Standard Operating Procedure EAP129, Version 1.0

Short-term Continuous Data Collection with a Multiparameter Sonde, Part 1: Field Procedures

December 2019
Publication 19-03-229
[Approved 2019]

Purpose of this Document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication Information

This SOP is available on the Department of Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1903229.html.

Ecology's Activity Tracker Code for this SOP is 19-033.

Recommended citation
Mathieu, N. and T. Stuart, 2019. Standard Operating Procedure EAP129, Version 1.0: Short-term Continuous Data Collection with a Multiparameter Sonde, Part 1: Field Procedures. Washington State Department of Ecology, Olympia.
https://fortress.wa.gov/ecy/publications/SummaryPages/1903229.html. [Approved 2019.]

Contact Information

For more information contact:

Publications Coordinator
Environmental Assessment Program
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
Phone: (360) 407-6764

Washington State Department of Ecology – ecology.wa.gov

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Union Gap 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Original Author – Nuri Mathieu, Modeling and TMDL Unit, Western Operations Section,
Tighe Stuart, Eastern Operations Section

Date – 5/30/2018

Original Reviewer – Eiko Urmos-Berry, Eastern Operations Section

Date – 5/31/2018

QA Approval – Arati Kaza, Ecology Quality Assurance Officer

Approval Date – 5/14/2019

SIGNATURES AVAILABLE UPON REQUEST

SOP Revision History

Revision Date	Revision History	Summary of changes	Sections	Reviser(s)
5/30/2018	1.0	Original draft completed	All	Nuri Mathieu
5/31/2018	1.0	Reviewed and contributed	All	Tighe Stuart; Eiko Urmos-Berry

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for short-term (less than 6 months) continuous data collection using a deployed (unattended) multiparameter sonde. This SOP is intended for a variety of types of water quality studies, including Total Maximum Daily Load (TMDL), effectiveness monitoring, toxic loading, and other focused water quality studies.

1.2 Deploying sondes in the aquatic environment requires careful planning, routine dedicated maintenance, and thorough review of data record for usability and quality.

1.3 For long-term (greater than 6 months) or high-flow-conditions sonde deployment, consider requesting the Freshwater Monitoring Unit's assistance with installing a long-term deployment station.

1.4 For deployment in an estuarine or marine environment, consider requesting the Marine Monitoring Unit's assistance with selecting appropriate equipment and installing a deployment station.

1.5 Several of the methods and information presented in this SOP were taken or adapted from the USGS techniques and methods 1D-3: Guidelines and Standard Procedures for Continuous Water Quality Monitors: Station Operation, Record Computation, and Data Reporting (Wagner et al., 2006).

2.0 Applicability

2.1 This document should be used for deploying sondes in freshwater rivers, streams, and other waterbodies for project-level water quality assessments of limited duration.

3.0 Definitions

3.1 ABS — Acrylonitrile butadiene styrene, a type of plastic.

3.2 Fouling — the accumulation of unwanted material on solid surfaces to the detriment of function. The fouling materials can consist of either living organisms (biofouling) or a non-living substance (inorganic and/or organic).

3.3 Sonde — an instrument probe that transmits or logs information about its surroundings underground, under water, in the atmosphere, etc.

3.4 Thalweg — the line that connects the lowest points in a valley or river channel and, thus, the line of fastest flow or deepest water along a river's course.

4.0 Personnel Qualifications/Responsibilities

4.1 In general, field staff should be trained in safety procedures for work in streams. Ecology field staff must undergo annual training and certification for safety, invasive species decontamination, and heat stress.

4.2 Job classifications that typically perform this work: Natural Resource Scientist 1/2/3, Environmental Engineer 1/2/3, Environmental Specialist 1/2/3/4/5, Hydrogeologist 1/2/3/4.

5.0 Equipment, Reagents, and Supplies

5.1 Multiparameter sonde — Currently, EAP staff conducting water quality studies use three different types of sondes:

- 5.1.1 Hydrolab® Series 4 and 5 Datasondes and Minisondes.
- 5.1.2 Hydrolab® HL4/HL7 Multiparameter Sonde.
- 5.1.3 YSI® EXO 1/2/3 Multiparameter sonde.

5.2 Short-term sonde deployment tube. Schedule 40 or 80 PVC with holes drilled at one end for flow (Figure 2).

5.3 ABS bottom plates with large u-bolts and holes for staking (Figure 2).

5.4 Rebar or construction stakes 24 to 48 inches long.

5.5 Galvanized or stainless steel hardware (bolts, nuts, pipe clamps, stops/ferrules).

5.6 ¼-inch (or larger) cable or chain in various lengths (optional).

5.7 Life Vest/Personal floatation device (PFD).

5.8 Hip or Chest Waders.

5.9 Padlocks (optional).

5.10 Galvanized or stainless steel strut channel (optional).

5.11 Heavy duty deployment tube. Galvanized metal pipe with holes drilled at one end for flow (optional).

5.12 Concrete blocks, such as cinder or pier blocks (optional).

5.13 12V Hydrolab external battery in carrying case (if using).

5.14 Ammo box for external battery (if using).

5.15 Hydrolab underwater connection cable (if using external battery).

5.16 “Split” cable for connecting underwater connection cable to external battery (if using).

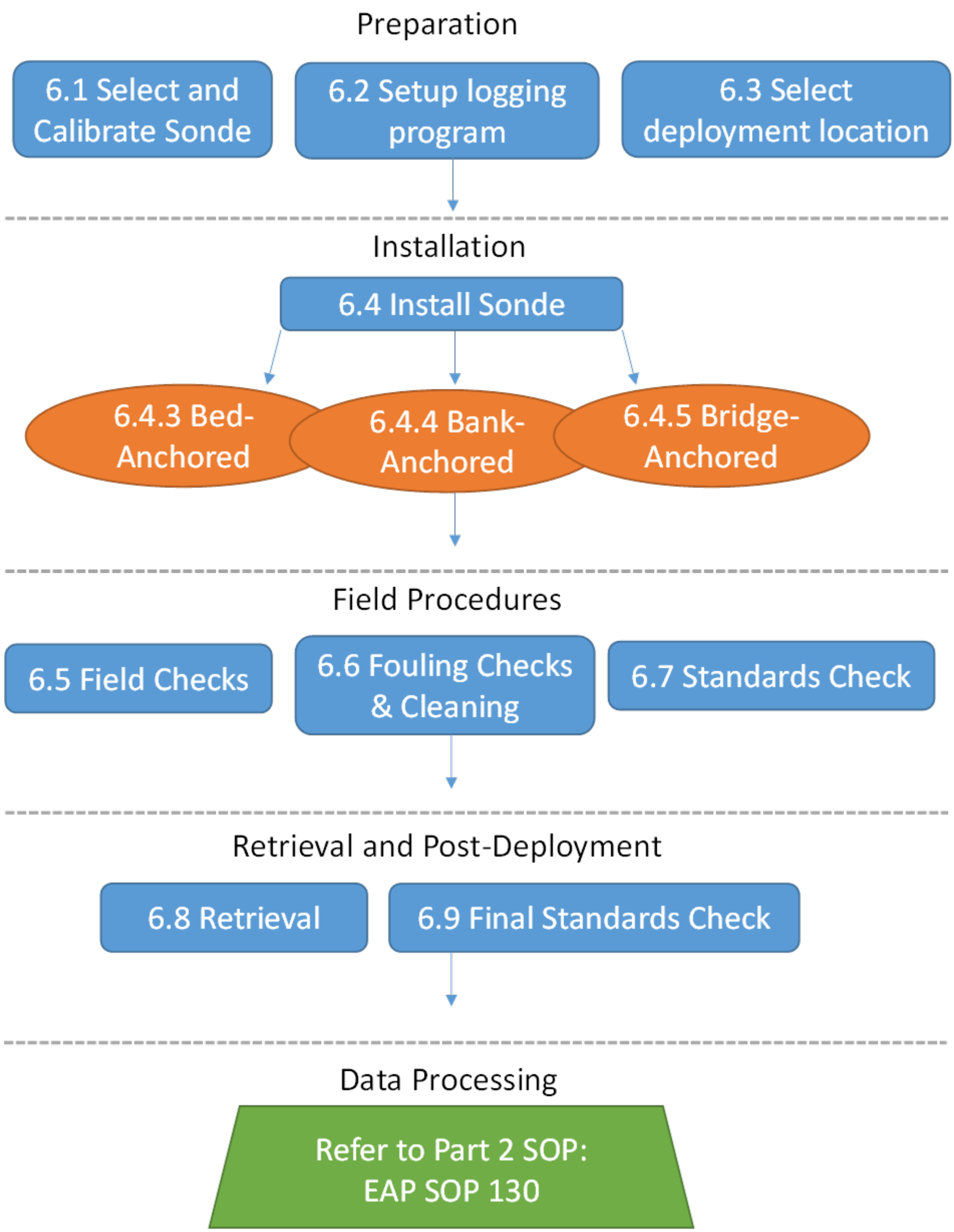

Figure 1. Summary of SOP for Field Procedures

6.0 Summary of Procedure

6.1 Pre-deployment sonde maintenance, calibration, and selection. In general, follow maintenance and calibration procedures outlined in EAP SOP 033 (Anderson, 2016).

6.1.1 Check sonde repair and maintenance history located on the EAP SharePoint site in the "Sonde repair status" spreadsheet in the Hydrolab Reservations SharePoint library. Choose a sonde/s with sensors that are in good repair and equipped with the parameters necessary to meet project objectives.

6.1.2 Designate which sondes will be used for deployment and which will be used to collect instantaneous field checks. For pH and DO in particular, assign sondes with newer sensors to locations that are critical to the study.

6.1.3 For pH, the Hydrolab sondes employ a reference probe that is installed in a separate port from the glass-bulb sensor. These reference probes require dedicated maintenance including routinely replacing the Teflon screw-on junction and replenishing reference electrolyte. For deployments of longer than 5 days, or deployments in low-ionic-strength waters, additional salt crystal pellets can be added to the electrolyte solution.

6.1.4 After replacing electrolyte solution or Teflon junction, it is very important to soak the sensors in tap or clean ambient water BEFORE calibrating the sonde. Ideally, the sonde should be set to log once every 15 minutes over the course of an overnight soak. Alternatively, if short on time or you forget to log overnight, then the sonde should be powered on for at least 15 minutes consecutively in the soaking solution before calibration.

6.2 Pre-deployment sonde setup for unattended logging

6.2.1 Deployments can be setup using either the handheld display unit (handheld) or a computer with the corresponding software installed. The internal logging setup for each of the different multiparameter sondes requires the same basic information including start time, log interval, and site or filename. The manuals for the sondes and handhelds provide more detailed information.

6.2.2 For water quality deployments that include pH and DO measurements, **a logging interval of 15 minutes is recommended**. For all other parameters, a maximum interval of 1 hour is recommended.

6.2.3 To maximize battery and sensor life, it is recommend to start/activate/enable internal logging files in the field immediately prior to deployment. Alternately, if the relative deployment time can be anticipated, the log file may be setup for a delayed start. Another alternative is to activate logging in advance, but leave the sonde disconnected from power until installation in the field. Upon connection to power, logging will commence.

6.2.4 The sondes can also be connected to an external data logger with the appropriate adapters and settings. The sondes can be configured with specific parameters in a specific order (assigned to channels). The parameters and order must match the data logger exactly.

6.2.5 Logging setup information specific to the YSI EXO 1/2/3

6.2.5.1 On the Exo Handheld, the ⚙ (gear) symbol leads to the deployment settings

6.2.5.2 The Exo sondes allow the user to setup the deployment up for a specified time zone. It is recommended that all deployments be setup in Pacific Standard Time (PST), which is always 8 hours behind the Coordinated Universal Time (UTC -0800). It is also acceptable to set the sonde to UTC time and correct to PST when processing the data. Both PST and UTC time avoid data-management issues in the data recorded during daylight savings transitions, such as two duplicate times in a row (in the fall) and skipping ahead 2 hours (in the spring). Record the time zone setting for each sonde after deployment setup is completed. It is also important that field staff record the time zone associated with measurements collected in the field.

6.2.5.3 The Exo sondes allow for an averaging duration to be specified. If pH is being collected for the study, it is important to set an averaging duration other than zero. Two to 3 minutes is suggested. The reason for this is that if the average duration is set to zero (default), only an instantaneous measurement will be collected at each measurement interval. The pH probe will likely not have adequate warmup time to equilibrate, and biased pH data could result. Note that after deployment, it is important to set the averaging duration back to zero for calibration post-checks, to get quick response to each standard/buffer.

6.2.6 Logging setup information specific to the Hydrolab HL4

6.2.6.1 The Hydrolab sondes require that the user enter a sensor warmup time, or how long the sensors will be powered on before collecting a measurement. **A minimum warmup time of 30 seconds is recommended (2-minute warmup if collecting pH)** to allow enough time for sensors to equilibrate to the water without draining battery power excessively. The warmup time must be smaller than the logging interval.

6.2.6.2 An HL4 with a fresh D battery can log for about a week with 15-minute interval and 30-second sensor warmup time; or about 2 days with a 2-minute sensor warmup time.

6.2.7 Logging setup information specific to the Hydrolab Series 4/5

6.2.7.1 As with the HL4, a warmup time of 30 seconds (or 2 minutes if collecting pH) should be used.

6.2.7.2 Similar to HL4, an MS5 with 8 fresh AA batteries can log for about a week with 15-minute interval and 30-second sensor warmup time; or about 2 days with a 2 minute sensor warmup time. This can be significantly extended by using a 12V external battery.

6.2.7.3 ***Important:*** When setting up a log file using HYDRAS3LT, parameters from the "parameters in sonde list" must be selected and added to the "parameters in log file" list, and then "update settings" must be selected. The sonde will NOT automatically log all equipped parameters/sensors.

6.2.7.4 ***Important:*** When setting up a log file using HYDRAS3LT, after configuring logging settings and parameters, **ENABLE** must be selected in order for the deployment to be activated. By default, the log file is disabled until this step is completed.

6.2.7.5 ***Important:*** When setting up log file using terminal mode (via HyperTerminal, Tera Term, or similar), it is important to add all parameters to the scrolling display before creating the log file. The log file will include all parameters displayed at the time the file is created. It is not necessary to do a separate "enable" step when using terminal mode; logging will be armed as soon as file is created.

6.3 Site selection and preparation

6.3.1 The most important step of deployment is selecting a location that is representative, accessible, safe, and relatively private.

6.3.2 To ensure a well-mixed, representative river deployment location, select a spot with adequate but not turbulent velocity (ideally ~1 ft/sec) that is located in the thalweg or main channel of flow and is not influenced by poorly mixed sources.

6.3.3 Good reconnaissance of the deployment location (both in the field and with GIS/aerial photography) is necessary to ensure there are no tributaries, outfalls, or groundwater seepage immediately upstream. As a general rule, equipment should be deployed upstream of bridge crossings to avoid influence from roadside drainage ditches and also upstream of recreational wading/swimming.

6.3.4 A location that is accessible, safe, and private can be difficult to locate and may require obtaining permission from a landowner to access private property.

6.3.5 Section 9.0 and the EAP Safety Manual contain guidelines for assessing site safety.

6.3.6 In some cases, public access with high visibility and recreational activity is the only option for deployment. In this case, make sure to deploy the sonde during a period of low activity such as early morning. Choose a location in the stream that is difficult to access without waders and is not suited to recreation. (Avoid swimming holes, shallow sandy areas, and within a ~50 foot radius of trail or bridge access.)

6.3.7 Deployment may require physical removal of interference and minor alterations of the streambed. Be mindful not to disturb fish and wildlife habitat, keeping impacts on the stream bed and riparian area to a minimum.

6.3.8 Representativeness cross-section surveys

6.3.8.1 If it is unclear whether the deployment location is representative, then a cross-section survey of spot measurements should be taken across the width of the channel. The cross-section should include, at a minimum, measurements at the desired deployment location, within several feet of both banks, and in the thalweg (if different from the deployment location).

6.3.8.2 For deeper or vertically-stratified rivers and streams, vertical profiles of spot measurements should be made at the deployment location and in the thalweg or deepest location nearby. At a minimum, profile measurements should be taken just below the water surface, at the deployment depth and near the streambed, with measurements at other levels to provide a representative profile.

6.3.8.3 For larger rivers or waterbodies, it may be necessary to determine an area-weighted mean for sonde parameters. This can be accomplished by taking equal width and depth increment measurements at the deployment transect. See USGS protocols, including Webb et al. (1999) and Wilde and Radtke (2005) for area-weighted measurements and calculations. Mathieu (2016) provides an example of area-weighted measurement and calculation for salinity.

6.3.8.4 If the sonde cannot be safely deployed in the most representative location, the data may be adjusted for location bias following procedures in Part 2 of this SOP, provided there are at least 3 area-weighted measurements to determine the adjustment factor.

6.4 Installation of sonde

6.4.1 There are three general types of sonde installations: bed-anchored, bank-anchored and bridge anchored, with several modifications within each type. Additional methods for sonde installation (not covered by this SOP) are available including boom-arm and flow-through monitoring installations.

6.4.1.1 Boom-arm installations are possible with assistance from the Freshwater Monitoring Unit's long-term deployment staff. These deployments allow the sonde deployment tube some flexibility of movement in the water column to avoid damage from flood debris.

6.4.1.2 Flow-through monitoring stations are typically the most expensive and require additional housing and justification; installation of these stations should be addressed in a project-specific QAPP, and are generally not applicable to short-term deployments.

6.4.2 Select the installation type that is best for your site and study objectives. Bed-anchored stations are often the best choice for very short deployments (two weeks or less) during stable flow conditions. Bank-anchored installations provide more security for multiple month or wet season deployments. Bridge-anchored installations may be the best choice if the waterbody is deep and the thalweg is limited to the center of the channel. Table 1 provides a list of advantages and disadvantages for each installation type.

Installation Type	Advantages	Disadvantages
Bed-anchored	• Less exposure to vandalism • Easily relocated • More locations suitable • Can be located anywhere across the transect • No/little permitting	• Susceptible to sedimentation. • Susceptible to debris damage • Servicing sensors limited during high water/flooding • Vandalism more likely to result in damage or loss • Not suitable for non-wadeable stream depth or substrate
Bank-anchored	• Sensors can be serviced during all conditions • Less susceptible to debris damage • Vandalism less likely to result in damage or loss* • Suitable for non-wadeable stream depth or substrate	• May require two installations (high and low flow). • More exposure to vandalism • Difficult to relocate • Fewer locations suitable • Must be located near bank • May require additional permitting. • May require private access.
Bridge-anchored	• Can be located anywhere across the transect • Easy to adjust depth • Sensors can be serviced during all conditions • Less susceptible to debris damage • Can be deployed at public access. • Suitable for non-wadeable stream depth or substrate.	• Fewer locations suitable • Requires additional permitting or permissions. • Additional traffic management and safety precautions required.

Table 1. Advantages and disadvantages for bed-, bank-, and bridge-anchored sonde installations

* If deployed in galvanized metal pipe attached to strut channel.

6.4.3 Bed-anchored installations

6.4.3.1 Bed-anchored installations require attachment to stream substrate or an object permanently embedded in the streambed (such as an abandoned piling, large tree, or boulder). Bed installations require wadeable stream access to the deployment location.

6.4.3.2 Bed deployments typically involve placing the sonde inside a deployment tube and attaching to rebar driven into the substrate. Concrete blocks, natural substrate, and large woody debris can be used to keep the sonde suspended above the bed. Pipe clamps, u-bolts, chain, braided steel cable with thimbles and cable clamps, concrete anchors, and heavy duty plastic ties are used to attach and anchor the sonde.

6.4.3.3 Bottom plates made from ABS, with holes drilled for rebar and u-bolts, provide an effective deployment platform. Figure 2 illustrates an example bed deployment configuration and Figure 3 depicts two examples of deployment.

6.4.3.4 The deployment tube may also be attached to abandoned pilings vertically with pipe clamps, cable, chain, rope, or webbing.

6.4.3.5 If changes in flow are expected, installations should be anchored at multiple points.

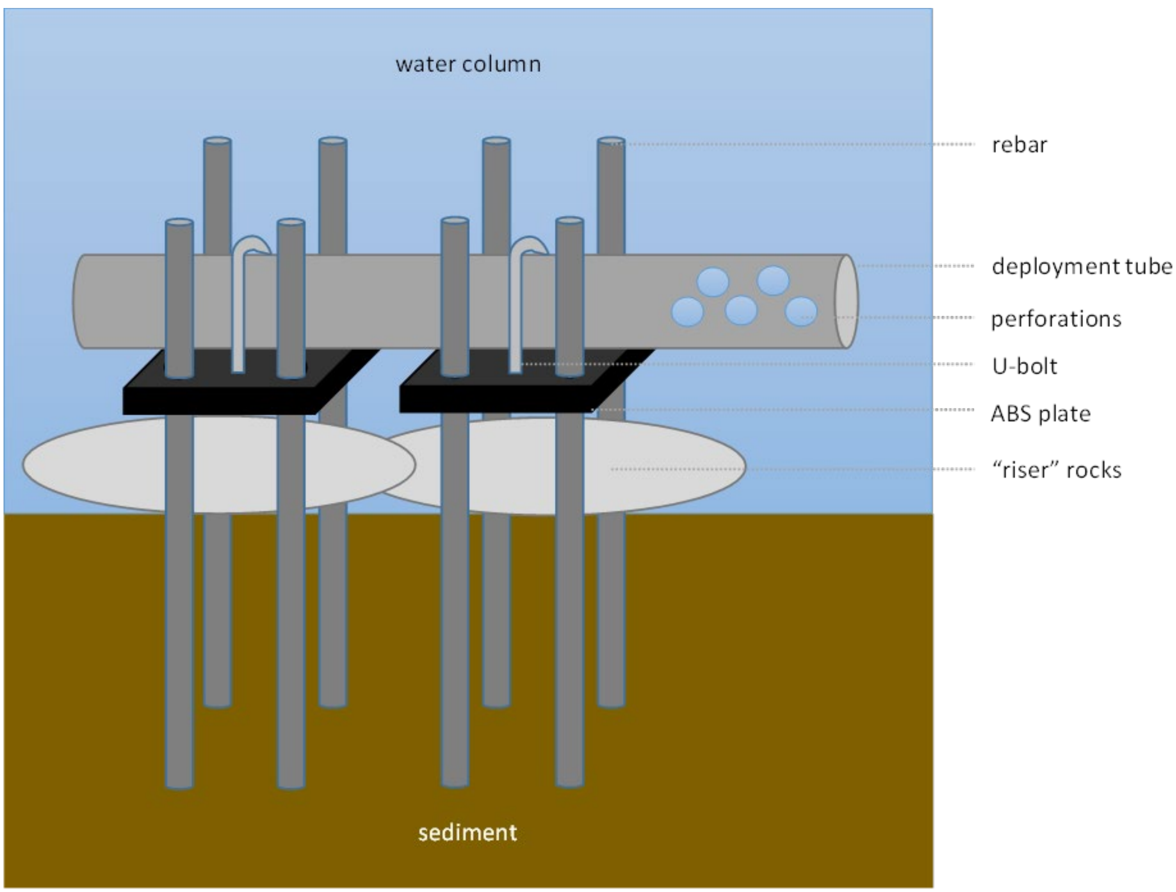

Figure 2. Bed anchored sonde installation using rebar, u-bolts, ABS plates, and PVC deployment tube.

Figure 2. Examples of bed-anchored installations.

6.4.4 Bank-anchored installations

6.4.4.1 Bank-anchored installations range from more involved (such as galvanized metal pipe housing with strut channel anchors: Figure 4) to relatively simple (such as using a chain or cable to anchor a PVC deployment tube to a large tree).

6.4.4.2 Bank-anchored stations provide access during a wide variety of flow conditions and the additional security of being able to anchor to permanent objects on the bank, riparian area, or floodplain.

6.4.4.3 Typically these deployments work best on the outer bank of a river bend where the thalweg, good velocity, and adequate depth are accessible during a wider range of conditions.

6.4.4.4 If possible, the deployment tube should be configured in such a way that the angle or depth can be adjusted as flow conditions change.

Figure 3.Examples of strut-channel (left) and simple rebar (right) bank-anchored installations.

6.4.5 Bridge-anchored installations

6.4.5.1 Bridge-anchored installations may be suspended from bridge railing/barrier or attached to bridge piers/pilings.

6.4.5.2 Bridge deployments should be installed downstream of a bridge piling to protect the sonde from debris damage. The depth of the sonde should be checked and adjusted at least monthly and may need more frequent adjustments during periods of rapidly changing water levels.

6.4.5.3 Before deploying the sonde from a bridge, permission must be obtained from the transportation/engineering department of the jurisdiction responsible for maintaining the bridge.

6.4.6 External battery power

6.4.6.1 Deployments of longer than 2 weeks typically require an external source of power to avoid frequent site visits and protect against data loss.

6.4.6.2 A variety of external power options are available based on the sonde manufacturer and deployment situation.

6.4.6.3 The Hydrolab HL4 and EXO sondes require the sonde be connected to a communications module and external data logger in order to utilize an external power source. Figure 5 shows the external battery options and associated adapters that can be connected to the Series 5 Hydrolab via a field cable.

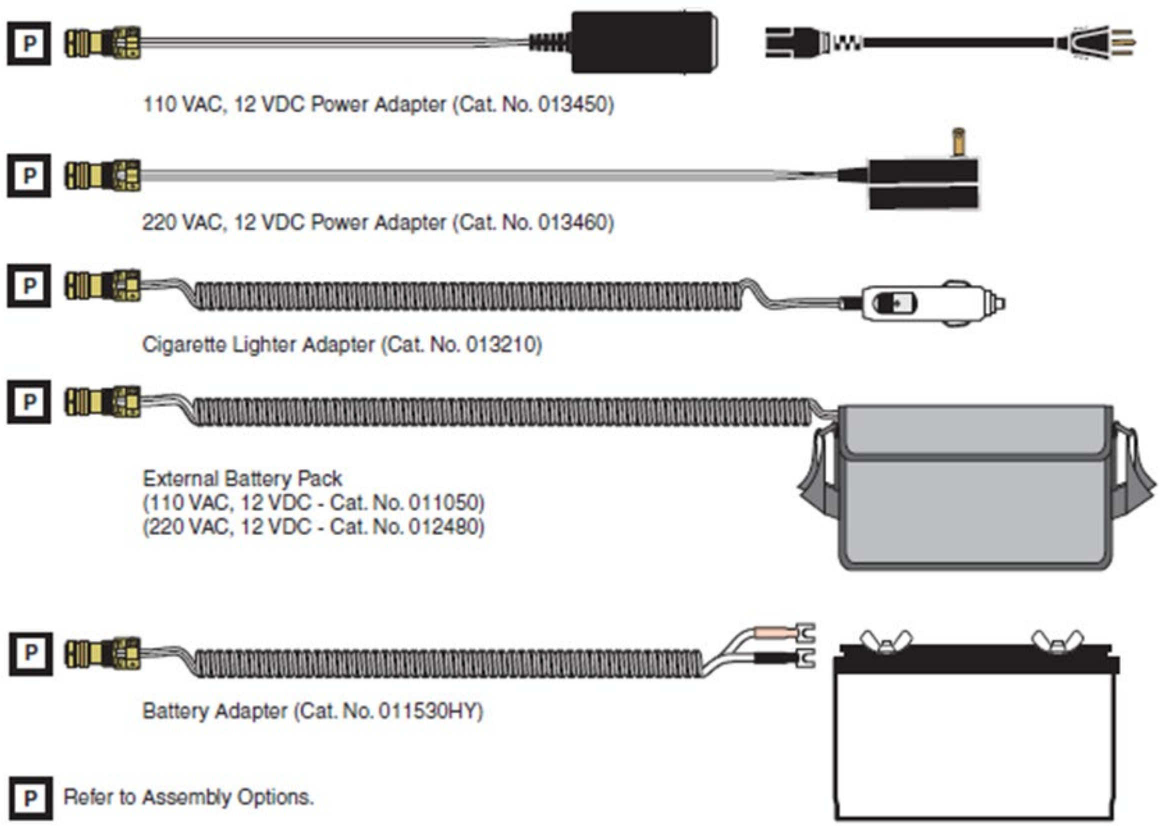

Figure 4. Series 5 Hydrolab external power options (taken from user manual).

6.4.6.4 12-volt DC batteries of varying sizes, stored in waterproof electrical boxes, are typically used to extend the amount of time between site visits.

6.4.7 Rapid deployment module

6.4.7.1 Typically real-time data transmission via telemetry only occurs at long-term-monitoring deployments. However, rapid-deployment telemetry modules can be set up to meet this need for short-term deployments.

6.4.7.2 A small waterproof electrical box is used to house the necessary equipment, including the data logger, data-collection platform radio set (DCPRS), battery, and extra communications cable.

6.4.7.3 PVC is used to cover the cable between the stream and housing. For these short-term deployments, housing can be installed closer to sensor (doesn't need to accommodate as wide of a range of flows).

6.4.7.4 Data is transmitted via the Geostationary Operational Environmental Satellite (GOES) network to Ecology's long-term continuous data management system.

6.5 Performing field checks

6.5.1 Field-check measurements using a separate calibrated sonde or instrument of comparable quality are collected upon deployment, mid-deployment, and at retrieval to help assess the data quality of the deployment measurements.

6.5.2 A list of acceptable field check instruments is maintained in the Programmatic Water Quality Impairment QAPP (McCarthy and Mathieu, 2017).

6.5.3 Upon deployment, the sonde should be allowed at least 5 minutes to equilibrate in the stream. If a logged measurement occurs less than 5 minutes after deployment, then the field check should be collected near the second logged measurement time. For example, if the sonde is deployed at 8:56 and set up to log every 15 minutes starting at 9:00, then the field-check measurement should be collected closer to the 9:15 logged measurement. This initial field check is important for assessing potential drift issues with the sensors.

6.5.4 At least one field check must be collected mid-deployment, unless the deployment is less than 48 hours. The mid-deployment field check can be collected as part of a fouling check (see Section 6.6).

6.5.5 It is recommended to locate the field check sonde as close to the deployed sonde sensors as possible (Figure 6) and to record field checks as close to the logged measurement time on the deployed sonde as possible.

6.5.6 A final field check must always be collected upon retrieval of the deployed instrument. This is the most important field check to collect.

6.5.7 If dissolved oxygen is being measured, a Winkler sample should be collected with each field check as an additional quality check on DO. If a fouling check is being conducted, the Winkler should be collected immediately after the fouling check.

Figure 5. Example of side-by-side field check on a deployed sonde.

6.6 Sonde cleaning and fouling checks

6.6.1 Cleaning of the sonde/sensors and a fouling check should be completed during site visits when a sonde has been left unattended for a period of 1 week or longer and upon instrument retrieval for any deployment of 1 week or longer. More frequent cleaning and fouling checks may be necessary in very eutrophic conditions or during periods of sedimentation.

6.6.2 Fouling check procedure.

6.6.2.1 Conduct site inspection for damage, obstructing debris, sedimentation, and general observations. Record all observations.

6.6.2.2 Upon arriving at the site, immediately place the field-check sonde/instrument in the water near the deployed sonde and power on the handheld. This will allow the field check instrument the appropriate warmup time.

6.6.2.3 **If there is NOT a cable permanently attached to the deployed sonde**, allow the sonde to log one final reading, and then record the pre-cleaning field-check readings at or near the same time.

6.6.2.4 **If there is a cable permanently attached to the sonde**, attach a second handheld to the deployed communications cable and power on the handheld. Allow the appropriate sensor warmup time (2 minutes for pH, 30 seconds for all other parameters), record the deployed sonde readings, and then record the pre-cleaning field check readings at or near the same time.

6.6.2.5 After the pre-cleaning measurements have been completed, immediately remove sonde from the deployment tube, and thoroughly clean sensors following sensor cleaning procedure in 6.6.3. Clean and flush the deployment tube after removing sonde. Figure 7 depicts two examples of sensors with fouling post-deployment.

6.6.2.6 Return the sonde to the same deployment location, allow parameters to stabilize, and record post-cleaning readings and time.

6.6.2.7 At the same time or immediately after, record post-cleaning readings and time from the field check instrument. Take measurement as near to the deployed sonde as possible.

6.6.2.8 Finally, after cleaning is completed collect a Winkler sample (See EAP SOP #023; Ward, 2016) as an additional check on DO.

6.6.2.9 At the end of the fouling check you should have four sets of measurements: 1) deployed sonde pre-cleaning, 2) field check pre-cleaning, 3) deployed sonde post-cleaning, and 4) field check post-cleaning.

6.6.2.10 Make note of any rapid changes in the parameters on the field-check instrument. The pre- and post-cleaning field check readings are used to determine any change in the parameters not associated with fouling. For example, if the stream temperature is warming rapidly.

Figure 6.Sensor fouling due to sedimentation/debris accumulation (top) and eutrophic conditions (bottom).

6.6.3 Sensor cleaning procedure.

6.6.3.1 In general, always follow individual manufacturer's guidelines for cleaning the sonde and attached sensors.

6.6.3.2 After removing the sonde, the deployment tube or apparatus should be flushed with a bucket of water to remove sediment buildup and scrubbed with a hard-bristled brush attached to a long handle or pole.

6.6.3.3 The electrical connector pins of the sonde, cables, and handhelds should be dry and free of debris prior to connecting and powering on. A small container of compressed air is helpful for drying and cleaning connectors.

6.6.3.4 The bodies of the sonde and individual sensors can be carefully scrubbed with a soft-bristled brush or toothbrush and ambient or DI water.

6.6.3.5 The sensor membranes, bulbs, cells, and any other "working parts" should be cleaned with a damp, lint-free cotton swab and DI water, unless otherwise specified by the manufacturer.

6.6.3.6 For turbidity sensors, Wagner et al. (2006) recommends: "the optic lens should be carefully cleaned with alcohol by using a soft cloth to prevent scratching (or as recommended by the manufacturer), rinsed three times with turbidity-free water, and carefully dried. If the readings are unusually high or erratic during the sensor inspection, entrained air bubbles may be present on the optic lens and must be removed."

6.7 Mid-deployment standards check

6.7.1 After cleaning is completed, if the deployed sensors deviate from the field checks by greater than the thresholds identified in Table 2, then the sensors should be checked against NIST-certified standards. A standards check is only necessary for the individual parameters that exceed their respective threshold, not for the entire sonde.

Table 1. Deviation thresholds (field check vs. deployed sonde) which trigger a standards check.

Parameter	Deviation Threshold (Field check vs Deployed sonde)	Bias MQO from Programmatic QAPP
Specific Conductance	± 10%	± 10%
pH	± 0.2	± 0.2
DO	± 0.5 mg/L	± 0.5 mg/L
Turbidity	± 10% or 1 NTU/FNU**	± 10%

** whichever is greater.

6.7.2 If the deployed sensors (except for DO) deviate from the standards by greater than the thresholds identified in Table 3, then the sensors should be recalibrated. Recalibration is only necessary for the individual parameters that exceed their respective thresholds, not for the entire sonde.

6.7.3 For DO, if the difference between the deployed and field check values exceeds 0.5 mg/L (Table 2), then a saturation check should be performed on both the deployed and field check instrument. In general, recalibration of DO is not recommended in the field. The Winkler samples, mid-deployment saturation checks, and post-deployment saturation checks can be used during data processing to assess, and potentially adjust for, bias.

Table 2. Deviation thresholds (standards vs. deployed sonde) which trigger recalibration.

Parameter	Deviation Threshold (Standards vs Deployed sonde)	MQO from Programmatic QAPP
Specific Conductance	± 10%	± 10%
pH	± 0.2	± 0.2
DO	± 0.5 mg/L	± 0.5 mg/L
Turbidity	± 10% or 1 NTU/FNU**	± 10%

** whichever is greater

6.7.4 The temperature of standards/buffers used for calibration can change rapidly in the field due to differences between the ambient, vehicle, and overnight storage temperatures. Pay close attention to temperature readings during calibration and only enter the temperature-adjusted calibration value immediately before calibrating. Note any rapid temperature changes in the buffer on the calibration form or field log book.

6.7.5 If possible, the buffers and sonde should be kept out of direct sunlight during field calibration to avoid temperature changes due to direct solar radiation.

6.7.6 Two options are available for saturation field checks on DO: 1) a small aquarium bubbler can be setup in a small open-top container of water and the sonde placed inside or 2) a bottle of water that has equilibrated to ambient air temperature may be shaken for 40 seconds and then poured into the sonde's calibration cup. See SOP EAP033 (Anderson, 2016) for further detail.

6.7.7 DO saturation field checks require the local barometric pressure. This can be measured in the field with a barometer or can be obtained from a local weather station. The YSI Exo Handheld is equipped with a barometer, and DO saturation can be viewed in %EU mode to obtain readings automatically corrected to the live barometric pressure reading. Most weather stations report the barometric pressure adjusted to sea level. These values must be adjusted for the site elevation using the equation:

$$\text{Pressure at sea level in mmHg} = (\text{Site Elevation} \times 0.0254)$$

6.7.8 During DO saturation field checks, record the DO in mg/L, water temperature, and specific conductance of the water at saturation. The temperature and specific conductance readings can be used to calculate the theoretical DO at saturation in mg/L using the USGS DO saturation tables (https://water.usgs.gov/software/DOTABLES/).

6.7.8.1 The DO tables can be printed out and used in the field for reference.

6.7.8.2 The sonde and theoretical DO values, in mg/L, at saturation can be compared to assess the potential error in mg/L. This information is useful during the data-processing stage.

6.8 Retrieval of sonde and deployment equipment

6.8.1 After collecting the final field, fouling, and Winkler checks, the sonde should be removed from the water and fitted with the sensor storage cup. A small amount of tap or site water should be placed in the storage cup to protect the sensors against damage or drift.

6.8.2 The data should be downloaded, backed-up, and visually checked before leaving the site. Data quality or logging issues may require re-deployment of the same or a different sonde.

6.8.3 Disturbance of the streambed and riparian area should be minimized upon station removal. All materials (rebar, strut channel, concrete blocks, etc.) brought to the site for installation must be removed from the site. The stream and surrounding areas should be restored to their pre-deployment condition, to the extent possible.

6.9 Post deployment reference checks

6.9.1 Both the deployed and field instruments should be checked against reference materials upon retrieval. This is similar to the pre-deployment calibration procedure; however, the sensors should **NOT** actually be calibrated to reference values. This is particularly important for 2- or 3-point calibrations, such as pH, where the second and third readings are affected by the first calibration point.

6.9.2 The purpose of the post-check is to assess the sensors for potential drift or bias issues, NOT to recalibrate the sonde for subsequent data collection.

7.0 Records Management

7.1 Field measurements and observations recorded in a field notebook should be checked for errors and omissions before leaving each site and then entered into the appropriate discharge spreadsheet as soon as possible upon return from the field.

7.2 Electronically recorded measurements should be saved to another device (e.g. usb drive, tablet, or laptop) as soon as possible (preferably in the field) and entered/imported into the project database as soon as possible upon return from the field.

7.3 For Ecology staff, the raw data files should be saved to network drive in order to ensure routine backup of files.

8.0 Quality Control and Quality Assurance

8.1 QA/QC procedures will be addressed thoroughly on a project-by-project basis in the Quality Assurance Project Plan (QAPP) for the project.

8.2 In the absence of a project specific QAPP, QA/QC procedures and objectives should follow those outlined in Section 6 of this SOP, in the Programmatic Water Quality Improvement QAPP (McCarthy and Mathieu, 2017), and in the Part 2 Data Processing SOP.

9.0 Safety

9.1 Wading streams is one of the most dangerous activities undertaken by field staff especially during higher flows. Two people are required at all times when streams are to be waded. Life jackets are to be worn if there is any chance of being pushed downstream or being submerged after falling into the water. Life jackets should also be worn when new sites are being established and when stream conditions to be encountered are unknown.

9.2 Assess whether or not the velocity and depth of the stream are low enough to safely wade across it. As a rule of thumb: **Do NOT wade in flowing water when the product of depth (in feet) and velocity (in feet per second) equals 10 or greater.** For example, if the stream is estimated to be 3 feet deep and have a velocity of 4 ft/s, do **NOT** wade across the stream. This is only a general rule; take extra precautions where the substrate is unstable (slippery or moving), water visibility is impaired (high turbidity or glare), or other challenges are present.

9.3 If there is any chance of the streamflow being strong enough to potentially cause injury (by being swept downstream into rocks or other dangerous settings, drowning, hypothermia, etc.), do not consider wading in the stream. When in doubt, err on the side of safety.

9.4 For further field health and safety measures refer to Environmental Assessment Program's Safety SharePoint site.

10.0 References

10.1 Environmental Assessment Program (EAP), 2019. *Environmental Assessment Program Safety Manual*. Washington State Department of Ecology. Revised 03/19

10.2 Anderson, P. 2016. Standard Operating Procedure EAP033: Hydrolab® DataSonde®, MiniSonde®, and HL4 Multiprobes. Environmental Assessment Program, Washington State Department of Ecology, Olympia.
ecology.wa.gov/quality

10.3 Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 pp. + 8 attachments.
http://pubs.water.usgs.gov/tm1d3

10.4 Ward, W.J, 2016. Standard Operating Procedure EAP023: Collection and Analysis of Dissolved Oxygen (Winkler Method). Environmental Assessment Program, Washington State Department of Ecology, Olympia.
ecology.wa.gov/quality

10.5 Webb, W.E., Radtke, D.B., and Iwatsubo, R.T., 1999. Surface-water sampling: Collection methods at flowing-water and still-water sites: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chapter A6, Section 4.1.
http://pubs.water.usgs.gov/twri9A4

10.6 Wilde, F.D., and Radtke, D.B., 2005. General information and guidelines: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chapter A6, Section 6.0, 36 pp.
http://pubs.water.usgs.gov/twri9A6