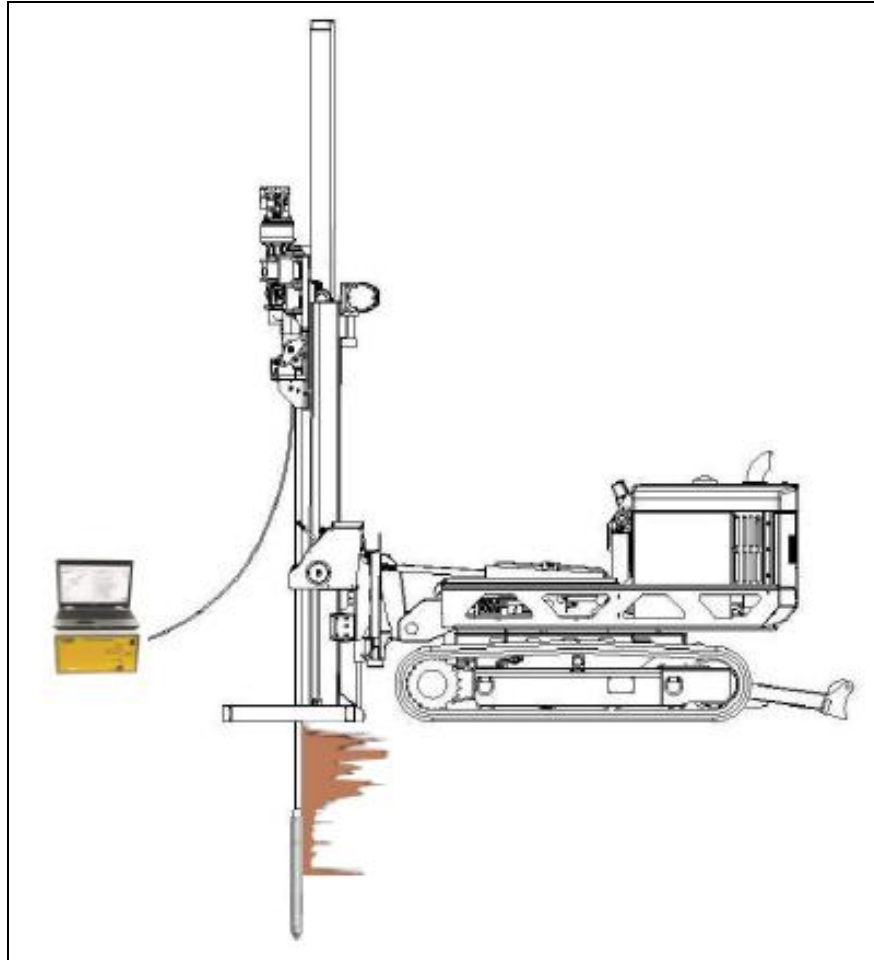


GEOPROBE SYSTEMS® ELECTRICAL CONDUCTIVITY (EC) SYSTEM

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3201

Prepared: January, 2015



1.0 Objective

This document serves as the standard operating procedure for the Geoprobe® Electrical Conductivity (EC) system. In this procedure, the EC system is used to measure the soils ability to conduct a current to assist with characterization of soil type. This document has been updated from Geoprobe Systems® Technical Bulletin No. to show the use of an FI6000 field instrument for EC system control and data acquisition.

2.0 Background

2.1 Definitions

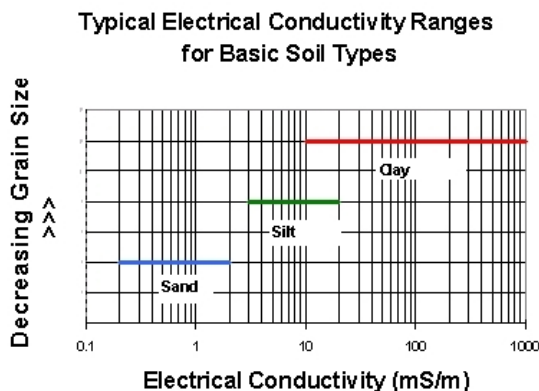
Geoprobe®*: A brand of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and testing, electrical conductivity and contaminant logging, grouting, and materials injection.

**Geoprobe® and Geoprobe Systems® are registered trademarks of Kejr, Inc., Salina, Kansas.*

Electrical Conductivity System: A system manufactured by Geoprobe Systems® to evaluate the soils ability to conduct an applied current for the determination of subsurface soil types. The tool is advanced through the subsurface at a constant rate and a current is sent through the formation between two probe contacts. This current is measured along with the voltage that results. Both electrical conductivity and rate of push are logged versus depth.

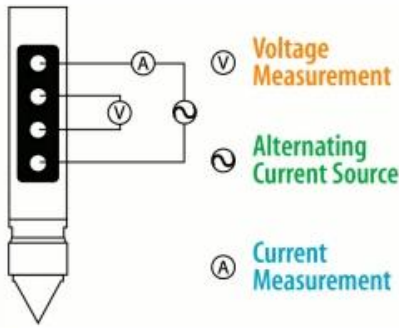
2.2 Discussion

The field instrument induces a current across electrical dipoles placed in the soil. The system measures electrical current and voltage and from these parameters, calculates electrical conductivity. Higher electrical conductivities typically are representative of finer grained sediments, such as silts and clays, while sands and gravels have distinctively lower conductivities. Ionic contaminants in the soil or pore water can increase the measured conductivity.



Interpretation of EC logs comes with field experience and an initial core sample to confirm lithologic changes. As a generalization, a high conductivity reading indicates a smaller particle size and a low conductivity reading indicates a larger particle size (Figure 2.1).

Figure 2.1: General Conductivity Ranges



The EC probe comes in two different configurations, Dipole Array and Wenner Array. Both configurations have the same theory of operation. A current is sent through the formation between two probe contacts. This current is measured along with the voltage that results (Figure 2.2). The conductivity is a ratio of current to voltage times a constant. The resulting reading is in milli-Siemens per meter (mS/m).

Figure 2.2: Wenner Array for Conductivity Measurements

3.0 Tools and Equipment

The following equipment is required to perform and record an EC log using a Geoprobe® 66- or 78-Series Direct Push Machine. Refer to Figures 3.1, 3.2, and 3.3 for identification of the specified parts.

<u>Basic EC System Components</u>	<u>Quantity</u>	<u>Material Number</u>
Field Instrument, 120V (Model FI6000).....	-1-	213940
Field Instrument, 220V (Model FI6003).....	*	213941
Acquisition Software	-1-	214128
EC Probe, 1.75 inch	-1-	214236
1.75 inch Connection Tube.....	-1-	211310
1.5 inch Drive Head	-1-	203794
EC Cordset - 97ft.....	-1-	214229
EC Cord Adapter	-1-	214231
EC Probe, 2.25 inch	**	214238
2.25 Connection Tube	**	219455
2.25 Inch Water Seal Drive Head.....	**	212089
2.75 Inch Water Seal Drive Head.....	**	209796
EC Water Seal.....	-1-	209568
Trunkline Water Seal Spacers.....	-1-	207596
EC Probe Test Jig	-1-	214237
EC Test Load.....	-1-	208075
EC Bypass Cable	-1-	204025
Stringpot, 100-inch	-1-	214227
Stringpot Cordset, 65-feet (19.8 m).....	-1-	202884

*Use in place of 120V components if desired.

**Use in place of 1.75 inch probe and components if desired.

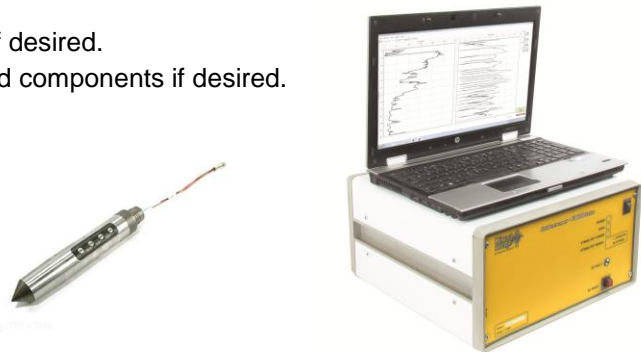


Figure 3.1: EC Probe (214236) and FI6000 (213940)

4.0 Assembly

Threading the Rods

- Protect the end to be threaded through the rods with electrical tape or shrink tubing.
- Probe rods must alternate directions prior to threading the trunkline.
- The end of the EC trunkline with chrome connectors is the downhole or probe end.
- The probe end of the trunkline always enters the male end and exits the female end of the probe rods.
- The instrument end will always enter the female end and exit the male end of the probe rods.
- After the trunkline is through the probe rods make sure the downhole end is threaded through the male end of the drive head and connection tube prior to connecting to the probe.
- The trunkline is now ready to connect to the instrument and EC probe.

5.0 Field Operation

5.1 Instrument Setup

1. Connect the Field Instrument (FI6000) and laptop (Fig. 5.1) to an appropriate power source.
2. Connect the FI6000 to the field laptop with the USB cable.
3. Secure the EC wires into the Green terminal block connector and insert into the FI6000. The wires match to the EC dipoles in the following top down order when the probe tip is on the ground – white, black, yellow and blue (Fig 5.2).
4. Connect the USB cable between the USB interface port on the rear of the FI6000 to USB input on the field laptop computer.
5. A stringpot is required to measure depth. Bolt the stringpot onto the machine and the stringpot onto the bracket. Connect the plastic connector end of the stringpot cable to the “Stringpot” connector on the back of the Field Instrument and the metal connector to the stringpot. Pull the stringpot cable and attach to the stringpot piston weight which should be mounted to the probe machine foot and pull the keeper pin so the weight is free to move.



Figure 5.1: EC Instrument (FI6000)

5.2 Starting the Software

1. Make sure the FI6000 is powered on and connected to the computer by the USB cable for the software to load properly.
2. Start the DI Acquisition Software which will open in EC mode.
3. Select “Start New Log”. The software will request log information and have you browse for a storage location and create and save a file name for the log (Fig. 5.2).

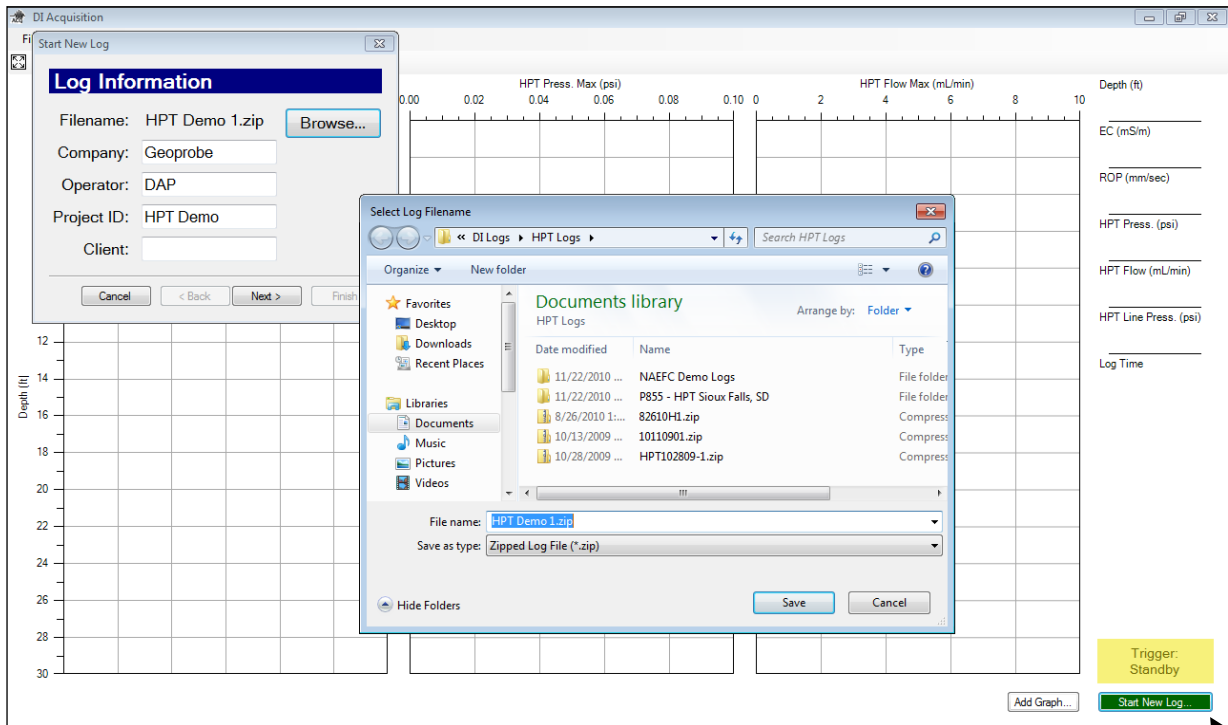


Figure 5.2: DI Acquisition Software – Start New Log Sequence

4. Select “Next”. If the software has been run before it will show a list of previous settings including Probe Type, EC Configuration, Stringpot length, rod length. If any of these have changed or you are unsure select “No” but if they are all the same select “yes”. If you select “No” the software will have you select the proper settings after the EC Load Test, if you selected “Yes” the selection of these settings will be bypassed.

5.2 QA Testing the EC Systems

The EC components must be tested before and after each log. This is required to ensure that the equipment is working properly and capable of generating good data before and after the log.

A. Electrical Conductivity Load Test

1. Secure the EC 3 position test load connector (208075) to the test input jack on the back of the Field Instrument.
2. Secure the EC Probe Test Jig (214237) into the input on the EC 3 position test load.

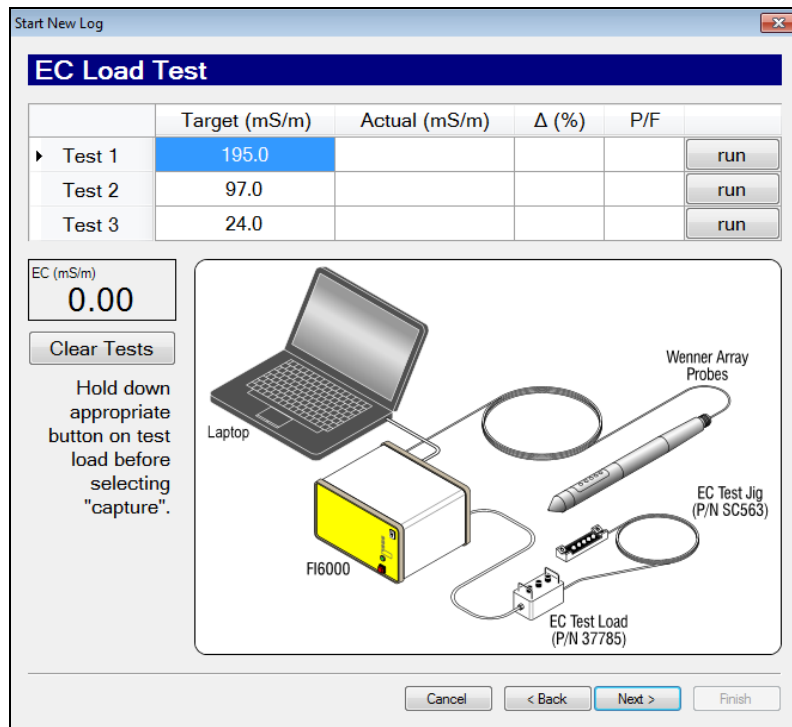


Figure 5.3: EC Load Test Screen

3. Clean and dry the EC dipoles as well as several inches of the probe body above the pins.
4. Place the EC Test Jig so that the four springs on the test jig touch the four dipoles of the Wenner EC array (Fig. 5.3). Make sure the trunkline and test jig wires go in the same direction. The other spring on the test jig will ground the probe body above the Wenner array. Make sure the springs are pulled out far enough to make a solid contact on the dipoles.
5. When you get to the EC Load Test Screen and the EC test load and test jig are in place on the probe press down on the test 1 button on the test load and select “run” of Test 1 (Fig. 5.4). After 5 seconds the actual value will acquire and will pass if within 10% of the target value. Continue on with Test 2 and 3.
6. If any of the EC load tests fail do not pass within the allowed 10% acceptance range you can make adjustments on the test jig and rerun the test by just re-clicking the “run” button for an individual test.
7. If the tests continue to fail, select “Next” and the software will conduct the “EC Troubleshooting Tests.” The Instrument Calibration Tests (Fig. 5.4) checks of the calibration within the FI6000. If these are far out of range it will influence the EC Test load values and will need to return to Geoprobe® for repair. The “Probe Continuity and Isolation Tests” confirm each of the wires is a complete circuit and is fully isolated from one another. If a probe continuity test fails just outside the target range of <8ohms this is typically a contact issue with the test jig and the dipoles. If the continuity is in the thousands of ohms this is a break in the EC wire circuit – either in the probe, the trunkline or the connection between them.

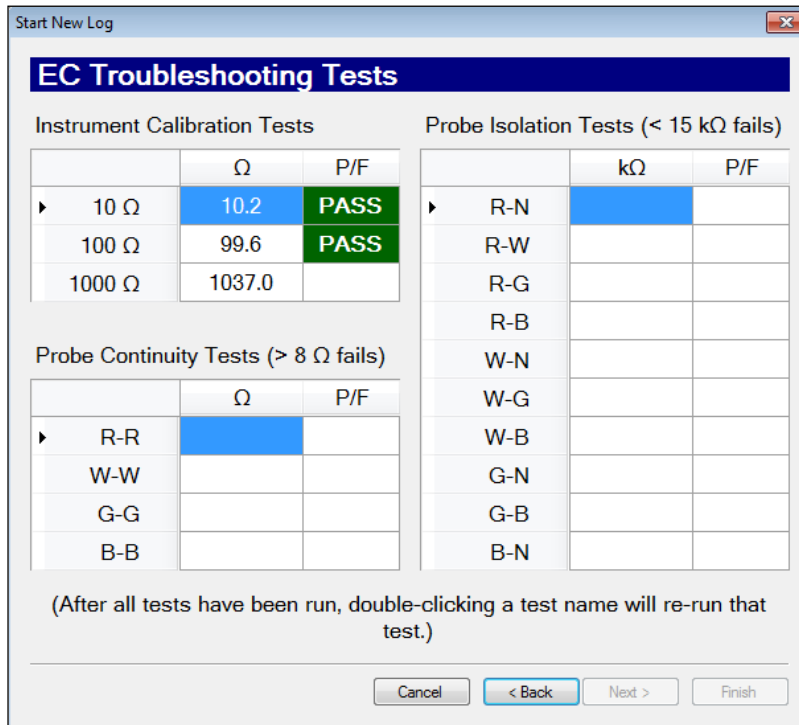


Figure 5.4: EC Troubleshooting Test Screen

8. When these tests are complete select next. In the next screen, the software will provide an EC option, if one is available. The EC Load Test will only work if EC can be operated in Wenner array meaning all of the EC wires in the continuity test pass with results <8ohms on the individual circuits. EC can be operated and collect good data in one of the dipole areas: top, middle or bottom dipole. If the R-R test fails but the others pass the software will provide the option in the next screen to run either middle dipole or bottom dipole arrays. If R-R and G-G are both an incomplete circuit then no EC array is available to run and a new probe must be connected or the problem fixed. In the Wenner configuration it requires 2 adjacent dipoles to operate in dipole mode. If an EC array is chosen and run in this last manner then all of the EC information collected will be bad data.
9. When the EC check has passed click “next”. If the rod length, stringpot length have not been selected previously do that now. Select “Next”.

5.3 Running an EC Log

1. Place the rod wiper on the ground over the probing location and install the drive cushion in place of the anvil of the probing machine.
2. Place the probe tip in the center of the rod wiper, and place the slotted drive cap on top of the EC probe.
3. Adjust the probe so that it is vertical and advance the probe until the EC dipoles are split half in half out of the ground.
4. Click the trigger button in the lower right hand corner of computer screen. (The Trigger label will flash and the background will change from yellow to green).
5. Advance the probe at a rate of 2 cm/s. If necessary, feather the hammer to maintain this advance rate.
6. The trigger may be turned off at any time to make adjustments w/o recording any probe movement. With the trigger turned "off", the cable may be disconnected to add rods or to add an additional cable. When everything is reconnected and ready to advance turn the trigger "on".
7. After completing the log, press the trigger button again and select "Stop Log".
8. Disconnect the stringpot cable and pull the rod string using either the rod grip pull system or a slotted pull cap.
9. Run a post-log EC test (Section 5.3).
10. Open the log using the DI Viewer software, adjust the scales and log settings as desired and print the log (Figure 5.5).

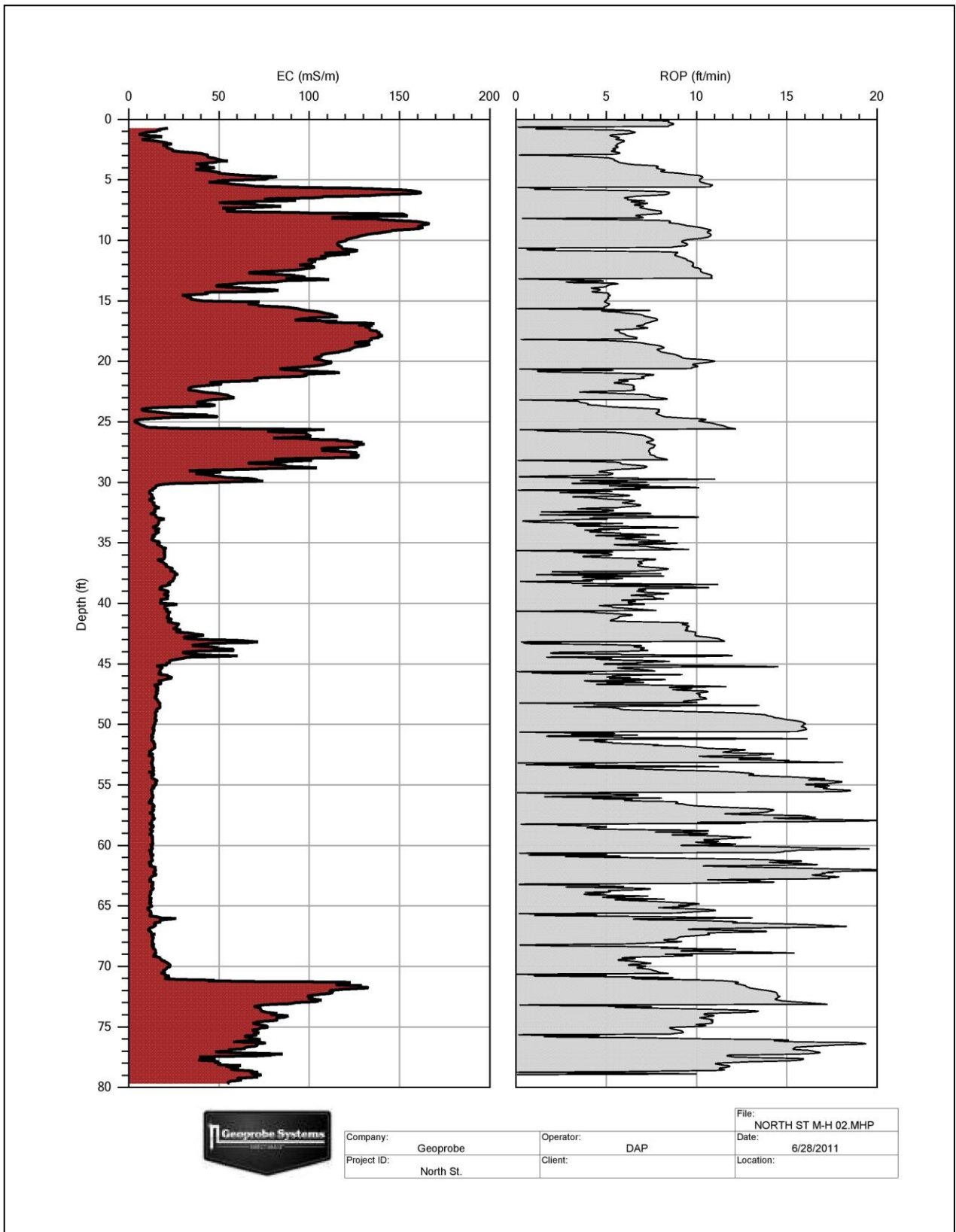
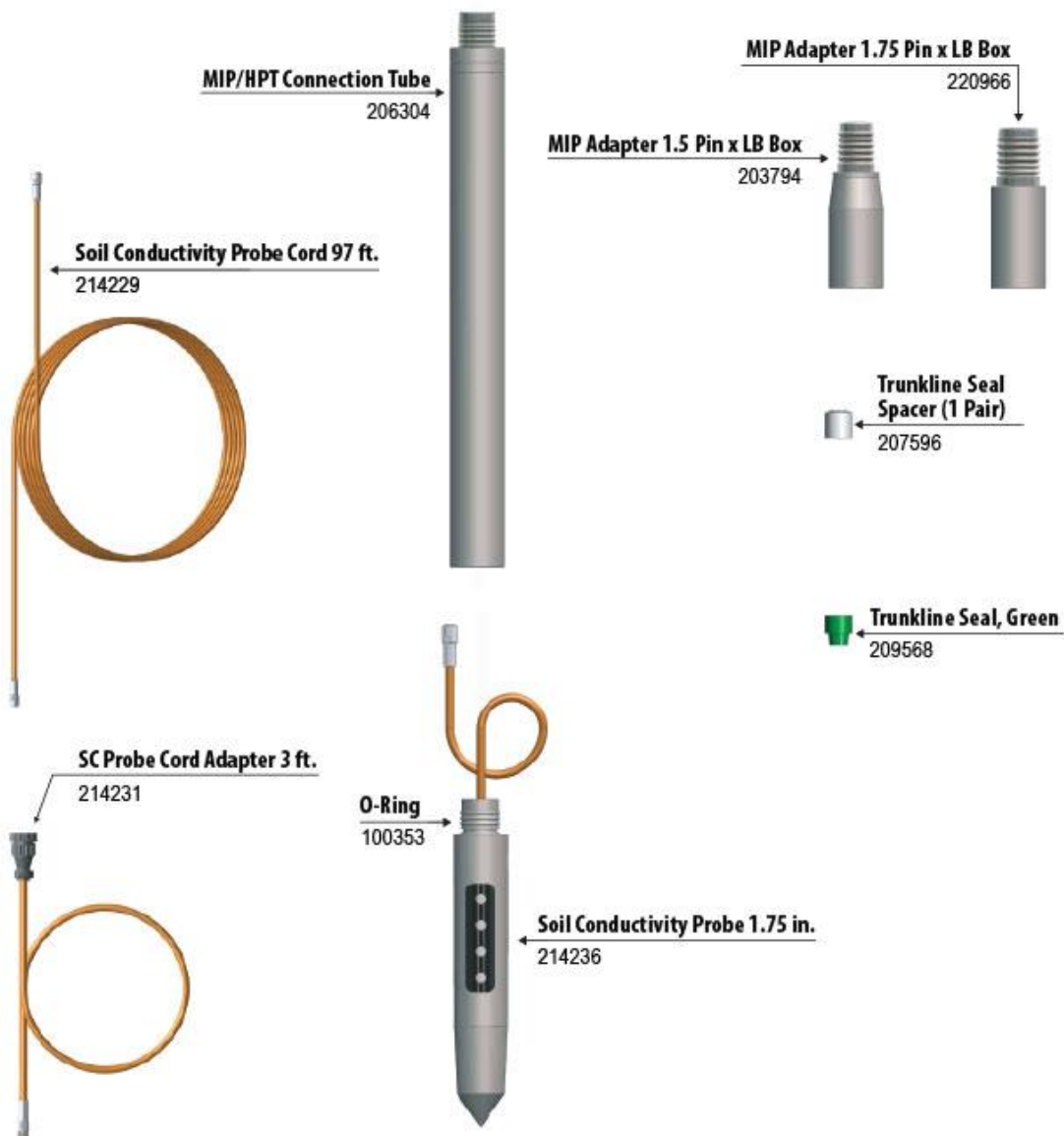


Figure 5.5: Example EC Log

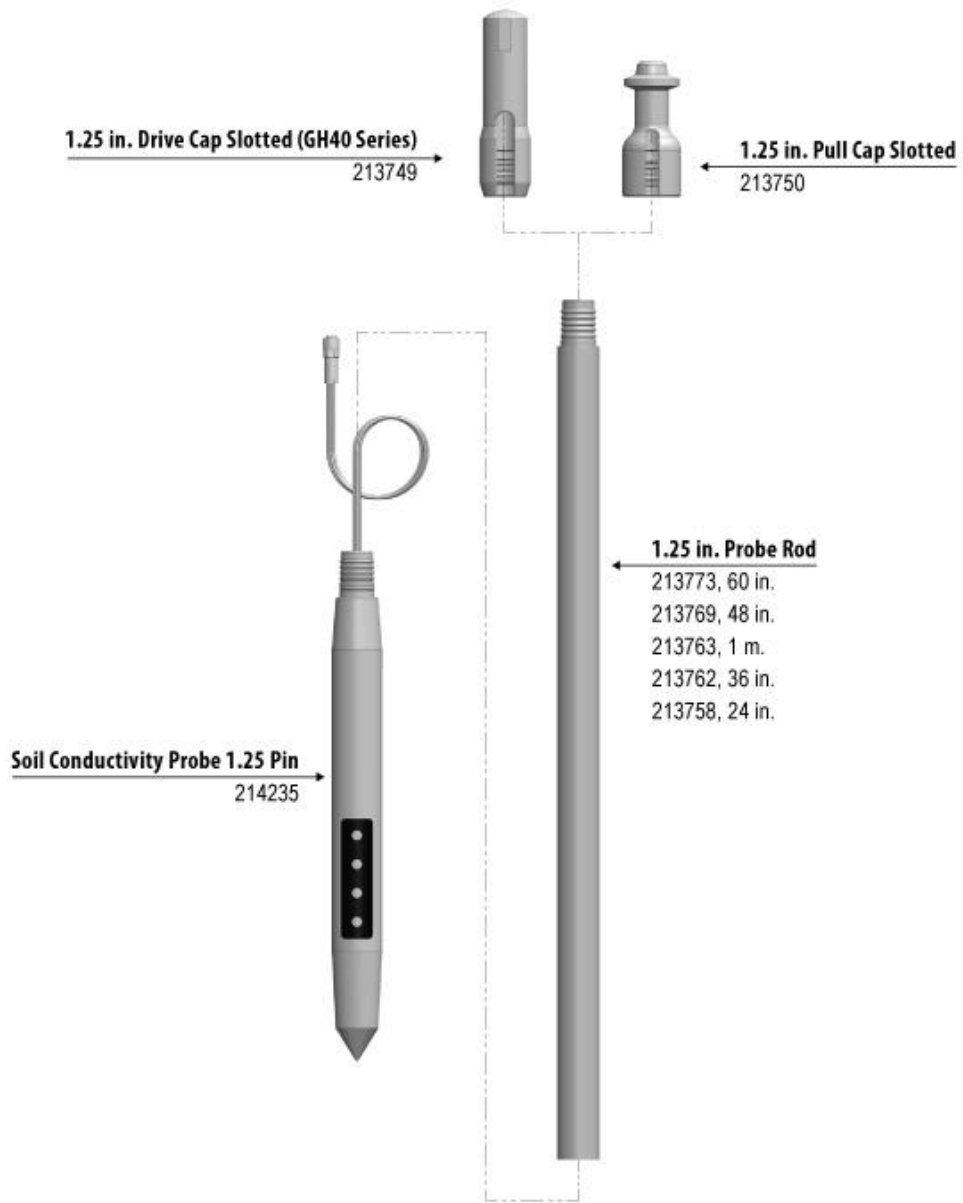
APPENDIX VI

EC Tool Configurations

EC – SC520 (1.5 in / 1.75 in. system)



EC – SC400 (1.25 in. system)



EC – SC820 (2.25 in. system)

