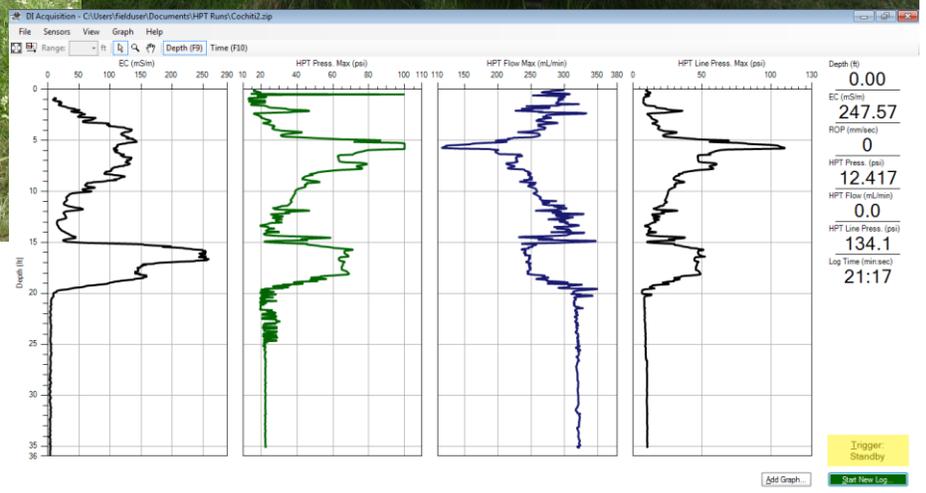


RECLAMATION

Managing Water in the West

The Geoprobe® Hydraulic Profiling System

Setup and Use



Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The Geoprobe® Hydraulic Profiling System

Setup and Use

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Introduction

Geoprobe®, located in Salina Kansas, developed the Hydraulic Profiling Tool (HPT) system to evaluate the hydraulic behavior of unconsolidated materials. The system can be used to collect data on subsurface soil properties. Various uses of this data can be made, including: potential contaminant pathways, subsurface injection zones, determine and target zones of interest for further study through groundwater and slug testing. At the Bureau of Reclamation Technical Service Center (TSC), use of the HPT system has revolved around subsurface investigation in support of agricultural drainage design.

General Considerations

This paper has been developed to assist the user in setting up the HPT system, and performing tests using the tool. Interpretation of the results and incorporating them into designs is beyond the scope of this paper, involving extensive knowledge and understanding of soil properties, design considerations, and experience.

The HPT system is made up of six primary components: 1) Direct push machine, 2) HPT Probe Assembly, 3) HPT Trunkline, 4) HPT Flow Module (K6300 Series), 5) Geoprobe® Field Instrument (FI 6000 Series), 6) DI Acquisition Software. Setup and utilization of each of these components will be presented in this paper.

System Setup and Configuration

This portion of the paper will describe the setup and preparation required in advance of making a testing run with the HPT system.

Direct Push Machine

Any rig capable of driving the tool into the ground, through a combination of direct push and hammer, at a constant rate of 2 cm/sec can be used in HPT data collection. For the purposes of this paper, an AMS PowerProbe 9500-VTR is used (figure 1). The initial configuration of the drive rig is usually done just once. Setup consists of setting the drive rate and the attachment of the Geoprobe® String Pot, used for precise measurement of the depth of ground penetration.



Figure 1: AMS PowerProbe 9500-VTR

In the case of the 9500-VTR, setup of drive rate to the 2 cm/sec required by the HPT is accomplished using a set of locking knobs located directly behind the control panel (figure 2). Setting the drive rate is an iterative process in which the user sets the knobs, then, using a stop watch, times the rate of descent of the drive head.



Figure 2: Drive rate control

The process is then repeated until the drive head moves at the proper rate of speed. Once done, unless another tool requires a different rate of speed, calibration of the speed should be done a couple time per year.

The stringpot (figure 3) is a device used to accurately measure the distance the unit has been driven into the ground. Again, once the stringpot has been attached, unless the space is required for another instrument, it can remain attached even when the HPT is not being used. Calibration is accomplished in the software.

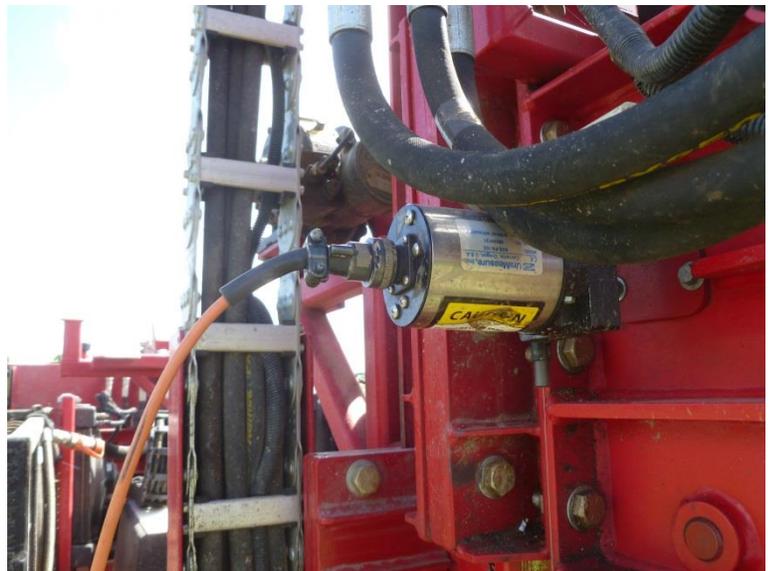
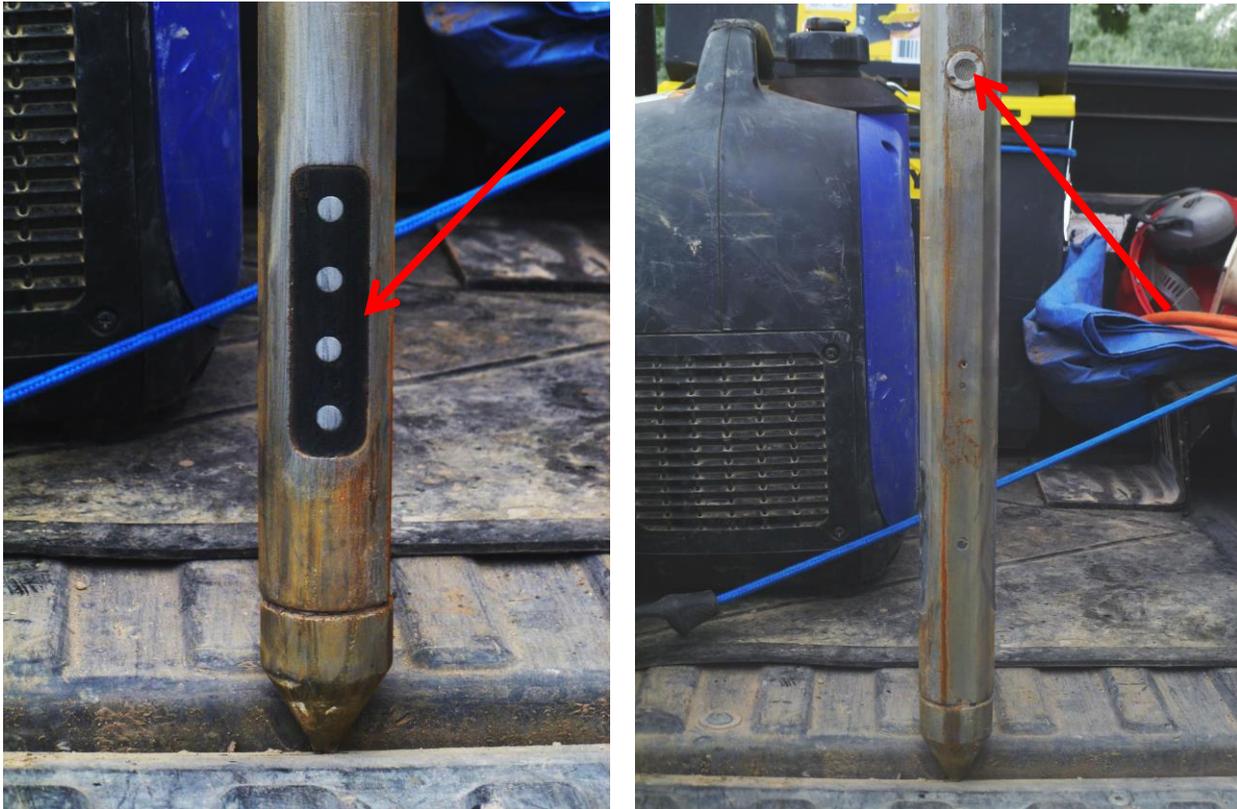


Figure 3: Stringpot attachment

HPT Probe Assembly

The HPT probe assembly includes three pieces. The HPT probe is the end piece consisting of a hardened, pointed end piece and which houses the electrical conductivity sensor array (figure 4) and flow injection screen (figure 5). Flow and pressure measurements are made at the Flow Module and within the body of the HPT Assembly.



The HPT Connection Tube houses and protects all of the electrical and hydraulic connections (joining the HPT probe with the trunkline). The HPT adapter tops the assembly, sealing the unit together and providing the threaded end piece that will attach to the extension rods. Once the three components (HPT Probe, HPT Connection Tube, HPT Adapter) of the assembly is connected and threaded tightly together, it should not need to be disassembled except for component replacement or repair. The HPT probe assembly is approximately 3 feet in length, shown in figure 6 attached to the 9500-VTR just prior to initial driving.

HPT Trunkline

The HPT trunkline is a cable that connects the HPT probe assembly with the data recording components of the system. Various lengths are available from Geoprobe® up to 200 feet. The cable system is made up of seven wires (in two bundles) and a water delivery tube as shown in figure 7. The four-wire bundle (white, yellow, black, blue) connects the HPT EC sensors to the

Field Instrument. The three-wire bundle (orange, red, brown) connects to the Flow Module. The blue tube connects to the Flow Module and delivers water to the HPT assembly.

The trunkline delivers continuous data through electrical signals and water flow and pressure measurements. Once a test is underway, the HPT Probe Assembly, HPT Trunkline, Field Instrument, and Flow Module must remain continuously connected. Because of this, the user must have some sense of how deep he must go to get sufficient data appropriate for his needs, and plan accordingly by providing enough extension drive rods to reach the desired depth. These rods must, before connecting the trunkline to the measurement modules, be threaded with the trunkline. To make an appropriate connection between drive rods, the trunkline must be threaded entering the drive rod through the female end, and exiting through the male end (figure 8). The trunkline is then passed through the next extension rod. During testing, these rods are added to the HPT assembly in order, sliding them into place along the trunkline. Because the trunkline includes a tube through which water is flowing to the HPT probe, care must be exercised when threading and adding rods to the assembly to not kink or crush the trunkline. Once the trunkline is threaded through the extension rods, if a suitable means of transportation and storage is available, it can be left indefinitely. Figures 9 and 10 show the trunkline threaded



Figure 6: HPT Assembly prior to driving

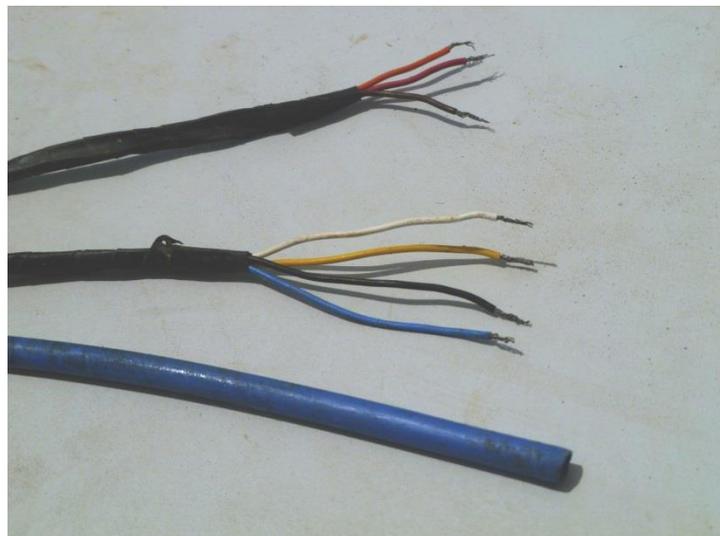


Figure 7: Trunkline electrical wires and blue water supply tube

and configured for transport. Note the large loops in the trunkline used here to insure the water delivery tube is not kinked. The seven wires in the trunkline are connected to both the HPT Flow Module and Field Instrument are made using green terminal blocks (provided by Geoprobe®) shown in figure 11. These connectors cannot be passed through the extension rods and must be removed (and reattached) prior to threading or unthreading the rods. Specific wire colors are shown on the back of the HPT Flow Module and Field Instrument for ease in reconnecting the wires, as discussed later.

HPT Flow Module (K6300 Series)

The HPT flow module is one of two electrical units required to perform an HPT test. This unit controls the water delivery and reports the flow rate and pressures at the HPT probe.

Figure 12 displays the front of the unit, including master water



Figure 8: Threading the trunkline through the extension rods



Figure 9: Threaded extension rods (view 1)



Figure 10: threaded extension rods (view 2)

pump switch (A), on/off valve (B) and flow rate adjustment knob (C). Figure 13 shows the HPT Flow Module back with trunkline electrical connections (A), Water connections (B), and data inter connection to the Field Instrument (C).

Each of the connections will be discussed in detail.

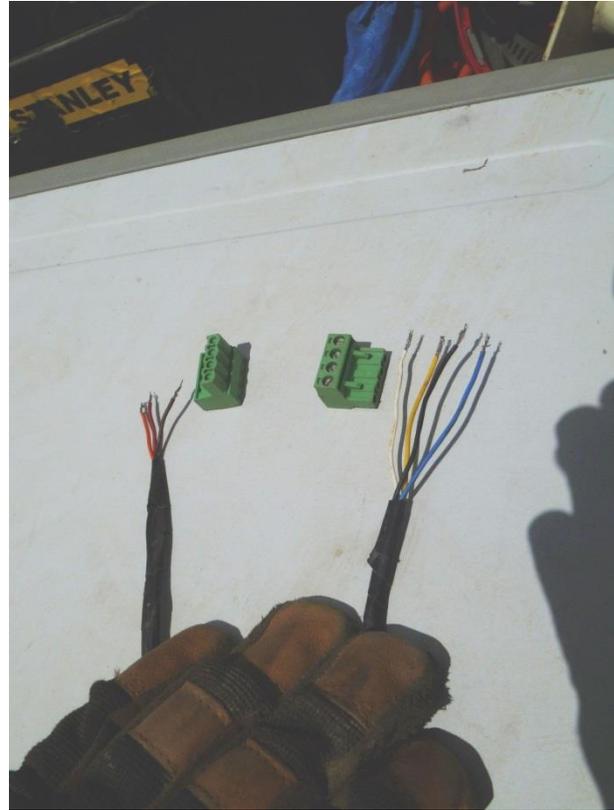


Figure 11: Geoprobe® terminal blocks



Figure 12: HPT Flow Module (K6300 Series) front view



Figure 13: HPT Flow Module (K6300 Series) rear view

HPT Flow Module Electrical Connection

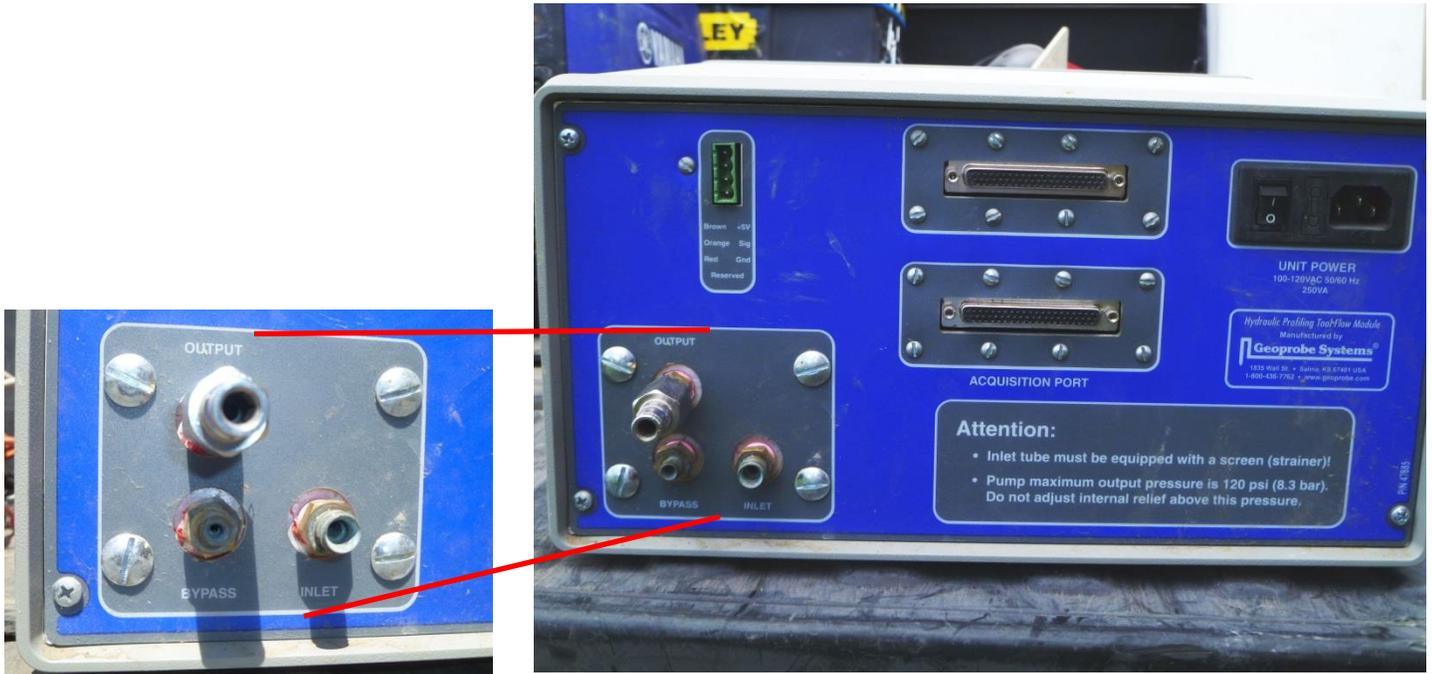
Figure 14 shows a blowup of the electrical connection between the HPT trunkline (3-wire bundle) and the Flow Module (labeled “A” on figure 13). This connection reports water pressure at the HPT probe. From the top of the port, the colored wire order is: brown, orange, red, reserved (no wire).



Figure 14: Flow Module electrical connections

HPT Flow Module Hydraulic Connections

Figure 15 shows the hydraulic connections to be made to the back of the HPT Flow Module (labeled “B” on figure 13).



The “Inlet” (clear tube) and “Bypass” (yellow tube) ports are used to connect the Flow Module to the water supply. The “Output” port is connected to the blue trunkline tube which hydraulically connects the Flow Module with the HPT probe. These connections are shown in figure 16. Prior to conducting tests with the HPT system, the hydraulic connections should be made and water run through the system for 5-10 minutes. This allows air to be purged from the pump, trunkline and HPT probe, as well as allowing the user to make the proper flow adjustments. Flow should be approximately 300 ml/min during testing.

The Acquisition port will be discussed later.



Figure 16: HPT Flow Module with water supply and delivery tubes connected

Geoprobe® Field Instrument (FI 6000 Series)

Figure 17 shows the front of the Field Instrument. The only switch here is in the upper right corner power toggle. Figure 18, on the other hand, displays the back of the Field Instrument with many connections, including: Acquisition port (A), String Pot connector (B), Trunkline connection (C), EC Test Input port (D), and the USB Interface (E). As was done with the HPT Flow Module, each of the connections will be discussed in more detail.



Figure 17: Geoprobe® Field Instrument (FI 6000 Series) front view



Figure 18: Geoprobe® Field Instrument (FI 6000 Series) rear view

Acquisition Port

The acquisition port on both the HPT Flow Module (labeled “C” on figure 13) and Field Instrument (labeled “A” on figure 18) is used to connect both modules together. Since the Field Instrument provides the data connection to the computer, this connection allows the software to read data input from both units. Figure 19 shows the link using the 62-pin serial connector.

String Pot Connection

As discussed earlier, a string pot is required to accurately measure the depth of the HPT probe assembly. Attachment of the string pot to the direct push machine is shown in figure 3 (image repeated here). Figure 20 displays the electrical connection between the Field Instrument and the string pot mounted on the machine. The string pot is mounted to the actual drive head of the machine. The string itself is attached to the unmoving foot of the machine during testing, shown in figure 21.



Figure 19: Acquisition port connection

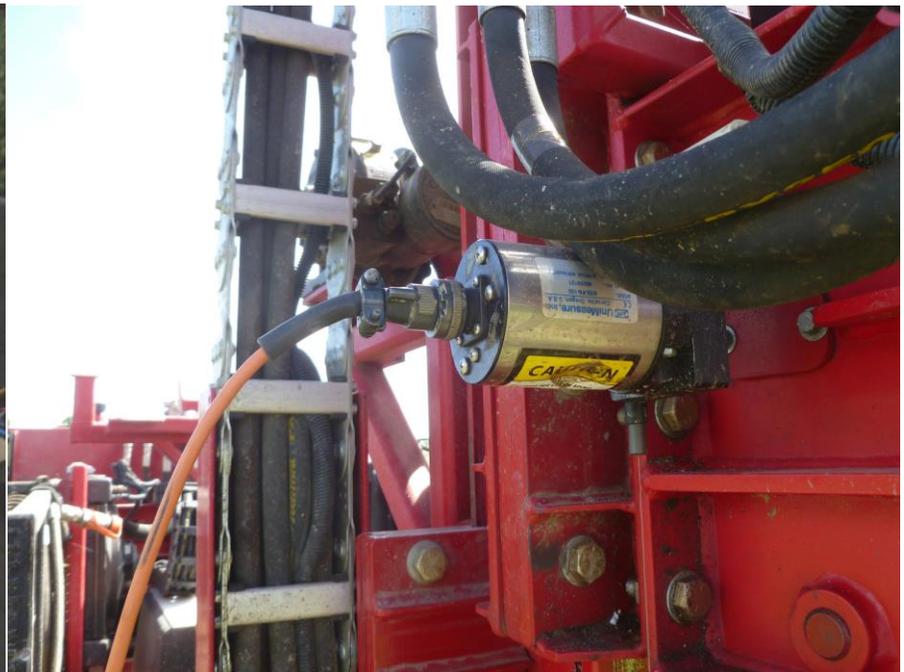


Figure 20: String pot connection to machine and Field Instrument



Figure 21: String connection between the string pot and the machine

Trunkline Connection

This connection is very similar to the HPT Flow Module electrical connection discussed earlier. A second green terminal block is attached to the 4-wire bundle of the HPT trunkline and attached to the Field Instrument. The wire color connections are hand written on the Field Instrument to assist in proper electrical connections. This connection is used to collect data from the EC sensor array of the HPT probe. Figure 22 displays this connection. Four wires are connected to this port. The colored wire order from the top of the port to the bottom is: white, black, yellow, blue.

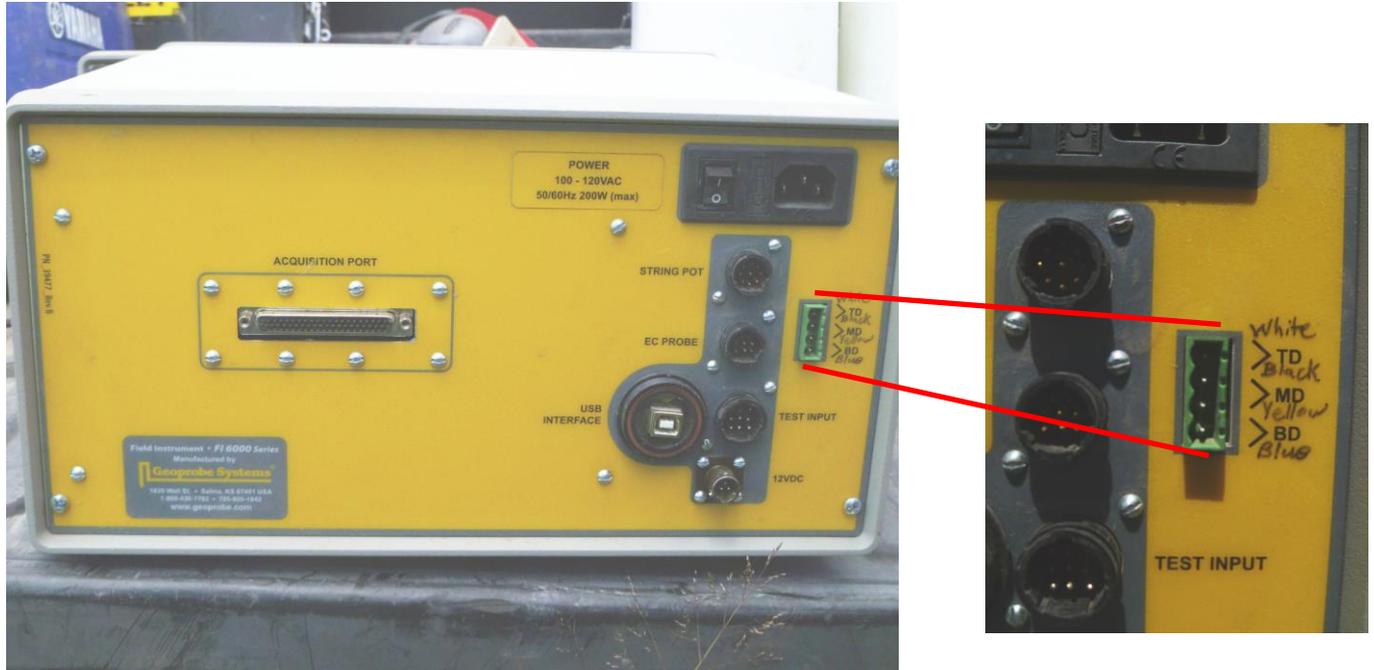


Figure 22: Field Module electrical connection

EC Test Input Port

Before attaching anything to this port, the EC test unit must first be assembled. The test unit consists of two pieces, the test jig and the test loader, shown on figure 23. The cable from the test jig is attached to the port of the test loader as shown on the figure. The cable from the test loader is then attached to the Field Instrument EC test input port displayed in figure 24. The EC test unit will be used during the QA/QC calibration of the HPT probe both pre and post-test.

USB Interface

This port is used to connect the Field Instrument to the computer for data collection by the acquisition software. The USB cable is a standard A-Male to B-Male connection (just like those commonly used to connect computers to printers). Figure 25 shows the cable connected to the USB Interface port.



Figure 23: EC test unit assembly



Figure 24: EC test unit connection to Field Instrument



Figure 25: USB cable connection

DI Acquisition Software

It is assumed that the acquisition software is already installed on the computer. If not, follow the instructions that came with the software distribution media. No additional software setup is required.

Hydraulic Profiling Tool data Acquisition

Once the HPT system is assembled, all connections have been made, and the system provided with electrical power, it is ready to begin collecting data. This section presents the steps required to log a test using the software and HPT system. The steps to follow are: 1) start the acquisition software, 2) create a new log, 3) begin driving the HPT probe, 4) dissipation testing, 5) post-test requirements.

Starting the acquisition software

With all connections made, electrical power provided, and water bled from the trunkline and HPT probe, the system is ready to conduct hydrologic soils testing. The acquisition software is accessed by double clicking the icon on the computer screen, labeled DI Acquisition, shown on figure 26. Once the software starts, the screen will look like that shown in figure 27. If some of the connections to the HPT Flow Module or Field Instrument are missing or not working properly, one or more data traces (column on the display) may be missing, please check the connections again and restart the software.



Figure 26: DI Acquisition Software Icon on Windows 7

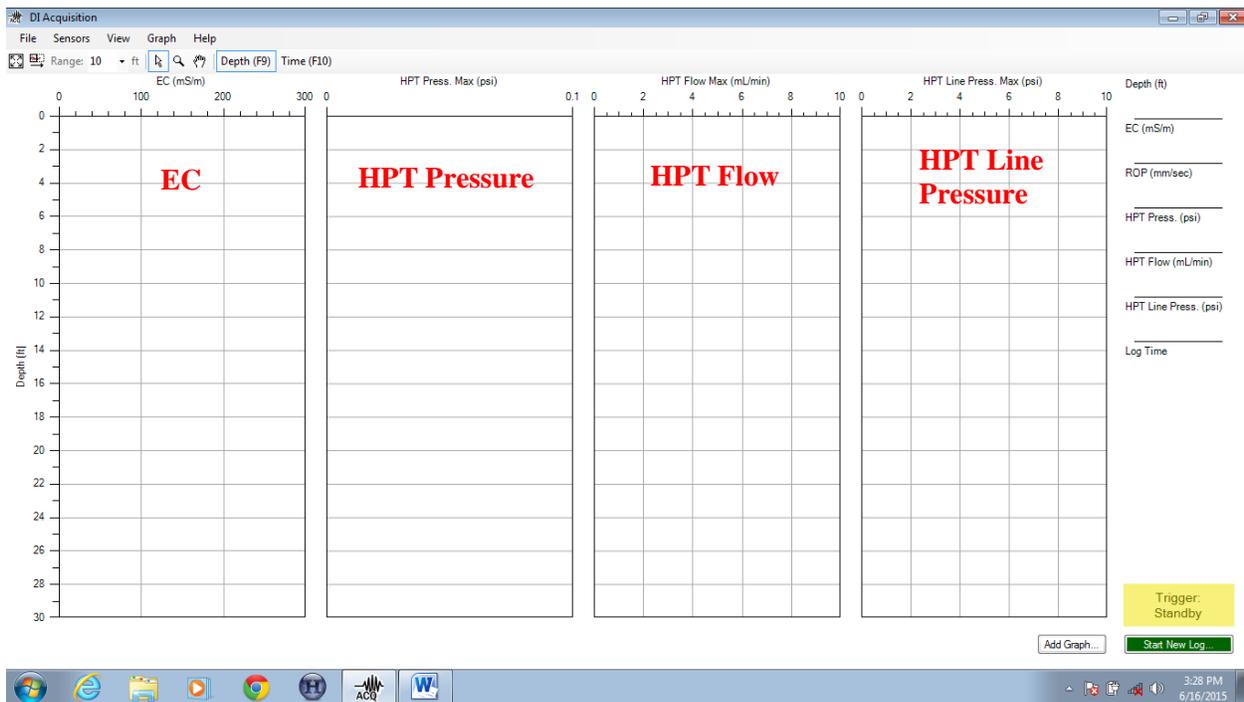


Figure 27: Di Acquisition software startup screen

Create a new log

By clicking the “Start New Log” button (green bar in the lower right of the screen), the user is presented with a log information screen (Figure 28). Only the filename field is required, but the other fields can be populated to help in organizing and identifying different logs. When all

information is to the users satisfaction, click the “Next” button at the bottom of the window. This displays the HPT Probe-specific data to be used in the run (Figure 29). Note that most of the data will not change from run to run. Geoprobe® makes two types of probe, K6050 and K8050. Both of the probes currently in use at the TSC are the K6050 type. Each probe has a different HPT transducer number. If the probe assemblies are changes, be sure to make the appropriate adjustment to this field. The Di Acquisition software remembers these data from the previous run. If nothing has changed, there is no need to make adjustments. If data fields need to be changed, click the “no” button and proceed.

Figure 28: Start New Log information screen

When all is to the users satisfaction, click the “Next” button to begin pre-test EC and pressure testing and calibration. The first calibration the software conducts is the verification of correct EC array readings. The software interface for this testing is displayed in figure 30. This test is accomplish using the EC Test Loader assembly (discussed previously, figure 23). The test jig has 5 springs at specific intervals 4 of which match the EC sensor array dipoles, with the fifth used as a ground. The test jig is attached to the HPT probe using care to be sure the 4 springs are in contact with the four dipoles on the HPT probe assembly. The jig is held in place with magnets (figure 31). The test jig cable should be towards the top of the HPT probe (where the trunkline emerges for the assembly). The testing and calibration is accomplished by pressing and holding each of the test

Figure 29: HPT Assembly specific settings

buttons on the EC test loader (figure 32), then clicking on the corresponding “run” button on the EC Load Test interface. In other words, the user is to press the “Test 1” button on the EC test loader, and, while holding the button, click the “run” button to the right of the “Test 1” fields in the EC Load test interface. This is then repeated for Test 2 and Test 3. If the EC load measured during the test is within acceptable limits, a green “PASS” is displayed in the P/F column of the software interface. When all tests have been successfully passed, the “Next” button can be clicked moving on to the HPT Reference Test.

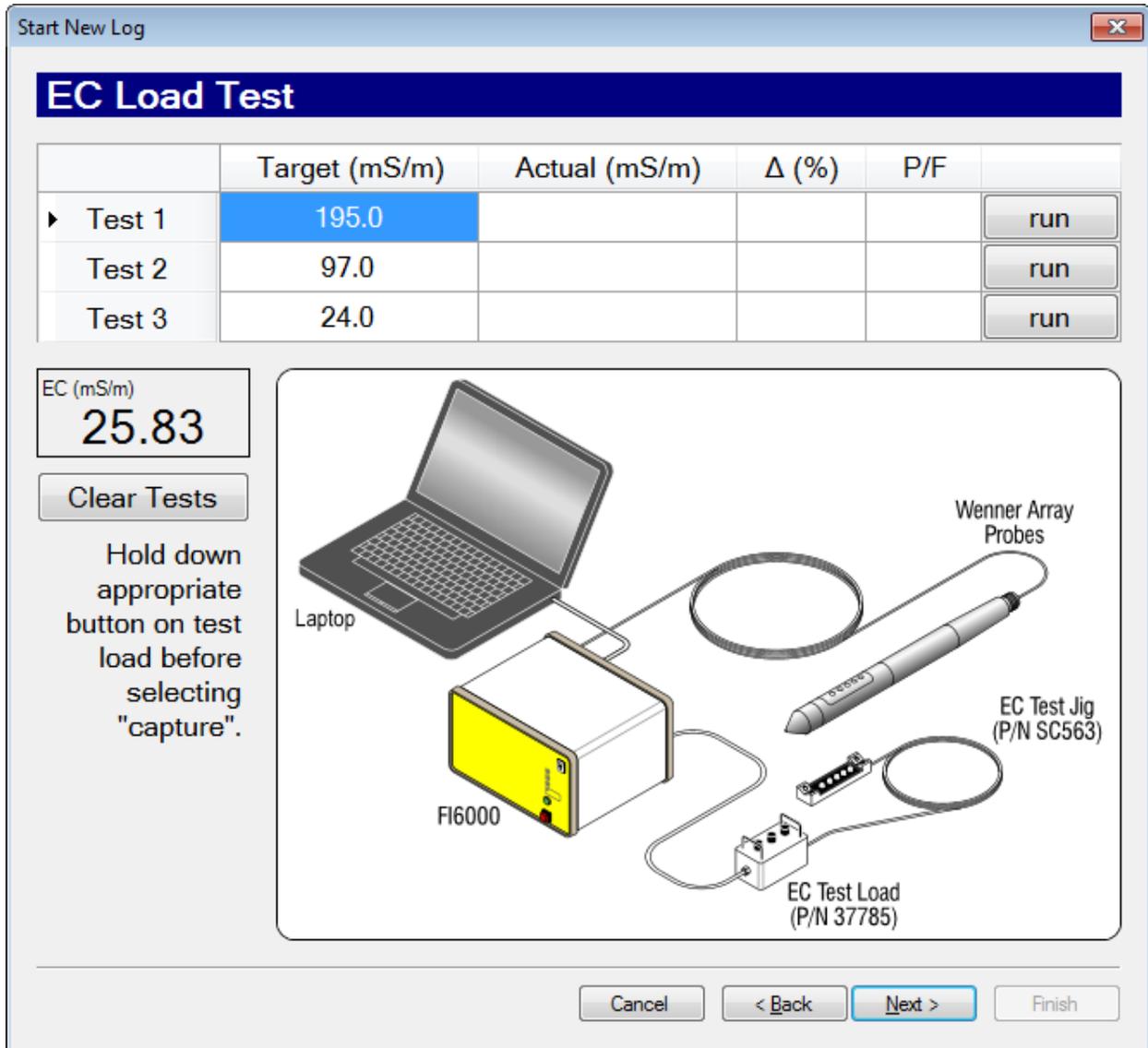


Figure 30: EC test and calibration software interface



Figure 31: EC test jig attached to the EC Sensor array on the HPT Probe Assembly



Figure 32: EC test Loader

The HPT reference Test is done to verify that the pressure sensing systems of the HPT system are in working order. The software interface is shown in figure 33. This test requires the use of

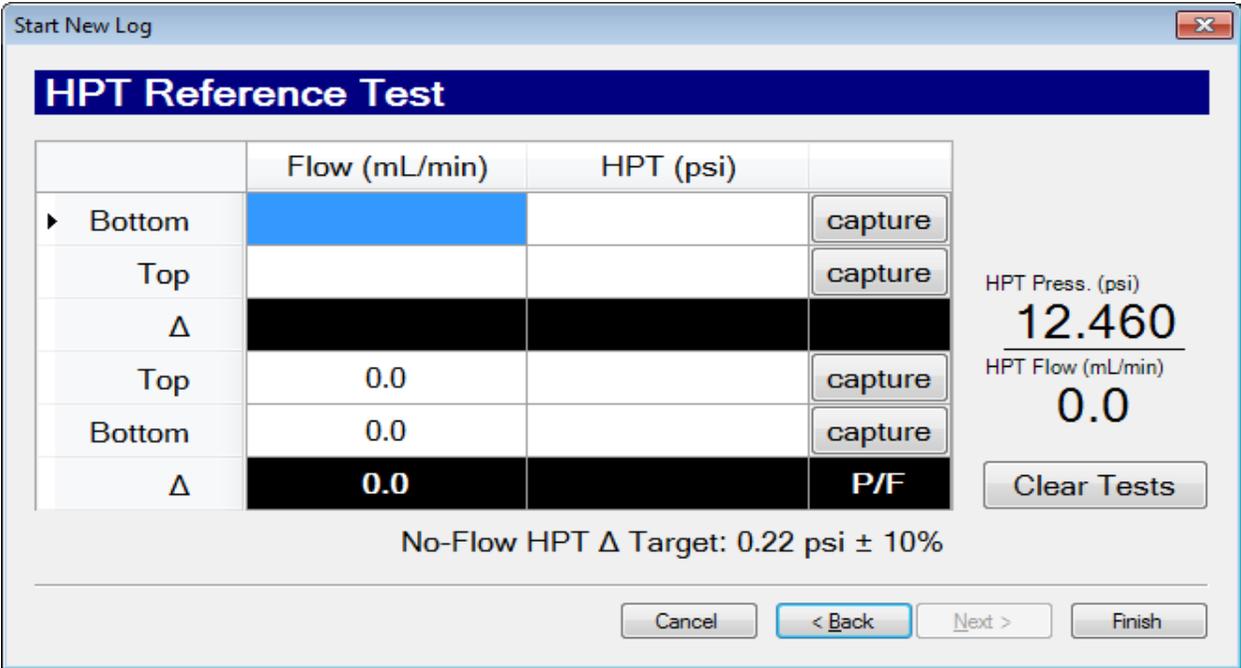


Figure 33: HPT Reference Test software interface

the HPT reference tube, a vertical tube with a valve near the top (figure 34). The HPT probe is inserted into the Reference tube and the flow from the HPT Probe is allowed to fill the tube until water flows freely from the valve in the side of the tube (see figure 34). With the water flowing freely, the “capture” button in the interface corresponding with the top field is clicked. The Reference Tube valve is then closed and water is allowed to finish filling the tube. When water is flowing freely over the top of the tube, the “capture” button second from the top is clicked. Water flow is then ended. With the flow stopped, the water at the top of the tube is allowed to stabilize, then the “capture” button third from the top is clicked. Finally, the Reference Tube valve is reopened and the water is allowed to drain until it no longer flows from the valve. The bottom “capture” button is then clicked. If all is successful, a green “PASS” will appear in the lower right corner of the interface. The test should be repeated until a PASS condition exists. Once the test has been passed, click “Next”. This ends the testing and calibration phase. The user is returned to the main software acquisition interface (figure 27).

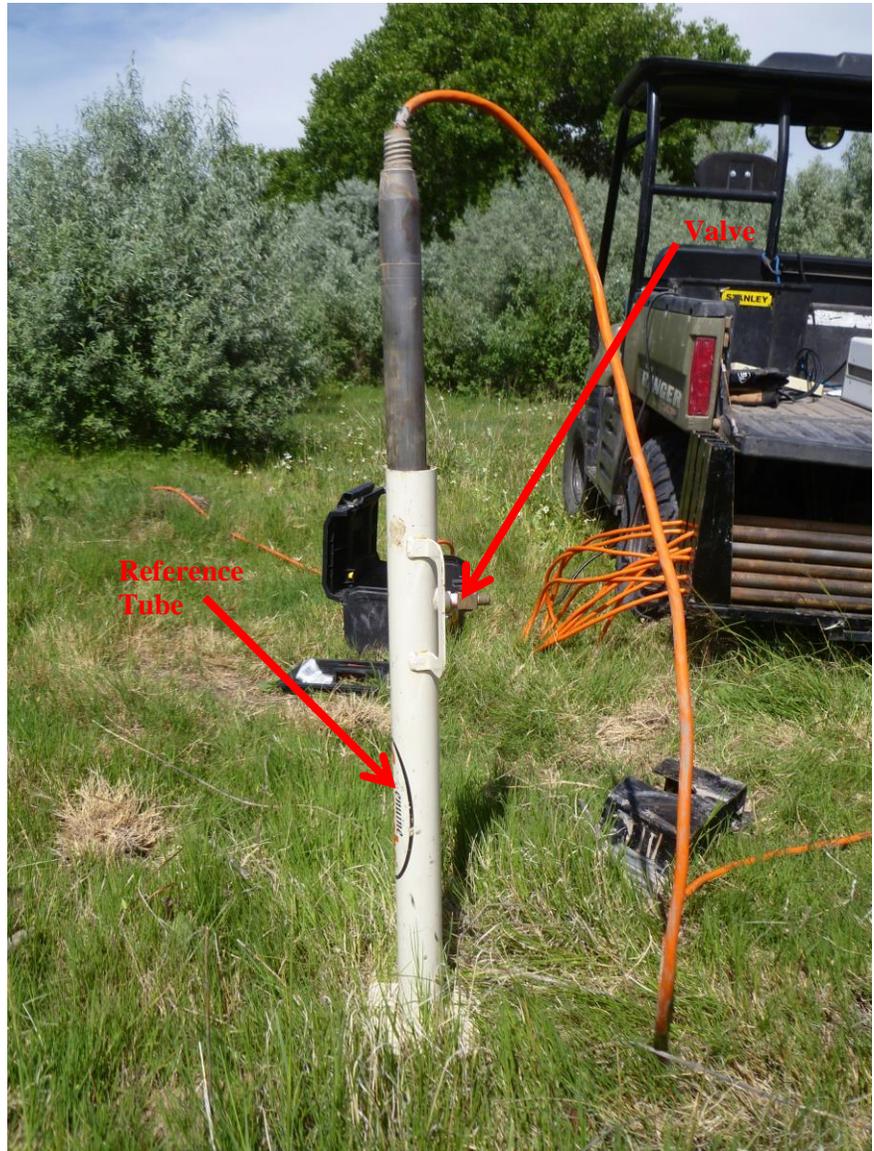


Figure 34: HPT Probe inserted into the Referene Tube

Begin driving the HPT probe

With the testing and calibration complete, the user is ready to begin driving the HPT Probe Assembly into the ground and collect soil hydraulic and electrical conductivity data. Figure 35 shows the initial driving of the HPT Probe. The rod wiper (commonly referenced as a “donut”) is placed on the ground and the HPT Probe tip is inserted into the hole. A slotted drive cap is

placed over the threads at the top of the probe and nested in the hammer assembly of the direct push machine. The probe is then leveled and driven into the ground (through the donut hole) until the water injection screen (see figure 5) just disappears into the donut. Careful leveling of the 9500-VTR and the HPT probe is essential to prevent undue binding and excess wear of the drive rods and threads. At this point the water flow is turned on and the “Trigger” button, located in the lower right corner of the acquisition software interface, is clicked. The “Trigger” button, up to this point, should have been yellow, and read “Standby”, meaning the system was not actively logging. When the “Trigger” button is clicked, it should change to green and the label should now read “Logging”. The unit is advanced into the ground, adding extension rods as needed until the desired depth is reached.

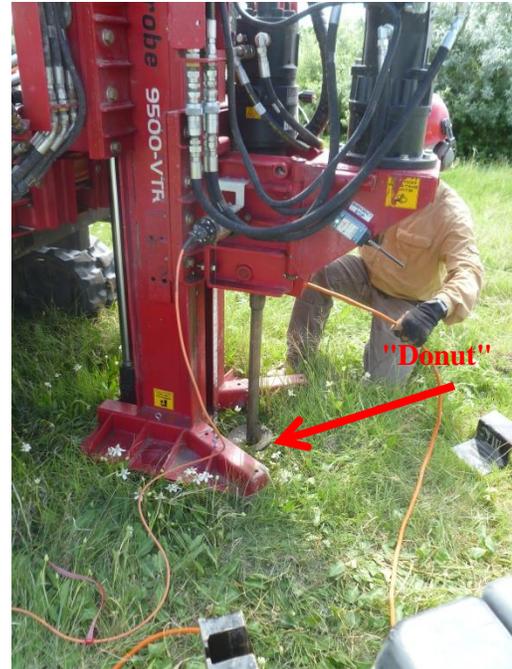


Figure 35: Initial Probe push through the "Donut"

A general knowledge of expected water table depth is necessary to complete the testing, since the analysis of the resulting hydraulic profile needs to know the water table depth to be able to adjust the measurements, removing pressure influences of the water table from the calculations. If test holes have been installed, and the exact depth to the water table is known, this information can be entered directly into the software during analysis. If the depth of the water table isn't known, the Acquisition software provides the means to measure the depth to water during the data collection phase. This feature is referenced as “Dissipation testing”

Dissipation Testing

During testing, as the HPT Probe is driven into the ground, the DI Acquisition software displays real-time data on the screen. Figure 36 shows what a screen may look like. Four columns of data are displayed; from left to right: EC, Maximum HPT Pressure, Maximum HPT Flow, and Maximum HPT Line Pressure. Since the dissipation test is designed to measure static water pressure of the groundwater, and from that data to calculate the depth to the water table, the user must refrain from running dissipation tests until sure the HPT Probe has entered the ground water. Once the user is sure the HPT Probe is in the ground water, she/he looks for a zone of relatively permeable soil. The zone between 20 and 25 feet displayed in figure 36 is a prime candidate. To determine an appropriate zone to use, the user should look closely at the second column of the interface (maximum HPT pressure) and choose a zone when the pressure is as low as possible. Typically, one doesn't want to do dissipation testing until the pressure readings are below 40 psi or the test will take a long time to conclude. Advancement of the probe is halted, and the interface is switched from the depth display to the time display by pressing F10. A different interface, shown in figure 37 is displayed. Once the three traces have stabilized, click the “Run Dissipation Test” button in the lower corner of the screen. The background display color changes from grey to white. Turn the pump off using the switch on the Flow Module (figure 12-A). As soon as the HPT Line Pressure trace (bottom graph) reaches zero, close the

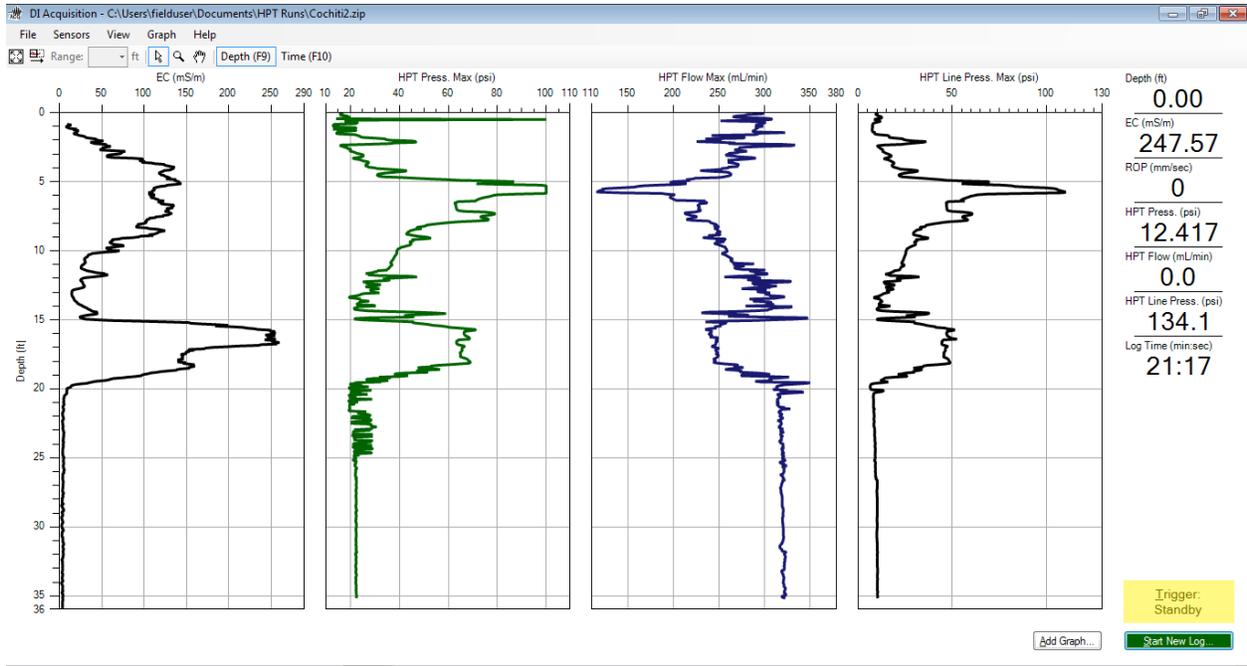


Figure 36: Acquisition software interface after testing

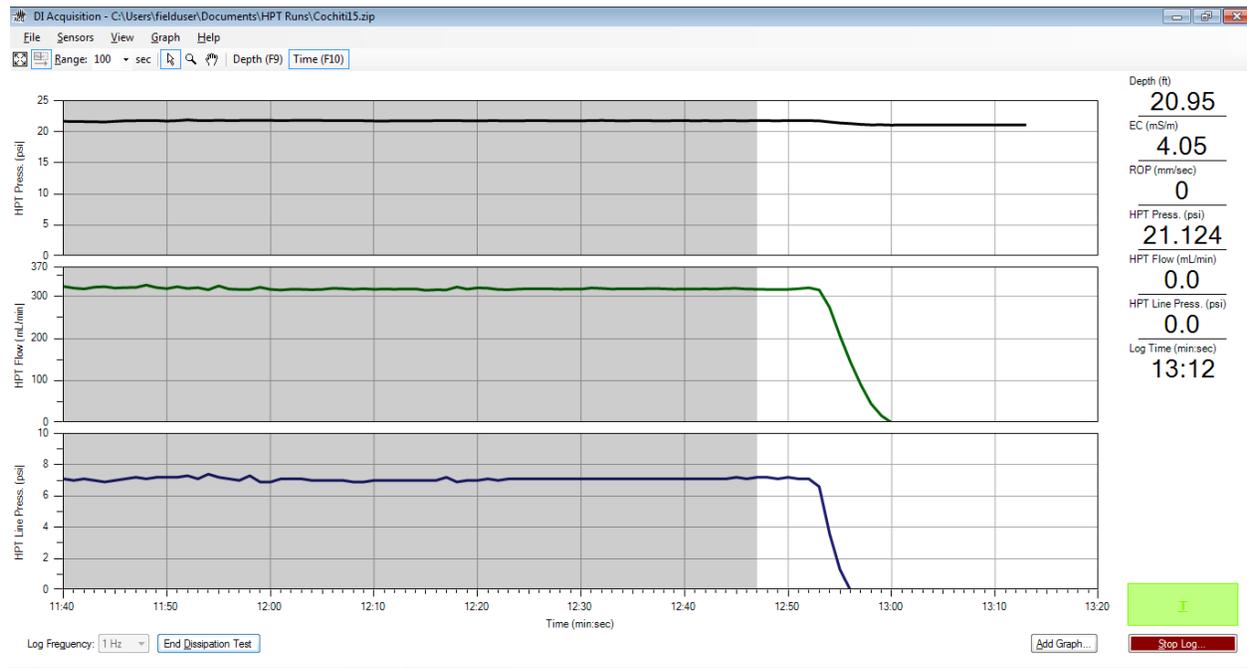


Figure 37: Time display screen and the start of the dissipation test

flow valve (figure 12-B). Wait until the HPT Pressure trace (top graph) has stabilized, then turn the flow valve followed by the Flow Module pump switch back on. Once all three traces have recovered and are stable (figure 38), click the “End Dissipation Test” button in the lower left corner of the interface. The interface background color will change back from white to grey. Return to the depth screen, by pressing F9, and continue to advance the tool into the ground.

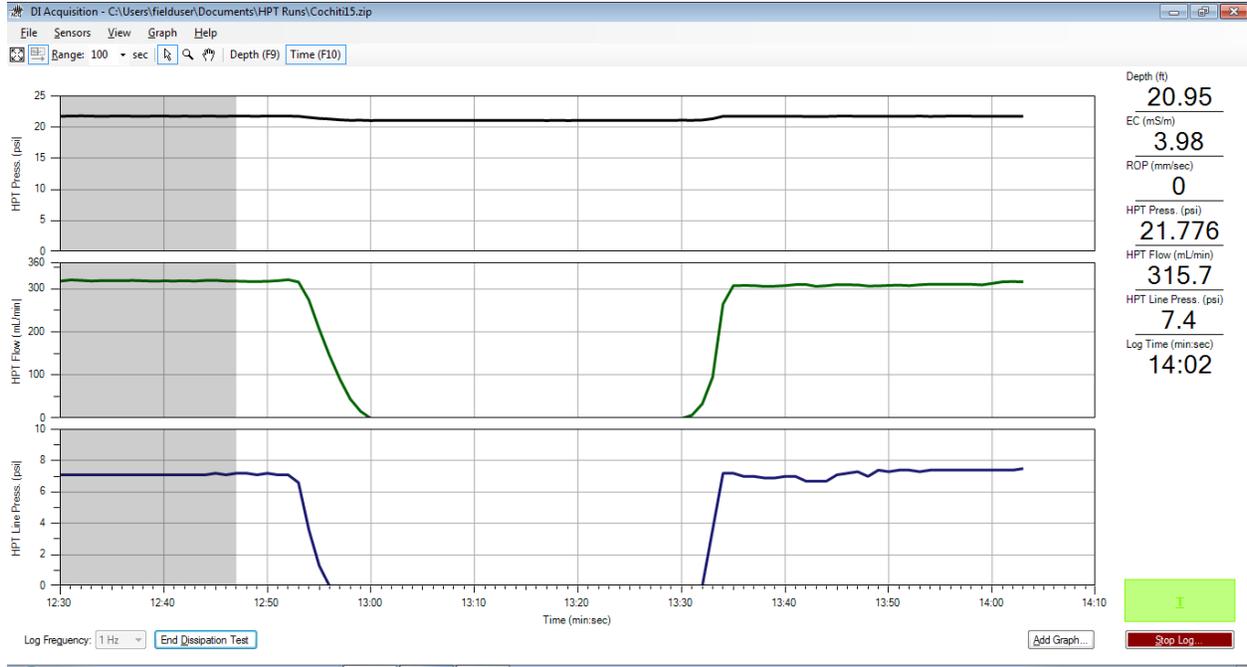


Figure 38: Dissipation Test recovery phase

Any number of dissipation tests can be done. Several are recommended if the user doesn't have a reasonable understanding of what depth the water table occurs

Post-Test requirements

After the HPT Probe has been driven as far as the user wants to go, the user, once again, clicks the "Trigger" button in the lower right corner of the interface (figure 27).. The button color will change from green to yellow, and the text will change from "Logging" to "Standby". Click the button directly below labeled "Stop Log". This ends data collection and prompts the user for post-test QA and calibration checks. These checks are exactly the same as the pre-test EC and pressure testing and calibration outlined above. The exact same interface screens are displayed in the same order. The procedures outlined previously on pages 15 through 18 are followed exactly. Before running the post-test calibration, the HPT Probe must be retrieved. A steel saddle (figure 39) is provided by Geoprobe® to hold the donut in place as the HPT Probe is recovered. This is placed around the rod, above the donut and held in place by the foot of the drive rig. During extraction, it is important to keep the pump



Figure 39: Geoprobe® donut saddle

on and water flowing through the HPT probe. The water flowing helps prevent the flow injection screen becoming plugged with soil as it passes up the test hole. Once the HPT Probe has been recovered, begin the post-test calibration, starting with the EC Load test, followed by the HPT Reference Test.

Conclusion

The Geoprobe® Hydraulic Profiling Tool is a fast, simple system that can give initial understanding of subsurface soil properties. Used in conjunction with traditional soil sampling, previously conducted soil survey logs and slug testing, the HPT can help to classify hydraulic properties of the subsurface to assist in understanding the soils and to help in engineering design.