TRIP REPORT – COW MOUNTAIN – THIRD-PARTY TESTING AND INSPECTION

COW MOUNTAIN
Ukiah Field Office

Latitude: 39° 07'48.07"N
Longitude: 123° 04'35.83"W

Top View of Facility

Image of Facility

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SECTION 01 45 23 – THIRD-PARTY TESTING AND INSPECTION SERVICES

1.0 SUMMARY

A. T.E.D.S, LLC was contracted by the BLM to perform pre-construction review of designs, review of below grade photos during construction, and post construction testing and inspection of the Cow Mountain radio facility located in the State of California.

B. PEPRO, LLC provided design drawings to T.E.D.S LLC prior to the facility inspection.

C. Digital photographs of below grade grounding system components and installation were provided during construction and reviewed by T.E.D.S LLC.

D. T.E.D.S, LLC visited the facility and completed the inspection on September 18, 2019. The following individuals attended the inspection:

1. Ted Sumners – Third-Party Inspector – Technical Evaluation and Development Services, LLC
2. Randy Durnil – BLM Technician

1.1 THIRD-PARTY INSPECTOR QUALIFICATIONS

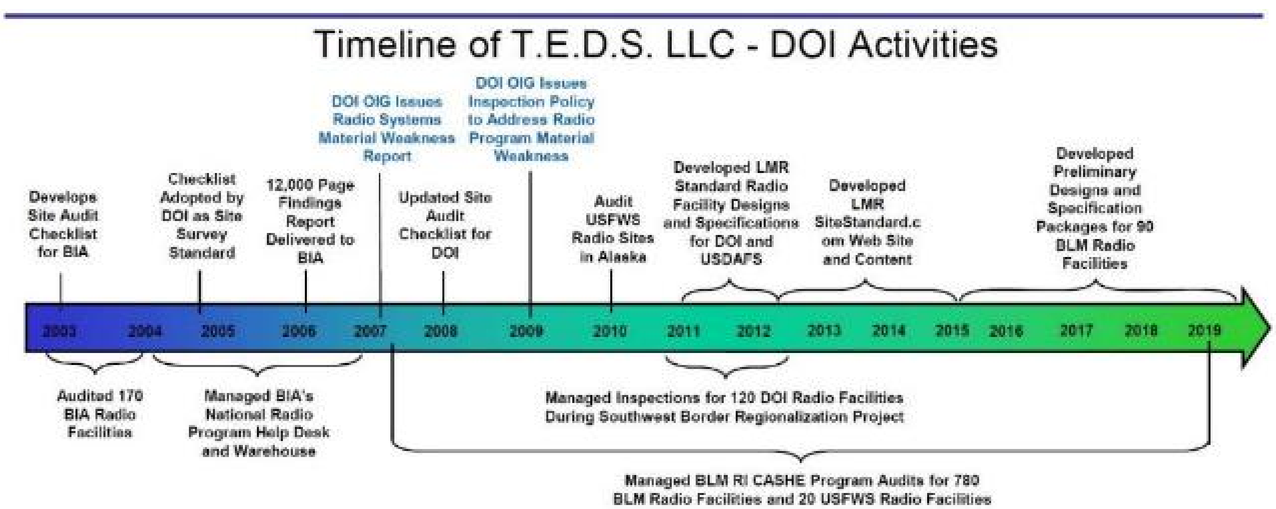
A. T.E.D.S. LLC Founder and President (Ted Sumners) has been serving as a BLM radio infrastructure expert, for the BLM since 2007.

B. Ted has 33 years of experience with the design, installation, maintenance, and repair of remote mountain top LMR radio systems, repeaters, remote controls, multiplexers, antenna systems, microwave systems, battery backup systems, and solar power systems.

C. Ted has designed, installed, and maintained mission essential communications systems. Decades of experience have produced an in-depth knowledge of the fundamental radio facility characteristics required to increase the functionality and durability of radio communications systems.

D. Ted stays current with industry standards and has developed the standards, tools, and methodologies to perform a comprehensive analysis of a radio communication facility.

E. Ted Sumners has been proactively involved in shaping the Department of the Interior's radio facility inspection program for more than 16 years.



2.0 SUMMARY OF CONTRACTOR'S SCOPE OF WORK:

A. PEPRO LLC was tasked with provision, delivery and installation a new outdoor equipment cabinet meeting DOI requirements including the following :

1. Providing, delivering, and installing the shelter meeting BLM requirements as specified in the DOI Standard Radio Facility Design including the following specifications:
   a. Section 13 34 18.13 – Aluminum Cabinet with Articulating Mast
   b. Section 33 79 84 – Internal Shelter Grounding Conductors
   c. Section 33 79 84.13 – Bonding Equipment to the Internal Grounding System
   d. Section 33 79 86 – Ground Bus Bars
   e. Section 33 79 84.16 – Rack Ground Bus Bar
   f. BOCA National Building Code
   g. NFPA 101 - Life Safety Code, 2009 or latest edition
   h. ASCE 7-88 (formerly ANSI A58.1) - Minimum Design Loads for Buildings and Other Structures
   i. UL 752 - Requirements for low, medium and high power rifle (as required)
   j. NFPA 70 - National Electric Code (NEC), 2011 or latest edition
   k. OSHA - Occupational Safety and Health Administration
2. Installation of a compliant external grounding system meeting Motorola R56 requirements and DOI Specifications to include the following specifications:
   a. Section 33 79 83.53 – Grounding Electrode System Resistance
   b. Section 33 79 15.23 – Aluminum Cabinet with Articulating Mast Grounding
   c. Section 33 79 83 – External Grounding Conductors
   d. Section 33 79 86 – Ground Bus Bars
   e. Section 33 79 83.13 – Grounding Electrodes

2.1 THIRD-PARTY INSPECTION SUMMARY

A. T.E.D.S, LLC was contracted by the BLM to perform an on-site inspection of the facility and to perform a ground resistance test as detailed in Paragraph 3.4 of this Section.

1. T.E.D.S, LLC has provided a punch-list report describing each identified deficiency.
   a. The report includes a summary of punch list items with references to the specification section(s), down to the subparagraph level, and photos of each deficiency.
   b. Each punch list item has a corrective action that complies with the Contract requirements and the BLM RI CASHE requirements.
   c. The Punch-List report is provided as Attachment A.

2.2 INSPECTION RESULTS

The following items were inspected in accordance with the Summary of Work (SOW) provided to the Contractor.

A. Cabinet Structure Design and Installation – FAIL

1. The cabinet structure meets size and structural requirements detailed in Section 13 34 18.13 and further meets the minimum specifications of the Telecommunications Industries Association's (TIA) standards, National Electric Code (NEC), applicable building, and mechanical codes, and Motorola R56 requirements.
2. The cabinet was properly installed and level.
3. The support frame for the shelter is mounted at each corner to a concrete pedestal providing a footer placed directly on the ground. Four 100-pound steel plates are placed on each corner of the frame to provide ballast. The four plates are fastened together using all-thread and placed directly on the steel frame. The following deficiency is noted:

    a. The ballast plates are not fastened to the frame to prevent movement.

B. External Grounding Components – FAIL

1. Observations of the grounding system included a review of photos provided by PEPRO during the installation of the belowground external grounding system and physical inspection of aboveground components during the site visit. The following observations are made:
    a. Review of the belowground grounding system installation was completed and approved in prior to backfill of the trenches. The review included belowground photos of trench depth, installation of grounding electrodes, grounding conductors, and exothermic connections between components.
    b. The support frame for the shelter is mounted at each corner to a concrete pedestal providing a footer placed directly on the ground. Each concrete pedestal is designed with a concrete encased electrode (UFER) encased in the concrete. A grounding connection is made between each UFER and the ground ring using one of the bolts used to secure the frame to the pedestal. The top of each pedestal is above grade and mechanical, single-hole connections are used to bond the #2 AWG, bare, tinned, solid grounding conductor to each pedestal. Below ground connections are made using exothermic welds.
2. The tower ground bus bar is fastened to the cabinet near the RF cable entrance. The tower ground bus bar is properly grounded to the ground ring with a #2 AWG, bare, tinned, solid conductor. The conductor is bonded to the bus bar using a two-hole, irreversible crimp connector and stainless steel hardware. The connection to the ground ring is made using an exothermic weld.
3. The cabinet is equipped with two roof-mounted solar panels. The solar panels are mounted on framework constructed of channel brackets (Unistrut). The following deficiencies are noted:
    a. The solar panels and the framework are not grounded.

C. Internal Grounding Components – PASS

1. Observations of the internal grounding and bonding of ancillary devices meets the minimum requirements. PEPRO shelters are designed with an aluminum unibody structure and all surface mounted ancillary devices are properly bonded to the structure. In addition, the following grounding observations were made:
    a. Each door is bonded internally internal door is bonded to the unibody shelter frame.
    b. Rack ground bus bars are installed vertically on each rack assembly and properly grounded to the pass-through bus bar installed below the electrical entrance to the cabinet.

D. Grounding Electrode System Resistance – PASS

1. Testing of the grounding electrode system was conducted during the site visit. Testing revealed the following result:
    a. The grounding system measures 16.3 Ohms and meets the minimum 25 Ohm requirement.
2. See the ground resistance field report (Attachment A).
3. See the grounding system design (Attachment B).

E. External Solar Panel Wiring Installation – FAIL

1. The cabinet is equipped with two roof-mounted solar panels. The solar panels are mounted on framework constructed of channel brackets (Unistrut).
2. Wiring between the solar panels and the electrical entrance is fastened to the side of the cabinet. The following deficiencies are noted:
    a. Wiring between the solar panels and the electrical entrance is not fastened to the support frame is 24-inch increments.

F. Radio Equipment and Antenna Systems – Not Installed

1. Radio equipment was not installed at the time of the inspection. BLM is responsible for installation and grounding of the internal radio and ancillary devices.
2. Antenna systems and RF cabling was not installed at the time of inspection. BLM is responsible for installation, grounding, and surge protection for antenna systems.
3. The battery is connected to the solar charger/controller and the circuit breakers are energized. BLM is responsible for connection of the radio equipment to the DC power system.

2.3 INSPECTION PHOTOS

Site View

Site View

Frame Fastened to Concrete Pedestal at each Corner

Steel Ballast Plates Installed at Each Corner

Tower Ground Bus Bar Installed Near RF Cable Entrance

Tower Ground Bus Bar Grounded to Ground Ring

Solar Panels Installed on Roof

Solar Panel Wiring Not Properly Fastened to Framework

Solar Panels and Framework Not Grounded

Rack Ground Bus Bar #1

Rack Ground Bus Bar #2
Grounded to Pass-Through Bar

Door Grounded to Cabinet
Unibody Structure

Solar Charger/Controller

Battery Installed and Connected
to Solar Charger/Controller

Pass-Through Bar Grounded to
Ground Ring

ATTACHEMENT A – ON-SITE INSPECTION PUNCH-LIST

Facility Name: Cow Mountain
Facility State: California
Contractor Name: PEPRO, LLC
Third-Party Company: Technical Evaluation and Development Services, LLC (T.E.D.S, LLC)
Third-Party Inspector: Ted Sumners
Inspection Date: September 18, 2019

3.0 PUNCH-LIST ITEMS IDENTIFIED DURING INSPECTION

3.1 CABINET STRUCTURE DESIGN AND INSTALLATION

A. The support frame for the shelter is mounted at each corner to a concrete pedestal providing a footer placed directly on the ground. Four 100-pound steel plates are placed on each corner of the frame to provide ballast. The four plates are fastened together using all-thread and placed directly on the steel frame. The following deficiency is noted:

   a. The ballast plates are not fastened to the frame to prevent movement.

Ballast Plates Installed on Each Corner of the Frame

Plates Fastened Together But Not to the Frame

Plates Fastened Together But Not to the Frame

3.1.1 CORRECTIVE ACTIONS:

A. PEPRO shall fasten the plates to the support frame at each corner by providing a U-Bolt or other fastening mechanism to ensure the ballast plates are secured in place to the support frame.

3.2 EXTERNAL GROUNDING

A. The cabinet is equipped with two roof-mounted solar panels. The solar panels are mounted on framework constructed of channel brackets (Unistrut). The following deficiencies are noted:

   a. The solar panels and the framework are not grounded. The mechanical connection between the solar panel support frame and the welded Unistrut is not a compliant grounding bond.

Two Solar Panels Not Grounded

Solar Panel Support Frame Fastened to Top of Cabinet

Support Frame Not Grounded

3.2.1 CORRECTIVE ACTIONS:

A. PEPRO shall complete the following: 1) Ground the solar panel support frame to the tower ground bus bar with a #2 AWG, bare, solid, tinned copper conductor using UL 467 listed, single-hole, irreversible crimp connectors and through-bolted stainless steel hardware; and 2) Bond each solar panel to the support frame with a #2 AWG, bare, solid, tinned copper conductor using UL 467 listed, single-hole, irreversible crimp connectors and through-bolted stainless steel hardware including star or lock washers.

3.3 EXTERNAL SOLAR PANEL WIRING INSTALLATION

A. The cabinet is equipped with two roof-mounted solar panels. The solar panels are mounted on framework constructed of channel brackets (Unistrut). Wiring between the solar panels and the electrical entrance is fastened to the side of the cabinet. The following deficiencies are noted:

1. Wiring between the solar panels and the electrical entrance is not fastened to the support frame is 24-inch increments. Excess DC power wiring is coiled and laying on top of the equipment cabinet.

Excess DC Power Wiring Coiled

DC Wiring Not Adequately Fastened to Framework

3.3.1 CORRECTIVE ACTIONS:

A. PEPRO shall fasten the DC power wiring in 24-inch increments to the solar panel support frame using cable anchors with through-bolted stainless steel hardware.

3.4 BLM RESPONSIBILITIES

A. BLM shall be responsible for remediation of the following deficiencies noted in the trip report.

1. Install radio and ancillary devices inside the cabinet. Ground the radio and ancillary devices to the rack ground bus bars. Properly route and support DC power wiring.
2. Install antenna systems on the antenna mast and support RF cables in 36 inch increments. Install new RF cable ground kits on the RF cables above the tower ground bus bar level. Route the ground kit conductors in a continuous downward path toward the tower ground bus bar. Bond the ground kits to the bus bar using single-hole or two-hole, irreversible crimp connectors and stainless steel hardware. Install RF surge protection devices inside the cabinet and ground to the rack ground bus bar.
3. Properly route and support DC power wiring for the radio equipment.

3.5 PUNCH-LIST ITEM RESPONSE

A. The Construction Contractor is required to submit a schedule to the Government Contracting Officer (CO) and Contracting Officer's Technical Representative (COTR) addressing each punch-item and corrective action plan within three days of receipt of the Punch-List report from the Third-Party Inspector.

   1. The Construction Contractor is required to provide photographs of corrected punch-list items to the Government and to the Third-Party Inspector.

B. The Government and Third-Party Inspector will review the corrected punch items identified by the Third-party Inspector and determine terms for final acceptance.

3.6 CERTIFICATION

A. Technical Evaluation and Development Services hereby certifies that all other installation work included in the Contractor's scope of work, and not listed in the Punch-List, is in compliance with the applicable standards and inspections.

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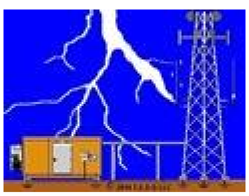


4.0 GROUNDING ELECTRODE SYSTEM RESISTANCE

A. Ground resistance testing shall comply with methods approved and described in IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System (Current Revision IEEE 81-2012 dated 12/28/2012).

B. The following forms are to be used for recording test results of the grounding electrode system.

1. Attachment B – Fall-of-Potential Slope Method Ground Resistance Field Report

C. The Third-Party Inspector shall complete the ground resistance testing using one of the methods described below and complete the corresponding Ground Resistance Field Report. The Third-Party Inspector shall provide an electronic copy of the report to the Government and the Construction Contractor.

4.1 GROUNDING ELECTRODE SYSTEM RESISTANCE TESTING METHODS

A. <u>Clamp-on Ground Resistance Testing</u>

1. The Clamp-on ohmmeter test can be performed on both single grounding (earthing) electrode and multibonded/multi-grounding electrode system (such as at a communications site). However, the test can only be accurately performed on sites supplied by commercial power.
2. For a single grounding electrode system, the test is considered very reliable and can be easy to perform. However, for a multi-bonded/multi-grounding electrode system, the test can be more difficult to perform and may result in an error reading due to parallel paths. The test procedure in this section has provisions to help avoid such errors.
3. The clamp-on ohmmeter works on the basis of injecting current, from a known voltage source, into the grounding (earthing) electrode system in order to create a current flow whose value is a function of the grounding electrode system resistance. The test current flows from the grounding electrode system through the earth, returning to the grounding electrode system via the power company's multi-grounded neutral wire. The meter then measures this current and converts the measurement to a resistance reading using Ohm's Law (R= E/I). As such, the meter displays a resistance of the grounding electrode system in ohms. Because the power company's grounding system is so extensive, the meter considers it to be of negligible value and disregards its effect on the reading.
4. This test does not require disconnection of the site grounding (earthing) electrode system from the power company grounded conductor (may be a neutral wire). The power company grounded conductor is required in order for the meter to display valid reading. However, for a multi-bonded/multi-grounding electrode system it may be necessary to de-energize the site from commercial power if significant unbalanced current flow is present on the grounded conductor. Unbalanced current flow may create noise on the meter, resulting in the inability of the meter to display an accurate reading; the noise condition is typically indicated by the clamp-on ohmmeter.

B. <u>Fall-of-Potential Testing – Small Grounding systems – 62% Rule</u> (1 to 6 Grounding Electrodes)

1. The fall-of-potential method is often referred to as the "three point method". Utilizing a ground resistance meter (digital is preferred), two auxiliary electrodes are driven into the soil at predetermined distances (up to 10 times the cross-sectional dimension of the grounding system), per the testing specifications, in a straight line from the ground being tested.
2. During a normal test of ground rod(s) the meter supplies a constant current between the ground rod(s) under test and the most remote auxiliary electrode. A series of measurements of the voltage drops between the ground rod(s) under test and the remote electrode are made by moving the intermediate electrode in steps away from the ground rod under test. The goal is to reach the actual rod's resistance and this is most often reached at the 62% distance point.

C. <u>Fall-of-Potential Testing – Large Grounding systems</u> (6 or More Grounding Electrodes) The usual method of measurement that works very well has one disadvantage; namely, that it is generally necessary to place the auxiliary current probe at a considerable distance from the earth-electrode system. In some cases, this distance can be as much as 3000 ft., and this is not always convenient or possible.

1. <u>Intersecting Curves</u>: An alternative method, in which such long leads are not necessary, has been devised called Intersecting Curves. The basic principle is to obtain earth resistance curves for several current-

electrode spacing and, by assuming a number of successive positions for the electrical center of the system, to produce intersection curves which will give the earth resistance and the position of the electrical center.

a. Some rather difficult problems are encountered when the resistance of an earth-electrode system, consisting of a number of grounding electrodes, ground rods, plates, etc., all connected in parallel and spread over a large area, is to be measured.

2. Slope Method is a variation of the Intersecting Curves method. This method does not require long lengths of test leads. Section 33 79 83.53 – Grounding Electrode System Resistance provides a detailed explanation of the Slope Method, including relevant tables.

4.2 FALL-OF-POTENTIAL SLOPE METHOD:

A. The Slope Method can be used effectively because it does not require the user to find the “flat” portion of the curve or to know the electrical center as a point from which to measure. Readings are taken at 20 percent, 40 percent, and 60 percent of the current probe distance and fit into a mathematical model of the resistance characteristic.

B. It is the purpose of this method to reduce that distance to the current probe, and this appears to have been achieved, but there are some additional points to be noted. From the work, which has been done on the method, there are certain limits to the distance to the current probe.

1. To comply, if the grounding system is in the form of a square, the minimum distance to the current probe should not be less than the side of the square. On the other hand, the maximum distance should not be too great. If it is, the resulting curve is very flat, and the intersection point becomes rather indefinite.
2. For a square grounding system, this maximum distance should not exceed twice the side of the square. For other shapes of earth-electrode systems, it is necessary to judge suitable minimum and maximum values for the distance to the current probe.
3. Suppose that all measurements are made from an arbitrary starting point O, the distance Z to the current probe and the variable distance Y to the potential probe being measured from this point. Then a curve such as *ABC* (See Figure Below), giving the measured resistance against the value of Z, can be obtained.
4. Now suppose the electrical center of the earth-electrode system is actually at D, distance X from O. Then the true distance from the center to the current probe is Z + X, and the true resistance is obtained when the potential probe is at a distance 0.618 (Z + X) from D. This means that the value of Y, measured from O, is 0.618 (Z + X) - X.
5. If X is now given a number of values, the corresponding values of P can be calculated and the resistance read off the curve. These resistances can be plotted against the values of X in another curve. When this process is repeated for a different value of C, and another curve of resistance against X obtained, the two curves should cross at the required resistance. The process can be repeated for a third value of C as a check. These curves are called intersection curves. It has been assumed that D, O and C are in the same straight line.

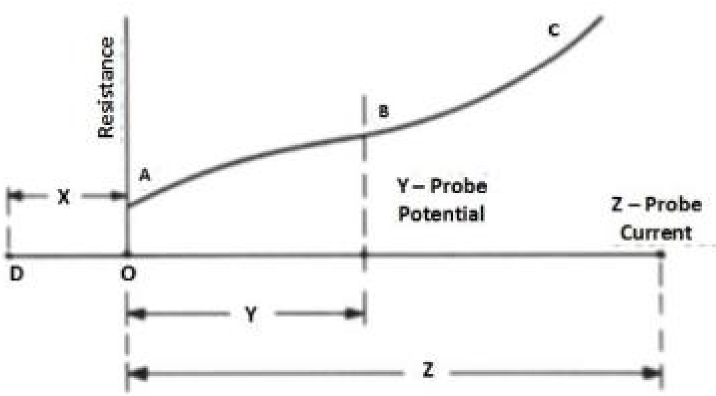


IMAGE 4.4 A

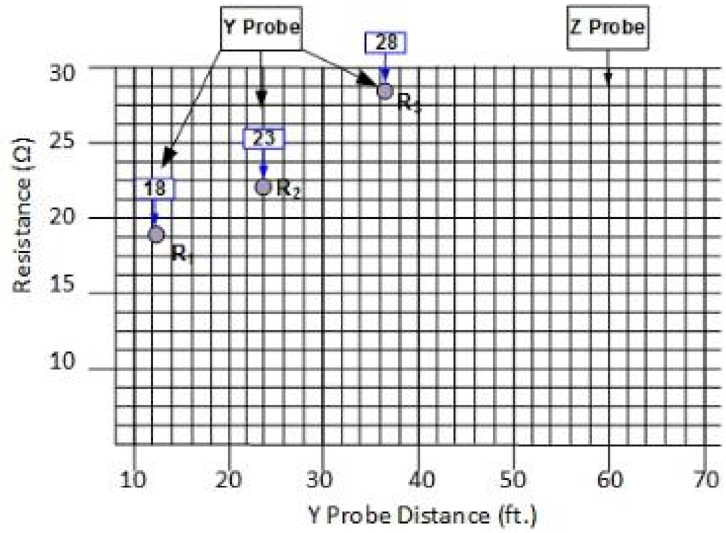


IMAGE 4.4 B

Probe Setup		Enter Resistance Measurement	*U Calculation*	Enter Value From Table based on Calculated u Value in Column D		Place Y Probe (Yellow) at Calculated Distance	Enter Resistance Measurement
Reading	Distance to Y	Measurement Ohms	R3 - R2 = **u** R2 - R1	**u = D_P/D_C** from Table	Distance to Z Probe (ft.) **(DZ)**	True Resistance Distance (ft.) = **(u x DZ)**	True Resistance (Ohms)
R_1 - 60%	36	28	1.00	0.542	60	33	25
R_2 - 40%	24	23					
R_3 - 20%	12	18					

TABLE 4.6 A – EXAMPLE OF CALCULATIONS

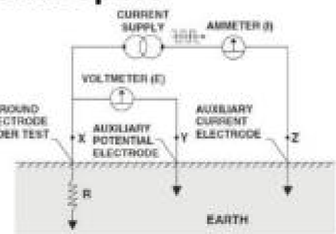
6. The other challenges faced in testing large ground systems relate to the capabilities of the test instrument. Improved technology has made it possible for instruments to be designed that address problems created by the characteristics and conditions found in and around large ground systems.
7. For the Slope Method to provide meaningful results, accurate measurement of the variations at different points is critical. Since large ground systems typically have resistance values of less than 0.5 Ω, the differences can be quite small. An instrument with 1 mΩ measurement resolution can indicate the small differences between low readings.
8. Noise is a major problem in testing large ground systems and must be addressed to ensure accurate results. To be effective, the test instrument must be designed to overcome the effects of significant noise in the test environment. Among the technical capabilities that can help offset the noise problem are:
   a. A variable test frequency (rather than a single, fixed test frequency) which can help remove any stray noise that could affect the reading.
   b. A high peak-to-peak interference suppression level.
   c. A sophisticated filter system to reject more noise.
   d. Various current settings to improve the signal-to-noise ratio when necessary.

μ	D_P/D_C		μ	D_P/D_C		μ	D_P/D_C		μ	D_P/D_C		μ	D_P/D_C
			0.65	0.606		0.91	0.560		1.17	0.502		1.43	0.418
0.40	0.643		0.66	0.604		0.92	0.558		1.18	0.499		1.44	0.414
0.41	0.642		0.67	0.602		0.93	0.556		1.19	0.497		1.45	0.410
0.42	0.640		0.68	0.601		0.94	0.554		1.20	0.494		1.46	0.406
0.43	0.639		0.69	0.599		0.95	0.552		1.21	0.491		1.47	0.401
0.44	0.637		0.70	0.597		0.96	0.550		1.22	0.488		1.48	0.397
0.45	0.636		0.71	0.596		0.97	0.548		1.23	0.486		1.49	0.393
0.46	0.635		0.72	0.594		0.98	0.546		1.24	0.483		1.50	0.389
0.47	0.633		0.73	0.592		0.99	0.544		1.25	0.480		1.51	0.384
0.48	0.632		0.74	0.591		1.00	0.542		1.26	0.477		1.52	0.379
0.49	0.630		0.75	0.589		1.01	0.539		1.27	0.474		1.53	0.374
0.50	0.629		0.76	0.587		1.02	0.537		1.28	0.471		1.54	0.369
0.51	0.627		0.77	0.585		1.03	0.535		1.29	0.468		1.55	0.364
0.52	0.626		0.78	0.584		1.04	0.533		1.30	0.465		1.56	0.358
0.53	0.624		0.79	0.582		1.05	0.531		1.31	0.462		1.57	0.352
0.54	0.623		0.80	0.580		1.06	0.528		1.32	0.458		1.58	0.347
0.55	0.621		0.81	0.579		1.07	0.526		1.33	0.455		1.59	0.341
0.56	0.620		0.82	0.577		1.08	0.524		1.34	0.452		1.60	0.338
0.57	0.618		0.83	0.575		1.09	0.522		1.35	0.448		1.61	0.335
0.58	0.617		0.84	0.573		1.10	0.519		1.36	0.445		1.62	0.331
0.59	0.615		0.85	0.571		1.11	0.517		1.37	0.441		1.63	0.328
0.60	0.614		0.86	0.569		1.12	0.514		1.38	0.438		1.64	0.325
0.61	0.612		0.87	0.567		1.13	0.512		1.39	0.434		1.65	0.322
0.62	0.610		0.88	0.566		1.14	0.509		1.40	0.431		1.66	0.319
0.63	0.609		0.89	0.564		1.15	0.507		1.41	0.427		1.67	0.316
0.64	0.607		0.90	0.562		1.16	0.504		1.42	0.423		1.68	0.313

TABLE 4.6 B

ATTACHEMENT B –GROUND RESISTANCE FIELD REPORT – SLOPE METHOD

Fall-of-Potential Ground Resistance Field Report



Date of Test: 09/18/2019

Radio Facility Name: Cow Mountain

Conditions: Dry, 60 Degrees (Rain Previous Day)

Facility Type: Remote Radio Facility

Resistance Requirement: 25 Ohms Minimum Per RI CASHE

Test Company: Technical Evaluation and Development Services (TEDS)

Test Instrument Manufacterer: Extech

Tester Name: Ted Sumners

Test Instrument Model: GRT300

Calibration Date: 2/1/2019

Serial Number: 1804667

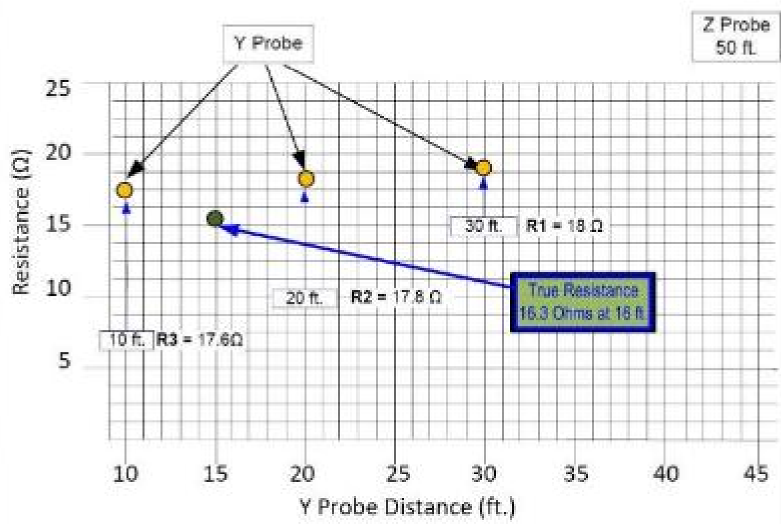
Test Configuration: Z- Probe set 50 ft. from grounding system

Test Procedure: **Slope Method (Intersecting Curves)**
Y-Probe moved in 20% increments to obtain values R_1, R_2 and R_3
Calculations made to obtain True Resistance Distance

TESTING RESULTS – PASSED at 16.3 Ohms

μ	D_P/D_C	μ	D_P/D_C	μ	D_P/D_C
0.40	0.643	0.83	0.575	1.26	0.477
0.41	0.642	0.84	0.573	1.27	0.474
0.42	0.640	0.85	0.571	1.28	0.471
0.43	0.639	0.86	0.569	1.29	0.468
0.44	0.637	0.87	0.567	1.30	0.465
0.45	0.636	0.88	0.566	1.31	0.462
0.46	0.635	0.89	0.564	1.32	0.458
0.47	0.633	0.90	0.562	1.33	0.455
0.48	0.632	0.91	0.560	1.34	0.452
0.49	0.630	0.92	0.558	1.35	0.448
0.50	0.629	0.93	0.556	1.36	0.445
0.51	0.627	0.94	0.554	1.37	0.441
0.52	0.626	0.95	0.552	1.38	0.438
0.53	0.624	0.96	0.550	1.39	0.434
0.54	0.623	0.97	0.548	1.40	0.431
0.55	0.621	0.98	0.546	1.41	0.427
0.56	0.620	0.99	0.544	1.42	0.423
0.57	0.618	1.00	0.542	1.43	0.418
0.58	0.617	1.01	0.539	1.44	0.414
0.59	0.615	1.02	0.537	1.45	0.410
0.60	0.614	1.03	0.535	1.46	0.406
0.61	0.612	1.04	0.533	1.47	0.401
0.62	0.610	1.05	0.531	1.48	0.397
0.63	0.609	1.06	0.528	1.49	0.393
0.64	0.607	1.07	0.526	1.50	0.389
0.65	0.606	1.08	0.524	1.51	0.384
0.66	0.604	1.09	0.522	1.52	0.379
0.67	0.602	1.10	0.519	1.53	0.374
0.68	0.601	1.11	0.517	1.54	0.369
0.69	0.599	1.12	0.514	1.55	0.364
0.70	0.597	1.13	0.512	1.56	0.358
0.71	0.596	1.14	0.509	1.57	0.352
0.72	0.594	1.15	0.507	1.58	0.347
0.73	0.592	1.16	0.504	1.59	0.341
0.74	0.591	1.17	0.502	1.60	0.338
0.75	0.589	1.18	0.499	1.61	0.335
0.76	0.587	1.19	0.497	1.62	0.331
0.77	0.585	1.20	0.494	1.63	0.328
0.78	0.584	1.21	0.491	1.64	0.325
0.79	0.582	1.22	0.488	1.65	0.322
0.80	0.580	1.23	0.486	1.66	0.319
0.81	0.579	1.24	0.483	1.67	0.316
0.82	0.577	1.25	0.480	1.68	0.313

Reading	Distance to Y Probe (ft.)	Measurment Ohms	R3 - R2 = u / R2 - R1	D_P/D_C from Table	Distance to Z Probe (ft.) (DZ)	True Resistance Distance (ft.) = (u x DZ)	True Resistance (Ohms)
R_1	30	18	1.00	0.542	50	27	16.3 Ohms
R_2	20	17.8					
R_3	10	17.6					



ATTACHEMENT C – GROUNDING SYSTEM DESIGN