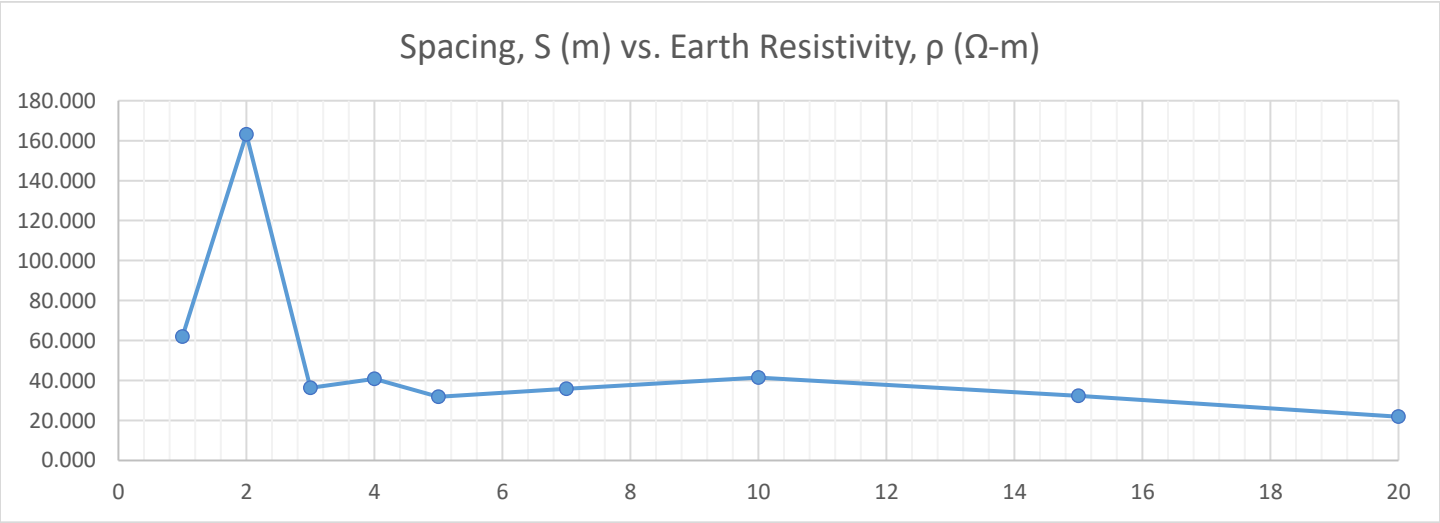
Test No. 16:

Test Point:	**16. T-2B5C (X=423446.00 m, Y=2312781.00 m, Z = 31.638 m), Soil type: clay-sand-rock mixture (Hill top)**			
Date:	**14-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**61.900**	**61.952**	**9.860**
2	**2**	**163.200**	**163.238**	**12.990**
3	**3**	**36.400**	**36.417**	**1.932**
4	**4**	**40.800**	**40.816**	**1.624**
5	**5**	**31.900**	**31.981**	**1.018**
6	**7**	**35.900**	**35.934**	**0.817**
7	**10**	**41.400**	**41.406**	**0.659**
8	**15**	**32.300**	**32.327**	**0.343**
9	**20**	**21.900**	**21.991**	**0.175**



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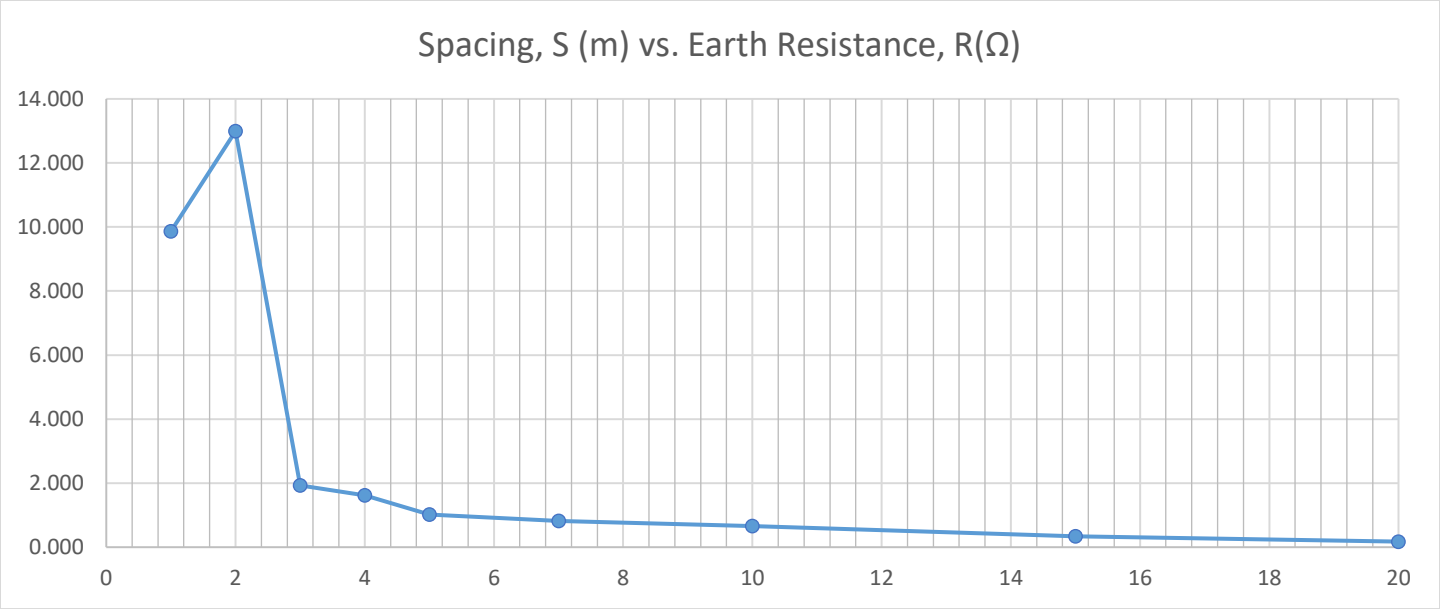

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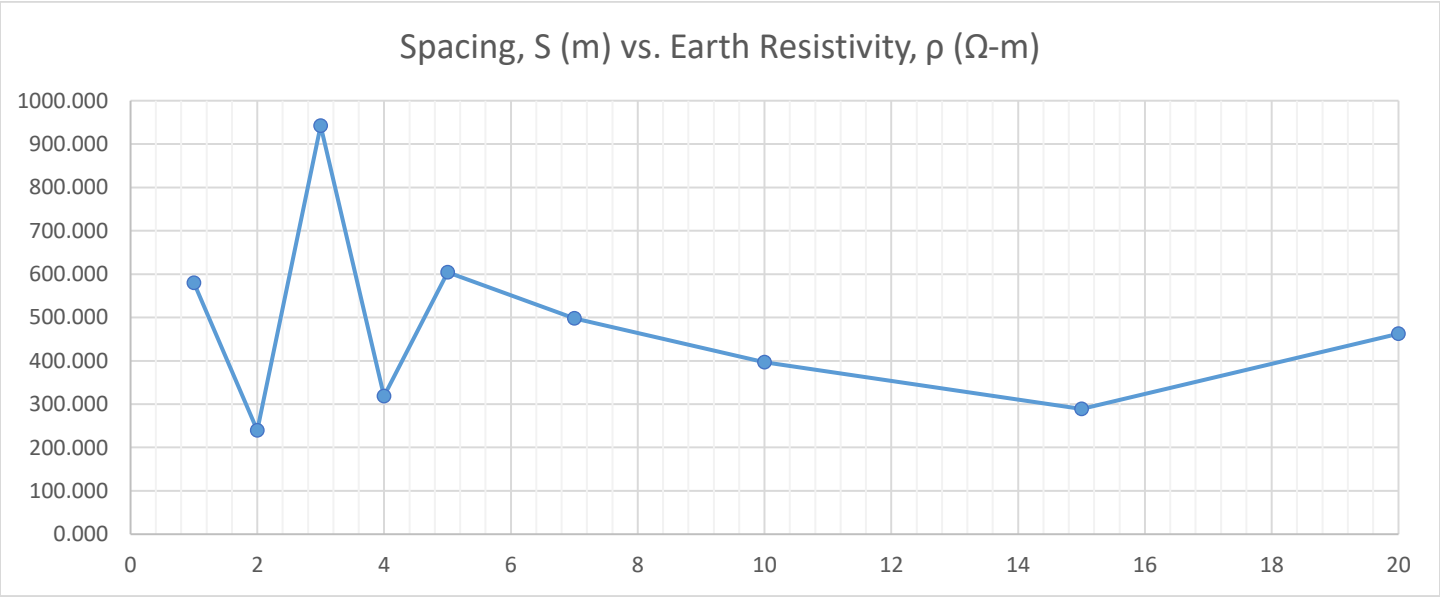
Test No. 17:

Test Point:	**17. T-2B6C (X=423859.00 m, Y=2312809.00 m, Z = 22.783 m), Soil type: clay-sand mixture (Hill top)**			
Date:	**14-Oct-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**579.900**	**579.939**	**92.300**
2	**2**	**239.500**	**1597.189**	**127.100**
3	**3**	**942.400**	**942.480**	**50.000**
4	**4**	**318.400**	**318.433**	**12.670**
5	**5**	**604.100**	**604.130**	**19.230**
6	**7**	**497.800**	**497.881**	**11.320**
7	**10**	**397.000**	**397.098**	**6.320**
8	**15**	**289.300**	**289.341**	**3.070**
9	**20**	**462.400**	**462.444**	**3.680**



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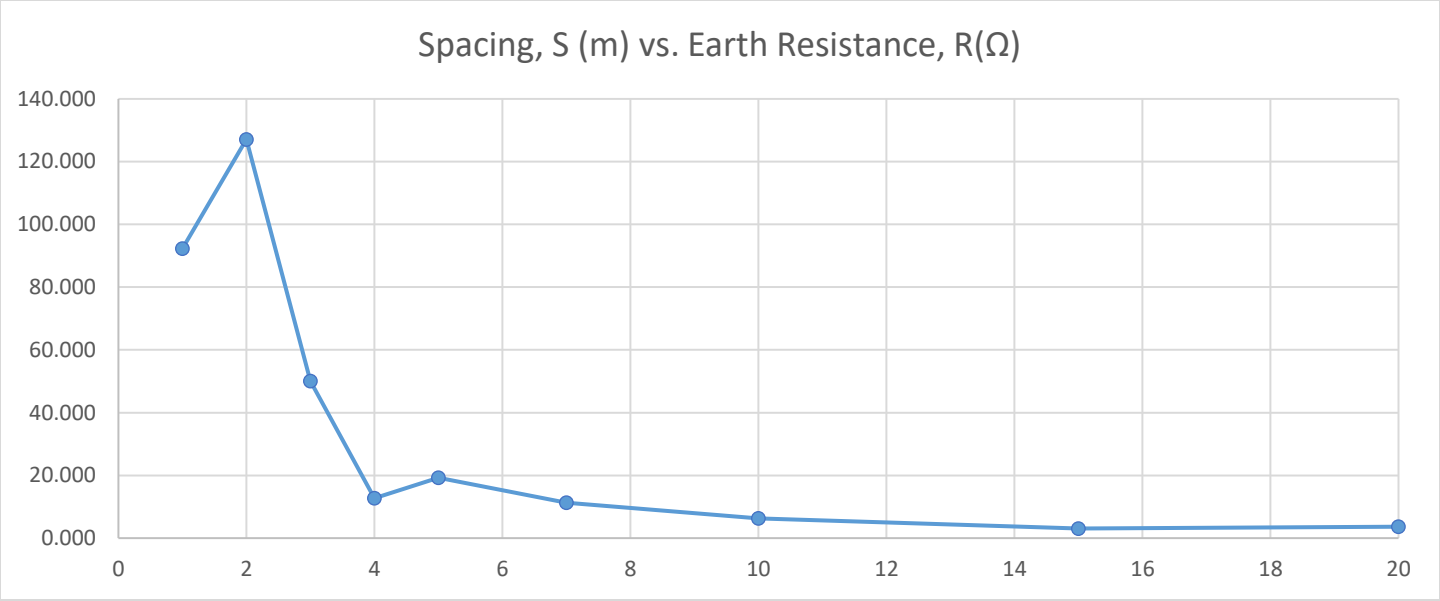

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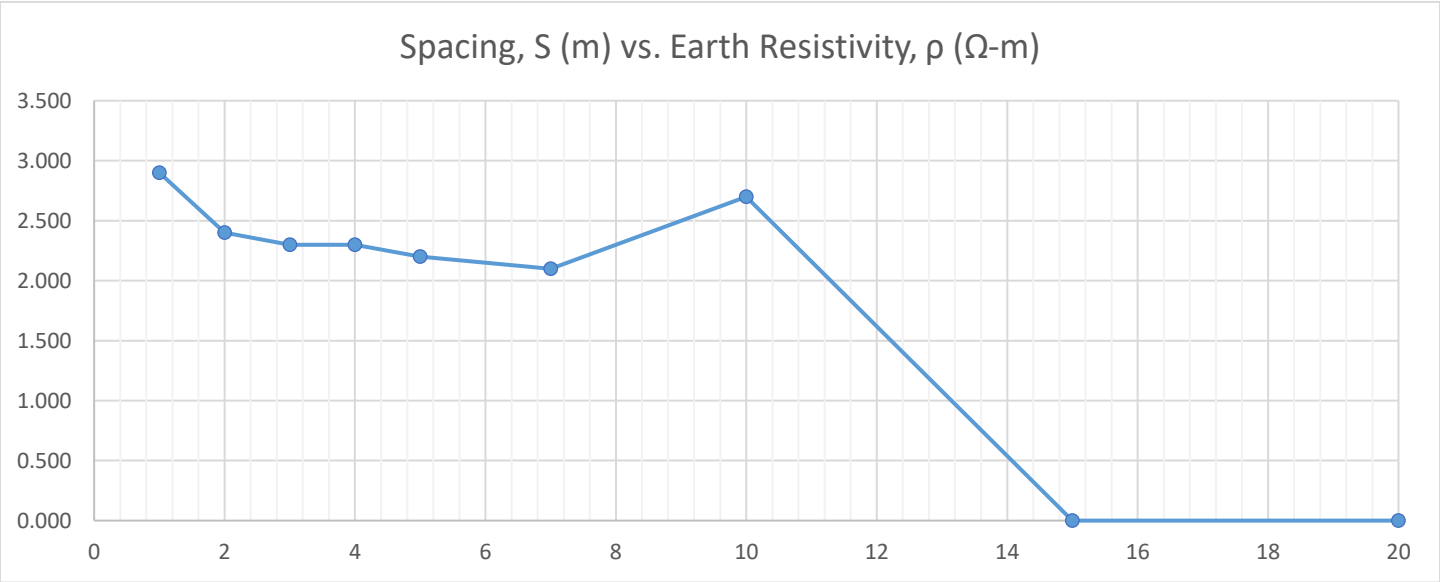
Test No. 18:

Test Point:	**18. T-2B7C (X=424357.00 m, Y=2312844.00 m, Z = -1.578 m), Soil type: clay-sand-water mixture (coastal area)**			
Date:	**2-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**2.900**	**2.909**	**0.463**
2	**2**	**2.400**	**2.488**	**0.198**
3	**3**	**2.300**	**2.394**	**0.127**
4	**4**	**2.300**	**2.312**	**0.092**
5	**5**	**2.200**	**2.231**	**0.071**
6	**7**	**2.100**	**2.243**	**0.051**
7	**10**	**2.700**	**2.765**	**0.044**
8	**15**	**0.000**	**0.000**	**0.000**
9	**20**	**0.000**	**0.000**	**0.000**



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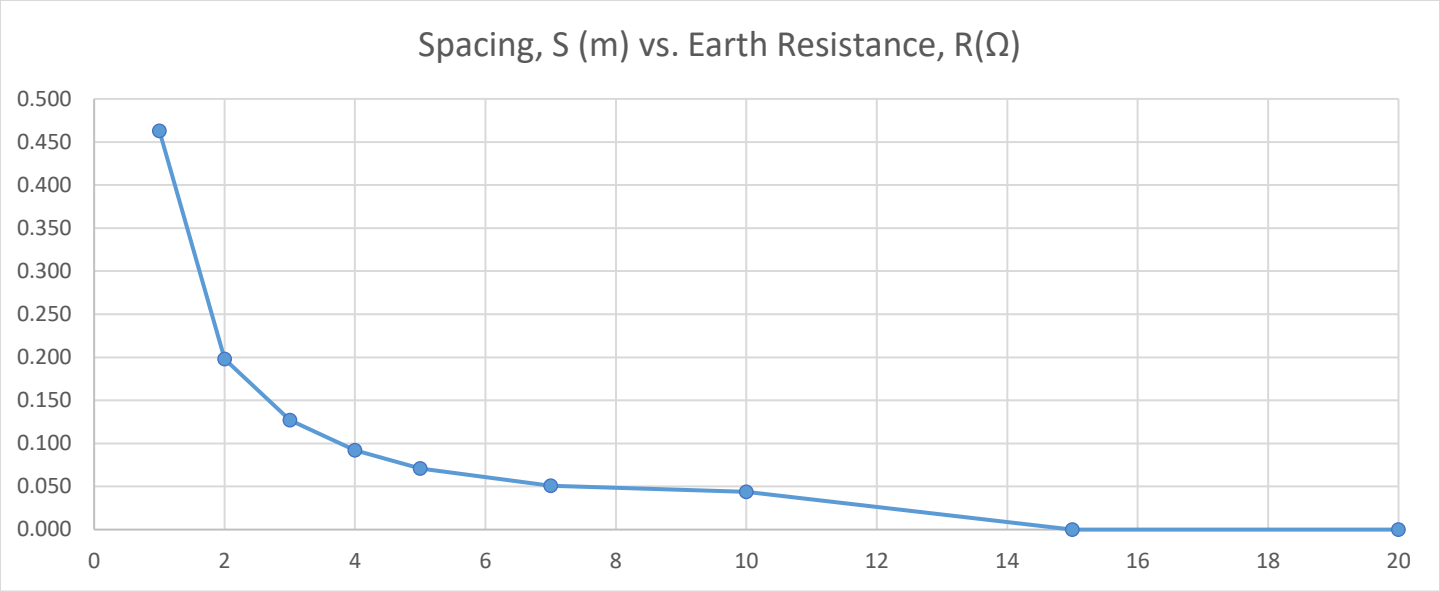

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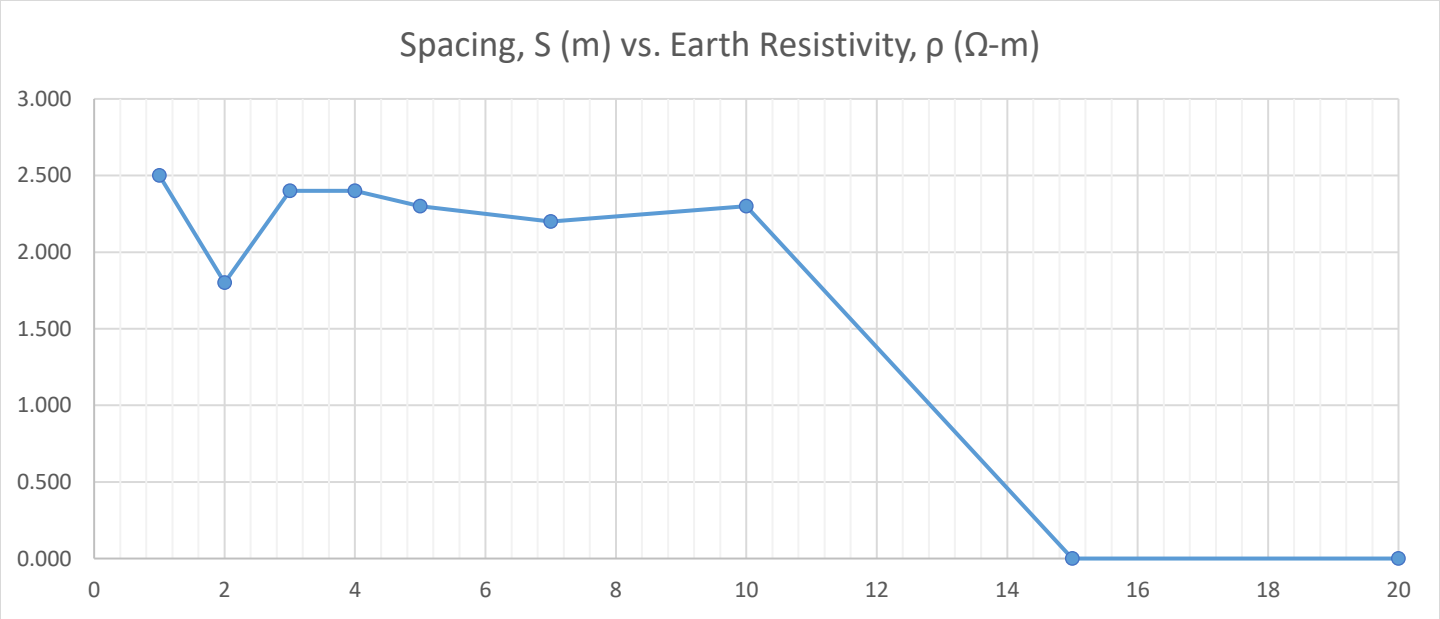
Test No. 19:

Test Point:	**19. T-2B7C (Additional Point) (X=424365.00 m, Y=2312848.00 m, Z = 1.043 m), Soil type: Sandy (coastal area)**			
Date:	**2-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**2.500**	**2.582**	**0.411**
2	**2**	**1.800**	**1.835**	**0.146**
3	**3**	**2.400**	**2.413**	**0.128**
4	**4**	**2.400**	**2.413**	**0.096**
5	**5**	**2.300**	**2.388**	**0.076**
6	**7**	**2.200**	**2.243**	**0.051**
7	**10**	**2.300**	**2.325**	**0.037**
8	**15**	**0.000**	**0.000**	**0.000**
9	**20**	**0.000**	**0.000**	**0.000**



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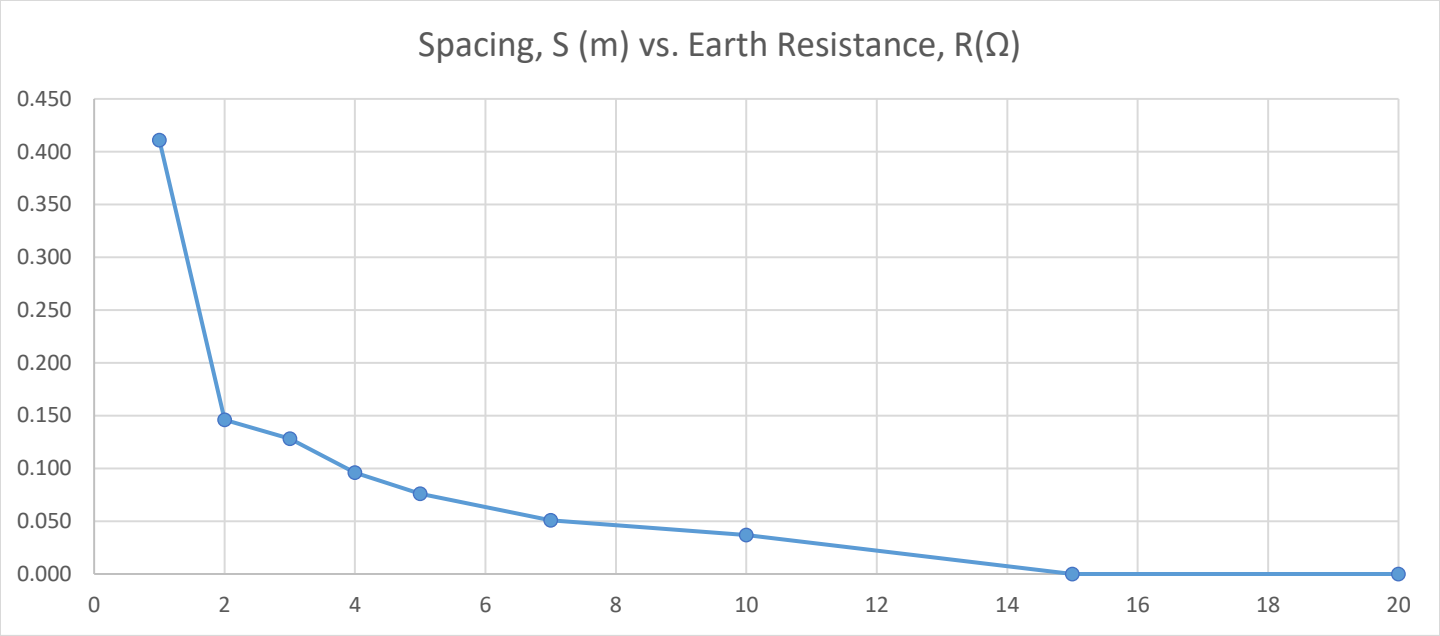

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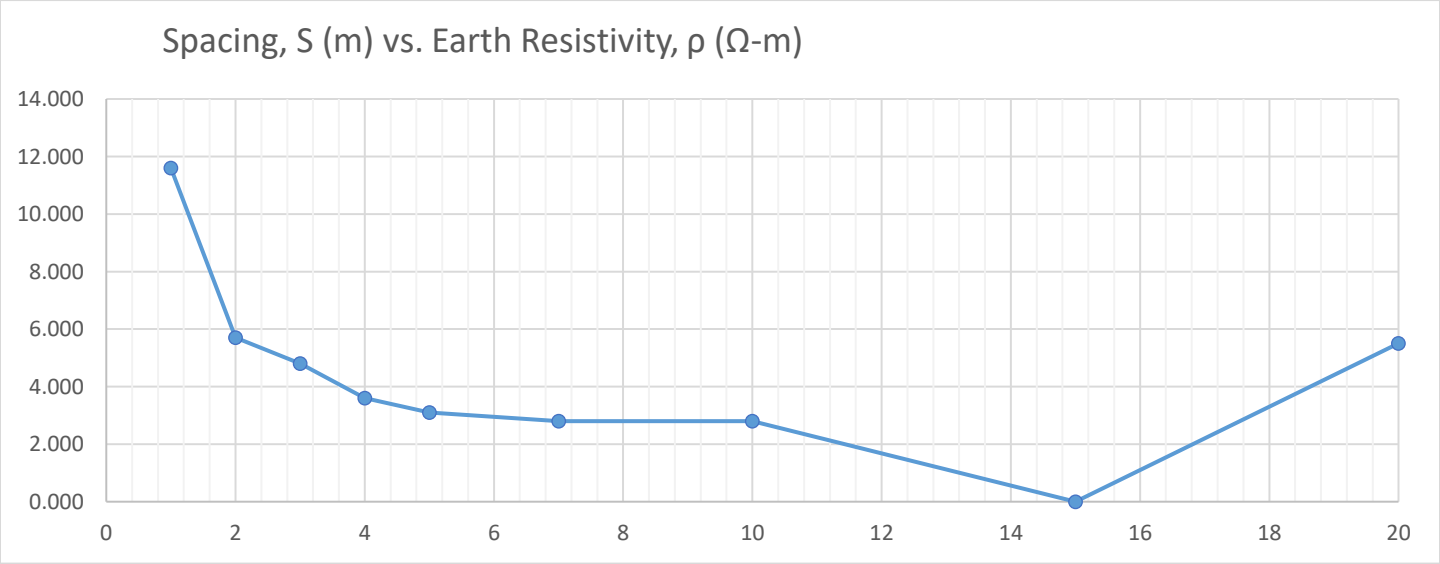
Test No. 20:

Test Point:	**20. T-2B7C (Additional Point) (X=424365.00 m, Y=2312848.00 m, Z = 1.043 m), Soil type: Sandy (coastal area)**			
Date:	**2-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**11.600**	**11.655**	**1.855**
2	**2**	**5.700**	**5.755**	**0.458**
3	**3**	**4.800**	**4.863**	**0.258**
4	**4**	**3.600**	**3.619**	**0.144**
5	**5**	**3.100**	**3.173**	**0.101**
6	**7**	**2.800**	**2.859**	**0.065**
7	**10**	**2.800**	**2.890**	**0.046**
8	**15**	**0.000**	**0.000**	**0.000**
9	**20**	**5.500**	**5.529**	**0.044**



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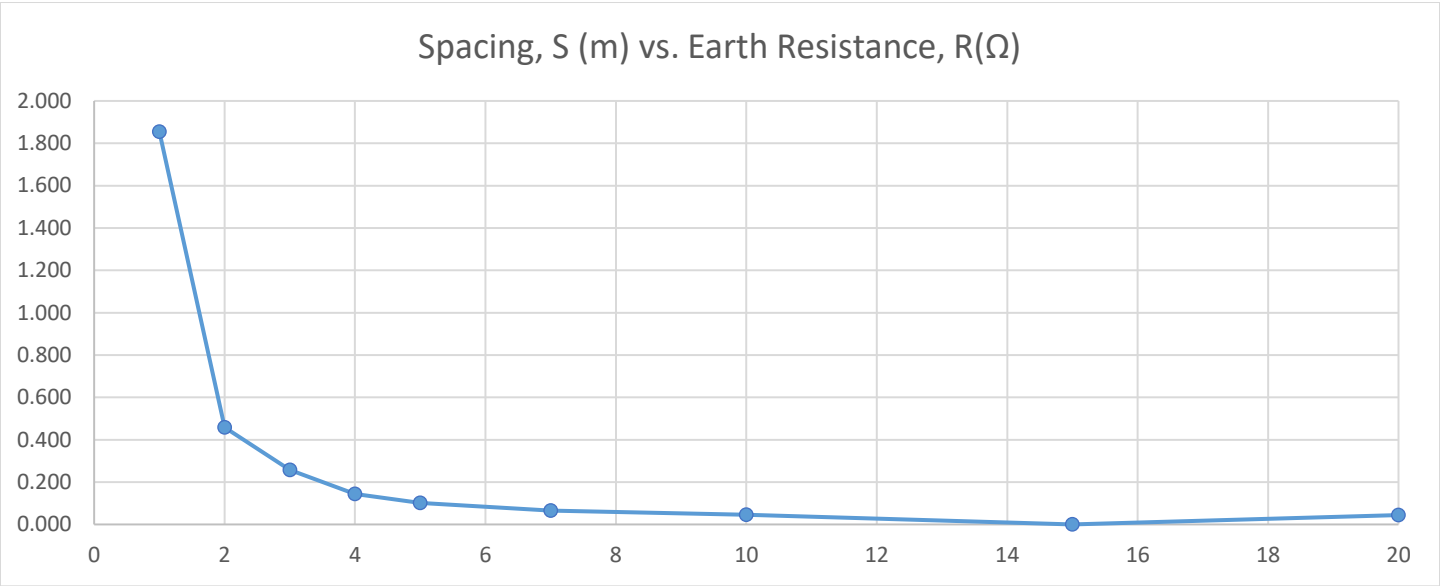

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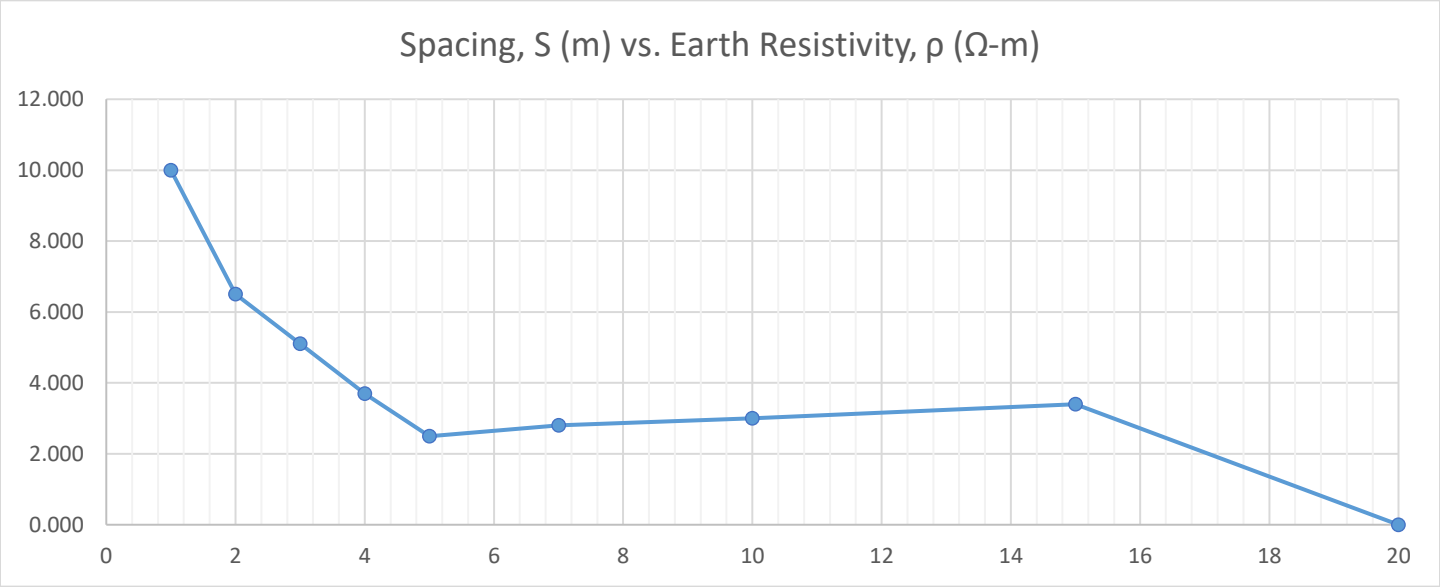
Test No. 21:

Test Point:	**21. T-2B7C (Additional 3)** **(X=424367.00 m, Y=2312835.00 m, Z = 1.032 m), Soil type: Sandy (coastal area)**			
Date:	**2-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m)** **Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**10.000**	**10.047**	**1.599**
2	**2**	**6.500**	**6.547**	**0.521**
3	**3**	**5.100**	**5.146**	**0.273**
4	**4**	**3.700**	**3.770**	**0.150**
5	**5**	**2.500**	**2.545**	**0.081**
6	**7**	**2.800**	**2.859**	**0.065**
7	**10**	**3.000**	**3.079**	**0.049**
8	**15**	**3.400**	**3.487**	**0.037**
9	**20**	**0.000**	**0.000**	**0.000**



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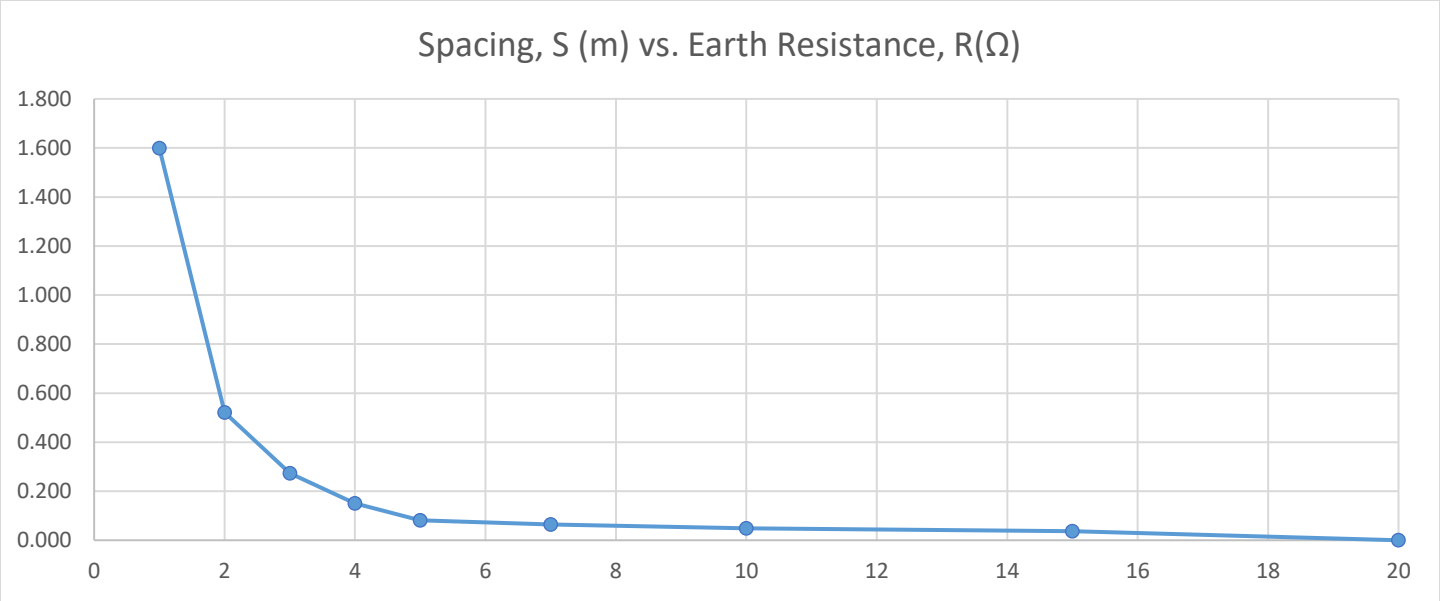

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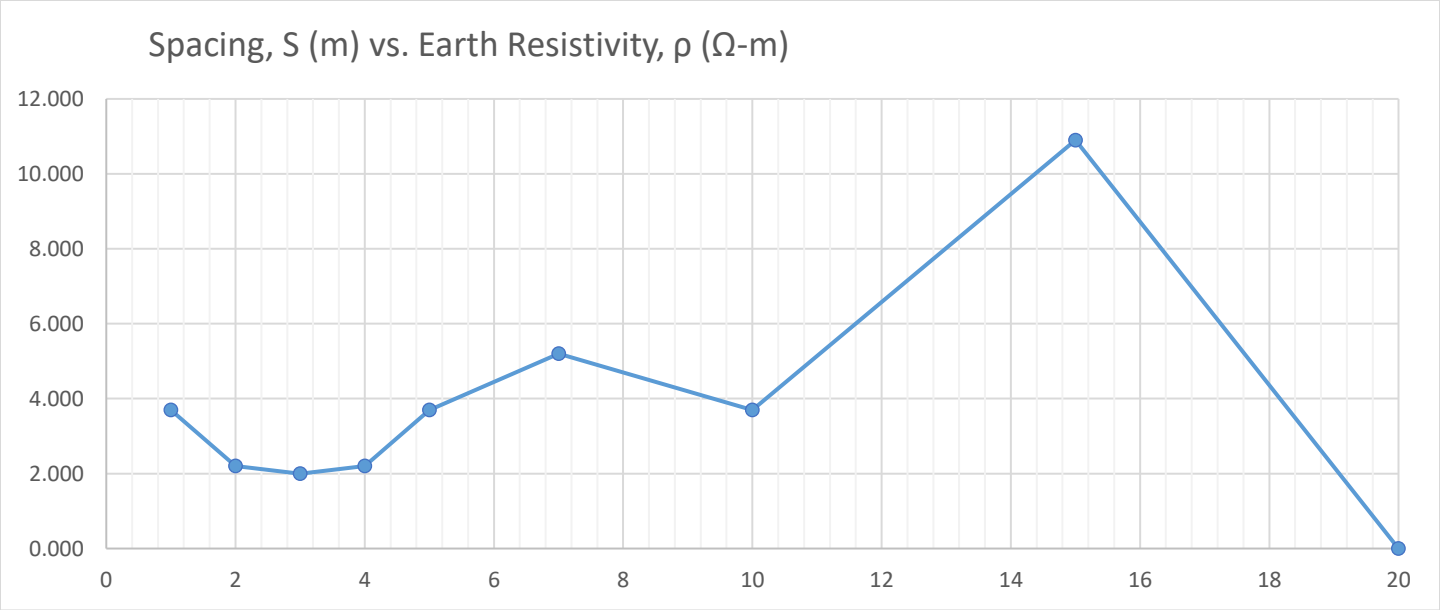
Test No 22:

Test Point:	**22. T-2B7C (Additional 4) (X=424369.00 m, Y=2312824.00 m, Z = 1.124 m), Soil type: Sandy (coastal area)**			
Date:	**2-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**3.700**	**3.707**	**0.590**
2	**2**	**2.200**	**2.262**	**0.180**
3	**3**	**2.000**	**2.073**	**0.110**
4	**4**	**2.200**	**2.262**	**0.090**
5	**5**	**3.700**	**3.770**	**0.120**
6	**7**	**5.200**	**5.278**	**0.120**
7	**10**	**3.700**	**3.770**	**0.060**
8	**15**	**10.900**	**10.933**	**0.116**
9	**20**	**0.000**	**0.000**	**0.000**



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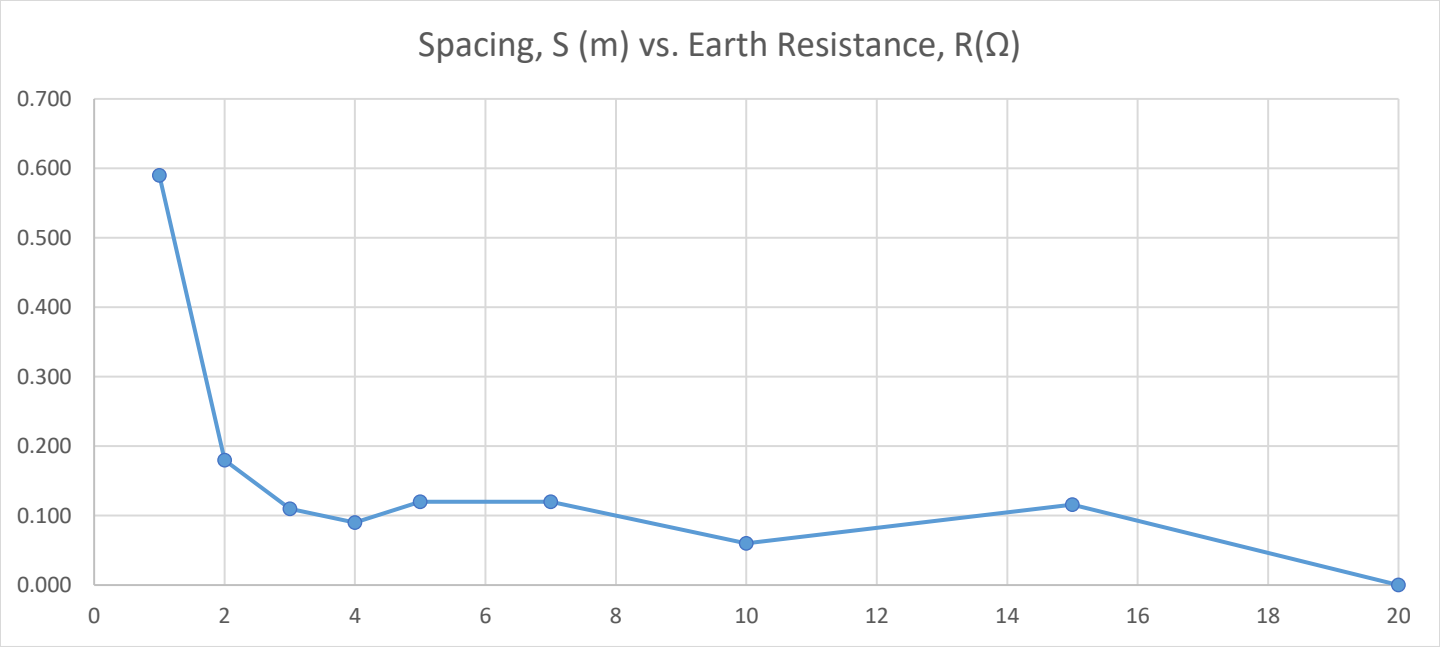

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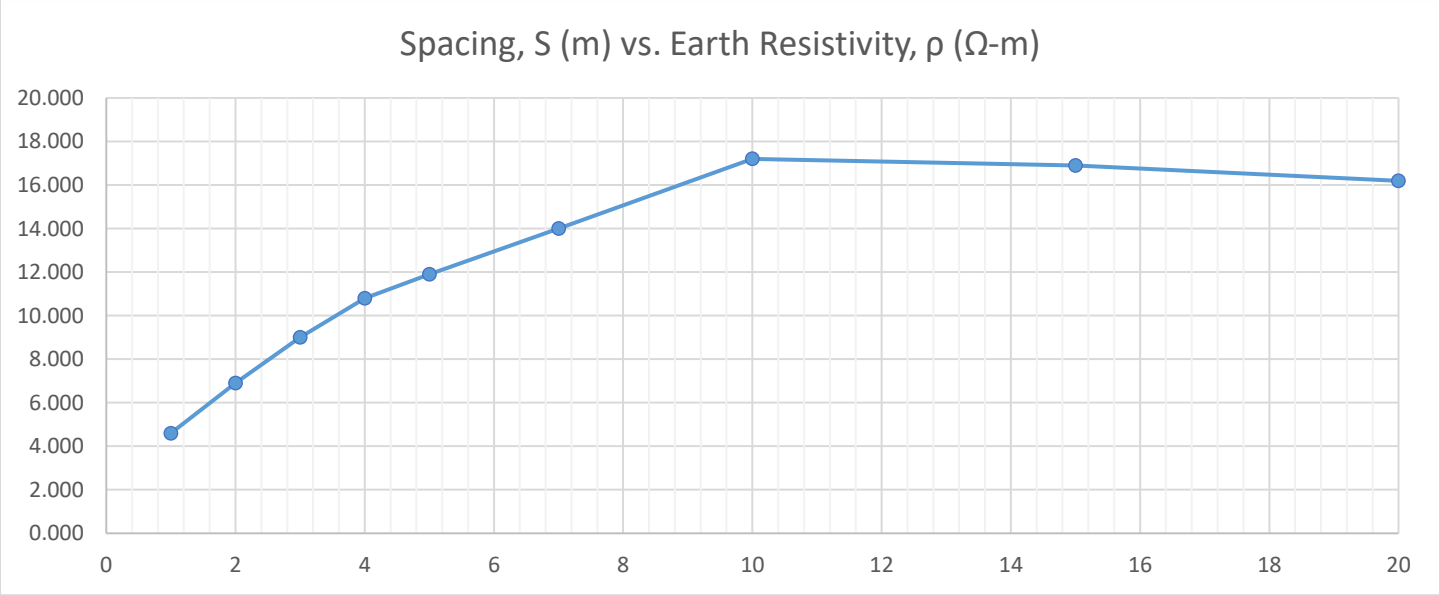
Test No. 23:

Test Point:	**23. Station-A, Point-1 (Z = 3.605 m), Soil type: sandy clay (paddy field)**			
Date:	**1-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**4.600**	**4.650**	**0.740**
2	**2**	**6.900**	**6.912**	**0.550**
3	**3**	**9.000**	**9.048**	**0.480**
4	**4**	**10.800**	**10.807**	**0.430**
5	**5**	**11.900**	**11.938**	**0.380**
6	**7**	**14.000**	**14.074**	**0.320**
7	**10**	**17.200**	**14.703**	**0.234**
8	**15**	**16.900**	**16.965**	**0.180**
9	**20**	**16.200**	**16.211**	**0.129**



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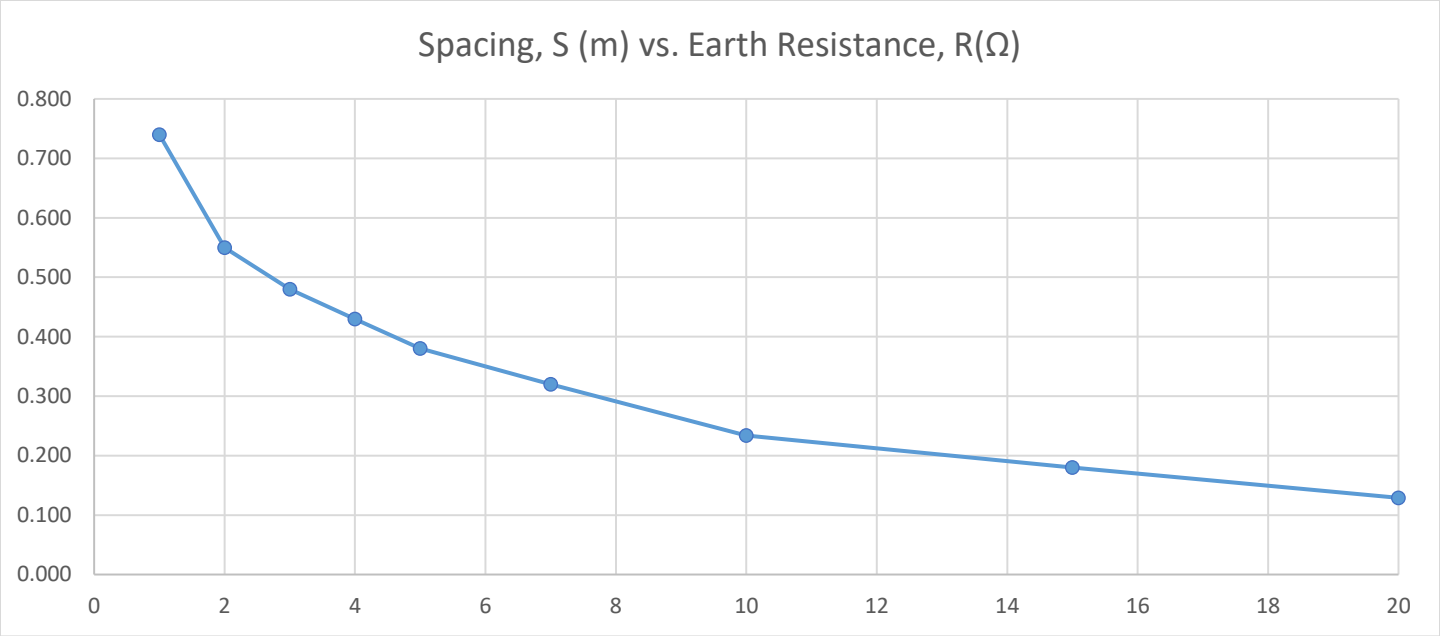

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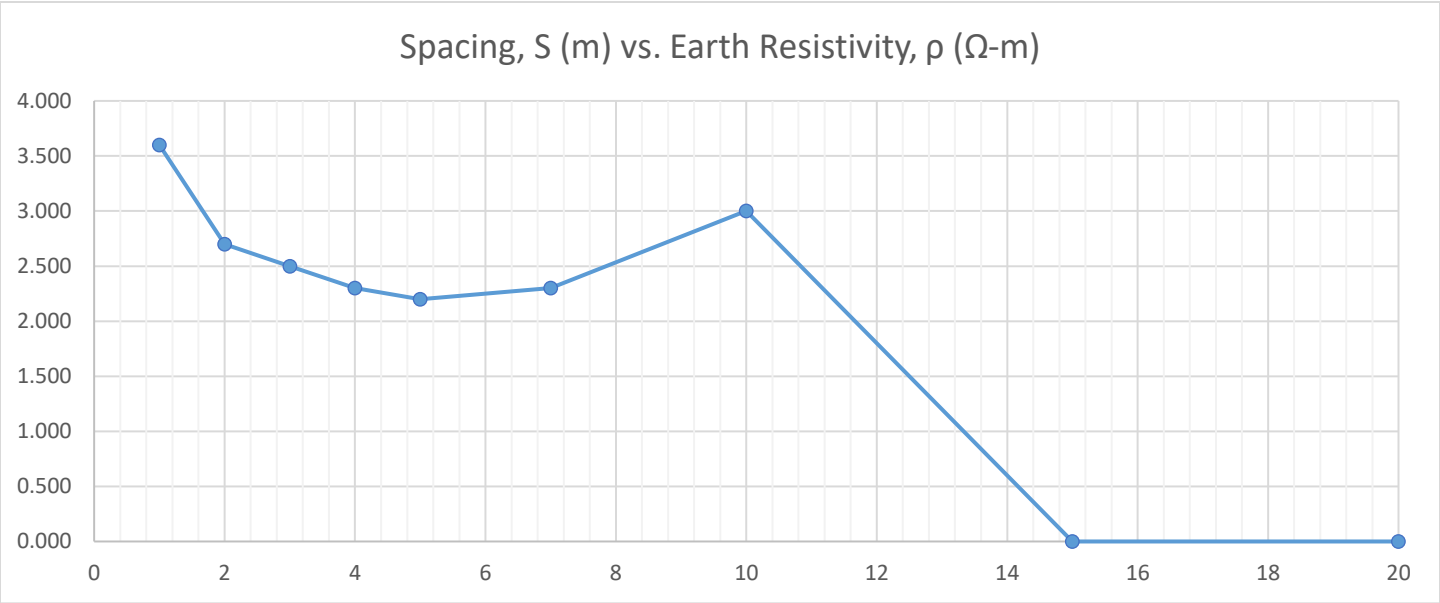
Test No. 24:

Test Point:	**24. Station-A, Point-2 (Z = 3.605 m), Soil type: sandy clay (paddy field)**			
Date:	**1-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**3.600**	**3.644**	**0.580**
2	**2**	**2.700**	**2.790**	**0.222**
3	**3**	**2.500**	**2.507**	**0.133**
4	**4**	**2.300**	**2.337**	**0.093**
5	**5**	**2.200**	**2.231**	**0.071**
6	**7**	**2.300**	**2.331**	**0.053**
7	**10**	**3.000**	**3.016**	**0.048**
8	**15**	**0.000**	**0.000**	**0.000**
9	**20**	**0.000**	**0.000**	**0.000**



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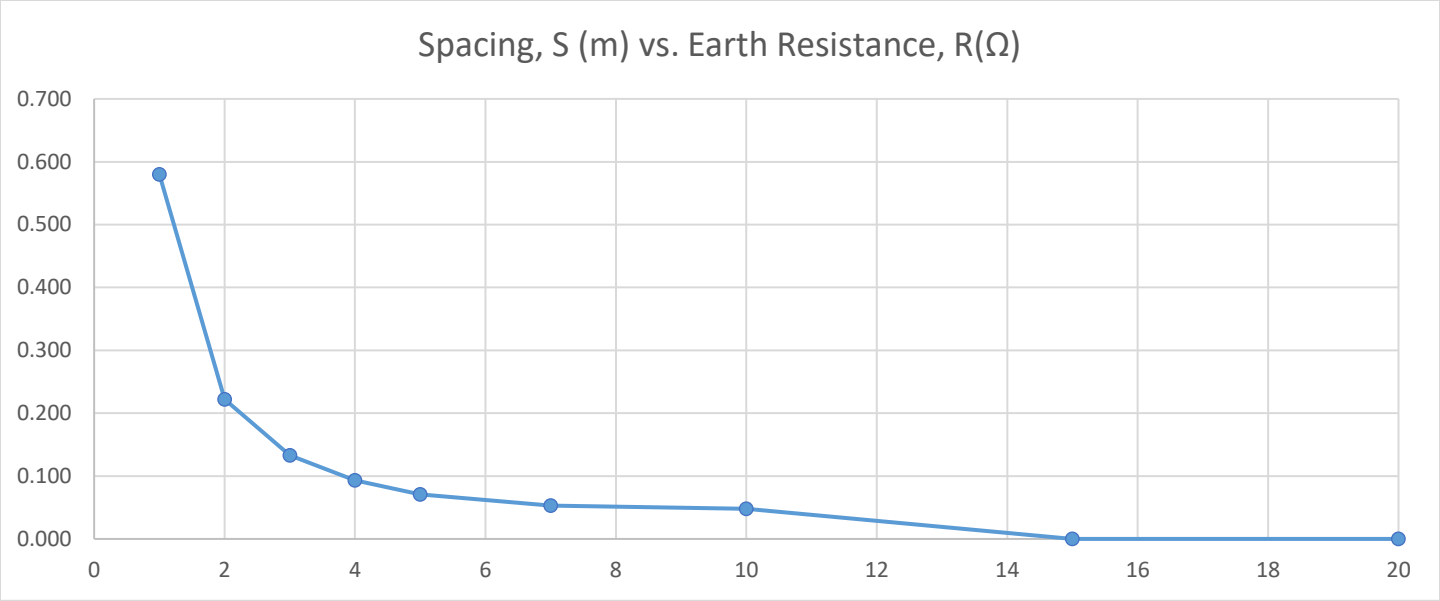

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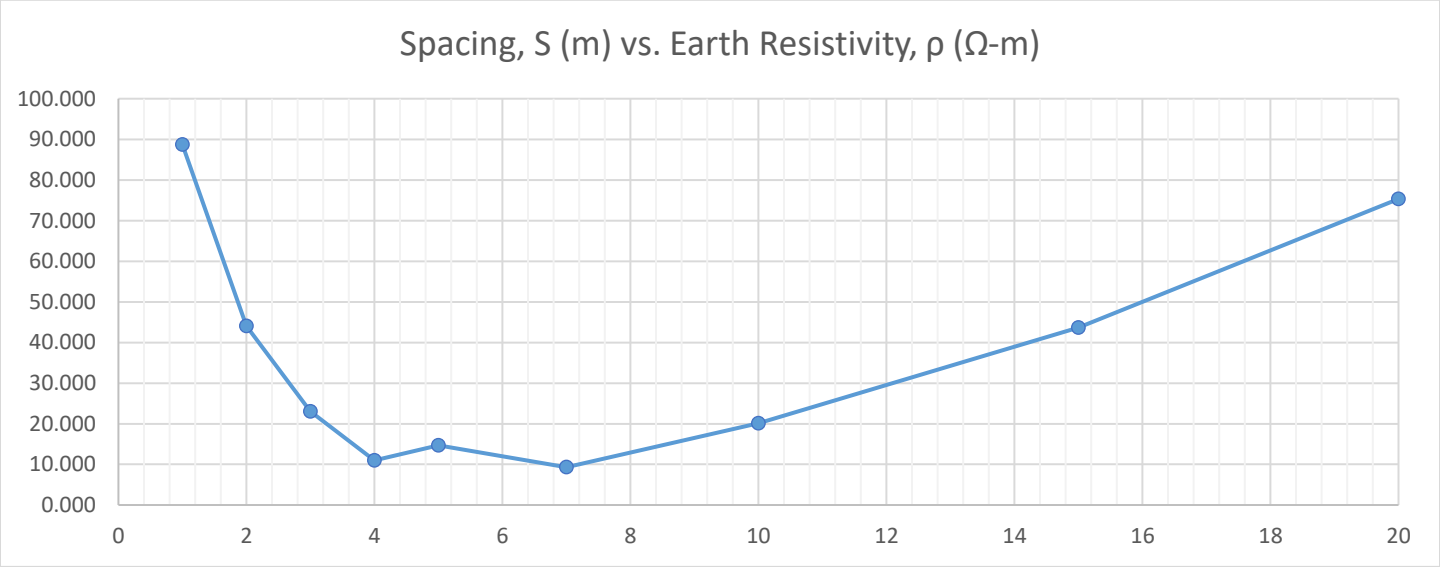
Test No. 25:

Test Point:	**25. Statiion-A, Point-3 (Z = 3.605 m), Soil type: sandy clay (paddy field)**			
Date:	**1-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**88.700**	**88.782**	**14.130**
2	**2**	**44.100**	**44.108**	**3.510**
3	**3**	**23.000**	**23.053**	**1.223**
4	**4**	**11.000**	**11.033**	**0.439**
5	**5**	**14.700**	**14.766**	**0.470**
6	**7**	**9.300**	**9.324**	**0.212**
7	**10**	**20.100**	**20.106**	**0.320**
8	**15**	**43.700**	**43.731**	**0.464**
9	**20**	**75.300**	**75.398**	**0.600**



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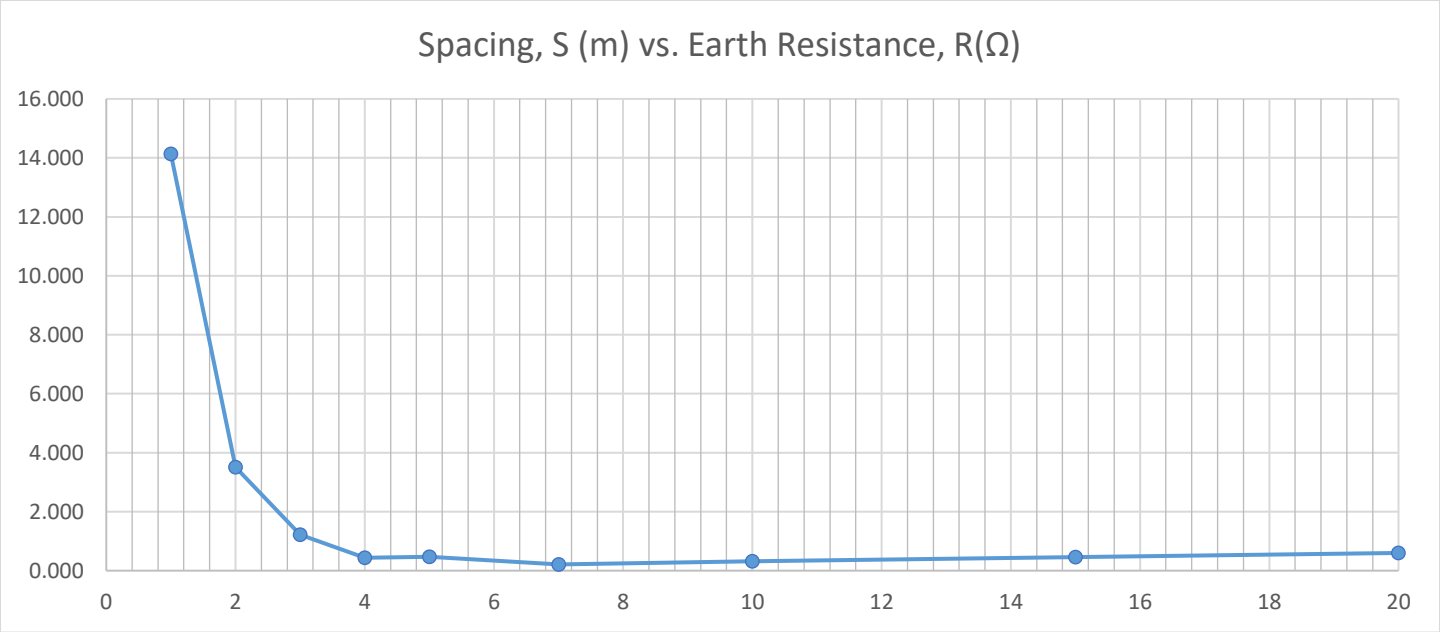

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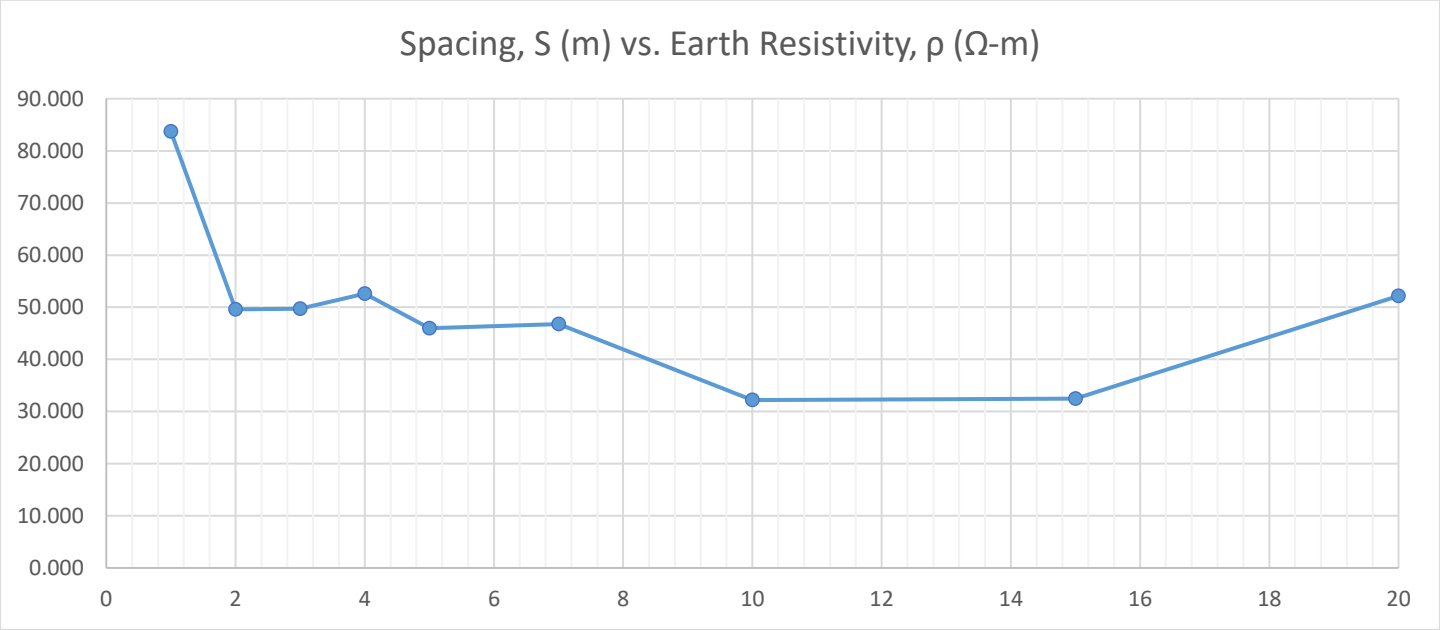
Test No. 26:

Test Point:	**26. Statiion-A, Point-4 (Z = 3.605 m), Soil type: sandy clay (paddy field)**			
Date:	**1-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**83.700**	**83.755**	**13.330**
2	**2**	**49.600**	**49.637**	**3.950**
3	**3**	**49.700**	**49.763**	**2.640**
4	**4**	**52.600**	**52.678**	**2.096**
5	**5**	**46.000**	**46.056**	**1.466**
6	**7**	**46.800**	**46.885**	**1.066**
7	**10**	**32.200**	**32.296**	**0.514**
8	**15**	**32.500**	**32.516**	**0.345**
9	**20**	**52.200**	**52.276**	**0.416**



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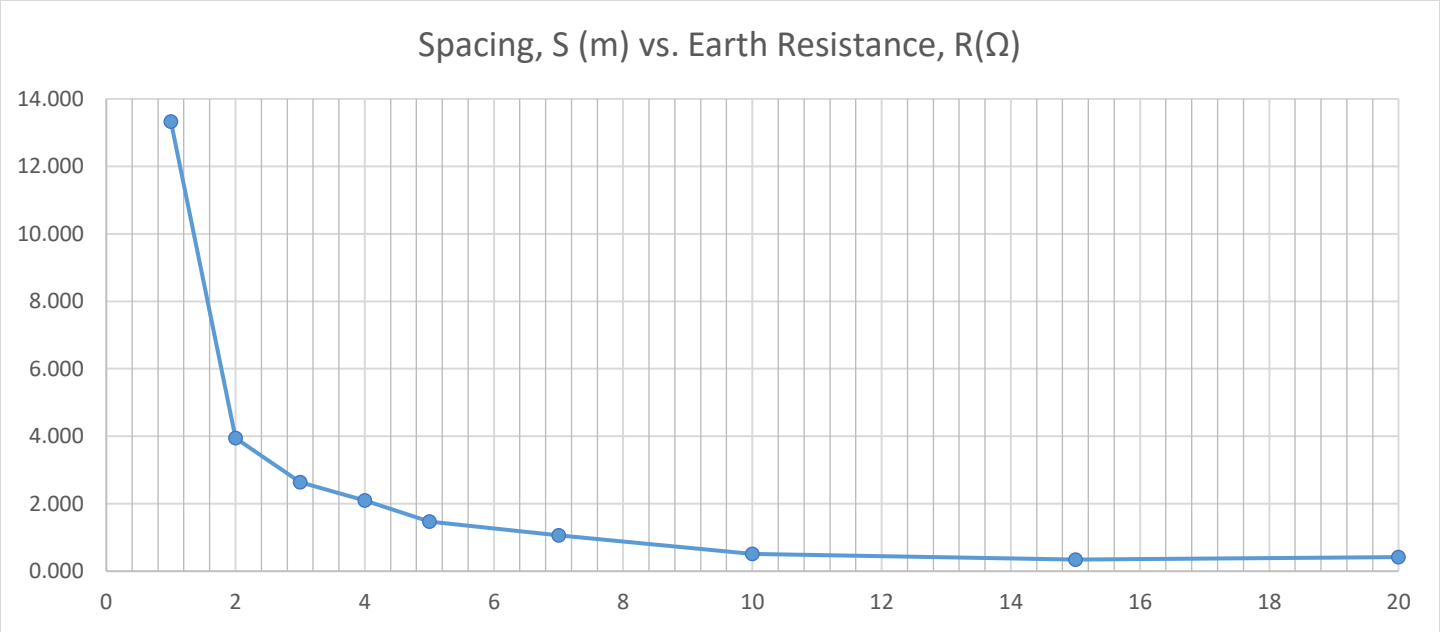

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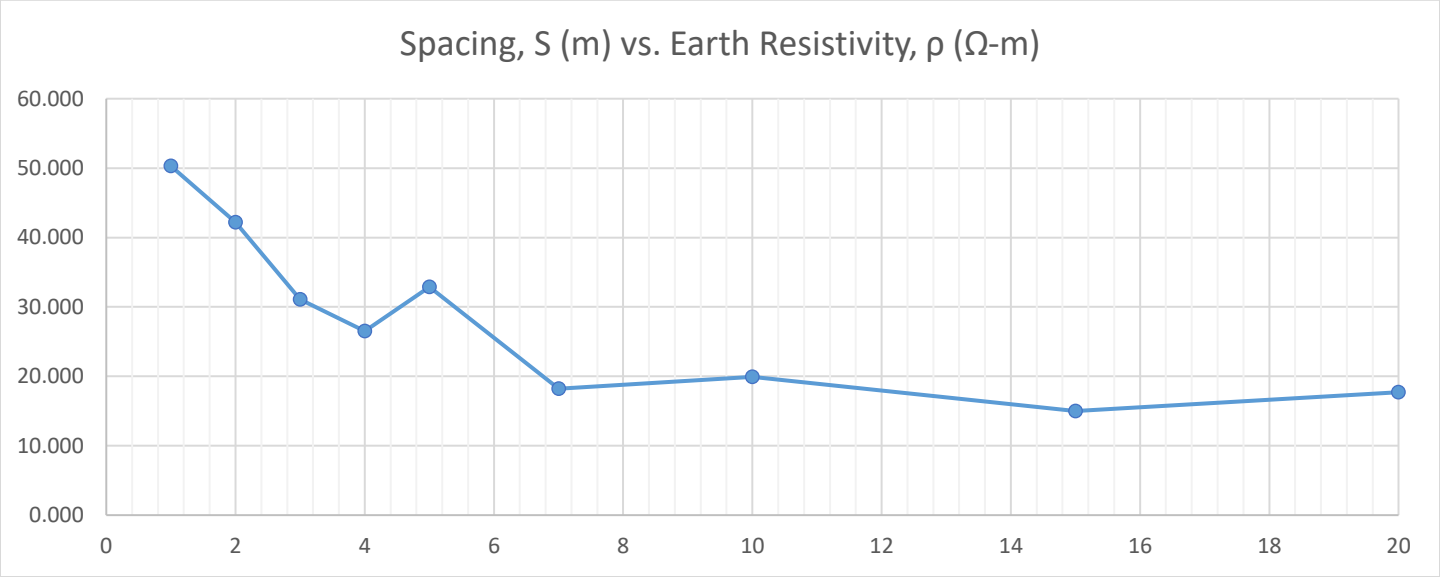
Test No. 27:

Test Point:	**27. Statiion-A, Point-5 (Z = 3.605 m), Soil type: sandy clay (paddy field)**			
Date:	**1-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**50.300**	**50.391**	**8.020**
2	**2**	**42.200**	**42.223**	**3.360**
3	**3**	**31.100**	**31.158**	**1.653**
4	**4**	**26.500**	**26.591**	**1.058**
5	**5**	**32.900**	**32.987**	**1.050**
6	**7**	**18.200**	**18.253**	**0.415**
7	**10**	**19.900**	**19.981**	**0.318**
8	**15**	**15.000**	**15.080**	**0.160**
9	**20**	**17.700**	**17.719**	**0.141**



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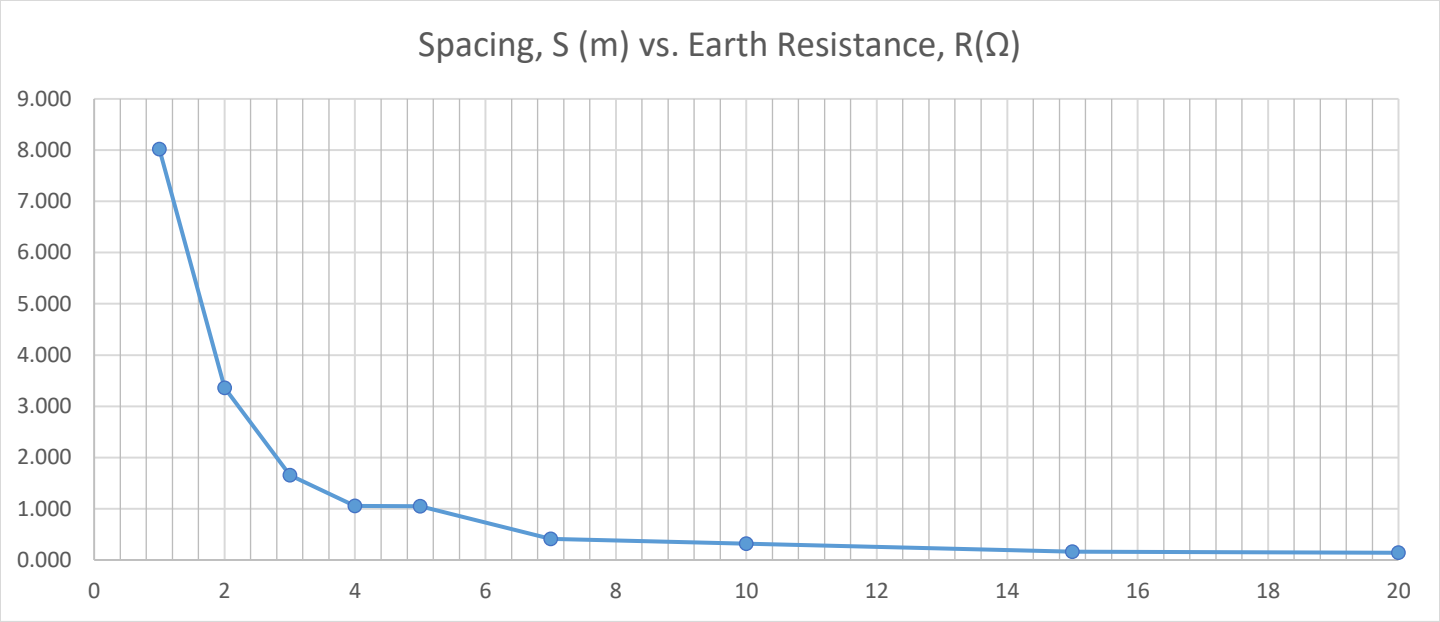

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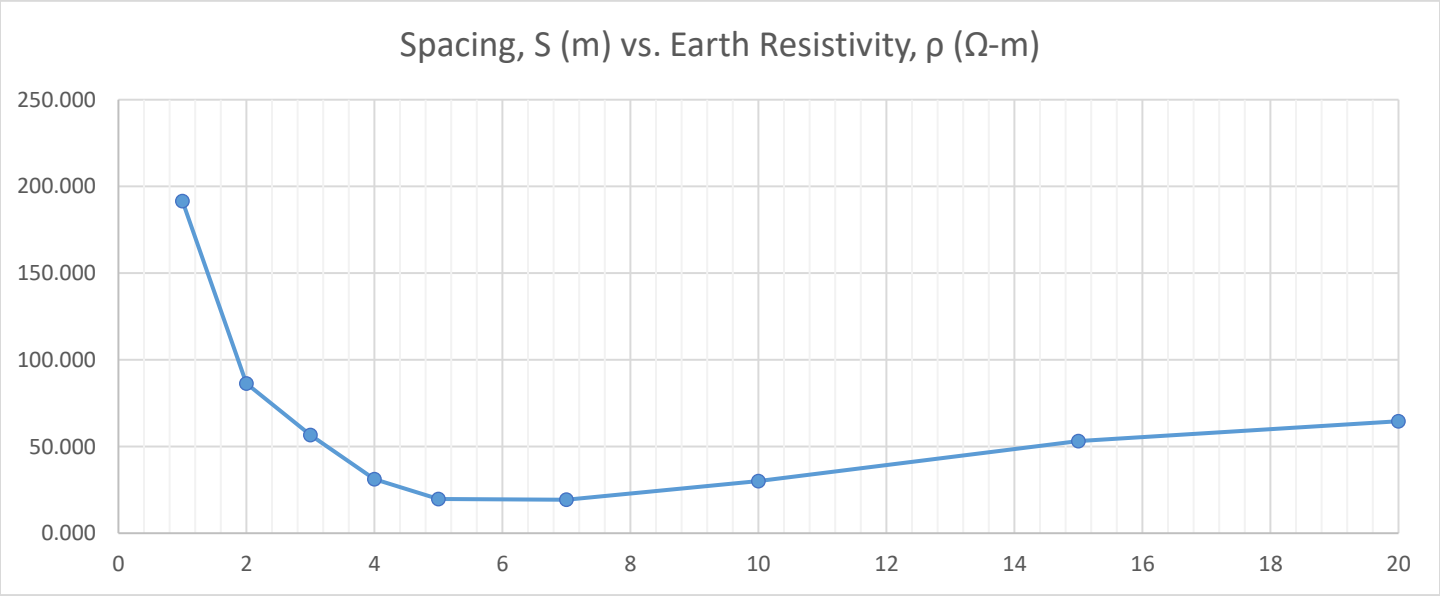
Test No. 28:

Test Point:	**28. Station-A, Additional Pont-1(Right side) (Z = 3.605 m), Soil type: sandy clay (paddy field)**			
Date:	**1-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**191.600**	**191.638**	**30.500**
2	**2**	**86.400**	**86.457**	**6.880**
3	**3**	**56.700**	**56.737**	**3.010**
4	**4**	**31.200**	**31.290**	**1.245**
5	**5**	**19.800**	**19.823**	**0.631**
6	**7**	**19.300**	**19.396**	**0.441**
7	**10**	**30.000**	**30.034**	**0.478**
8	**15**	**53.200**	**53.250**	**0.565**
9	**20**	**64.500**	**64.591**	**0.514**



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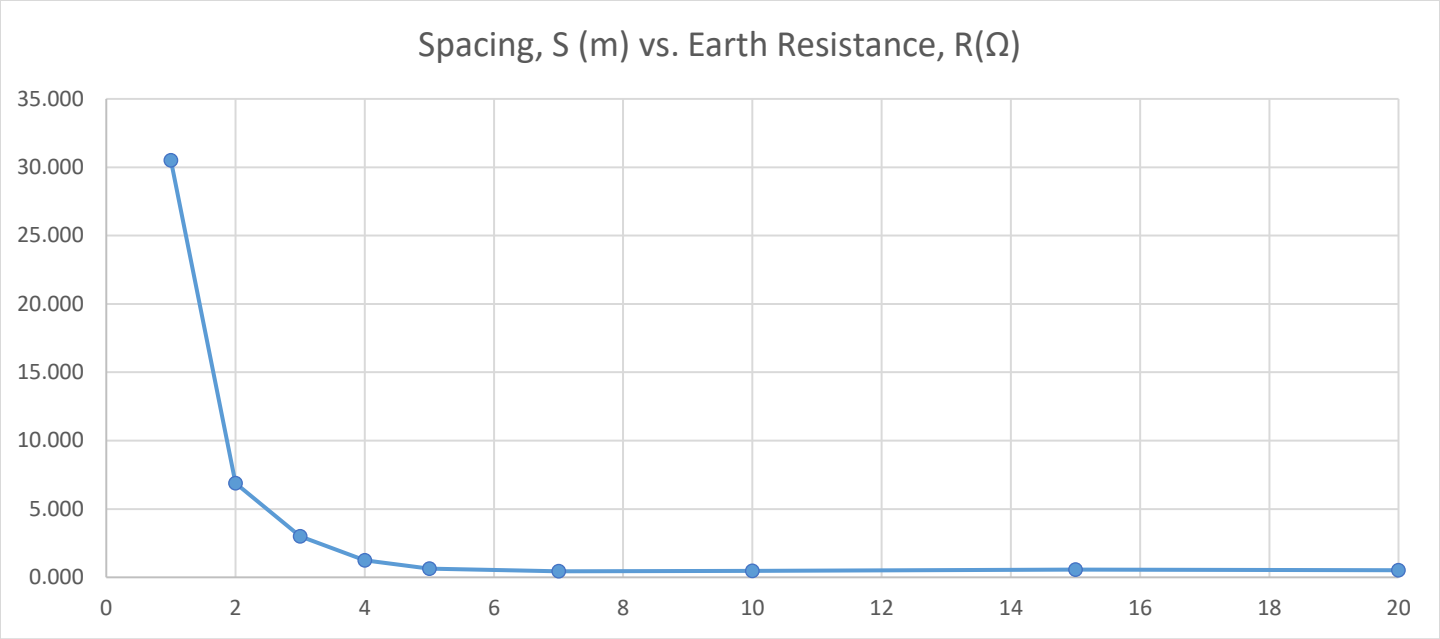

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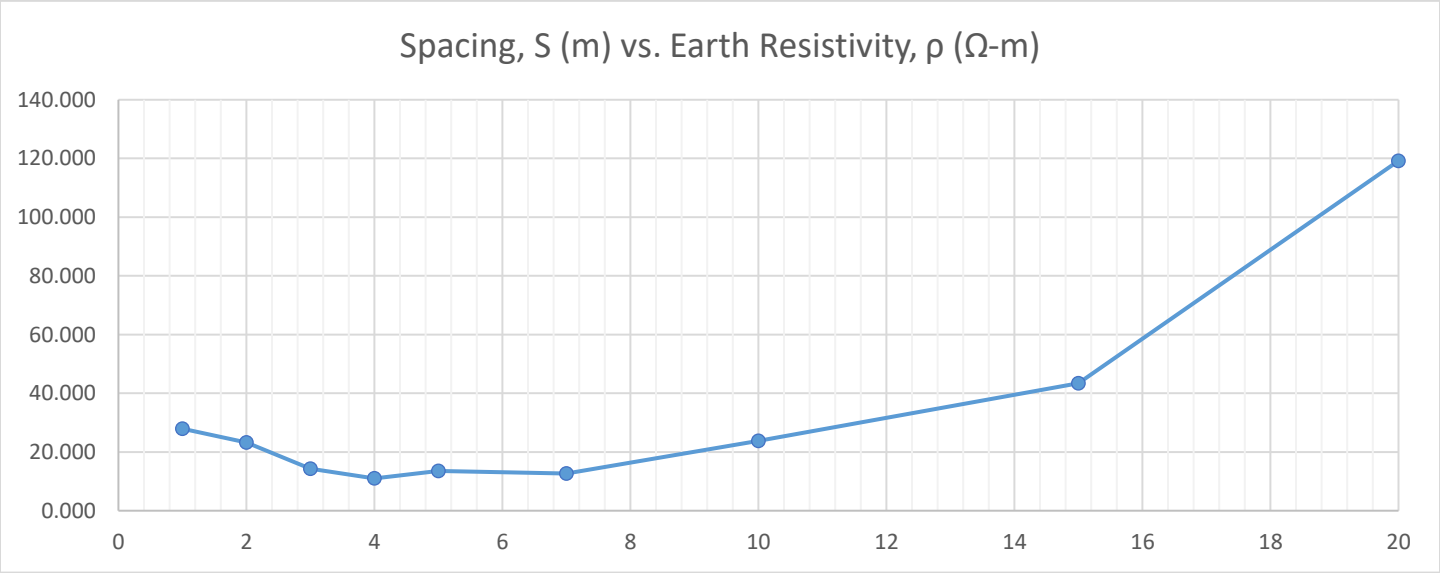
Test No. 29:

Test Point:	**29. Station-A (Additional Point -7, Left side) (Z = 3.605 m), Soil type: sandy clay (paddy field)**			
Date:	**1-Dec-21**			
Test Results				
Sl.No.	**S (m)**	**ρ (Ω-m)**	**ρt (Ω-m) Calculated (2*Pi*S*R)**	**R (Ω)**
1	**1**	**27.900**	**27.960**	**4.450**
2	**2**	**23.200**	**23.248**	**1.850**
3	**3**	**14.300**	**14.326**	**0.760**
4	**4**	**11.000**	**11.058**	**0.440**
5	**5**	**13.500**	**13.509**	**0.430**
6	**7**	**12.700**	**12.711**	**0.289**
7	**10**	**23.800**	**23.813**	**0.379**
8	**15**	**43.400**	**43.448**	**0.461**
9	**20**	**119.200**	**119.255**	**0.949**



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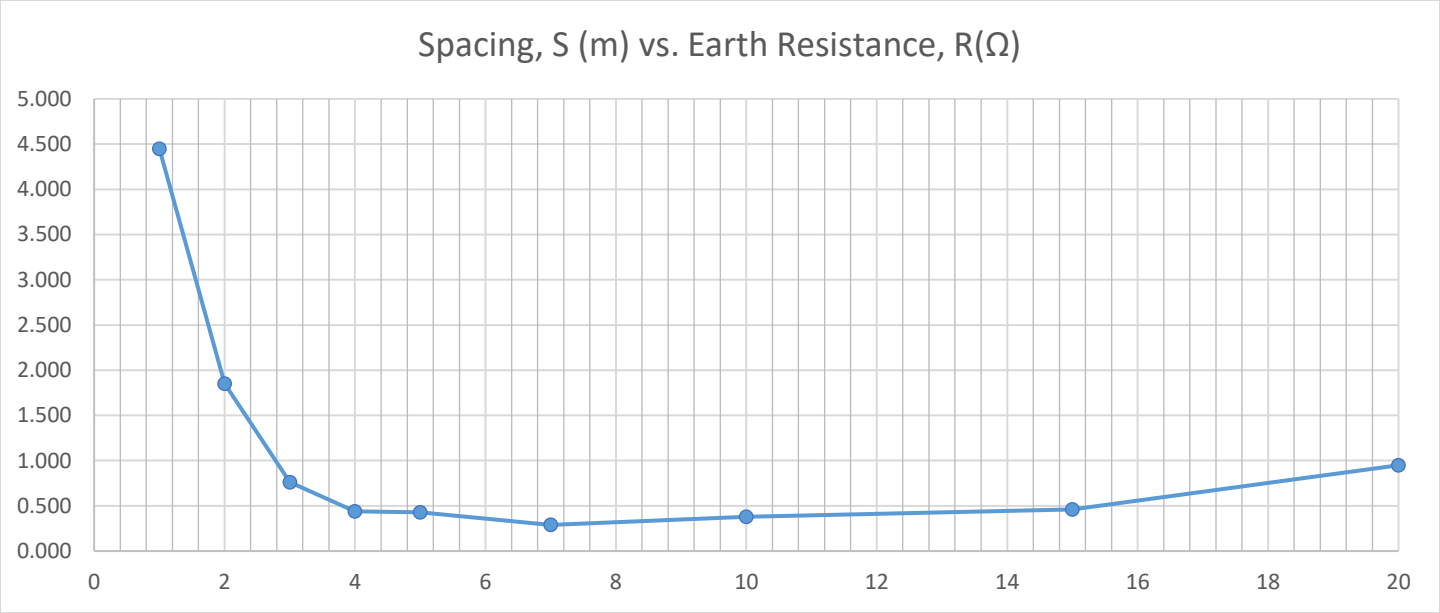

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2. Recommendations:

Earth electrodes and their installation: The earth electrode shall, as far as practicable, penetrate into moist soil (which will remain moist even during the dry season) preferably below ground water table. The resistance of an earthing system after measured after the installation of earth electrodes (individually or combined as a single group) **shall be around one ohm**.

The types of earth electrodes are to be used for earthing of electrical installations of a building and their sizes shall be as under:

(a) Copper rod earth electrode: shall have a minimum diameter of 12.5 mm of minimum length of 3.33 m. Multiple copper rod earth electrodes may have to be installed to achieve an acceptable value of earthing resistance of around 1 ohm.

(b) Copper plate earth electrodes: shall be 600 mm x 600 mm x 6 mm minimum in size. The copper plate shall be buried at least 2 m below the ground level. Multiple Copper plate earth electrodes may have to be installed to achieve an acceptable value of earthing resistance of around 1 ohm.

(c) Galvanized Iron (GI) pipes: GI pipe earthing shall have a minimum diameter of 38 mm and of minimum length of 6.5m. Multiple GI pipes Earth Electrode may have to be installed to achieve an acceptable value of earthing resistance of around 1 ohm.

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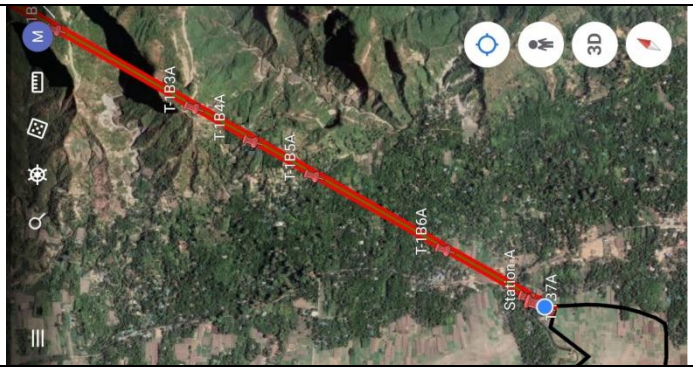
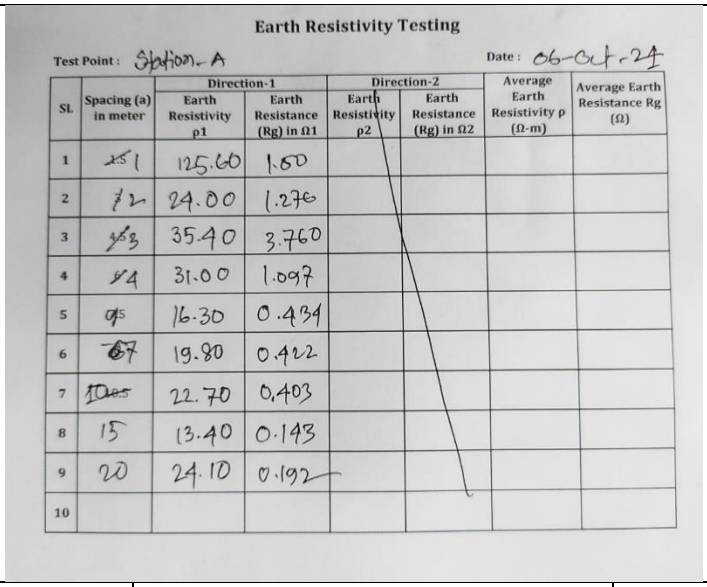
Picture Evidence of the Testing Work

1. T-1B7A

Geo Location





Earth Resistivity Testing

Test Point : Station- A Date : 06-Oct-24

SL	Spacing (a) in meter	Direction-1 Earth Resistivity ρ1	Direction-1 Earth Resistance (Rg) in Ω1	Direction-2 Earth Resistivity ρ2	Direction-2 Earth Resistance (Rg) in Ω2	Average Earth Resistivity ρ (Ω-m)	Average Earth Resistance Rg (Ω)
1	~~2~~ 1	125.60	1.80				
2	~~4~~ 2	24.00	1.276				
3	~~6~~ 3	35.40	3.760				
4	~~8~~ 4	31.00	1.097				
5	~~10~~ 5	16.30	0.434				
6	~~12~~ 6	19.80	0.422				
7	~~14~~ 10	22.70	0.403				
8	15	13.40	0.143				
9	20	24.10	0.192				
10							

Reading-2 (2 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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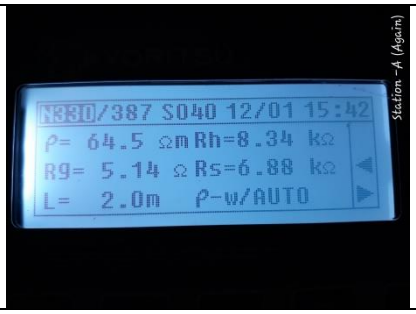
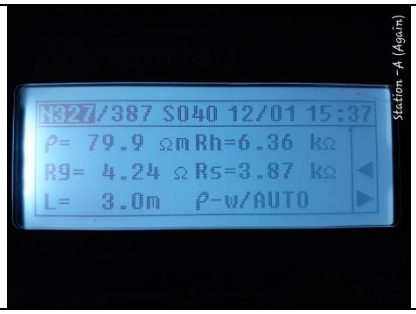
2. Station –A (Again)

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
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		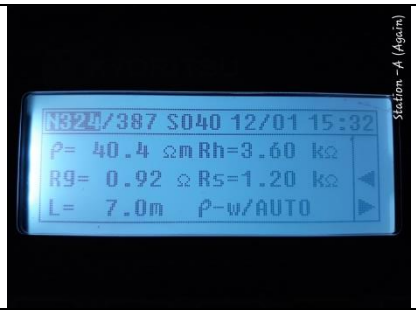
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	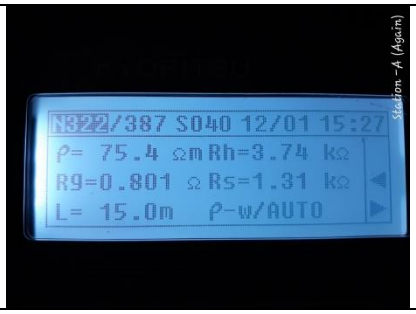	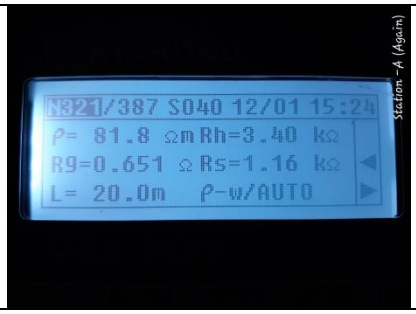

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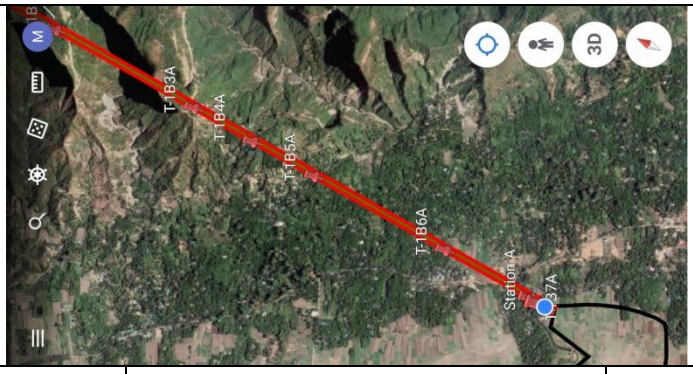
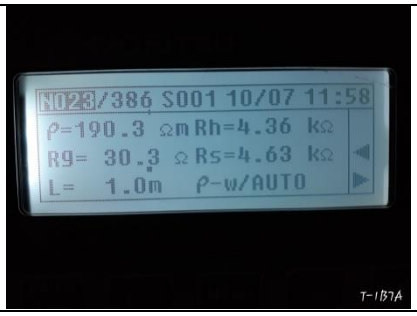
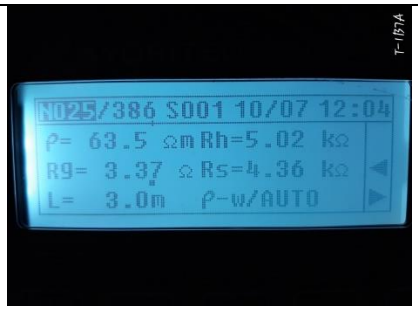
3. T-1B7A

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
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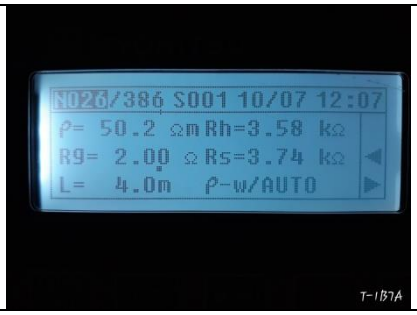	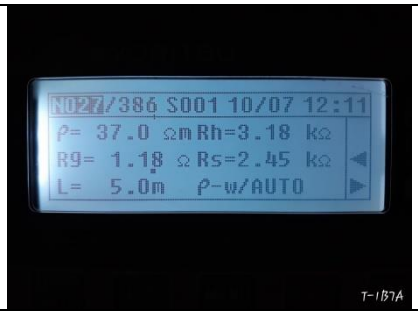	
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	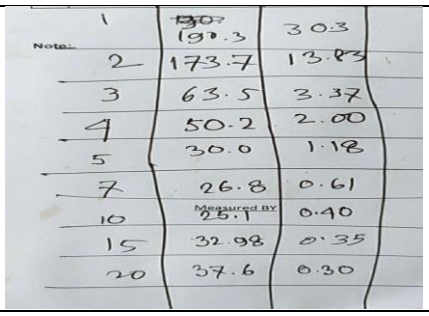	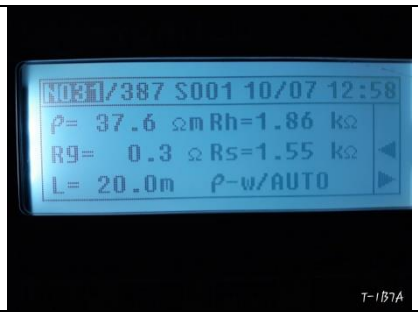

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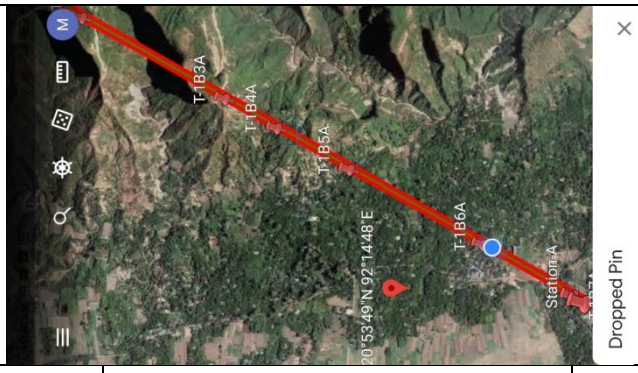
4. T-1B6A

Geo Location



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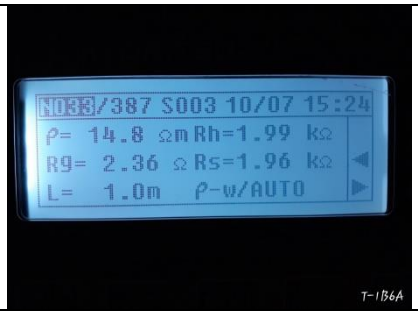		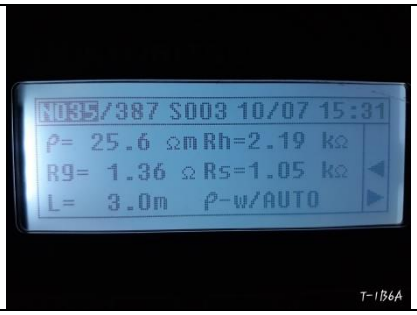
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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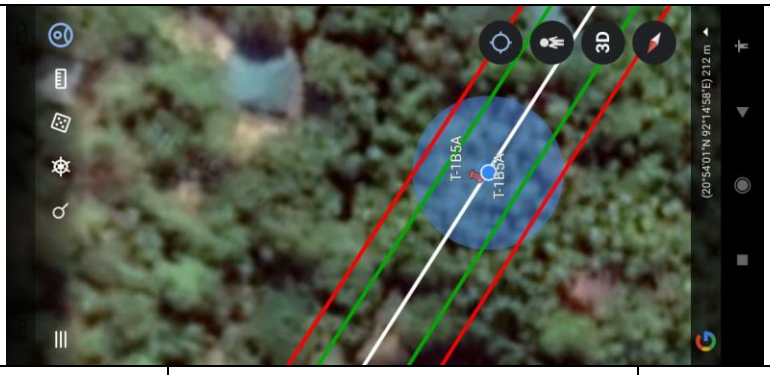
5. T-1B5A

Geo Location



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	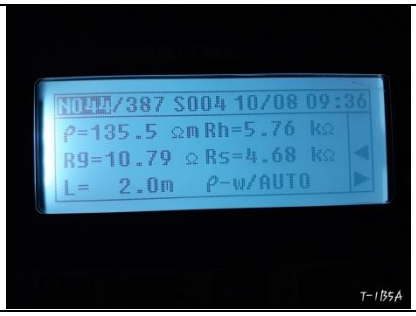	
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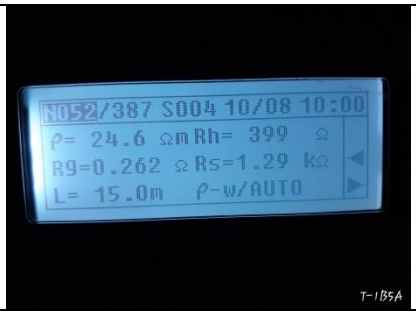
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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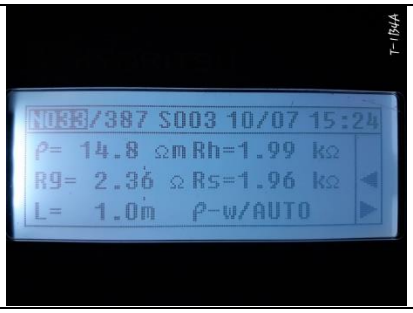
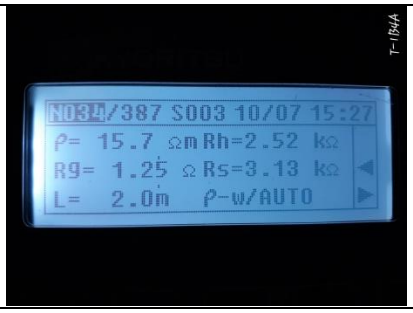
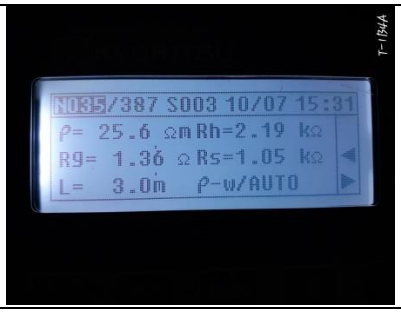
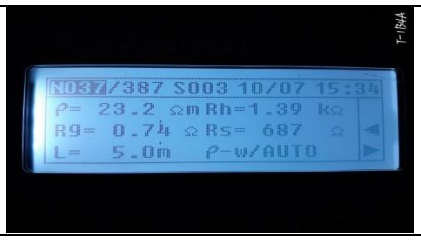
6. T-1B4A

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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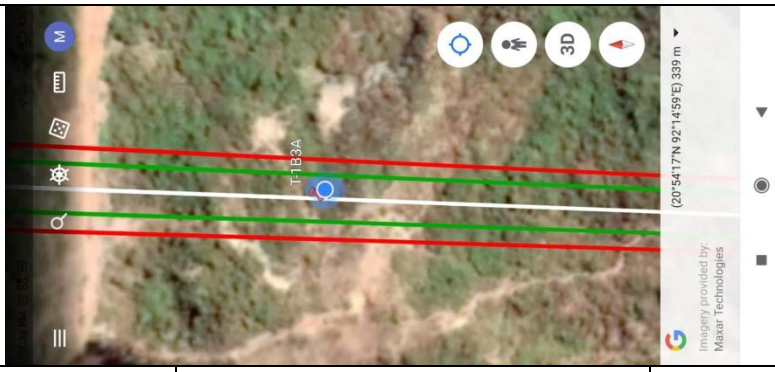
7. T-1B3A

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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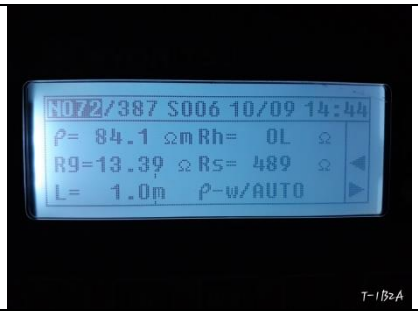
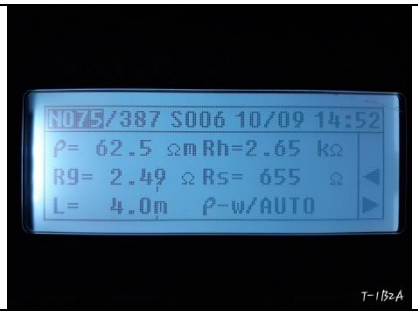
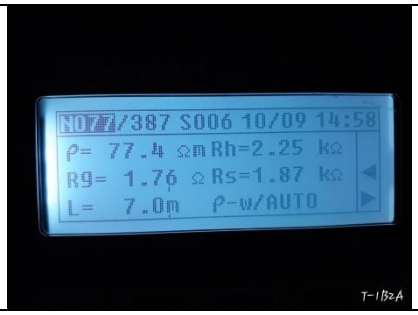
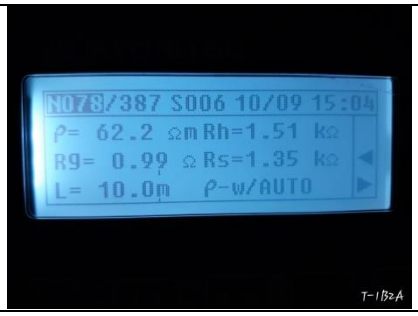
8. T-1B2A

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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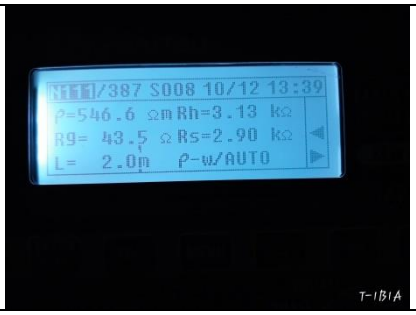
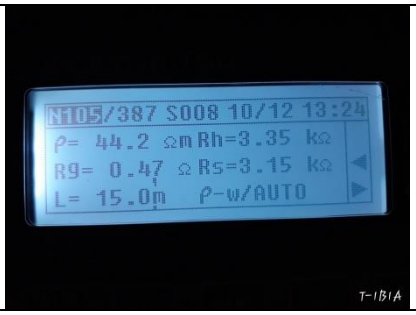
9. T-1B1A

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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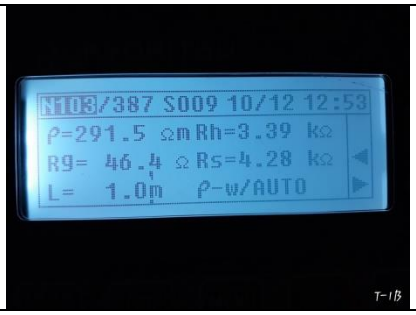
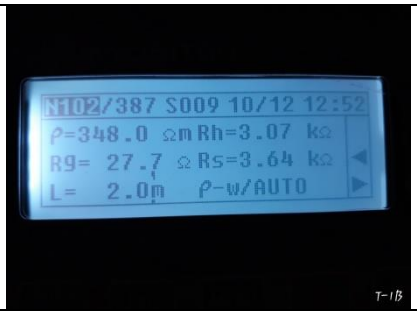
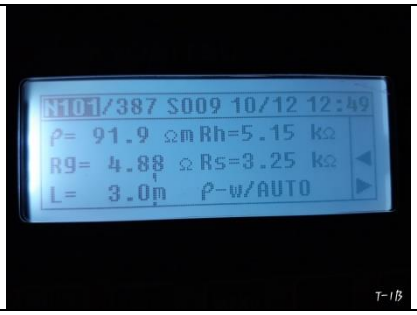
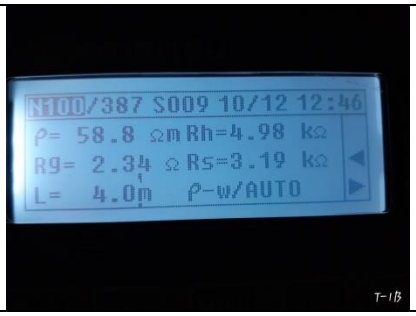
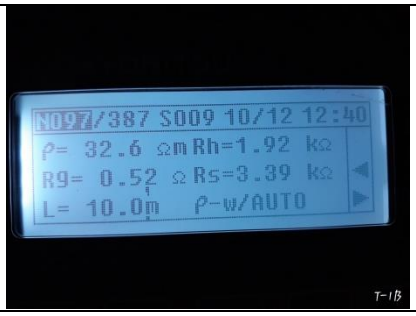
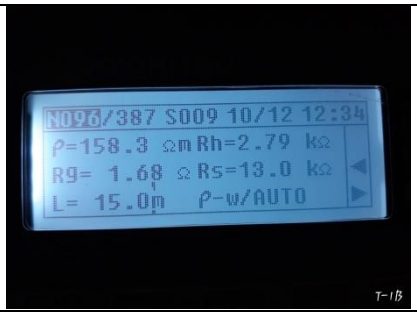
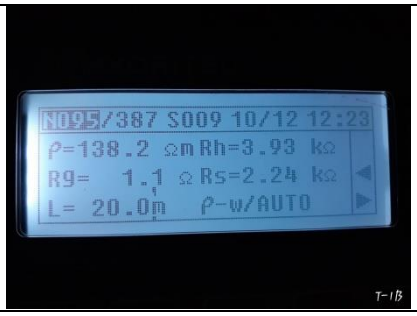
10. 1B

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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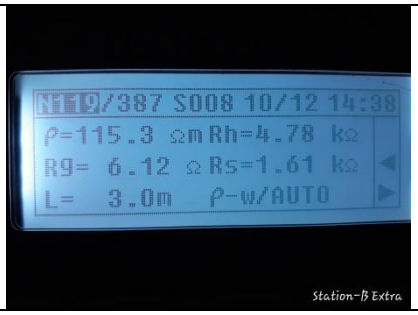
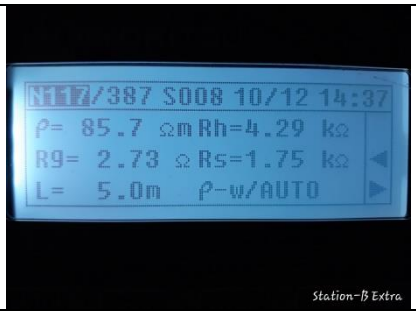
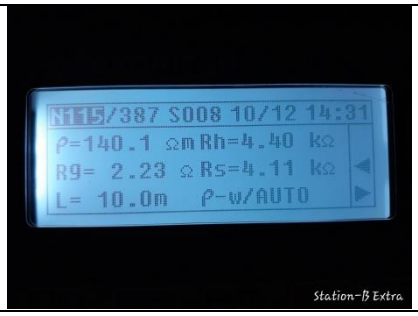
11. Station-B Extra

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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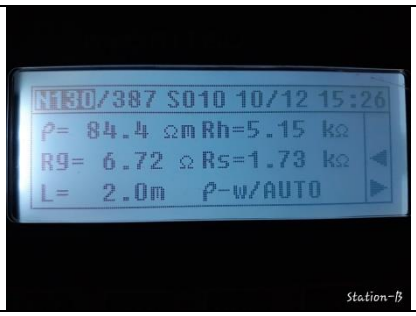
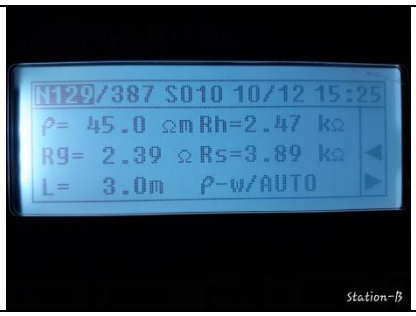
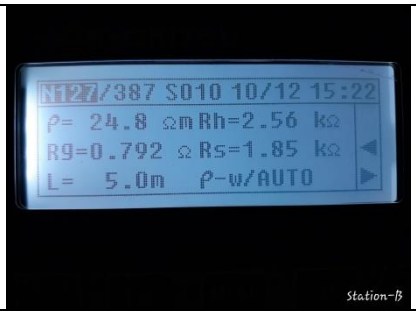
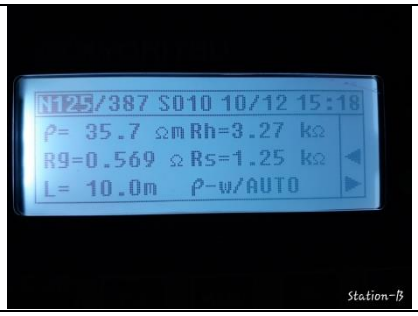
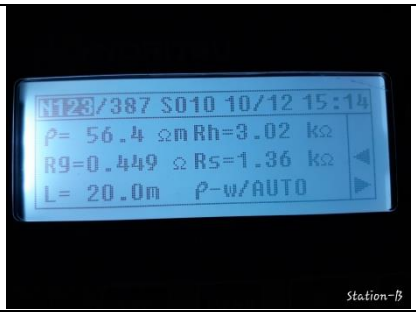
12. Station-B

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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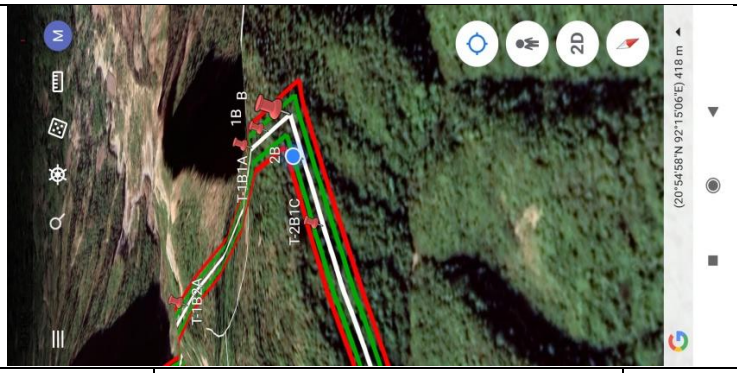
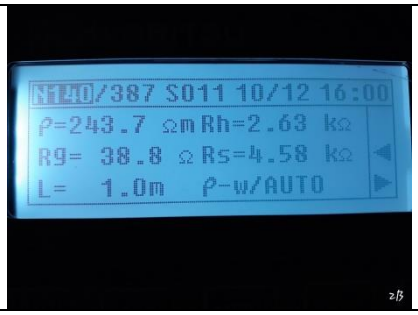
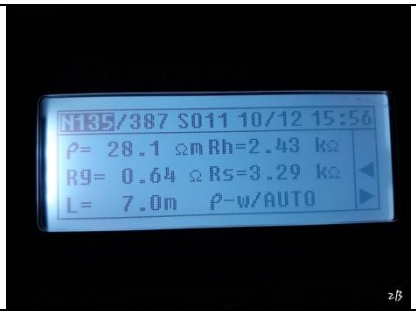
13. -2B

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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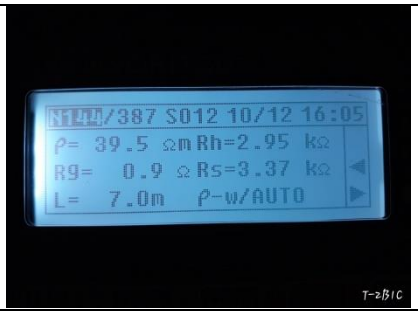
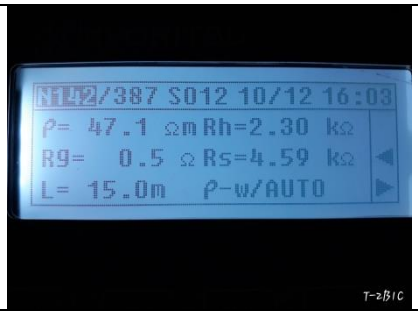
14. T-2B1C

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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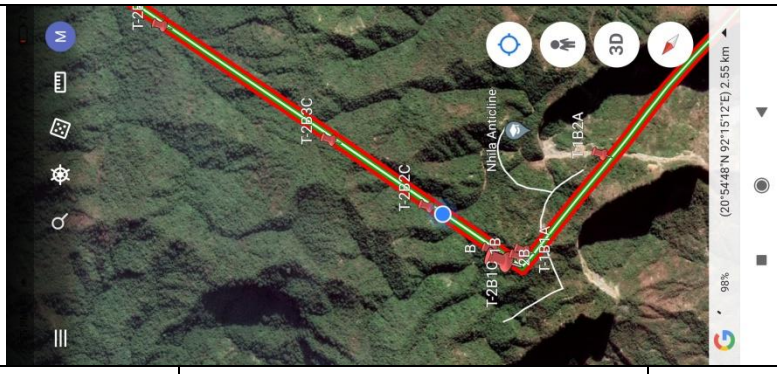
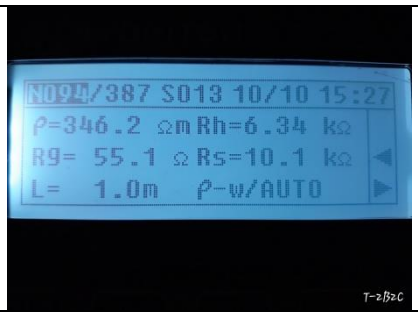
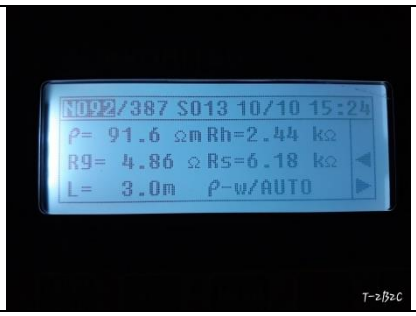
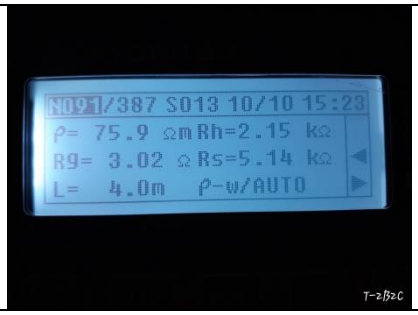
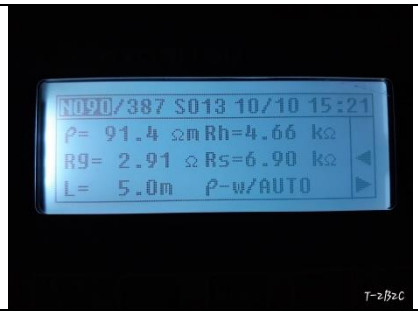
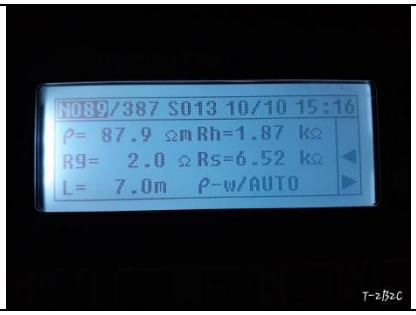
15. T-2B2C

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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16. T-2B5C

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		**Data Missing**
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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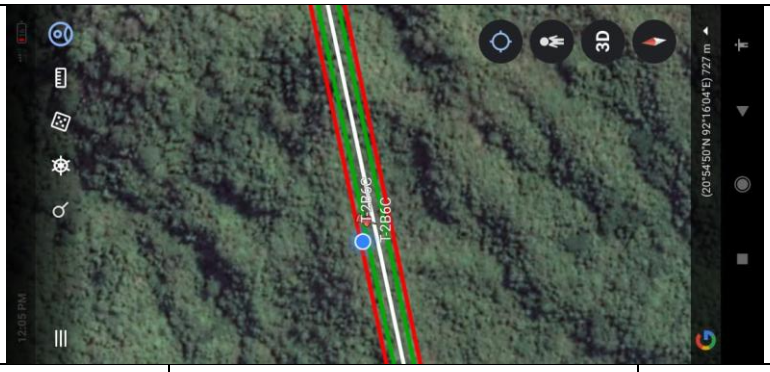
17. T-2B6C

Geo Location

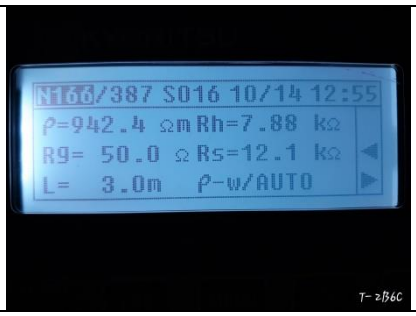


Reading-1 (1 Meter)

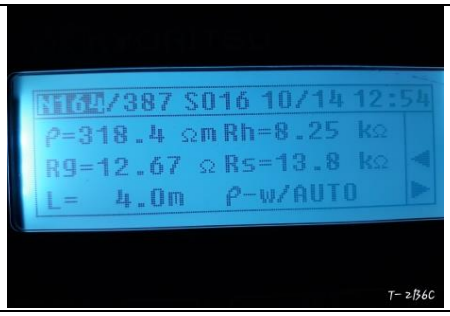
Reading-2 (2 Meter)

S (m)	ρ (Ω-m)	Pt (Ω-m)	R (Ω)
2	239.5	1597.189	127.1

Reading-3 (3 Meter)

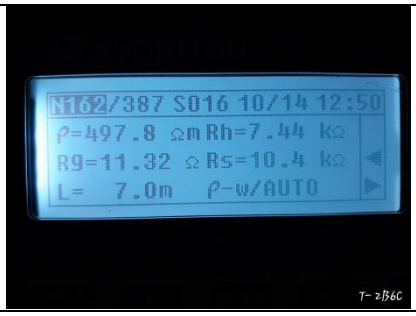


Reading-4 (4 Meter)

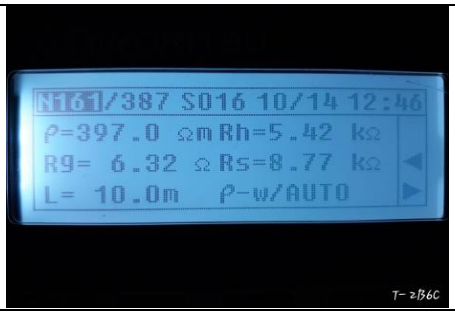


Reading-5 (5 Meter)

Reading-6 (7 Meter)



Reading-7 (10 Meter)



Reading-8 (15 Meter)

Reading-9 (20 Meter)

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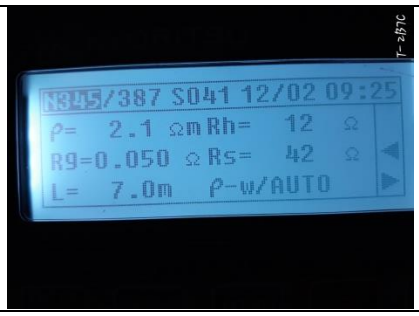
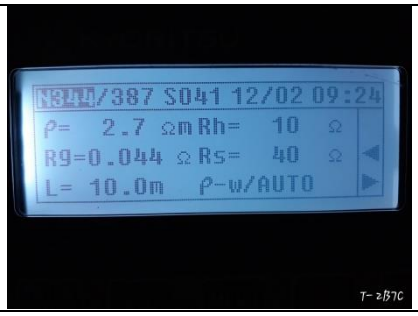
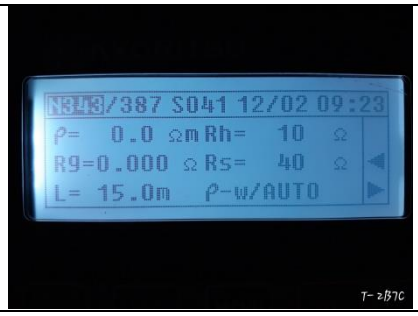
18. T-2B7C

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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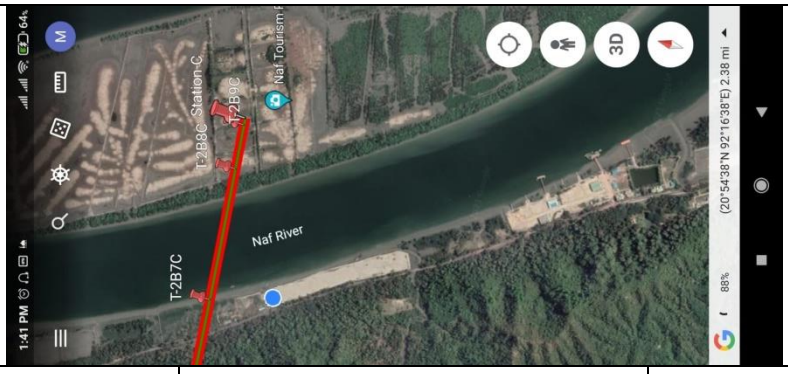
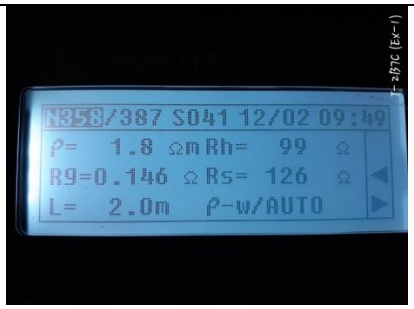
19. T-2B7C (Additional Point -1)

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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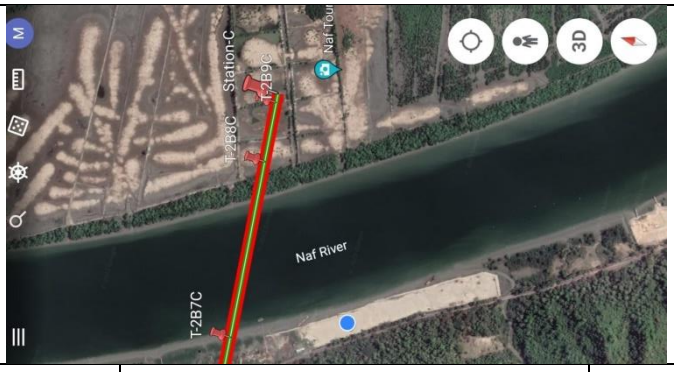
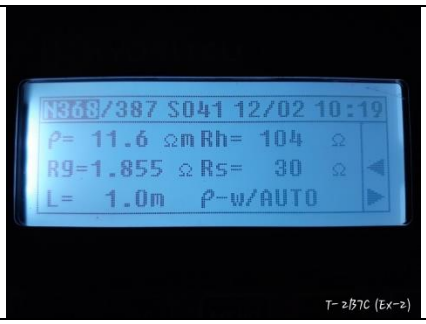
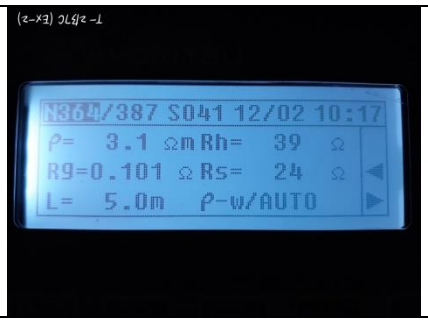
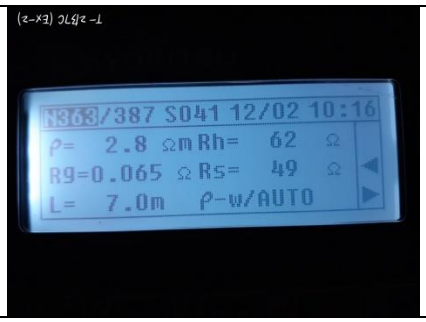
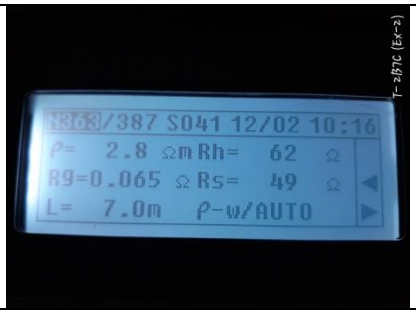
20. T-2B7C (Additional Point -2)

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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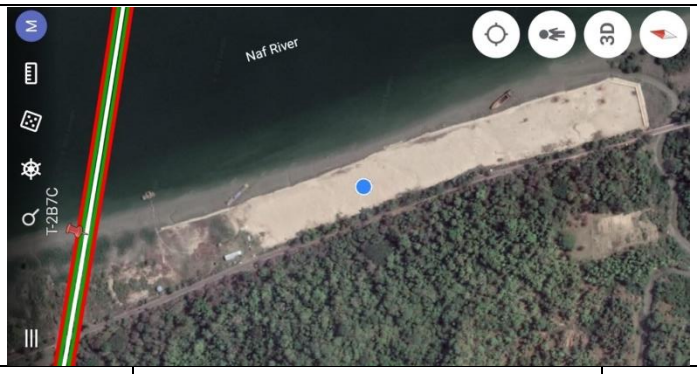
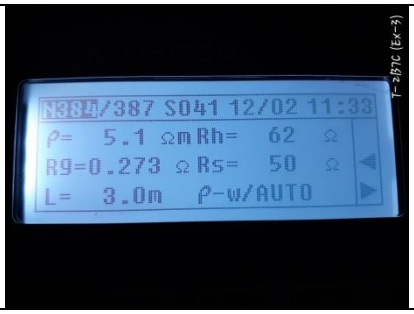
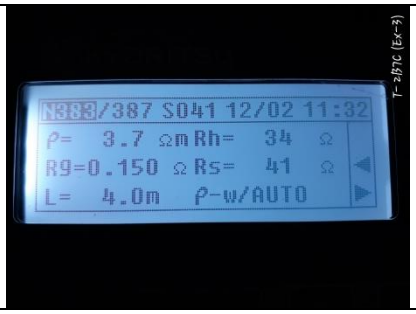
21. T-2B7C (Additional Point -3)

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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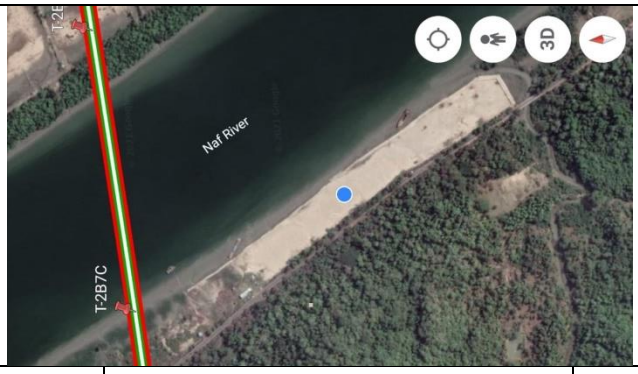
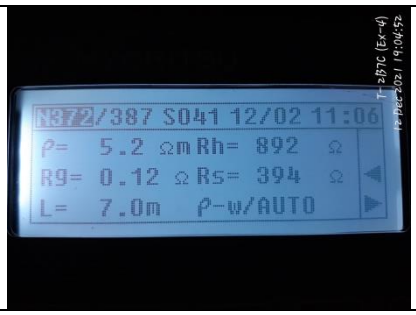
22. T-2B7C (Additional Point - 4)

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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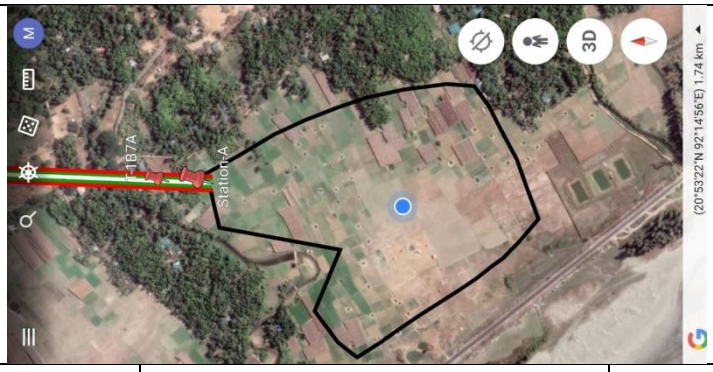
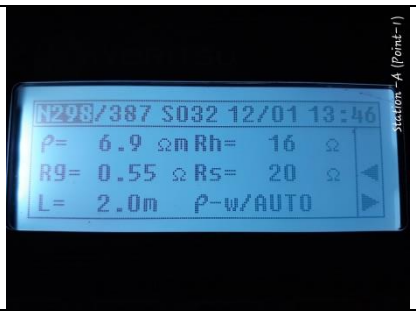
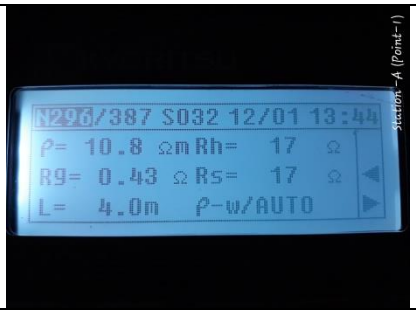
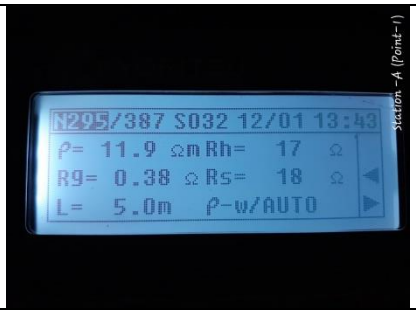
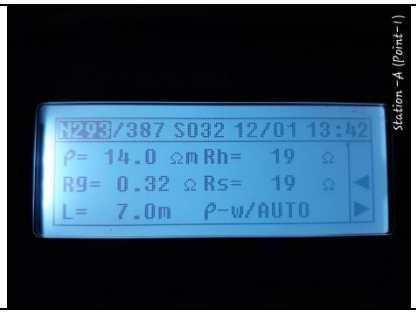
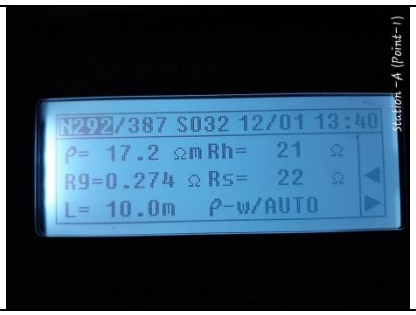
23. Station –A, Additional Point-1

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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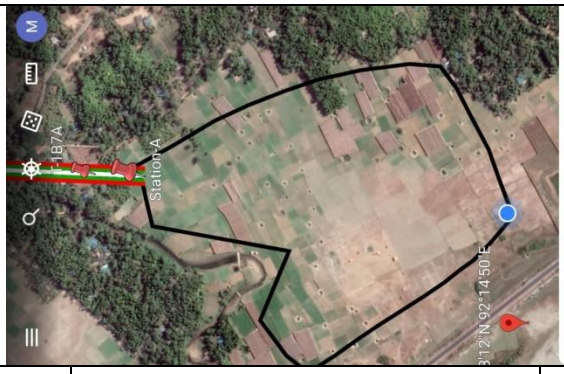
24. Station–A, Additional Point-2

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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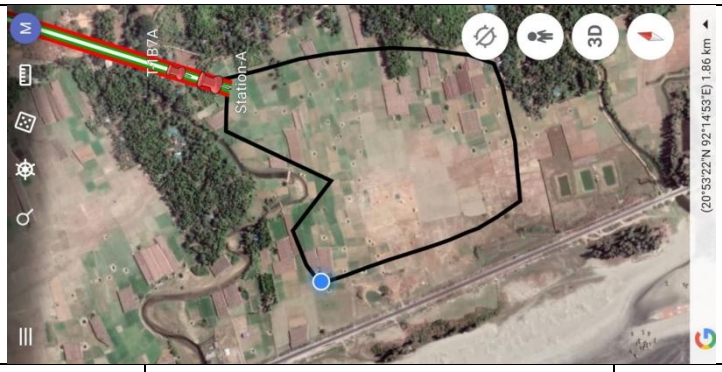
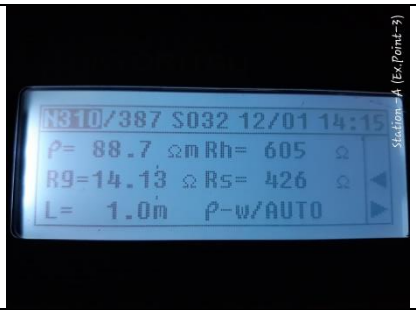
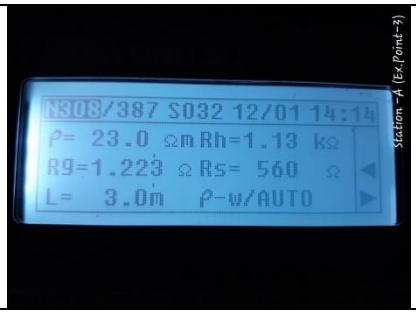
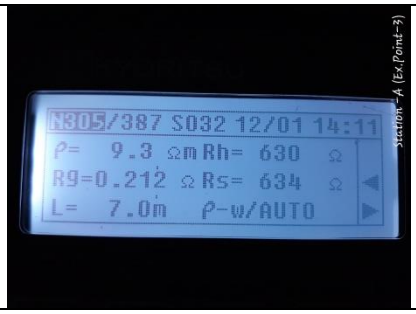
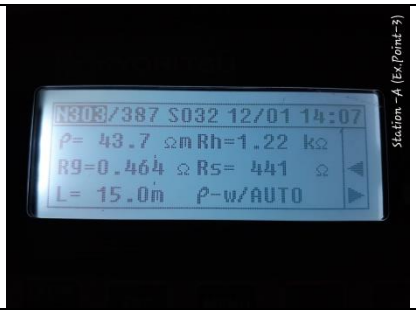
25. Station –A, Additional Point-3

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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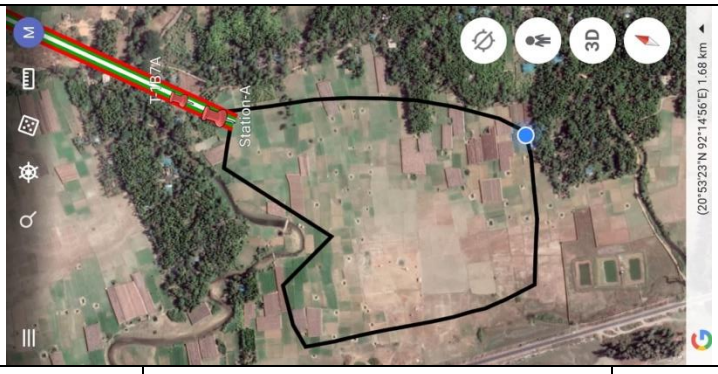
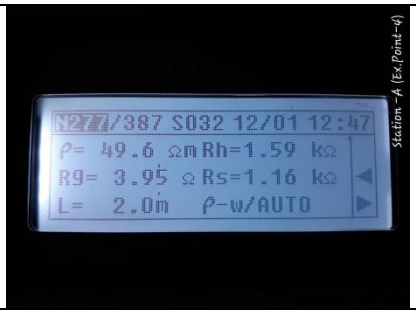
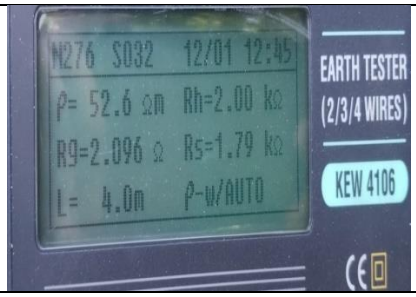
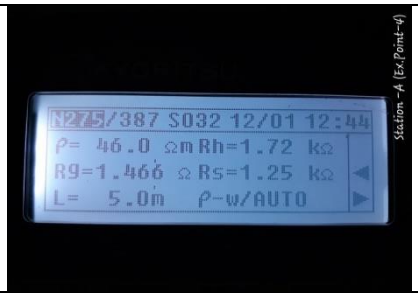
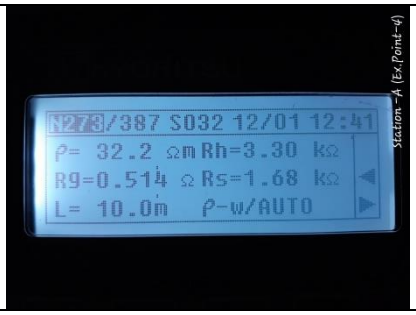
26. Station –A, Additional Point-4

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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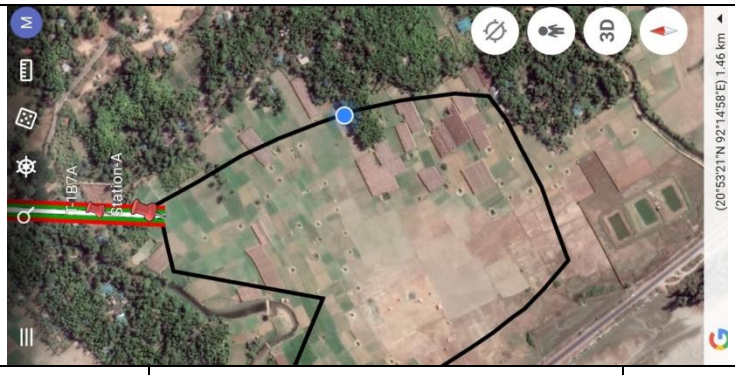
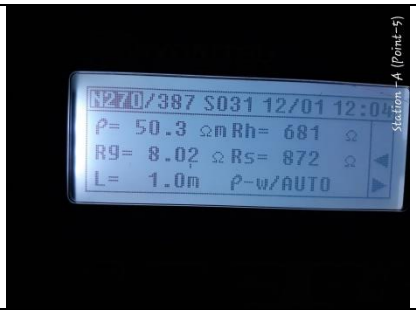
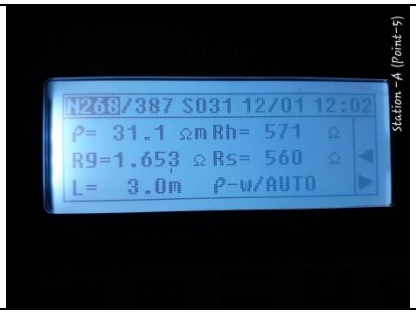
27. Station –A, Additional Point-5

Geo Location



Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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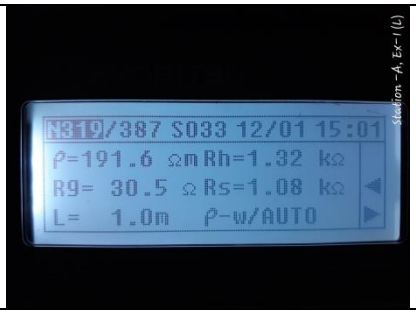
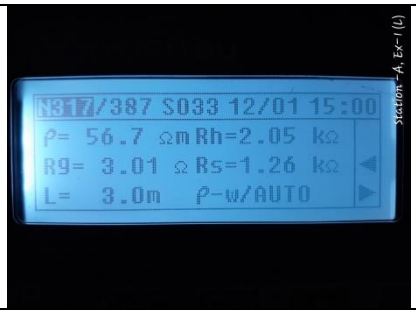
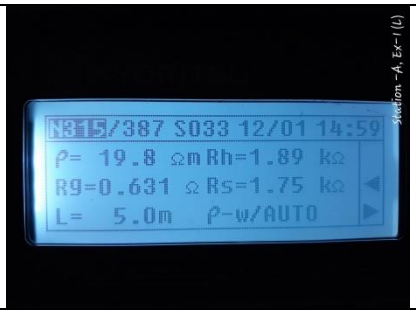
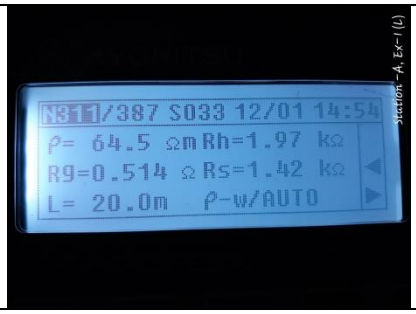
28. Station–A, Additional Point -1(Right side)

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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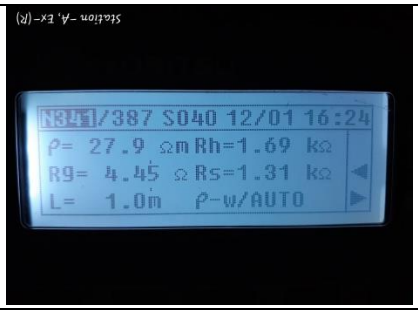
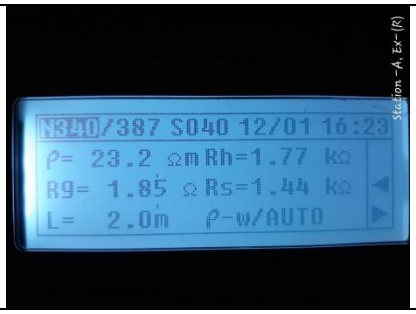
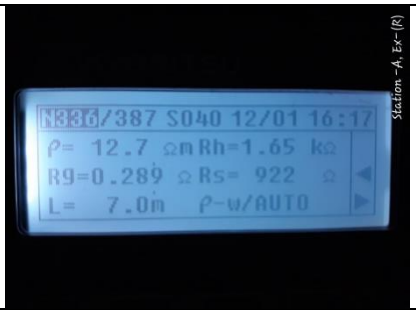
29. Station–A, Additional Point -2(Left side)

Geo Location

Reading-1 (1 Meter)	Reading-2 (2 Meter)	Reading-3 (3 Meter)
		
Reading-4 (4 Meter)	Reading-5 (5 Meter)	Reading-6 (7 Meter)
		
Reading-7 (10 Meter)	Reading-8 (15 Meter)	Reading-9 (20 Meter)
		

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