NEON PREVENTIVE MAINTENANCE PROCEDURE: AIS GROUNDWATER WELLS

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	02/20/2018	ECO-05377	Initial release.
B	10/18/2018	ECO-05794	Added D18/19 well measurement instructions. Removed JIRA References and modified GWW Shutdown Procedure to inform FOPS not to disconnect Ports 9 and 10 remotely. These ports are fiber ports and require FOPS to travel onsite to reconnect them.
C	01/03/2019	ECO-05953	Added procedure in Section 5.3.3.4 to secure mesh wire basket to sensor in the event it is not retightened/becomes loose during maintenance activities. Added procedure in Section 9.5 on how to adjust solar panels and added the use of a dry non-stick lubricant to prevent ice accumulation on panels.

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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 a mandatory procedures and recommended practices for preventive maintenance of **AIS Groundwater Wells (GWW)** to meet the objectives of the NEON project, 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 GWW infrastructure and Aqua TROLL 200 (***HB08410000*** *Subsystem, Water Level/ Conductivity/ Temperature, Groundwater Well*) at Aquatic Instrument System (AIS) sites. This includes preventive maintenance procedures and requirements for the instrument, subsystem and supporting infrastructures.

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 Manual
AD [02]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD [03]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD [04]	NEON.DOC.004257	All Systems Standard Operating Procedure: Decontamination of Sensors, Field Equipment, and Field Vehicles
AD [05]	NEON.DOC.001972	AIS Comm Interconnect Map
AD [06]	NEON.DOC.000620	AIS Verification Checklist
AD [07]	NEON.DOC.004569	How-To: Configure AIS Ground Water Well (GWW) Radios
AD [08]	NEON.DOC.001173	NEON Sensor Command, Control and Configuration – Aqua TROLL
AD [09]	NEON.DOC.001601	Schematic, Ground Water Well
AD [10]	NEON.DOC.002495	Schematic, Aquatic Radio Interconnect Board
AD [11]	NEON.DOC.002905	AOS Protocol and Procedure: Water Chemistry Sampling in Surface Waters and Groundwater
AD [12]	NEON.DOC.005038	NEON Standard Operating Procedure (SOP): Sensor Refresh

2.2 Reference Documents

The reference documents (RD) listed below may provide complimentary information to support this procedure. Visit the NEON Document Warehouse for electronic copies of these documents.

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms
RD [03]	NEON.DOC.004638	AIS Verification Checklist
RD [05]	NEON.DOC.000769	Electrostatic Discharge Prevention Procedure
RD [06]	NEON.DOC.001637	Aquatic Met Station Installation Procedure
RD [07]	NEON.DOC.004821	NEON Preventive Maintenance Procedure: Aquatic Meteorological (Met) Station
RD [08]	NEON.DOC.004470	DAS GROUNDWATER WELL FORMAL VERIFICATION PROCEDURES
RD [09]	NEON.DOC.004471	WATER LEVEL/ CONDUCTIVITY/ TEMPERATURE, GROUNDWATER WELL FORMAL VERIFICATION PROCEDURES
RD [10]	NEON.DOC.001328	NEON Algorithm Theoretical Basis Document: Groundwater Level, Temperature, and Specific Conductivity
RD [11]	NEON.DOC.000562	STCDD - 031773000 Assembly, Sensor Aqua TROLL 200
RD [12]	NEON.DOC.004651	Domain 18 (D18) AIS Oksrukuyik Creek (OKSR) Alternate Power Site Standard Operating Procedure (SOP)
RD [13]	NEON.DOC.004822	Domain 14 (D14) AIS Sycamore Creek (SYCA) Alternate Power Site Standard Operating Procedure (SOP)

RD [14]	NEON.DOC.002767	AIS Subsystem Architecture, Site Configuration and Subsystem Demand by Site – SCMB Baseline
RD [15]	NEON.DOC.003880	NEON Preventive Maintenance Procedure: AIS Stream Infrastructure
RD [16]	NEON.DOC.004361	NEON Preventive Maintenance Procedure: AIS Surface Water Level
RD [17]	NEON.DOC.002190	Aqua TROLL 200 Installation Plan
RD [18]	NEON.DOC.004886	NEON Preventive Maintenance Procedure: Aquatic Portal & AIS Device Posts

2.3 External References

The external references (ER) listed below may contain supplementary information relevant to maintaining specific commercial products for the GWW sensor and subsystem. These documents are external to the NEON project and Battelle Ecology, Inc. (BEI).

ER [01]	In-Situ, Inc. Aqua TROLL-100-200 Operator's Manual, 0061340. August 2016. *https://in-situ.com/wp-content/uploads/2014/11/Aqua-TROLL-100-200_Manual.pdf*
ER [02]	In-Situ, Inc. Aqua TROLL CTD Data Loggers Spec Sheet. November 2017. *https://in-situ.com/wp-content/uploads/2014/11/SS_AquaTROLL_100_200_Nov2017.pdf*
ER [03]	In-Situ, Inc. Water Level Instruments Brochure. October 2016. *https://in-situ.com/wp-content/uploads/2016/02/In-Situ_Water_Level_Brochure.pdf*
ER [04]	In-Situ, Inc. Win-Situ 5 Software. *https://in-situ.com/support/documents/win-situ-5-software/*
ER [05]	In-Situ, Inc. YouTube Channel, Win-Situ5 Software Training Instructions. *https://www.youtube.com/watch?v=umfmSOWohf4*
ER [06]	Field Environmental Inc. How to Use the QWD: Six Easy Steps. *http://www.fieldenvironmental.com/assets/files/Manuals/QWater%20Developer%20User%27s%20Guide.pdf*
ER [07]	Qwater Well Developer. How To Use: Environmental Series. *https://www.welldeveloper.com/how-to-use*
ER [08]	W.A. Hammond Drierite Co., LTD, Drierite, Indicating Safety Data Sheet (SDS), *https://in-situ.com/wp-content/uploads/2014/11/blue_silica_gel_sds.pdf*
ER [09]	In-Situ, Inc. Care and Maintenance of Aqua TROLL® and Level TROLL® Instruction Sheet. *https://in-situ.com/wp-content/uploads/2014/11/Aqua_Level_TROLL_Maintenance_Guide.pdf*
ER [10]	In-Situ, Inc. TROLL O-Ring Replacement Kit Instructions. *https://in-situ.com/wp-content/uploads/2014/11/TROLL-O-ring-Replacement-Kit_Instruction.pdf*
ER [11]	In-Situ, Inc. TROLL® Shield Nose Cone Information Sheet. *https://in-situ.com/wp-content/uploads/2014/11/Antifouling-TROLL-Shield-Nose_Instruction.pdf*
ER [12]	In-Situ, Inc. Antifouling System Extends Instrument Deployment by Up to Six Weeks. *https://in-situ.com/wp-content/uploads/2015/01/Antifouling-System-for-the-Aqua-TROLL-200-Instrument-Extends-Instrument-Deployment-by-Up-to-Six-Weeks.pdf*
ER [13]	In-Situ, Inc. USB TROLL COM Cable Connect Instructions. *http://www.fondriest.com/pdf/in-situ_0052500_manual.pdf*

2.4 Acronyms

A/R	As Required
AK	Alaska

AOS	Aquatic Observation Systems
ARIK	Arikaree Creek (Domain 10)
Comm	Communication
CVAL	Calibration Validation and Audit Laboratory
DAS	Data Acquisition System
DECON	Decontaminate
DSF	Domain Support Facility
DC	Direct Current
GWC	Ground Water Chemistry
GWW	Groundwater Wells
LiFePO4	Lithium Iron Phosphate
Met or MET	Meteorological
OKSR	Oksrukuyik Creek (Domain 18)
P/N	Product Number or Part Number
PDS	Power Distribution System
PoE	Power over Ethernet
PPE	Personal Protection Equipment
PRLA	Prairie Lake, Domain 09
QWD	Q-water Well Developer
S-2	Sensor Set 2 (Downstream Sensor Set)
TEP	Terminal Emulator Program
TOS	Terrestrial Observation Systems
V	Volt

2.5 Terminology

The use of common names for NEON instrumentation and subsystems vary 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
GWW, Troll, pressure transducer *Note: AIS Stream Sites use the Level Troll*	**Aqua Troll**
Desiccant container, Desiccator	**Desiccant Canister**
Power Box, Comm Box, National Electrical Manufacturers Association (NEMA) Enclosure, Power/Comm Infrastructure	**AIS Device Post**
Power Box and Comm Box, NEMA Enclosure	**Combination (Combo) Box**
Aquatics Instrument System (AIS) power distribution system (PDS) and data acquisition system (DAS), Portal *Note: Equivalent to the Instrument Hut for Terrestrial Instrument System (TIS) sites*	**Aquatic Portal**

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 AIS GWW Infrastructure may require the use of a special equipment to access the sensor subsystem assemblies. Follow Domain site-specific EHS plans via the Network Drive and NEON safety training procedures when conducting maintenance activities. Conduct a Job safety Analysis (JSA) prior to accessing the sensor subsystems onsite. Reference the Safety Office SharePoint portal 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 Project's Issue Management and Reporting System (i.e., ServiceNow) for alternative methods to conduct AIS preventive/corrective maintenance and Sensor Refresh procedures.

⚠ **WARNING!** The blue silica gel indicating desiccant (drying agent) from In-Situ, Inc. is effective for the sensor, but poses health hazards as a skin, eye or inhalation irritant (ER [08]). **DO NOT RECHARGE THIS INDICATING DESICCANT IN THE DOMAIN OFFICE.** The TOS Oven does not vent outside, it vents into the Domain Office. Review alternative desiccant ingredients to verify they are OK to recharge inside the Domain Support Facility.

4 GROUNDWATER WELL OVERVIEW

4.1 Description

Groundwater Wells (GWWs) are the NEON project's AIS and AOS conduit to sample feedbacks between groundwater and surface water. AIS GWW measurements capture high-resolution temporal changes, as well as water quality characteristics on a seasonal basis. AIS sites have between three and eight GWWs that calculate the magnitude and direction of groundwater flow from the sensor measurements (Figure 1). Site GWW numbers depend on the ability to dig viable sampling wells, based on individual sites superficial geology and hydrology.

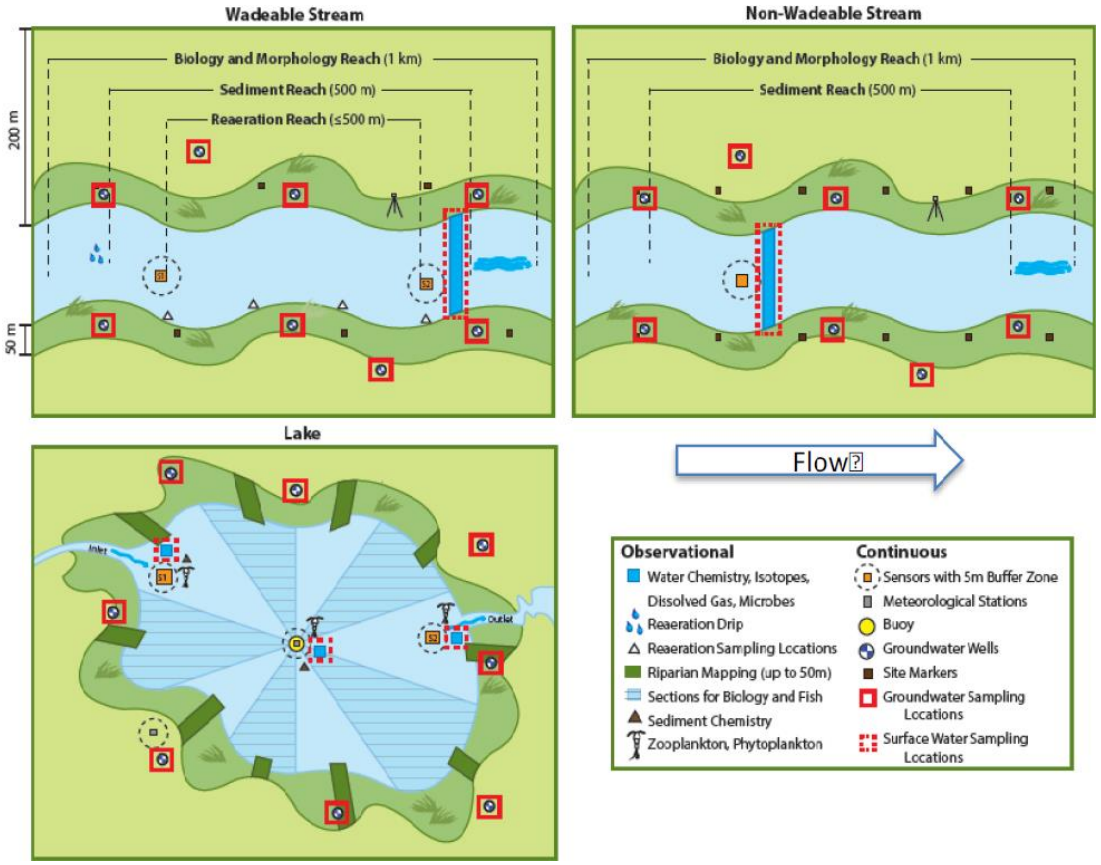

Figure 1. NEON GWW Sampling Scheme

GWW depths vary (from a few feet to over 60 feet), dependent on the superficial geology and depth of the unconfined aquifer. Boreholes are generally 2" in diameter. Each NEON GWW is fitted with a sensor and well infrastructure designed to protect the well seal, and power and house the sensor.

Note: Refer to site-specific As-Built documentation in the NEON SharePoint Document Warehouse to verify site-specific AIS GWW Infrastructure Sensor subsystems.

An individual GWW sensor and subsystem consists of four parts – In-Situ Aqua TROLL 200 instrumentation (Figure 2), well

Figure 2. In-Situ, Inc. Aqua TROLL 200

mechanical infrastructure, PDS (standalone Direct Current (DC) solar power system), and DAS (GWW radios) or Grapes for sites with access to direct power. The Aqua TROLL 200 measures and records pressure, conductivity, and temperature.[i] Sensor accessories include a copper anti-fouling guard (***0317730001*** *Sensor Accessory, In-Situ TROLL Shield Antifouling Guard for Aqua TROLL 200 Sensor*), desiccant canister (***0320150002*** *Desiccant canister - size Large, refillable, titanium twistlock connector…*), and a cap well cap installation kit (***HB06610000*** *Kit, Aqua Troll Well Cap Installation*).

The DAS subsystems (HB14000000 and HB14200000) enable the AIS GWWs to communicate with the NEON network. The communications path starts with the Aqua TROLL 200, which connects to a remote/slave radio at the well. The GWW remote/slave radio transmits to a master/base radio. The GWW master/base radio connects to a Merlot (12V) Grape on the Aquatic Met Station Device Post. The Grape connects to the Aquatic Met Station Comm box, which transmits data to the LC in the Aquatics Portal. Some AIS sites may have GWW DAS infrastructure on a different device post near Aquatic instrumentation (e.g., the GWW DAS is at the S-2 AIS Device Post for D18 OKSR).

The PDS subsystem (***HB13500000***) is a standalone DC power system using a solar panel and Lithium Iron Phosphate (LiFePO4) battery. The following components power are present in each GWW radio box:

- 0332040000 Genasun, Solar Charge Controller, Model# GV-5-Li-14.2, 12.8V LiPO4, 65W
- 0332050000 Battery, LiFePO4, 12.8V 25AH
- 0343770000 Radio Modem, 900 MHz, RS485

Figure 3. GWW DAS Components on Aquatic Met Station Device Post

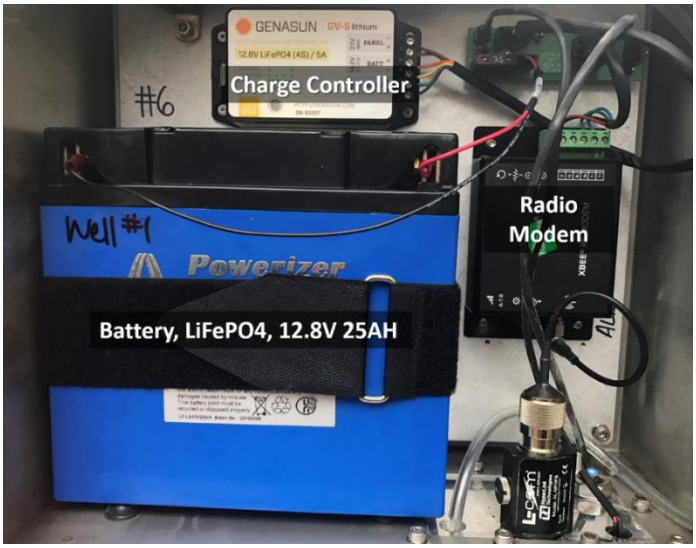

Figure 4. Power/Telemetry Components in GWW NEMA Enclosure

- 0342640000 L-COM Model# HG906U-PRO, Antenna, Omnidirectional, 900 MHz, 6dBi, N-female

These components in the power box mount on a ground arbor consisting primarily of Unistrut components. Figure 5 is a summary of AIS GWW infrastructure components.

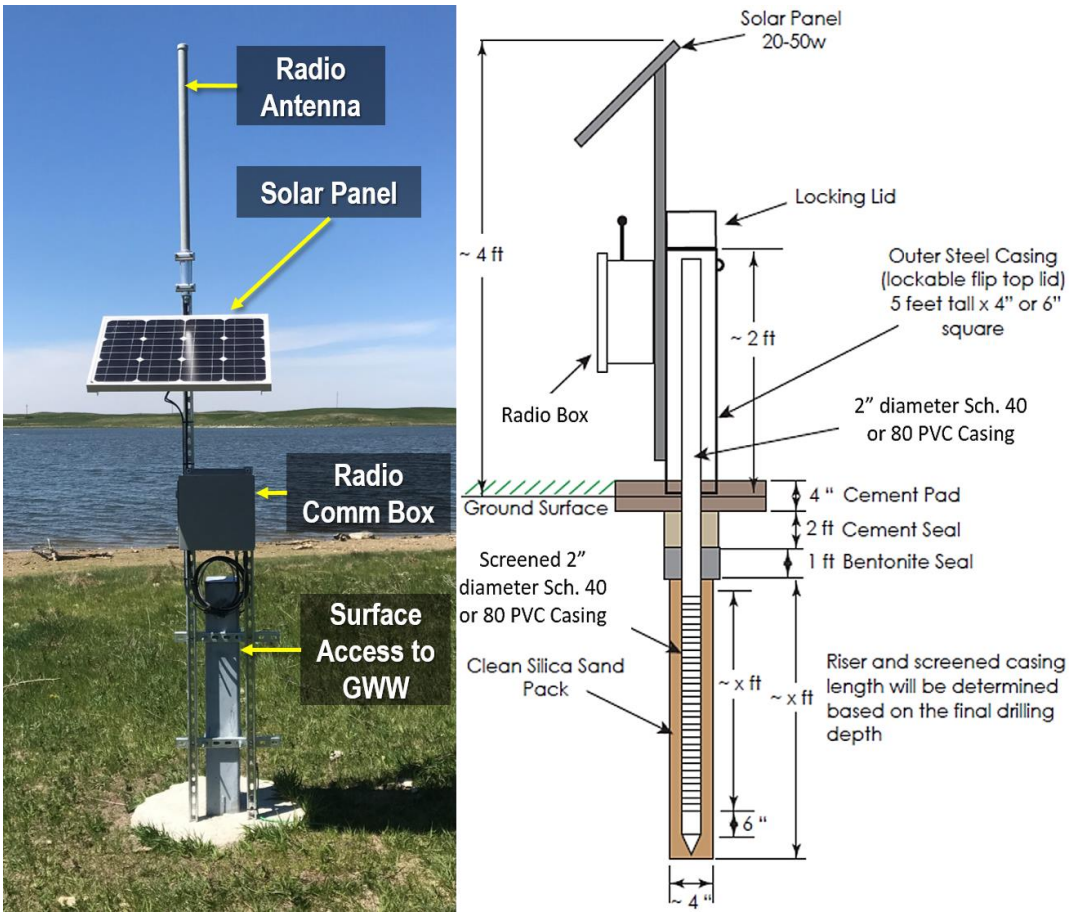

Figure 5. AIS GWW Overview of Components (Left: GWW from D09 PRLA)

4.2 Handling Precautions

4.2.1 DAS/PDS Infrastructure Components Handling Precautions

Grapes, PoE Switches and Sensors contain ESD sensitive parts; therefore, these 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.

Note: When handling Grapes, follow ESD protocols (see RD [05]) and never hot swap sensor connections. When power is ON, disconnect the RJF/Eth-To Comm Box cable BEFORE disconnecting the sensor cable. Connect the sensor cable BEFORE connecting the RJF/Eth-To Comm Box cable.

The Aquatics Portal contains hazardous voltage (240V). Always wear PPE in accordance with AD [01]. Conduct a JSA to address electrostatic (ESD) and Lock-out/Tag-out (LOTO) procedures when handling/accessing or conducting maintenance on electrical and communication equipment.

4.2.2 Sensor-specific Handling Precautions

The Aqua TROLL 200 internal pressure membrane may crack if the sensor incurs damage from drops, falls or careless shipping and handling. Use care when moving the instrument to maintain secure connection/hold to prevent dropping the sensor in a GWW (some GWW depths/locations make lost sensor retrieval difficult).

4.3 Operation

In each AIS GWW, an Aqua TROLL 200 sensor captures groundwater hydraulic gradients through continual conductivity, temperature, and pressure (depth) measurements. The Aqua TROLL 200 holds its calibration coefficients within internal memory and performs the analog to digital data conversion internally before any data output occurs. In addition, AIS GWWs allow for the collection of groundwater samples on a semi-annual basis for the same suite of water chemistry parameters. Figure 6 provides an overview of the AIS GWW PDS and DAS functions in operation.

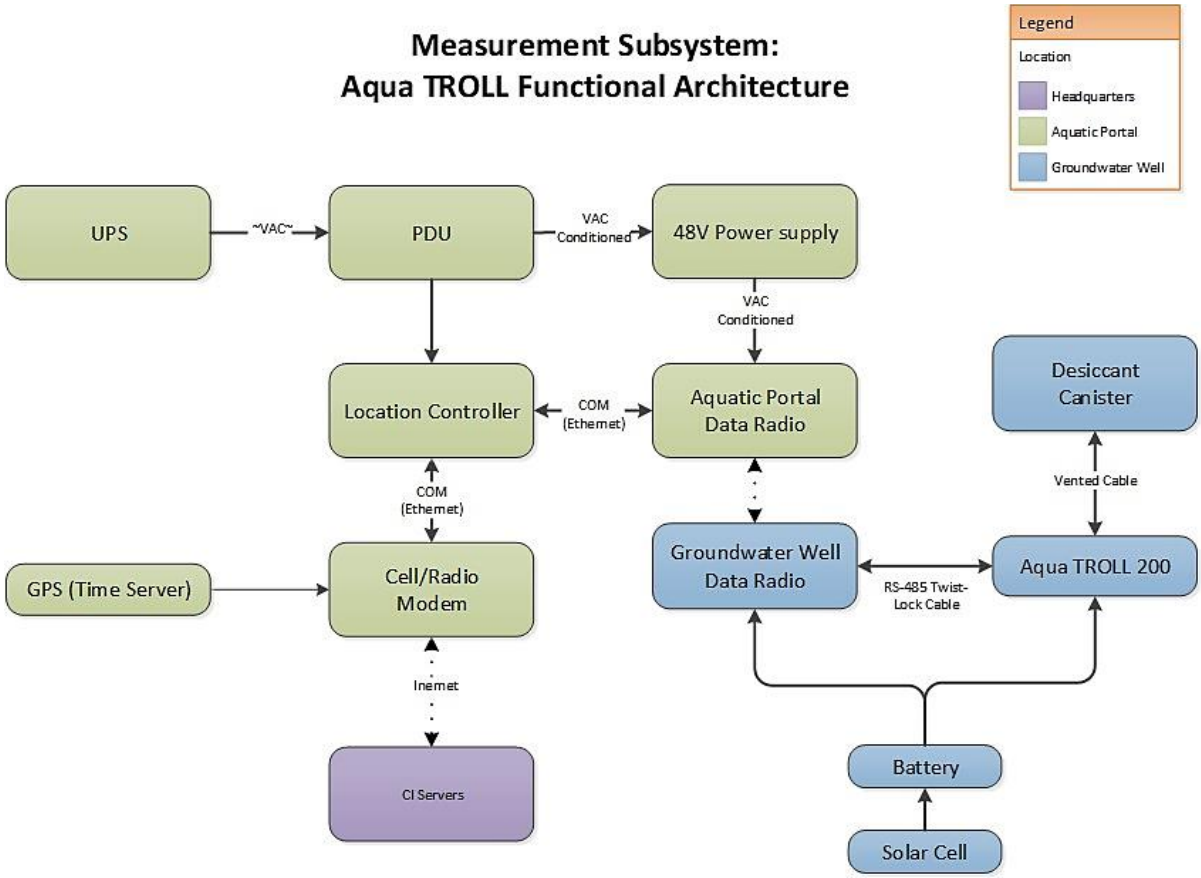

Figure 6. AIS GWW Functional Architecture

Reference AD [08] for the command, control and configuration of this sensor. NEON HQ data quality personnel may flag the data with the help of FOPS Technicians reporting events using the NEON project Issue Management and Reporting System using the "**AIS Data Quality**" component tag in the ticket, title and/or description.

5 INSPECTION AND PREVENTIVE MAINTENANCE

Note: Groundwater wells should be powered down at the grape for any activity that involves removing the Aqua TROLL sensor from the well. See section 8.1.1 for this process.

5.1 Equipment

Note: When working on power systems, use tools with insulated handles.

Table 1. Maintenance Equipment List

P/N	NEON P/N	Description	Quantity
		Tools	
GENERIC		Flush cutters/Scissors (to remove zip-ties)	1
GENERIC		Common landscaping tools (to maintain vegetation)	A/R
NEON, IT		NEON Laptop	1
GENERIC		Ethernet Cable (to connect to network in Aquatics Portal)	
GENERIC		Hex Wrench Set (to remove Grapes/Grape Shields, as appropriate for sensor swap/refresh)	1
GENERIC		Flathead screwdriver (to access AIS device post boxes)	1
GENERIC		Aquatic PPE	A/R
4620	MX103120	3M Antistatic Wristband (ESD Requirement)	1
GENERIC		Small Wire Brush (for rust/corrosion removal from infrastructure)	1
GENERIC		Soft Brush	1
GENERIC		Wash Bottle	1
GENERIC		5 Gallon White Bucket (Drill a hole in one for tubing for Surge Block/Mini Monsoon/Typhoon or use a clamp to secure tubing to the bucket)	1-2
0090420	0320150001	In-Situ, Inc. Extra Large Desiccant Canister	A/R
		Camera (to document water clarity and site corrective actions)	1
36C774		ECOPROPVC-153 Disposable Bailer,1027mL,Clear PVC,PK24	A/R: 1 per GWW or 1 per site & DECON per GWW
	MX110049	Water Level Tape (to measure GWW depth and/or water level)	1
		Q-Water Environmental Series Well Developer Surge Block*	1-2
GENERIC See ER [06] or ER [07].		½ in. **Threaded** PVC Riser (for use with Surge Block)	A/R: Site's Deepest GWW or enough for four wells
		Couplings (for use with Surge Block to connect sections)	A/R: Site's Deepest GWW or enough for four wells
		PVC Elbow (for use with Surge Block to connect sections)	1
		¼ Turn Valve (for use with Surge Block to connect sections)	1
	Coupa	6ft ½" Vinyl Tubing (for use with Surge Block to connect sections)	1
		Vice Clamps (to hold sections in well while attaching additions)	A/R
	Coupa	Proactive Mini-Typhoon Pump (for sites where all wells are < 40 ft. deep)	1**
	Coupa	Proactive Mini-Monsoon Pump (for sites where wells are > 40 ft. deep)	1
GENERIC		Non-stick Oven Tray (to recharge desiccant)	1
GENERIC		Container (to store extra recharged desiccant)	1
GENERIC		Timer (for Slug Test)	1
GENERIC		Pipe Wrenches (to disconnect surge block materials)	2
		12V Battery (to power the Proactive Mini-Typhoon/Monsoon)	2

P/N	NEON P/N	Description	Quantity
GENERIC		Tube Cutter (to cut tubes for well redevelopment)	1
GENERIC		Funnel (to refill desiccant canisters with desiccant)	1-2
0081480		TROLL Shield Nose Cone	A/R
Consumable Items			
GENERIC		Paint pen/Sharpie Marker (to label infrastructure)	1
See Description	CB08180000	Kit, Grape Dust Caps (Amphenol caps for Ethernet cables/ Grapes) P/N: MS3181-10C, MS3181-12C, RJFC2G/SCP3181-18C-NE0N	A/R
GENERIC		Lint-free/microfiber cloths	A/R
GENERIC		Clean tap water	1 gallon
GENERIC		2% Bleach Mixture (to decontaminate well redevelopment tools)	A/R
GENERIC		Vinegar (to clean/remove significant biofouling from sensor)	A/R
GENERIC		Soft Sponge	1
GENERIC		Plastic Scouring Pad	1
GENERIC		Cotton swabs	½ a dozen
GENERIC		Non-Phosphate Liquid Detergent (biodegradable)	A/R
80337	0355220000	SAF-T-EZE Food/Drug Grade FDBT-8 Anti-Seize & Extreme Pressure Lubricating Compound (Thread Lubricant) 8 oz. Brush Top	1
0719752		7” Zip-ties (to redress cables, as applicable)	A/R
0719793		14”Zip-ties (to redress cables, as applicable)	A/R
GENERIC		Rope (for use with Bailer)	A/R: Site’s Deepest GWW
GENERIC		Notebook (for Slug Test)	1
0029140		In-Situ, Inc. Desiccant Refill Kit – See ER [08] SDS.	A/R
Resources			
PuTTY: http://www.putty.org/ or MobaXterm https://mobaxterm.mobatek.net/			1
SAS: http://sas.ci.neoninternal.org/			1
IS Monitoring Suite: N:\Common\CVL\Field_Calibration\Required Directory\Test_Data\Current Executables\IS Control and Monitoring Suit			1
Site Specific IP Addresses: N:\Common\SYS\Site Network Configurations			A/R
Location Controller Username: user, password: resuresu			1
Win-Situ 5: https://in-situ.com/support/documents/win-situ-5-software/			1
TOS Oven (to recharge non-cobalt desiccant) – *Do not impede TOS activities. Use only when available.*			1
**Select parts for Schedule 40 or Schedule 80 PVC per the diameter of the GWW size onsite. This info may not exist in current as-built documentation and may require Technicians to measure the GWW diameters onsite to verify size.* ***If all wells at a site are <3m deep, no pump is required.*			

5.2 Subsystem Location and Access

GWWs reside at core and relocatable AIS sites. An Aqua TROLL 200 sensor resides within each GWW. The sensors are set at the following depths: 0.5 meters from the bottom of wells >3m, and 0.2 m from the bottom for wells < 3m deep*. An outer steel casing sits on the top of each well with a combination or key lock to protect access to the well instrumentation and groundwater. Number and location of GWWs vary per AIS site. *Refer to site-specific As-Built documentation in the NEON SharePoint Document Warehouse to verify site-specific AIS GWW Infrastructure and Sensor subsystems.*

Note: The Flint River site (FLNT) deviates from these sensor depths due to variations during installation of flood-prevention snorkel caps. There is currently sufficient water to submerge the

sensors at FLNT; however, sensor placement at this site will need to be revisited if the water table drops below the sensor elevation.

5.3 Maintenance Procedure

Table 2. Groundwater Well Infrastructure Maintenance Intervals

Maintenance		Bi-weekly	Monthly	Quarterly	Bi-Annual	Annual	As Needed	Type
Groundwater Wells								
	Visual Inspection	X						P
	Inspect Water Clarity with Bailer			X			X*	P
	Check Well Depth					X		P/R
	Redevelop Wells					X	X	P/R
	Flood Preparation					X	X	P
Aqua TROLL Sensors								
	Remote Monitoring	X					X	P
	Visual Inspection			X				P
	Elevation Check					X		P
	Internal Battery Check	*X*		X			X	P
	Check Desiccant		*X***				X	P
	Replace Desiccant	*X*	*X*				X	P
	Synchronize Internal Clock			X			X	P
	Winter Preparation for AK					RD [12]		P
Electrical & Communications Infrastructure								
	Remote Monitoring	X					X	P
	Visual Inspection	X					X	P
	Replace Cable Ties						X	R
	Clean Biofouling from Cables/Wires						X	P/R
	Clean Solar Panels	*X*		X				P/R
	Winter Preparation for AK					X		P
	Winter Maintenance for Operational Sites						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.
**Conduct after root removal, as appropriate.*
*** AIS Sites with high humidity levels must change desiccant more frequently, while some sites may reduce the frequency of inspection during drier seasons.*

5.3.1 Remote Monitoring

Conduct remote monitoring daily using the SAS report. To access static smart devices onsite, reference site-specific IP Addresses/Network Configurations via the NEON Network Drive (N:\Common\SYS\Site Network Configurations). Prior to traveling to the site, conduct a state of health check at the Domain on the sensors via their data streams using the SAS report for a daily snapshot or use terminal emulator program (TEP), such as PuTTy or MobaXterm, for real-time review of data streams. This action enables Technicians to prepare and prioritize any root cause analysis/corrective action to sensors onsite with missing or abnormal data streams on the AIS Infrastructure. Verify data streams using Table 3. Use this to verify function of Grapes and Sensors post-Sensor Refresh, too.

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*

Note: For AIS sites using an Alternate Power System with no network connection, skip to the next section.

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

Remote Monitoring Commands	Description
`vd | grep 7CE0440015FD`	This displays the data from the grape with the MAC Address (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.

Note: Reference AD [08] or Section 11 for the AIS GWW command, control and configuration requirements.

5.3.2 Visual Inspection

An objective of AIS is to measure natural conditions. Maintenance of the infrastructure must result in little to no disturbance to the natural conditions of the AIS site. Employ care and use judgement when conducting maintenance on the site to mitigate or reduce our impacts to the site.

Conduct a visual inspection on components onsite to maintain structural integrity, science and engineering requirements. If the following tasks require corrective action, submit a ticket in the NEON project Issue Management and Reporting System.

1. Inspect the GWW infrastructure and sensors for fallen debris/trash, vandalism, or if any components seem out of place or display evidence of tampering (if sensors are not in their configured location, solar panels are askew, etc.).

2. Inspect components for damage and/or if their installation location is no longer meeting science requirements due to sustained lowering of the water table below the well bottom or inclement

weather events. Note that the water table may drop below the well bottom due to dry conditions on a seasonal or annual basis. Dry wells may represent part of the natural cycle and sensor data will be flagged for these times. If a dry well persists for multiple years, it may then require consideration for decommissioning.

a. Verify instruments are in accordance with site-specific science requirements. *Refer to site-specific As-Built documentation in the NEON SharePoint Document Warehouse to verify site-specific GWW sensors and subsystems.*

b. Select AIS GWW sites may receive a modification to their well caps (Figure 7) to withstand high-water flood events and prevent groundwater contamination. The operation of the valve is automatic. When the valve is submerged, the needle element closes the valve and when the water has subsided, the needle opens the valve. Inspect these caps for blockages. Remove any debris that obstructs the function of these caps.

Figure 7. Snorkel cap modification for flood-risk sites.

3. Verify that the cable is in the correct position. Cables should be marked where they cross the metal ring when sitting in the well. Any misalignment should result in a trouble ticket notifying AIS Staff to provide science evaluation/guidance.

4. Pull up Aqua TROLL sensors. Be careful to watch for snakes/biologics in the well housing. *Reference N:\Common\EHS to review Domain EHS plans to identify local potential hazards.* Groundwater sampling bouts can count towards the quarterly inspection. **Due to the risk of altering the sensor position, conduct this on a quarterly basis rather than bi-weekly, and aim for it to coincide with groundwater chemistry sampling when possible.**

a. Note any resistance to remove the Aqua TROLL, as this could indicate an infiltration of materials into the well. If excessive resistance is felt when attempting to remove the Aqua TROLL, notify the Domain Manager. If root intrusion is found to be an issue, sites may be required to increase the frequency of troll inspection in order to determine the rate of root growth.

b. Inspect sensor for physical damage and biofouling.

5. Inspect vegetation growth around wells and device posts.

   a. Maintain the vegetation surrounding the GWW to enable safe access to components requiring maintenance and/or troubleshooting.

   b. Remove vegetation that is obstructing the GWW infrastructure from normal operations, such as tree roots growing into the well.

Figure 9. Example of GWW Fencing (D09 PRLA)

6. Inspect the cables and connectors connecting to the Aqua TROLL sensors and Radio/Power box.

   a. Redress cables/replace cable ties, as appropriate.

   b. Verify connectors that are not in use have covers/dust caps (Figure 8).

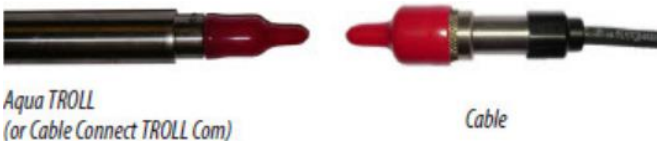

Figure 8. Red Plastic Nipple Caps/Dust Caps (Source: ER [01])

   c. Check for evidence of corrosion, tampering, fraying, kinks or loose connections.

   d. If the sensor cable shows minor damage is not adversely affecting the function of the sensor, photograph the damage and submit a ticket to monitor the condition of the incident from first discovery. If the sensor cable shows sufficient damage to adversely affect the sensor measurements (exposed wire or erratic sensor behavior), remove the sensor and cable. Cover the connector on the bottom of the Radio/Power box with a red plastic nipple cap (Figure 8).

   e. Secure with electrical tape (two different sizes of the red plastic caps exist for the cable and Radio/Power box connectors; installation of the correct size is “snug” on the connector). If a red plastic nipple cap (Figure 8) is unavailable, use electrical tape to temporarily protect the connector and follow normal reporting procedures for corrective actions. *Request additional red plastic nipple caps from In-Situ, Inc. per NEON-10945.*

7. Inspect infrastructure mechanical components on the well and AIS Device Post. Check structural integrity of Unistrut post, enclosures, cables, mounts, well outer and inner casings, bolts, nuts, washers, and screws.

Figure 10. Combo Box Ground Strap

   a. Ensure there are no insects/insect nests/rodents and/or rodent damages in the enclosures, wells or to any of the other components (such as rodent damage to conduit). Employ caution and remove insect nests. Consult with the Domain Manager and NEON Safety Office in the event additional guidance is necessary to remove biologics.

   b. If a site has cattle, verify structural components are intact from cattle grazing nearby well infrastructure. If there is evidence of damage from cattle grazing, consult with NEON AIS and ENG staff to determine if cattle fencing is appropriate for some or all GWWs at the site in question. Figure 9 is an example of fencing for GWWs to protect infrastructure.

   c. Inspect component hardware for deterioration (rust, corrosion, oxidation, etc.).

      i. If light corrosion is present, attempt to clean with a small wire brush and lubricate with specified thread lubricant, as applicable, from Table 1.

      ii. If heavy corrosion is present, clean with a small wire brush and/or replace hardware. Follow up by lubricating with specified thread lubricant in Table 1.

   d. Inspect the Combo box door gaskets and ground strap (Figure 10) to ensure they are not enabling water intrusions or biologics into the enclosure.

   e. Inspect GWW cement pads for cracks that could result from upheaving of the well casing, if applicable to your site.

   f. Inspect solar panels for debris, snow, or ice and clean panels, as necessary. If snow and/or ice are present on the panels, conduct the preventive maintenance procedures in *Section 9.5 Winter Maintenance for Operational Sites* on page 71.

8. Verify the infrastructure is level using a digital level. If the infrastructure is ±5° out of alignment, submit a ticket for AIS Science Staff to review and determine if corrective actions are necessary.

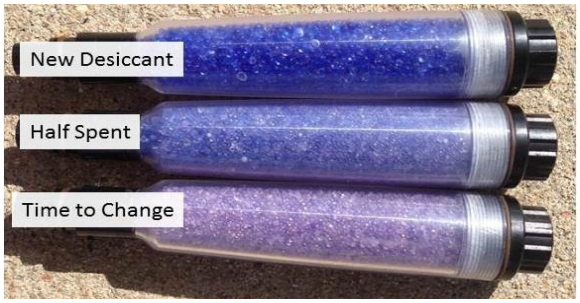

Figure 11. Evolution of Desiccant Use/Color Changes

9. Inspect the Aqua TROLL desiccant housing/tubing and desiccant. Ensure there are no obstructions, bends or kinks in the

vented cable/tube to the sensor. The minimum bend radius for the vented cable is 13.5 mm (0.54 in).

a. Desiccant requirements may vary across sites depending on relative humidity of each site. Expired desiccant (changes color when expired as shown in Figure 11) may allow water build up in the vent tube, causing blockages that affect the data. *Reference Section 5.3.3.5 clean, remove/replace and recharge expired desiccant.*

5.3.3 Aqua TROLL 200 Sensor Maintenance

5.3.3.1 Sensor Cleaning Procedure

The body of the In-Situ Inc. Aqua TROLL 200 Groundwater Well sensor may require maintenance on an as needed basis to remove significant biofouling from the sensor. An example of significant biofouling is discovering biofouling on the sensor's antifouling guard or copper cap during routine visual inspection. For the examples in Figure 11, the biofouling is only on the anti-fouling guard. FOPS Technicians may remove the guard to clean at the Domain Office, and the sensor may remain without it for a short timeframe (within two weeks) to continue collecting data. If available, replace the copper nose cone with the original black plastic cover for when removing the cooper guard for lab cleaning. Technicians may clean the entire sensor at the Domain Office if they are able to reinstall the sensor within a short timeframe (within a couple days).

Figure 11. Examples of Biofouling on Aqua TROLL 200

Removing biofouling enables the sensor to capture more accurate groundwater well data. Conduct the following procedure to clean the sensor.

1. Stop the Aqua TROLL 200 from transmitting data to the NEON, HQ to "flag" the timeframe for PM manually (by stopping any bad data from transmitting). *Reference Section 8 Groundwater Well (GWW) Power Down Procedure*.
2. Remove the Aqua TROLL from the GWW. *Reference Section 6.*
3. Wear powder-free plastic gloves to handle and clean the sensor.

4. Clean the sensor body, nose cone, cable head and antifouling copper protective caps with distilled water or with distilled water and mild detergent mixture to remove excessive biofouling/dirt build up (Figure 12). Use a soft brush or plastic scouring pad to clean.
5. Dry using a microfiber or lint-free cloth.
6. If unable to remove biofouling from these components using DI water/mild detergent, soak the components overnight in a mild acidic solution, such as household vinegar. Conduct this step in the domain laboratory.
7. Allow components to air dry or dry with a lint-free/microfiber cloth. If using a cloth, refrain from applying any pressure to the sensor diaphragm.

Figure 12. Aqua TROLL 200 Components

Under some circumstances, FOPS may encounter ice when servicing the sensor. Document ice presence/absence when conducting routine maintenance on the site. **DO NOT POUR ANY WARM WATER INTO THE GWW TO REMOVE SENSORS FROM ICE.** Leave the sensor in the GWW.

5.3.3.2 Pressure Port Cleaning Procedure

If the pressure ports in the front end of the sensor (Figure 13) contain silt or mud, try one or more of the following to remove the fouling.

Figure 13. Ports for Pressure Sensor

1. Agitate the instrument vigorously in a bucket of clean water.
2. Apply a gentle stream of water from a wash bottle.
3. Clear the front end with a cotton swab.
4. In severe cases, remove the nose cone and clean out the holes with a soft brush or pipe cleaner.
5. Allow components to air-dry. Wet reassembly is OK, too.

Note: The nose cone protects a sensitive pressure sensor diaphragm within the body of the sensor. Removing the nose cone completely exposes this sensitive component. Do not insert any object into the sensor opening or attempt to dig out dirt or other materials. Replace the nose cone as soon as possible!

5.3.3.3 Pressure Sensor Diaphragm Cleaning Procedure

If FOPS observes significant contamination in the GWW, it may result in needing to conduct a deep cleaning of the sensor. This includes cleaning the sensor's pressure sensor diaphragm. This situation is rare. **Use the following cleaning procedure only with the explicit consent/oversight of AIS staff.**

Figure 14. Sensitive Pressure Sensor

Note: Removing the copper guard from the Aqua TROLL exposes the electrodes. While they are not extremely delicate, treat these with care and gently clean the components following the cleaning procedures in this section.

1. Soak the diaphragm for several hours using household vinegar.
2. Apply a gentle stream of undiluted vinegar using a wash bottle. Do not spray the pressure sensor directly. Use the wash bottle to spray the sidewalls and swirl the vinegar vigorously down around the sensor by gently rotating/swaying the sensor while spraying.
3. If necessary, use a cotton swab to **gently** clean the sensor. **DO NOT SHOVE OR PUSH CLEANING UTENSILS OR MATERIALS INTO THE SENSOR (Figure 14). The Pressure sensor is delicate and easily susceptible to damages from cleanings.**
4. Allow components to air dry or reassemble wet.

- ***Note: Too much pressure may easily damage or scratch the sensor. If the above steps do not adequately clean the sensor, replace the sensor. Contact AIS Science Staff at NEON HQ to determine next steps.***

5.3.3.4 Sensor Cables and Connector Maintenance

Cables are GWW specific. The cable attaches to the well casing using a mesh wire basket that grabs the cable at a point setting the length specified by AIS site-specific GWW science requirements. The cable lengths vary to because the GWW lengths vary. Maintaining a static cable length is of critically important because water table elevation is derived by using the initial cable length measurements to correct the sensor pressure values.

The cable connects to the sensor using a twist-lock cable connection. **The sensor and cable design is not meant to disconnect during routine maintenance.** Both the sensor and cable connector have a flat side to line up the pins inside the connector to the correct orientation (Figure 15).

Figure 15. Aqua TROLL Connector "Flat" Side to Align Connectors

The connector itself has a slot and pin system to twist and lock the connector (Figure 16).

Figure 16. Aqua TROLL Connector Pin and Slot

The slot is located in a moveable sleeve, which may slide up and down on the connector in order to secure or loosen the union of the two ends that make up the connection. Figure 16 displays the sleeve moving from position A to position B.

Figure 17. Moveable Sleeve Position A to B

To complete the connection, insert the sensor connector firmly into the cable connector. Position the flat edges so they will connect properly, and insert the instrument connector firmly into the cable connector. Slide the sleeve on the cable toward the sensor until the pin on the sensor fits in the slot on the cable connector. Grasp the textured section of the cable connector in one hand and the Aqua TROLL sensor in the other. Push and twist firmly so that the pin on the instrument connector slides along the slot on the cable connector and locks securely (Figure 18).

Figure 18. Lock Cable with Pin and Slot

For more detail, refer to the In-Situ Inc. Aqua TROLL Owner's Manual (ER [01]).

Inspect these cables and connectors at each GWW to ensure they are intact without any breaks or cracks, and the cables securely fastened to the Aqua TROLL (so no sensors fall to the bottom of a well). Inspect the cables and connectors for visible foreign material or wear and tear. If FOPS observes a buildup of dirt, clean the cable or connectors with a clean, dry microfiber/lint-free cloth or portable vacuum.

Note: The cable connector must remain dry. Do not submerge the connector in water unless it securely connects to the Aqua TROLL sensor.

After conducting maintenance, ensure the wire mesh basket is not loose. Gently tug on the mesh to verify it is tight around the cable to ensure the sensor will not move from its specified location. (The mesh basket acts like a finger-trap around the cable.) To prevent the wire mesh basket from loosening due to other environmental or unanticipated causes, secure it with a small zip tie as shown in Figure 19. Ensure the zip tie is secure, but also allows the sensor cable tube to function (do not crush the tube). Use flush cuts to trim the remaining portion of the zip tie. Use a piece of colored tape to mark the cable where the zip tie is attached for help in repositioning the sensor should the basket move or for reference post-maintenance or corrective action activities.

Figure 19. Secure Mesh Wire Basket to Sensor Cable

5.3.3.5 Desiccant Maintenance

The Aqua TROLL 200 uses a vented cable, which requires a desiccant canister (***0320150001*** *Desiccant Canister*) to prevent moisture accumulation in the vent tube. Excess moisture in the vent tube may cause blockages, resulting in inaccurate data. The desiccant canister resides in the GWW Radio/Power box and attaches to a tube that exits from the bottom plate and connects to the Aqua TROLL (Figure 20).

The vent tube attaches to the canister with the same style pin-lock connector that the Aqua TROLL uses in Figure 21.

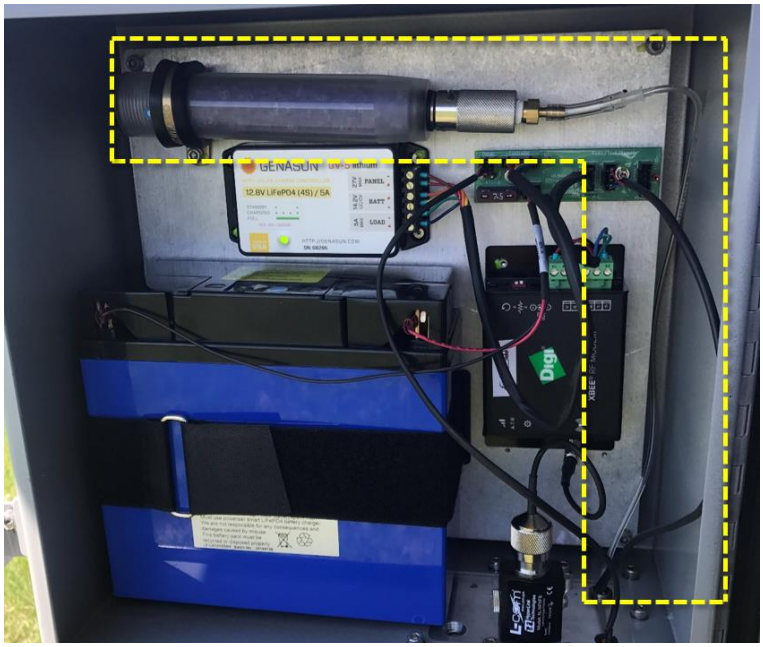

Figure 20. Desiccant Location in GWW Radio/Power Box (D09)

Figure 21. Desiccant in Radio Box with Vent Tube Attachment Close-up

Inspect the vent tube and confirm the tube fully connects to the hose barb at each end (Figure 20 and Figure 21). Remove any foreign matter and clean the connectors with a clean, dry microfiber/lint-free cloth. Do not use abrasive cleaning devices, as a protective oxide layer will form on the metal components. The O-ring is part of the replaceable desiccator and does not require maintenance cleaning. Do not lubricate the O-ring.

Note: The pin-lock connection on the desiccant canister is not spring-loaded for a positive lock feel. An O-ring serves this function. It compresses slightly when the desiccant connector locks. FOPS must visually check the connector to ensure the pins fully seat in the connection.

5.3.3.6 Desiccant Replacement Procedure

If more than 50% of the desiccant is pink or light purple, replace the desiccant. Figure 11 on page 23 provides the color scale to determine the lifespan of desiccant in use in the GWW Radio/Power box. Humid sites must replace desiccant on a more frequent basis. Conduct the following procedure to replace the desiccant canister:

1. Access the GWW Radio/Power box using a flathead screwdriver.

2. Loosen the clamp that mounts the desiccant canister to the back of Radio/Power box using a 5/32 hex wrench (Figure 22).

Figure 22. Loosen Clamp Securing Desiccant Canister to Radio/Power Box Back Plate with 5/32 Hex Wrench

3. Remove the desiccant canister from the Radio/Power box. Disconnect the twist-lock connector by rotating counterclockwise ¼ turn.
4. Install a new desiccant canister or refill with freshly recharged or new desiccant. Line up the flat side of the connectors, push, twist, and click to lock the desiccant canister to the tubing.
    - Visually ensure the pins engage in the connector, twist clockwise ¼ turn to the stop.
    - *Reference Section 5.3.3.6.1 to recycle expired desiccant.*
    - Remove the red dust cap from the desiccant canister vent, if present.
5. Ensure there are no kinks or sharp bends in the tubing connecting to the desiccant canister and leading outside of the Radio/Power box.
6. Close the GWW Radio/Power box using a flathead screwdriver.

5.3.3.6.1 Desiccant Recharge Procedure

⚠ **WARNING!** The blue silica gel indicating desiccant (drying agent) from In-Situ, Inc. is effective for the sensor, but poses health hazards as a skin, eye or inhalation irritant (ER [08]). **DO NOT RECHARGE THIS INDICATING DESICCANT IN THE DOMAIN OFFICE.** The TOS Oven does not vent outside, it vents into the Domain Office. Review alternative desiccant ingredients to verify they are OK to recharge inside the Domain Support Facility.

Recycle non-toxic desiccant by recharging it at the Domain Support Facility (DSF). Technicians may recharge the desiccant until it no longer returns to its original color. Please increase ventilation during this process by opening doors and windows to the facility.

1. Access each GWW Radio/Power box using a flathead screwdriver.
2. Remove the old desiccant from each applicable GWW Radio/Power box desiccant canister and swap with new desiccant. Do not leave a GWW Radio/Power box without desiccant.
    a. Use a wrench to remove the cap on the desiccant canister.

b. Pour the old desiccant into a separate plastic container. If the Domain has extra desiccant canisters, then swap a fresh desiccant canister with an old desiccant canister onsite.

3. In the Domain Office, evenly spread the expired desiccant beads on a non-stick oven tray.
4. Set the oven for 275°F. Bake in the TOS oven for 1½-2 hours (adjust accordingly since ovens may vary across the Observatory).

PRO TIP: *This is a good timeframe to clean dirty desiccant canisters, too!*

5. Allow the desiccant to cool.
6. Refill desiccant canister(s) and reuse or store in an airtight container for reuse later. Cover the storage container opening with electrical tape.

5.3.4 Groundwater Well (GWW) Maintenance

The following section applies to all NEON groundwater wells at **non-permafrost sites**. The sites in Domains 18 and 19 have a modified maintenance and data collection procedure that is in Section 12.

5.3.4.1 Well Depth Measurement Procedure

Annually measure the total depth of the well from the top of the PVC casing to the bottom of the well using water tape (see Table 1 for water tape sensor specification). Clean the water tape with DI between wells.

1. Power down Aqua TROLL data transmission to NEON HQ. This acts as a flag to prevent collecting bad data during maintenance activities. *Reference Section 8 Groundwater Well (GWW) Power Down Procedure.*
2. The Aqua TROLL may remain in the GWW; however, if it impedes the procedure, remove the Aqua TROLL from the well and place it in a dry bucket nearby. Do not disconnect the Aqua TROLL from the power box.
3. Measure each GWW using water tape and record each GWW measurement to monitor well changes per site (Figure 23).
    - Temporarily turn the water level tape OFF to stop the beeping that alerts users it has reached water. Lower the water level tape into the well until you hit the bottom of the

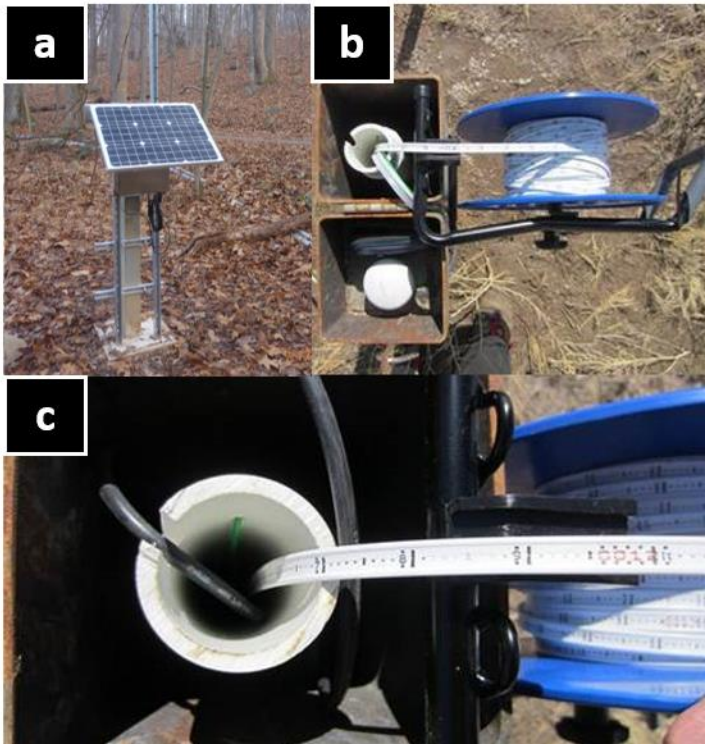

Figure 23. (a) Standard groundwater well at a NEON site (b) Water-level tape attached to outer well casing. (c) Reading the depth to water from the water-level tape. The tapes are marked in "meters" with each foot increment marked in red. (Source: AD [11])

well. The tape will lose its tautness. To narrow in on the actual depth of the well, hold the tape with your hand and raise and lower it in the well feeling for the tapping of the tape on the bottom of the well.

- Read and record the total well depth (as measured from the top of the PVC casing) from the water tape.
  - Report to AIS staff if the total depth displays a >10cm change. It may indicate sediment deposition within the well casing.

5.3.4.2 Water Column Connectivity and Development

The well infrastructure requires regular maintenance in order to ensure that the well water column directly connects to and represents the surrounding aquifer.

Use well-specific bailers or clean thoroughly with DI between wells.

5.3.4.2.1 Groundwater Column Clarity Test

Visually inspect the water column quarterly to determine the GWW state of health.

1. Power down Aqua TROLL data transmission to NEON, HQ to flag the data during maintenance activities. *Reference Section 8 Groundwater Well (GWW) Power Down Procedure.*
2. Pull up the Aqua TROLL 200 and inspect for deposition of biological material or sediment. Note any resistance to removal of the troll as this could indicate infiltration of materials into the well.

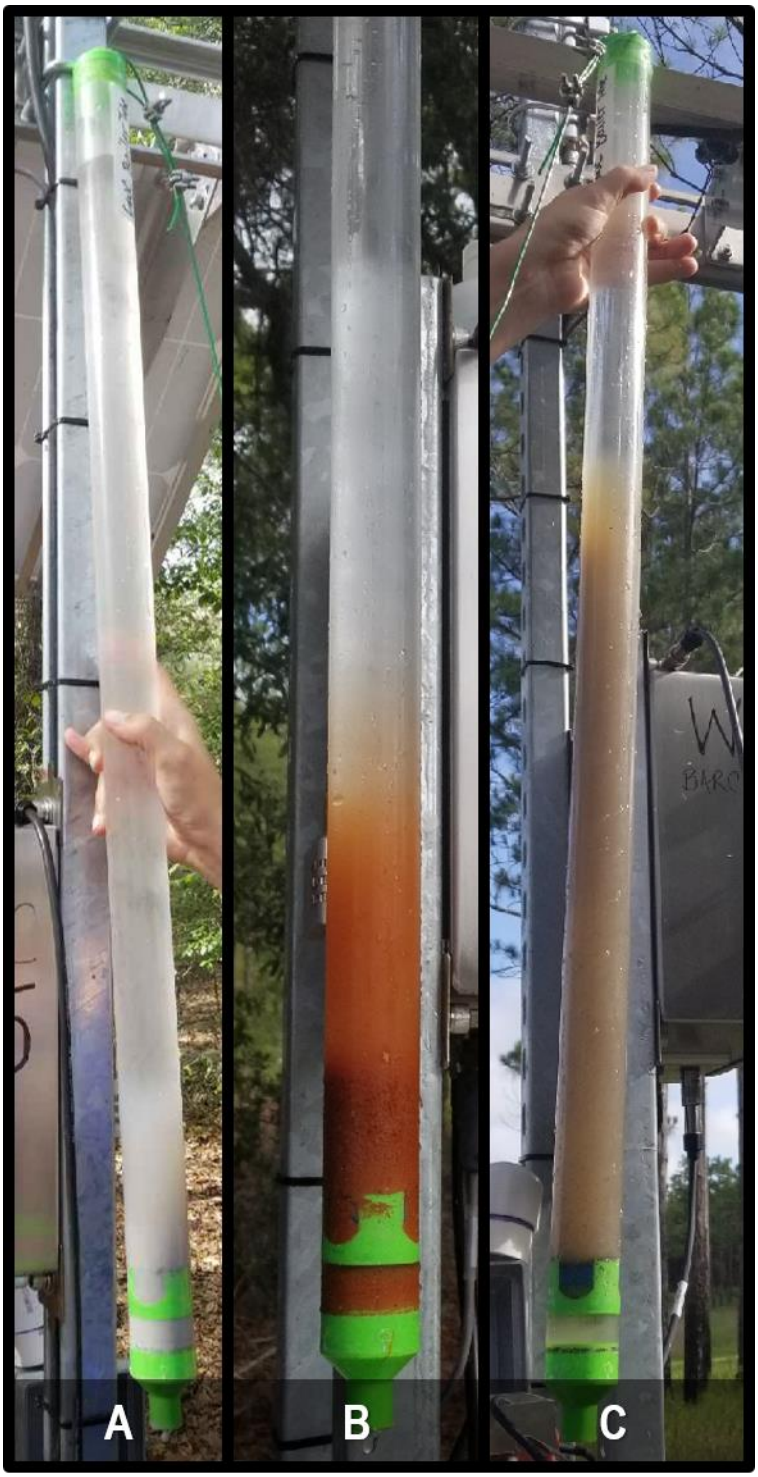

Figure 24. Water Clarity Sample in Bailer Tube Examples (D04)

3. Use a designated bailer tube for each well to obtain a sample from the bottom of the water column.
4. Check the bailer water sample for clarity, and the inclusion of any sediment, and/or organic material.
5. Take a picture of the sample, to monitor water quality changes over time for each GWW to determine if any require reporting in ServiceNow.
6. If the water is cloudy, and/or there is more than 10cm sediment accumulation like in Example B and C (Figure 24), the well requires redevelopment. Consult with NEON, HQ AIS staff to determine next steps and identify appropriate corrective actions.
7. Example A in Figure 24 may wait until annual redevelopment. If the water column is completely transparent or has less than 10cm of sediment accumulation, redevelopment is not required.

5.3.4.2.2 GWW Re-Development Process

Development is the process of restoring the formation to the pre-drilling conditions. This continual process improves well yield and clarity over time. Development can also be an important corrective action when the groundwater wells fail in either water quality and/or water quantity.

FOPS Technicians must redevelop GWWs annually or more often, as applicable. The frequency shall depend on site-specific dynamics and requirements. Annual well redevelopment may occur at any time, as long as it is not within the two weeks prior to Ground Water Chemistry (GWC) sampling. At sites that experience dramatic lowering of the water table on a seasonal basis, conduct redevelopment when the water table is highest to ensure sufficient water level available to flush sediment from the well screen. To conduct this process, Technicians must acquire a mini-typhoon or mini-monsoon pump and surge block (Figure 25). Wells shallower than 3m do not require a pump. Reference Table 1 for equipment part numbers. The surge block is site-specific (one per site). The pump is OK for use at all sites within a Domain.

Prior to going into the field, treat the pump by soaking in a non-phosphate liquid detergent, followed by rinsing and drying. Treat all other materials by using a 2% bleach solution, followed by rinsing and drying.

While on site, use the following procedure to minimize cross-contamination between wells.

- Purchase sets of materials equal to the maximum number of wells that you expect to visit in a single day. This is typically four wells.
    - Materials per well include a bailer, pump tubing, and set of PVC tubes.
- Use an individual set of the materials above for each well visited in a single day. This enables efficiencies in the field, saving time and labor from cleaning additional equipment. This option also reduces microbe transport between wells and helps to avoid known surge block corrective actions/troubleshooting stemming from grit in the PVC threading
- Between wells, rinse the pump and ball-bearing head of the surge block DI water to flush sediment.

Note: The installation of select NEON GWWs use schedule 40 PVC, while some use schedule 80 PVC, which consists of slightly different inner well diameters. It is important to purchase a surge block

that matches the inner diameter of the GWW. Measure the diameter of the GWWs at each site to determine appropriate Surge Block size(s) for the Domain.

Figure 25. GWW Re-Development Equipment

A surge block is a flat seal that closely fits the casing interior and operates like a plunger beneath the water level. Because it seals closely to the casing, it has a very direct positive action on the movement in the well.[ii] The plunger should drop rapidly on the down stroke to lift turbid water out of the connecting tubing. The Proactive mini-typhoon pump is capable of pumping up to 40 feet from ground level using a 12V battery.[iii] The Proactive mini-monsoon pump is capable of pumping up to 70 feet from ground level using a 12V battery for power.[iv] Acquire these tools referencing Table 1 and conduct the following process to rehabilitate/redevelop a GWW using Table 4.

READ THIS PROCEDURE COMPLETELY BEFORE CONDUCTING IT IN THE FIELD. Do not conduct this procedure if it is raining or if the GWW is frozen. This procedure takes approximately an hour to complete per GWW (~45 minutes of well redevelopment and ~15 minutes of decontamination of equipment). Allocate additional time when conducting this procedure for the first time.

Table 4. GWW Re-Development Procedure

STEP 1 | Power down the sensor data transmission to HQ. *Reference Section 8 Groundwater Well (GWW) Power Down Procedure*. If Technicians are unable to connect to the internet to access the PoE switch, disconnect the sensor cable from the power box and place the Aqua TROLL in a clean dry bucket nearby.

Figure 26. Unlock GWW (D09 PRLA)

STEP 2 | Unlock combo/key lock to access groundwater well (Figure 26).

Figure 27. Remove GWW Cap (D19 CARI)

STEP 3 | Remove the cap and remove the Aqua TROLL sensor from the groundwater well. Place it in a dry bucket nearby during this process (Figure 27).

Do not disconnect the sensor from its power source unless Technicians are unable to access the PoE switch to conduct the power down procedures.

Figure 28. GWW Water Clarity Sample (D10 ARIK)

STEP 4 | Collect a water clarity sample from the bottom of the well using a bailer (Figure 28).

1. Tie bailer rope to well infrastructure to prevent dropping it in the well.
2. Insert the bailer into the well. Allow it to slowly sink to the bottom.
3. Once it reaches the bottom, remove the bailer in a smooth quick motion.
4. Capture a photo and document observations of the GWW water clarity.
5. A given well does not require redevelopment if you send a bailer to the bottom of the well and it comes up clear with less than 10cm of settled sediment in the bottom of the bailer tube. Take a photo and document in maintenance notes. Continue to check water clarity as required on a quarterly basis and revisit redevelopment of this well if clarity conditions change.

PRO TIP: *Use your hands off to the side in photos to identify the GWW number for water clarity samples and other observational photographs.*

Note: If anything other than sediment is apparent in the bailer sample, do not reuse redevelopment materials without decontaminating. Write a trouble ticket and submit to Science.

Figure 29. Connect Mini-Typhoon/Monsoon to 12V Battery (D10 ARIK)

STEP 5 | Assemble a proactive mini-typhoon or monsoon. Use the mini-typhoon for sites with wells <40 ft. deep or the mini-monsoon for site with wells >40 ft.

1. Cut ½" ID PEX tubing so that the typhoon can be lowered to the bottom of the well and the tubing can come out of well and reach a bucket (= well depth + ~6 ft.). Use dedicated tubing for each well.
2. Clamp tubing wire to 12V battery (Figure 29) and it will immediately start flowing. Do not use the 12V battery in the GWW power box for this procedure. Purchase a separate or extra 12V battery for this procedure.

PRO TIP: *If the pump "pulsates", it may indicate that the battery voltage is critically low (below 11 volts). The battery requires charging. Check the charge on the battery and/or purchase and bring a backup battery for this procedure, esp. if servicing up to eight wells or more than one site in one day.*

Figure 30. GWW Prep with Mini-Typhoon (D10 ARIK)

STEP 6 | Only perform Step 7 for wells that recharge quickly. If a well contains little water or is low-yield (takes more than a minute to refill after the extraction of water with the bailer tube), skip Step 7 and move on to Step 8.

Use a mini-typhoon or mini-monsoon for a few minutes as a preliminary step to remove free-floating debris. This helps to minimize sediment clogging when using the surge block.

Watch for water clarity to moderately improve (Graphic 3 in Figure 30).

PRO TIP: *drill a hole in the bucket to hold the tubing in place.*

Figure 31. Assemble Surge Block (Source: ER [07])

Figure 32. Screw Surge Block to PVC TIGHTLY (D10 ARIK)

STEP 7 | Assemble the surge block. Reference ER [06] and ER [07] (Figure 31). *Please Review these resources prior to traveling to the field.*

Use 1/2-inch Schedule 40 or thin wall (DWV) PVC pipe from your local hardware store for the surge block riser. Tighten the small setscrew on top of the surge block into the PVC pipe.

Attach a rope to the surge block to prevent losing it in the GWW. Lower the surge block into the well, adding PVC lengths as needed, holding each link at the top with vice grips.

Note: It is important to screw the surge block on tightly to the PVC (Figure 32). If not, the risk of losing the surge block in the well significantly increases. It is very difficult to retrieve a surge block from a GWW.

Figure 33. Set up Surge Block (D10 ARIK)

STEP 8 | Once the surge block is at the bottom of the well and the PVC extends 2 to 3 feet above the top of the well casing, add the quarter-turn valve, with 90-degree elbow, and then add 6 to 7 feet of 1/2-inch ID clear vinyl tubing.

Insert the tubing end into a 5-gallon bucket (white, if available) (Figure 33).

Either clamp the tubing onto the bucket or drill a 5/8-inch hole into the bucket near the top and insert the tubing through the hole.[v]

PRO TIP: Drill a small hole through the surge block and lowest section of PVC tubing. Attach a rope line as backup in case anything falls into the well.

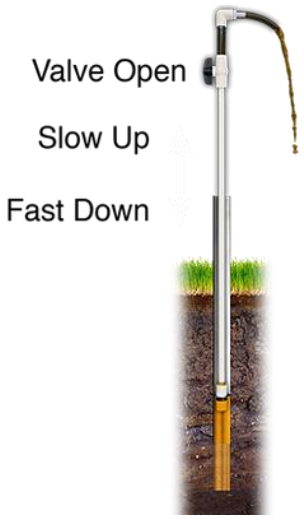

Figure 34. Flush GWW with Surge Block (ER [07])

STEP 9 | Use surge block to flush screened area free of sediment. Begin at the bottom of the well.

With the valve **OPEN**, raise and lower the surge block ~1 ft. going up slowly and down quickly (Figure 34).

Surge each foot of screen for 1-2 minutes while working your way upwards until you are no longer submerged. (A 15ft water column takes approximately 15-30 minutes of surging.)

If well is unable to produce enough water, partially close off the flow with the ¼ turn valve.

Figure 35. Muddy Water from Aggressive Mixing (D10 ARIK)

STEP 10 | The flushing should get easier throughout the process, but the water may continue to appear muddy from the aggressive mixing (Figure 35). This is OK!

The point of the surge block is to loosen up all of the material and improve the connection between the well and surrounding aquifer.

***PRO TIP*: If the surge block is not flushing GWW water into the bucket, remove the surge block from the well and check the couplings for leaks. Verify couplings are secure on the PVC. Flush dirt from the couplings/PVC to ensure they connect properly before reassembling. Additionally, ensure the ball is freely moving in the end of the surge block, allowing water to enter the device.**

Figure 36. Water Clarity via Mini-Typhoon/Monsoon (D10 ARIK)

Note: Ideally, the amount of material that settles out of the development water in a 5-gallon bucket should be less than a teaspoon per gallon. The length of time to develop a well depends on many factors, including the nature of the formation. Poorly-sorted fine grain materials take longer to develop than well-sorted coarse grains. Some wells may always run clear, while particularly poorly yielding wells may take up to a day to redevelop.

STEP 11 | After surging 1-2 minutes per ft. of water, use the mini-typhoon/monsoon to pump until the groundwater well water is clearer. This process may take about 5 minutes, which results in roughly 3 buckets of water (Figure 36).
In the case of shallow or low-yield wells, do not use the high flow rate mini-typhoon pump, as it causes wells to drain immediately.

After surging, remove the sediment with a bailer and monitor the recovery data with AIS science staff to evaluate the time it takes to refill with groundwater to determine re-development timelines/expectations for the low yield well.

Note: For extremely shallow water tables, there may not be enough water for the surge block to function. In this case, well redevelopment is not possible and annual maintenance will be limited to using the bailer to stir up and remove any sediment present in the well column.

Figure 37. Post-Process Water Clarity Samples (D10 ARIK)

STEP 12 | Collect a couple final water clarity samples and photos.

Due to the mixing the water column, the water clarity samples may result a cloudy mixture for up to 30 minutes.

Figure 37 displays (A) water clarity sample immediately after using the mini-typhoon/monsoon and (B) water clarity sample collected about 15 minutes later.

Figure 38. Place Cap on GWW and Secure Cover (D09 PRLA)

STEP 13 | After the Aqua TROLL is replaced, place cap back on groundwater well (Figure 38). Secure the well with the same lock.

Figure 39. Disassemble Equipment (D10 ARIK)

STEP 14 | Disassemble equipment (Figure 39). Use pipe wrenches, if possible.

Figure 40. Sediment from Surge Block (D10 ARIK)

STEP 15 | The surge block and bailer may fill with sediment (Figure 40). Flush the surge block and bailer between wells at the same site with DI water to remove build up.

Upon completion of a GWW, conduct decontamination on the equipment. Treat materials using a 2% bleach solution, followed by rinsing and drying.

For the mini-typhoon/monsoon, immerse these items and the wire into a bucket of warm water with non-phosphate liquid detergent.

5.3.5 Data Acquisition and Power Distribution Subsystems Maintenance

5.3.5.1 GWW Base and Master Radio Maintenance

The GWW radios do not require regular maintenance. If a radio or related component requires replacement, see RD [08] for setup and configuration procedures. The GWW Base radio mounts to an AIS Device Post. It connects to a Merlot (12V) Grape, which also mounts to the same AIS Device Post, to power and facilitate GWW data transmission back to NEON, HQ through the Device Post to the Aquatics Portal. The Merlot (12V) Grape requires annual calibration and validation from CVAL. *See Section 5.3.5.3 for Sensor Refresh information pertaining to this assembly.*

5.3.5.2 GWW Standalone Power Distribution System (PDS) Maintenance

The primary GWW PDS is a standalone DC power system consisting of one solar panel, one charge controller and one 12V LiFePO4 battery. Select GWW sites may have a hardwired PDS installation due to site-specific location requirements (i.e., too much shade to use solar panels and GWWs proximity to utility power is achievable with a cable). If this power system is not present at any AIS GWW sites within your Domain, please skip to *Section 5.3.5.3 Sensor Internal Battery Check* on page 44.

5.3.5.2.1 Solar Panel Maintenance

Conduct a visual inspection of the PDS exterior components, if not already complete from Section 5.3.2. Inspect each GWW solar panel for debris accumulation, dust/dirt build-up and/or obstructions from weather events. Ensure the panel securely connects to the charge controller inside the Radio/Power box. *Reference Section 9.5.1.3 to remove snow/ice from GWW solar panels that remain operational over winter.* Disregard this maintenance if the system is down for the winter.

Note: The solar panels must receive direct sunlight to ensure full power output. If the panels are no longer receiving direct sunlight due to their orientation or vegetation shading, please submit a ticket to the NEON Issue Management/Reporting System for remediation.

5.3.5.2.2 Charge Controller Maintenance

Conduct a visual inspection of the PDS interior components (Radio/Power box), if not already complete from Section 5.3.2. Inspect the charge controller and surge protector components. The charging light on the charge controller displays a blinking green LED to display the solar panel is charging the battery or displays a solid green LED to indicate the battery is charged. A red LED indicates a problem and alternating red/green may indicate a bad battery or other problem.

5.3.5.2.3 12V Battery Maintenance

Inspect the 12V LiFePO4 battery inside the Radio/Power box. Ensure posts are corrosion-free and that connections are secure. Use the test button on the top of the battery to check the charge level (Figure 41).

Figure 41. Press 12V Battery Test Button to Check Charge Level

Pressing this test button illuminates LED indicators. All three indicators means the battery has a full charge and the battery is good. However, please be aware, the built-in test button is known to fail when the battery is still charging. If the test button indicates a failure, verify using a Digital Multi-Meter (DMM).

Figure 43. Use a DMM to Verify Battery Voltage

Note: The battery should be approximately 12.8V. Allowing the battery to discharge below 11.2V can lead to premature failure. If a battery is found to be discharged, and the charge controller is operating correctly, the battery may be damaged (unable to fully charge), or the solar panel may not be providing enough power due to shading.

1. Configure the DMM to measure in DC Volts before reading the battery voltage. The DMM is polarity sensitive under DC voltage settings.
    a. Red goes to positive +
    b. Black goes to negative –

2. Disconnect the battery plug from the board (reference Figure 42. Radio Interconnect Board) and wait ~10 minutes for the battery to stabilize to prevent false readings.

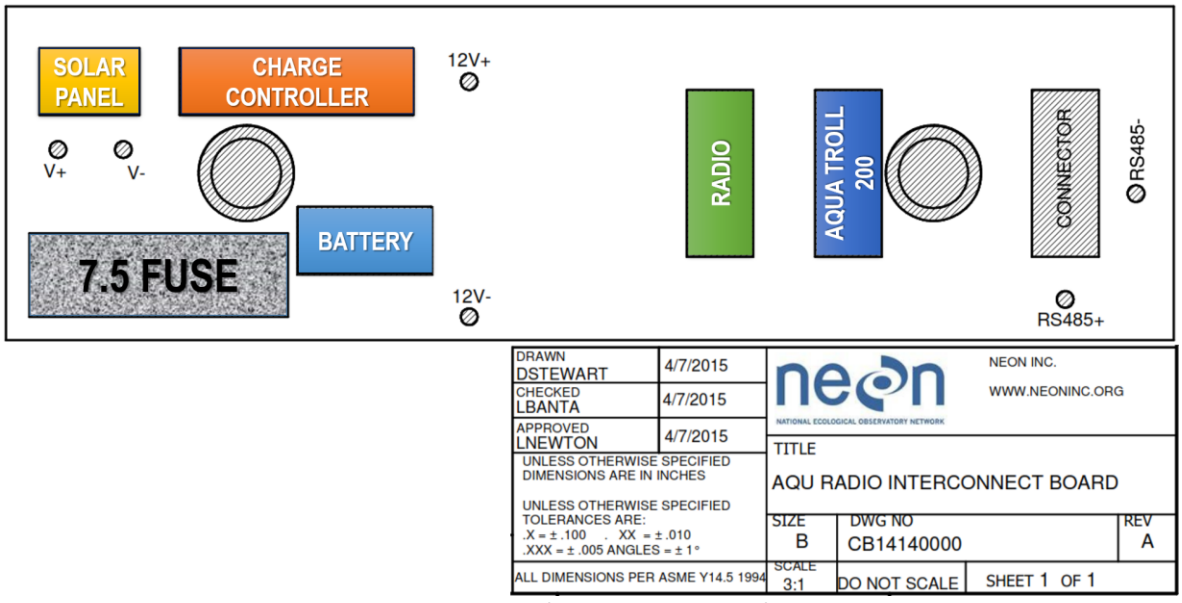

Figure 42. Radio Interconnect Board

3. Use the DMM to check the voltage of the battery (Figure 43).
    a. Greater than 12.8 volts means the battery is nominal. Plug it back into the board in the Radio/Power box. Verify the charge controller indicator light is green, either blinking or constant.

b. Less than 11.2 volts may mean the system requires a new battery or the system is not charging due to a failure upstream (with the charge controller or solar panel).

5.3.5.3 Sensor Internal Battery Check

The Aqua TROLL Instrument operates on 3.6 VDC, supplied by a sealed, **non-replaceable** AA lithium battery. That means once the battery dies, so does the sensor. Battery life depends on sampling speed. The battery typically lasts for 5 years or 200,000 readings, whichever occurs first. One reading is defined as date, time, and all available parameters polled or logged from the device.[vi] To maximize battery life, do not allow the sensor to log data internally and verify function of the standalone PDS system using the information from the sections above.

If FOPS notices data interruptions in SAS or is aware of a known/intermittent PDS issues for AIS GWW(s), start checking/monitoring the Aqua TROLL internal battery biweekly. Technicians may check the status of the internal battery using the sensor Win-Situ 5 software (Figure 44). ***Once the internal battery drops below 50%, report it the issue using the NEON project Issue Management/Reporting System. Once it drops below 45-30%, power off the Aqua TROLL until an external power source is available to consistently power the sensor.***

Figure 44. Win-Situ 5 Internal Battery Status Bar Screenshot

5.3.5.4 O-Ring Inspection and Maintenance

The O-rings insure a watertight seal between the sensor connector (Figure 45). Per ER [09] and ER [10], examine O-rings for wear, dryness, discoloration, stretching, cracks, nicks, and brittleness during sensor refresh and after long durations of sensor deployment and after seasonal weather/ environmental changes/significant temperature fluctuations. Replace O-rings when any of these conditions are present. Replace O-Rings on an annual basis, regardless their condition, is the best way to protect against moisture damage. Perform the following steps to replace an O-ring.

1. Remove and discard the damaged or old O-ring.
2. Use a clean, dry, soft cloth to clean the O-ring groove on the sensor to remove dirt or residue.
3. Lubricate the new O-ring sparingly using high-vacuum grease.
    a. Wash hands thoroughly.

Figure 45. O-Ring Location on Level TROLL Sensor (Same Location for Aqua TROLL sensor)

b. Apply a small amount of grease to the pad of index finger, and rub index finger and thumb together to spread the grease evenly.
c. Inspect the new O-ring and remove any debris stuck to it.
d. Rub fingers around the O-ring until there is a thin layer of grease on the entire O-ring.
4. Install the O-ring in the groove and remove any excess lubricant with a clean cloth.

Note: Do not allow water or lubricant to enter the connector!

6 REMOVAL AND REPLACEMENT

6.1 Equipment

Table 5. Removal and Replacement Equipment List

P/N	NEON P/N	Description	Quantity
Tools			
GENERIC		Flush cutters/Scissors (to remove zip-ties)	1
		NEON Laptop w PuTTy or MobaXterm	1
		Extra Ethernet cable (to verify sensor function via portal onsite)	
GENERIC		Hex Key/Wrench Set	1
GENERIC		Wrench Set	1
GENERIC		Flathead screwdriver (to access AIS device posts)	1
		Digital Level	1
GENERIC		Aquatic PPE	A/R
4620	MX103120	ESD Wrist Strap (to follow ESD protocols)	1
	0317730003	Well Dock	A/R
	0317730001	Antifouling Kit	1 per GWW
		TROLL Configuration Adapter (Figure 79)	1
		Female-to-female TROLL cable (Figure 79)	1
		Serial to USB Cable (some TROLLs require this cable) (Figure 79)	1
Consumable Items			
		ESD Bags (for Grape swaps)	3
		Amphenol caps (for Ethernet cables/Grapes)	2-4
0719752		7” Zip-ties (to redress cables, as applicable)	A/R
0719793		14”Zip-ties (to redress cables, as applicable)	A/R
GENERIC		Contractor Trash Bags	A/R
	0320150001	Desiccant Canister	1 per GWW
Resources			
	Win-Situ 5: https://in-situ.com/support/documents/win-situ-5-software/		1

Note: When working on power systems, use tools with insulated handles. Always shutdown the power prior to removing or replacing any components.

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 project 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 6 for sensor refresh requirements for the subsystem infrastructure on the GWW.

Table 6. GWW Subsystem Sensor Refresh Requirements

	LOCATION		TIMEFRAME			
	CVAL	*FIELD*	*BIWEEKLY*	*ANNUAL*	*NA*	COMMENTS
Merlot (12V) Grapes	**X**			**X**		Primarily at the Met Station for the GWW Radios. D18 OKSR GWW Grape is at the S-2 Combo Box Device Post. Other nuances may exist among the Observatory. For sites hardwired to Grapes (no radio), these Grapes have the same Sensor Refresh requirements.
Aqua TROLL 200	**X**			**X**		

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. Wear an anti-static wristband and tie to earth ground. Employ ESD protocols when handling Grapes. Reference RD [05].
2. Power down the site. *Reference Section 8 Groundwater Well (GWW) Power Down Procedure*.
3. Disconnect the armored Ethernet cable connecting to the RJF/Eth to Comm connection.
4. Disconnect sensor connection(s).
5. Remove the one Merlot Grape via its Grape Shield (Figure 46). Remove the four screws that affix the Grape to the Grape Shield using a hex wrench.

Figure 46. Remove Grape from Grape Shields (D06 KING)

a. If there is a need to remove the Grape Shield from the Unistrut, remove the Grape Shield Unistrut mount/clamp using a 3/16" hex wrench (Figure 47).

PRO TIP: It is easier to reinstall the Grape in the Grape Sheild when the mount is removed from the infrastructure (Figure 47).

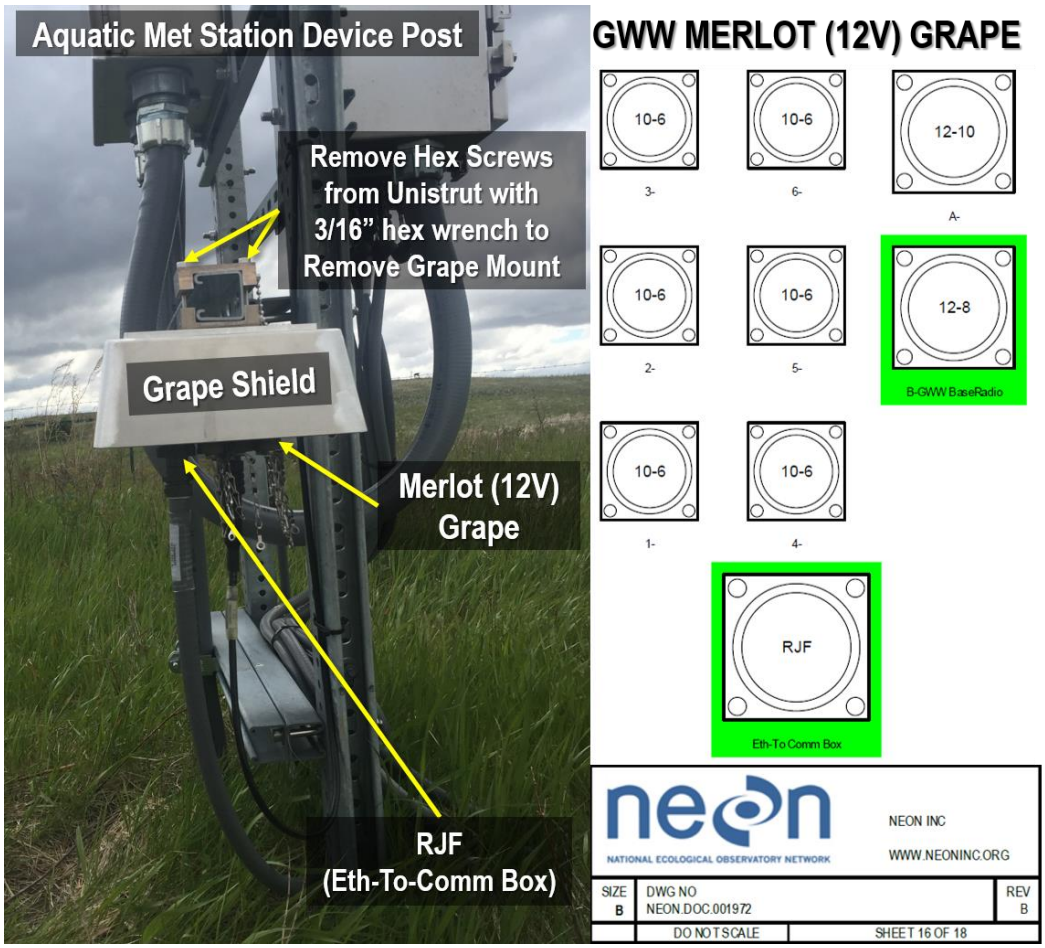

Figure 47. GWW Grape Location (D09 PRLA) and Port Mapping (See AD [05])

6. Place dust caps on Amphenol connectors of old Grape.

7. Reinstall new Grape to the Grape Shield by threading the four screws that affix the Grape to the Grape Shield using a hex wrench.

8. Remove dust caps on sensor connectors and Eth-To-Comm connector. Re-connect sensor and armored Ethernet cable in accordance with AD [05].

9. Re-energize the site and verify Grape function. Connect locally to the Aquatics Portal or from the Domain using a Terminal Emulator Program (TEP), such as PuTTy or MobaXterm, and Table 3. View Grape and Sensor Data Streams (MAC and EPROM ID are Examples for this Command).

6.2.2 Aqua TROLL Sensor Removal/Replacement Procedure

6.2.2.1 Aqua TROLL Sensor Removal Procedure

Use this procedure to remove the sensor for annual Sensor Refresh. Acquire the tools from Table 5 necessary to conduct the procedure in Table 7.

Table 7. Aqua TROLL Sensor Removal Procedure

STEP 1 | Power down the site. *Reference Section 8 Groundwater Well (GWW) Power Down Procedure*.
 **Figure 48. Disconnect Sensor Cable (D19 CARI)** **STEP 2** | Remove wire connected to troll from the bottom of the instrumentation box by pushing the plug upward while simultaneously twisting clockwise (Figure 48). Place red plastic nipple dust caps at the end of the Aqua TROLL cable connector (Figure 49) and power box connector.      **Figure 49. Red Plastic Nipple Cap (ER [01])**
 **Figure 50. Unlock GWW (D19 CARI)** **STEP 3** | Unlock combo/key lock to access GWW inside (Figure 50).

Figure 51. Remove PVC Cap from GWW (D19 CARI)

STEP 4 | Remove cap from GWW (Figure 51).

Figure 52. Remove Well Dock from GWW (D19 CARI)

STEP 5 | Remove well dock from (metal ring) from PVC (Figure 52).

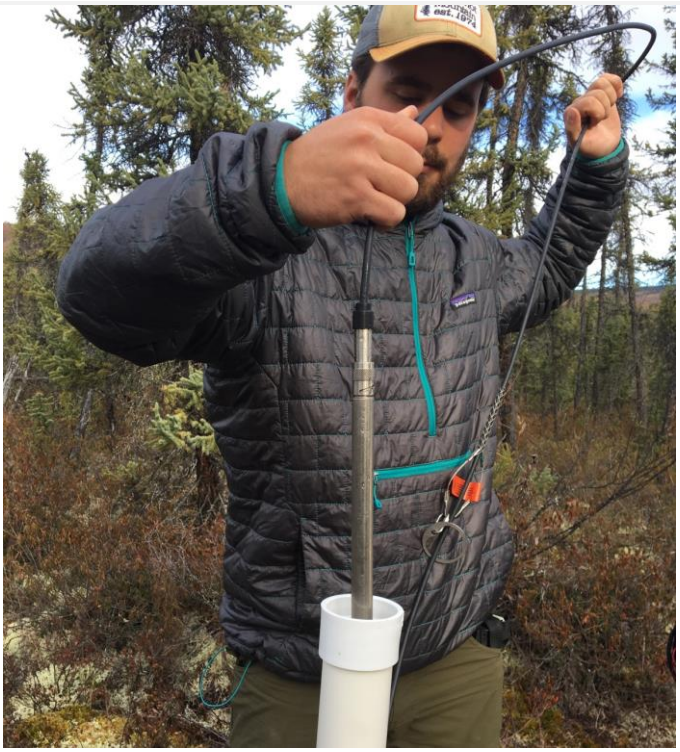

Figure 53. Remove Aqua TROLL 200 from GWW (D19 CARI)

STEP 6 | Remove the Aqua TROLL 200 sensor from the GWW by pulling the troll cable out of the well (Figure 53).

For Sensor Refresh, remove the copper biofouling guard by twisting the black collar to loosen it and then slide it gently down and off the sensor.

Remove the copper nose cone and replace with a black nose cap.

Keep antifouling components (Figure 55 in the next section) at the Domain Office and send the Aqua TROLL to HQ with the black plastic nose cone.

STEP 8 | Reference Section 5.3.3.4 to separate sensor from cable.

6.2.2.2 Sensor Reinstallation at Groundwater Wells

6.2.2.2.1 Installation Preparation

STEP 1 | Unpack sensor and verify items using a packing list. Inspect for shipping/handling damage.

Figure 54. Unthread Black Nose Cone from Sensor

STEP 2 | Remove black nose cone form the sensor (Figure 54).

Figure 55. Install Antifouling Parts on Sensor

STEP 3 | Install the anti-fouling kit onto the sensor exterior (Figure 55). Tighten by turning the black barrel to finger tight.

Figure 56. Cable and Wire Basket with Well Dock Orientation

STEP 4 | Assembly cable with wire basket assembly and well dock. Orient the cable using the wire basket as the guide with the big wire loop pointing away from the sensor end (Figure 56). Position the basket a few feet from the top of the cable.

Note: If it is ever necessary to move the wire basket, slide it up or down the cable by pushing from the bottom of the wire basket. Pulling on wire basket causes the device to tighten and lock in place.

Figure 57. Cable to Sensor Connectors

STEP 5 | To connect instrument cables reference Section 5.3.3.4.

These are the same for the sensor (Figure 57) and desiccant canister (Figure 58).

Figure 58. Desiccant Canister to Vented Cable Connectors

STEP 6 | Log onto the Aqua TROLL 200. Check internal battery level and clear any residual logs. *Reference Section 5.3.5.3 for instructions to check internal battery level and Reference Section 11 to access the logging area of the sensor in Win-Situ 5 software.*

6.2.2.2.2 Installing Sensor Assembly in Well

1. Set the cable length to the value specified by AIS. **DO NOT CHANGE CABLE LENGTHS WITHOUT NOTIFYING AIS STAFF!** Report cable length changes via the NEON project's Issue Management/Reporting System. Measure cable length from the well dock ring (Figure 60) to the position on the Aqua TROLL where the copper nose cone connects to the instrument (Figure 59).

Figure 59. Red Line Identifies the Position to Measure for Sensor Cable Length

PRO TIP: Use a paint pen/Sharpie marker to mark the location of each GWW cable to ensure accurate reinstallation of cable length/placement. For consistency between sites, mark the cable where it crosses the metal ring when sitting in the well. Any misalignment should result in a trouble ticket notifying AIS Staff to provide science evaluation/guidance.

2. Lower the sensor slowly into the well (conduct the reverse action of Figure 53 in Table 7) until the well dock seats at the upper collar. Never allow a sensor to fall freely down a well. Ensure the well dock sits flush with the collar. Figure 60 displays an example of a seated well dock in PVC.

Figure 60. Well Dock in PVC casing

3. Locate the true position of the sensor in the well. Conduct the following steps to determine the position of the Aqua TROLL in the GWW.

    a. Check the depth to water in the GWW using the Water Level Tape (Figure 61). Water Level Tape measurement is in Meters.

        1. Lower the probe slowly into the well until a signal is audible (a beeping sound).

        2. Pull the probe back up by a few inches and very slowly lower the probe back into the well until the signal is barely audible.

3. Read the marking on the tape and record this value. This value represents ***Depth to Water*** measurement.

Figure 61. Water Level Tape to Measure Depth to Water

b. Measure and record the distance from the metal dock ring to the top of the PVC.

c. Connect a laptop to the Aqua Troll to collect the sensor depth reading.

   - Open the Win-Situ 5 software and select the home screen where it displays the sensor depth reading. This value is also in Meters and represents the ***Aqua TROLL depth*** (sensor depth from the water surface or how deep into the water the Aqua TROLL is).

PRO TIP: *Check the level of water above the sensor, then move it and read again to be sure the sensor presents a reasonable reading and shows change. This action verifies potential location errors from installation.*

d. Convert measurements to align unit of measurement and confirm values.

e. Add top of well casing to water surface + sensor depth from water surface and compare total measurement with cable length + dock to PVC total measurement. Figure 62 is a graphic example of this equation. Adjust the position of the Aqua TROLL to align with the cable length + doc to PVC measurement.

   - In the event FOPS Technicians are not able to complete this action due to well water level or other unforeseen/unanticipated issues, submit a ticket in the NEON project Issue Management/Reporting System.

4. Configure the Aqua TROLL referencing Section 11.
5. Disconnect from the Aqua TROLL and connect the Aqua TROLL to its power source.
    a. Gently tuck any remaining cable into the void between the PVC well pipe and outer casing of the well. Do not kink any cables.
    b. Do not allow the vented cable to kink or bend beyond its recommended minimum bend radius of 13.5 mm (0.54 in or approximately 2X the cable radius).

Note: Maintain extra red plastic dust caps for future maintenance/use and the Aqua TROLL sensor asset tags in the AIS Device Post Combo Box. Environmental factors and inclement weather may destroy the tags if they remain on the sensor. Maintain consistent use and tracking of asset tags within the Domain, across all AIS sites.

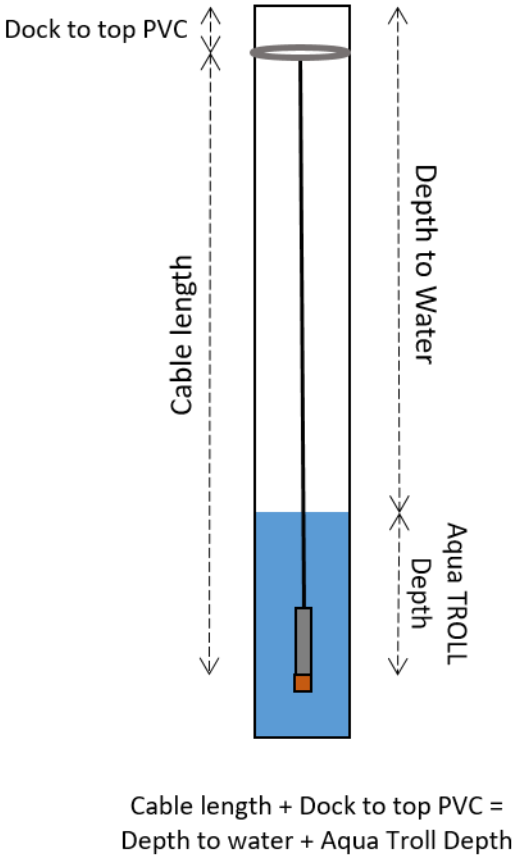

Figure 62. Measurements for Setting and Checking Sensor Position

6. Close the well casing cap and move to the next well.
7. Close the well casing cap and secure the GWW. Move to the next GWW.
8. After each GWW is complete, reference Section 8.1.1to connect to the PoE Switch to enable data logging post 30 minutes after reinstallation of the last Aqua TROLL. The next section describes this waiting timeframe as Stabilization Time in more detail.
9. Verify data transmission and logging using the information in Section 5.3.1 Remote Monitoring.

6.2.2.2.3 Stabilization Time

Stabilization time improves sensor data quality. After returning the sensor to the GWW, allow the sensor to stabilize to the water conditions for about thirty minutes before enabling data logging from the PoE Switch. Temperature stabilization and stretching may cause discrepancies in sensor readings. Submit an **AIS Data Quality** ticket to inform AIS staff of GWW maintenance and sensor swaps to monitor the data post-stabilization time to determine if the timeframe requires adjustment.

For well redevelopment efforts, re-enable data transmission immediately after the work is complete and notify AIS staff of the work timeframe to correlate and monitor the GWW data post-redevelopment at HQ.

6.3 Sensor Storage Requirements

Store the Aqua TROLL Instrument in an environmentally controlled, clean and dry place. Place the protective red plastic nipple cap on the cable end, or store the sensor with cable attached to protect the connector pins and O-ring. Wrap the open end of the cable with a plastic baggy and electrical tape for temporary protection or use a red plastic nipple cap. Store the instrument in secure packaging to prevent crushing or dropping the sensor. The sensor storage temperature range is -40°C to 65°C (-40°F to 149°F).

Note: Verify the Aqua TROLL is NOT Logging prior to storage. Logging will drain the Aqua TROLLs internal battery. The internal battery is not user replaceable and results in requiring a completely new Aqua TROLL for the site. Reference Section 11.2 to disable logging.

6.4 Cleaning & Packaging of Returned Sensor

Field Operations staff clean, package, and ship the sensors back to the CVAL at the NEON project HQ (Battelle Ecology) for annual sensor swap/calibration requirements. (Please note: if a sensor is defective, submit a trouble ticket and affix a red tag with the trouble ticket number on it.) Clean the Grape (also known as decontamination; *Reference AD [04]*) 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 instruments prior to packing and shipping. Reference AD [04].

For the cleaning and packaging of Grapes and Sensors post-removal, conduct the following steps:

1. Check mounting holes for spiders and spider webs. Remove biologics and clean connectors.
2. Cap all connectors.
3. Conduct decontamination and remove any additional biologics from the devices. Use a 10% bleach solution for the Grape(s). Reference AD [04] for the sensor and use Section 5.3.3 for additional cleaning guidance. Replace the copper antifouling parts with the black plastic protectors for shipping/handling. Decontaminate the copper antifouling parts to place on the new sensor.
4. Pack the devices for shipping/handling.
    a. Place Grape(s) in an ESD bag and shipping container.
    b. Verify Aqua TROLL was decontaminated and antifouling components were swapped with clean black plastic protective caps.
    c. Place sensor in an ESD bag. Ship the sensor back to HQ in the same shipping package CVAL provided for the “refreshed” Aqua TROLL sensor.
    d. On the packing list or the ESD bag on a piece of tape, label the old Aqua TROLL’s GWW number. This informs CVAL staff of the sensor’s assigned number to communicate with the sensor for calibration/validation.

5. 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 TRANSIT/DxxSUPPORT.

6. 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.
7. Prepare an Electronic Transfer Request (ETR) and Bill of Lading.

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

For Sensor Refresh, package sensor items via packaging from CVAL HQ with packing list or per guidance via the Issue Management System and return to the NEON project HQ using the following address:

BATTELLE ECOLOGY, **ATTN: CVAL**
1685 38TH STREET, SUITE 100
BOULDER, CO 80301

Only include sensors/subsystems for refresh. Additional equipment must ship separately as they may require attention from other NEON HQ departments. Sensor refresh shipments go direct to CVAL. If sensors are shipping to HQ to address a trouble ticket, per guidance via the Issue Management System, return to the NEON project HQ using the following address:

BATTELLE ECOLOGY, **ATTN: REPAIR LAB**
1685 38TH STREET, SUITE 100
BOULDER, CO 80301

6.5 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.

6.5.1 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 recordkeeping 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 TRANSIT/DxxSUPPORT.

7 ISSUE REPORTING OUTPUTS

FOPS must report issues encountered while conducting preventive maintenance in the NEON project 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 aquatic infrastructure, relevant 2nd/3rd order effects to infrastructure, possible cause(s) [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 8. GWW Metadata Output Checklist

Issue Reporting Datasheet		
Datasheet field	**Entry**	
NEON Site Code		
Maintenance Date		
Maintenance Technician		
Preventive Maintenance	**Issue Noted**	**Issue Summary**
Aqua TROLL Sensor - Configuration Check – Data streams on Network/SAS?	☐	
Site – Condition Check	☐	
GWW Infrastructure - Condition Check	☐	
Sensor – Condition Check	☐	
Sensor Cables & Connectors - Condition Check	☐	
Environmental Information	☐	
Notes		

8 GROUNDWATER WELL (GWW) POWER DOWN PROCEDURE

8.1.1 GWW Shut Down Procedure

Powering down the instrumentation enables Technicians to perform work with fewer 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. A solar charged LiFePO4 battery independently powers each GWW. When performing routine GWW maintenance, disable all GWW sensors by turning off the GWW Merlot (12V) Grape, which either mounts to the Aquatic Met Station device post or other local AIS device post with the Master Radio, by disabling power at the device post PoE (Power over Ethernet) switch.

1. Acquire the following equipment: Fully charged NEON laptop, Ethernet cable, Combo for portal lock/flathead and Philips-head screwdriver to access equipment in device posts, a paper copy of this procedure to reference onsite, applicable PPE and PM equipment from procedures above, as applicable.

2. Connect a NEON laptop to an open port on one of the PoE switches in the Aquatics Portal, Aquatic Met Station Comm box, or S-1/S-2 device post, as applicable per site-specific installation of the GWW Grape location.

3. Find the GWW Merlot (12V) Grape MAC (media access control) address. There are two ways to find the for this procedure MAC address.

    a. Option 1: Look at the MAC address barcode physically on the grape. This begins with "**7CE04400**" in Figure 63.

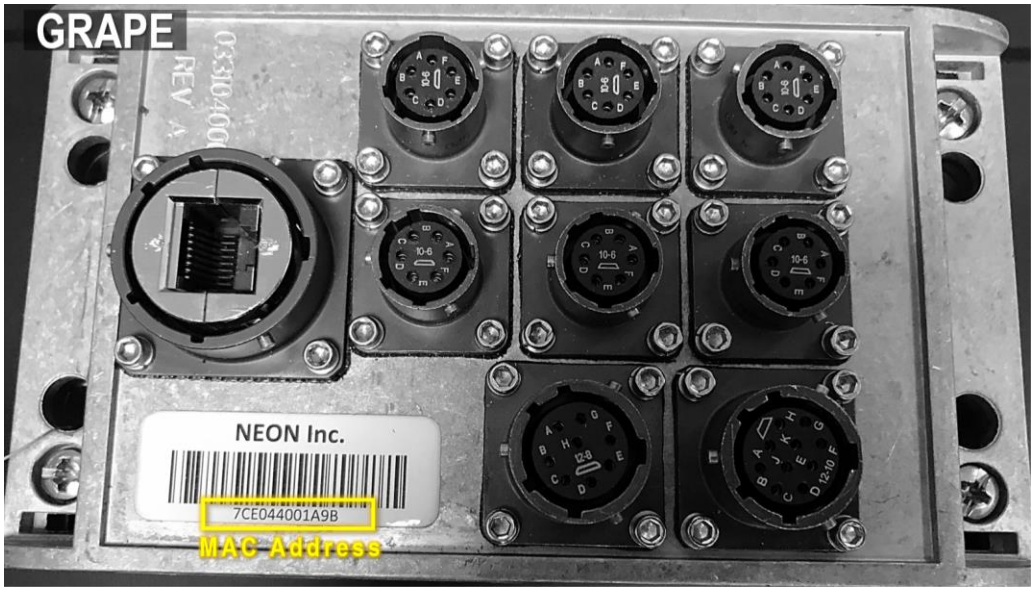

Figure 63. Location of MAC Address on Grape

b. Option 2: Use a terminal emulator program (TEP), such as PuTTy or MobaXterm, to login to the LC. Run "**`nc localhost 30200`**" to list the Grapes in the system. Reference Figure 64.

```
user@D03-BARC-LC1:~$ nc localhost 30200
1    7ce044001185 10.103.129.14    NEON-BUOY            80141          0              0              0x0      15389


1    7ce044001fae 10.103.129.24    NEON       Grape     159861         0              0              0x0      137302655377326        32008
                26044

1    7ce044001466 10.103.129.27    NEON       Grape     137268         0              0              0x0      35820                  1373026
55374438        12755

1    7ce044002048 10.103.129.30    NEON       Grape     82037          0              1              0x0      137302655377480        22714
                12036                 2274                  22713                 22728                 23706                  22720

1    7ce044001b03 10.103.129.31    NEON       Grape     94324          0              0              0x0      137302655376131        20706
                21155

1    7ce044001b11 10.103.129.38    NEON       Grape     94325          0              0              0x0      137302655376145        20711
                21121
```

Figure 64. Example of using LC to find grapes

i. In Figure 64, the Aqua TROLL EEPROMs at D03-BARC are **22714**, **12036**, **2274**, **22713**, **22728**, **23706**, and **22720**. Reference site sensor mapping documents if they are kept current.

c. The GWW Merlot (12V) Grape MAC address for this example is "**7CE044002048**".

4. Open a web browser and connect to the Aquatic Met Station (or other applicable device post) PoE switch (Figure 65).

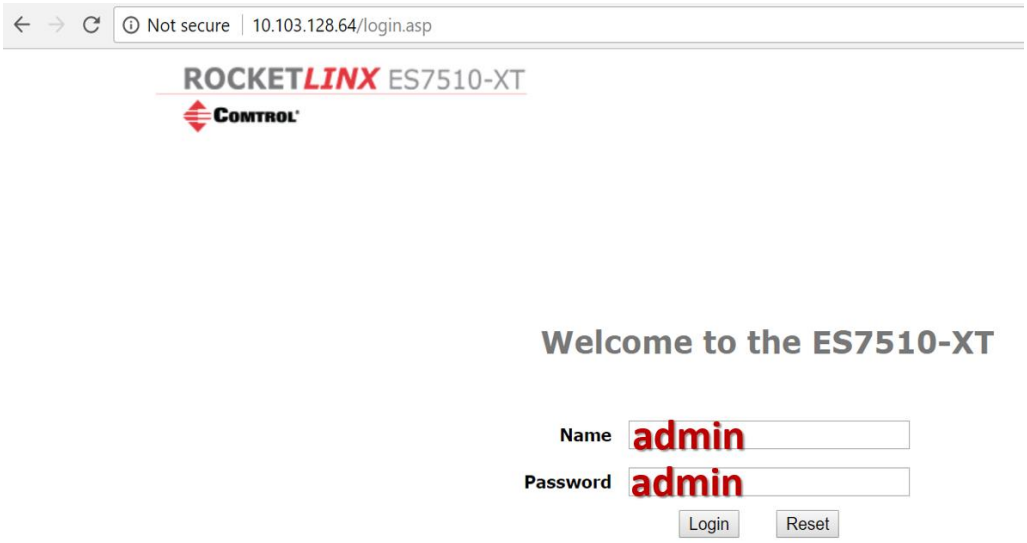

Figure 65. PoE Switch Login Page

a. This is generally **10.<DOMAIN>.<SITE>.64** (e.g., for D03-BARC, the Met Station PoE switch is **10.103.128.64**). Enter username and password and click Login.

5. Verify that this is the Aquatic Met Station PoE Switch. The System Name should be "**DOMAIN-SITE-SW-MET**" (Figure 66). If the system name does not end in SW-MET, refer to site-specific network configuration to find the correct IP address via the NEON Network Drive (N:\Common\SYS\Site Network Configurations).

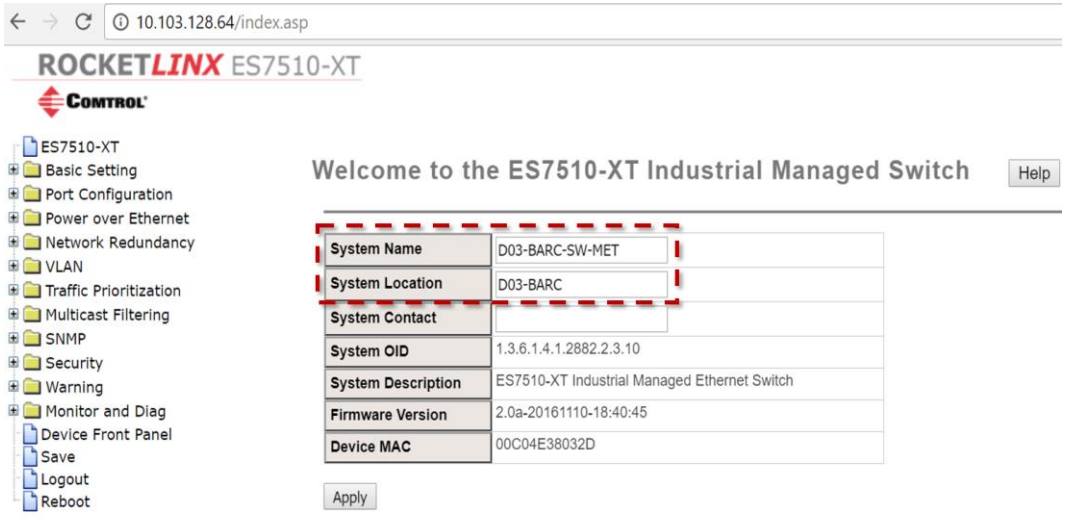

Figure 66. PoE Switch Home Page

6. Select the **Mac Address Table** under the **Monitor and Diag** folder (Figure 67).

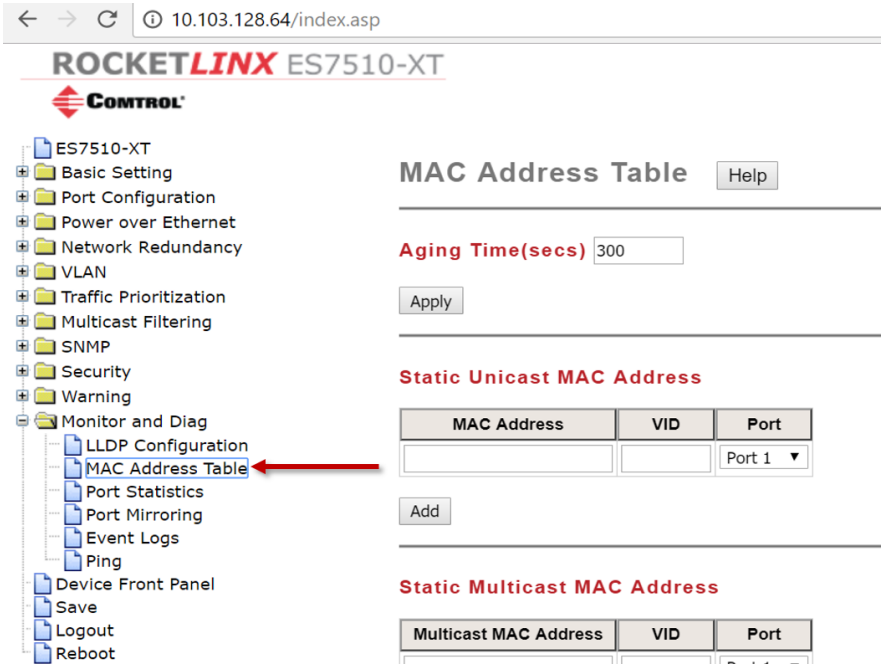

Figure 67. PoE Switch MAC Address Table Selection

7. Scroll down the screen to view the **MAC Address Table** (Figure 68). Locate the MAC Address of the GWW Merlot (12V) Grape in the **MAC Address Table** to identify its Port location on the PoE Switch. In this example, "**7CE044002048**" is located in PoE Switch Port "**8**". **DO NOT DISABLE PORT 9 OR 10 REMOTELY. THESE PORTS CONNECT TO FIBER, NOT THE GRAPE.**

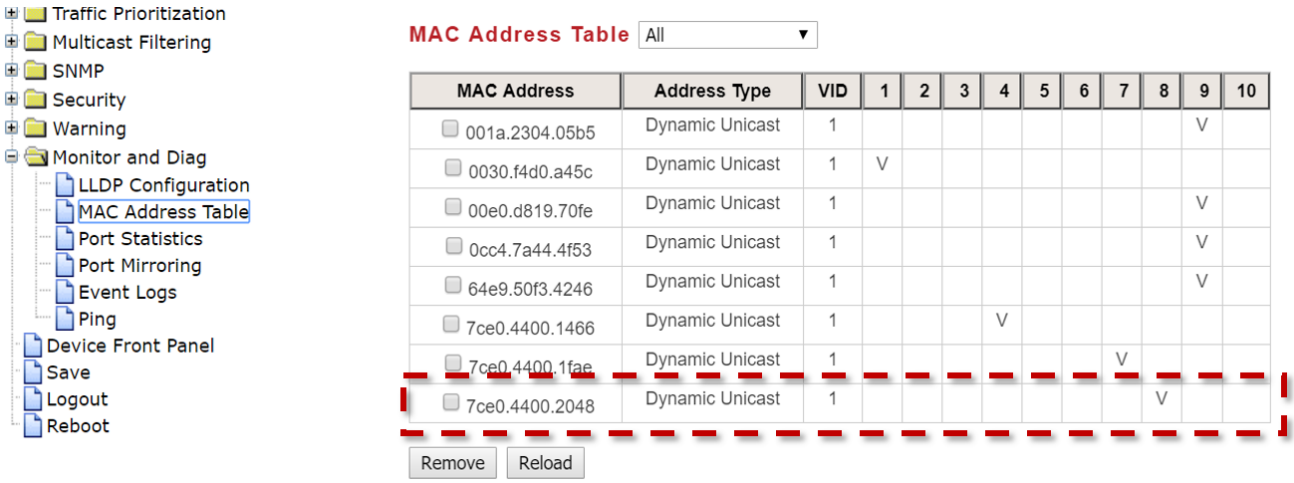

Figure 68. PoE Switch MAC Address Table

8. Select **PoE Control** from the **Power over Ethernet** folder (Figure 69).

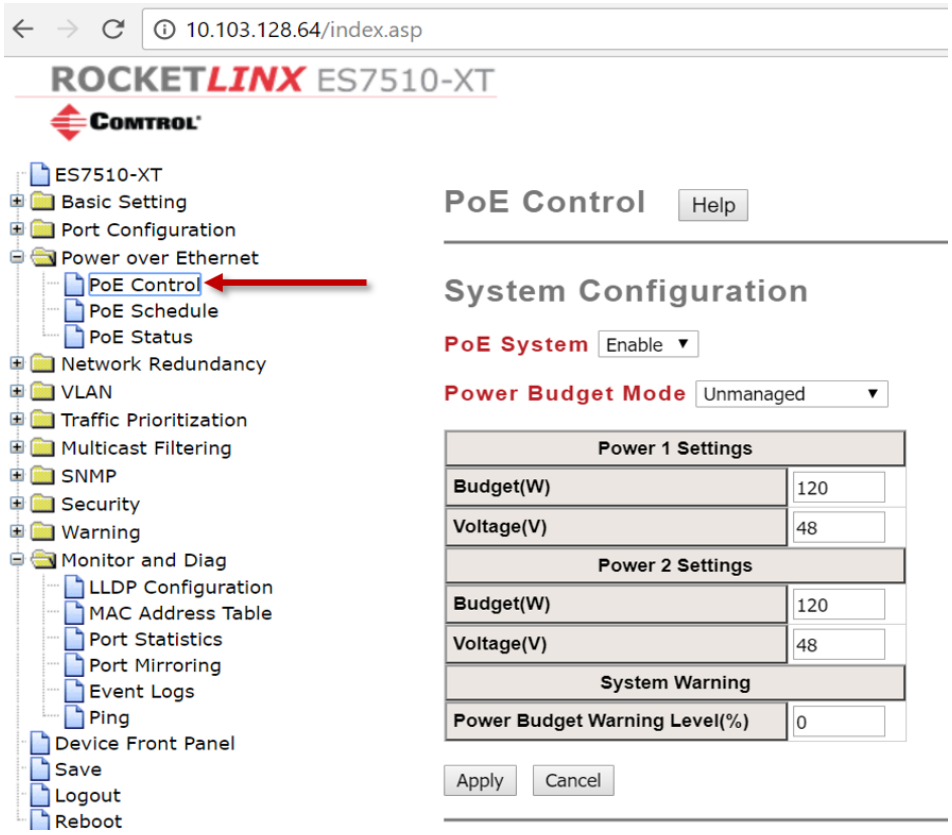

Figure 69. PoE Switch PoE Control

9. Scroll down on the screen to view the **Port Configuration** table (Figure 70). Under the **Mode** column, select "**Disable"** for the Port "**8**" and click "**Apply**" to turn off the port. **DO NOT DISABLE PORT 9 OR 10 REMOTELY. THESE PORTS CONNECT TO FIBER, NOT THE GRAPE.**

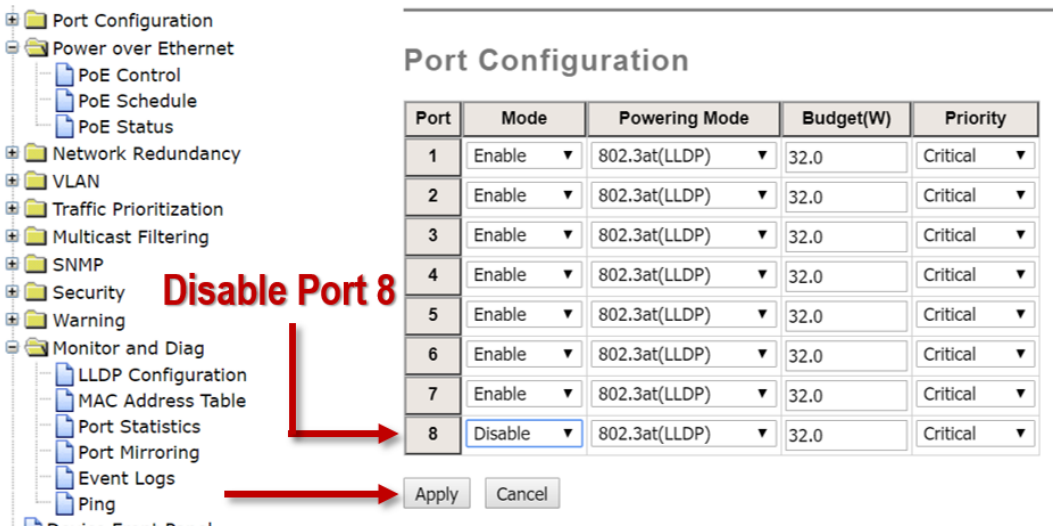

Figure 70. PoE Switch Port Configuration

10. Select "**OK**" at the prompt (Figure 71).

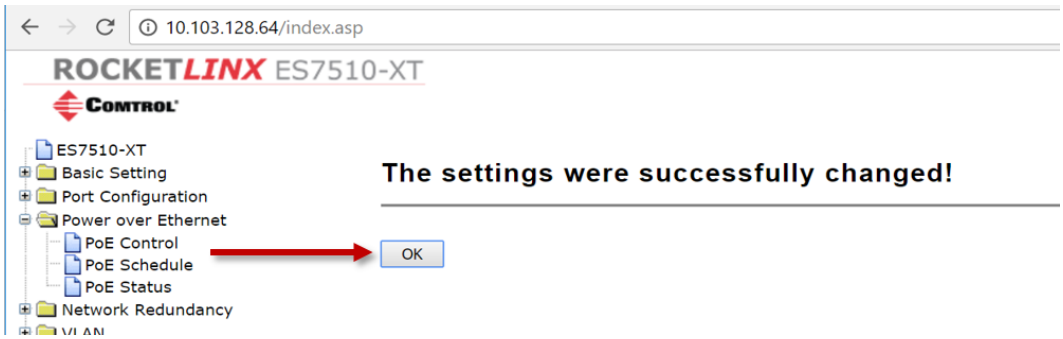

Figure 71. PoE Switch Settings Changed

11. Verify the GWW Merlot (12V) Grape is OFF. In the same TEP to locate Grape MAC Address, run "**`vd |grep -i [MAC Address]`**". When the Grape is on, it displays state of health streams and data (Figure 72). ***When the Grape is OFF, there are no outputs from view data.***

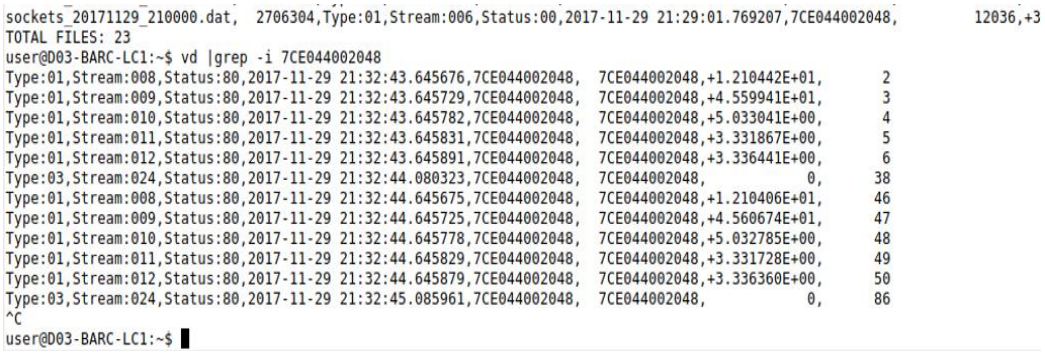

Figure 72. Verify Grape Activity

12. This stops the transmission of GWW data to NEON, HQ to "flag" the data during regular biweekly preventive maintenance occurs on the Aqua TROLLs/GWWs.

13. To turn the GWW Merlot (12V) Grape ON, conduct the same procedure with the exception of changing Port "**8**" dropdown to "**Enable"** in the "**Mode**" column, and click "**Apply**".

8.1.2 Aquatic Met Station Shut Down Procedure

If additional sensors/subsystems require maintenance at the Met Station, it is also acceptable to power down the Aquatic Site Met Station Device Post/Comm box providing power to the GWW Grape and Master Radio. Powering down the site enables Technicians to perform work with fewer 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.

Note: This procedure de-energizes the Aquatic Met Station power and data collection, and only the GWW data collection. The GWWs still receive power from their standalone DC power system.

1. Power down the site from the AIS Device Post power box via the breakers. Use Figure 73 for this procedure.

    a. Open the Power Box using a Philips head screwdriver.

    b. Flip both breakers from RED to GREEN.

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

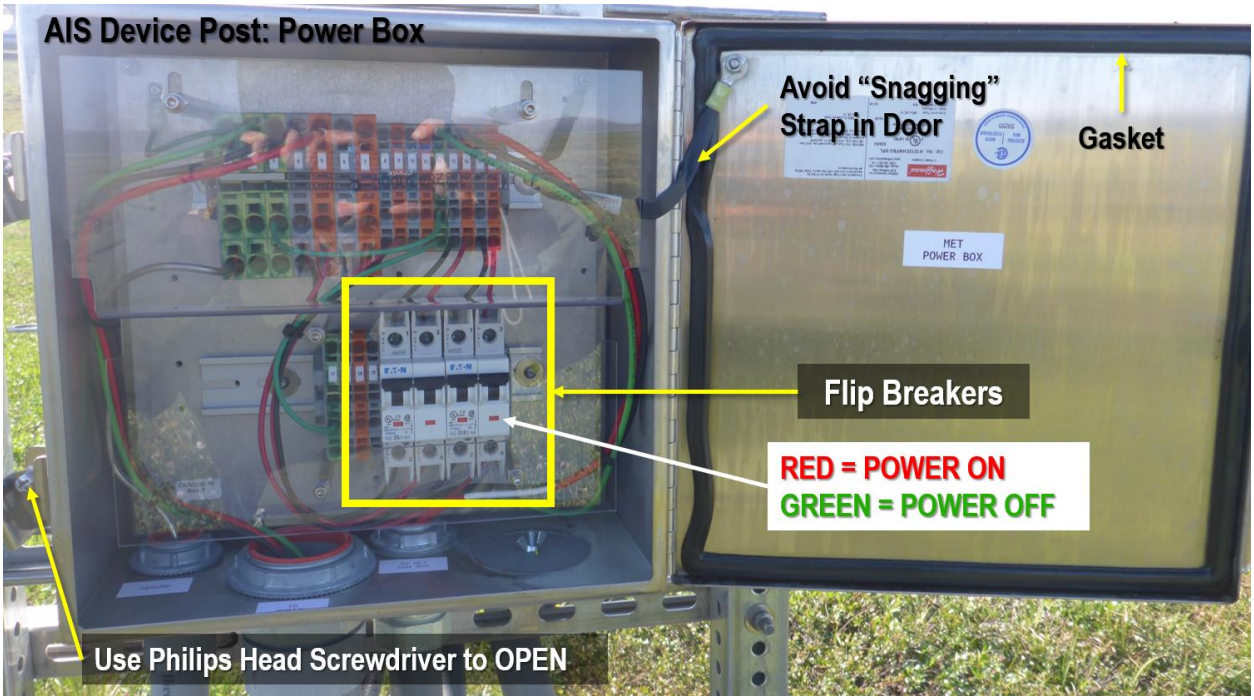

Figure 73. AIS Device Post: Power Box Components (Domain 18 OKSR AIS Aquatic Met Station)

If there is a need to remove a sole sensor assembly onsite, then power down the sensor assembly from its Grape. Remove the armored Ethernet cable from the Merlot Grape RJF/Eth-To-Comm connector before disconnecting or connecting the master connection. Removing connections after removing the RJF/Eth-To-Comm cable is required practice to avoid accidental hot swapping when the power is ON. *Reference* AD [05] *for AIS Grape mapping.* Follow ESD procedures in RD [05].

9 GROUNDWATER WELL (GWW) WINTERIZATION REQUIREMENTS

9.1 GWW Winterization Requirements

This procedure specifically applies to sites that incur winter temperatures that fall below infrastructure environmental thresholds, as applicable (D05, D09, D12, D18, and D19 per NEON.AIS.4.1314). **This is mandatory for sites in Alaska (D18 and D19).** AIS Science is addressing the remaining sites on a case-by-case basis to monitor and evaluate the success of vented caps and weather patterns to determine best-case scenario or determine if there is a need to remove the instrument and battery from each GWW (D05, D09, D13 and D12).

The Domain Manager must use their discretion to determine the most appropriate time to shut down the site as October arrives, and when to start-up in May (per TIS Science guidance for snowpack at D18 TOOL). Follow the AIS Science ice-on/ice-off rule of thumb – remove/shutdown when ice accumulates and reinstall/startup when ice melts.

Note: Dates for removal/reinstallation are subject to change as Domains experience and gain additional insight on weather patterns. Track dates using the NEON Project Issue Management and Reporting System.

See Table 9 for specific guidance on infrastructure equipment requiring removal from the AIS sites over winter.

Table 9. GWW Winterization Requirements

Equipment	Remove	Leave	Comment/Additional Actions
NEMA Enclosure		**X**	
Solar Panel		**X**	
Solar Charge Controller, 12.8V LiPO4, 65W		**X**	Operating Temp: -40°C - 85°C 10 Year Warranty Trickle charge to recover dead battery
Radio Modem, 900 MHz, RS485		**X**	Operating Temp: -40°C to 85°C
Battery, LiFePO4, 12.8V 25AH	**X**		No need for a trickle charger. Requires charging prior to re-installation. Charge battery pack with specific charger, 0.2 C20A constant Current/constant voltage to 15.2V. Storage Temperature: -10~40℃ Best storage temperature for long durations: 20±5℃
Antenna, Omnidirectional, 900 MHz, 6dBi, N-female		**X**	Operating Temp: -40°C to 60°C
Molex Connectors		**X**	Non-operating/Operating: - 40°C to + 105°C
Cables	**X**	**X**	Ice may form on cables that remain onsite. Remove ice from cables when able to access equipment onsite.

Aqua TROLL 100 and 200 Instruments	
Temperature ranges[1]	Operational: -5 to 50° C (23 to 122° F) Storage: -40 to 65° C (-40 to 149° F) Calibrated: 0 to 50° C (32 to 122° F)
Dimensions & Weight	Diameter (OD): 1.83 cm (0.72 in.) Length: 31.5 cm (12.4 in.) Weight: 188 g (0.41 lb)
Materials	Titanium body and sensors, Delrin® nose cone, and PVC conductivity cell
Output options	Modbus/RS485, SDI-12, and 4-20 mA
Battery type & life[2]	3.6V lithium. 5 years or 200,000 readings[3]
External power	8-36 VDC; Measurement current: 15 mA; Sleep current: 40 mA
Memory Data records[4] Data logs	4.0 MB 190,000 50
Log types[5]	Linear, Linear Average, and Event
Fastest logging rate	Linear: 1 per minute. Linear Average: 1 per minute. Event: 1 per second
Fastest output rate	1 per second

Figure 74. Aqua TROLL 200 Specifications (Source: ER [02])

9.2 Equipment

Table 10 provides a list of equipment to removal/reinstall the GWW batteries, Aqua TROLL 200 and remove ice from cables, locks, and solar panels.

Table 10. Winterization Equipment Removal Procedure Equipment List

P/N	NEON P/N	Description	Quantity
Tools			
GENERIC		Flathead Screwdriver (to open Power/Comm boxes)	1
CH-LF12810A	0354920000	AA Portable Power Corp, Smart Charger (designed to charge the GWW LiFePO4 batteries)	1
33401		Oatey SCS 33401 2 in. Gripper Mechanical Plastic Test Plug (to plug GWW PVC opening)	3-8
		Winter Weather Equipment	A/R
GENERIC		¼" allen wrench (to adjust solar panels in winter)	1
GENERIC		½" socket or combination wrench (to adjust solar panels in winter)	1
Consumable Items			
GENERIC		Packaging (to protect batteries in transit to the Domain)	A/R

P/N	NEON P/N	Description	Quantity
555628126		DuPont Non-stick dry film lubricant (Teflon fluoropolymer) in a squeeze bottle	4 oz.
GENERIC		Towel/Rag (for dry film lubricant application)	1-2
		Red Plastic Nipple Caps (in-situ caps that come with assembly)	6-16
GENERIC		Plastic Baggy	3-8
GENERIC		Electrical Tape (use Tape rated for -70°C and Rain for covering connectors on the power box, regular tape to cover cables temporarily for storage at the DSF)	1 Roll
3M		ESD Bags	3-8

9.3 GWW Radio Box Battery Removal/Reinstallation Procedure

The GWW Radio Box battery is part of the standalone solar DC power system that resides over or near each GWW.

9.3.1 Remove GWW Radio Box Battery

1. Unplug the Aqua Troll power cable from the Radio/Power box (Figure 75).

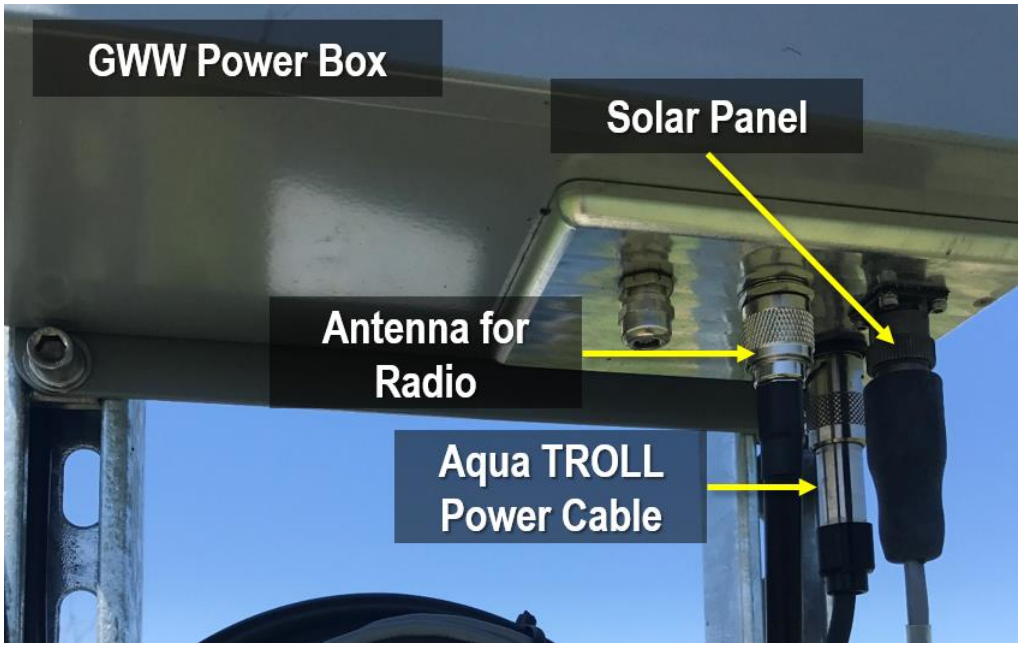

Figure 75. GWW Power Box External Connectors

2. Cap the Aqua Troll power cable connector. Use the red nipple provided with the assembly or a small plastic bag with electrical tape.

3. Cap the connector on the Radio/Power Box. Use the red rubber nipple initially provided with the assembly and secure it with electrical tape to the Comm box.

4. Open GWW Radio/Power Box using a flathead screwdriver.

5. Unplug the solar panel connector from the junction board (*CB14140000*) using Figure 76. ***Squeeze the locking tab prior to pulling the cable from the board. Be gentle to prevent un-seating any of the pins in the connectors.***

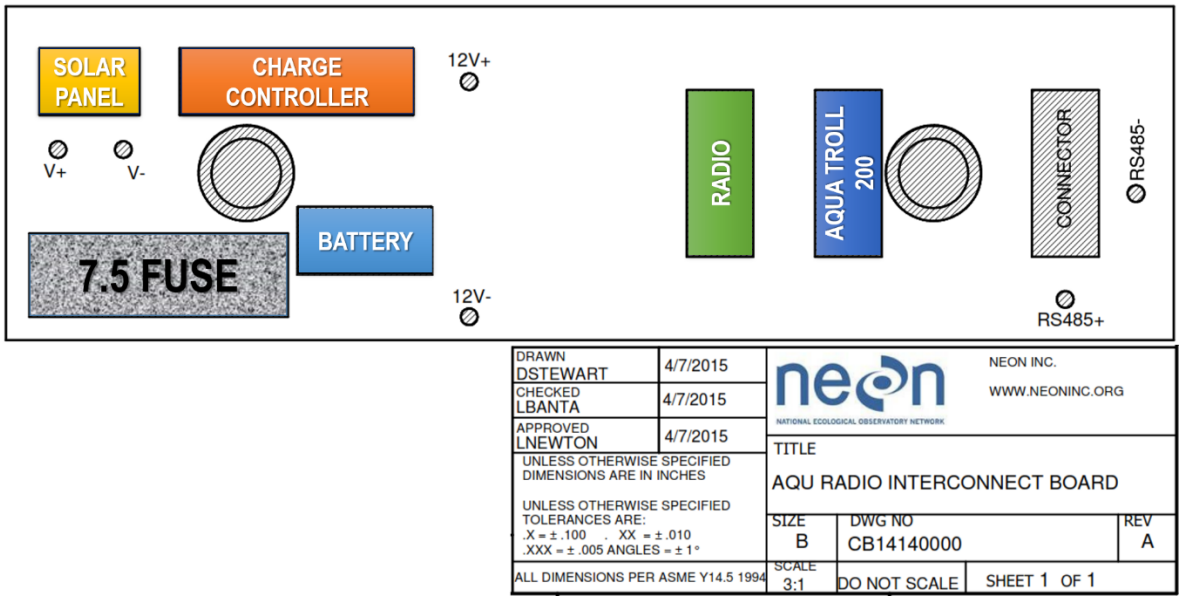

Figure 76. Graphic Overlay of Connectors on CB14140000

6. Unplug the battery connector from the junction board in the upper right hand area of the NEMA enclosure/ Radio/Power box (see Figure 76 and Figure 77). The red and black leads connect together at this connection. ***Squeeze the locking tab prior to pulling the cable from the board. Be gentle to prevent un-seating any of the pins in the connectors.***

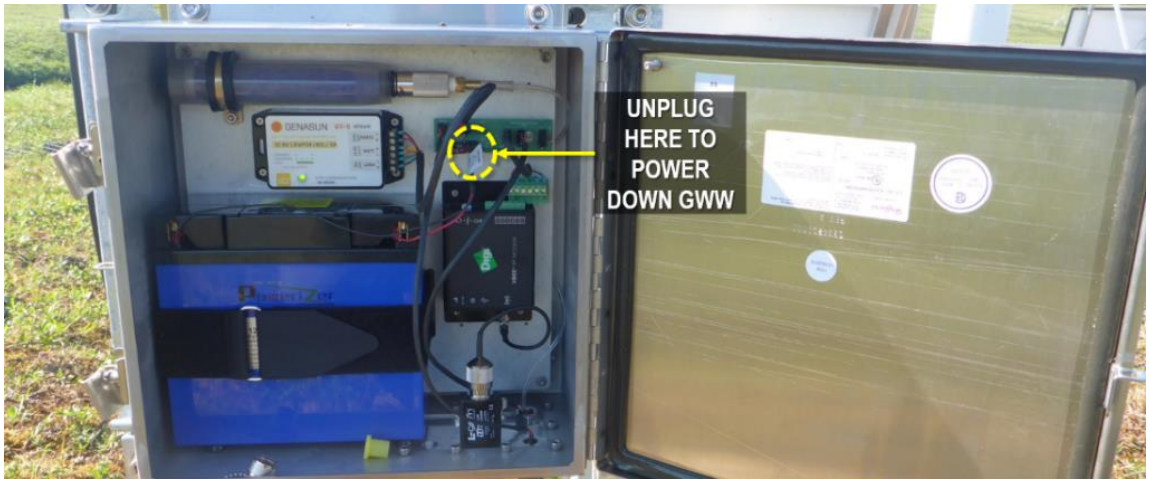

Figure 77. Unplug the Battery Cable to Power Down the GWW

7. Release battery from Velcro strap and place in packaging/bag/box.

8. Close GWW Radio/Power Box using flathead screwdriver.

9. Conduct this process at each GWW Radio/Power Box (NEMA Enclosure).
10. Store the eight batteries in an environmentally controlled storage space/Domain Office.
11. See Table 10 for battery charger information.

9.3.2 Reinstall the GWW Radio Box Battery

1. Verify batteries have a full charge prior to heading to the site. Use the charger or equivalent listed in Table 10 for this step.
2. Open GWW Radio/Power box using a flathead screwdriver.
3. Reattach battery in Velcro strap. **WAIT to plug in the battery.**
4. Remove the red rubber nipples from the Cable and Radio/Power box connectors.
5. Reinstall GWW instrumentation and connect to Radio/Power box.
6. Plug in the battery in the upper right hand corner of the NEMA enclosure (see Figure 76 and Figure 77 for location). ***Only connect the battery when the GWW instruments are in place and connected to the Radio/Power box components.*** The solar power system does not have switches to control for power like the alternate power system.
7. Plug in Solar Panel connector to the junction board (CB14140000) using Figure 76.
8. Close GWW Radio/Power Box using flathead screwdriver.
9. Conduct this process at each GWW Radio/Power Box (NEMA Enclosure).

9.4 Aqua TROLL 200 Removal/Reinstallation Procedure

9.4.1 Remove the Aqua TROLL 200

1. Follow the procedure to remove the GWW Radio Box Battery to power down the assembly and disconnect the Aqua TROLL 200 cable.
2. Remove the sensor from the GWW. Follow the procedure in *Section 6.2.2 Aqua TROLL Sensor Removal/Replacement* Procedure

    a. To ensure the cable wire trap does not move at the top of the cable, use tape to mark the wire trap location to monitor changes in GWW depth for infrastructure reinstallation in the spring.

    b. Verify the Aqua TROLL is not logging data internally. Logging drains the internal battery. The internal battery is not a user serviceable component. The Domain will require a new Aqua TROLL sensor for the GWW. *Reference Section 11.*

3. Conduct decontamination to remove biofouling, etc. *Reference Section 5.3.3.*

4. Package Aqua TROLLs in ESD bags and store at Domain Office or send back to NEON, HQ for Sensor Refresh (CVAL creates the schedule for Sensor Refresh, store at the Domain Office until it is time to conduct Sensor Refresh procedures) or until snow/ice recedes at GWW locations.

5. Plug groundwater PVC opening with a plug (see Table 10 for plug product information).

9.4.2 Reinstall the Aqua TROLL 200

1. Follow the procedure to reinstall the GWW Radio Box Battery to power down the assembly and reconnect the Aqua TROLL 200 cable.

    a. Remove and clean any connectors with residue from electrical tape.

2. Remove the cap on the PVC opening of the well.

3. Follow the procedure in *Section 6.2.2.2.2 Installing Sensor Assembly in Well* on page 52 to reinstall the sensor.

9.5 Winter Maintenance for Operational Sites

For procedures involving ice removal, conduct a personnel safety assessment to determine if the site is safe to visit and/or conduct the procedures below. FOPS must coordinate with the NEON Safety Office to determine site safety criteria/hazard identification to determine when it is safe to conduct AIS winter preventive maintenance on the equipment.

9.5.1.1 Remove Ice from GWW Lock

To remove ice from the GWW, use self-heating hand warmers or thermos of hot water as long as no water falls into the well.

9.5.1.2 Remove Ice from Cables

Use hands in gloves or a wooden dowel (.50 dia x 36” Lg.) to move the cables to break off ice**. DO NOT HIT THE CABLES**. Brush the snow away from the connectors as much as possible. Break off any hanging icicles, as appropriate (consult with the NEON Safety Office to establish criteria for winter hazard identification or conduct a JSA to determine if the site/icicle is safe to approach). **Do not remove icicles when staff or specific equipment are present below.** A gentle tap with a wooden rod on the icicle base should suffice.

9.5.1.3 Remove Snow and/or Ice from Solar Panels

For solar panel winter preventive maintenance, use equipment similar to removing ice from a car windshield (solar panel exterior is tempered glass) or use a specific snow removal tool/telescoping squeegee. Field Science may use a non-stick dry film lubricant (Teflon fluoropolymer) in a squeeze bottle. Apply it to a rag, and wipe it on the panel glass, carefully to ensure it does not drip onto the ground.

Do not use ethanol; it increases the risk of spills/site contamination. Do not use special window/car treatments for ice - no RainX, rock salt or car wax.

9.5.1.4 Solar Panel Adjustments

For best solar radiation in the winter months, tilt the site's panel latitude plus 15 degrees from horizontal. Thus, if the site is at 39 degrees north latitude, tilt the panel/s to 54 degrees from horizontal starting around late October and ending around late March. Follow local weather patterns to determine specific dates. In late March, tilt the solar panel 10-15 degrees LESS than the site's latitude. Thus, at 39 degrees north latitude, the panel/s would tilt between 24 and 29 degrees from horizontal.

In northern climates, where snow is prevalent, it is important to keep snow accumulation on the panel/s to a minimum, add 20 degrees to the latitude to help snow slide off.

The area to adjust the solar panels is circled in red in Figure 78 below. Use a ¼" allen wrench and ½" socket or combination wrench to make these adjustments.

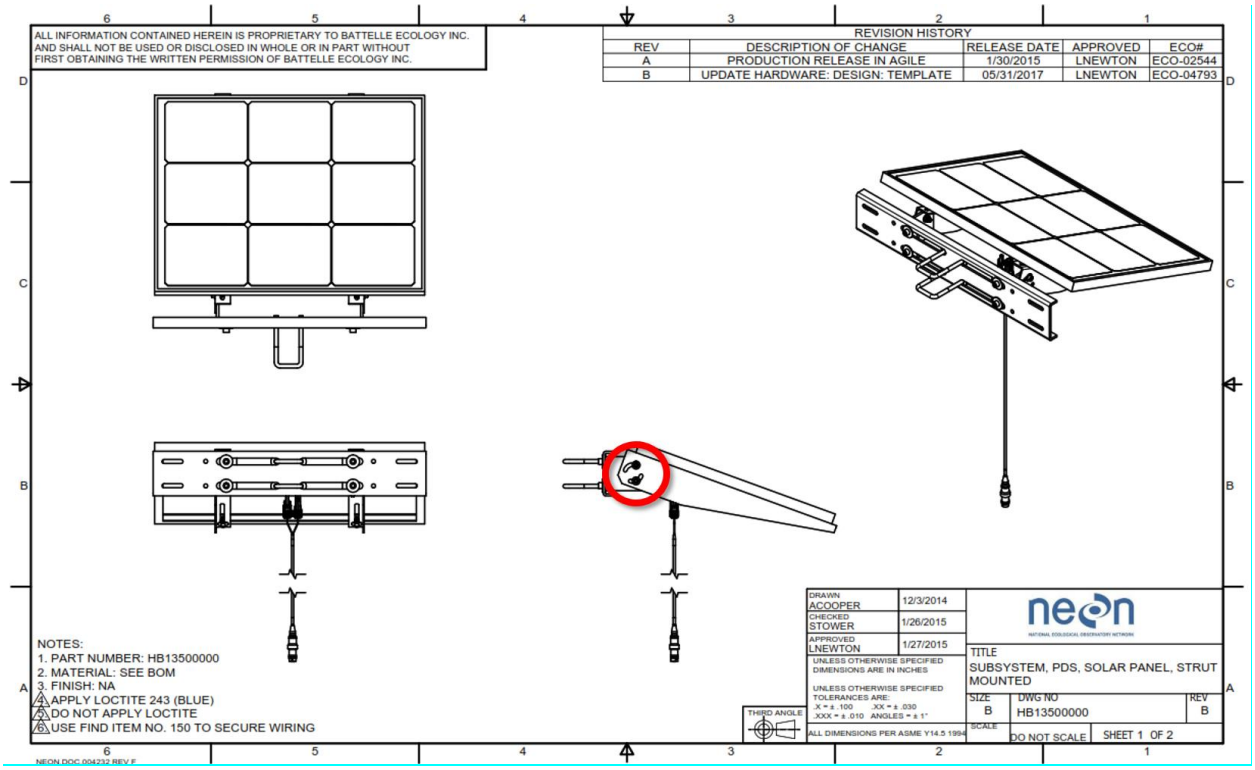

Figure 78. HB13500000 Subsystem, PDS, Solar Panel, Strut Mounted - Area in Red to Make Adjustments to Panel

10 GROUNDWATER WELL (GWW) FLOOD PROCEDURES

10.1 Equipment

Table 11. Flood Preparation Procedure Equipment List

P/N	MX or NEON P/N	Description	Quantity
Tools			
Consumable Items			

10.2 Procedure

This procedure includes information for sites using the snorkel (***HB06610010*** *Kit, Aqua Troll Well Cap Installation).* Updates to this section to occur in the near future.

11 AQUA TROLL 200 CONFIGURATION PROCEDURE

11.1 Equipment

Table 12. Aqua TROLL Configuration Equipment List

P/N	NEON P/N	Description	Quantity
Tools			
		Flathead Screwdriver (to open Power/Comm boxes)	1
NEON, IT		Laptop	1
		Aqua TROLL 200	3-8
	Option A	TROLL Configuration Adapter (Figure 79)	1
		Female-to-female TROLL cable (Figure 79)	1
		Serial to USB Cable (some TROLLs require this cable) (Figure 79)	1
0052510	Option C	USB, Direct-Connect: Uphole end connects to a USB port. Downhole end has a female connector that connects directly to the data logger. **Use Direct-Connect TROLL Coms to download data only.**	Optional
0052500	Option B *(HQ recommends this option)*	USB, Cable-Connect: Uphole end connects to a USB port. Downhole end has a male connector that links to the twist-lock connector on the data logger cable. ***In-Situ, Inc. recommends this cable for field deployment.***	1
Resources			
	Win-Situ5: https://in-situ.com/support/documents/win-situ-5-software/		
	USB TROLL COM Cable Connect Instructions: http://www.fondriest.com/pdf/in-situ_0052500_manual.pdf		

Figure 79 displays the cables for option 1 to configure GWW Aqua TROLL 200 sensors. FOPS must acquire cable(s) from Option 1 or Option 2 in Table 12. Aqua TROLL Configuration Equipment List.

Figure 79. Cables to Configure Aqua TROLLs

11.2 Procedure: How to Configure an Aqua TROLL 200

1. Ensure a copy of each EPROM ID and Asset Tag for each Aqua TROLL is available to verify the site has the correct sensors in MAXIMO. The Aqua TROLLS have separate assets tags and to associate them, FOPS must connect to the Aqua TROLL to view the EPROM in their settings. Every GWW has a unique CFGLOG.
2. Download the Win-Situ5 software (**WS5Setup.exe**) on a NEON Laptop using the link in Table 12. Disregard this step if already complete or if using a CD to download the software.
3. Synchronize Laptop time to UTC (Coordinated Universal Time) or GMT (Greenwich Mean Time).

4. Open the Win-Situ5 software application (Figure 80).

Figure 80. Win-Situ5 Icon

5. A pop-up window may appear asking you to select a COM port for communication if this is your first time opening the software. Select "**No**" (Figure 81).

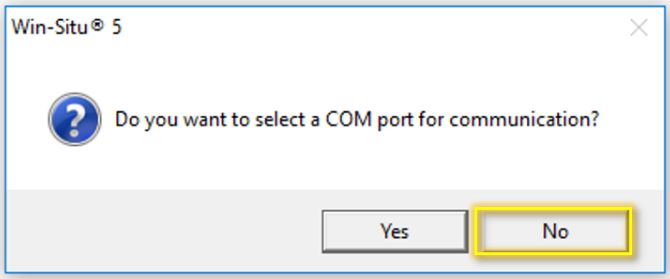

Figure 81. COM Port Pop-up Window

6. The pop-up window most users will experience is one asking if you would like to "**Connect to device now?**" pop-up window. Select "**No**" (Figure 82).

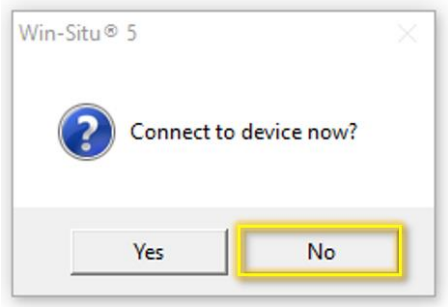

Figure 82. Connect to Device Pop-up Window

7. If a "**Failed to connect at settings: Comm ## Addr: # (ASCII, 9600, 8, N, 1). Do you want to try other common settings?**" pop-up window appears, select "**No**".

8. In Win-Situ5 main program window, select the "**Preferences**" tab in the upper left-hand corner of the screen and select "**Comm Settings…**" from the dropdown options.

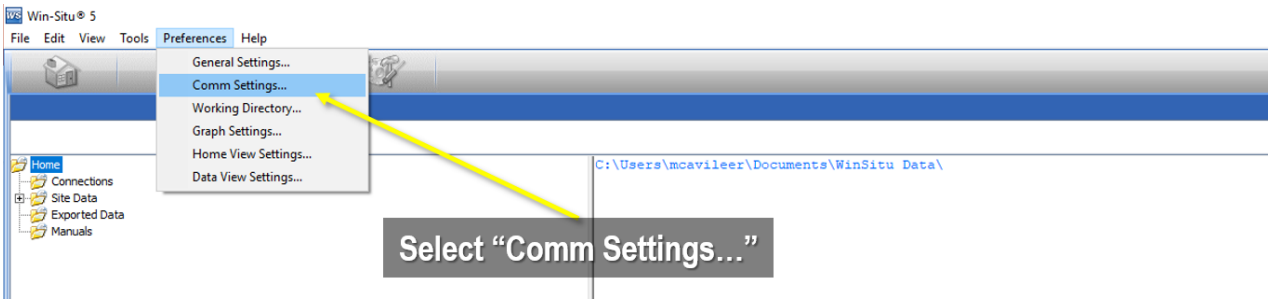

Figure 83. Select "Comm Settings…"

9. In the "Default Communication Settings" window, set the following serial communication settings in Figure 84.

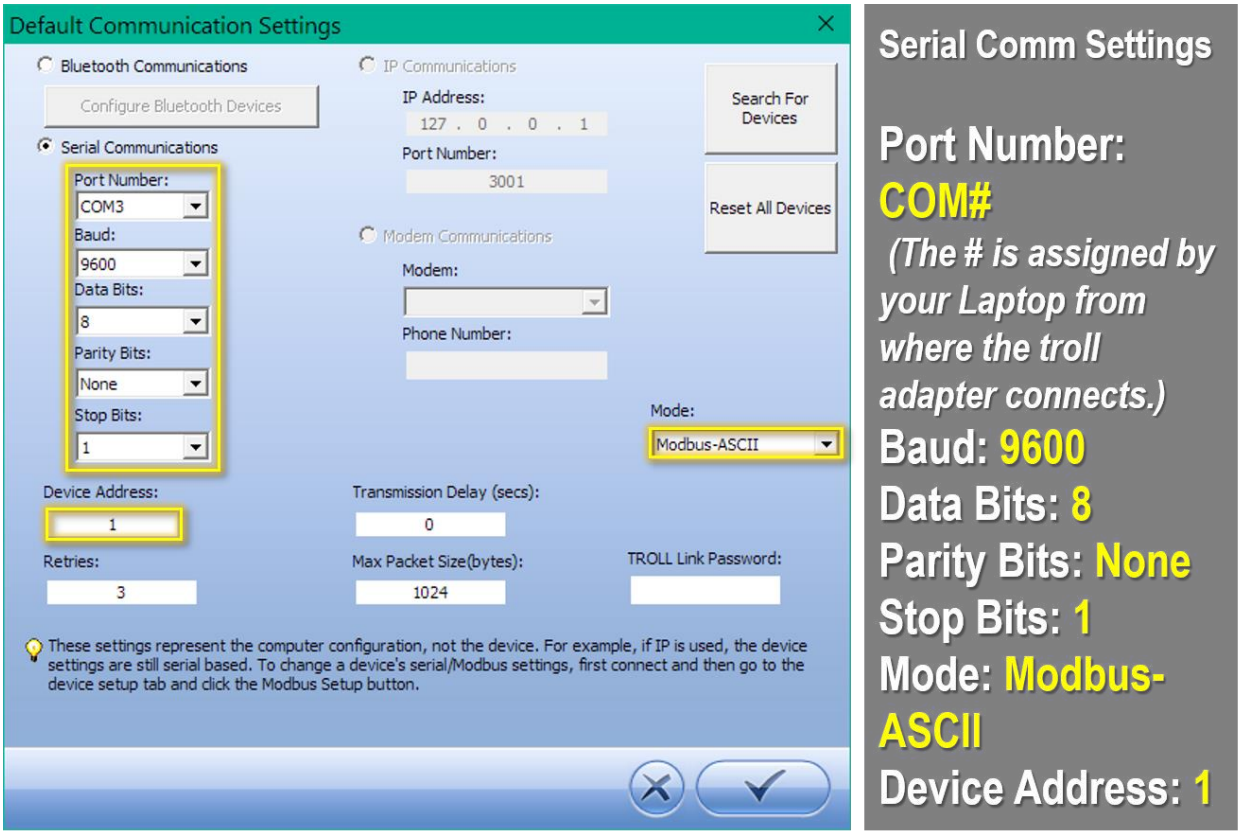

Figure 84. Configure Default Communication Settings

PRO TIP: *The **Port Number (COM#)** varies across computers. It may also vary from the connector selected for use. To determine which port you are using or verify the port the computer is using is correct, check the **Device Manager** settings.*

IMPORTANT: CVAL configures the Aqua TROLLS **Device Address** to "**1**" as a default setting. If FOPS is initially connecting to an Aqua TROLL post-sensor refresh to configure its settings, the **Device Address** must be "**1**". However, post-installation and verification of the sensor, the **Device Address** will correspond to the GWW number (e.g., for example, the **Device Address** for an Aqua TROLL at GWW 4 must use "**4**" instead of "**1**"). Reconfigure the Aqua TROLL back to "**1**" prior to shipping the instrument back to CVAL for Sensor Refresh. If you cannot connect to the Aqua TROLL, try another GWW number. DO NOT HIT "**RESET TO DEFAULT**." This is the nuclear option and wipes the sensor configuration in accordance with AD [08] from the sensor. If you use "**RESET TO DEFAULT**", reconfigure the sensor per AD [08]. Submit an informational ServiceNow ticket to CVAL with screenshots of the sensor configuration post-reconfiguration.

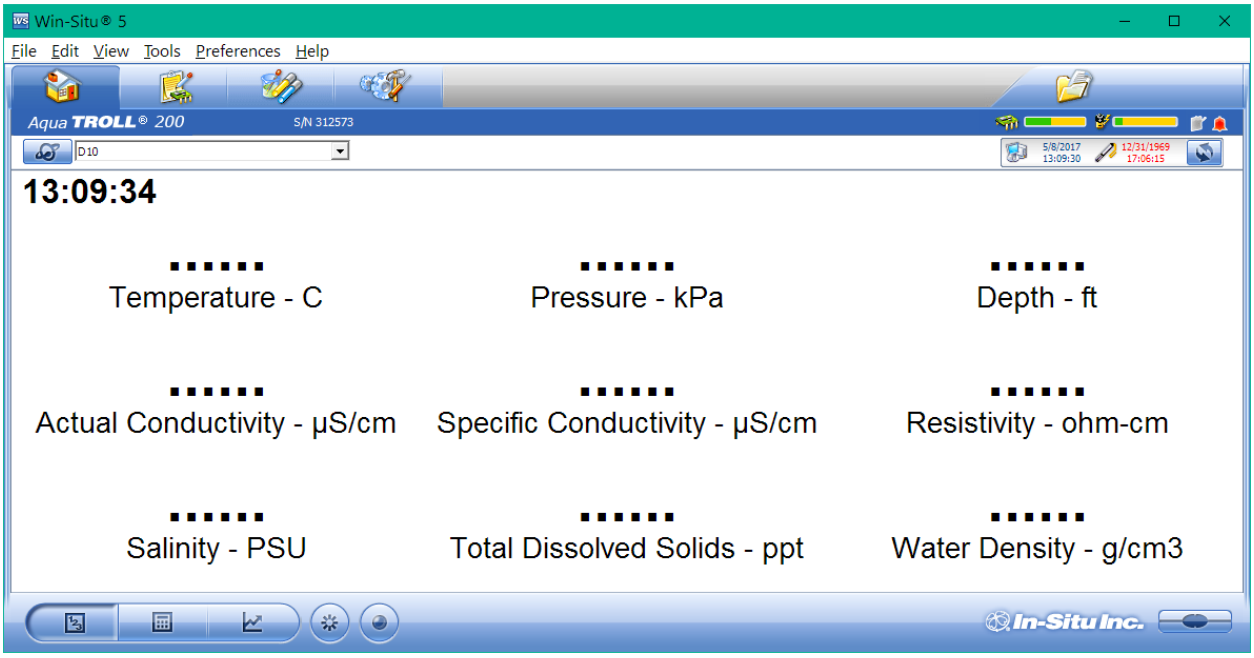

Figure 85. Select "Search for Devices" and Connect to an Aqua TROLL

10. Select the **Logging** tab in the upper right-hand corner of the window to cease logging and/or delete logs (Figure 86). This step is to verify the Aqua TROLL is not logging post-refresh or to turn off logging.

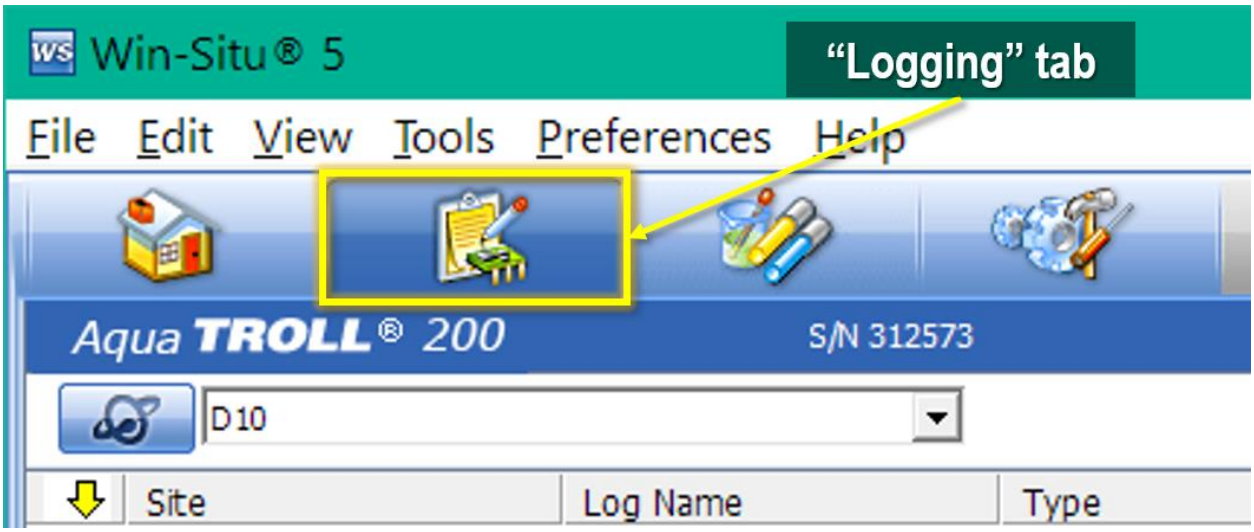

Figure 86. Select the "Logging" Tab

11. If the Aqua TROLL has logs from other sites and/or is currently logging, select the log and click the "**Stop**" button at the bottom of the screen (Figure 87).

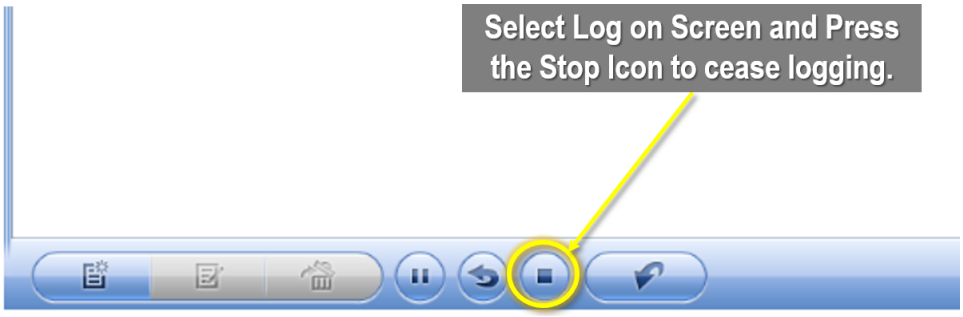

Figure 87. Select the "Stop" Button to Stop Logging

Note**: In the event of a PDS interruption, logging may drain the internal battery on the sensor. This constitutes as irreparable damage to the sensor and the site must request an entirely new Aqua TROLL assembly. Until NEON, HQ establishes a program to ingest the Aqua TROLL internal data logs, this function poses more of an issue to the sensor state of health, especially for sites that may encounter intermittent PDS issues. **As a result, all Aqua TROLLS must cease logging until further notice from NEON, HQ.

12. Delete any logs that are not relevant by selecting the log or log(s) and selecting the Trashcan icon/button at the bottom of the screen (Figure 88).

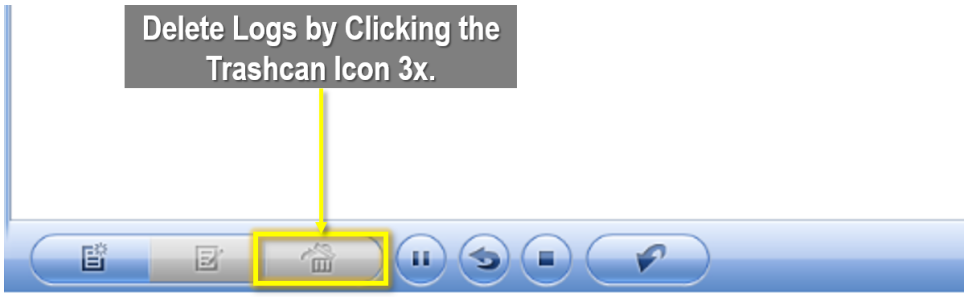

Figure 88. Delete Logs by Selecting Trashcan Icon

13. Return to the main program window. Synchronize the Aqua TROLL clock to the Laptop UTC or GMT clock in the upper right-hand corner of the window (Figure 89). Wait a few seconds before continuing to the next step.

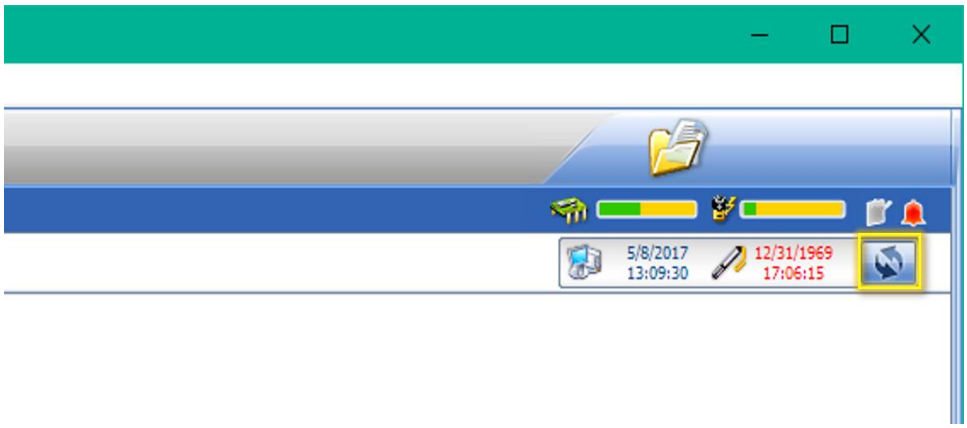

Figure 89. Synchronize the Aqua TROLL clock to the Laptop UTC

Note**: If logging is already OFF, FOPS may synchronize the clock immediately. The Aqua TROLL clock drifts over time. **NEON, HQ recommends synchronizing the clock quarterly to prevent significant drift time accounting.

14. Select fourth tab to verify and configure Aqua TROLL communication settings (Figure 90).

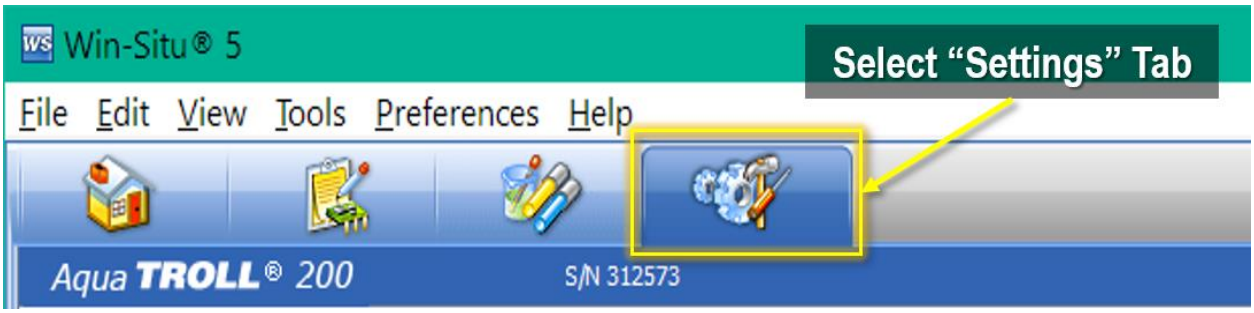

Figure 90. Select "Settings" Tab

15. Verify sensor EPROM ID under **Device Information** (Figure 9190). **NEVER CHANGE THE EPROM ID OR IT VOIDS THE SENSORS CALIBRATION**. If there is a discrepancy, conduct root cause analysis on MAXIMO and submit a ticket.

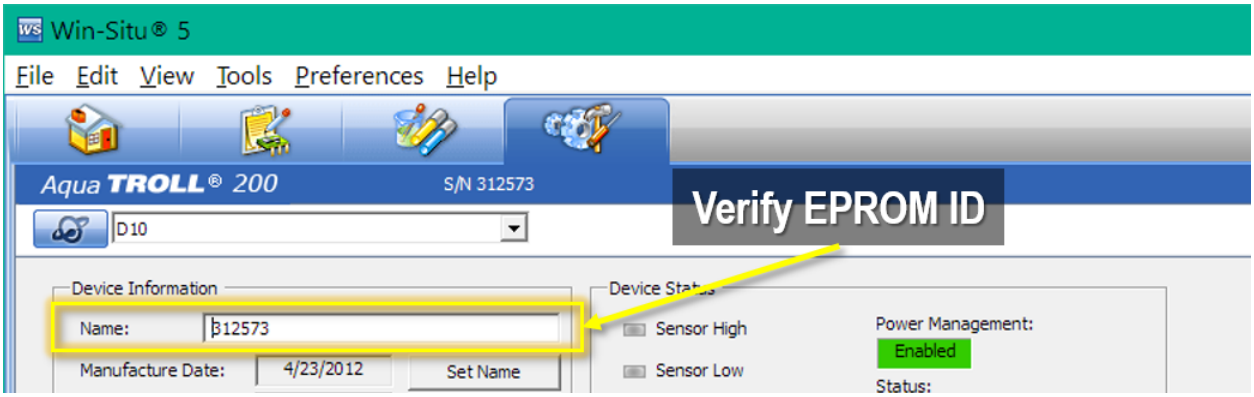

Figure 91. Verify Sensor EPROM ID

16. At the bottom of the same page, select "**Mobus Setup…**" (Figure 92) to verify communication settings per Figure 84, with the exception of the **Device Number**.

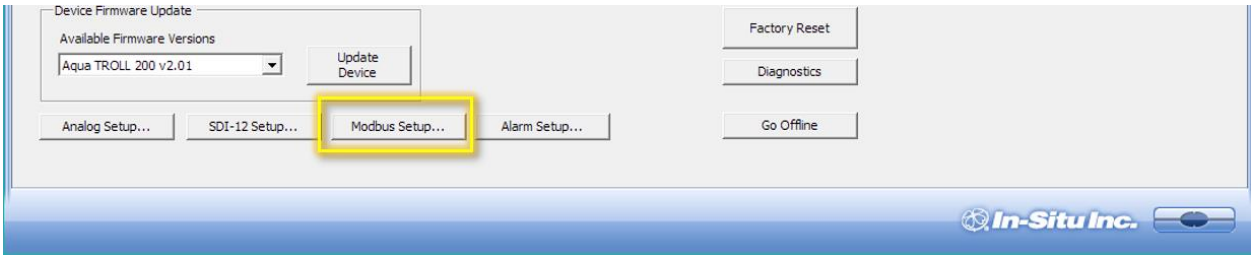

Figure 92. Select "Mobus Setup…"

17. Update the **Device Number** with the Aqua TROLL GWW number. Select the check to accept changes (Figure 93).

Important: After connecting to the TROLL using Device Address 1 and conducting the steps above, change the **Device Address** to reflect the **GWW#** for each Aqua TROLL. For example, the **Device Address** for an Aqua TROLL at GWW 2 must use "**2**" instead of "**1**" in Figure 93 below. If the setting is not updated to reflect the GWW location where the Aqua TROLL resides, then Technicians cannot view data from remote locations. In addition, reconfigure the Aqua TROLL back to "**1**" prior to shipping the instrument back to CVAL for Sensor Refresh. If you cannot connect to the Aqua TROLL, try another GWW number. DO NOT HIT "**RESET TO DEFAULT**." This is the nuclear option and wipes the sensor configuration in accordance with AD [08] from the sensor. If you use "**RESET TO DEFAULT**", reconfigure the sensor per AD [08]. Submit an informational ServiceNow ticket to CVAL with screenshots of the sensor configuration post-reconfiguration.

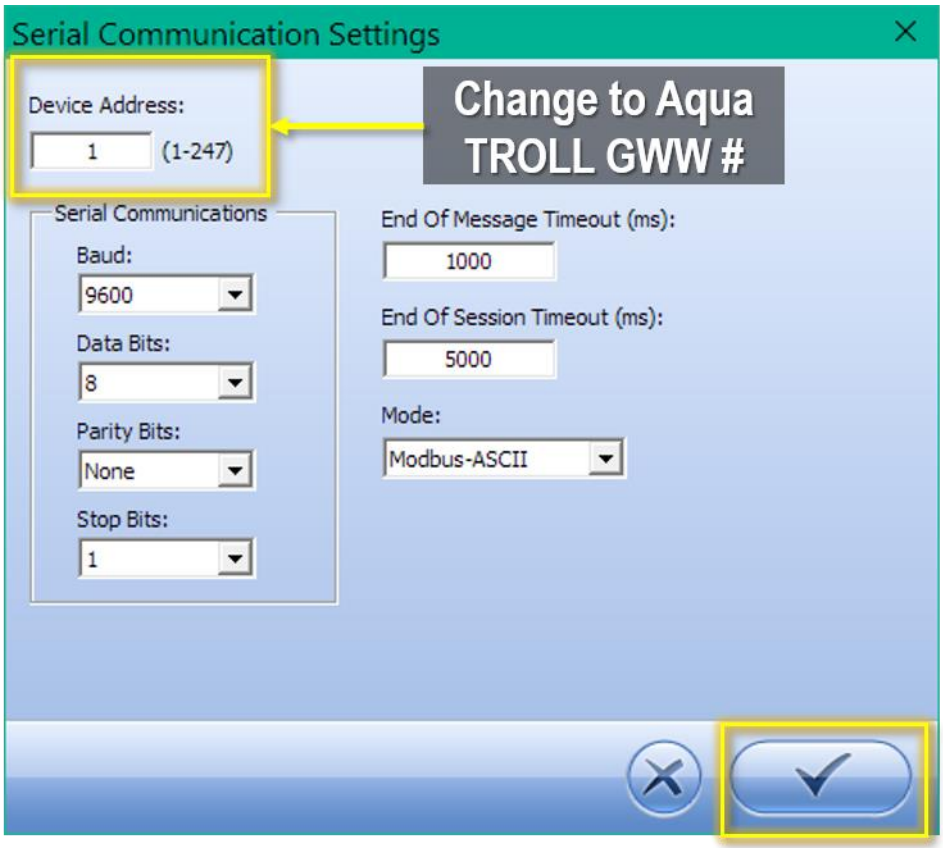

Figure 93. Update Device Number to Reflect Sensor GWW #

18. Select "**Yes"** when a pop-window arises stating "The device communication settings will be changed. You may lose the device connection. Proceed?" Technicians should not lose communication with the Aqua TROLL when selecting "**Yes**", if no other changes were made to the communication settings.

19. Select "**No"** if a pop-window arises stating "Do you want to save the communication changes as the new default settings?" This stops the software from looking for that specific device number again, which may cause issues knowing that Aqua TROLLS come out of CVAL with device number "**1**", instead of the specific GWW number.

12 PROTOCOL FOR DOMAIN 18 AND 19 ACTIVE LAYER MEASUREMENTS

Groundwater availability, distribution, and seasonal variability have significant influence on ecological processes. The NEON data product Elevation of Groundwater (DP1.20100.001) enables the study of these influences at most NEON sites; however, there are significant challenges in measuring groundwater elevation in permafrost ecosystems. The first issue that the freeze/thaw cycle of the ground causes frost heaving, which has led to nonstationary wells with no meaningful sensor reference point. Secondly, NEON Aquatic sites installed in locations without permafrost have a relatively spatially fixed surface elevation and the lower confining layer (i.e., bedrock) create a stable boundary to confine the water table and allows for calculations of groundwater inputs, storage, and outputs in the system using continuous groundwater pressure data. However, artic permafrost systems, including all NEON sites in AK, have dynamic upper and lower water table boundaries due to surface elevation fluctuations from frost heave and seasonal fluctuations in the underlying active layer, which is the ground layer above the permafrost that seasonally freezes and thaws.

In these permafrost ecosystems, the active layer is a primary ecohydrologic driver, influencing nutrient cycles, biological processes, and downstream water quality. This unique driver requires additional measurements for the NEON project's Alaska sites, in comparison to the rest of the network. The goal of this protocol is to provide key measurements of the active layer, including the depth to liquid water from the ground surface, if present, and depth to the active layer thaw. Similar to groundwater elevation in stationary ecosystems, these data are useful for addressing water table related questions of groundwater availability and seasonal variability.

Due to the nature of permafrost, and the inability to monitor GWWs using the standard well design, the NEON project requires a D18/19 Field Ecologist to maintain groundwater well infrastructure and collect data during the thaw period.

12.1 Permafrost Measurement Procedure

1. Visit all wells on a weekly basis during the thaw season, from when the active layer melts until it refreezes. The periods of the thaw season will vary by year, but should correspond roughly with late June through late September for the D18 sites. The window will be slightly larger for D19 Caribou Creek. When visiting wells, attempt to disturb the ground as little as possible by using the boardwalk and standing downhill of the well.

2. Each well site will be equipped with a slotted PVC well. Push each screened well down by hand to the frozen interface. This may involve pulling the PVC out of the ground and removing some of the saturated soil below.

3. Lower the sensor to the bottom of the inside of the well. The sensor should sit loose on the well bottom and no hanging apparatus is required. If ice is present in the well, attempt to free the sensor and reposition on the well bottom. Note that the sensors will be capturing continuous conductivity and temperature data, and depth, but the groundwater pressure data stream will not be published. Pressure relies on a fixed elevation for the well casing as a reference point, and because traditional wells move in permafrost, we cannot reliably collect that data.

4. Straighten the well if needed and record measurements of the depths to liquid and frozen positions of the active layer for each well using the water tape as described below. See Figure 94 where "A" is

the top of well to ground surface; “B is the top of well to liquid water; and “C” is the top of well to refusal. If possible, have the same technician take these measurements each week to maintain consistency in the readings.

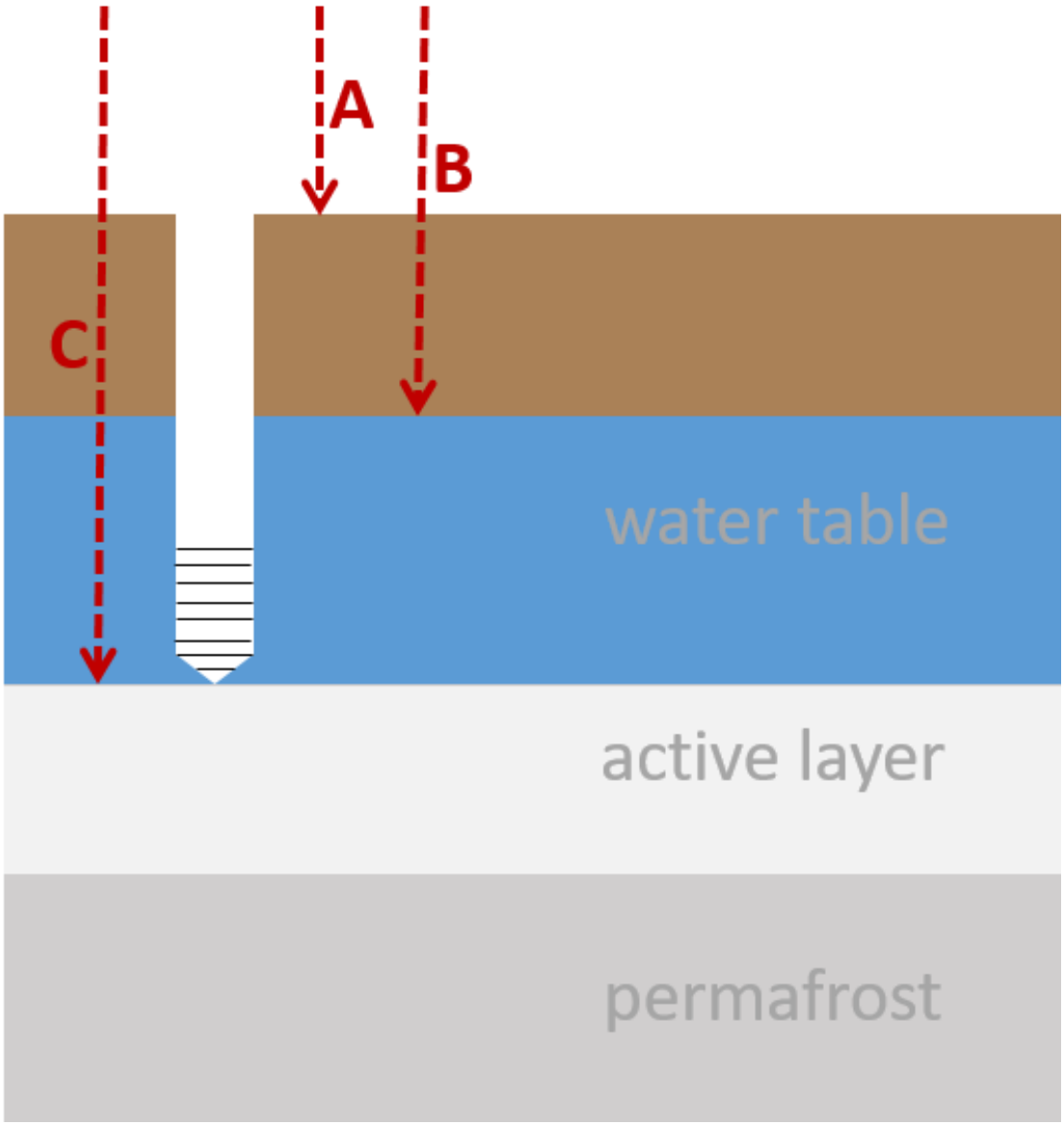

Figure 94. Key active layer measurements for D18/19 GWWs

a. Top of well to ground surface (Figure 95): With the well cap removed, measure the distance between the top of the well casing and the ground surface. Define the ground surface as where

you feel resistance when pushing upon the ground with a flat hand. The wells should be marked so that the measurement can be taken on the same side each week.

b. Top of well to water (m), if present: With the well cap removed, use the water tape to measure depth to water from the top of the well casing.

c. Top of well to refusal (m): This is the depth of the frozen interface. Lower the water tape as deep as possible inside the well and record the depth.

d. Use the thaw probe to record 10 additional measurements of thaw depth within a 2m radius of each well (Figure 96). Push the thaw probe into the soil down to the frozen interface. Attempt to avoid rocks, which can typically be identified as they omit a higher pitch sound when hit by the probe. After inserting the probe, grab the probe at the ground surface where your thumb and forefinger feel resistance (A in Figure 96). Remove the probe and record the corresponding centimeter mark (B in Figure 96).

Figure 95. Measure from the Top of the GWW (with the cap removed) to the Ground Surface

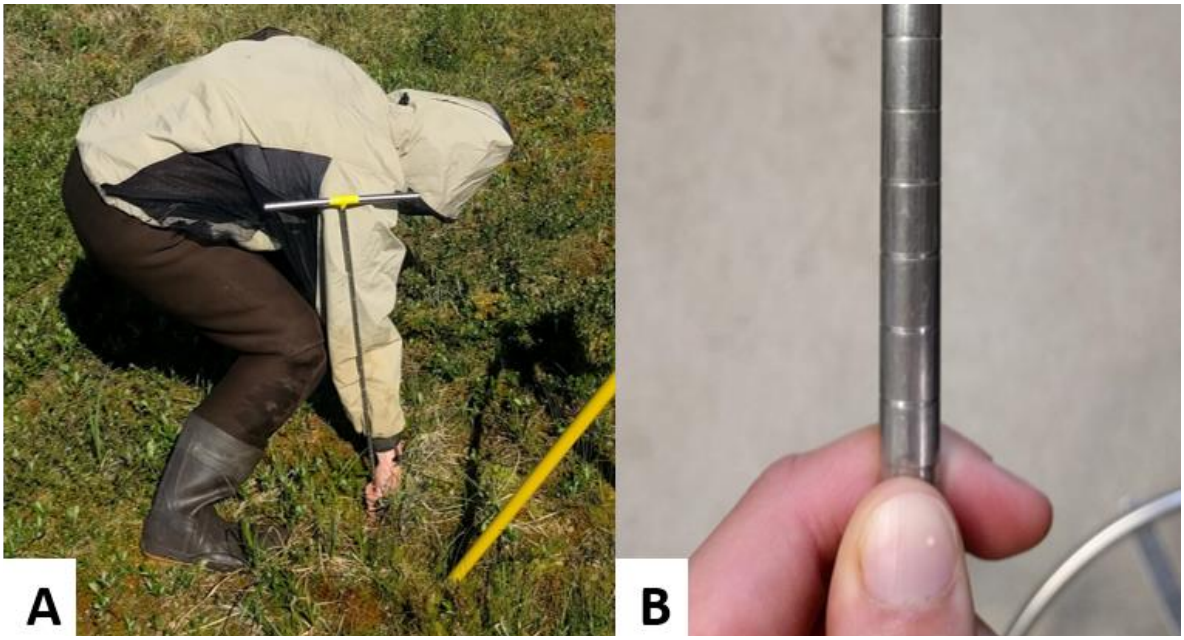

Figure 96. Measure thaw depth by inserting the thaw probe to the frozen interface (A) and reading the corresponding centimeter mark (B).

12.2 End and beginning of season instructions

The end of the season will be determined at the Domain's discretion as the frozen layer begins to rise within the well. At the end of the season, as the wells begin to freeze, remove the sensor and insert a PVC plug into the well that is equal to the inner diameter of the well casing. This will prevent the well somewhat from filling with ice over the winter. Cut the inner PVC plug so that it is slightly longer than the well casing. In the spring, use channel locks or large crescent wrenches to hold the outer PCV in place the then twist the inner PVC loose and replace the sensor. If the wells have heaved over the winter, push down the thaw layer before recording measurements.

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Model(s): Andrew Keller, Genevieve Faria, Dan Stewart, Josh Buza, Nora Catolico, D04 FOPS Technicians, Josh Monroe

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