NEON PREVENTIVE MAINTENANCE PROCEDURE: SOIL TEMPERATURE PROFILE

PREPARED BY	ORGANIZATION	DATE
Edward Ayres	FIU	01/27/2016
David Durden	FIU	01/27/2016
Rachael Willingham	SE	09/06/2017
Geoff Simonds	SE	12/11/2017
Madeline Cavileer	ENG	08/29/2022

APPROVALS	ORGANIZATION	APPROVAL DATE
Kim Nitschke	IS	11/30/2022
Kirsten Ruiz	FS	11/30/2022

RELEASED BY	ORGANIZATION	RELEASE DATE
Tanisha Waters	CM	11/30/2022

See configuration management system for approval history.

The National Ecological Observatory Network is a project solely funded by the National Science Foundation and managed under cooperative agreement by Battelle. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	05/09/2016	ECO-03670	Initial Release
B	04/04/2017	ECO-04604	Added procedure to check that cables and other infrastructure are at least 30 cm from the sensors. Added maintenance procedures for soil temperature sensor assemblies that are installed directly in the soil (i.e., not inside an access tube).
C	03/30/2018	ECO- 05509	Pump run time increased from at least 15 seconds to at least 1 minute to ensure any water present begins to flow out of the tube. Added Section 6 and added/organized content from ENG and SIV and for clarity.
D	11/30/2022	ECO-06877	Incorporated minor revisions and clarifications from NCC WFH Project 16. Updated branding, formatting, and terminologies. Removed redundant information in Section 6. Fixed broken links. Added Figure 1 in Section 4.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

1 DESCRIPTION

1.1 Purpose

NEON sites host sensors that take measurements from air, water, wind, soil, and sun. Regular maintenance of sensors and infrastructure is necessary for the continued operation of the observatory. It is important to identify small problems before they escalate.

This document establishes mandatory procedures and recommended practices for preventive maintenance of the **Soil Temperature Profile** to meet the objectives of the NEON Program, and its respective stakeholder and end users.

1.2 Scope

Preventive Maintenance is the planned maintenance of sensors and infrastructure with the goal of ensuring that the instrument and/or infrastructure performs correctly to ensure the collection of the best available science, by preventing excess depreciation and impairment. This maintenance includes, but is not limited to, inspecting, calibrating, adjusting, cleaning, clearing, lubricating, repairing, and replacing, as appropriate. The procedures in this document are strictly preventive and do **not** address corrective actions.

This document addresses preventive maintenance procedures to maintain the Thermometrics Climate platinum resistance temperature (PRT) Probe (*100-ohm platinum single 4-wire resistance temperature detector (RTD) for soil temperature measurements*) at applicable NEON Terrestrial Instrument System (TIS) site soil plots (SP). This includes preventive maintenance procedures and requirements for the Soil Temperature Profile sensors, subsystem and supporting infrastructures (***CF00610000*** *Assembly, Soil PRT Terminated Cable, 25 feet* and ***CF00620000*** *Assembly, Soil PRT Terminated Cable, 35 Feet*).

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

The following applicable documents (AD) contain mandatory requirements and/or supplementary information that are directly applicable to the topic and/or procedures herein. Visit the NEON Document Warehouse for electronic copies of these documents.

AD [01]	NEON.DOC.004300	Environmental, Health, Safety and Security (EHSS) Policy, Program and Management Plan
AD [02]	NEON.DOC.004301	EHSS Environmental Protection Manual
AD [03]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD [04]	NEON.DOC.001436	TIS Comm Interconnect Map
AD [05]	NEON.DOC.000804	Site Flora and Fauna Maintenance Plan
AD [06]	NEON.DOC.00XXXX	Site-specific Flora and Fauna Maintenance Plan
AD [07]	NEON.DOC.000442	NEON Sensor Command, Control and Configuration – Soil Temperature Profile
AD [08]	NEON.DOC.000769	Electrostatic Discharge Prevention Procedure
AD [09]	NEON.DOC.000847	NEON Installation Procedure: Soil Temperature
AD [10]	NEON.DOC.004570	Soil Temperature Profile Verification Procedure
AD [11]	NEON.DOC.000779	TIS Soil Plot Layout
AD [12]	NEON.DOC.003146	Soil Sensor Depth Selection

2.2 Reference Documents

Reference documents contain information complementing, explaining, detailing, or otherwise supporting the information included in the current document.

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms
RD [03]	NEON.DOC.004257	All Systems Standard Operating Procedure: Decontamination of Sensors, Field Equipment, and Field Vehicles
RD [04]	NEON.DOC.002768	TIS Subsystem Architecture, Site Configuration and Subsystem Demand by Site - SCMB Baseline
RD [05]	NEON.DOC.004637	TIS Verification Checklist
RD [06]	NEON.DOC.001726	Soil Temperature Top Level Tube Assembly Instruction

2.3 Acronyms

Acronym	Description
A/R	As Required
AC	Alternating Current
ADC	Analog to Digital Converter
DSF	Domain Support Facility
CPER	Central Plains Experimental Range
Comm	Communication

LC	Location Controller
M	Meters
NA	Not Applicable
JSA	Job Safety Analysis
P/N	Product Number or Part Number
PoE	Power over Ethernet
PRT	Platinum Resistance Temperature
QLS	Quantum Line Sensor
RTD	Resistance Temperature Detector
SP	Soil Plot
TALL	Talladega National Forest
TEP	Terminal Emulator Program
V	Volts

2.4 Terminology

The use of common names for NEON instrumentation and subsystems varies across departments and domains. This section aims to clarify and associate the common names with the technical names herein. The aim of this section is to marry up terms under one name so Technicians are aware of the component referenced in the procedures herein, but also aware they may be called another term in a group discussion with headquarters or training staff.

SYNONYMOUS COMMON NAME(S)	NEON TECHNICAL REFERENCE NAME
Power Box, Comm Box, National Electrical Manufacturers Association (NEMA) Enclosure, Power/Comm Infrastructure, Combo Box, Arbor	**Device Post**

3 SAFETY AND TRAINING

Personnel working at a NEON site must be compliant with safe fieldwork practices in AD [01] and AD [02]. The Field Operations Manager and the Lead Field Technician have primary authority to stop work activities based on unsafe field conditions; however, all employees have the responsibility and right to stop work in unsafe conditions.

All technicians must complete safety training and procedure-specific training to ensure the safe implementation of this protocol per AD [03]. Refer to the site-specific EHSS plan via the NEON Safety document portal for electronic copies.

Preventive maintenance of TIS Soil Arrays may require the use of a special equipment to access the sensor subsystem assemblies. Follow Domain site-specific EHS plans and the NEON program's safety training procedures when conducting maintenance activities. Conduct a Job safety Analysis (JSA) prior to accessing the sensor subsystems onsite. Reference the My NEON Safety Office SharePoint site for JSA templates and additional hazard identification information.

In the event the current method to conduct the procedures herein are no longer safe for use due to unforeseen or unknown site dynamics, consult with the NEON Safety Office via the NEON Program's Issue Management and Reporting System (i.e., ServiceNow) for alternative methods to conduct TIS preventive/corrective maintenance and Sensor Refresh procedures.

4 SENSOR OVERVIEW

4.1 Description

Soil temperature influences the rate of many soil processes, as well as the occurrence and activity of soil organisms and plant roots, making it an important soil property to monitor. At most NEON terrestrial sites, the soil temperature profile consists of nine 4-wire platinum resistance temperature (PRT) sensors in a vertical profile within a soil plot (**Figure 1**).

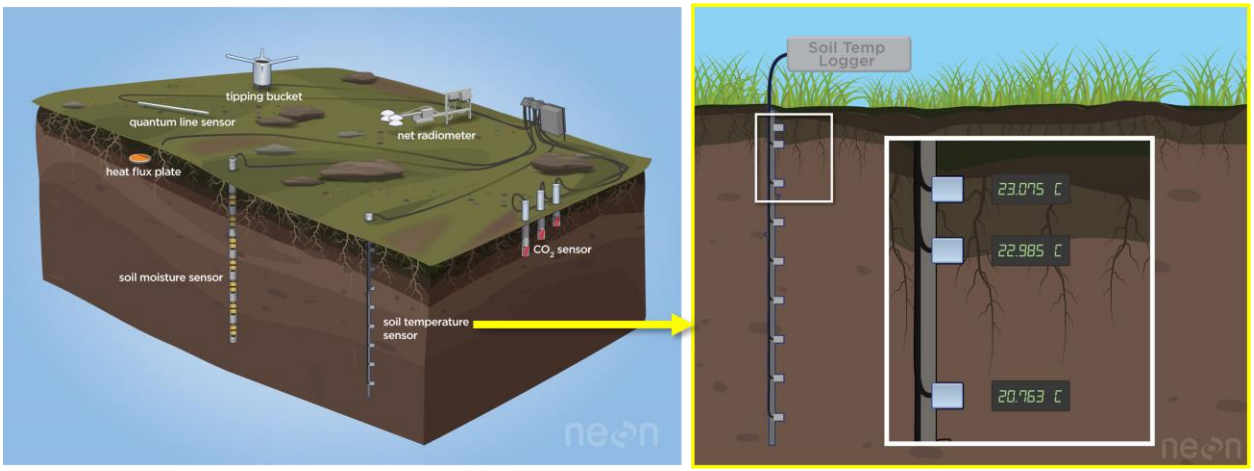

Figure 1. Soil Temperature 4-Wire PRT Sensors Vertical Profile in a Soil Plot.

The spacing between temperature measurements is smaller near the top of the profile, since this area is the most dynamic, and based partly on soil horizon thickness characterized at a nearby location with similar soils (AD [12]). The soil temperature profile extends to 2 meters (m) deep at most TIS sites, assuming soil depth is not comprising of bedrock or other tough sediment features, and to 3 m at most Alaskan sites to capture permafrost dynamics.

Two soil temperature profile installation designs exist at TIS sites. One design consists of the permanent installation of the sensor in an outer tube in a borehole. Approximately seven sites have this design in their TIS soil array. The second design consists of the sensors directly buried into the soil (into a borehole, which is filled with a slurry/soil; no outer tube). This installation design is more prevalent at our terrestrial sensor sites. **Figure 2** displays the two installation deigns for the sensor after removing the top cap.

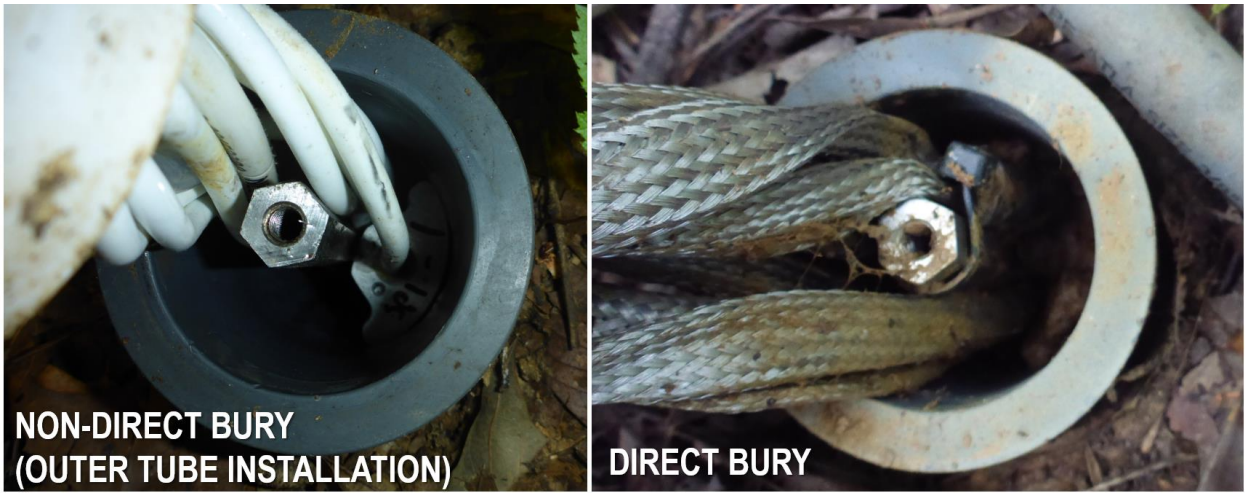

Figure 2. Non-Direct Bury (Outer Tube Installation) and Direct Bury Sensor Installations.

4.1.1 Soil Temperature Profile Outer Tube Assembly

The outer tube contains metal rings at each measurement depth that provide strong thermal conductivity between the soil outside the tube and the sensors within the tube (**Figure 3**).

Figure 3. Soil Temperature Profile Outer Tube Assembly.

The top of the assembly is shown on the left of **Figure 3** (top cap and conduit are not shown). PVC tubing with low thermal conductivity separates the metal rings to maintain independent measurement depths. The temperature sensors mount on a rod that inserts to and from the outer tube without disturbing the surrounding soil, which enables access to conduct maintenance activities. The temperature sensor sits in the outer tube against the inside of the metal rings to measure the temperature fluctuation in the surrounding soil.

4.1.2 Soil Temperature Profile Direct Bury Assembly

Installation of the sensor rod is directly buried in the soil (**Figure 4**)[i] and steel cable braids connect to the Grape box on the arbor via conduit. This design prevents issues found with the initial design and is present at most NEON TIS sites.

Figure 4. Soil Temperature Profile without Outer Tube.

4.2 Sensor Specific Handling Precautions

4.2.1 Instrument

Employ Electrostatic Discharge (ESD) protocols per AD [08] when handling PRTs for Sensor Refresh or while conducting maintenance activities.

4.2.2 Subsystem

Grapes contain ESD sensitive parts; therefore, all Grapes require ESD (antistatic) packaging and handling during inter- and intra-site transport, reception, and storage. As a rule, when handling (installing, removing, and servicing) these electrical components, all Technicians must ground themselves. Reference AD [08]. Conduct Lockout/Tagout (LOTO) procedures when handling power equipment over 50V to prevent the release of hazardous energy while performing service and maintenance activities.

4.3 Operation

NEON TIS soil temperature derives from a four-wire measurement PRT, which measures changes in resistance due to temperature. The four-wire design decreases dependence on cable length and increases the accuracy and reliability of the resistance measurement when comparing to a two- or three-wire measurement PRT.

Using a fixed current source, the four-wire measurement detects the voltage drop across the PRT using a high impedance input analog-to-digital converter (ADC). Both the current source and the ADC are in the Grape (**Figure 5**). The voltage drops across the PRT, in conjunction with known current source, to calculate the PRT resistance.

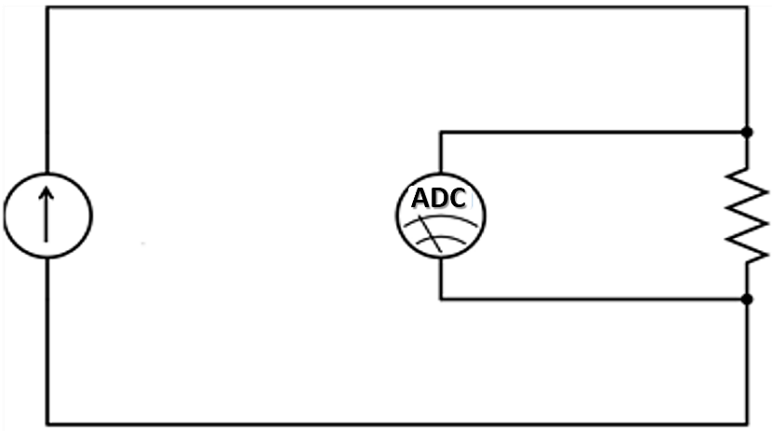

Figure 5. Four-wire Measurement for a PRT.

5 INSPECTION AND PREVENTIVE MAINTENANCE

5.1 Equipment

Table 1. Equipment needed for Preventative Maintenance.

Item No.	Description	Quantity
Tools		
NEON, IT	NEON Laptop	1
	Ethernet Cable	1
	Battery powered drill (for outer tube design only)	1
	Drill pump (for outer tube design only)	1
	Stopwatch or other timer (for outer tube design only)	1
	Bucket (≥20 liter, ~5 gallon, capacity) (for outer tube design only)	1
	Container with 100 ml marking (for outer tube design only)	1
	Short garden hose section with connector (~2-4' long) (for outer tube design only)	1
	#2 Philips head screwdriver	1
	Camera	1
	Compass	1
Resources		
	Terminal Emulator Program (TEP) (i.e., PuTTY, MobaXterm, other SSH/Telnet client)	

5.2 Subsystem Location and Access

All the sensors within the soil plots are making measurements of the environment immediately surrounding them. **Figure 6** provides an example of a soil plot in Domain 10 at the Central Plains Experimental Range (CPER) TIS site. (This site does not have a canopy and no longer uses a Throughfall Collector; however, this provides graphical overview of all soil plot sensors that reside at TIS sites.)

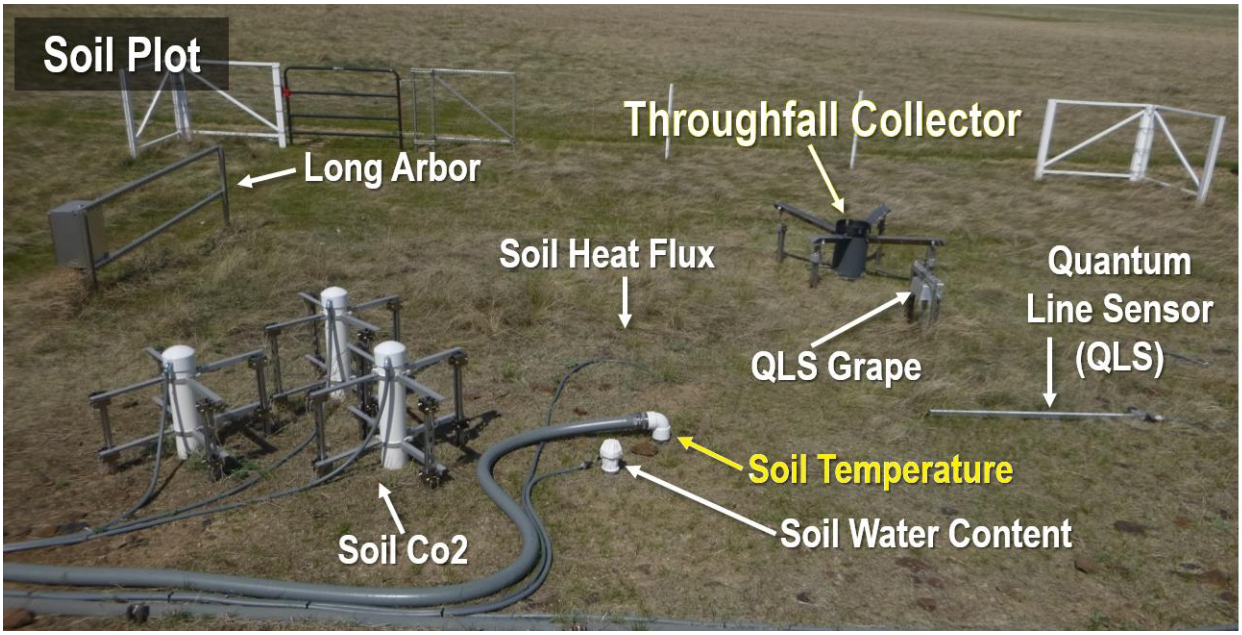

Figure 6. Soil Plot 1 (Domain 10, CPER) with Cattle Fencing (Not Shown: Device Post, Short Arbor, HMP, Apogee, and NR01).

It is important that Field Science does not disturb the soil plot and surrounding area while conducting maintenance activities. The NEON Program headquarters (HQ) recommends grouping sensor maintenance activities together to minimize influencing the surrounding area and reduce Field Science ecological footprint in each plot. Minimize the amount and frequency of trips in and out of each plot and surrounding area as much as possible.

Access to the soil plots shall follow the designated route that was established during site construction. Typically, this route starts at the staging area and follows a clearly marked path that passes the instrument hut before reaching the soil array path. The NEON Program only permits foot traffic between the soil array path and each soil plot (i.e., no wheeled carts or other machinery), with the exception of equipment to perform maintenance to meet the conditions specified in the Flora and Fauna plans in AD [05] and AD [06]. For example, a rototiller to mimic plowing at an arable site.

Important: Once Technicians reach the device post at the relevant soil plot, they must walk towards the soil plot following the route of the conduit from the device post to the soil plot arbor remaining at least 1m (~3.3') outside of the soil plot at all times (see **Figure 7**). Always travel the shortest route towards the assembly that remains at least 1m outside of the soil plot.

Remain at least 1m outside of the plot unless maintenance activities require close contact with a sensor. When approaching a soil plot, do not step or place tools on the ground within 30cm (~1') of any sensors within the soil plot to minimize disturbance to the soil and vegetation surrounding the sensor.

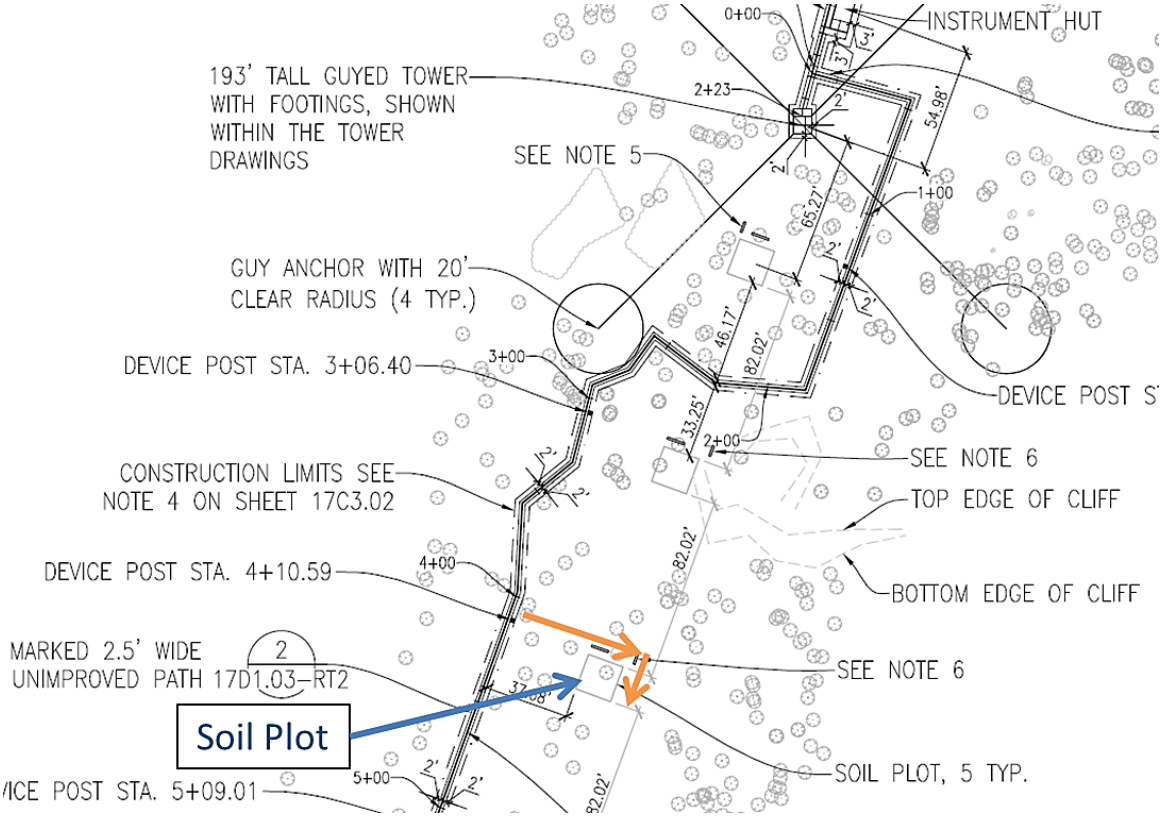

Figure 7. Walking Route Example (Orange Arrows) from the Soil Array Path to a Soil Plot (D17 SOAP Civil Construction).

A soil temperature profile resides in each soil plot at a TIS site (each TIS site contains five soil plots). **Figure 8** displays the visible portion of the soil temperature profile sensor in the soil plot. Reference AD [11] for more information on soil plot sensor locations.

Figure 8. Top of Soil Temperature Profile Assembly.

5.3 Maintenance Procedure

Table 2. Soil Temperature Profile Maintenance Intervals.

Maintenance		Bi-weekly	Quarterly	Bi-Annual	Annual	As Needed	Type
Soil Temperature Profile							
	Remote Monitoring	X				X	P
	Visual Inspection	X				X	P
	OUTER TUBE ASSEMBLY ONLY: Pump Water from Tube	X				X	P
NOTE: The biweekly and annual inspections should be carried out regardless of whether they coincide or not. P = Preventive, R = Repair, X = Indicates preventive maintenance task time interval may increase due to environmental (season/weather) or unforeseen/unanticipated site factors.							

5.3.1 Remote Monitoring

Verify TIS soil sensors are sending data to HQ via the SAS Report. For soil temperature profile data streams that are missing/red via SAS, conduct a real time verification of each missing/failed data stream to double check if the data streams are online, but failing to transmit data streams to HQ. Otherwise, look up to view if the subsystem components have power. Conduct this check using a Terminal Emulator Program (TEP), such as PuTTY or MobaXterm, to connect to each Concord Grape in the soil array. The data state of health presents indicators to focus preventive maintenance efforts; anomalies in the data or if the entire Soil Temperature Profile is off the network, it may dictate preventive maintenance tasks for investigation to determine if onsite corrective action is necessary. Use the Grape MAC address/Sensor EPROM ID with the command prompts in **Table 3**.

PRO TIP: *To perform these functions, Technicians must acquire the Grape MAC address and/or the EEPROM ID (from Maximo) of the sensor. Use this to verify function of Grapes and Sensors post-Sensor Refresh, too. Reference these from site sensor mapping documents and update these documents accordingly to have relevant information on hand.*

PuTTY Login Username: **user** | Password: **resuresu**

Table 3. View Grape and Sensor Data Streams (MAC and EPROM ID are Examples for this Command).

Remote Monitoring Commands	Description
`vd | grep [MAC address]`	This displays the data from the grape with the MAC Address entered (e.g., using "7CE0440015FD"). Enter either in decimal or hexadecimal format. Use "**grep –i**" to ignore case.
`vd –s [sensor eeprom id]`	To view data from a sensor. For example, "root@D23-HQTW-LC1:~# vd -s 3171982"
`vd –s [sensor eeprom id] –r [stream number]`	To view data from a sensor and specific data stream.

Verify the PRT data streams in Data Monitor/TEP are reasonable, and sampling at 0.1 Hz. Topmost PRT data (#1) is close to ambient, with deeper PRT data warmer or cooler depending on time of day / year. Calculation of sample rate:

Sample rate (Hz) = 1/(Time1-Time0)

Reference AD [10] for more information on the verification procedure for this sensor.

5.3.2 Visual Inspection

Conduct a bi-weekly visual inspection on the Soil Temperature assembly and subsystem. Conduct following maintenance inspections.

Note: Do not stand or place tools on the ground closer than 30 cm (~1 foot) from the edge of the sensor location or any other sensor within the soil plot. Stand outside of the soil plot and observe the location of the Soil Temperature assembly unless you need to get closer to perform this task.

1. If there is no snow or standing water around the sensor check for noticeable soil erosion, deposition, and burrowing around the assembly location and within 30 cm radius of the sensor location. Also check for any gaps between the edge of the assembly tube and the wall of the borehole (the assembly tube should be flush with the surrounding soil).

*Note: If snow or standing water is present, **DO NOT** perform this check.*

    a. If soil disturbance is noticeable or if a gap between the assembly and the borehole is present, submit a ticket in the NEON Program Issue Reporting/Management System for science evaluation to determine corrective actions, if necessary. Photograph the erosion for the trouble ticket to enable a quicker evaluation response.

2. If no snow or standing water is present around the assembly, ensure there are no cables or other infrastructure within 30 cm of the assembly. Exclude the cable that connects to the assembly.

    a. If there are no cables within 30 cm of the assembly, do nothing.

    b. If there is a cable within 30 cm of the assembly, if possible, move the cable so that it is at least 30 cm from the assembly, and submit a ticket in the NEON Program Issue Reporting/Management System including a description and photo showing distance of the cable from the assembly.

3. Check that the direction of the conduit that exits the assembly to ensure it is on the north side of the assembly, where north side is defined as clockwise from 315°-45° (0° is true north) to prevent shading where the sensor sits underground. (If using a magnetic compass, remember to account for magnetic declination at the site.)

a. If not, submit a ticket including the angle that the conduit leaves the assembly and photo.

5.3.3 OUTER TUBE ASSEMBLY ONLY: Water Removal Procedure

This procedure applies to soil plots with soil temperature sensors in an outer tube design. It does not apply to direct bury soil temperature sensors. **Do not perform this test if the air temperature is below 1°C, as the water may freeze in the drainage tube and cause damages.** Check for water in the soil temperature assembly by running the pump every 14 days (±2 days). Conduct this procedure at the soil array arbor where the soil temperature sensor Grape box resides, not by the sensor in the plot.

1. Remove the cap from the drainage tube located on the bottom of the enclosure that the soil temperature conduit connects to on the arbor. Reference **Figure 9**.

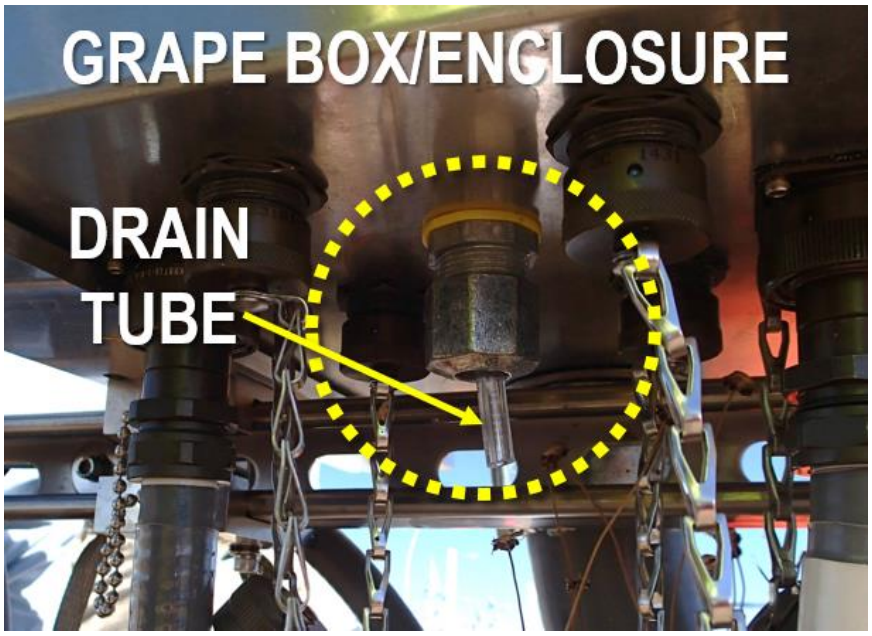

Figure 9. Drainage tube located on bottom of box on arbor (drainage tube cap not shown).

PRO TIP: *If the drainage tube is not present at the bottom of the arbor box, it may have slipped back inside the box. If so, remove the lid of the arbor box by loosening the screws using a Philips head screwdriver. The drainage tube should be visible among the bundle of white wires coming from the soil temperature assembly between the two Concord Grapes.*

2. Attach the "**IN**" part of the drill pump to the drainage tube. Reference **Figure 10**. This ensures that the flow of water from the sensor assembly to the open end of the tube is consistent with the design of the pump.

Figure 10. Drill pump with the direction of water flow indicated by "IN" and "OUT".

3. Attach the short section of garden hose to the "**OUT**" end of the drill pump and place the other end of the hose in the bucket. Reference **Figure 11**.

Figure 11. Close-up and expanded view of drill pump connection to sensor drainage tube and garden hose.

   a. Before attaching the drill to the drill pump, set the drill rotation direction to match the direction marked on the drill pump. Reference **Figure 12**.

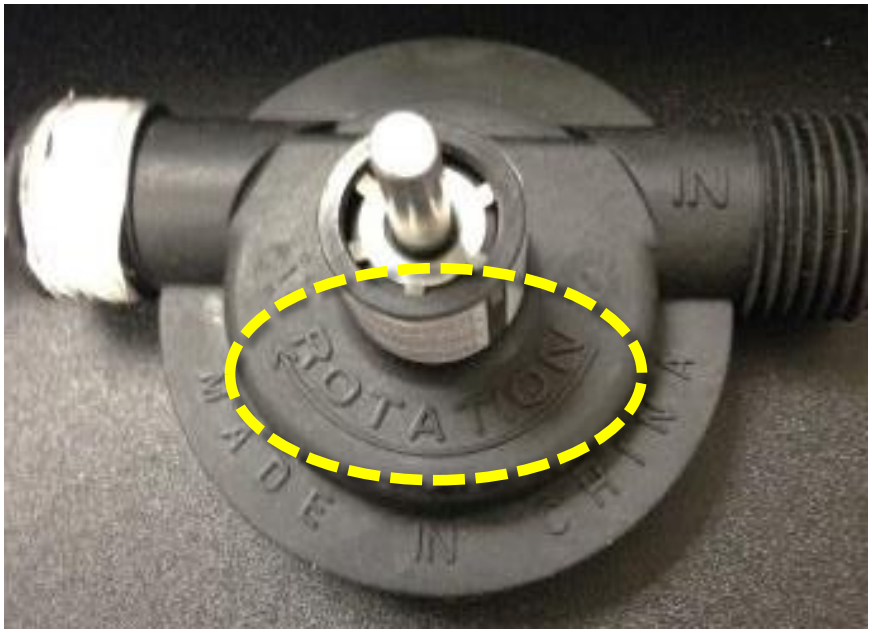

Figure 12. Set the drill rotation to match the rotation indicated on the drill pump.

4. Attach the drill to the drill pump (**Figure 13**).

Figure 13. Drill attached to drill pump.

5. Operate the drill for at least one (1) minute to determine if water is present in the outer tube.

    a. If no water results from one minute of pumping, then the outer tube does not require additional water removal. No further action is necessary.

    b. If water results from pumping, continue to run the pump until water ceases to pour from the hose.

6. IF WATER IS PRESENT: Document and submit a ticket stating the following information for TIS data quality monitoring:

    - Sensor Assembly
    - Soil Plot Number
    - Quantity of water was less than or greater than 100 ml

Note: Reference site-specific As-Built documentation to verify soil sensor assemblies and soil plot numbers at your site via the NEON Document Warehouse.

7. Once pumping is complete, disconnect the drill and pump, and re-cap the tube.

8. Dispose any collected water. Dispose quantities <100 ml on the soil array access route. Dispose quantities >100ml at the TIS staging area.

9. Clean the equipment after conducting this procedure on all soil temperature profile assemblies within a site.

6 REMOVAL AND REPLACEMENT (SUBSYSTEM ONLY)

The soil temperature profile does not require removal or replacement for preventive maintenance. This applies to both installation designs. The sensor subsystem, the Concord Grape(s), require removal and replacement for annual calibration and validation requirements (Sensor Refresh).

6.1 Equipment

Table 4. Removal and Replacement Equipment List.

Item No.	Description	Quantity
Tools		
GENERIC	#2 Philips head screwdriver (to open Grape box on Arbor)	1
GENERIC	Hex Wrench Set	1
MX103120	3M Antistatic Wristband (ESD Requirement)	1
GENERIC	Wood plank, rubber mat, or similar (~60 x 40 cm) for standing on in soil plot	1
GENERIC	Landscaping/mechanics gloves for traction removing cap/handling objects	1 Pair
Consumable Items		
See below	ESD Packaging for Grape(s)	5
MX105865	3M Bag, ESD Shielded, 8 inch x 11 inch, Cushioned	A/R
MX105931	3M Bag, ESD, Static Shield, 6 x 8 Inches, Zip Closure, Non-Cushioned	A/R
MX105864	3M Bag, ESD Shield, 6 Inch X 7 Inch, Cushioned	A/R
MX105866	3M Bag, ESD Shielded, 14 Inch X 15 Inch Cushioned	A/R
MX105935	3M Bag, ESD, Static, 15 x 18 Inches, Zip-Closure Top	A/R
MX104219	Grainger Red Inspection Tag, Paper, Rejected, PK1000	A/R
CB08180000	Plastic Grape Dust Caps Kit	2-6

Note: When working on power systems, use tools with insulated handles. Always shut down the power prior to removing or replacing any components. Do not hot-swap (removing sensors while Grape is powered) any component or sensor connections.

6.2 Removal and Replacement Procedure

The Field Operations Domain Manager is responsible for managing the removal and replacement of the sensors onsite for preventive maintenance and/or sensor swaps and manages field calibration and validation of sensors, as appropriate. The NEON Program Calibration, Validation and Audit Laboratory (CVAL) is responsible for the calibration and validation of select sensors and manages Domain sensor refresh (swap) schedules.

To minimize data downtime and optimize the availability of sound data, coordinate instrumentation and subsystem annual calibration, validation, and preventive maintenance requirements to occur within the same timeframe. See **Table 5** for sensor refresh requirements for the subsystem infrastructure on the Soil Temperature Profile sensor.

Table 5. TIS Soil Temperature Profile Sensor Refresh Requirements.

	LOCATION		TIMEFRAME			
	CVAL	*FIELD*	*BIWEEKLY*	*ANNUAL*	*NA*	COMMENTS
OUTER TUBE: Soil Temperature Profile Sensor					X	No sensor refresh requirements for this sensor at this time.
DIRECT BURY: Soil Temperature Profile Sensor					X	No sensor refresh requirements for this sensor at this time.
Concord (24V) Grape	X			X		Follow ESD protocol.

Note: Always shutdown the power prior to removing or replacing any components. Remove the Ethernet Cable from the Grape to power down the Soil Heat Flux sensor and Grape.

As a reminder, please maintain ESD (antistatic) packaging and handling during inter- and intra-site transport, reception, and storage of Grapes.

6.2.1 Grape Removal/Replacement Procedure

1. Record EPROM ID, "Property of" Asset Tag number, Removal/Replacement date and time. The following template is an example for capturing Sensor Refresh information to update logistic records and monitor the Grape state of health via the Location Controller (LC) pre- and post-swap.

AIS / TIS (Circle One) | Site Name: _____
Merlot / Concord / Catawba (Circle One) Grape | Location: S - ___ / ML - ___ / Other _____

	Old Grape	New Grape
EPROM ID/ MAC Address		
14-digit Asset Tag (Property of)		
Uninstall / Install Date and Time		
Moved in Maximo?		

2. Employ ESD protocols when handling Grapes. Reference AD [08].

3. Power down the site at the Soil Plot Device Post. *Reference Appendix A – How To Power Down A Soil Plot (SP) Power Box.*

4. Open the enclosure (**Figure 14**) housing the two Concord 24V Grapes for the soil temperature Sensors (white cables) and the Soil CO_2 concentration sensor (black cables) using a Philips head screwdriver (**Figure 14**). This box may reside on the short or long arbor (location is site-specific).

Figure 14. Grape Box/Enclosure on Arbor for Soil Temp & CO_2 Sensors (D06 KONZ).

5. Disconnect the white Ethernet cable from the RJF/Eth to Comm connection. Reference AD [04] and/or **Figure 15**.

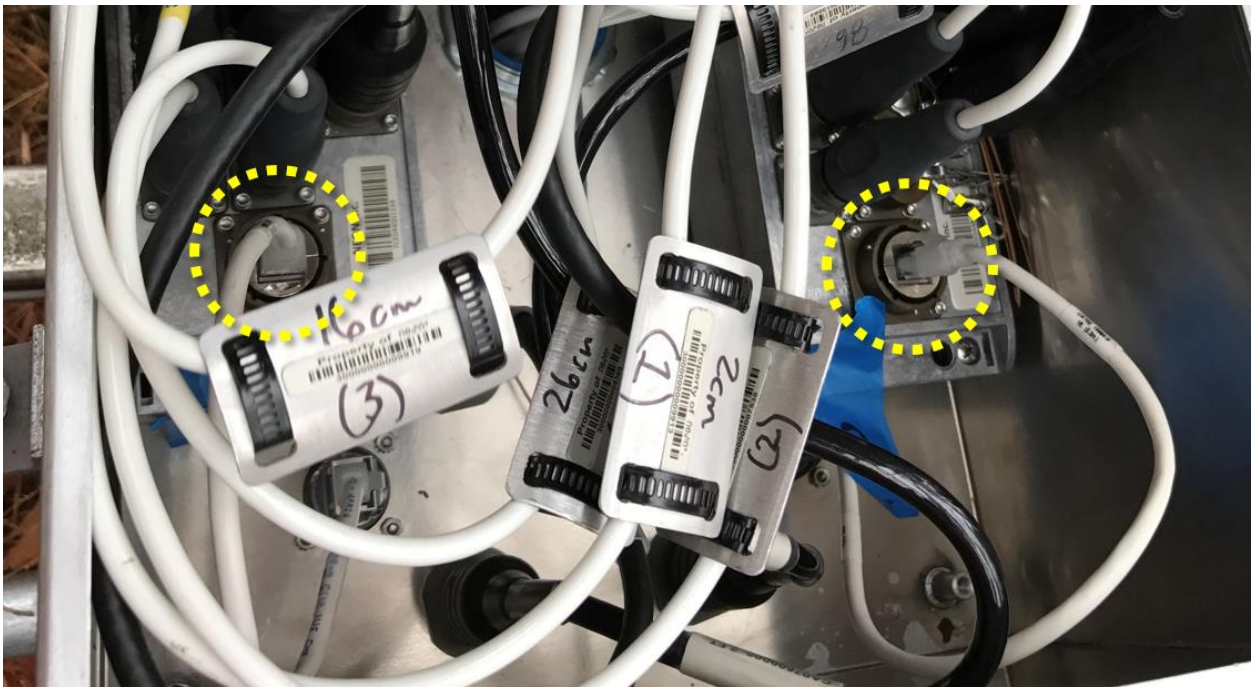

Figure 15. Disconnect the RJF/Eth to Comm Connection.

6. Disconnect sensor connection(s).
7. Disconnect grounding and remove Concord Grape(s) from enclosure on Arbor.
8. Place dust caps on the Amphenol connectors of the old Grape and remove caps from the new Grape (s).
9. Reinstall new Grape(s) into the enclosure on the SP Arbor and reground Grape(s) to box.

10. Re-connect sensor and armored Ethernet cable connections in accordance with AD [04].

11. Re-energize the site and verify Grape and Soil Temperature Profile sensor function. Connect locally to the Soil Plot Arbor Comm Box DIN Rail PoE Switch or Instrument Hut LC or from the Domain using a TEP (e.g., PuTTY) and **Table 5**.

6.3 Cleaning & Packaging of Returned Sensor

Field Operations staff clean, package, and ship the sensors back to the CVAL at the NEON Program HQ (Battelle) for annual sensor swap/calibration requirements. (Please note: if a sensor is defective, submit a trouble ticket and affix a red tag (**Figure 16**) with the trouble ticket number on it.) Clean the Grape (also known as decontamination; *Reference* RD [03]*)* by removing all biologics from the device prior to capping the connections and placing in ESD packaging.

Please remove all arachnids and/or insects from tower instruments prior to packing and shipping. Reference RD [03].

For the cleaning and packaging of the Concord Grape(s) post-removal, conduct the following steps:

1. Check mounting holes for spiders and spider webs.

2. Remove biologics and clean connectors.

3. Cap all connectors on Grapes and Cables.

4. Conduct decontamination on the Grape(s) per RD [03].

5. Pack 24V Concord Grape in an ESD bag/packaging.

6. Update asset records via the NEON's project Asset Management and Logistic Tracking System (e.g., All devices in transit to HQ shall be moved to TRANSIT in Maximo). NEON HQ, Logistics Warehouse (LOGWAR) receives the Grapes for refresh and distributes to CVAL.

Note: In general, to minimize errors for CI, all devices leaving a CFGLOC must move to SITE first, then DxxSUPPORT, and finally TRANSIT.

7. Provide an electronic packing list to CVAL with the Box number and Asset Tag number (14-digit Property Tag ID ("Property of") number) of each item. CVAL uses this information to verify items via LOGWAR/general HQ distribution of shipments.

8. Prepare a Bill of Lading.

For any Non-CVAL initiated sensor returns, please notify CVAL of the return.

6.4 Sensor Refresh Record Management of Assets

In addition to the physical movement of devices, the sensor refresh process requires dedicated and accurate record management of asset movement and location.

6.4.1 NEON Asset Management and Logistic Tracking System Requirements

Technicians must update the instrumentation records via the NEON's project Asset Management and Logistic Tracking System (MAXIMO). NEON HQ must maintain accurate record keeping on the location, date, and time offline of an instrument to ensure NEON HQ, Computer Infrastructure, Data Products, and CVAL are aware to apply the correct algorithms, calibrations, and processing factors. Ensure the CFG location reflects the current site of the sensor. All devices leaving a CFGLOC must move to SITE first, then DxxSUPPORT, and finally to TRANSIT.

7 ISSUE REPORTING OUTPUTS

Field Science must report issues encountered while conducting preventive maintenance in the NEON Program Issue Management/Reporting System. To ensure a quick response and remedy to an issue, please include as much information and detail, as possible. This includes, but is not limited, to the following:

- Domain and Site name
- Date and Time
- Technician Full Name
- Issue Narrative (detailed narrative of the issue, specific location of issue on tower infrastructure, relevant 2nd/3rd order effects to infrastructure, possible cause [e.g., weather event, obstruction, human activity])
- Multiple Photographs (to capture vantage points/perspectives for remote diagnostic)
- Provide Part Number/Manufacturer Information, EPROM ID, Asset Tags, IP/MAC Address, etc.
- Provide Diagnostic Information (from firmware, if applicable), such as error codes, values, etc. Provide screenshots.

Table 6. Soil Temperature Profile Metadata Output Checklist.

Issue Reporting Datasheet		
Datasheet field	**Entry**	
NEON Site Code		
Maintenance Date		
Maintenance Technician		
Preventive Maintenance	**Issue Noted**	**Issue Summary**
Sensor – Remote Monitoring Data Check	☐	
Sensor with Outer Tube – Water in Tube?	☐	
Cables & Connectors - Condition Check	☐	
Sensor - Other Specific Checks	☐	
Environmental Information	☐	
Notes		

Ship all defective equipment/assets with a red “Rejected” tag. **Figure 16** displays the minimum information requirements for each tag.

Figure 16. Red Rejected Tag for Defective Assets.

8 APPENDIX A – HOW TO POWER DOWN A SOIL PLOT (SP) POWER BOX

Powering down the soil plot enables Technicians to perform work while minimizing hazards to themselves and to the equipment. It also mitigates requiring NEON Headquarters to conduct data quality analysis when Technicians are onsite close enough to the sensors to influence data collection.

1. Power down the plot from the Soil Plot Device Post Power Box.

    a. Open the Power Box using a Philips head screwdriver (**Figure 17**).

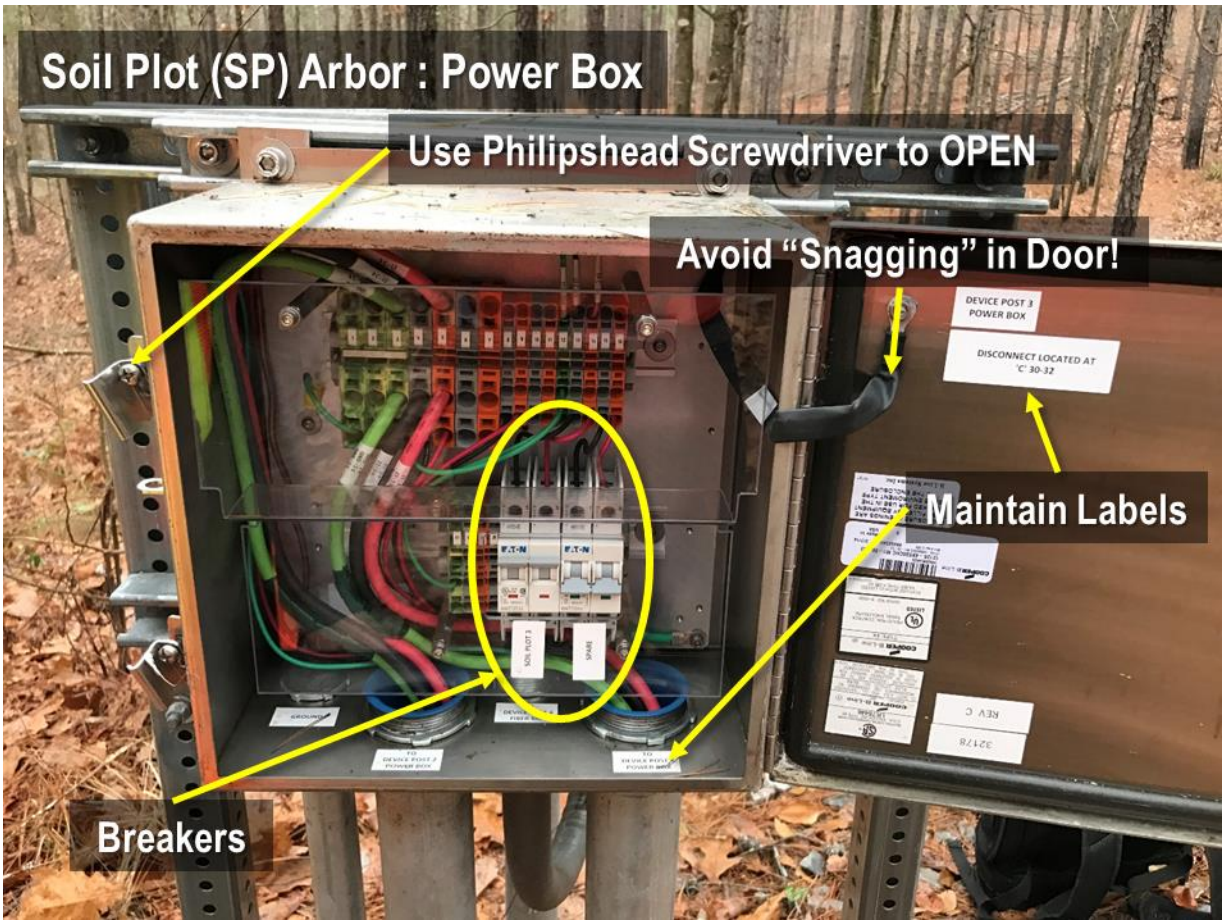

Figure 17. Open Soil Plot Device Post Power Box (D08 TALL).

    b. Flip both breakers from RED to GREEN to de-energize the sensors (**Figure 18** on the next page).

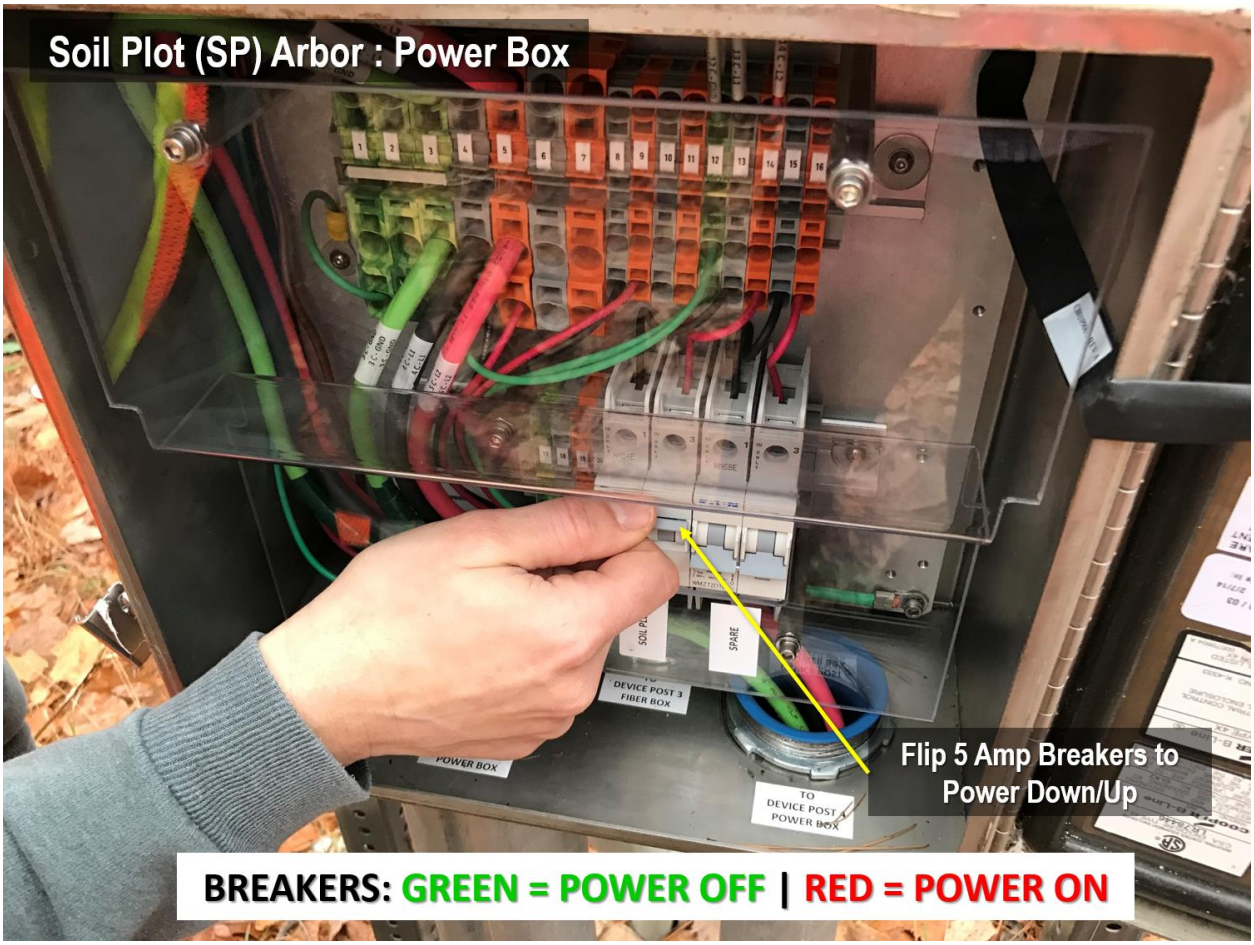

Figure 18. Flip 5Amp Breakers (D08 TALL).

c. Conduct LOTO procedures and proceed with the Preventive Maintenance, Sensor Refresh and/or Corrective Maintenance.

If there is a need to remove a single sensor assembly onsite, then power down the sensor assembly from its Grape. Remove the Ethernet cable from the Concord Grape RJF/Eth-To-Comm connector before disconnecting or connecting sensor connections.

[i] After implementation of the initial design at several sites, NEON HQ discovered the outer tube was consistently leaking, causing issues with the sensor's functional capabilities. To mitigate these issues, a retrofit kit with shrink-wrap was prescribed to the Domains containing these sensors. In addition, to prevent this issue, the design for the sensor installation was adjusted to remove the outer tube.