LONG CREEK
Watershed Management District

Long Creek Quality Assurance Project Plan

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A.2 PROJECT / TASK ORGANIZATION

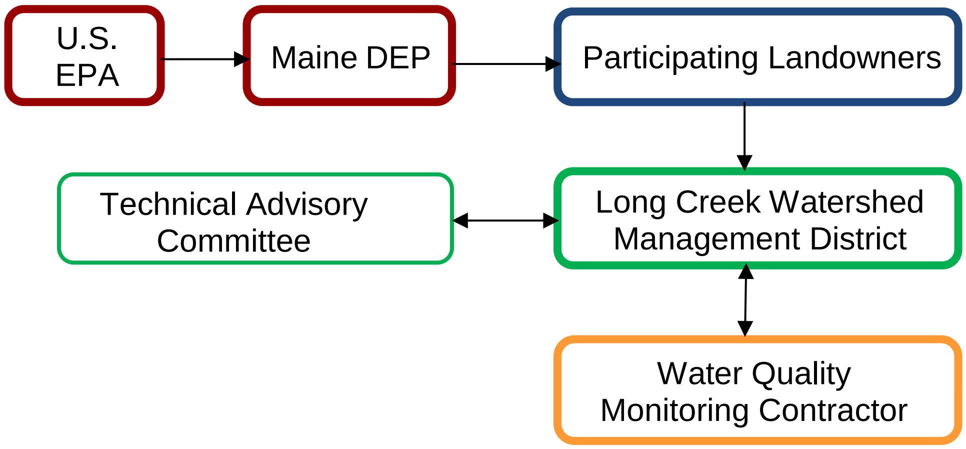

Figure 1: Project Organizational Flow Chart

A.3 PURPOSE

The *General Permit – Post Construction Discharge of Stormwater in the Long Creek Watershed* (MEPDES Permit #MEG190000/Wastewater Discharge License #W-9052-5Y-B-N) issued by the Maine Department of Environmental Protection on October 29, 2009, and renewed on April 21, 2015, provides for the implementation of the *Long Creek Watershed Management Plan* (Management Plan) which lays out a course of action toward improving water quality in Long Creek and meeting water quality goals by 2020.

This *Long Creek Quality Assurance Project Plan* (QAPP) and the accompanying *Long Creek Monitoring Plan* (Monitoring Plan) (**Appendix A**) provide the means and methodologies for monitoring water quality within Long Creek to assess progress toward meeting the water quality goals in accordance with the timeline laid out in the Management Plan. Specifically, the monitoring activities presented in the Monitoring Plan will provide water quality data to assess the effectiveness of program interventions and monitor the recovery of Long Creek.

The Monitoring Plan is implemented by the Long Creek Watershed Management District (LCWMD) through a monitoring contractor. Implementation is overseen by the Maine Department of Environmental Protection (MEDEP) and the U.S. Environmental Protection Agency (EPA).

A.4 PROJECT BACKGROUND

Long Creek is a freshwater urban stream system in southern Maine. The Long Creek Watershed is approximately 3.45 square miles and is located in Portland, South Portland, Westbrook, and Scarborough, Maine. The stream currently does not meet Maine water quality standards due to the influences of increased concentrations of metals, chloride, phosphorus, nitrogen, polycyclic aromatic hydrocarbons (PAHs), and reduced dissolved oxygen (DO) concentrations. The degraded water quality is caused by substantial nonpoint source (NPS) discharges to Long Creek. Water quality is also adversely affected by altered hydrological conditions and increased water temperatures from lack of shading in certain areas.

Development over the past several decades has converted the landscape from mostly forests and fields to commercial, light industrial, retail, and transportation uses. One of the primary results of this conversion process has been the creation of IC such as roads, driveways, parking lots, sidewalks, rooftops, and any other impermeable surfaces of the built environment. IC prevents water from infiltrating into the ground and acts as a conveyance method for a wide variety of pollutants commonly carried into adjacent surface waters by stormwater or melting snow.

A direct correlation has been established between IC and the health of aquatic ecosystems. In general, stream watersheds with less IC exhibit stream flows that are less variable, which encourages a healthier biotic community. It has been shown that as IC increases above 10% there is a corresponding increase in stormwater flows and degradation in water quality, stream habitat, and diversity of aquatic life. Some areas of the Long Creek Watershed have an IC of greater than 60%. This impervious cover alters the hydrology of Long Creek and acts as a conveyance for pollutants into adjacent surface waters by stormwater or melting snow. High IC increases the volume of runoff directed to Long Creek by decreasing filtration through soils and directing of overland flows to ditches and storm drains.

A.5 MONITORING PROGRAM

The purpose of the Long Creek monitoring program is to gather information needed for long-term management of this urban impaired stream. Stream health will be assessed through approved methods and with the collaboration of local stakeholders. The goals of this project as defined by the Monitoring Plan are:

1. To determine whether or not Long Creek meets applicable water quality standards;
2. To gather information to improve management of Long Creek; and
3. To document effectiveness of restoration programs and progress toward meeting standards.

A representative set of aquatic health indicators should in many cases be measured each year and changes in these indicators interpreted. After initial, post-planting, or post-construction monitoring has occurred, some parameters might only need to be measured every two to three years to confirm expected rates of recovery and to reduce costs. The monitoring program includes an assessment of:

1. Water quality via synoptic grab sampling and laboratory analysis (phosphorous, metals, and chloride) and continuous *in situ* measurements for key water quality parameters (specific conductance, DO, and temperature);
2. Hydrology via continuous stream flow measurements correlated with precipitation data;
3. Biology via macroinvertebrate and fish surveys;
4. Riparian/floodplain/in-stream habitat to determine the extent of adjacent land use modifications and habitat improvements via parameters such as in-stream large wood abundance, habitat diversity, flow velocity heterogeneity, bank stability, etc.; and,
5. Targeted sediment quality via composite sampling and laboratory analysis for key sediment quality parameters, which may include, but are not limited to, total organic

carbon, metals, acid volatile sulfide and simultaneously extracted metals [AVS/SEM], PAHs, and pesticides.

Table 1 presents an overview of the various aspects of the Long Creek Watershed monitoring program.

Table 1: Overview of the Long Creek Watershed Monitoring Program

Parameter	Method	Locations	Conducted by
Hydrologic Alteration			
Stream Hydrology	Stage-discharge relationship via surveyed cross sections, flow meter, and transducer measurements	Primary Sites	LCWMD
Weather	Temperature, precipitation, and snowfall	Portland International Jetport	NOAA
Addressing Water Quality Standards			
Continuous water chemistry – specific conductance, DO, water temperature	Data loggers	Primary Sites	LCWMD
Biomonitoring – macroinvertebrates	Rock bags/baskets	Primary Sites	MEDEP or LCWMD
Biomonitoring – fish surveys	Electrofishing	Primary Sites	Maine DOT or LCWMD
Chloride	Base-flow sampling	Primary and Secondary Sites	LCWMD
	Melt-flow sampling	Primary Sites	LCWMD
	Storm-flow sampling	Targeted Sites	LCWMD
Documenting Watershed Processes			
Conventional Pollutants: Phosphorus	Base-flow samplingsamples	Primary and Secondary Sites	LCWMD
	Storm-flow sampling	Targeted Sites	
Field measurements – specific conductance, DO, water temperature	Base-flow sampling	Primary and Secondary Sites	LCWMD
	Storm-flow sampling	Targeted Sites	
Stream hydrology to determine stage-discharge curves and evaluate remedy effectiveness	Temporary monitoring	Restoration project sites	LCWMD
	Periodic monitoring	Primary Sites	LCWMD
Toxicity and Toxic Chemicals			
Metals	Base-flow sampling	Primary and Secondary Sites	LCWMD

	Storm-flow sampling	Targeted Sites	LCWMD
Hardness	Base-flow sampling	Primary and Secondary Sites	LCWMD
	Storm-flow sampling	Targeted Sites	LCWMD

The monitoring program design allows both longitudinal documentation of trends at single locations and upstream-downstream comparisons to evaluate changes occurring within the watershed.

A.5.1 MONITORING LOCATIONS

Ongoing monitoring will be focused at pre-determined monitoring locations (**Figure 2** and **Table 2**). Monitoring at those locations generates a long-term record that will be informative of changing conditions in Long Creek and its tributaries.

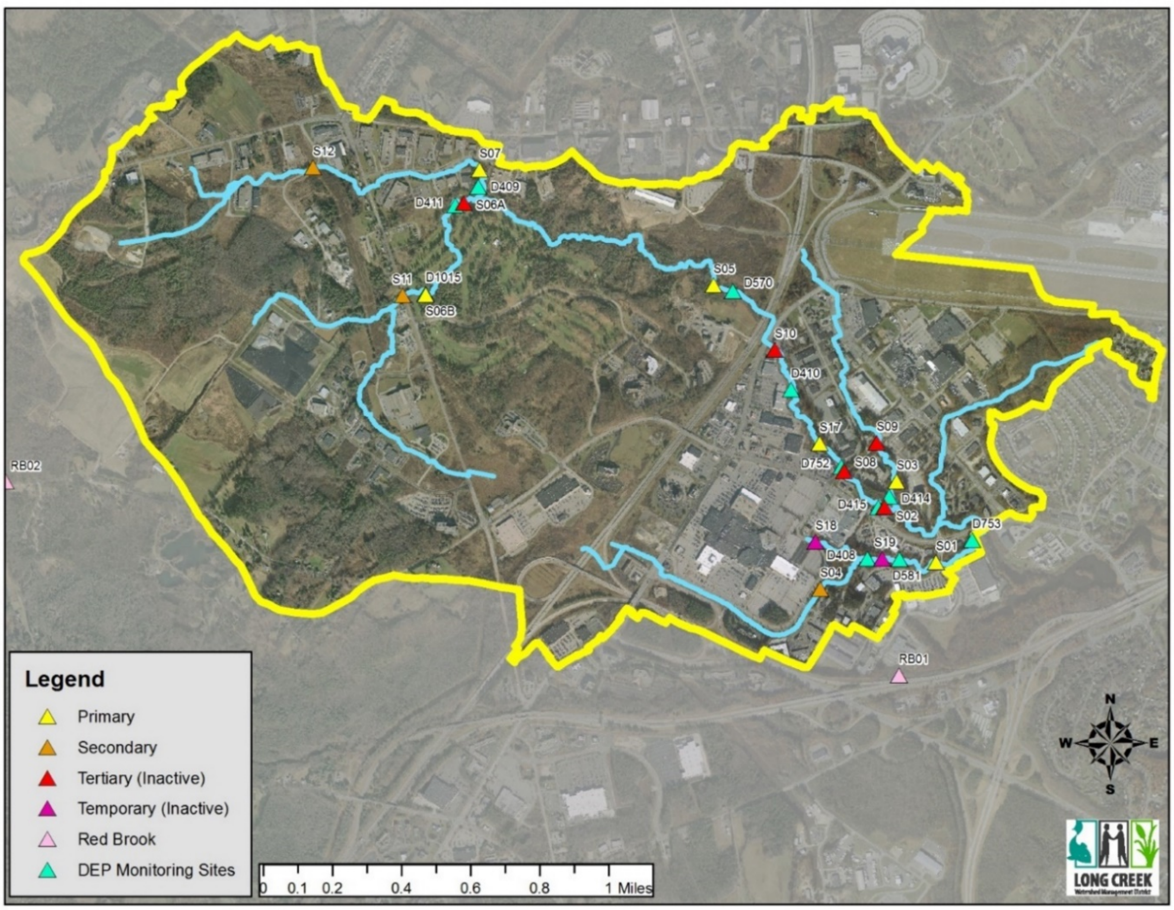

Figure 2: Long Creek Monitoring Locations

Table 2: Monitoring Locations in Long Creek

Site Type	Site No.	Monitoring Location	MEDEP Biomonitoring Site Code
Primary	S01	South Branch above Clarks Pond access road	Station 753
	S02 (inactive)	Main Stem above confluence with North Branch	Station 415
	S17[1]	Main Stem above Foden Road	Station 752
	S03	North Branch above confluence with Main Stem	Station 414
	S05	Main Stem above Maine Turnpike	Station 570
	S06 (inactive)	Main Stem above confluence with Blanchette Brook	Station 411
	S06B[2]	Main Stem above confluence with Blanchette Brook	Station 1015
	S07	Blanchette Brook above confluence with Main Stem	Station 409
Secondary	S04	South Branch below Econolodge Motel	Stations 408, 581
	S11	Upper Main Stem above Spring Street crossing	--
	S12	Blanchette Brook above Spring Street crossing	--
Tertiary	S08	Main Stem above Foden Road crossing	--
	S09	North Branch above Foden Road crossing	--
	S10	Main Stem below Maine Mall Road//Maine Turnpike	Station 410
Temporary	S13 (inactive)	Main Stem above S05, below Portland snow storage	--
	S14 (inactive)	Main Stem above S05, above Portland snow storage	--
	S15 (inactive)	Blanchette Brook downstream of B-21 BMP	--
	S16 (inactive)	Blanchette Brook upstream of B-21 BMP	--

Monitoring locations are divided into four site types: primary, secondary, tertiary, and temporary. The primary, secondary, and tertiary monitoring locations were selected based

[1] Site No. S02 was moved to this location and designated Site No. S17.

[2] Site No. S06A was moved to this location and designated Site No. S06B.

upon data collected by MEDEP that indicated degraded water quality and biological impairments. Of the 12 sites identified, six were designated Primary Sites, where near-continuous water quality and flow measurements are collected. The Primary Sites were selected to provide a synoptic view of stream conditions across the watershed. Secondary Sites have identified or likely impairments due to nearby activities and are monitored for a selected subset of parameters (*e.g.*, periodic analytical or flow measurements). Tertiary Sites have been used to collect samples for PAHs, however, PAH sampling at these locations was suspended in 2012 due to the limited utility of the information provided by the data. Temporary Sites may be established at the discretion of LCWMD to provide flexibility to the Monitoring Program. Temporary Sites may be utilized to monitor the effectiveness of BMPs within the watershed that are not currently bookended by primary or secondary sample locations, or for any other purpose deemed appropriate by the LCWMD. Based on the results collected from the Primary Sites, activities for the Secondary Sites, Tertiary Sites, and Temporary Sites will be periodically evaluated.

A.5.2 SUMMARY OF MAJOR PARAMETERS

Table 3 summarizes the major parameters associated with each monitoring location and the periods during which they will be implemented. The Monitoring Plan provides a more detailed rationale for parameter selection. In general, sample parameters were identified based on a site's documented history of water quality and biological degradation, land usage in the area, and the goal to evaluate changes in constituents across the watershed. This program is not designed to be a comprehensive delineation of sources of constituents nor is it designed to define all areas of impact within the watershed. This program will evaluate changes within the specific sites in the watershed over time and provide a long-term dataset that will be integrated into any future post-construction or post-restoration monitoring program as appropriate.

Table 3: Major Parameters Associated with Each Monitoring Location

Site No.	Type	Continuous Monitoring	Hydrologic Monitoring	Biological Monitoring	Phosphorous	Metals	Chloride
S01	Primary	2010-2020	2010-2020	2013, 2018	2010-2020	2010-2020	2010-2020
S17	Primary	2014-2020	2014-2020	2015, 2018	2014-2020	2014-2020	2014-2020
S03	Primary	2010-2020	2010-2020	2010, 2013, 2015, 2018	2010-2020	2010-2020	2010-2020
S04	Secondary	--	--	--	2010-2020	2010-2020	2010-2020
S05	Primary	2010-2020	2010-2020	2010, 2013, 2015, 2018	2010-2020	2010-2020	2010-2020
S06B	Primary	2013-2020	2013-2020	2015, 2018	2013-2020	2013-2020	2013-2020
S07	Primary	2010-2020	2010-2020	2010, 2013, 2015, 2018	2010-2020	2010-2020	2010-2020

S08	Tertiary	--	--	--	--	--	--
S09	Tertiary	--	--	--	--	--	--
S10	Tertiary	--	--	--	--	--	--
S11	Secondary	--	--	--	2010-2020	2010-2020	2010-2020
S12	Secondary	--	--	--	2010-2020	2010-2020	2010-2020
S13	Temporary	2012	--	--	--	--	2012
S14	Temporary	2012	--	--	--	--	2012
S15	Temporary	2013	--	--	2013	2013	2013
S16	Temporary	2013	--	--	2013	2013	2013

Sample methodology and purpose is presented in detail in the Monitoring Plan and below (sections A.5.3 – A.5.11).

A.5.3 MONITORING FREQUENCY

Table 4 summarizes the timing and frequency of major monitoring parameters during each monitoring season.

Table 4: Monitoring Schedule and Parameters

		Primary Locations (S01, S17, S03, S05, S06B, S07)							Secondary Locations (S04, S11, S12)				Tertiary Locations (S08, S09, S10)
Month	Type	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Logger	Transducer	Flow Curve Check	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	PAHs
Feb-Mar	Melt	--	--	X	--	X*	X		--	--	--	--	--
Feb-Mar	Melt	--	--	X	--	X*	X		--	--	--	--	--
Feb-Mar	Melt	--	--	X	--	X*	X		--	--	--	--	--
Mar-Apr	Melt	--	--	X	--	X*	X		--	--	--	--	--
May	Base flow	X	X	X	X	--	--	X	X	X	X	X	--
July	Base flow	X	X	X	X	--	--		X	X	X	X	--
Sept	Base flow	X	X	X	X	--	--		X	X	X	X	--
Mar-Nov	Continuous	--	--	--	--	X	X		--	--	--	--	--
*Specific conductance only.													

A.5.4 GRAB SAMPLE COLLECTION

Grab samples will be collected throughout the monitoring season. The program has been designed to evaluate spring-melt, base-flow, and targeted storm-flow conditions.

The following factors must be addressed prior to the sampling event:

- Methodology must ensure, to the extent practicable, that samplers fill contemporaneously.
- Sufficient samplers must be deployed to collect necessary sample volume. Care must be taken to ensure that samples are composited in such a way as to be representative of that which is identified to be sampled. Any vessels used to composite samples must be pre-cleaned and either disposable (single use) or properly decontaminated between sample sites. If reusable compositing vessels are used, daily equipment blanks must be collected.
- Discrete sample times must be ascertained for each sample site.
- Birds or other wildlife must not foul the sampler between deployment and sample collection.

Laboratory analyses will include: Total Chloride for spring-melt samples; TAL Metals (total copper, lead, nickel, and zinc), Hardness, Total Phosphorus, and Total Chloride for base-flow and storm-flow samples; and any one or more of these parameters for storm-flow samples, plus any other parameters for which a need is identified for storm-flow sampling.

Specific grab sample dates are to be determined; however, the program will have the following structure:

A minimum of three, and a maximum of four, rounds of melt samples will be collected at all primary monitoring locations from February through April (or from the beginning of melting until no snow remains in the watershed), on days with temperatures above freezing when either warm weather conditions or spring rain have contributed to the melting of any remaining snowpack and the introduction of runoff to the Long Creek Watershed.

One base flow round of synoptic samples will be collected at all primary and secondary sample locations in the Long Creek Watershed in May, July, and September of each calendar year. These data are intended to provide a consistent dataset for the evaluation of stream water quality conditions and for use in statistical analysis.

Targeted storm-flow sampling may be conducted to answer specific questions with a tailored sampling design that ensures collection of usable data.

Table 5 summarizes monitoring locations and grab sampling parameters.

Table 5: Summary of Monitoring Locations and Grab Sampling Parameters

Site	Type	Sampling Event	Nutrients	Metals	Other
S01	Primary	Base	Total P	Cu, Pb, Ni, Zn	Hardness, Chloride, Field Parameters
		Melt			Chloride, Field Parameters
S17	Primary	Base	Total P	Cu, Pb, Ni, Zn	Hardness, Chloride, Field Parameters
		Melt			Chloride, Field Parameters

S03	Primary	Base	Total P	Cu, Pb, Ni, Zn	Hardness, Chloride, Field Parameters
		Melt			Chloride, Field Parameters
S04	Secondary	Base	Total P	Cu, Pb, Ni, Zn	Hardness, Chloride, Field Parameters
S05	Primary	Base	Total P	Cu, Pb, Ni, Zn	Hardness, Chloride, Field Parameters
		Melt			Chloride, Field Parameters
S06B	Primary	Base	Total P	Cu, Pb, Ni, Zn	Hardness, Chloride, Field Parameters
		Melt			Chloride, Field Parameters
S07	Primary	Base	Total P	Cu, Pb, Ni, Zn	Hardness, Chloride, Field Parameters
		Melt			Chloride, Field Parameters
S11	Secondary	Base	Total P	Cu, Pb, Ni, Zn	Hardness, Chloride, Field Parameters
S12	Secondary	Base	Total P	Cu, Pb, Ni, Zn	Hardness, Chloride, Field Parameters

Base-flow samples will be collected during dry weather conditions with a minimum of 72 hours without precipitation[3] preceding sample collection. Surface water samples collected during spring-melt and base-flow conditions will be collected using either disposable, pre-cleaned dippers, or clean bottles provided by a certified laboratory and following the *Standard Operating Procedure, Methods for Collecting Surface Water Grab Samples* (Surface Water Grab Sample SOP) provided in **Appendix B**.

Storm-flow sampling, if performed, will be conducted using Nalgene Storm Water Samplers installed in the stream channel preceding a targeted storm event expected to exceed 0.25 inches of precipitation to capture the first flush of stormwater runoff entering the stream. Storm Water Samplers (also known as rising stage samplers) are in-stream water sampling

[3] The 72-hour condition for base flow was determined in a study conducted in Long Creek between 2010 and 2012. *See* Frederik Schuele, URS Corporation, memorandum to Kate McDonald, Long Creek Watershed Management District, April 15, 2013, Long Creek Monitoring Program, Estimation of baseflow conditions in Long Creek based on in-stream specific conductance data for the purpose of defining timing of baseflow monitoring events.

devices that fill with water when the stream reaches a determined stage and isolate the sample until a technician can remove it for analysis. The storm samplers are useful to capture storm events without requiring a person to be at the site. Equipment will be the Nalgene Storm Water Sampler model 1100-1000 or equivalent (see *Nalgene/I-Chem model 1100-1000 Rising Stage Sampler*, **Appendix C**). Alternatively, storm-flow samples may be collected using dippers or similar methods on the rising stage (as determined by established flow curves). The standard operating procedure for this approach must be submitted to LCWMD in writing, and approved by LCWMD in writing, prior to implementation.

The height of the auto-samplers will be determined by reviewing in-stream pressure transducer data to ascertain the typical stream height for a qualifying rain event. National Oceanic and Atmospheric Association (NOAA) weather data will be used to determine the approximate time that the auto-sampler began to fill. If no sample is able to be collected during the sampling event due to low or no water, data points will be labelled as “DRY."

Duplicate samples will be collected at a rate of one duplicate per ten samples (1:10) for each sampling event. If less than ten samples are collected for a sampling event, one duplicate sample will be collected for the sampling event.

Water quality field parameters will be collected concurrent with each synoptic grab\sampling event and will include specific conductance, DO, and temperature. Water quality field parameters are measured using a handheld electronic meter. The equipment used in this study is a YSI Pro2030, or equipment of equivalent accuracy (see *YSI Pro2030 User Manual*, **Appendix D**).

For those parameters for which a calibration procedure is specified, the meter will be calibrated in accordance with the manufacturers specifications at least once daily prior to use. Post-calibration readings must be within +/-10% of anticipated standard value, with the exception of zero DO solution, which should be <0.5 mg/L.

A.5.5 CONTINUOUS MONITORING

Data loggers are used to continuously gather information on in-stream water quality parameters such as specific conductance, dissolved oxygen, and temperature. These parameters are linked to stream health and productivity. Continuous monitoring allows trends and relationships to be researched and understood in a specific stream system. The data loggers will be deployed continuously during the sampling season. HOBO U24-001 (see *HOBO U24 Conductivity Logger Manual*, **Appendix E**) and HOBO U26-001 models (see *HOBO Dissolved Oxygen Logger (U26-001) Manual*, **Appendix F**) will be deployed annually.

Submersible pressure transducers (data loggers) are used to gather continuous in-stream information regarding stream stage. Using data loggers to collect measurements at a set interval throughout a set time period will improve accuracy of the stage-discharge curves used in predicting stream discharge. HOBO U20 Water Level Loggers will be deployed annually (see *HOBO U20 Water Level Logger (U20-001-0x and U20-001-0x-Ti) Manual*, **Appendix G**).

An additional HOBO U20 Water Level Logger will be maintained in ambient air at site 06B to record air barometric pressure. Barometric pressure data from this pressure transducer is used for adjusting water level and DO % saturation data in-stream data files. Barometric pressure data from the NOAA weather site is not used for these purposes because the NOAA data would need to reformatted into a format usable by software for the loggers, the data logging interval on the data loggers is every 30 minutes whereas the NOAA data is hourly, and the logger data is collected on the hour and the half hour whereas the hourly NOAA weather data is not is not necessarily collected on the hour.

Based on the findings of the monitoring program to date, and LCWMD's data needs, the continuous monitoring schedule through 2020 will meet the following criteria:

(1) Data loggers and stream stage monitoring equipment (*i.e.*, transducers) will be deployed as early as practicable once weather conditions allow, typically late March.
(2) Data loggers and transducers will be maintained throughout the flow season until consistent freezing temperatures necessitate removal, typically late November or early December.

Details concerning calibration, launch, deployment, and data retrieval, adjustment, and validation for the HOBO U20, U24, and U26 Data Loggers are in the *Standard Operating Procedure, HOBO U20, U24 and U26 Data Loggers* (**Appendix H**).

A.5.6 HYDROLOGY

Cross-sections of the stream channel and floodplain will be surveyed once annually with a rod and level at all primary locations (except at location S07 where flow is measured in a culvert). The survey data will be collected relative to the existing elevation benchmark at each monitoring location.

Stream stage is monitored at all primary monitoring locations at 30-minute intervals using HOBO U-20 pressure transducers installed in stilling wells as described in the *Technical Application Note for Constructing a Stilling Well* (**Appendix I**). To calculate actual stream elevations for hydrologic monitoring data, the elevation of in-stream stage monitoring equipment will be correlated to a constant reference elevation through benchmarks established at each primary monitoring location. Benchmarks will be registered to a common vertical datum (i.e., North American Vertical Datum 1988, or similar) to an accuracy of +/- 0.01 feet. If the in-stream monitoring equipment is moved, or relocated, during the monitoring season, elevations of the equipment and stream (or culvert) bottom will need to be re-surveyed to the existing benchmark at each monitoring location.

Stream discharge is calculated as the product of stream velocity times the area of the cross section of the stream channel. To determine discharge, stream velocity and stream channel cross-sectional area (except at location S07 where flow is measured in a culvert) will be measured annually during a rain event between June and October at each primary monitoring location. Stream velocity is measured using a HACH 950 flow meter, or equivalent. Stream cross-sectional area is measured with a wading rod.

Flow meters are electromagnetic velocity meters such as the HACH 950, or equivalent. (see *Hach 950 Portable Velocity Meter*, **Appendix J**). Flow meters provide data used in the calculation of stage-discharge curves.

Instantaneous stage readings taken concurrently with flow measurements will conform to USGS-cited methods such as staff-rod, pressure transducer, or fixed stage marker.

A.5.7 STREAM GEOMORPHOLOGY

Stream geomorphology will be evaluated in accordance with standard procedures as outlined in the MEDEP *Stream Survey Manual* (MEDEP 2009) and as specified in the Monitoring Plan. Geomorphology shall include evaluations of:

- Stream channel stability;
- Habitat complexity; and,
- Channel morphology.

An overall stream geomorphology assessment was conducted in 2015.

A.5.8 BIOLOGICAL MONITORING

The macroinvertebrate community is sampled by deploying standardized sampling devices (rock bags or rock baskets) on the stream bottom for a period of four weeks and collecting the organisms that colonize the bags. The collected organisms are identified and quantified and the resulting data is used to calculate 23 variables that are used in linear discriminant models which predict the probability that the community will meet the aquatic life criteria for a given stream classification (A, B, or C). The criteria are defined in Chapter 579 of the MEDEP's *Rules*, *Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams*.

Samples for stream invertebrates will be collected at all six primary monitoring locations twice in every five-year period (*i.e.*, in 2010, 2013, 2015, and 2018).

The stream channel at each site will be qualitatively assessed for stream channel stability, geomorphology, in-stream wood, and channel morphology as part of a visual assessment that will occur when collecting and deploying sampling devices. The stream channel is important for biotic habitat and conveyance of water. Changes in morphology of the stream can indicate adjustments of flow and health of the local environment. This program will be implemented in accordance with the protocols and procedures included in the *Methods for Biological Sampling and Analysis of Maine's Rivers and Streams* in **Appendix K**.

A.5.9 *IN SITU* TOXICITY TESTING

To identify whether water quality or other factors (*i.e.*, habitat and hydrology) are the primary stressors to macroinvertebrates, *in situ* toxicity testing events may be conducted within Long Creek in accordance with **Appendix L**, modified as necessary to meet the specific circumstances encountered in Long Creek. If conducted, one test will be performed during late-summer base-flow conditions (chronic exposure) and one test will be performed during spring-melt conditions (acute exposure).

The *in situ* toxicity testing program evaluates survivability of aquatic invertebrates at monitoring locations in Long Creek that have historically shown elevated levels of chloride (*i.e.*, locations S01 and S03), and relatively lower levels of chloride (*i.e.*, locations S02 and S07). Test chambers utilized for the *in situ* toxicity testing are to use clean substrates (*i.e.*, rocks), without additional food sources (*i.e.*, coarse particulate organic matter or detritus), so as to reduce additional variability for the test.

Activities to be performed as part of the *in situ* toxicity testing program include:

- Collection of stream velocity and water depth at all locations in order to standardize exposure conditions between sites, to the extent possible.
- Collection of micro habitat data at each location during initial station characterization.
- Daily grab water quality parameter collection during the exposure period at each testing location, to include specific conductance, DO, turbidity, and temperature. The water quality parameter collection will be performed twice a day (once in morning and once in the late afternoon) from a sampling port of each test chamber to determine any potential changes to water quality within the chambers.

A.5.10 RAPID BIO-ASSESSMENT

A physical habitat characterization to evaluate differences in stream and riparian habitat quality between monitoring locations in Long Creek may be performed in accordance with Chapter 5 of the EPA *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers* (Barbour 1999). Rapid bio-assessment is most likely to be used to determine the effectiveness of restoration efforts by conducting pre-and-post restoration assessments. The timing of this program, and the subwatersheds to be evaluated, will be determined by LCWMD.

A.5.11 SEDIMENT INVESTIGATION

If sediment sampling is performed, surficial (0-6”) sediment samples will be collected from depositional areas in the stream channel in accordance with **Appendix M**, modified as necessary to meet the specific circumstances encountered in Long Creek. Key sediment quality parameters and associated analytical methods, include, but are not limited to:

- Total Organic Carbon via Method 9060 - Lloyd Kahn
- Select TAL Metals (arsenic, cadmium, chromium, copper, lead, nickel, and zinc) via Method EPA 6020C
- Acid Volatile Sulfide (AVS) and Simultaneously Extracted Metals (SEM) via Method EPA-121-R91-100
- Polycyclic Aromatic Hydrocarbons (PAHs) via Method EPA 8270D
- Pesticides via Method EPA 8081B

A.6 DATA QUALITY OBJECTIVES AND CRITERIA

A.6.1 REPRESENTATIVENESS

Primary monitoring stations are located throughout the Long Creek Watershed at the downstream end of sub-watersheds identified within the Long Creek Watershed, and at locations higher in the watershed to facilitate upstream-downstream comparisons. Secondary monitoring stations are located in areas where specific water quality issues have been identified. Stream monitoring varies by location and timing to account for seasonality and the differing environments and flow regimes along the creek channels.

A.6.2 COMPARABILITY

Monitoring locations are fixed throughout the watershed. Locations are monitored for the same parameters at approximately concurrent times. Stations do not change during the course of this project unless new information is discovered and all parties to this Project QAPP review and accept the proposed change(s). Any station changes will be described and included in an addendum to this Project QAPP.

Comparability of data collected to other similar projects will be ensured by using standard operating procedures that are widely accepted, have been in use for many years, and are publicly available.

A.6.3 COMPLETENESS

It is expected that at least 80% of data logger deployment times will return usable data when analyzed. This will be determined on the basis of each parameter (excluding depth at locs where a permanent fixed location is not reasonably achievable). At least five stage-discharge comparisons will be made before a rating curve is attempted, and the stages are to be well-distributed across as wide a discharge range as is feasible, given weather and safety constraints. Data loggers are continuous monitoring instruments, therefore, replicate or duplicate samples are not appropriate; however, handheld instruments will be used to verify the data logger measurements at the time of deployment and retrieval to ensure data quality. Duplicate grab samples will be collected at each opportunistic sampling site.

A.6.4 ACCURACY, RESOLUTION, AND MEASUREMENT RANGE

Data ranges for water quality testing will depend on the testing methods of the laboratory. Data outside of the acceptable range will be noted in the report and accuracy will be accounted for in future recommendations. The annual review process will adjust the monitoring program to target sampling results. The following two tables display the parameters monitored in the project and associated limitations.

Table 6: Data Limitations of Instantaneous Water Quality Parameter Methods

Parameter (units)	SOP Reference	Accuracy	Resolution	Range	Calibration check
Temperature (°C) on HOBO data loggers	HOBO U-24-001 Manual	± 0.1 °C	0.01 °C	-2 to 36 °C	NIST-certified thermometer
	HOBO U-26-001 Manual	± 0.2 °C	0.02 °C	-2 to 36 °C	
Temperature (°C) on hand-held meter	YSI Pro2030 User Manual	± 0.3°C	0.1°C	-5 to 55°C	NIST-certified thermometer
Dissolved oxygen (% and mg/L) on data logger (optical)	HOBO U-26-001 Manual	± 0.2 mg/L up to 8 mg/L; ±0.5 mg/Lrom 8 mgL to 20 mg/L.	0.02 mg/L	0-300% air saturation; 0-30 mg/L	Zero DO solution; 100% saturation. HOBOware software

Dissolved oxygen (% and mg/L) on hand-held meter (galvanic)	YSI Pro2030 User Manual	0-200% ±2%; 200%-500% ± 6%; 0 mg/L–20 mg/L ±2% or ±0.2 mg/L; 20mg/L-50mg/L ± 6%	1% or 0.1%; 0.1 or 0.01 mg/L	0-500% air saturation; 0-50 mg/L	Quick DO Calibration Procedure; titration for mg/L; as required by user manual
Specific conductance data logger	HOBO U-24-001 Manual	Low range: 3% of reading or 5 µS/cm; High range: 3% or reading or 20 µS/cm	1 µS/cm	0-10,000 µS/cm	Specific conductance reference standards
Specific conductance on hand-held meter	YSI Pro2030 User Manual	1% of full scale (four-point calibration)	Multiple, range based: 0.1 µS/cm to 0 µS/cm	0 to 500 µS/cm	Specific conductance reference standards
Stream Stage via data logger	HOBO U-20-001 Manual	±0.05% full scal 0.5 cm water	<0.02 kPa, 0.21cm water	0-207 kPa, ~0-9m water at sea level	Factory Calibration

[1] *EPA Volunteer Water Monitoring: A Guide for State Managers*, 1990, EPA 440/4-90-010, p. 39; based on data provided by the Chesapeake Bay Citizen Monitoring Program.

Table 7 Data Limitation of Manual Flow Measurements

Parameter	Sampling & Analysis Method	Measurement Range (Detection Limits) Minimum/Maximum		Duplicate Precision	Accuracy	Resolution
Current Velocity	electromagnetic velocity meter (HACH 950, or equivalent.)	0 ft/sec	20 ft/sec		±2% of reading ±0.05 ft/sec 0 to 10 ft/sec; ± 4% of reading from 10 to 16 ft/sec	0.01 value < 100; 0.1 value < 1000; 1.0 value ≥ 1000
Discharge	Based on current velocity, following USGS methods; Rantz et al. [1982]	1 cubic ft/sec	Dependen t on size of stream and conditions	Based on field measurements of current velocity.	--	1 cubic ft/sec
Water Level (stage) via wading rod	Wading rod (USGS methods ; Rantz et al. [1982])	0.01 ft	Approx. 5 ft	field: ± 15%	Approx. 0.02 ft (wading rod marked in 0.1 ft increment)	0.02 ft using 0.1 ft increments

A.7 TRAINING AND CERTIFICATION REQUIREMENTS

Project personnel will have the following minimum credentials:

- Lead water resource specialist(s) for the project will have at least a bachelor of science/art degree in water resources, biology, ecology, chemistry, environmental science, environmental/civil engineering or related field, plus at least two years of professional experience in these disciplines.
- Field technicians for the local project will have a bachelor of science/art degree in any natural science, environmental science, environmental/civil engineering or related field, plus at least two months of environmental fieldwork experience (preferably water-monitoring-related); or a degree in any field and four years of experience in water resources science.
- Field assistants may participate in the study. There are no formal training or experience requirements for field assistants. They must be accompanied and supervised by a lead water resource specialist or field technician while participating in the study.
- LCWMD will maintain records documenting the qualifications of personnel noted above.

A.8 DOCUMENTS AND RECORDS

All final formal documentation shall be maintained in both paper and electronic formats. All electronic data shall be backed up on a secondary system daily.

A.8.1 STANDARD OPERATING PROCEDURES

Please refer to the appendices to this Project QAPP for the Monitoring Plan, *Long Creek Data Loading Quality Assurance Project Plan* (July 2017) (Data Loading QAPP), Standard Operating Procedures, and manuals used for the monitoring program.

A.8.2 DATA LOGGER CALIBRATION AND DEPLOYMENT SHEETS

A data logger calibration and deployment sheet, as provided for in the *Long Creek HOBO Meters Calibration and Deployment Form* (**Appendix N**) will be filled out for each data logger deployment event. Post-calibration will be conducted and recorded during each calibration event and these data will be reviewed during QA/QC evaluation. Original data files from the data loggers will be electronically archived by LCWMD. Calibration sheets will be maintained by the contractor and provided to LCWMD monthly. Sheets will be maintained by LCWMD while the monitoring project is active and arrange for the sheets to be archived in a secure location for 10 years following completion of the project.

A.8.3 DATA LOGGER MAINTENANCE RECORDS

A log book will be maintained of all maintenance records associated with the data loggers. The log book will contain model and serial numbers for all data loggers and probes. In addition, events such as repeated calibration failure, probe replacement, and factory repairs will be noted. Records will be maintained by LCWMD while the monitoring project is active and arrange for records to be archived in a secure location for 10 years following completion of the project.

A.8.4 FLOW METER FIELD SHEETS

The flow meter will be tested according to approved procedures prior to each field event. Flow monitoring and stream cross-section field data sheets (see *Flow Measurement Field Sheet*, **Appendix O**) will include the sample location, equipment used, sample date and time, recent weather and current stream flow regime (i.e. storm flow, base flow), staff identification, stream depth at stilling well, stream width at time of monitoring, start and end times, cross-sectional intervals/widths, stream depths, and flow rates.

All data will be entered into a data spreadsheet and data entry will be checked by a person not involved in the data entry. The data spreadsheet will be maintained by the contractor responsible for implementing the monitoring program with copies provided to LCWMD upon request. Field sheets will be maintained by LCWMD's monitoring contractor and provided to LCWMD monthly. Records will be maintained by LCWMD while the monitoring project is active and arrange for records to be archived in a secure location for 10 years following completion of the project.

A.8.5 FLOW METER MAINTENANCE RECORDS

All flow meters will be inspected and repaired as needed prior to each use. Records will be maintained by LCWMD's monitoring contractor and provided to LCWMD monthly. Maintenance records shall become part of the project file and will be maintained by LCWMD while the monitoring project is active and arrange for the records to be stored in a secure location for 10 years following completion of the project. The record will serve to describe all actions to the flow meter such as cleanings, deployments, and repairs.

A.8.6 FIELD PARAMETER CALIBRATION SHEETS

Water quality field parameter data is collected concurrent with each grab sampling event using a YSI Pro2030 meter, or a meter with comparable capabilities. A calibration sheet (see *Long Creek Pro2030 Multimeter Calibration Form*, **Appendix P**) will be filled out prior to each use. Post-calibration results will be recorded after field sampling is completed and/or at the end of a field sampling work day, and any significant calibration changes or drift that may affect the values recorded throughout the sampling event will be noted and discussed with LCWMD staff within 24 hours. If calibration error is significant enough to warrant exclusion of data, the error for pertinent parameters will be noted on the field data sheet or log book.

Water quality parameters will be recorded on a field data sheet at each surface water sample location.

All field sample data sheets will be maintained by LCWMD's monitoring contractor and provided to LCWMD monthly. Field sample data sheets will be stored in both hard copy and electronic (*i.e.*, PDF) format by LCWMD's monitoring contractor. Sample data sheets will be maintained by LCWMD while the monitoring project is active and arrange for the records to be stored in a secure location for 10 years following completion of the project.

Section B DATA GENERATION AND ACQUISITION

B.1 EXPERIMENTAL DESIGN

The experimental design of the monitoring program is described in detail in the Monitoring Plan. Sampling began during August 2010 and was conducted in general accordance with a prior version of this QAPP. Deviations from this QAPP will be noted in final reporting and data usability will be assessed in accordance with Section D of this QAPP.

B.2 SAMPLING METHODS

Methods used to carry out the monitoring plan are based on guidance and associated Standard Operating Procedures (SOPs) from the MEDEP's *Framework for Impaired Stream Quality Assurance Project Plans* (March 2010). Many of the SOPs are based on well-established methods from EPA and other states. The geomorphology assessment was covered by a separate MEDEP QAPP, which was based on a New Hampshire model. Other monitoring tasks completed by EPA (sediment toxicity analysis) and MEDEP (biomonitoring) are covered in their own separate QAPPs/SOPs. For a list of applicable SOPs associated with this QAPP, please refer to the appendices.

B.3 SAMPLE HANDLING AND CUSTODY

Samples for conventional pollutants (*e.g.*, phosphorus, hardness) will be collected either using rising-stage stormwater samplers (Nalgene/I-Chem Storm Water Sampler model 1100-1000) or using traditional methods and collecting on the rising stage of the stream. A field data sheet (see *Surface Water Sample Data Sheet*, **Appendix Q**) and chain of custody form (**Appendix R**) will be used each time samples are taken. A field data sheet template is provided in the Surface Water Grab Sample SOP. Chains of custody are laboratory-specific and must include, at a minimum, laboratory name and address, sample identification, analytes requested, number and type of sample containers, sample preservative(s), and be signed by relinquisher and recipient of samples.

If stormwater samplers are used, they will be retrieved as soon as stream conditions allow. Storm conditions may create unavoidably hazardous conditions which delay collection of the sample beyond normal hold times. If holding times are exceeded, data will be appropriately qualified. Once collected, samples will be preserved on ice at <4°C and protected from light until delivery to a Maine-certified water quality analysis laboratory. The laboratory shall receive the samples under chain of custody, properly preserved, and within 24 hours of collection where practicable. Occasionally, samples may be held by the monitoring contractor for more than 24 hours due to weekends, holidays, or other extenuating circumstances. Under such conditions, the monitoring contractor shall ensure that the samples are maintained at <4°C and protected from light (*i.e.* in coolers) for the duration of the hold time.

B.4 ANALYTICAL METHODS

In situ water quality measurements measured in this project do not require laboratory analysis. Data analysis is covered under subsequent sections dealing with Quality Control, Section B.5, and Data Management, Section B.10.

Table 8: Field Analysis Parameter Table

Parameter	Method	Reference	Modification
Temperature	Thermometric	170.1 (a)	Alcohol-filled thermometer
Temperature	Electrometric	(b) and (c)	HOBO U-24 and U-26; YSI Pro2030, or equivalent
Dissolved Oxygen	Electrometric	360.1 (a) and (c)	YSI Pro2030 or, equivalent; HOBO U-26
Specific Conductance	Electrometric	120.1 (a) and (c)	YSI Pro2030, or equivalent; HOBO U-24

(a) U. S. Environmental Protection Agency. 1979 (revised 1983). Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. Environmental Monitoring and Support Laboratory, Cincinnati, OH.
(b) Comparative measurements will be made with EPA-approved methods during QA sessions where possible.
(c) YSI Pro2030 User Manual.

Table 9: Laboratory Analytical Methods and Required Detection Limits

Task	Method	Quantitation Limits	Maine CCC(1)
Metals – Cadmium	EPA Method 6020	0.04 µg/L(2)	0.08 µg/L(3)
Metals – Copper	EPA Method 6020	1 µg/L(2)	2.36 µg/L(3)
Metals – Lead	EPA Method 6020	0.2 µg/L	0.41 µg/L(3)
Metals – Nickel	EPA Method 6020	6.5 µg/L	13.4 µg/L(3)
Metals – Zinc	EPA Method 6020	15 µg/L	30.6 µg/L(3)
Hardness	Standard Method 2340B	5 mg/L	NE
Phosphorus	EPA 365.1	10 µg/L	NE
Orthophosphate	EPA 300.0	10 µg/L	NE
Total Kjeldahl Nitrogen	ASTM D3590-02A	0.5 mg/L	NE
Chloride, nitrate, nitrite	EPA Method 300.0	500 µg/L	230,000 µg/L
PAHs	EPA Method 610	Method-specific	

(1) CCC – Maine Freshwater Criterion Continuous Concentration

(2) Quantitation limit is ½ the Maine Chronic Criterion Concentration. This may not be achievable using recommended method. Alternate method that can meet the criterion will be considered by LCWMD prior to sample analysis.

(3) Criterion is hardness-dependent. Value listed assumes a hardness of 20 mg/L.

NE – Not Established

B.5 QUALITY CONTROL

Quality control (QC) of HOBO U-24 and HOBO U-26 data will be conducted in accordance with the manufacturer's guidelines, and the Data Loading QAPP (**Appendix S)**. Due to the continuous, *in situ* nature of this sampling program, and the cost in time and equipment to prepare a data logger for deployment, additional sampling (duplicates or replicates) is not planned. Instead, deployments are preceded by thorough and well-documented calibration procedures, checks on battery voltage, and probe diagnostics (*e.g.*, pH millivolts, DO charge, *etc*.), which are intended to ensure adequate data quality and completeness, and minimize equipment failure. Deployments are also limited in duration to six to eight weeks at a time before data is downloaded to minimize the loss of data should there be equipment failure. The use of qualified field staff provides a further measure of QC.

When data loggers are deployed and retrieved, a hand-held meter is used to measure specific conductance, DO, and temperature, which are compared to data collected by the data logger as a quality control check. Data from the hand-held meter will be collected up to 15 minutes from the time of the last data logger readings. DO readings will need to be within 0.6 ppm, and temperature readings within 1 °C, to be considered acceptable for QC purposes.

Quality control of the downloaded data logger data will follow the guidelines of the Data Loading QAPP. These guidelines focus on inspection of the data for outliers and discontinuities in the data stream, identifying times when the data logger was out of the water or displaced, and rejection of data which are out of sensor range.

At least 10% of current velocity measurements will be repeated as a quality assurance check. Where these replicate measures are less than 15% apart, the measurements will be considered to pass the QA/QC check. If these replicate measures do not pass, the QA/QC Manager will ensure that corrective measures are taken, such as, cleaning and oiling the current meter, examining the current meter for damage and repairing if necessary, or further training for the field technician.

Duplicate grab samples will be collected at a rate of one duplicate per ten samples (1:10) for each sampling event and analyzed by a state-certified laboratory to protect quality control of secondary opportunistic data. If less than ten samples are collected for a sampling event, one duplicate sample will be collected for the sampling event.

Analytical lab results will be reviewed and compared to the database download. Grab samples will also be reviewed in the database and compared to field sheets and analytical lab results to ensure data is accurate and representative of each synoptic round.

B.6 INSTRUMENT TESTING, INSPECTION, AND MAINTENANCE

The field technician will keep a log that details the dates of all instrument and sampling equipment inspections and maintenance performed, along with serial numbers of data loggers and probes. He or she will also keep records for the dates that all laboratory supplies are received, reagents and standards are replaced, and any problems that are encountered with instruments, sampling gear, or lab reagents.

Data loggers and hand-held meters will be checked for accuracy as described in Table 6. Membranes, sensor caps, and solutions for hand-held meters will be replaced according to manufacturer's specifications. Maintenance records will be maintained by the monitoring contractor and provided to LCWMD monthly.

B.7 INSTRUMENT / EQUIPMENT CALIBRATION AND FREQUENCY

The primary monitoring instruments are the HOBO U-24-001 (specific conductance and temperature), HOBO U-26-001 (DO and temperature), and YSI Pro2030 (specific conductance, DO, and temperature). Instruments used to measure water quality monitoring parameters will be calibrated and reagents will be checked against standards according to manufacturer's specifications as indicated in Table 10. Standards will be purchased from a chemical supply company or prepared by (or with the assistance of) a professional laboratory. Calibrations will be performed as shown in Table 10; calibration records will be kept in the instrument maintenance log where they can be easily accessed before and after equipment use. Calibrations that are performed by monitors in the field are recorded on the field data sheets. Field data sheets shall be maintained both electronically and in the paper file and submitted to LCWMD monthly.

Table 10: Calibration Frequency for Water Quality Monitoring Equipment

Parameter	Calibration Frequency	Standard or Calibration Instrument Used
Temperature	Before each field deployment	None needed for logger, per HOBO user manual; NIST-certified thermometer used as check for YSI Pro2030, but there is no temperature calibration for the meter.
Dissolved Oxygen	Before each field deployment	Water-saturated air and zero DO solution for data loggers according to manufacturer's instructions; Water-saturated air for YSI Pro2030 hand-held meter.
Specific conductance	Before each field deployment	None needed for logger, per HOBO user manual; YSI Pro2030 hand-held meter calibrated with 1,000 µs/cm standard solution.

B.8 INSPECTION / ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Upon receipt, standards and reagents used in field kits will be inspected by the field technician for leaks or broken seals. Standards/reagents are only accepted if their expiration date is well within the expected use period. All other sampling equipment will be inspected for broken or missing parts and will be tested to ensure proper operation. Reagents are replaced before the expiration date provided by the manufacturer. These shelf lives are typically one to two years. However, specific replacement dates can be determined by providing the reagent lot number to the manufacturer.

B.9 NON-DIRECT MEASUREMENTS

The project incorporates temperature and precipitation data generated by NOAA's National Weather Service (NWS) in Gray, Maine. Monthly climate statistics broken down by day and originating from the Portland International Jetport are obtained from the NWS website[4]. NOAA/NWS controls the accuracy of data obtained through this website.

B.10 DATA MANAGEMENT

B.10.1 DATA LOGGER DATA RETRIEVAL

Logger data will be downloaded and processed within three days upon retrieval of the instrument by the field technician, using the latest version of HOBOware.

B.10.2 FIELD DATA COLLECTION

The field technician will record field measurements at times of deployment and retrieval of data loggers using a hand-held meter (YSI Pro2030, or equivalent) to measure specific conductance, DO, and temperature. These data sets are used to screen the data logger results for gross inaccuracies. Dissolved oxygen readings that are not within ±0.6 ppm and temperature readings that are not within ±1°C will be investigated further and documented.

B.10.3 DATA ENTRY, PROCESSING, AND ANALYSIS

Since data loggers generate electronic data files, there are no data entry needs associated with them, aside from calibration and maintenance logs. Data files will be downloaded and processed by the field technician within three days of retrieval. This processing will include importing tabular data into a spreadsheet and scanning for discontinuities and outliers which may indicate instrument malfunction or tampering. The field technician will conduct an initial inspection of the data for temporal completeness and basic sensor functioning. For example, the field technician will ensure that batteries maintained sufficient voltage and that all readings are within expected range. Any potential issues will be noted on the data sheet. Once the data have been examined, the original files will be archived on a computer, and regularly backed up on an external drive, second computer, or web-based storage.

The laboratory will provide all laboratory analytical data in format that can be electronically uploaded to the project database maintained by LCWMD, thereby, eliminating the need for data entry. In the event of a specialized methodology or situation where manual entry of data is required, the quality check system described below for historical data shall be implemented.

Data collected from field instruments that do not generate electronic files (*i.e.*, handheld water quality meters) will be documented on field data sheets which are maintained in the project file as described in Section B.7. Upon return to the office, the data on the field data

[4] NOAA historic data website: https://www.ncdc.noaa.gov/cdo-web/search; NOAA discrete data website: https://www7.ncdc.noaa.gov/CDO/cdopoemain.cmd?datasetabbv=DS3505&countryabbv=&georegionabbv=&resolution=40.

sheets will be entered into the project water quality monitoring database maintained by LCWMD. Historical analytical data that is not provided in compatible database format by the laboratory shall also be manually entered into the database.

All data entry shall undergo a 100 percent quality check by a person not associated with the initial data entry prior to any data usage. The 100 percent check requires that the data from each database entry be compared to the original documentation to ensure correctness. Documentation of data entry and the quality check shall be maintained in the project file.

Data processing for spring-melt, base-flow, and storm-flow analytical, field parameter, and data logger data will consist of compiling all data in a database that is capable of recording data over the lifetime of the project.

Section C **ASSESSMENT AND OVERSIGHT**

C.1 ASSESSMENTS AND RESPONSE ACTIONS

Review of all field and data activities is the responsibility of LCWMD's monitoring contractor Quality Assurance/Quality Control manager (QA/QC Manager), with the assistance and oversight of LCWMD. Given the reliance on electronic data collection under this program, assessments will focus on proper calibration methods and record-keeping, concordance of hand-held meter data to downloaded data logger measurements, and data completeness. All field and laboratory activities and records may be reviewed by State and EPA quality assurance officers upon request.

At a minimum, the monitoring contractor's QA/QC manager will perform a preliminary QA/QC audit following the monitoring contractor's first round of data collection. A memorandum of findings will be provided to LCWMD within two business days of the audit and will include a list of deficiencies and corrective actions (as needed). Any corrective actions will be implemented immediately and a second audit will be completed within 30 days. Upon demonstration of successful completion of an audit (*i.e.* with no corrective action needed), additional audits will be conducted annually or at a frequency determined by LCWMD. Conditions that necessitate an audit include:

- Greater than 50% project team turnover;
- Field team is not being led by supervisor who has undergone a successful audit for this project; or,
- Data quality checks indicate that field data collection is inconsistent or having methodological issues.

In addition to the monitoring contractor's QA/QC audit, LCWMD may conduct its own audit at any time during the contract period. LCWMD will conduct a minimum of one audit per year.

C.2 REPORTS TO MANAGEMENT

Reports to management will be in the form of technical memos authored by the monitoring contractor and submitted to LCWMD, who will then redistribute to team members and stakeholders, as needed.

- A pre-deployment memo will be created to describe the final sample locations, parameters to be measured, equipment and techniques to be used to deploy the data loggers and expected deployment dates.
- A mid-season memo will be submitted to outline any issues that may be arising, and to propose solutions.
- A final, end-of-season memo will summarize the locations, parameters, dates, and highlights of results of the season's deployments.
- Comprehensive data summary reports shall be generated annually. Reports shall include, at a minimum, sample locations, parameters, dates, field data sheets, analytical results, and recommendations for evaluation of project objectives.

Section D DATA VALIDATION AND USABILITY

D.1 DATA REVIEW, VERIFICATION, AND VALIDATION

All data logger deployments are documented with a calibration/deployment/retrieval data sheet. The use of this sheet ensures that all calibrations are documented, the field technician is noted, deployment times and notes are recorded, data are inspected and stored upon retrieval, and that sensors are still performing within their expected range at the end of the deployment. In addition, it provides a space to record water quality data from a quality control instrument, such as a hand-held specific conductance, DO, and temperature meter, to ensure that data logger readings are within expected range. The field technician is responsible for ensuring that the data sheets are filled out completely, and that no errors or out-of-range conditions occur during calibration.

The QA/QC Manager reviews data logger calibration/deployment/retrieval documentation resulting from sample collection, laboratory analysis, instrument maintenance and calibration, and data reduction. Data review shall occur following each sampling round or logger deployment. The QA/QC Manager and field technician perform corrective measures such as: 1) include an explanation of identified problems associated with a particular data, 2) re-calibrate, repair, or retire the data logger as needed to ensure data collection remains accurate, and data coverage for the season is as complete as possible, or 3) retrain field personnel to ensure complete data collection/recording.

D.2 VERIFICATION AND VALIDATION METHODS

In cases where post-calibration checks reveal an issue that may have interfered with accurate water quality data, the data record and the instrument will be examined more closely. If such problems are determined to have happened, suspect data will be deleted from the processed data set (the original files downloaded from the data logger will be kept regardless) and the data logger will be repaired.

Data that pass the initial inspection process will be imported into a spreadsheet. Given that the data are downloaded from the logger directly in tabular format, no data entry will occur. Outliers or suspect data will be reviewed initially by the field technician, then once again by the QA/QC Manager. These anomalies may include readings outside of the expected range or those outside of the historical range for that site. Final determination on validity of data will be made based on the judgment of both the field technician and the QA/QC Manager and analysis that may include statistical evaluation of the data. Data points may be removed, flagged as suspect, retained with comment, or retained.

D.3 RECONCILIATION WITH USER REQUIREMENTS

Calculations or determinations for precision, accuracy, and completeness will be made following each logger deployment/sampling event, and when possible preceding the next deployment/event. If data quality objectives are not met, the samples will be noted and corrective action will be taken depending on the nature of the problem (*e.g.*, re-calibrate instruments, re-sample site, or re-evaluate data quality objective). All such corrective actions will be documented.

Section E **REFERENCES**

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Appendix A

LONG CREEK
Watershed Management District

Long Creek Monitoring Plan

Original Plan: April 2010

Revision 1: March 2011

Revision 2: June 2013

Revision 3: September 2018

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Appendix

1. INTRODUCTION

Long Creek is a freshwater urban stream system in southern Maine. The Long Creek Watershed is approximately 3.45 square miles and is located in Portland, South Portland, Westbrook, and Scarborough, Maine. The stream currently does not meet Maine water quality standards due to the influences of increased concentrations of metals, chloride, phosphorus, nitrogen, polycyclic aromatic hydrocarbons (PAHs), and reduced dissolved oxygen (DO) concentrations. The degraded water quality is caused by substantial nonpoint source (NPS) discharges to Long Creek. Water quality is also adversely affected by altered hydrological conditions and increased water temperatures from lack of shading in certain areas. The health of Long Creek is important to the health of Clark's Pond, the Fore River, and ultimately, the Casco Bay Estuary.

Development over the past several decades has converted the landscape from mostly forests and fields to commercial, light industrial, retail, and transportation uses. One of the primary results of this conversion process has been the creation of impervious cover (IC) such as roads, driveways, parking lots, sidewalks, rooftops, and any other impermeable surfaces of the built environment. IC prevents water from infiltrating into the ground and acts as a conveyance method for a wide variety of pollutants commonly carried into adjacent surface waters by stormwater or melting snow.

A direct correlation has been established between IC and the health of aquatic ecosystems. In general, stream watersheds with less IC exhibit stream flows that are less variable, which encourages a healthier biotic community. It has been shown that as IC increases above 10% there is a corresponding increase in stormwater flows and degradation in water quality, stream habitat, and diversity of aquatic life. Some areas of the Long Creek Watershed have an IC of greater than 60%. This impervious cover alters the hydrology of Long Creek and acts as a conveyance for pollutants into adjacent surface waters by stormwater or melting snow. High IC increases the volume of runoff directed to Long Creek by decreasing filtration through soils and directing of overland flows to ditches and storm drains.

The *General Permit – Post Construction Discharge of Stormwater in the Long Creek Watershed* (MEPDES Permit #MEG190000/Wastewater Discharge License #W-9052-5Y-B-N) issued by the Maine Department of Environmental Protection (MEDEP) on October 29, 2009, and renewed on April 21, 2015, provides for the implementation of the *Long Creek Watershed Management Plan* (Management Plan).[1] The Management Plan is implemented by the Long Creek Watershed Management District (LCWMD). Implementation of the Management Plan is overseen by the Maine Department of Environmental Protection (MEDEP) and the U.S. Environmental Protection Agency (EPA). The Management Plan lays out a course of action toward improving water quality in Long Creek and meeting water quality goals by 2020.

[1] FB Environmental Associates, Inc. (2009), *Long Creek Watershed Management Plan*, July 2009.

As a means of evaluating progress toward this goal, the Management Plan requires the establishment of a monitoring and assessment program to evaluate water quality conditions in Long Creek. This *Long Creek Monitoring Plan* (Monitoring Plan) establishes the monitoring and assessment program to evaluate water quality conditions in Long Creek in accordance with the Management Plan.

This Monitoring Plan is supported by the associated *Long Creek Quality Assurance Project Plan* (Project QAPP) and *Long Creek Data Loading Quality Assurance Program Plan* (Data Loading QAPP). In the event of overlap with either the Project QAPP or Data Loading QAPP, the more-specific provision applies.

1.1. Project Background

The Management Plan stipulates that its goal is to improve conditions in the Long Creek Watershed sufficiently to attain applicable water quality classification standards by 2020. As a means of evaluating progress toward this goal, the Management Plan established a monitoring and assessment program to evaluate water quality conditions in Long Creek. The requirements of the monitoring and assessment program are detailed in this Monitoring Plan, as amended.

The purpose of the monitoring and assessment program is to:

- Determine whether Long Creek meets applicable water quality standards
- Gather information to improve management of Long Creek
- Document progress toward meeting standards

Implementation of the monitoring and assessment program began in June of 2010, and is ongoing. Data collection activities occur under the following programs:

- Grab Sampling for Water Quality Monitoring
- Continuous Sampling for Water Quality Monitoring
- Hydrology and Flow Monitoring
- Weather Monitoring
- Biological Monitoring
- Sediment Investigation

Since 2010, a significant volume of grab sample and continuous sample water quality data have been compiled in the project water quality monitoring database maintained by LCWMD. Grab samples are collected during periodic sampling events conducted in Long Creek under spring-melt, base-flow, and storm-flow conditions. Historically, grab sample water quality data has included laboratory analytical results for phosphorus, metals, hardness, and chloride. In 2017, analysis for metals and hardness was eliminated for spring-melt samples because prior monitoring results show that metals have not been near toxic levels based on the surface water quality criteria for metals set forth in Table 2. Furthermore, analysis of these samples required that they be sent to an out-of-state laboratory resulting in a significant expense for information of limited value. In 2018, synoptic storm-flow sampling was discontinued and replaced with the opportunity to conduct targeted storm-flow sampling. Synoptic storm-flow sampling was discontinued because it was determined that the method of conducting storm-flow sampling was not being conducted in a manner in which useful data was being acquired.

Water quality field parameters are collected concurrent with each grab sampling event using a hand-held meter. Historically, water quality field parameters included specific conductance, DO, oxidation reduction potential, pH, turbidity, and temperature. In 2017, turbidity, oxidation reduction potential, and pH were eliminated as field parameters. Turbidity was eliminated as a field parameter because adequate data had been collected by this point to serve as a baseline for turbidity in the Long Creek Watershed, therefore, further data collection would not have a significant return on the investment of collecting this information. Experience has shown that oxidation reduction potential and pH vary very little in Long Creek and, therefore, were eliminated given they will have little operational impact. Elimination of turbidity, oxidation reduction potential, and pH as field parameters also allowed the use of simpler and less expensive monitoring equipment. Water quality field parameters were measured with a Horiba U50 until 2017, at which time the Horiba meter was replaced with a YSI Pro2030.

Continuous samples for water quality monitoring data are collected using sondes deployed at various locations in Long Creek. Parameters monitored include specific conductance, DO, and temperature. The project initially used YSI-600 OMS series meters. In 2015, the YSI meters were replaced with parameter-specific HOBO data loggers.

Hydrologic monitoring is performed at several locations along Long Creek to document changes in stream geomorphology and flow. Data collection includes continuous measurements of stream stage (water surface elevation) using *in situ* HOBO Level Logger dataloggers, in-field measurements of stage and stream flow (velocity), and measurements of the stream channel. This information is used to develop stream-discharge curves for each hydrologic monitoring location. In addition, cross sections of the stream channel and floodplain are surveyed and measured to document changes in stream geomorphology.

Two weather stations were originally used to monitor precipitation and temperature within the Long Creek Watershed. These included a National Oceanic and Atmospheric Administration (NOAA) weather station located at the Portland International Jetport and a HOBO H-21 Microstation Datalogger situated on the western edge of the watershed. Use of the HOBO H-21 Microstation Datalogger was discontinued in 2017 because the data at this station was not significantly different from the data collected by the NOAA weather station. Weather monitoring data are evaluated in conjunction with hydrologic monitoring data to evaluate stream response to precipitation events.

Biological monitoring is completed by either the Maine Department of Environmental Protection (MEDEP) or LCWMD twice during a five-year period at specified locations. The MEDEP biological monitoring program consists of benthic macroinvertebrate sampling using rock bags under MEDEP protocols.

In accordance with the Management Plan, the Monitoring Plan was executed using an "adaptive management" approach, which allows for updates and modifications, as deemed necessary and appropriate, during the course of its implementation. The Monitoring Plan presented herein was developed using the adaptive management approach, and presents the monitoring and assessment program that will be implemented in the Long Creek Watershed until future updates and/or modifications are deemed necessary and appropriate.

2. TECHNICAL APPROACH

2.1. Monitoring Locations

The original monitoring locations used to evaluate water quality conditions in Long Creek included sites S01 through S07 as primary monitoring locations for the grab and continuous water quality monitoring programs. Tertiary sites S08, S09, and S10, and secondary sites S11 and S12, were monitored for limited constituents (such as phosphorus and PAHs). Continuous monitoring for conductivity and temperature was conducted at temporary sites S13 and S14 during 2012, and at temporary sites S15 and S16 in 2013.

In 2014 and 2015, Pennsylvania State University conducted monitoring for specific conductance at two stations in Long Creek, at S18 in the South Branch, and at S19 in the Main Stem near Clark's Pond. LCWMD is in possession of the raw data files for these sites, but the data has not been, and was not intended to be, uploaded into the project water quality monitoring database maintained by LCWMD.

The sample locations have been modified since the inception of the Monitoring Plan with current monitoring locations identified in **Table 1** and **Figure 1**. Monitoring locations have been modified to provide a consistent dataset that specifically targets grab analytical sampling and continuous monitoring to provide a better understanding of the long-term health of the Long Creek Watershed.

2.1.1. Primary Monitoring Locations

Water quality, stream hydrology, and biological monitoring are conducted at six primary monitoring locations within the Long Creek Watershed — sites S01, S17 (which replaced S02 in 2014), S03, S05, S06B (S06 was moved to this location in 2013), and S07. Each of these locations is situated at the downstream end of sub-watersheds identified within the Long Creek Watershed.

Stream characteristics at S02 were shallow and wide during storm events and, therefore, did not provide adequate stream stage information. In 2014, site S17 was established as a primary monitoring location in the Main Stem of Long Creek upstream of Foden Road to replace S02.

Site S04, located in the South Branch, was included in the original set of primary monitoring locations, however, site S04 was removed from the list of primary monitoring locations in 2013 because it exhibits wetland conditions including low flow rates and dense wetland vegetation. Site S04 is currently monitored as part of the secondary monitoring location program. This location may be reinstated as a primary monitoring location after the implementation of best management practices (BMPs) or in-stream/riparian restoration in the South Branch.

In 2013, site S06 was relocated approximately 600 feet upstream to a location that has a more clearly defined stream channel. This location is identified as site S06B to differentiate the data collected at this location from data historically collected at site S06.

Sample sites S01, S17, S03, S05, S06B, and S07 are sampled continuously with in-stream water quality instruments and stream height is continuously gauged using in-stream pressure transducers. Grab samples are collected for laboratory analysis during spring-melt and base-flow regimes for phosphorus, metals, hardness, and/or chloride. Water quality field parameters are collected concurrent with each round of grab sampling. Stream flow rates will be measured once annually. Primary monitoring locations will be employed during Biological Monitoring.

2.1.2. Secondary Monitoring Locations

Secondary monitoring locations include sites S04, S11, and S12. Site S04 has historically been monitored for water quality field parameters (DO, pH, temperature, ORP, and specific conductance), Target Analyte List (TAL) metals (total copper, lead, nickel, and zinc), phosphorus, and chloride, and sites S11 and S12 have historically been monitored for phosphorus including orthophosphate and total phosphorus. Secondary sampling locations are sampled twice each in May, July, and September during base-flow conditions, concurrent with grab analytical sampling of the primary monitoring locations, to create a synoptic dataset of the watershed. Base-flow samples are analysed for phosphorus, metals, hardness, and chloride. Water quality field parameters are collected concurrent with each grab sampling round.

2.1.3. Tertiary Monitoring Locations

Grab samples have historically been collected from tertiary sites S08, S09, and S10 for PAHs. PAHs are a class of organic compounds found in a variety of petroleum products and produced as a by-product of combustion of hydrocarbons. They tend to be found in higher concentrations in areas with heavy automobile use. During 2010, 2011, and 2012, PAHs were sampled in water at tertiary sites where elevated levels are most likely to occur. These monitoring data showed PAHs to be below detection limits with the exception of several constituents commonly associated with coal tar-based asphalt sealants which were detected at low levels. Since the PAH detections in surface water are likely associated with coal tar-based sealants and are transient in the system monitoring was suspended at these locations in 2012. Targeted aqueous sampling may be undertaken by LCWMD in the future to study the effects to coal tar sealants at specific locations.

2.1.4. Temporary Monitoring Locations

Temporary monitoring locations may be established at the discretion of LCWMD to provide flexibility to the monitoring program. Temporary monitoring locations may be utilized to monitor the effectiveness of BMPs within the watershed that are not currently bookended by primary or secondary monitoring locations, or for any other purpose deemed appropriate by LCWMD.

Continuous monitoring for conductivity and temperature was conducted at temporary sites S13 and S14 during 2012, and at temporary sites S15 and S16 in 2013.

2.2. Water Quality Criteria

Based on MEDEP and EPA water quality standards for freshwater or urban streams, LCWMD has identified water quality criteria for target metals and general water chemistry in Long Creek, as presented in **Table 2**.

2.2.1. Metals

All five of the Target Analyte List (TAL) metals (i.e., cadmium, copper, lead, nickel, and zinc) were analyzed in the first monitoring year (2010). The second monitoring year (2011) incorporated a combined metals analytical program that includes eight events where the complete TAL metals list was analyzed and six events where Cu and Zn, the most common metals in urban runoff (Driscoll et al. 1990), were tested as indicator metals. The 2011 dataset did not indicate that there was good statistical correlation between the concentrations of TAL metals and indicator metals; therefore, the full TAL metals list will be retained with the exception of cadmium. Due to the difficulty in obtaining a detection limit that is below the ecological criterion for cadmium, this metal has been eliminated from the program. If future data indicates that cadmium sampling is necessary, additional data will be collected. To determine appropriate regulatory criteria for TAL metals, samples will be analyzed for hardness.

2.2.2. Specific Conductance and Chloride Regression

In most urban watersheds not influenced by ocean waters, chlorides are highly correlated with specific conductance, which is measured nearly continuously with water quality data loggers at primary monitoring locations (except for Site 06B). Specific conductance is also a field parameter collected during grab-sampling events using a hand-held meter.

Specific conductance is not a water quality parameter governed by a water quality standard, but is instead used as a proxy for chloride. LCWMD has developed a chloride-specific conductance statistical model and regression analysis using chloride results from grab water quality samples and corresponding specific conductance water quality field parameter readings (see **Appendix A**). Chloride analytical grab samples and water quality field parameter measurements of specific conductance will continue to be collected as part of the Long Creek monitoring program and these data will be used to update the regression on an annual basis. The regression equation will be used to estimate chloride concentrations from cumulative specific conductance data collected via the continuous monitoring program and water quality field parameter measurements to provide a more in-depth picture of potential chloride fluctuations within Long Creek seasonally and across flow regimes.

2.2.3. Total Phosphorus

Total phosphorus levels are measured periodically by in-stream grab sampling. Data is collected at primary and secondary monitoring locations during synoptic monitoring rounds.

2.2.4. Dissolved Oxygen

Dissolved oxygen is a water quality parameter that is directly linked to the overall health of Long Creek. Low DO values are caused by respiration of excess algal and other in-stream plant growth due to high nutrient load, high bacteria load or high concentrations of plant material in decomposition in the stream, high water temperatures, or a lack of turbulence. Values below 5 milligrams per liter (mg/l), or 60 percent saturation, are considered to be below the State of Maine Class C water quality criteria for DO.

Dissolved oxygen is measured nearly continuously with water quality data loggers at primary monitoring locations (except for Site 05). Dissolved oxygen is also a field parameter collected during grab-sampling events using a hand-held meter.

2.2.5. Macroinvertebrates

The benthic macroinvertebrate community is used as a surrogate to determine conformance with statutory aquatic life standards. Related statutory definitions, and statutory provisions for the implementation of biological water quality criteria to quantify aquatic life standards for Classes AA, A, B, and C waters are defined in MEDEP's rule *Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams*, 06-096 CMR 579. Methods described in this rule will be used to make decisions about classification attainment.

3. GRAB SAMPLING FOR WATER QUALITY MONITORING

Because concentrations of known contaminants in Long Creek vary seasonally, between flow regimes, and across the watershed, grab sampling will be conducted to provide LCWMD with samples representative of the variable conditions and locations found throughout the watershed. An overview of the grab sample water quality monitoring program is included in **Table 3** and a more detailed list of the analytical sampling program is included in **Table 4**. Information regarding spring-melt, base-flow, and storm-flow monitoring is detailed below. These data are intended to provide a representative dataset for the evaluation of stream water quality conditions and for use in statistical analysis.

Three general flow regimes have been identified in the Long Creek Watershed: (1) melt flows during late winter to spring months when warm weather or rain contribute to the melting of snowpack and snow banks along the impervious surfaces in the watershed; (2) base flow during dry days in the spring through fall annually; and (3) storm flow during and following precipitation events.

3.1. Spring-Melt Sampling

Spring melt contains significant amounts of salt from winter ice treatment on roadways, pedestrian walkways, and parking areas. A minimum of three, and a maximum of four, rounds of analytical samples will be collected at all primary monitoring locations from February through April (or from the beginning of consistent melting temperatures until no snow remains in the watershed). Samples will be collected on days with temperatures above freezing when either warm weather conditions or spring rain have contributed to the melting of any remaining snowpack or snow piles and the introduction of runoff to Long Creek.

Analytical methods and quantitation limits for spring-melt grab samples is limited to total chlorides.

Water quality field parameters will be collected concurrent with each grab sampling round.

3.2. Base-Flow Sampling

Base-flow samples will be collected at all primary and secondary monitoring locations once each in May, July, and September of each calendar year.

Specific conductivity data from Long Creek reflects that conductivity in Long Creek is sharply supressed after a rain event and increases quickly after a rain event. On eleven occasions between 2010 and 2012 data was collected at seven locations in Long Creek to estimate the number of days it takes for specific conductivity in Long Creek to return to base flow levels after a rain event to inform the timing of base-flow monitoring events. According to data obtained from the conductivity study, dry weather conditions (base flow) for the Long Creek Watershed are achieved within three days after a storm event.[2] Based on this data, base-flow samples will be collected during dry weather conditions with a minimum of 72 hours without precipitation preceding sample collection. Laboratory analysis for base-flow samples include the following constituents:

- Total Phosphorus
- TAL Metals (total copper, lead, nickel, and zinc)
- Hardness (as CaCO3)
- Total Chloride

Water quality field parameters will be collected concurrent with each synoptic grab sampling event.

3.3. Storm-Flow Sampling

Targeted storm-flow (an event exceeding 0.25 inches of precipitation) sampling may be conducted to answer specific questions with a tailored sampling design that ensures collection of usable data. Storm samples will be retrieved as soon as stream conditions allow and will be submitted for laboratory analysis for constituents which may include, but are not limited to:

- Total Phosphorus
- TAL Metals (total copper, lead, nickel, and zinc)
- Hardness (as CaCO3)

[2] *See* Frederik Schuele, URS Corporation, memorandum to Kate McDonald, Long Creek Watershed Management District, April 15, 2013, Long Creek Monitoring Program, Estimation of baseflow conditions in Long Creek based on in-stream specific conductance data for the purpose of defining timing of baseflow monitoring events.

- Total Chloride

Water quality field parameters will be collected concurrent with each synoptic grab sampling event.

3.4. Polycyclic Aromatic Hydrocarbons Sampling

During 2010, 2011, and 2012, PAHs were sampled in water at tertiary sites where elevated levels are most likely to occur. These monitoring data showed PAHs to be below detection limits with the exception of several constituents commonly associated with coal tar-based asphalt sealants which were detected at low levels. Since the PAH detections in surface water are likely associated with coal tar-based sealants and are transient in the system monitoring was suspended at these locations in 2012. Targeted aqueous sampling may be undertaken by LCWMD in the future to study the effects of coal tar sealants at specific locations.

3.5. Quality Assurance/Quality Control and Data Management

All grab samples submitted for laboratory analysis will be collected in method-specified containers and with method-specific equipment. Samples will be submitted to the laboratory under proper chain of custody procedures.

Duplicate samples will be collected at a rate of one duplicate per ten samples (1:10) for each sampling event. If less than ten samples are collected for a sampling event, one duplicate sample will be collected for the sampling event.

Laboratory analytical results and water quality field parameter readings will be added to the project water quality data database maintained by LCWMD. An updated database file will be transmitted to LCWMD within one month of each significant data collection event.

4. CONTINUOUS SAMPLING FOR WATER QUALITY MONITORING

Specific conductance, DO, and temperature continue to be significant constituents of concern within Long Creek. HOBO U-24 data loggers (specific conductance and temperature) and HOBO U-26 data loggers (DO and temperature) are used for the continuous water quality monitoring program.

Continuous monitoring of specific conductance, DO, and temperature is conducted at primary monitoring locations S01, S17, S03, and S07. Site S05 will only be monitored for specific conductance and temperature. Site S06B will only be monitored for DO and temperature. Site S05 is not monitored for DO and Site S06B is not monitored for specific conductance because data show there has been little fluctuation of these parameters at these locations, therefore, it was determined that resources for monitoring these parameters would be better allocated elsewhere.

4.1. Equipment Deployment and Maintenance Schedule

All continuous monitoring meters will be installed securely as early in the calendar year as is practicable according to manufacturer's guidelines, typically March, and will be removed from the stream before freezing conditions may damage the equipment, typically late November or early December. At installation, the meters will be programmed to log results at 30-minute intervals. Continuous monitoring meters will be retrieved, maintained, data downloaded, and reinstalled approximately once every six to eight weeks, depending on battery life, data storage capabilities, and calibration drift.

4.2. Quality Assurance/Quality Control and Data Management

Upon data retrieval, all continuous monitoring data files will be evaluated for completeness. Data will be evaluated to identify any instances when the meters were logging data but were not installed in the stream (i.e. when meters are set to log parameters but have been removed from the stream channel for recalibration, or when high storm events could have pushed the meters onto the stream bank and then receded) and these data will be noted for deletion. Data will also be evaluated for accuracy, using pre-and-post-installation calibration data, and the dataset will be adjusted for any calibration drift.

Continuous monitoring data will be added to the project water quality data database maintained by LCWMD. An updated database file will be transmitted to LCWMD within one month after each significant data collection, or data download, event.

5. HYDROLOGY AND FLOW MONITORING

Stream flow affects the geomorphology of the stream which has significant effects on habitat structure and function for invertebrate and vertebrate species. Due to the high percentage of IC in the Long Creek watershed, as well as the low transmissivity of local shallow soils, the stream's height and flow rates increase rapidly and intensively in response to rain events. This has an effect of scouring sediment from the stream's bottom and banks, depositing sediment behind natural dams, and covering gravel and cobble substrate (which are the preferred spawning material for brook trout and growth substrate for several invertebrate species) with finer material. During base-flow conditions, the stream height becomes shallow and in-stream temperatures and contaminant concentrations increase; these conditions are inhospitable to the growth and survival of invertebrate and fish species. Ultimately, one of the goals of the Long Creek Restoration Project is to reduce the amount of runoff being discharged directly into the stream channel during, and after, precipitation events, and to normalize stream height and in-stream flow rates.

5.1. Hydrology

Typical elevation survey procedures will be utilized to generate stream cross sections along which stream response will be measured. Cross-sections of the stream channel and floodplain will be surveyed once annually with a rod and level at all primary locations (except at location S07 where flow is measured in a culvert). The survey data will be collected relative to the existing elevation benchmark at each monitoring location.

5.2. Stream Stage Monitoring

Stream stage (water surface elevation) is monitored at all primary monitoring locations at 30-minute intervals using HOBO U-20 pressure transducers. The meters will be deployed securely at each location as early in the calendar year as is practicable according to the manufacturer's guidelines, typically March, and will be removed from the stream before freezing conditions may damage the equipment, typically late November or early December. Data will be downloaded every six to eight weeks, based on data storage capabilities of the equipment and battery life.

5.3. Stream Discharge Measurement

Stream discharge (volume) will be monitored throughout the Long Creek Watershed at primary monitoring locations. Stream discharge is based on measurements of stream flow (velocity) and stream channel cross-sectional area. These measurements will be made using a velocity meter and staff gauges. Data will be gathered following standard USGS methods.[3]

5.4. Stage-Discharge Relation

Stream stage and stream discharge information gathered during hydrologic monitoring events will be used to modify and update existing empirical stage-discharge relationship curves that have been developed for each primary monitoring location. These relationships are statistically derived based on simultaneous field measurements of stage (water surface elevation) and discharge. As data points are added to the existing curve, the regressions will be updated according to methods outlined in Book 3, *Applications of Hydraulics*, *Techniques of Water-Resources Investigations of the U.S. Geological Survey*[4].

5.5. Quality Assurance/Quality Control and Data Management

Upon data retrieval from pressure transducers, data files will be evaluated for completeness. Data will be evaluated to identify any instances when the meters were logging data but were not installed in the stream (i.e. when meters are set to log parameters but have been removed from the stream channel for recalibration, or when high storm events could have pushed the meters onto the stream bank and then receded) and these data will be noted for deletion. Data will also be evaluated for accuracy, using pre-and-post-installation calibration data, and the dataset will be adjusted for any calibration drift.

Hydrologic monitoring data will be added to the project water quality database maintained by LCWMD. An updated database file will be transmitted to LCWMD within one month after each significant data collection, or data download, event.

6. WEATHER MONITORING

Weather monitoring data, including temperature, precipitation, and snowfall are used to contribute to the overall understanding of conditions affecting the watershed. Weather information including temperature (daily maximum, minimum, and average),

[3] Techniques of Water-Resources Investigations of the U.S. Geological Survey, http://pubs.usgs.gov/wdr/WDR-WA-03-1/pdf/ADR_O.pdf.

[4] Techniques of Water-Resources Investigations of the U.S. Geological Survey, http://pubs.usgs.gov/wdr/WDR-WA-03-1/pdf/ADR_O.pdf.

precipitation (hourly and daily total), and snowfall (daily total) from the NOAA weather station located at the Portland International Jetport is available on-line.[5] NOAA weather data will be downloaded from the NOAA website and added to the project database maintained by LCWMD every six to eight weeks and will include weather data for each full calendar year.

6.1. Quality Control/Quality Assurance and Data Management

Upon data retrieval, data files will be evaluated for completeness and accuracy. NOAA's QA/QC procedures will be relied on for the accuracy of data obtained from NOAA.

7. BIOLOGICAL MONITORING

7.1. Invertebrates

Invertebrate monitoring will be performed in proximity to primary monitoring locations in accordance with MEDEP Biological Monitoring Program protocols[6] twice every five years (i.e., 2010, 2013, 2015, and 2018). MEDEP performed invertebrate monitoring in Long Creek in 2010 and 2015. LCWMD performed invertebrate monitoring in 2013 and is responsible for the event to be performed in 2018.

7.2. Fish

Fish monitoring will be performed at all primary monitoring locations in accordance with MEDEP Biological Monitoring Program Electro-Shock protocols every three to five years.

7.3. *In Situ* Toxicity Testing

In situ toxicity testing evaluates the survivability of aquatic invertebrates. *In situ* testing may be used at monitoring locations in Long Creek that have historically shown elevated levels of chloride, and relatively lower levels of chloride.

LCWMD conducted *in situ* testing in Long Creek in September and October of 2014. Nine macroinvertebrate chambers were deployed, three chambers each at two locations in Long Creek and three chambers at one location in a reference stream. Each chamber was populated with 10 mayflies. It was found that 67% of mayflies survived in the reference stream, with survivorship of 50% and 40% at the Long Creek locations. Although the Long Creek survivorship rates were lower than the reference stream, the study reflects that macroinvertebrates were able to survive in Long Creek, at least for short periods of time.

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[5] NOAA historic data website: https://www.ncdc.noaa.gov/cdo-web/search; NOAA discrete data website: https://www7.ncdc.noaa.gov/CDO/cdopoemain.cmd?datasetabbv=DS3505&countryabbv=&georegionabbv=&resolution=40.

[6] Davies, Susan, P. and Tsomides, Leonidas (2002), Methods for Biological Sampling and Analysis of Maine's Rivers and Streams, Maine Department of Environmental Protection, Bureau of Land and Water Quality, January 1987, revised August 2002, http://www.maine.gov/dep/water/monitoring/biomonitoring/materials/finlmeth1.pdf.

Future *in situ* toxicity testing events may be conducted in Long Creek at LCWMD's discretion. If testing occurs, one test will be performed during spring-melt conditions (acute exposure) and one test will be performed during base-flow conditions (chronic exposure). If utilized, this program will be implemented in accordance with the protocols and procedures provided in the QAPP, modified as necessary to meet the specific circumstances encountered in Long Creek.

Activities to be performed as part of the *in situ* toxicity testing program include:

- Collection of stream velocity and water depth at all locations to standardize exposure conditions between sites, to the extent possible.
- Collection of micro-habitat data at each location during initial station characterization.
- Daily water quality field parameter collection during the exposure period at each testing location. The water quality field parameter collection will be performed twice a day (once in morning and once in the late afternoon) from a sampling port of each test chamber to determine any potential changes to water quality within the chambers.

7.4. EPA Rapid Bioassessment Program

A physical habitat characterization to evaluate differences in stream and riparian habitat quality between monitoring locations in Long Creek may be performed at LCWMD's discretion in accordance with Chapter 5 of the EPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers*[7], modified as necessary to meet the specific circumstances encountered in Long Creek.

LCWMD conducted a rapid biological assessment in Long Creek in 2014.[8] One-hundred meter reaches at the six primary monitoring locations were evaluated. Selected parameters were evaluated and rated on a numerical scale, of up to 200 points, and then compared to a reference condition representing the "best attainable" condition for a given study. Red Brook in Scarborough, Maine served as the reference stream for this assessment. In this study, the reference site scored a 134 out of a possible 200. The lowest score documented for the Long Creek sites was a score of 53 and the highest was a score of 110.

8. SEDIMENT INVESTIGATION

8.1. Sediment Sampling

Targeted sediment sampling may be conducted in the Long Creek Watershed to address specific questions generated by evaluation of the biological community.

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[7] Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling (1999). *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition*. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water, Washington, D.C., http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm.

[8] *See* Jeremy Deeds, FB Environmental, memorandum to Kate McDonald,CCSWCD, September 29, 2014, Rapid Biological Assessment Habitat Survey of Long Creek.

Sediment sample collection methodology will be dependent upon site conditions. Sediment quality benchmarks for Long Creek are presented in **Table 5**. Sediment data will be screened against the Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Data will be evaluated in context of the range of conservative sediment quality screening guidelines ranging from threshold effect concentrations (TECs, NECs, *etc.*) to probable effects thresholds (PECs, PELs, *etc*.).

For constituents not included in the consensus-based guidelines, sediment quality benchmarks may be obtained from additional sources, including but not limited to:

- U.S. EPA Assessment and Remediation of Contaminated Sediments Program[9]
- EPA Region 3 Biological Technical Assistance Group (BTAG) freshwater sediment benchmarks[10]
- Environment Canada's Canadian Environmental Quality Guidelines[11]

8.2. Quality Assurance/Quality Control and Data Management

Sediment samples submitted for laboratory analysis will be collected in method-specified containers and with method-specific equipment. Samples will be submitted to the laboratory under proper chain of custody procedures.

Duplicate samples will be collected at a rate of one duplicate per ten samples (1:10). If less than ten samples are collected for a sampling event, one duplicate sample will be collected for the sampling event.

Sediment analytical results will be added to a standalone Microsoft Excel spreadsheet file maintained by LCWMD.

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[9]EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL., http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html; http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html.

[10]Region III BTAG Freshwater Screening Benchmarks. 2006, https://www.epa.gov/sites/production/files/2015-09/documents/r3_btag_fw_sediment_benchmarks_8-06.pdf.

[11]Persaud, D.,.R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Onatario Ministry of the Environment. Queen's Printer of Ontario, http://www.itrcweb.org/contseds-bioavailability/References/guide_aquatic_sed93.pdf.

Tables

Table 1
Monitoring Locations
Long Creek Monitoring Plan
Long Creek Watershed Management District

Site Type	Site No.	Monitoring Location	Installation Period (temporary locations only)	DEP Biomonitoring Site Code
Primary	S01	South Branch above Clarks Pond access road	--	Station 753
	S02 (inactive)	Main Stem above confluence with North Branch	--	Station 415
	S17	Main Stem above Foden Road crossing	--	Station 752
	S03	North Branch above confluence with Main Stem	--	Station 414
	S05	Main Stem above Maine Turnpike	--	Station 570
	S06 (inactive)	Main Stem above confluence with Blanchette Brook	--	Station 411
	S06B	Main Stem above confluence with Blanchette Brook	--	Station 1015
	S07	Blanchette Brook above confluence with Main Stem	--	Station 409
Secondary	S04	South Branch below Econolodge Motel	--	Stations 408, 581
	S11	Upper Main Stem above Spring Street crossing	--	--
	S12	Blanchette Brook above Spring Street crossing	--	--
Tertiary	S08	Main Stem above Foden Road crossing	--	--
	S09	North Branch above Foden Road crossing	--	--
	S10	Main Stem below Maine Mall Road/Maine Turnpike	--	Station 410
Temporary	S13 (inactive)	Main Stem above S05, below Portland snow storage	Spring-Fall 2012	--
	S14 (inactive)	Main Stem above S05, above Portland snow storage	Spring-Fall 2012	--
	S15 (inactive)	Blanchette Brook downstream of B-21 BMP	Spring-Fall 2013	--
	S16 (inactive)	Blanchette Brook upstream of B-21 BMP	Spring-Fall 2013	--

Table 2
Surface Water Quality Criteria
Long Creek Monitoring Plan
Long Creek Watershed Management District

Constituent	Units	CMC	Source	CCC	Source
METALS					
Copper	ug/L	3.07	1	2.36	1
Lead	ug/L	10.52	1	0.41	1
Nickel	ug/L	120.2	1	13.4	1
Zinc	ug/L	30.6	1	30.6	1
GENERAL WATER CHEMISTRY					
Chloride	ug/L	860,000	1	230,000	1
Hardness (as CaCO3)	--	--	--	--	--
Phosphorus	ug/L	--	--	30	2
FIELD PARAMETERS					
Dissolved Oxygen	mg/L	--	--	5	2

Notes:
ug/L = Micrograms per liter
mg/L = Milligrams per liter
-- = Not applicable, no criteria published or defined for Long Creek project.

Sources:

[1]Freshwater Criterion Continuous Concentration (CCC) and Criteria Maximum Concentration (CMC), from MEDEP Chapter 584, Surface Water Quality Criteria for Toxic Pollutants, Appendix A, Table I - Criteria for Priority Pollutant Listed Pursuant to 304(a) of the Clean Water Act, and Table 2 - Criteria for Non-priority Pollutants. For the CCC and CMC criteria that are hardness dependent, the value provided in Table I (corresponding to a hardness of 20 mg/L) was used.

[2]Criteria for phosphorous and dissolved oxygen as specified by the Long Creek Watershed Management District.

Table 3
Monitoring Program Summary
Long Creek Monitoring Plan
Long Creek Watershed Management District

	Grab Water Quality Monitoring						Continuous Water Quality Monitoring			Hydrology		Weather Monitoring	Biomonitoring			Habitat Evaluation
	TAL Metals	Hardness	Chloride	Total Phosphorus	PAHs	Water Quality Field Parameters (Sp. Cond., DO, Temperature)	Dissolved Oxygen	Temperature	Specific Conductivity	Stream Gauging	Flow Monitoring and Site Hydrologic Condition Evaluation	NOAA Jetport: Temperature (daily maximum, minimum, and average); Precipitation (hourly and daily total); and Snowfall (daily total)	Invertebrates	In-situ Toxicity Testing	Fish	EPA Rapid Bio-Assessment Program
Primary Monitoring Locations - S01, S03, S05, S06B, S07, S17																
February	--	--	0-1 Melt Round	--		0-1 Melt Round	--	--	--		--					
March	--	--	2 Melt Rounds	--		2 Melt Rounds	--	--	--		--					
April	--	--	1 Melt Round	--		1 Melt Round	--	--	--		--					
May	1 Baseflow Round	1 Baseflow Round 1 Stormflow Round	1 Baseflow Round	1 Baseflow Round		1 Baseflow Round					--					
June					--	--				All Primary Locations	Once between June and October annually to refine flow curves and provide stream cross-sections	January - December	Monitoring to be performed in accordance with ME DEP Biological Monitoring Program protocols twice every five years (2010, 2013, 2015, and 2018)	--	Maine DEP Electro-Shock Protocol to be implemented every 3 to 5 years. Start date to be determined by the LCWMD.	--
July	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round		1 Baseflow Round	S01, S03, S06B, S07, S17	All Primary Locations	S01, S03, S05, S07, S17							
August	--	--	--	--		--										
September	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round		1 Baseflow Round										
October	--	--	--	--		--										
November	--	--	--	--		--					--					
December	--	--	--	--		--					--					
Secondary Monitoring Locations - S04, S11, S12																
February	--	--	--	--		--										
March	--	--	--	--		--										
April	--	--	--	--		--										
May	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round		1 Baseflow Round										
June	--	--	--	--		--										
July	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	--	1 Baseflow Round	--	--	--	--	--	January - December	--	--	--	--
August	--	--	--	--		--										
September	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round		1 Baseflow Round										
October	--	--	--	--		--										
November	--	--	--	--		--										
December	--	--	--	--		--										

Notes:
TAL Metals = copper, lead, nickel, zinc.
Base flow is defined as a sampling event with no precipitation for the preceeding 72 hours (minimum).

Table 4
Analytical Sampling Schedule
Long Creek Monitoring Plan
Long Creek Watershed Management District

Draft

Year	Month	Type	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus
		Site ID	S01				S17				S03				S04				S05				S06B				S07				S11				S12				TOTAL SAMPLES/EVENT			
2015	Feb-Mar	Melt	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	6	6	6	0
2015	Feb-Mar	Melt	2	2	2	0	1	1	1	0	1	1	1	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	7	7	7	0
2015	Feb-Mar	Melt	2	2	2	0	1	1	1	0	1	1	1	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	7	7	7	0
2015	Mar-Apr	Melt	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	6	6	6	0
2015	May	Baseflow	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	14	14	10
2015	May	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2015	July	Baseflow	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	14	14	10
2015	July	Storm	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	10	10	10	10
2015	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	13	13	13	9
2015	Sept	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2015	15	15	15	9	10	10	10	6	10	10	10	6	6	6	6	6	10	10	10	6	10	10	10	6	10	10	10	6	6	6	6	6	6	6	6	6	95	95	95	57
																																							95	**95**	**95**	**57**
		Site ID	S01				S17				S03				S04				S05				S06B				S07				S11				S12				TOTAL SAMPLES/EVENT			
2016	Feb-Mar	Melt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	Feb-Mar	Melt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	Feb-Mar	Melt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	Mar-Apr	Melt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2016	May	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2016	July	Baseflow	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	10	10	10	10
2016	July	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	2	1	1	2	1	1	1	1	1	1	1	1	10	10	10	10
2016	Sept	Baseflow	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	10	10	10	10
2016	Sept	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	5	5	5	5
		Subtotal 2016	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	5	6	6	5	5	5	5	5	7	6	6	7	5	5	5	5	5	5	5	5	53	53	53	53
																																							53	**53**	**53**	**53**
		Site ID	S01				S17				S03				S04				S05				S06B				S07				S11				S12				TOTAL SAMPLES/EVENT			
2017	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2017	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2017	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2017	Mar-Apr	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2017	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	May	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	July	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	July	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	Sept	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2017	6	6	10	6	6	6	10	6	6	6	10	6	6	6	6	6	6	6	10	6	6	6	10	6	6	6	10	6	6	6	6	6	6	6	6	6	54	54	78	54
																																							54	**54**	**78**	**54**
		Site ID	S01				S17				S03				S04				S05				S06B				S07				S11				S12				TOTAL SAMPLES/EVENT			
2018	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2018	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2018	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2018	Mar-Apr	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2018	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2018	May	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2018	July	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2018	July	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2018	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2015	5	5	9	5	5	5	9	5	5	5	9	5	5	5	5	5	5	5	9	5	5	5	9	5	5	5	9	5	5	5	5	5	5	5	5	5	45	45	69	45
																																							45	**45**	**69**	**45**
		Site ID	S01				S17				S03				S04				S05				S06B				S07				S11				S12				TOTAL SAMPLES/EVENT			
2019	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2019	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2019	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2019	Mar-Apr	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2019	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2019	July	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2019	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2016	3	3	7	3	3	3	7	3	3	3	7	3	3	3	3	3	3	3	7	3	3	3	7	3	3	3	7	3	3	3	3	3	3	3	3	3	27	27	51	27
																																							27	**27**	**51**	**27**
		Site ID	S01				S17				S03				S04				S05				S06B				S07				S11				S12				TOTAL SAMPLES/EVENT			
2020	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2020	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2020	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2020	Mar-Apr	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2020	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2020	July	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2020	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2017	3	3	7	3	3	3	7	3	3	3	7	3	3	3	3	3	3	3	7	3	3	3	7	3	3	3	7	3	3	3	3	3	3	3	3	3	27	27	51	27
																																							27	**27**	**51**	**27**

Primary Monitoring Locations
Secondary Monitoring Locations
* 2016 reflects actual samples collected

Table 5
Sediment Quality Benchmarks
Long Creek Monitoring Plan
Long Creek Watershed Management District

Analyte	Screening Value	Literature Based Potential Effects Threshold	Units	Source
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)				
Acenapthene	6.7	88.9	ug/kg	Canadian PEL[3]
Acenapthylene	5.9	128	ug/kg	Canadian PEL[3]
Anthracene	57.2	845	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Fluoranthene	423	2230	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Fluorene	77.4	536	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Napththalene	176	561	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Phenanthrene	204	1170	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Benzo(a)anthracene	108	1050	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Benzo(g,h,i)perlyene	170	6300	ug/kg	ARCS PEC[1]
Benzo(k)fluoranthene	240	*	ug/kg	EPA Region III BTAG[4]
Benzo(a)pyrene	150	1450	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Chrysene	166	1290	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Diebenzo(a,h)anthracene	33	135	ug/kg	Canadian PEL[3]
Indeno(1,2,3-cd)pyrene	17	837	ug/kg	ARCS PEC[1]
Pyrene	195	1520	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Total PAHs	1610	22800	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
METALS				
Arsenic	9.79	33	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Cadmium	0.99	4.98	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Chromoium	43.4	111	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Copper	31.6	149	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Lead	35.8	128	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Nickel	22.7	48.6	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Zinc	121	459	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
PESTICIDES				
Heptachlor Epoxide	2.47	2.47	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Chlordane	3.24	17.6	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
BHC, alpha	6	*	ug/kg	EPA Region III BTAG[4]
BHC, beta	5	*	ug/kg	EPA Region III BTAG[4]
BHC, delta	6400	*	ug/kg	EPA Region III BTAG[4]
Dieldrin	1.9	61.8	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Sum DDD	4.88	28	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Sum DDE	3.16	31.3	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Sum DDT	4.16	62.9	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Total DDTs	5.28	572	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Endrin	2.22	207	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Heptachlor	68	*	ug/kg	EPA Region III BTAG[4]
Lindane (gamma-BHC)	2.37	4.99	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Aldrin	2	*	ug/kg	EPA Region III BTAG[4]
Toxaphene	0.1	*	ug/kg	EPA Region III BTAG[4]

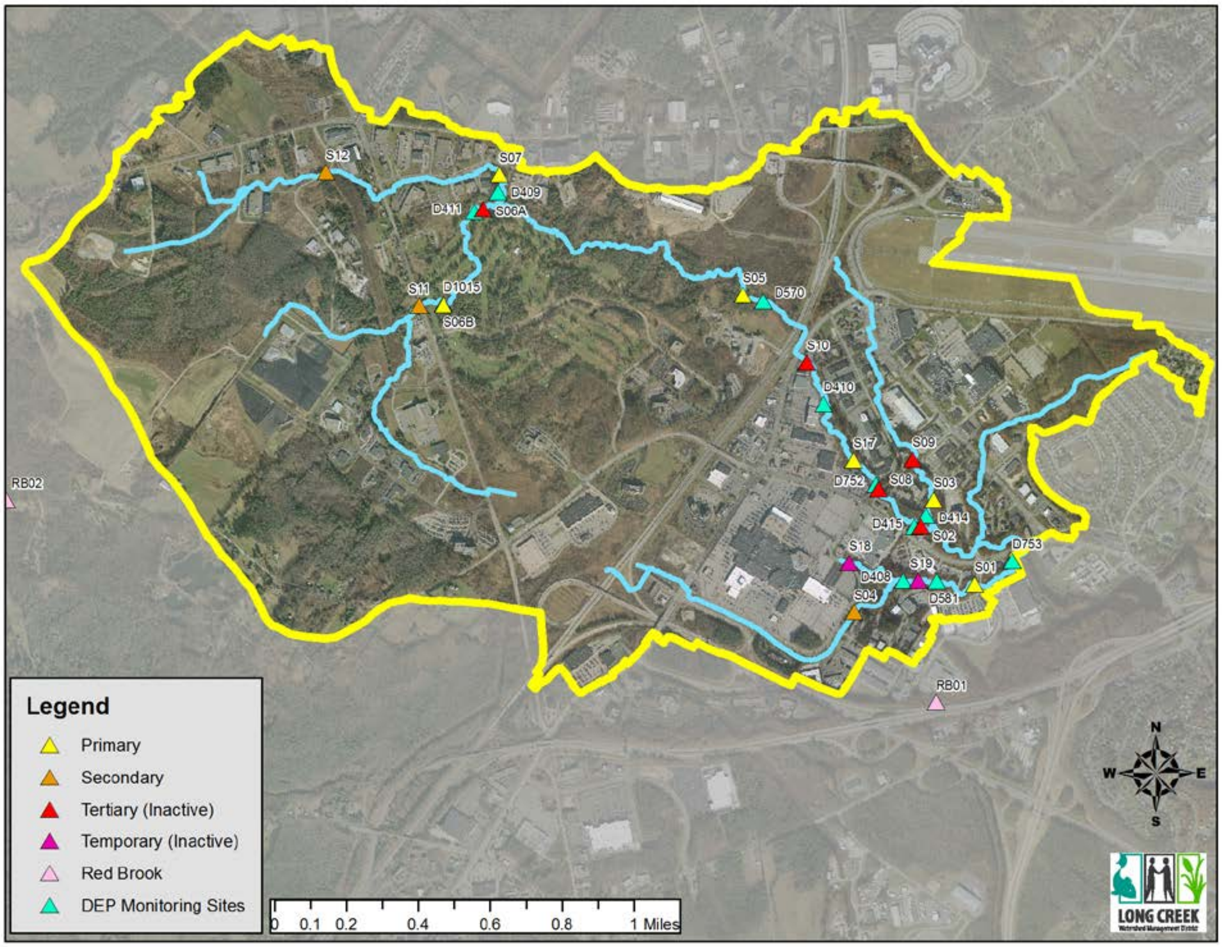
Notes:
Screening Values = Concentration below which adverese effects are not expected to occur.
Potential Effects Threshold = Concentration above which adverese effects are expected to occur.
* = Potential Effects Thresholds not available
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram

Sources:

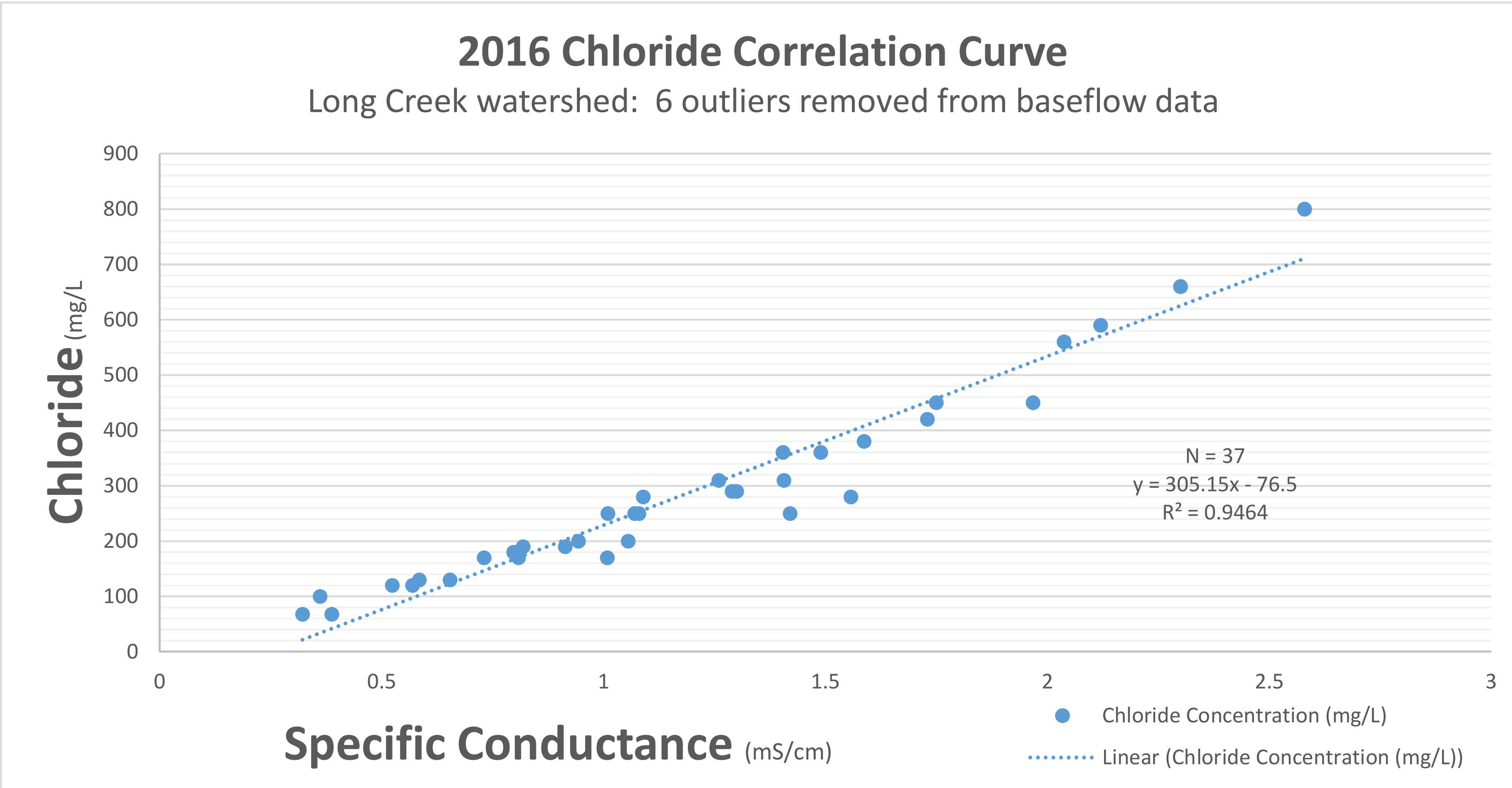
1 - EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL., http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html) (http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html.
2 - MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater Contam. Toxicol. 39: 20-31. ecosystems. Arch. Environ.
3 - Persaud, D.,.R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Onatario Ministry of the Environment. Queen's Printer of Ontario, http://www.itrcweb.org/contseds-bioavailability/References/guide_aquatic_sed93.pdf.
4 - Region III BTAG Freshwater Screening Benchmarks. 2006, https://www.epa.gov/sites/production/files/2015 09/documents/r3_btag_fw_sediment_benchmarks_8-06.pdf.

Figures

Figure 1: Sample Location Plan



Appendix A


2016 Chloride Correlation Curve
Long Creek watershed: 6 outliers removed from baseflow data
Chloride (mg/L
Specific Conductance (mS/cm)
0
100
200
300
400
500
600
700
800
900
0
0.5
1
1.5
2
2.5
3
N = 37
y = 305.15x - 76.5
R² = 0.9464
Chloride Concentration (mg/L)
Linear (Chloride Concentration (mg/L))

Appendix B

Standard Operating Procedure
Methods for Collecting Surface Water Grab Samples

I. **Applicability.** This standard operating procedure (SOP) is used by the Long Creek Watershed Management District (LCWMD), its Contractors, and its partnering organizations. It applies to the collection of water grab samples for water chemistry analysis of rivers and streams in Maine.

II. **Purpose.** The purpose of this SOP is to provide standardized methods for collecting water grab samples from rivers and streams in Maine.

III. **Definition.** A water grab sample is a sample of river and stream water collected for the purpose of analyzing its constituent water chemistry.

IV. **Responsibilities**

A. Long Creek Watershed Management District Staff and Subcontractors

1. **Experience.** The personnel conducting sampling for, or on behalf of, LCWMD shall have a minimum of 3 years of experience collecting samples at similar project site. Personnel with fewer than 3 years of experience shall be directly overseen by a Field Supervisor with requisite experience. More stringent criteria may be required on a project-by-project basis and will be specified in the project-specific Quality Assurance Project Plan (QAPP).
2. **Water Sample Collection.** It is the responsibility of the personnel to collect water samples as specified in project-specific Sampling and Analysis Plan (SAP).
3. **Data Recording.** It is the responsibility of the individual obtaining this data to record the results and additional qualifying information on current field data sheets (example attached) which are to be obtained by LCWMD.
4. **Submitting Samples to Approved Laboratories.** Personnel will submit water grab samples to a State of Maine-certified laboratory for analyses following protocols outlined in their approved sampling and analysis plan (SAP). This includes the completion of laboratory chain of custody forms and following appropriate procedures.
5. **Data Quality Checks and Data Submission.** The data manager for LCWMD or the Contractor will collect and enter field sheet data onto the appropriate computer file, perform quality assurance checks as per the QAPP, and submit data to the LCWMD.

B. State of Maine-Approved Laboratories

1. **Sample Processing.** Laboratories will accept water quality samples and chain of custody forms and then process/analyze the samples.
2. **Sending Data and Quality Assurance Results.** Laboratories will send water quality data and quality assurance results per the project-specific QAPP.

C. Long Creek Watershed Management District Project Manager

1. **Oversight of LCWMD Staff and Contractors.** The LCWMD Project Manager will oversee LCWMD staff and Contractors through a variety of ways including maintaining an up-to-date quality assurance program plan (QAPP); reviewing Contractor sampling and analysis plans (SAPs); conducting quality assurance checks on data submitted by LCWMD Staff, Contractors, and laboratories.

V. **Guidelines and Procedures**

A. Sampling period and location. Sampling period and site location information will be documented in SAPs that are submitted prior to the beginning of a sampling season. Sampling sites are pre-determined by LCWMD with input from project stakeholders and Contractors as appropriate.

Sample sites are not to be prelocated without prior approval from LCWMD or the entities specified in the project QAPP.

B. Supplies

1. For water samples:
   a) Water quality kits from a State of Maine-approved laboratory, which include containers specific to parameter(s) measured and preservatives, as required
   b) Waterproof labels (BE SURE TO STICK ON CONTAINER PRIOR TO SAMPLING)
   c) Approved water sampling device, if using OPTION 3 [i.e., sampling from bridges or boats; see section C below]
   d) Laboratory chain of custody sheets
   e) Permanent marker
   f) Pencil
2. Miscellaneous supplies (as needed)
   a) Cooler with ice
   b) Waders
   c) Nitrile gloves (required)
   d) Personal floatation device (PFD)
   e) Anchor, if sampling from a boat (e.g., OPTIONS 2 or 3)

C. Collecting Water Grab Samples in Field

1. Determine analytical criteria and prepare bottleware.
2. Complete waterproof labels with waterproof ink and attach to bottleware.
3. Record the bottle number (pre-assigned by the laboratory) on the Sample Data Sheet.
4. Collect water samples using appropriate sample container before stirring up sediments from the river or stream bottom, or, alternatively, collect samples upstream of any agitated (stirred-up) water where you have walked. Collect samples choosing one of the following OPTIONS:
   ❖ Option 1: (wading),
   ❖ Option 2: (collecting from edge of river/stream or boat by reaching one's arm or by using an extension pole), or
   ❖ Option 3: (water sampling device, from either a bridge or boat), as appropriate.
5. Avoid eddies, pools, and deadwater as much as possible.
6. Avoid touching the inside or lip of the sample containers (e.g., bottles, cubitainers, Whirl-Pak® bags) or caps.
7. **OPTION 1** ("wading method", collecting from within a stream/river)
   a) Caution should be used in all cases, but especially when wading in rivers and streams deeper than two feet. If sampling within a stream or river, wearing waders and a USCG-approved Type-III floatation vest (PFD) are recommended. Additional caution should be used when the streambed or streambanks are composed of loose or slippery material such as rocks, bedrock, clay, or mud. Algae can make these materials even more slippery. ***Do not wade into streams/rivers that are deeper than your thighs.***
   b) Be sure waterproof label is on container and is properly labeled.
   c) Approach the stream from a downstream location, walking upstream to the sampling site. (This prevents the disturbance of bottom sediments that could contaminate the water quality sample.)
   d) Rinse sample containers in stream water three times (only for certain parameters, as specified in Appendix A of this document).
   e) *If using a Whirl-Pak ® for bacteria sampling (avoid collecting surface film)* The Whirl-Pak ® may be opened before submerging it to collect the water sample. Submerge it under water and remove once it is approximately half-full. Roll up (whirl) the bag to close it and

seal it by tying the two yellow tabs together. Using clean tongs with alligator clips that attach to the Whirl-Pak ® bag by its two yellow tabs is acceptable for holding the bag.

f) *For all other containers (in both options, avoid collecting surface film):*
   (1) (Alternative 1-a; submersing bottle before cap is unscrewed) With cap still screwed on, submerse bottle underwater. (It is okay to loosen cap before submersion.) Tip container upright, remove cap (keeping hand downstream of bottle), and allow water to fill container. Once container is full, place cap on while the container is still submersed. Remove container from water.
   (2) (Alternative 1-b; unscrewing cap first and then submersing bottle) Remove cap from bottle. With bottle pointed upside-down, quickly submerse the bottle under water, turn it upright, and allow it to fill with water. Once container is full, quickly remove it from water and cap.

8. **OPTION 2** (Collecting from edge of river/stream or boat by reaching one's arm or by using an extension pole.)
   - ❖ Edge of River or Stream: Reaching to collect a sample from edge of river/stream is only acceptable if center of flow is less than arm's-length away [this is generally only the case in narrow streams]. Otherwise, use an extension pole to collect sample.
   - ❖ Boat Situations: For boat situations, refer to Appendix B to determine whether samples can be collected by reaching or whether an approved sampling device (OPTION 3) is required.

   a) Reaching Method
      (1) Caution should be used in all cases. If in a boat, wear a USCG-approved Type-III flotation vest (PFD) at all times for safety. Anchor the boat when in the correct position to sample. When sampling from a boat, sample from the upstream side of the boat.
      (2) Be sure waterproof label is on sampling container and is properly labeled.
      (3) Be careful not to contaminate the cap, neck, or inside the container with your fingers or other foreign objects.
      (4) Rinse sample containers in stream water three times.
      (5) *If using a Whirl-Pak ® for bacteria sampling (avoid collecting surface film)* The Whirl-Pak ® may be opened before submerging it to collect the water sample. Submerge it under water and remove once it is approximately half-full. Roll up (whirl) the bag to close it and seal it by tying the two yellow tabs together. Using clean tongs with alligator clips that attach to the Whirl-Pak ® bag by its two yellow tabs is acceptable for holding the bag.
      (6) *For all other containers (in both options, avoid collecting surface film):*
         (a) (Alternative 1-a; submersing bottle before cap is unscrewed) With cap still screwed on, submerse bottle underwater. (It is okay to loosen cap before submersion.) Tip container upright, remove cap (keeping hand downstream of bottle), and allow water to fill container. Once container is full, place cap on while the container is still submersed. Remove container from water.
         (b) (Alternative 1-b; unscrewing cap first and then submersing bottle) Remove cap from bottle. With bottle pointed upside-down, quickly submerse the bottle under water, turn it upright, and allow it to fill with water. Once container is full, quickly remove it from water and cap.

   b) **Extension Pole Method** (not recommended for sampling by boat)
      (1) Be sure waterproof label is on container and is properly labeled.
      (2) Rinse the clamp end of the extension pole in the stream/river prior to sampling.
      (3) Remove lid or stopper from sample container prior to sampling. Be careful not to contaminate the cap, neck, or inside the container with your fingers or other foreign objects.

(4) Securely attach the sample container to the extension pole using the clamps.
(5) Extend the pole to desired length. Ensure that sample will be collected from the center of flow. (Do not, however, extend the pole too far when sampling in high velocity streams to avoid damage to the pole.)
(6) Rinse sample container in stream water three times (only for certain parameters as specified in Appendix A of this document).
(7) Prepare to collect water sample by first rotating the extension pole until the sample container is oriented upside down.
(8) Immerse the sample container to desired depth and then rotate the rod underwater to fill the container. (Avoid collecting surface film.)
(9) Once the sample container is full, remove it from the water, cap it and remove it from the clamp.

9. **OPTION 3** ("Approved water sampling device" method; if collecting from a bridge or from a boat;) (See Appendix D of this document for a list and description of approved sampling devices. See Appendix B of this document for information on acceptable location of sample collection.)
   a) Caution should be used in all cases. If sampling from a bridge, wear an orange vest for safety. If collecting samples from a boat, wear a USCG-approved Type-III flotation vest (PFD) at all times for safety.
   b) If on a boat, anchor it when in the correct position to sample.
   c) Be sure waterproof label is on appropriate containers and that they are properly labeled.
   d) Make sure the approved water sampling device has been cleaned ahead of time according to directions in Appendix C of this document.
   e) Rinse the sampling device and any associated sample containers in stream water three times. (Make sure this is done from a safe location!) When on a bridge, dump the rinse water at least 20 feet away from where you plan to take the water sample. When on a boat, dump the rinse water on the downstream side of the boat.
   f) Lower the sampling device from the upstream side of the bridge or boat (whenever possible) into the river to the appropriate depth. Completely fill the sampling device with water. (See Appendix B for information on appropriate depth for sampling.)
   g) Pull the filled sampling device up and carry to a safe location. (Be sure to watch out for traffic.) Avoid bumping the sampling device against the bridge as you raise it to avoid any potential sample contamination.
   h) Prepare to analyze your water sample. Place the sample container on a clean, stable surface such as the bottom of an upside-down 5 gallon bucket. Carefully open the sample device in order to access the water inside.
   i) *Dissolved oxygen and temperature:* In many cases personnel will be monitoring dissolved oxygen (DO) and temperature directly off of bridges using meters and probes with long cords that follow other standard operating procedures (SOPs). If, instead, you are analyzing dissolved oxygen and temperature from the water within your sampling device, analyze the sample for DO and temperature first, following the appropriate equipment SOPs, before analyzing else. Do not agitate the water before DO and temperature have been measured.
   j) *Other water quality parameters:* After DO and temperature have been measured, swirl and mix the water sample. Measure other parameters using the appropriate meters/probes (following their specific SOPs), or pour off water samples into their appropriate sample containers. (k) Follow Appendix C for directions on how to clean and store the water sampling device.
10. Store and transport samples in cooler with ice, as appropriate (refer to the project QAPP for more information).
11. Complete field data sheet and laboratory chain of custody sheet.

12. Drop off samples laboratory within the holding time frame discussed in the project QAPP. Include a completed chain of custody sheet.

D. Collecting Water Grab Samples in Field

1. For every project, a field duplicate will be collected for 10% (i.e., 1 for every 10 water grab samples) collected for laboratory analysis. However, if, for example, less than 10 samples were collected for a given parameter, 1 field duplicate must still be collected for that parameter. The field duplicate must be processed by the same laboratory.
2. Laboratory: quality control samples analyzed in the laboratory are specified in their respective SOPs and generally include duplicate, spiked, and blank samples. Unless otherwise specified in the QAPP, batch-QC results are acceptable.
3. Refer to the project QAPP for more QA/QC details.

VI. References

Maine Department of Environmental Protection (MDEP). 2004. Protocols for Collecting Water Grab Samples in Rivers, Streams, and Freshwater Wetlands. Prepared by Tom Danielson, MDEP, Augusta, Maine. Document ID: DEPLW0637.

Maine Volunteer River Monitoring Program (VRMP). 2009. Appendix 8: Catalog of Standard Operating Procedures Used by VRMP-Approved Laboratories.

Maine VRMP. 2009. Methods For Collecting Water Grab Samples in Rivers and Streams.

Massachusetts Water Watch Partnership (MassWWP). 2008. MADEP-DWM Sample Collection Rod. Last viewed on February 24, 2009 at: http://www.umass.edu/tei/mwwp/files/Sample%20Collection%20Staff.doc.

Appendix C

(NALGENE/I-CHEM MODEL 1100-1000)

Supplies

Rising Stage Sampler (e.g., Nalgene / I-Chem model 1100-1000 Storm Water Sampler)
Extra sample container cap (to replace the storm sample assembly when sample has been collected)
Sampler Housing
Fixed object to attach sampler to (e.g., stake, sign post, dock post, etc.), and hose clamps or other attachment hardware
Mallet, or other tool to install stake
Rising Stage Sampler Field Data Sheet
Residue-free, phosphorous-free cleaning solution (or other specialized cleaning solution based on analyte in question)
Waterproof labels (BE SURE TO STICK ON CONTAINER PRIOR TO SAMPLING)
Laboratory chain of custody sheets
Permanent marker
Pencil
Cooler with ice
Waders (if conditions warrant them)
Gloves

Figure 1: Nalgene® Storm Water Sampler

Overview

When precipitation begins, many pollutants that have accumulated on the land surface are mobilized into ditches, stormdrains, and streams. The initial period of increased flow harbors elevated levels of pollutants as they are washed from the land into waterways. Although precipitation may continue for some time, there is a "first flush" effect, meaning that higher levels of pollutants occur in the initial runoff than later in the storm. This first flush effect was found to exist for 70% of pollutants in runoff from commercial land uses, and 60% of pollutants in residential, institutional and the mixed land uses (Pitt, *et al*., 2004).

Collecting water samples from the first flush during a storm event is challenging. Exact timing depends on weather, which may be unpredictable. In addition, you may need samples from multiple locations at nearly the same time. Unattended sampling devices can facilitate capturing the stormwater first flush. The basic principle is that the intake is dry under normal conditions. Rising stream levels or water flowing into a storm drain grate cause the bottle to fill, and once full, a floating stopper prevents additional water from entering the bottle. Some samplers are commercially available, while others can be constructed with basic hardware and sample collection supplies.

This method of sample collection has the disadvantage of leaving the sample bottle open (except for a debris guard and screen) in the environment for hours or days prior to sample collection. Samples are susceptible to contamination during this period. One goal of sampling should be to minimize the chance of contamination by deploying the samplers as late as practical before the storm, and retrieving them promptly when conditions permit. In spite of the disadvantages, these samplers can help fill a valuable niche in sampling, providing samples that would be otherwise cost-prohibitive or impossible to collect.

Step by Step Guide to Using Storm Water Sampler

1. Prepare site
    a. Sampling periods and locations need to be documented in a DEP-approved Sampling and Analysis Plan (SAP).
    b. Affix post, deployment tube, and security anchor/cable. The Nalgene sampling kit comes with a 3 foot metal stake for this purpose. If installing in a stream bed, a larger, stronger sign-post style stake may be necessary. Use a two hose clamps (metal worm-clamps) to attached the deployment tube to the stake or post.
    c. There are two tie-off holes in the deployment tube through which a cable or anchor line may be tied. These should be used to prevent loss of the sampling system in the event of a washout.
    d. There are many considerations that be used to determine at what elevation to set the sampler. For a thoroughly studied site, it might be possible to use the stream's classification (e.g., Rosgen Stream Classification System, see Rosgen and Silvey, 1996), along with a stage-discharge relationship, to define a given return period of interest. Existing records of stream stage and precipitation should be obtained when possible. These records may be studied to determine what stream stage is most likely to collect early, rising-stage conditions after a typical rain event. At the same time, the level needs to be sufficiently high to avoid inadvertently collecting non-storm base flow. In the absence of these records, the use the following guidelines.
        i. Visit the stream during dry weather, low flow conditions and take careful notes on the stream level relative to nearby fixed objects. Set the intake level of the sampler safely above this level to avoid sampling baseflow.
        ii. Visit the stream soon after a typical precipitation event, and search for a debris line, wet banks, flattened vegetation, or other signs of the maximum depth the stream reached. Set the intake level below this level.

    e. Determine a reference elevation. Ideally, accurate, survey-grade equipment should be used to identify a benchmark elevation on a stable object, such as a cement wall, building foundation, large boulder, bridge abutment, etc., and would relate the deployment tube elevation to that benchmark.

2. OPTIONAL: Secure a source of weather data, and determine target storm conditions.
    a. A nearby NWS or NOAA weather station is ideal, especially if 30-minute precipitation records are available.
    b. Installing and maintaining a rain gauge in the watershed may be advisable.
    c. Installing a level sensor near the stormwater sampler, or even on the same stake, would be an excellent way to view the stream hydrograph during sample events. If properly installed and calibrated, it can provide the approximate time the sample was taken, as well.
    d. It is advisable to consider in advance what conditions will constitute a storm event, that is, how much rain must fall, over what period for the event to be considered a qualifying event. In addition, what is the minimum no-precipitation time period that must pass for the event to end.
3. Prepare sample bottle
   Both HDPE and glass bottle are available for this unit. The glass bottle may be used for certain analytes, such as metals.
    a. Wash and dry:
       NOTE: Although the manufacturer states the bottles are disposable, they may be washed and re-used.
       NOTE: Your SAP may specify more stringent bottle washing procedures, depending on analyte.
       Un-cap the container and disassemble cap. Use non-phosphate, DEP-approved detergent (e.g., Liqui-Nox). Rinse three times with deionized or distilled water by filling the container approximately half full, capping and swirling thoroughly, then pouring out. Reassemble. Dry with cap off, and store upside down or covered between sample events. Rinse three times with deionized or distilled water immediately before deployment.
    b. Assemble:
       The top portion of a Nalgene Storm Water Sampler consists of the following parts. With the cap upright, they should be assembled in this order:
        i. Large funnel cap, with small vent tube
        ii. Ball, serves as a check-valve when sample is full
        iii. Wide rubber o-ring stopper
        iv. Perforated plastic screen (“debris cassette”)
        v. Dome-shaped debris guard (note that vent tube is tucked inside the dome).
    c. Affix waterproof label and use permanent marker to indicate site, deployment date and time.
    d. Handle appropriately en route:
       Do not touch inside of bottle or cap. Handle the bottle from below the cap, once assembled to avoid touching the funnel or debris dome as much as possible. (Pressing down on the debris dome spire will be necessary during deployment.)

4. Deploy before storm
   Minimizing the time between deployment and sampling is ideal, since it reduces the chance of contamination.
   a. Inspect the deployment tube. Ensure it is securely mounted. Remove and clean both upper and lower grates. Visually inspect the flow path to verify that rising water will enter the deployment tube and fill the sample container. Place the sampler in the tube and snap on the debris grate.
   b. Deploy as soon before the storm event as possible. Exact time limits will be specified in your SAP. Typically, samplers are not left out more than two days.
   c. If high flows which trigger sample collection do not materialize within the expected time frame, the sampler must be washed and redeployed. Field washing is permitted. Follow all steps above, maintaining a controlled and clean work space (e.g., tarp or wide plastic bin), and transporting out used wash water.
5. Retrieve after storm
   a. Retrieve the sample as soon as practical after the storm event, ideally within 6 hours.
   b. Remove the deployment tube top grate, extract the sampler, and replace intake assembly on container with a clean cap. Note if bottle was less than full and therefore not sealed by the ball valve. Note time of sample collection on the sample bottle label.
   c. Your SAP may require the addition of chemical preservatives to the sample, or that the sample be transported on ice.
   d. Note site conditions. Estimate time of sample collection, and state how estimate was made. Also estimate maximum depth of stream, based on debris line, wet banks or tree trunks, etc.
   e. Deliver to lab, along with chain of custody form.
   f. Wash and rinse sample bottle as described above.
6. Remove post when sampling is completed

References

Nalgene® Storm Water Sampler and Mounting Kit. Cat. Nos. 1100-1000 and 1150-1000 Instructions.

Pitt, R., T. Brown and R. Morchque. 2004. National Stormwater Quality Database. Version 2.0. University of Alabama and Center for Watershed Protection. Final Report to U.S. Environmental Protection Agency.

Rosgen, D.L. and H.L. Silvey. 1996. Applied River Morphology. Wildland Hydrology Books. Fort Collins, CO.

2ndNature, LLC. September 15, 2008. Truckee River Water Quality Monitoring Plan. [See especially section 6.6 for description of deployment of rising stage samplers]

US EPA. October 30, 2000. Final Reissuance of National Pollutant Discharge Elimination System (NPDES) Storm Water Multi-Sector General Permit for Industrial Activities; Notice. Federal Register. Vol. 65, No. 210. pp. 64770-64772.

NALGENE® Storm Water Sampler and Mounting Kit

Cat. Nos. 1100-1000, 1120-1000 and 1160-1000

Storm Water Sampler NALGENE Cat. Nos. 1100-1000 and 1120-1000

(Single Use Disposable)

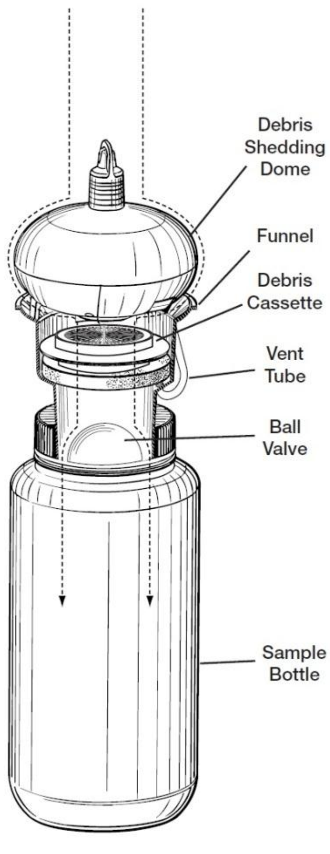
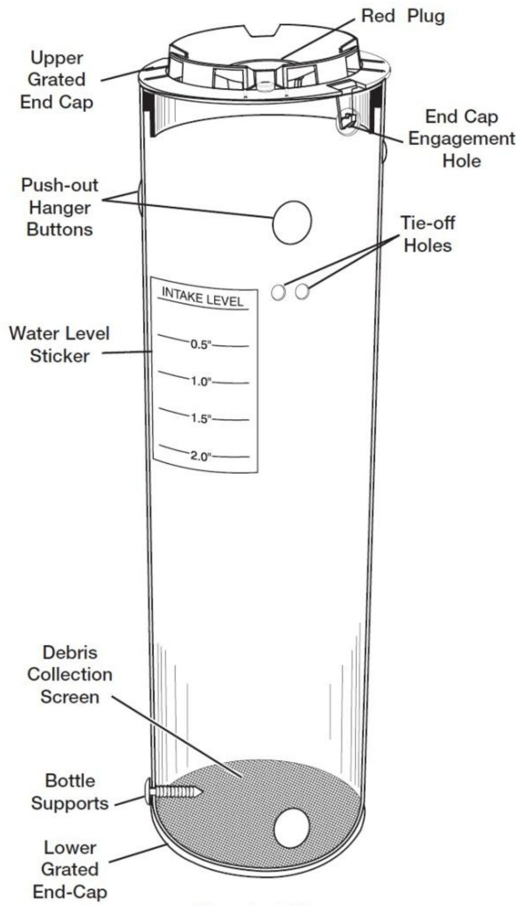


Fig. 1

Storm Water Mounting Kit NALGENE Cat. No. 1160-1000

(Reusable)



Important Note: NALGENE Storm Water Samplers (Cat. Nos. 1100-1000 and 1120-1000) are intended for one-time use. Performance not guaranteed for re-use. Unit as provided will fill in approximately 90 seconds; for faster fill and larger debris collection, the Debris Cassette may be removed.

NOTE: **Mounting kit is reusable,** is required for ditch and stream applications, and is recommended for storm grate mounting unless drain chamber space precludes use. Mounting kit benefits include:

- Protecting sampler from large debris that may damage the unit during outfall flow
- Collecting selected suspended solids for visual notation
- Protecting sampler from environmental exposure prior to a rain event
- Protecting the sample bottle from breakage (1120-1000)

Tools/additional materials required:

- Slotted-head screwdriver
- Rope (for stream mounting)
- Colored Tape or Ribbon
- T-Post (for stream mounting)
- Shovel (for ditch mounting)

Caution! When collecting samples for oil and grease analysis, handle the sampler only while wearing clean gloves to prevent sample contamination.

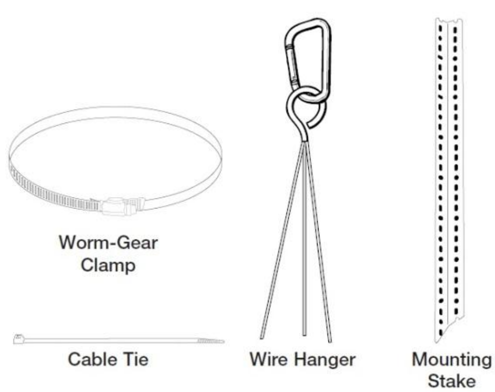


Fig. 2

Directions for Use:

Mounting Tube Loading:

a. Open the Mounting Tube by removing the upper grated end cap (End cap removes easily by inserting a pen or other object into one of the end cap engagement holes).
b. Position the Storm Water Sampler at the bottom of the Mounting Tube.
c. Replace the Upper Grated End Cap, making sure to snap the end cap into the engagement holes.

1. Position the loaded Mounting Tube in the outfall as diagrammed in Figures 3-5.

a. **<u>Grate Mounting</u>** (Figure 3.)
   i. Sampler may be suspended from a storm water grate without the Mounting Tube if the tube is too tall to fit in the space below the grate; however larger suspended solids will not be collected. If Mounting Tube is not used, suspend sampler on a wire or string threaded through the handle eye at the top of the dome.
   ii. To suspend Mounting Tube, push out the three Hanger Buttons on the tube and attach the Wire Hanger. Secure to grate with clip. It may be necessary to attach a wire or chain to the grate to which you can clip the Mounting Tube.
   *NOTE: Position sampler **near the edge** of the storm drain chamber (not in the middle) where it will intercept flow from the surface.*
   iii. Remove the red plug in the upper grated end cap to allow water to flow in from above.

b. **<u>Ditch Mounting</u>** (Figure 4.)
   i. Dig a hole deep enough to lower the sampler/Mounting Tube to the desired height above the bottom of the ditch.
   NOTE: Proper height must be determined by the anticipated flow elevation of a qualifying storm event.
   ii. Drive Mounting Stake into the downstream side of the hole with the open side of the "V" facing upstream.
   iii. Using a screwdriver, secure Mounting Tube to the open "V" side of the stake at the desired elevation by tightening the Metal Worm Clamp.
   iv. Backfill the hole around the Mounting Tube and flag the location with bright colored ribbon, tape or by other means to assist in locating the sampler for retrieval.
   v. Make sure the red plug is inserted in the upper grated end cap to prevent falling rain from being collected directly.

c. **<u>Stream Mounting</u>** (Figure 5.)
   i. Stream mounting generally requires the purchase of a taller post (T-posts are recommended and commercially available from most hardware stores). Drive the post securely into the stream bottom at the desired location.
   ii. Using a screwdriver, tighten the Metal Worm Clamp to secure the Mounting Tube to the downstream side of the post. Position the water "intake level" line at the desired height above water level.
   NOTE: Proper height must be determined by the anticipated flow elevation of a qualifying storm event.

   Important: do not submerge the sampler vent tube during set up, or it may airlock and prevent proper sample collection.

   iii. It is recommended that the mounting tube be secured to the stream bank by tying a rope through the two holes on the Mounting Tube, and tying it off to a secure location on bank (tree, mounting stake, etc.) The Cable Tie can be threaded through the two holes to create a larger loop to more easily tie off the Mounting Tube.
   iv. Make sure the red plug is inserted in the upper grated end cap to prevent falling rain from being collected directly.

2. Leave the sampler in position until a qualifying rain event occurs.

a. Storm Water Sampler will collect sample until the bottle is full, then the floating ball valve will close the bottle chamber to prevent sample dilution.

3. Retrieve the sampler from the mounting tube after a rain event that results in outfall flow.

a. Remove the grated end cap from the mounting tube and pull the sampler out.
b. Remove the disposable sampling device from the bottle, and cap the bottle with the closure provided.
   i. Collect and record visual sample data, as required.
   ii. If chemical analysis is required, follow laboratory directions for chemical sample preservation, and transport the sample to the lab on ice.
c. Suspended solids small enough to pass through the grated end-cap will be collected by the screen at the bottom of the mounting tube. Make visual notations as required, then remove the screen, clean it, and replace it in the bottom of the reusable mounting tube prior to next use.

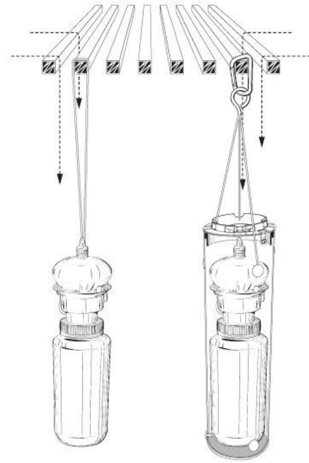


Fig. 3
Grate Mount

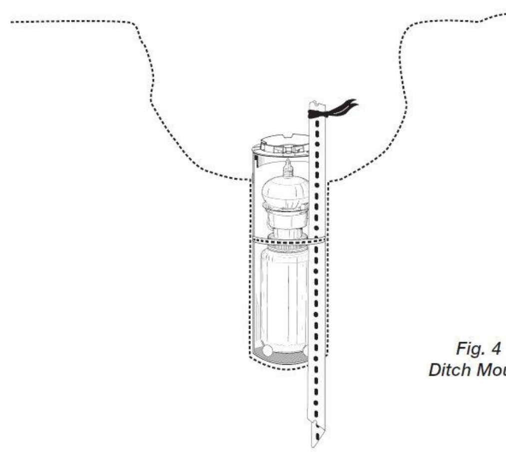


Fig. 4
Ditch Mount

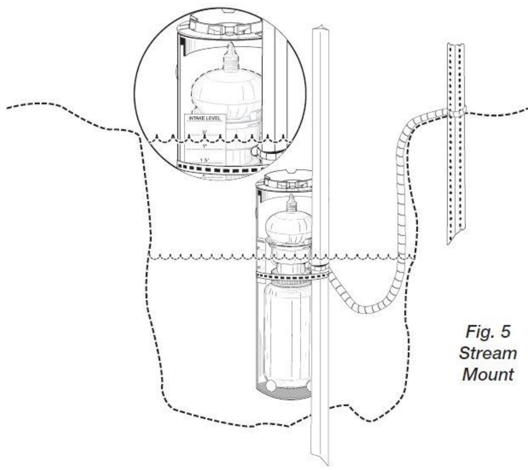


Fig. 5
Stream Mount

FM 31464
ISO 13485 Certified

NALGENE®

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Rochester, NY 14625-2385 U.S.A.
Visit us on the internet at:
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Appendix D

Pro2030

USER MANUAL

English

Item #605056
Rev C
Drawing # A605056
November 2010

CONTENTS

WARRANTY

The YSI Professional 2030 instrument (Pro2030) is warranted for three (3) years from date of purchase by the end user against defects in materials and workmanship, exclusive of batteries and any damage caused by defective batteries. Pro2030 cable assemblies are warranted for two (2) years from date of purchase by the end user against defects in material and workmanship. Pro2030 Polarographic sensors are warranted for one (1) year and Galvanic sensors are warranted for six (6) months from date of purchase by the end user against defects in material and workmanship. Pro2030 instruments, cables & sensors are warranted for 90 days from date of purchase by the end user against defects in material and workmanship when purchased by rental agencies for rental purposes. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, call your local YSI representative, or contact YSI Customer Service in Yellow Springs, Ohio at +1 937 767-7241, 800-897-4151 or visit www.YSI.com for a Product Return Form. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

LIMITATION OF WARRANTY

This Warranty does not apply to any YSI product damage or failure caused by:

1. Failure to install, operate or use the product in accordance with YSI's written instructions;
2. Abuse or misuse of the product;
3. Failure to maintain the product in accordance with YSI's written instructions or standard industry procedure;
4. Any improper repairs to the product;
5. Use by you of defective or improper components or parts in servicing or repairing the product;
6. Modification of the product in any way not expressly authorized by YSI.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI'S LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

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INTRODUCTION

Thank you for purchasing the YSI Pro2030, an instrument from the YSI *Professional Series* product family. The Pro2030 measures dissolved oxygen, conductivity and temperature in water. The Pro2030 features an impact resistant and waterproof (IP-67) case, a rugged MS-8 (military-spec) cable connector, backlit display, user-selectable sensor options, 50 data set memory, internal barometer and a rubber over-mold case.

The Pro2030 provides valuable instructions and prompts near the bottom of the display that will guide you through operation and use. However, reading the entire manual is recommended for a better understanding of the instrument's features.

The Pro2030 cannot communicate to a PC via a Pro Series communications saddle. Connecting the Pro2030 to a communication saddle may cause erratic instrument behavior.

GETTING STARTED

INITIAL INSPECTION

Carefully unpack the instrument and accessories and inspect for damage. Compare received parts with items on the packing list. If any parts or materials are damaged or missing, contact YSI Customer Service at 800-897-4151 (+1 937 767-7241) or the authorized YSI distributor from whom the instrument was purchased.

BATTERY INSTALLATION

The instrument requires 2 alkaline C-cell batteries. Under normal conditions, the average battery life is 425 hours at room temperature without using the back light. A battery symbol will blink in the lower, left corner of the display to indicate low batteries when approximately 1 hour of battery life remains.

To install or replace the batteries:

1. Turn the instrument off and flip over to view the battery cover on the back.
2. Unscrew the four captive battery cover screws.
3. Remove the battery cover and remove the old batteries if necessary.
4. Install the new batteries, ensuring correct polarity alignment (figure 1).

5. Place the battery cover on the back of the instrument and tighten the four screws. Do not over-tighten.

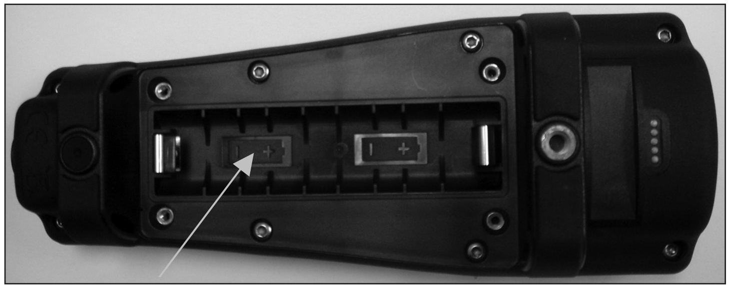


Figure 1. Pro2030 with battery cover removed. Notice battery symbols indicating polarities.

> ⓘ *The waterproof instrument case is sealed at the factory and is not to be opened, except by authorized service technicians. Do not attempt to separate the two halves of the instrument case as this may damage the instrument, break the waterproof seal, and will void the warranty.*

KEY PAD

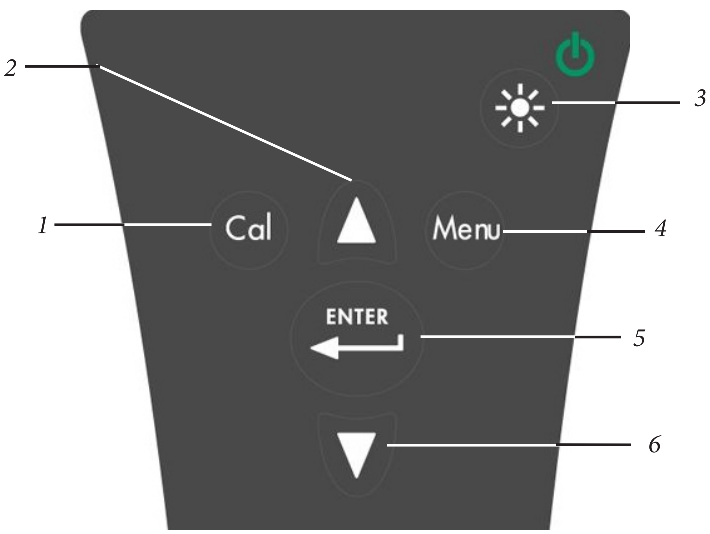
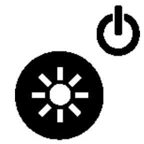


Figure 2, Keypad

Number	*Key*	*Description*
1		**Calibrate** Press and hold for 3 seconds to calibrate. Opens Calibrate menu from the Run screen.
2		**Up Arrow** Use to navigate through menus, to navigate through box options along the bottom of the Run screen and to increase numerical inputs.
3		**Power and Backlight** Press once to turn instrument on. Press a second time to turn backlight on. Press a third time to turn backlight off. Press and hold for 3 seconds to turn instrument off.
4		**Menu** Use to enter the System Setup menu from the Run screen.
5		**Enter** Press to confirm entries and selections.
6		**Down Arrow** Use to navigate through menus, to navigate through box options at the bottom of the Run screen and to decrease numerical inputs.

CONNECTING THE SENSOR AND CABLE

"Bulkhead" refers to the single-pin connector at the end of the probe/cable assembly where the dissolved oxygen (DO) sensor is installed (figure 3). The conductivity and temperature sensors are located above and next to the bulkhead respectively and are not user-replaceable.

> ⓘ *When a dissolved oxygen sensor is not installed in the cable, the sensor and cable's bulkhead connectors are not water-proof. Do not submerge the cable without a sensor installed. Submerging the cable without a sensor installed may cause permanent damage to the cable that is not covered under warranty.*

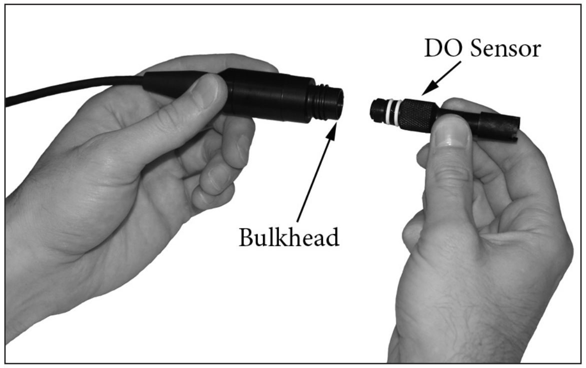


Figure 3

INSTALLING THE DISSOLVED OXYGEN SENSOR

The Pro2030 has two compatible dissolved oxygen sensors:

Polarographic – This sensor has a black sensor body and is engraved with the model number 2003. Polarographic will be abbreviated Polaro in the instrument's menu.

Galvanic – This sensor has a grey sensor body and is engraved with the model number 2002.

For information on the differences between these two types of sensors, see Sensor Type in the System Setup Menu section of this manual.

Before installing either sensor or connecting the cable to the instrument, the Sensor Type must be configured for the sensor being installed/connected. Failure to do this may result in damage not covered under warranty. The instrument will step you through this setup the first time the instrument is powered on. See the System Setup Menu section of this manual for instructions on configuring the Sensor Type after the first power on.

1. Remove the red plastic plug from the cable's bulkhead port by pulling it straight out of the port. This can be discarded.
2. Remove the red plastic plug from the sensor's connector by pulling it straight off the sensor. This can be discarded.
3. Ensure both the sensor connector and bulkhead connector on the cable are clean and dry.
4. Grasp the sensor with one hand and the cable bulkhead in the other.

5. Push the sensor into the connector on the cable until it is firmly seated and only 1 o-ring is visible. Failure to properly seat the sensor may result in damage.
6. Twist the sensor clockwise to engage the threads and finger tighten. Do NOT use a tool. This connection is water-tight.

For more detailed instructions, please refer to the sensor installation sheet that is included with each sensor.

CONNECTING THE PROBE/CABLE ASSEMBLY TO THE INSTRUMENT

To connect the cable, align the keys on the cable connector to the slots on the instrument connector. Push together firmly and then twist the outer ring until it locks into place (figure 4). This connection is water-proof.

Figure 4, Note the keyed connector.

MEMBRANE INSTALLATION

The sensing end of the dissolved oxygen sensor is shipped with a protective red cap that needs to be removed before using. Additionally, it is very important to install a new membrane with electrolyte solution onto the sensor after removing the red cap.

Prepare the electrolyte solution according to the instructions on the bottle. After mixing, allow the solution to sit for 1 hour. This will help prevent air bubbles from later developing under the membrane. Ensure you are using the correct electrolyte solution for your sensor. Galvanic sensors utilize electrolyte with a light blue label on the bottle and Polarographic sensors utilize electrolyte with a white label on the bottle. The dissolved oxygen sensor is supplied with cap membranes specific to the sensor type ordered (Polarographic or Galvanic). 5913 and 5914 membrane kits are for Galvanic sensors and the 5908 and 5909 membrane kits are for Polarographic sensors.

Remove and discard or save the red protective cap from the dissolved oxygen sensor by pulling it straight off. Thoroughly rinse the sensor tip with distilled or deionized water. Fill the cap membrane 3⁄4 full of electrolyte solution, then tap the cap with a finger to release any trapped air. Be careful not to touch the membrane portion of the cap. Thread the membrane cap onto the sensor, moderately tight. Do not use a tool. It's typical for some of the electrolyte solution to spill over. It is best to allow the new cap to remain on the sensor overnight before calibrating. For detailed instructions on changing a cap membrane, see the Care, Maintenance and Storage section of this manual.

RUN SCREEN

Press the power/backlight key to turn the instrument on. The instrument will run through a self test and briefly display a splash screen with system information before displaying the main Run screen (figure 5). The first time the Pro2030 is turned on, it will step through language, sensor and membrane selections; see the First Power On section of this manual for more information.

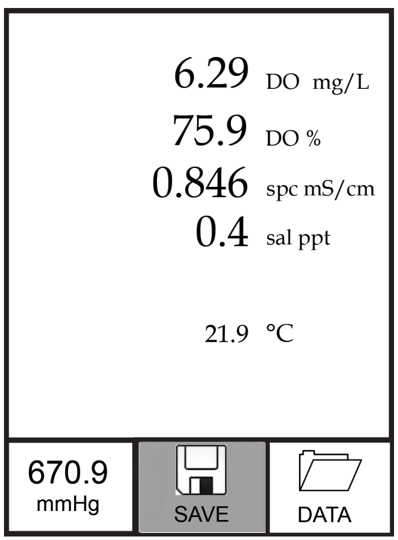


Figure 5, Run screen.

BACKLIGHT

Once the instrument is powered on, pressing the power/backlight key will turn on the display backlight. The backlight will remain on until the key is pressed again or after two minutes of not pressing any key on the keypad.

POWERING OFF

To turn the instrument off, press and hold the power/backlight key for three seconds.

NAVIGATION

The up and down arrow keys allow you to navigate through the functions of the Pro2030.

NAVIGATING THE RUN SCREEN

When in the Run screen, the up and down arrow keys will move the highlighted box along the bottom options. Once a box is highlighted, press enter to access the highlighted option.

Description of Run screen box functions from left to right:

Option	*Description*
Barometer reading	Highlight and press enter to calibrate the barometer.
SAVE	Highlight and press enter to save displayed data to memory.
DATA	Highlight and press enter to view and/or erase saved data.

NAVIGATING THE SYSTEM SETUP MENU

When in the System Setup menu, the up and down arrow keys will move the highlighted bar up and down the system setup options. See the System Setup menu section of this manual for more information about these options.

FIRST POWER ON

The instrument will step through an initial configuration when powered on for the first time. This will set the language, dissolved oxygen sensor type and membrane type. Use the up or down arrow keys to highlight the appropriate language, sensor and membrane, then press enter to confirm (figures 6). The Sensor Type must be configured for the dissolved oxygen sensor installed on the cable. Failure to do this may result in damage not covered under warranty. If an incorrect option is selected, it may be changed in the System Setup menu.

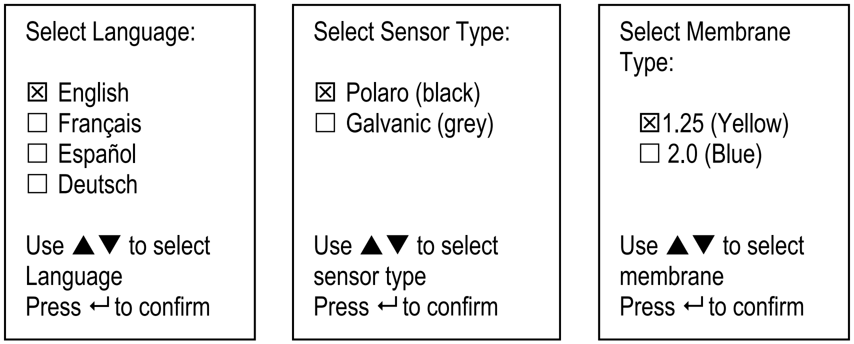


Figure 6, Select language, dissolved oxygen sensor and membrane.

After selecting a language, sensor and membrane, the Run screen will be displayed. The next time the instrument is powered up, the Run screen will display immediately after the splash screen. If the sensor type or membrane type is changed, ensure that it is updated in the System Setup menu.

SYSTEM SETUP MENU

Press the menu (Menu) key to access the System Setup menu. The System Setup menu contains multiple screens that are notated as 'pages'. The current page is indicated near the bottom of the display (figure 7).

Use the up and down arrow keys to scroll through menu options and menu pages.

EXITING THE SYSTEM SETUP MENU

To exit the System Setup menu, press the down arrow key until the ESC - Exit box is highlighted, then press enter to return to the Run screen.

DO LOCAL%

DO Local% can be enabled or disabled by using the up or down arrow keys to highlight it and then pressing enter (ENTER). An 'X' in the box next to DO Local% indicates it is enabled (Figure 7).

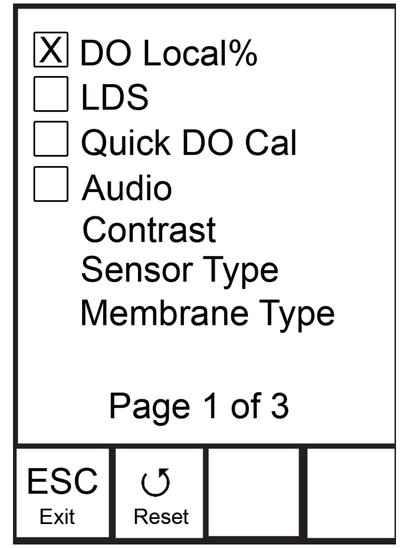


Figure 7, page 1 of System Setup menu. DO Local% is enabled.

When DO Local% is enabled, DO% values will be expressed as %L on the Run screen.

DO Local% allows for localized % saturation measurements, but does not affect the mg/L readings. When enabled, the DO% calibration value is always 100% regardless of the altitude or barometric pressure of the location. This deviates from YSI's traditional method of expressing DO% saturation where the % calibration value decreases with a decrease in barometric pressure, i.e. an increase in altitude (Appendix A). To determine the % calibration value when DO Local% is disabled, divide the local barometric pressure pressure in mmHg by 760 and then multiply by 100.

Example: 750/760 = 0.9868 x 100 = 98.68% calibration value when DO Local is disabled.

When DO Local% is enabled, the Pro2030 corrects for barometric pressure on each DO measurement instead of during calibration.

Example:
Instrument #1 with DO Local% enabled:
At 737 mmHg barometric pressure, roughly 841 ft above sea level, the instrument would calibrate to 100%.

When taking measurements at the same location (737 mmHg) in a 20°C fresh water sample that is completely air-saturated, the instrument would read:

DO %L value = 100%
DO mg/L value = 8.81 mg/L (9.09[1] x .9697[2])

Instrument #2 DO Local% disabled:
At 737 mmHg barometric pressure, roughly 841 ft above sea level, the instrument would calibrate to 737/760 x 100% = 96.97%

When taking measurements at the same location (737 mmHg) in a 20°C fresh water sample that is completely air-saturated, the instrument would read:

DO% value = 96.97%
DO mg/L value = 8.81 mg/L (9.09[1] x .9697[2])

Hence, the mg/L readings are unaffected by DO Local%.

1.) Value from oxygen solubility table (Appendix B).
2.) 737/760 x 100%, correction for barometric pressure.

LAST DIGIT SUPPRESSION (LDS)

Last Digit Suppression (LDS) can be enabled or disabled by using the up or down arrow keys to highlight it and pressing enter. An 'X' in the box next to LDS indicates it is enabled.

LDS rounds the DO value to the nearest tenth; i.e. 8.25 mg/L becomes 8.3 mg/L. LDS is automatically disabled during calibrations.

QUICK DO CALIBRATION (QUICK DO CAL)

Quick DO Cal can be enabled or disabled by using the up or down arrow keys to highlight Quick DO Cal and pressing enter. An 'X' in the box next to Quick DO Cal indicates it is enabled.

When Quick DO Cal is enabled, press and hold the calibration Cal key for 3 seconds while in the Run screen. Next, highlight Dissolved Oxygen and press enter to calibrate the DO sensor to the instrument's barometer reading. For more information on Quick DO Cal, see the Calibration section of this manual.

AUDIO

Audio can be enabled or disabled by using the up or down arrow keys to highlight Audio and pressing enter. When enabled, there will be an 'X' in the box next to Audio.

When Audio is enabled, the Pro2030 will beep twice to indicate stability when Auto Stable is enabled. The instrument will also beep when a key is pressed. When Audio is disabled, the Pro2030 will not beep.

CONTRAST

To adjust the display Contrast, use the up or down arrow keys to highlight Contrast, then press enter. Next, use the up or down arrow keys to adjust the contrast. The up arrow key will darken the contrast and the down arrow key will lighten the contrast. After adjusting the contrast, press enter to save and exit the Contrast adjustment option.

EMERGENCY CONTRAST ADJUSTMENT

If necessary, there is an alternate method of adjusting the contrast. To adjust the contrast, press and hold the menu key, then press the up arrow key to darken the contrast or press the down arrow key to lighten the contrast.

SENSOR TYPE

Sensor Type sets the type of dissolved oxygen sensor being used; either Polarographic (black) or Galvanic (grey).

> ⓘ *The instrument's Sensor Type must be configured for the sensor installed. Failure to do this may result in damage not covered under warranty. If you observe readings very close to 0 or extremely high readings, i.e. 600%, the Sensor Type setting may be incorrect.*

Use the up or down arrow keys to highlight Sensor Type, then press enter to open a submenu. Highlight the sensor type corresponding to the sensor installed on the cable and press enter to confirm. The enabled sensor type will have an 'X' in the box next to it. Next, use the down arrow key to highlight the ESC – Exit, then press enter to save changes and to close the sensor submenu.

The Pro2030 has two compatible sensors for use with a field cable:

Polarographic – This sensor has a black sensor body and is engraved with the model number 2003. Polarographic will be abbreviated Polaro in the instrument.

Galvanic – This sensor has a grey sensor body and is engraved with the model number 2002.

In terms of physical configuration, membrane material and general performance, YSI Professional Series Galvanic dissolved oxygen sensors are exactly like the Professional Series Polarographic sensors. The advantage of using Galvanic sensors is convenience. Galvanic sensors provide an instant-on sensor without the need for warm-up time but this affects the life of the sensor. Polarographic sensors last longer and have a longer warranty but require a 5-15 minute warm-up time before use or calibration.

MEMBRANE TYPE

Membrane Type sets the type of membrane used on the dissolved oxygen sensor; either 1.25 PE (Yellow) or 2.0 PE (blue). Use the up or down arrow keys to highlight Membrane Type and press enter to open the membrane submenu. Highlight the membrane type corresponding to the membrane installed on the sensor and press enter to confirm. The enabled membrane type will have an 'X' in the box next to it. Use the down arrow key to highlight the ESC – Exit box along the bottom of the display and press enter to save changes and to close the membrane submenu.

The dissolved oxygen sensor is supplied with membranes specific to the sensor type and are color coded as described in the following tables.

Galvanic Membrane Kits:

Item	*Color*	*Material*	*Description*
5913	Yellow	1.25 mil polyethylene (PE)	Faster response time and less flow dependence than traditional Teflon® membranes.
5914	Blue	2.0 mil polyethylene (PE)	Less flow dependence than 1.25 mil membrane but somewhat slower response.

Polarographic Membrane Kits:

Item	*Color*	*Material*	*Description*
5908	Yellow	1.25 mil polyethylene (PE)	Faster response time and less flow dependence than traditional Teflon® membranes.
5909	Blue	2.0 mil polyethylene (PE)	Less flow dependence than 1.25 mil membrane but somewhat slower response.

Selecting a Dissolved Oxygen Membrane:

Membrane Type	*Flow Dependence After 4 Minutes*	*Required Sample Movement*	*Typical Response Time (T-95)*
5913, 5908 Yellow	*25%*	*6 inches/second*	*8 seconds*
5914, 5909 Blue	*18%*	*3 inches/second*	*17 seconds*

AUTO STABLE

Auto Stable utilizes preset values to indicate when a reading is stable. The preset values are adjustable in the System Setup menu. The user can input a % change in readings (0.0 to 1.9) over 'x' amount of time in seconds (3-19). There are two separate Auto Stable controls, one for dissolved oxygen readings (DO Auto Stable) and one for conductivity readings (Cond. Auto Stable).

Highlight either DO Auto Stable or Cond. Auto Stable, then press enter to open the submenu.

Use the up or down arrow keys to highlight the % change or seconds (secs) input field, then press enter to make the highlighted field adjustable. Use the up or down arrow keys to adjust the selected value, then press enter to confirm changes. Once you have confirmed any changes, highlight the ESC-Exit box along the bottom of the display and press enter to close the Auto Stable submenu.

To disable Auto Stable, set the % Change input to 0.0.

When Auto Stable is enabled, an (AS) symbol will display next to the reading on the Run screen and blink during stabilization. When the dissolved oxygen and/or conductivity reading stabilizes based on the Auto Stable settings, the (AS) symbol will display steadily and the instrument will beep twice if Audio is turned on.

DO UNITS

Highlight DO Units and press enter to open a submenu that allows you to select the dissolved oxygen units to be displayed on the Run screen. Highlight a unit and press enter to enable or disable it. An enabled dissolved oxygen unit will have an 'X' in the box next to it. Highlight the ESC-Exit box along the bottom of the display and press enter to save any changes and to close the DO units submenu.

There are three options for displaying dissolved oxygen:

- mg/L will show DO readings in milligrams per liter on a scale from 0 to 50 mg/L.
- ppm (parts per million) is equivalent to mg/L and will show the DO reading on a scale from 0 to 50 ppm.
- % will show DO readings in a % saturation from 0 to 500%. This value will be expressed as %L when DO Local% is enabled.

mg/L and ppm cannot be enabled and therefore displayed at the same time. DO% and mg/L *or* ppm can be enabled and displayed simultaneously.

CONDUCTIVITY UNITS (COND. UNITS)

Highlight Cond. Units (Conductivity Units) and press enter to open a submenu that allows you to select the conductivity units to be displayed on the Run screen. Highlight a unit and press enter to enable or disable it. An enabled conductivity unit will have an 'X' in the box next to it. Highlight the ESC-Exit box along the bottom of the display and press enter to save any changes and to close the conductivity units submenu.

There are seven options for displaying conductivity. Only two units can be enabled at the same time:

- COND-mS/cm displays conductivity in milliSiemens per centimeter.
- COND-uS/cm displays conductivity in microSiemens per centimeter.
- SPC-mS/cm displays Specific Conductance in milliSiemens per centimeter. Specific Conductance is temperature compensated conductivity.
- SPC-uS/cm displays Specific Conductance in microSiemens per centimeter. Specific Conductance is temperature compensated conductivity.
- Sal ppt displays salinity in parts per thousand. The salinity reading is calculated from the instrument's conductivity and temperature values using algorithms found in *Standard Methods for the Examination of Water and Wastewater*.

- TDS g/L displays Total Dissolved Solids in grams per liter. TDS is calculated from conductivity and temperature using a user-selectable TDS constant.
- TDS mg/L displays Total Dissolved Solids in milligrams per liter. TDS is calculated from conductivity and temperature using a user-selectable TDS constant.

Note: 1 milliSiemen = 1,000 microSiemens.

SPECIFIC CONDUCTANCE

The conductivity of a sample is highly dependent on temperature, varying as much as 3% for each change of one degree Celsius (temperature coefficient = 3%/°C). In addition, the temperature coefficient itself varies with the nature of the ionic species present in the sample. Therefore, it is useful to compensate for this temperature dependence in order to quickly compare conductivity readings taken at different temperatures.

The Pro2030 can display non-temperature compensated conductivity as well as temperature compensated Specific Conductance. If Specific Conductance is selected, the Pro2030 uses the temperature and conductivity values associated with each measurement to calculate a specific conductance value compensated to a user selected reference temperature, see below. Additionally, the user can select the temperature coefficient from 0% to 4%.

Using the Pro2030's default reference temperature and temperature coefficient (25 °C and 1.91%), the calculation is carried out as follows:

$$\text{Specific Conductance (25°C)} = \frac{\text{Conductivity of sample}}{1 + 0.0191 * (T - 25)}$$

T = Temperature of the sample in °C

SPECIFIC CONDUCTANCE REFERENCE TEMPERATURE (SPC REF. TEMP.)

SPC Ref. Temp. (Specific Conductance Reference Temperature) is the reference temperature used to calculate Specific Conductance. The reference temperature range is 15 and 25 °C. The default value is 25 °C.

To change the reference temperature, highlight SPC Ref. Temp. and press enter to open the submenu. With the reference temperature highlighted, press enter to make the field adjustable. Next, use the up or down arrow key to increase or decrease the value. Press enter to save the new reference temperature. Next, highlight the ESC-Exit box and press enter to close the submenu.

SPECIFIC CONDUCTANCE TEMPERATURE COEFFICIENT (SPC %/°C)

SPC %/°C (Specific Conductance Temperature Coefficient) is the temperature coefficient used to calculate Specific Conductance. The coefficient range is 0.00 to 4.00. The default value is 1.91% which is based on KCl standards.

To change the temperature coefficient, highlight SPC %/°C and press enter to open the submenu. With the temperature coefficient highlighted, press enter to make the field adjustable. Next, use the up or down arrow key to increase or decrease the value. Press enter to save the new coefficient. Next, highlight the ESC-Exit box and press enter to close the submenu.

TDS CONSTANT

TDS Constant is a multiplier used to calculate an estimated TDS (Total Dissolved Solids) value from conductivity. The multiplier is used to convert Specific Conductance in mS/cm to TDS in g/L. The Pro2030's default value is 0.65. This multiplier is highly dependent on the nature of the ionic species present in the water sample. To be assured of moderate accuracy for the conversion, you must determine a multiplier for the water at your sampling site. Use the following procedure to determine the multiplier for a specific sample:

1. Determine the specific conductance of a water sample from the site;
2. Filter a sample of water from the site;
3. Completely evaporate the water from a carefully measured volume of the filtered sample to yield a dry solid;
4. Accurately weigh the remaining solid;
5. Divide the weight of the solid (in grams) by the volume of water used (in liters) to yield the TDS value in g/L for this site;
6. Divide the TDS value in g/L by the specific conductance of the water in mS/cm to yield the conversion multiplier. Be certain to use the correct units.

If the nature of the ionic species at the site changes between sampling studies, the TDS values will be in error. TDS cannot be calculated accurately from specific conductance unless the make-up of the chemical species in the water remains constant.

To change the TDS Constant in the Pro2030, highlight TDS Constant and press enter to open the submenu. With the TDS Constant highlighted, press enter to make the field adjustable. Next, use the up or down arrow key to increase or decrease the value. The input range is 0.30 to 1.00. Press enter to save the new TDS Constant. Next, highlight the ESC-Exit box and press enter to close the submenu.

TEMPERATURE UNITS

Highlight Temperature Units and press enter to open a submenu that allows you to change the temperature units displayed on the Run screen. Highlight the desired unit (Celsius or Fahrenheit) and press enter to enable. The enabled temperature unit will have an 'X' in the box next to it. Only one unit may be enabled at a time. Highlight the ESC-Exit box and press enter to save any changes and to close the Temperature Units submenu.

PRESSURE UNITS

Highlight Pressure Units and press enter to open a submenu that allows you to change the barometric pressure units displayed on the Run screen. Highlight the desired unit (mmHg, inHg, mbar, psi, or kPa) and press enter to enable. The enabled pressure unit will have an 'X' in the box next to it. Only one unit may be enabled at a time. Highlight the ESC-Exit box and press enter to save any changes and to close the Pressure Units submenu.

LANGUAGE

Highlight Language and press enter to open a submenu that allows you to change the language. Highlight the desired language (English, Spanish, German, or French) and press enter to enable. The enabled language will have an 'X' in the box next to it. Highlight ESC-Exit box and press enter to save any changes and to close the Language submenu.

The text in the boxes along the bottom of the Run screen will always be displayed in English regardless of the language enabled in the System Setup menu.

AUTO SHUTOFF

Auto Shutoff allows you to set the instrument to turn off automatically after a period of time. Use the up or down arrow keys to highlight Auto Shutoff, then press enter to open the submenu. Press enter while the minute field is highlighted to make it adjustable. Next, use the up or down arrow keys to adjust the shut off time from 0 to 60 minutes. Press enter to save the new shutoff time. Next, highlight the ESC-Exit box and press enter to close the submenu.

To disable Auto Shutoff, set the Time in Minutes to 0 (zero).

RESETTING THE SYSTEM SETUP MENU TO FACTORY DEFAULT

To reset the Pro2030 settings to factory default, press the down arrow key while in the System Setup menu until the Reset - ↺ box is highlighted, then press enter. The instrument will ask you to confirm the reset. Highlight Yes and press enter to continue with the reset or highlight No and press enter to cancel the reset. A Factory Reset will not affect data saved in the instrument's memory.

The following will be set in the Pro2030 after performing a reset:

Parameter	*Reset Defaults*
DO Local%	Off
LDS (Last Digit Suppression)	Off
Quick DO Cal	Off
Audio	On
Contrast	Set to mid range
Dissolved Oxygen Sensor Type	Last Setting Confirmed
Dissolved Oxygen Membrane Type	Last Setting Confirmed
Dissolved Oxygen Auto Stable	Off (0.0 % Change and 10 seconds)
Dissolved Oxygen Units	mg/L and %
Conductivity Units	cond mS/cm and spc mS/cm
Conductivity Auto Stable	Off (0.0 % Change and 10 seconds)
SPC Reference Temperature	25°C
SPC Temperature Coefficient	1.91%/°C
TDS Constant	0.65
Temperature Units	°C
Pressure Units	mmHg
Language	English
Auto Shutoff	30 minutes
Dissolved Oxygen Calibration	Reset to 100% for enabled membrane and sensor.
Conductivity Calibration	Cell constant reset to 5.0
Barometer Calibration	Reset to factory default*

*It is recommended to perform a barometer and dissolved oxygen calibration after performing a reset.

CALIBRATION

TEMPERATURE

All Pro2030 cables have built-in temperature sensors. Temperature calibration is not required nor is it available.

BAROMETER

The barometer in the Pro2030 is calibrated at the factory. The barometer reading must be accurate to ensure accurate DO% calibrations and readings. If the barometer requires an adjustment, use the up or down arrow keys to highlight the barometer box along the bottom of the Run screen, then press enter. Next, use the up or down arrow keys to adjust the barometer reading to the local, true barometric pressure. Continually depress the up or down arrow key to change the barometer value more rapidly. Press enter to confirm and save the barometer adjustment.

> ⓘ *Do not use a barometer value that is corrected to sea level. Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for barometer calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". An approximate formula for this "uncorrection" is:*
>
> True BP = [Corrected BP] – [2.5 * (Local Altitude in ft above sea level/100)]

Although the Pro2030 barometer range is 400.0 to 999.9 mmHg, you will be unable to adjust the value across the entire range. The barometer is very accurate and the instrument will not allow you to adjust the value drastically beyond what it is measuring.

DISSOLVED OXYGEN

The dissolved oxygen sensor can be easily calibrated with the press of two or three keys by enabling Quick DO Cal in the System Setup menu and following the Quick DO Calibration procedure.

Ensure the barometer is reading accurately before performing a Quick DO Cal, DO% or DO Local% calibration because these calibration procedures use the barometer reading during calibration. If the barometer reading is erroneous during a calibration, the dissolved oxygen measurements will be inaccurate.

> *It is not necessary to calibrate in both % and mg/L or ppm. Calibrating in % will simultaneously calibrate mg/L and ppm and vice versa. YSI recommends calibrating the dissolved oxygen sensor in % for both ease and accuracy.*

QUICK DO CALIBRATION

Perform this calibration procedure when Quick DO Calibration is enabled in the System Setup menu.

1. Ensure the DO sensor has a good membrane with electrolyte installed. A good membrane is free of wrinkles, tears, fouling and air bubbles. Install the sensor guard onto the probe.
2. Moisten the sponge in the grey calibration/storage sleeve with a small amount of clean water and install it over the sensor guard. The sponge should only be moistened and the calibration/storage sleeve should not have excess water in it that could cause water droplets to get on the membrane. The storage sleeve ensures venting to the atmosphere.
3. Power the instrument on and, if using a Polarographic sensor, wait approximately 5 to 15 minutes for the storage chamber to become completely saturated and for the sensor to stabilize. If using a Galvanic sensor, wait approximately 5 to 10 minutes for the chamber to become completely saturated. Auto Shutoff should be disabled or set to at least 20 minutes. See System Setup menu for more information on adjusting the Auto Shutoff.
4. Ensure the barometer is reading accurately. If necessary, perform a barometer calibration.
5. Press and hold the Calibrate key for 3 seconds. Using the up or down arrow key, highlight Dissolved Oxygen and press enter. The Pro2030 will indicate 'Calibrating %DO' on the display. The instrument will automatically calibrate the sensor to the current barometric pressure. If DO Local% is enabled, the sensor will calibrate to 100%. This may take up to 2 minutes depending on the age of the sensor and membrane. You can press the Cal key at this time to cancel the calibration.
6. 'Calibration Successful' will display for a few seconds to indicate a successful calibration and then the instrument will return to the Run screen.
7. If the calibration is unsuccessful, an error message will display on the screen. Press the Cal key to exit the error message and return to the Run screen. See the Troubleshooting guide for possible solutions.

CALIBRATING IN PERCENT (DO%)

Perform this calibration procedure when Quick DO Cal is disabled in the System Setup menu.

1. Perform steps 1-4 of the Quick DO Calibration procedure.
2. Press and hold the Calibrate key for 3 seconds. Highlight Dissolved Oxygen and press enter. Next, highlight % and press enter.
3. The Pro2030 will display the current DO% and temperature readings along with the % calibration value. The % calibration value is based on the barometer reading.
4. Wait at least 3 seconds, then, once the DO% and temperature readings are stable, press enter to complete the calibration. Or, press the Cal key to cancel the calibration.
5. 'Calibration Successful' will display for a few seconds to indicate a successful calibration and then the instrument will return to the Run screen.
6. If the calibration is unsuccessful, an error message will display on the screen. Press the Cal key to exit the calibration error message and return to the Run screen. See the Troubleshooting guide for possible solutions.

CALIBRATING IN PERCENT (DO LOCAL% ENABLED)

Perform this calibration procedure when DO Local% is enabled in the System Setup menu.

1. Perform steps 1-4 of the Quick DO Calibration procedure.
2. Press and hold the Cal key for 3 seconds. Highlight Dissolved Oxygen and press enter.
3. %Local will automatically be highlighted, press enter. The Pro2030 will display the current DO% and temperature readings along with the % calibration value. The % calibration value will always be 100% for DO Local%.
4. Wait at least 3 seconds, then, once the DO% and temperature readings stabilize, press enter to complete the calibration. Or, press the Cal key to cancel the calibration.
5. 'Calibration Successful' will display for a few seconds to indicate a successful calibration and then the instrument will return to the Run screen.
6. If the calibration is unsuccessful, an error message will display on the screen. Press the Cal key to exit the calibration error message and return to the Run screen. See the Troubleshooting guide for possible solutions.

CALIBRATING IN MG/L OR PPM

1. Power the instrument on and place the sensor into a sample that has been titrated to determine the dissolved oxygen concentration. The sample should cover the two holes of the conductivity sensor that are located near the cable, see figure 8. During the calibration, continuously stir or move the probe through the sample at a rate of at least 6 inches (15.5 cm) per second if using a yellow membrane or at least 3 inches (7.7 cm) per second if using a blue membrane. A stir plate may be helpful for this calibration procedure.
2. Allow the dissolved oxygen and temperature readings to stabilize. This may take 5 to 15 minutes, depending on the type and condition of the sensor.
3. Press the Cal key. Highlight Dissolved Oxygen and press enter.
4. Highlight mg/L or ppm depending on what is enabled in the System Setup menu and press enter.
5. Use the up and down arrow keys to adjust the mg/L (ppm) reading to the value of the titrated sample. Press enter to confirm the value and complete the calibration or press the Cal key to cancel the calibration.
6. 'Calibration Successful' will display for a few seconds to indicate a successful calibration and then the instrument will return to the Run screen.
7. If the calibration is unsuccessful, an error message will display on the screen. Press the Cal key to exit the calibration error message and return to the Run screen. See the Troubleshooting guide for possible solutions.

CONDUCTIVITY CALIBRATION

Ensure the conductivity sensor is clean and dry before performing a conductivity, specific conductance or salinity calibration.

> ⓘ *It is not necessary to calibrate conductivity, specific conductance and salinity. Calibrating one of these parameters will simultaneously calibrate the others. YSI recommends calibrating specific conductance for greatest ease.*

CALIBRATING SPECIFIC (SP.) CONDUCTANCE OR CONDUCTIVITY

Note: When calibrating Specific Conductance, the Pro2030 uses the factory default values for the Specific Conductance Reference Temperature and the Specific Conductance Temperature Coefficient regardless of what is configured in the System Setup Menu. The default value for the Reference Temperature is 25°C

and the default value for the Temperature Coefficient is 1.91%/°C. It is important to note that the Temperature Coefficient of a calibration solution is dependent on the contents of the solution. Therefore, YSI recommends using a traceable calibration solution made of KCl (potassium chloride) when calibrating Specific Conductance since these solutions typically have a Temperature Coefficient of 1.91%/°C. Additionally, be sure to enter the value of the solution as it is listed for 25°C when calibrating Specific Conductance.

1. Fill a clean container (i.e. plastic cup or glass beaker) with fresh, traceable conductivity calibration solution and place the sensor into the solution. The solution must cover the holes of the conductivity sensor that are closest to the cable (figure 8). Ensure the entire conductivity sensor is submerged in the solution or the instrument will read approximately half the expected value. Gently move the probe up and down to remove any air bubbles from the conductivity sensor.

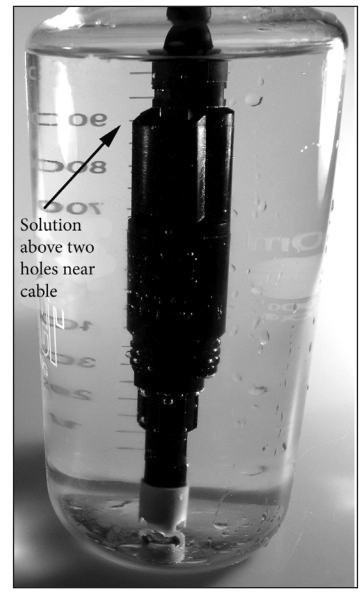


Figure 8, solution above two holes near cable.

2. Turn the instrument on and allow the conductivity and temperature readings to stabilize. Press the Cal key. Highlight Conductivity and press enter. Next, highlight the desired calibration method, Sp. Conductance or Conductivity, and press enter.
3. Highlight the units you wish to calibrate, either uS/cm or mS/cm, and press enter. 1 mS = 1,000 uS. Next, use the up or down arrow key to adjust the value on the display to match the value of the conductivity calibration solution. If calibrating conductivity, it is necessary to look

up the value of the solution at the current temperature and enter that value into the Pro2030. Most conductivity solutions are labeled with a value at 25°C. If calibrating specific conductance, enter the value listed for 25°C. Depressing either the up or down arrow key for 5 seconds will move the changing digit one place to the left. The Pro2030 will remember the entered calibration value and display it the next time a conductivity calibration is performed.

4. Press enter to complete the calibration. Or, press Cal to cancel the calibration and return to the Run screen.
5. 'Calibration Successful' will display for a few seconds to indicate a successful calibration and then the instrument will return to the Run screen.
6. If the calibration is unsuccessful, an error message will display on the screen. Press the Cal key to exit the calibration error message and return to the Run screen. See the Troubleshooting guide for possible solutions.

CALIBRATING IN SALINITY

1. Fill a clean container (i.e. plastic cup or glass beaker) with fresh, traceable salinity calibration solution and place the sensor into the solution. The solution must cover the holes of the conductivity sensor that are closest to the cable (figure 8). Ensure the entire conductivity sensor is submerged in the solution or the instrument will read approximately half the expected value. Gently move the probe up and down to remove any air bubbles from the conductivity sensor.
2. Turn the instrument on and allow the conductivity and temperature readings to stabilize. Press the Cal key. Highlight Conductivity and press enter. Next, highlight Salinity and press enter.
3. Use the up or down arrow key to adjust the value on the display to match the value of the salinity solution. Depressing either the up or down arrow key for 5 seconds will move the changing digit one place to the left. The Pro2030 will remember the entered calibration value and display it the next time a salinity calibration is performed.
4. Press enter to complete the calibration. Or, press Cal to cancel the calibration and return to the Run screen.
5. 'Calibration Successful' will display for a few seconds to indicate a successful calibration and then the instrument will return to the Run screen.
6. If the calibration is unsuccessful, an error message will display on the screen. Press the Cal key to exit the calibration error message and return to the Run screen. See the Troubleshooting guide for possible solutions.

TAKING MEASUREMENTS

Before taking measurements, be sure the instrument has been calibrated to ensure the most accurate readings. Turn the instrument on and wait 5-15 minutes if using a polarographic sensor. Install the sensor guard to protect the sensor and membrane. Place the probe in the sample to be measured and give the probe a quick shake to release any air bubbles. Be sure the conductivity sensor is completely submerged in the sample. The two holes near the cable should be covered by the sample for accurate conductivity readings (figure 8).

Allow the temperature readings to stabilize. Next, stir the probe in the sample to overcome the stirring dependence of the dissolved oxygen sensor. The dissolved oxygen sensor requires at least 6 inches (16 cm) per second of water movement if using the yellow membrane and 3 inches (7.62 cm) per second of water movement if using the blue membrane. The required sample movement can be achieved by the natural flow of the stream, physically stirring the probe in the sample or a combination of the two. Once the values plateau and stabilize you may record the measurement and/or store the data set. The dissolved oxygen reading will drop over time if stirring or movement is ceased. If placing the DO sensor into a stream or fast flowing waters it is best to place it perpendicular to the flow and not facing into the flow.

If using the DO sensor near an aeration device, it is helpful to make sure air bubbles do not burst on the membrane since that may cause unstable DO readings. You should be able to prevent this by pointing the sensor upwards so it's facing the sky and twist tying, zip tying or rubber banding the bulkhead to the cable. Essentially, making a simple curve to the cable without bending or breaking the cable will allow you to lower the sensor into the aerated sample while the sensor points skyward and air bubbles are no longer bursting on the membrane surface.

SAVING AND VIEWING DATA

The Pro2030 can store 50 data sets in non-volatile memory for later viewing. A data set includes the values currently on the display, i.e. temperature, dissolved oxygen and two conductivity parameters. Each data point is referenced with a data set number, 01 through 50.

SAVING DATA

> ⓘ *The Pro2030 can not communicate to a PC via a Pro Series communications saddle. Connecting the Pro2030 to a communication saddle may cause erratic instrument behavior.*

From the Run screen, use the up or down arrow keys to highlight the Save box and press enter to save the current readings. The instrument will indicate the data set is saved and display the saved data set's number (figure 9).

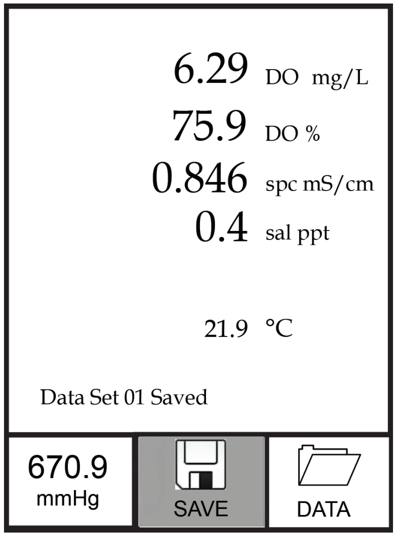


Figure 9, data set saved.

The instrument will display 'Memory Full' if all 50 data sets have been saved and you attempt to save another data set.

VIEWING AND ERASING SAVED DATA - DATA MODE

Data mode allows you to view and erase saved data. From the Run screen, use the up or down arrow keys to highlight Data and press enter to access Data mode. Note that the function boxes at the bottom of the display are different in Data mode (figure 10).

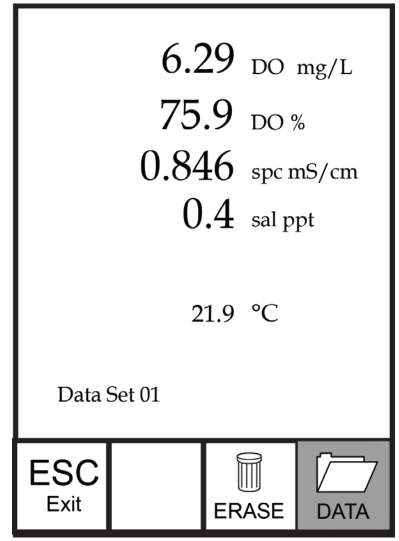


Figure 10, Data mode.

VIEWING DATA

Once in Data mode, use the up and down arrow keys to view saved data sets in sequential order or press enter to access the bottom functions. After accessing the bottom functions, highlight the Data box and press enter to regain access to viewing data. The data set displayed is indicated by the data set number, 01 through 50.

ERASING DATA

While viewing saved data, press the enter key to access the function boxes at the bottom of the display. Next, use the up or down arrow keys to highlight Erase, then press enter. The instrument will give you the option to erase one data set or all data sets (figure 11).

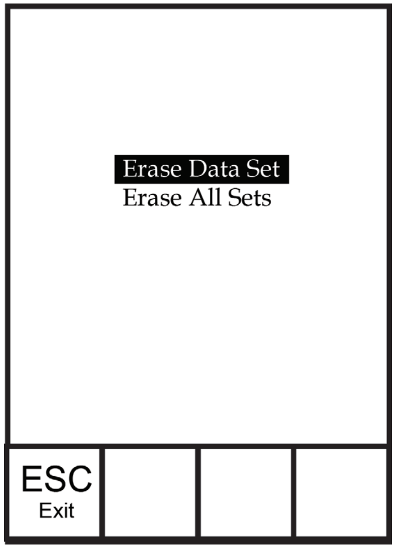


Figure 11, Erase data mode.

Use the up or down arrow key to select Erase Data Set, Erase All Sets or the ESC-Exit function box, then press enter to confirm.

Select ESC-Exit and press enter to exit Erase mode without erasing any data.

Select Erase Data Set and press enter to erase the data set that was displayed before entering Erase mode. For example, if data set 12 was displayed before entering erase mode, and Erase Data Set is selected, Data Set 12 will be erased from memory and the data sets AFTER that number will move up to keep them sequential. For example, if there are15 records and number 12 is erased then 13 becomes 12, 14 becomes 13, and 15 becomes 14. The instrument will return to Data mode after erasing one data set.
Select Erase All Data Sets and press enter to clear the Pro2030 memory and return to Data mode.

EXITING DATA MODE

While in Data mode, press enter to access the bottom functions. Next, highlight the ESC-Exit box and press enter to return to the Run screen.

CARE, MAINTENANCE AND STORAGE

This section describes the proper procedures for care, maintenance and storage of the sensors. The goal is to maximize their lifetime and minimize down-time associated with improper sensor usage.

GENERAL MAINTENANCE

GENERAL MAINTENANCE - GASKET AND O-RINGS

The instrument utilizes a gasket and o-rings as seals to prevent water from entering the battery compartment and the sensor port. Following the recommended procedures will help keep the instrument functioning properly.

If the gasket, o-rings and sealing surfaces are not maintained properly, it is possible that water can enter the battery compartment and/or sensor port of the instrument. If water enters these areas, it can severely damage the battery terminals or sensor port causing loss of battery power, false readings and corrosion to the sensors or battery terminals. Therefore, when the battery compartment lid is removed, the gasket that provides the seal should be carefully inspected for contamination (i.e. debris, grit, etc.) and cleaned with water and mild detergent if necessary.

The same inspection should be made of the o-rings associated with the dissolved oxygen sensor connector if and when the DO sensor is removed. If no dirt or damage to the o-rings is evident, then they should be lightly greased with the o-ring grease provided without removing them from their groove. However, if there is any indication of damage, the sensor o-ring should be replaced with an identical o-ring.

To remove the DO sensor o-rings:
Use a small, flat-bladed screwdriver or similar blunt-tipped tool to remove the o-ring from its groove near the sensor connector. Check the o-ring and the groove for any excess grease or contamination. If contamination is evident, clean the o-ring and nearby plastic parts with lens cleaning tissue or equivalent lint-free cloth. Alcohol can be used to clean the plastic parts, but use only water and mild detergent on the o-ring itself. Also, inspect the o-rings for nicks and imperfections.

> ⓘ *Using alcohol on o-rings may cause a loss of elasticity and may promote cracking. Do not use a sharp object to remove the o-rings. Damage to the o-ring or the groove may result.*

Before re-installing the DO sensor o-rings, make sure to use a clean workspace, clean hands and avoid contact with anything that may leave fibers on the o-ring or grooves. Even a very small amount of contamination (hair, grit, etc.) may create a path for water intrusion or contamination.

To re-install the DO sensor o-rings:
Place a small amount of o-ring grease between your thumb and index finger. (More grease is not better!)

Draw the o-ring through the grease while pressing the fingers together to place a very light covering of grease on the o-ring. Place the o-ring into its groove ensuring that it does not twist or roll.

Use the previously grease-coated finger to once again lightly go over the surface of the o-ring.

ⓘ *Do not over-grease the o-rings. The excess grease may collect grit particles that can compromise the seal. Excess grease can also cause the waterproofing capabilities of the o-ring to diminish, potentially causing leaks. If excess grease is present, remove it using a lens cloth or lint-free cloth.*

GENERAL MAINTENANCE - DO SENSOR PORT

It is important that the entire sensor connector end be dry when installing, removing or replacing the sensor. This will prevent water from entering the port. Once the DO sensor is removed, examine the connector inside the port. If any moisture is present, use compressed air to completely dry the connector or let it air dry. If the connector is corroded, contact YSI Technical Support or the YSI authorized dealer where you purchased the instrument.

ⓘ *Remove sensors upside down (facing the ground) to help prevent water from entering the port upon removal.*

SENSOR MAINTENANCE

SENSOR MAINTENANCE - TEMPERATURE

You must keep the temperature sensor free of build up. Other than that, no additional maintenance is required. A toothbrush can be used to scrub the temperature sensor if needed.

SENSOR MAINTENANCE - CONDUCTIVITY

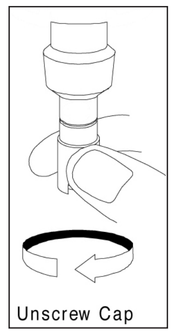
The openings that allow sample access to the conductivity electrodes should be cleaned regularly. The small cleaning brush included in the Maintenance Kit is intended for this purpose. Dip the brush in clean water and insert it into each hole 10 to 12 times. In the event that deposits have formed on the electrodes, it may be necessary to use a mild detergent (laboratory grade soap or bathroom foaming tile cleaner) with the brush. Rinse thoroughly with clean water, then check the response and accuracy of the conductivity cell with a calibration solution.

SENSOR MAINTENANCE - DISSOLVED OXYGEN

Membrane Cap Installation

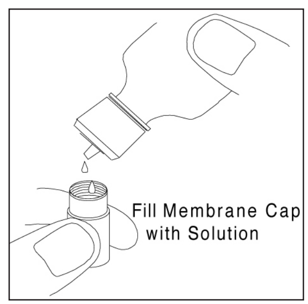
The DO sensor (Polarographic or Galvanic) is shipped with a protective red cap that needs to be removed before using. Remove the red protective cap or used cap membrane and replace it with a new cap membrane following these instructions:

Remove the sensor guard to access the sensor.



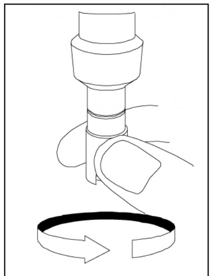
Remove the protective red cap by pulling it straight off the sensor. Or, unscrew and remove the used cap membrane by holding the sensor while unscrewing the cap membrane. Discard the used cap membrane.

Thoroughly rinse the sensor tip with distilled or deionized water.



Fill a new cap membrane 3/4 full with electrolyte solution that has been prepared according to the directions on the bottle. Be very careful not to touch the membrane surface.

Lightly tap the side of the cap membrane to release bubbles that may be trapped.



Thread the cap membrane onto the sensor. It is normal for a small amount of electrolyte to overflow.

Replace the sensor guard.

Polarographic Sensors – Model # 605203

The cap membrane and KCl (potassium chloride) electrolyte solution should be changed every 2-4 weeks during regular use. In addition, the electrolyte solution and membrane should be changed if (a) bubbles are visible under the membrane; (b) significant deposits of dried electrolyte are visible on the membrane; and (c) if the sensor shows unstable readings or other sensor-related symptoms.

During membrane changes, examine the gold cathode at the tip of the sensor and the silver anode along the shaft of the sensor (figure 12). If either the silver anode is black in color or the gold cathode is dull, the sensor may need resurfaced using the 400 grit wet/dry sanding discs included in the membrane kit. Do not sand the electrode every membrane change as this is not routine maintenance. In fact, visually, the anode may appear tarnished and operate properly. YSI recommends using the sanding disc if the sensor has difficulty stabilizing or calibrating after a regular membrane change.

To clean and resurface the sensor, follow the instructions on the next page.

Gold Cathode

For correct sensor operation, the gold cathode (figure 12) must be textured properly. It can become tarnished or plated with silver after extended use. Never use chemicals or abrasives that have not been recommended or supplied by YSI.

First dry the sensor tip completely with lens cleaning tissue. Wet a sanding disc and place it face up in the palm of you hand. Next, with your free hand, hold the sensor in a vertical position, tip down. Place the sensor tip directly down on the sanding disc and twist it in a circular motion to sand the gold cathode. The goal is to sand off any build-up and to lightly scratch the cathode to provide a larger surface area for the electrolyte solution under the membrane. Usually, 3 to 4 twists of the sensor are sufficient to remove deposits and for the gold to appear to have a matte finish. Rinse the sensor thoroughly with distilled or deionized

water and wipe the gold cathode with a wet paper towel before putting on a new cap membrane. If the cathode remains tarnished, contact YSI Technical Support or the YSI authorized dealer where you purchased the instrument.

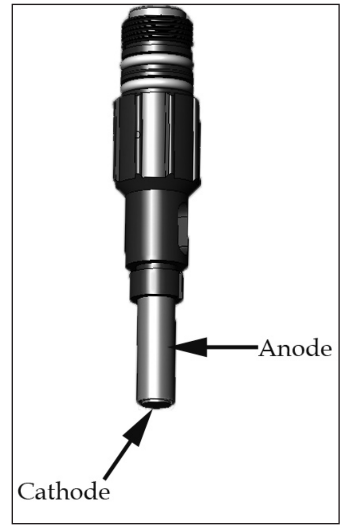


Figure 12, DO sensor with membrane removed.

Silver Anode

After extended use, a thick layer of Silver Chloride (AgCl) builds up on the silver anode (figure 12) reducing the sensitivity of the sensor. The anode must be cleaned to remove this layer and restore proper performance. The cleaning can be chemical and/or mechanical:

Mechanical cleaning: In order to sand the silver anode along the shaft of the sensor, simply hold the sensor in a vertical position. Wet the sanding disc and gently wrap it around the sensor and twist it a few times to lightly sand the anode (the goal is to simply sand off any build-up without scratching or removing layers of the anode itself). Usually, 3 to 4 twists of the sanding disc are sufficient to remove deposits.

After completing the sanding procedure, repeatedly rinse the electrode with distilled or deionized water and wipe with lens cleaning tissue to remove any grit left by the sanding disc. Thoroughly rinse the entire tip of the sensor with distilled or deionized water and install a new membrane.

> *IMPORTANT: Be sure to: (1) Use only the fine sanding discs provided and (2) Sand as mentioned in the above procedures. Not adhering to either of these instructions can damage the electrodes.*

Chemical cleaning: Remove the cap membrane and rinse the sensor with deionized or distilled water. Soak the sensing section of the sensor in a 14% ammonium hydroxide solution for 2 to 3 minutes or in a 3% ammonia solution overnight for 8-12 hours (most household ammonia cleaners are typically around 3%). Rinse heavily in cool tap water followed by a thorough rinsing with distilled or deionized water. The anode should then be thoroughly wiped with a wet paper towel to remove the residual layer from the anode. Trapping residual ammonia under the new membrane cap can quickly tarnish the electrode and/or give false readings and should therefore be avoided.

After performing a chemical cleaning on the polarographic sensor, lightly sand the cathode and anode following the mechanical cleaning procedures described previously.

> ⓘ *Chemical cleaning should be performed as infrequently as possible. First attempt a membrane change and recalibrate. If a new membrane does not resolve the problem, then proceed with cleaning.*

If this procedure is unsuccessful, as indicated by improper sensor performance, contact YSI Technical Support or the YSI authorized dealer where you purchased the instrument.

Galvanic Sensors – Model # 605202

YSI recommends that the Sodium Chloride (NaCl) electrolyte solution and cap membrane be changed every 2-4 weeks during regular use. In addition, the electrolyte solution and membrane should be changed if (a) bubbles are visible under the membrane; (b) significant deposits of dried electrolyte are visible around the membrane; and (c) if the sensor shows unstable readings or other sensor-related symptoms.

The Galvanic dissolved oxygen sensor is continuously reducing oxygen even when the instrument is turned off. This factor allows the sensor to be used with no warm-up period as soon as the instrument is powered on. However, because the sensor is "on" all the time, some solid from the oxidation of the zinc anode will form in the electrolyte within 1-2 weeks of activation. Small amounts of the solid will generally cause no performance problems, but excessive amounts may result in jumpy dissolved oxygen readings. The rate of solid formation is dependent on the type of membrane installed. The formation of solids typically form more rapidly with 5913 (1.25 mil PE) membrane, and less rapid with 5914 (2 mil PE) membranes.

> ⓘ *The Galvanic electrolyte solution will appear milky white after use but this will not affect the accuracy of the sensor unless there is excessive build up. The color change is acceptable and normal as long as DO readings remain stable.*

At the time the cap membrane is changed, YSI recommends that you rinse the anode and cathode (figure 12) with distilled or deionized water and wipe with a clean paper towel. If white deposits are evident on the anode after cleaning, YSI recommends that you remove this material by sanding the anode with the 400 grit wet/dry sanding disc included in the membrane kit following the "Mechanical Cleaning" instructions under the Polarographic Silver Anode maintenance section of this manual. If there are deposits on the cathode, sand the cathode with the 400 grit wet/dry sanding disc following the maintenance instructions listed in this manual for the Polarographic Gold Cathode.

> ⓘ *IMPORTANT: Be sure to: (1) Use only the fine sanding discs provided and (2) Sand as mentioned in the above procedures. Not adhering to either of these instructions can damage the electrodes.*
>
> *WARNING: Do not perform the Polarographic chemical cleaning on a Galvanic sensor.*

If this procedure is unsuccessful, as indicated by improper sensor performance, contact YSI Technical Support or the YSI authorized dealer where you purchased the instrument.

SENSOR STORAGE

SHORT TERM STORAGE

The instrument is supplied with a grey calibration/storage sleeve that slides over the probe guard. The sleeve is used for short-term storage (less than 30 days). Be sure to keep a small amount of moisture (clean tap water) on the sponge in the sleeve during storage. This is simply done to maintain a 100% water saturated air environment which is ideal for short-term sensor storage. The sensors should not be submerged in water.

LONG TERM STORAGE

The dissolved oxygen and conductivity sensors should be stored long term in a dry state. When storing for more then 30 days, remove the cap membrane and thoroughly rinse the dissolved oxygen sensor with distilled or deionized water. Once the sensor has been rinsed either blow it dry with compressed air or allow to air dry completely. Next, use a new clean, dry cap membrane to screw over the sensor. This will keep the sensor dry and protect the anode and cathode during storage. Ensure the conductivity sensor is clean and dry.

After storing for a long period of time, it is necessary to "condition" the dissolved oxygen sensor by installing a new membrane with electrolyte solution.

Long Term Storage Temperature: -5 to 70°C (23 to 158°F)

TROUBLESHOOTING

Symptom	*Possible Solution*
Instrument will not turn on, a battery symbol appears, or "Critical Shutdown" displays on the screen.	1. Low battery voltage, replace batteries. 2. Batteries installed incorrectly, check battery polarity. 3. Return system for service.
Barometer reads over/undr and calibrating Dissolved Oxygen results in a Barometric Pressure Over/Undr error message.	1. Barometer failure, return system for service
Temperature values display Over or Undr on Run screen.	1. Sample temperature is less than -5° C or more than +55°C. Increase or decrease the sample temperature to bring within the allowable range. 2. Contact YSI Tech Support.
Instrument will not calibrate dissolved oxygen; instrument displays "Calibration Over", "Calibration Under", or "Unstable Reading" during calibration.	1. Verify barometer reading. 2. Verify correct sensor and membrane type selection in the System Setup menu. 3. Calibration sleeve may not be 100% water saturated, ensure sponge is moistened. 4. Ensure adequate sample movement if performing mg/L or ppm calibration. 5. Allow sufficient stabilization time for dissolved oxygen and temperature AND wait at least 3 seconds before confirming a DO% or DO Local% calibration. 6. Replace membrane and electrolyte. 7. Clean sensor electrodes. 8. Contact YSI Tech Support.

Symptom	*Possible Solution*
DO readings are inaccurate.	1. Verify correct sensor/membrane type selection in the System Setup menu. 2. Verify conductivity readings are accurate. Conductivity is used in the calculation of mg/L. 3. Verify temperature readings are accurate. 4. Sample temperature should be between 0 and 45 °C, the temperature compensation range for DO mg/L. 5. DO sensor not properly calibrated, recalibrate the sensor. 6. Replace membrane and electrolyte. Recalibrate. 7. Clean sensor electrodes. 8. Contact YSI Tech Support.
Dissolved Oxygen values display Over or Undr on Run screen.	1. Verify correct sensor/membrane type selection in the System Setup menu. 2. If using a polarographic sensor, allow instrument to warm up for 5 – 15 minutes before use. 3. Sample dissolved oxygen concentration is more than 50 mg/L or 500%, or less than –0.02 mg/L or -0.3%. 4. Verify conductivity readings are accurate. 5. Verify temperature readings are accurate. 6. Replace membrane and electrolyte. Recalibrate. 7. Clean sensor electrodes. 8. Contact YSI Tech Support.

Symptom	*Possible Solution*
Instrument will not calibrate the Conductivity sensor; instrument displays "Calibration Over", "Calibration Under", or "Unstable Reading" during calibration.	1. Ensure the conductivity sensor is clean. Follow the cleaning procedures in the Care, Maintenance and Storage section of this manual. 2. Verify the calibration solution is above the two holes near the cable, see figure 8. 3. Verify the calibration solution is not expired or contaminated. Try a new bottle of solution. 4. Ensure you are entering in the correct value for the solution according to the measurement units. 1 mS = 1,000 uS. 5. Allow sufficient stabilization time for conductivity and temperature AND wait at least 3 seconds before confirming a calibration. 6. Contact YSI Tech Support.
Conductivity readings are inaccurate.	1. Ensure the conductivity sensor is clean. Follow the cleaning procedures in the Care, Maintenance and Storage section of this manual. 2. Verify the sample is above the two holes near the cable, see figure 8. 3. Verify calibration. 4. Verify temperature readings are accurate. 5. Verify the correct units are setup in the System Setup menu, i.e. uS vs mS and Conductivity vs. Specific Conductance. 6. Contact YSI Tech Support.
Conductivity values display Over or Undr on Run screen.	1. Ensure the conductivity sensor is clean. Follow the cleaning procedures in the Care, Maintenance and Storage section of this manual. 2. Verify the sample is above the two holes near the cable, see figure 8 3. Verify calibration. 4. Verify temperature readings are accurate. 5. Sample conductivity is outside the measurement range of the instrument, i.e. 0-200 mS. 6. Contact YSI Tech Support.

SPECIFICATIONS

These specifications represent typical performance and are subject to change without notice. For the latest product specification information, please visit YSI's website at www.ysi.com or contact YSI Tech Support.

Parameter	*Range*	*Resolution*	*Accuracy*
Temperature	-5 to 55°C*	0.1°C	± 0.3°C
Dissolved Oxygen	0 to 200% air saturation	1% or 0.1%, user selectable	± 2% of the reading or ± 2% air saturation, whichever is greater
	200 to 500% air saturation	1% or 0.1%, user selectable	± 6% of the reading
	0 to 20 mg/L	0.1 or 0.01 mg/L, user selectable	±2% of the reading or ± 0.2 mg/L, whichever is greater
	20 to 50 mg/L	0.1 or 0.01 mg/L, user selectable	±6% of the reading
Conductivity	0-500 uS/cm 0-5 mS/cm 0-50 mS/cm 0-200 mS/cm (auto ranging)	0.0001 to 0.1 mS/cm; 0.1 to 0 uS/cm (range dependent)	Instrument only: ± 0.5% of the reading or 1 uS/cm, whichever is greater. Instrument with 1 or 4 meter cables: ± 1.0% of the reading or 1 uS/cm, whichever is greater. Instrument with 10, 20, or 30 meter cables: ± 2.0% of the reading or 1 uS/cm, whichever is greater.
Salinity	0 to 70 ppt	0.1 ppt	± 1.0% of the reading or ± 0.1 ppt, whichever is greater.
Total Dissolved Solids (TDS)	0 to 100 g/L. TDS Constant range: 0.3 to 1.00 (0.65 default)	0.0001 to 0.1 g/L (range dependent)	Dependent on accuracy of temperature, conductivity and TDS Constant.
Barometer	500.0 to 800.0 mmHg**	0.1 mmHg	±5 mmHg within 15°C of calibration temperature

* Automatic dissolved oxygen temperature compensation range is -0 to 45 °C
**Available barometer units include: mmHg, inHg, mbars, psi, or KPa

ACCESSORIES / PART NUMBERS

Part Number	*Description*
6052030	Pro2030 Instrument
6262030-1, -4, -10, -20, or -30	1, 4, 10, 20, 30-meter cable assembly*
605202	Galvanic Dissolved Oxygen Sensor
605203	Polarographic Dissolved Oxygen Sensor
603077	Flow cell
603056	Flow cell mounting spike
603075	Carrying case, soft-sided
603074	Carrying case, hard-sided
603069	Belt clip
063517	Ultra clamp for instrument
063507	Tripod for instrument
603062	Cable management kit, included with all cables longer then 1 meter.
605978	Cable weight, 4.9 oz, stackable
603070	Shoulder strap
605306	5908 membrane kit, yellow 1.25 polyethylene for polarographic sensors
605307	5909 membrane kit, blue 2.0 polyethylene for polarographic sensors
605913	5913 membrane kit, yellow 1.25 polyethylene for galvanic sensors
605914	5914 membrane kit, blue 2.0 polyethylene for galvanic sensors
060907	Conductivity Calibration Solution, 1,000 µS/cm. 1 box of 8 pints.
060911	Conductivity Calibration Solution, 10,000 µS/cm. 1 box of 8 pints.
060660	Conductivity Calibration Solution, 50,000 µS/cm. 1 box of 8 pints.
065274	Conductivity Calibration Solution, 100,000 µS/cm. 1 box of 8 pints.

*All cables include a temperature and conductivity sensor. The dissolved oxygen sensor is sold separately.

DECLARATION OF CONFORMITY

The undersigned hereby declares on behalf of the named manufacturer under our sole responsibility that the listed product conforms to the requirements for the listed European Council Directive(s) and carries the CE mark accordingly.

Manufacturer:	YSI Incorporated 1725 Brannum Lane Yellow Springs, OH 45387 USA
Product Name:	Pro2030 Water Quality Instrument
Model Numbers	
Instrument/Accessory:	Pro2030 (6052030)
Probe/Cable Assemblies:	6052030-1, -4, -10, -20, and -30
Conforms to the following:	
Directives:	IEC 61326-1:2005 RoHS 2002/95/EC WEEE 2002/96/EC
Harmonized Standards:	• EN61326-1:2006 (IEC 61326-1:2005) Emission & Immunity
Supplementary Information:	All performance met the operation criteria as follows: 1. ESD, IEC 61000-4-2:2001, Performance Criterion B 2. Radiated Immunity, IEC 61000-4-3, Performance Criterion A 3. Electrical Fast Transient (EFT), IEC 61000-4-4:2004, +Corr. 1:2006 + Corr. 2:2007, Performance Criterion B 4. Radio Frequency, Continuous Conducted Immunity, IEC61000-4-6, Performance Criterion A 5. RF Emissions, EN 61326-1:2006 (IEC61326-1:2005) Class B
Authorized EU Representative	YSI Hydrodata Ltd Unit 2 Focal Point, Lacerta Court, Works Road Letchworth, Hertfordshire, SG6 1FJ UK

Signed: Lisa M. Abel

Date: 07 July 2010

Title: Director of Quality

RECYCLING

YSI is committed to reducing the environmental footprint in the course of doing business. Even though materials reduction is the ultimate goal, we know there must be a concerted effort to responsibly deal with materials after they've served a long, productive life-cycle. YSI's recycling program ensures that old equipment is processed in an environmentally friendly way, reducing the amount of materials going to landfills.

- Printed Circuit Boards are sent to facilities that process and reclaim as much material for recycling as possible.
- Plastics enter a material recycling process and are not incinerated or sent to landfills.
- Batteries are removed and sent to battery recyclers for dedicated metals.

When the time comes for you to recycle, follow the easy steps outlined at www.ysi.com.

BATTERY DISPOSAL

The Pro2030 is powered by alkaline batteries which the user must remove and dispose of when the batteries no longer power the instrument. Disposal requirements vary by country and region, and users are expected to understand and follow the battery disposal requirements for their specific locale.

CONTACT INFORMATION

ORDERING AND TECHNICAL SUPPORT

Telephone: 800 897 4151 (USA)
+1 937 767 7241 (Globally)
Monday through Friday, 8:00 AM to 5:00 ET

Fax: +1 937 767 9353 (orders)
+1 937 767 1058 (technical support)

Email: environmental@ysi.com
Mail: YSI Incorporated
1725 Brannum Lane
Yellow Springs, OH 45387 USA

Internet: www.ysi.com

When placing an order please have the following available:
1.) YSI account number (if available)
2.) Name and phone number
3.) Purchase Order or Credit Card number
4.) Model Number or brief description
5.) Billing and shipping addresses
6.) Quantity

SERVICE INFORMATION

YSI has authorized service centers throughout the United States and Internationally. For the nearest service center information, please visit www.ysi.com and click 'Support' or contact YSI Technical Support directly at 800-897-4151 (+1 937-767-7241).

When returning a product for service, include the Product Return form with cleaning certification. The form must be completely filled out for a YSI Service Center to accept the instrument for service. The form may be downloaded from www.ysi.com by clicking on the 'Support'.

APPENDIX A-DO% CALIBRATION VALUES

Calibration Value	Pressure			
D.O. %	in Hg	mmHg	kPa	mbar
101%	30.22	767.6	102.34	1023.38
100%	29.92	760.0	101.33	1013.25
99%	29.62	752.4	100.31	1003.12
98%	29.32	744.8	99.30	992.99
97%	29.02	737.2	98.29	982.85
96%	28.72	729.6	97.27	972.72
95%	28.43	722.0	96.26	962.59
94%	28.13	714.4	95.25	952.46
93%	27.83	706.8	94.23	942.32
92%	27.53	699.2	93.22	932.19
91%	27.23	691.6	92.21	922.06
90%	26.93	684.0	91.19	911.93
89%	26.63	676.4	90.18	901.79
88%	26.33	668.8	89.17	891.66
87%	26.03	661.2	88.15	881.53
86%	25.73	653.6	87.14	871.40
85%	25.43	646.0	86.13	861.26
84%	25.13	638.4	85.11	851.13
83%	24.83	630.8	84.10	841.00
82%	24.54	623.2	83.09	830.87
81%	24.24	615.6	82.07	820.73
80%	23.94	608.0	81.06	810.60
79%	23.64	600.4	80.05	800.47
78%	23.34	592.8	79.03	790.34
77%	23.04	585.2	78.02	780.20
76%	22.74	577.6	77.01	770.07
75%	22.44	570.0	75.99	759.94
74%	22.14	562.4	74.98	749.81
73%	21.84	554.8	73.97	739.67
72%	21.54	547.2	72.95	729.54

APPENDIX B-OXYGEN SOLUBILITY TABLE

Solubility of Oxygen in mg/L in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure.
Salinity = Measure of quantity of dissolved salts in water.
Chlorinity = Measure of chloride content, by mass, of water.
S(0/00) = 1.80655 x Chlorinity (0/00)

Temp °C	Chlorinity : 0 Salinity: 0	5.0 ppt 9.0 ppt	10.0 ppt 18.1 ppt	15.0 ppt 27.1 ppt	20.0 ppt 36.1 ppt	25.0 ppt 45.2 ppt
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.72	6.39

Temp °C	Chlorinity : 0 Salinity: 0	5.0 ppt 9.0 ppt	10.0 ppt 18.1 ppt	15.0 ppt 27.1 ppt	20.0 ppt 36.1 ppt	25.0 ppt 45.2 ppt
26.0	8.11	7.71	7.33	6.96	6.62	6.28
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.93	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	6.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.98	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

Item # 605056
Rev C
Drawing # A605056
November 2010

Appendix E

HOBO® U24 Conductivity Logger (U24-001) Manual

The HOBO U24 conductivity logger measures actual conductivity and temperature, and can provide specific conductance at 25°C with the HOBOware® Conductivity Assistant. These easily deployable, rugged loggers provide the data you need for monitoring water purity and the impact of pollutants in fresh water. There is an optional U2X Protective Housing accessory (HOUSING-U2X) available to protect the logger and simplify mounting in harsh environments.

HOBO Conductivity Logger

U24-001

Included Item:

- Communications window protective cap

Required Items:

- Coupler (COUPLER2-C) with USB Optic Base Station (BASE-U-4) *or* HOBO Waterproof Shuttle (U-DTW-1)
- HOBOware Pro 3.2 or later with the Conductivity Assistant 2.1 or later

Accessories:

- U2X Protective Housing (HOUSING-U2X)
- Replacement communications window protective caps (U22-U24-CAP)

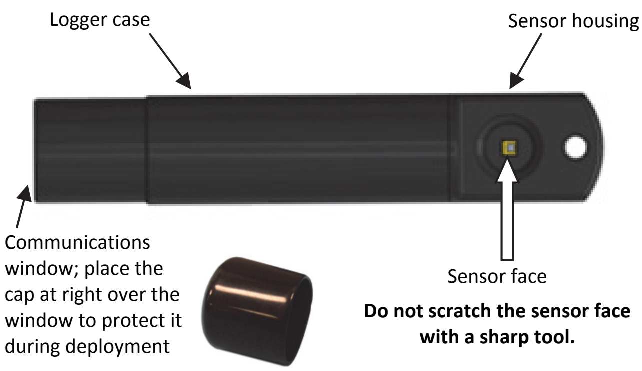
Specifications

Measurements	Actual Conductivity, Temperature, Specific Conductance at 25°C (calculated)
Conductivity Calibrated Measurement Ranges	Low Range: 0 to 1,000 µS/cm Full Range: 0 to 10,000 µS/cm
Conductivity Calibrated Range - Temperature Range	5° to 35°C (41° to 95°F)
Conductivity Extended Ranges	Low Range: 0 to 2,500 µS/cm Full Range: 0 to 15,000 µS/cm
Temperature Measurement Range	-2° to 36°C (28° to 97°F)
Specific Conductance Accuracy (in Calibrated Range)	Low Range: 3% of reading, or 5 µS/cm, and Full Range: 3% of reading, or 20 µS/cm, whichever is greater, using Conductivity Data Assistant and calibration measurements
Conductivity Resolution	1 µS/cm
Temperature Accuracy (in Calibrated Range)	0.1°C (0.2°F)
Temperature Resolution	0.01°C (0.02°F)
Conductivity Drift	Less than 3% sensor drift per year, exclusive of drift from fouling
Response Time	1 second to 90% of change (in water)
Operating Range	-2° to 36°C (28° to 97°F) - non-freezing
Memory	18,500 temperature and conductivity measurements when using one conductivity range; 14,400 sets of measurements when using both conductivity ranges (64 KB total memory)
Sample Rate	1 second to 18 hrs, fixed or multiple-rate sampling with up to 8 user-defined sampling intervals
Clock Accuracy	±1 minute per month
Battery	3.6 Volt lithium battery
Battery Life	3 years (at 1 minute logging)
Maximum Depth	70 m (225 ft)
Weight	193 g (6.82 oz), buoyancy in freshwater: -59.8 g (-2.11 oz)
Size	3.18 cm diameter x 16.5 cm, with 6.3 mm mounting hole (1.25 in. diameter x 6.5 in., 0.25 in. hole)
Wetted Housing Materials	Delrin®, epoxy, stainless steel retaining ring, polypropylene, Buna rubber O-ring, titanium pentoxide (inert coating over sensor)
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).

Protecting the Logger

IMPORTANT: This logger can be damaged by shock. Always handle the logger with care. The logger may be damaged if it is dropped. Use proper packaging when transporting or shipping the logger.

Do not attempt to open the logger case or sensor housing. Disassembling of the logger case or sensor housing will cause serious damage to the sensor and logger electronics. There are no user-serviceable parts inside the case. Contact Onset Technical Support at 1-800-LOGGERS (1-800-564-4377) or an authorized Onset dealer if your logger requires servicing.



Do not scratch the sensor face with a sharp tool.

Operation

An LED in the communications window of the logger confirms logger operation. When the logger is logging, the LED blinks once every one to four seconds (the shorter the logging interval, the faster the LED blinks). The LED also blinks when the logger is recording a sample. When the logger is awaiting a start because it was launched in “Start at Interval” or “Delayed Start” mode, the LED blinks once every eight seconds until logging begins.

The logger can record two types of data: samples and events. Samples are the sensor measurements recorded at each logging interval. Events are independent occurrences triggered by a logger activity, such as Bad Battery or Host Connected. Events help you determine what was happening while the logger was logging.

Communication

To connect the logger to a computer, use either the Optic USB Base Station (BASE-U-4) or HOBO Waterproof Shuttle (U-DTW-1) with a coupler (COUPLER2-C).

IMPORTANT: USB 2.0 specifications do not guarantee operation outside the range of 0°C (32°F) to 50°C (122°F).

To launch and read out the logger in the field, use one of these methods:

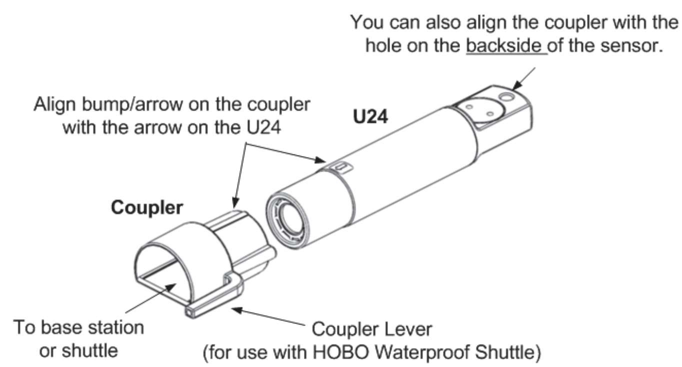
- Laptop computer with Optic USB Base Station (BASE-U-4) and a coupler (COUPLER2-C)
- HOBO Waterproof Shuttle (U-DTW-1, Firmware Version 3.2.0 or later) and a coupler (COUPLER2-C)
- HOBO U-Shuttle (U-DT-1, Firmware Version 1.14m030 or later) with Optic USB Base Station and coupler (COUPLER2-C)

The optical interface allows the logger to be offloaded without breaking the integrity of the seals. The USB compatibility allows for easy setup and fast downloads.

Connecting the Logger to a Computer or Waterproof Shuttle

1. Follow the instructions that came with your base station or Waterproof Shuttle to attach it to a USB port on the computer.
2. Attach the coupler to the base station or shuttle.
3. Wipe off any residue or slime from the area of the logger that will go into the coupler, including the communication window. This will help the logger slide in and out of the coupler more easily, and help with communication.
4. Insert the logger into the coupler, aligning the bump/arrow on the coupler with the arrow on the logger. Be sure that it is properly seated in the coupler. If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer.

   NOTE: If you are using the HOBO Waterproof Shuttle as a base station with a computer, briefly press the Coupler Lever to put the shuttle into base station mode.



WARNING: Do not leave the logger in the coupler for extended periods of time. When connected to a coupler, the logger is “awake” and consumes significantly more power than when it is disconnected and considered “asleep.” Always remove the logger from the Optic Base Station or HOBO Waterproof Shuttle as soon as possible after launching, reading out, or checking the status to avoid draining the battery.

Launching the Logger

Before deploying the logger in the field, perform the following steps in the office:

1. Start HOBOware.
2. Connect the logger to the computer as described in the previous section.

3. Verify the status. Click the status button on the toolbar and observe that the temperature is near the actual temperature.

4. Launch the logger with the correct range. Refer to the specifications on page 1 for both calibrated and extended ranges (the calibrated ranges are also printed on the logger housing). The logger will not record readings outside of the extended range selected. If in doubt on the range needed for your deployment, or for environments with wide fluctuations, select both ranges. This will shorten the deployment duration from 18,500 samples to 14,400 samples per parameter (not logging battery voltage). See the *HOBOware User's Guide* or online help for details on launching.

Note: Logging battery voltage is not essential because you can check the battery using the Status screen at launch or readout of the logger. Logging the battery voltage will reduce the number of conductivity and temperature readings you can log.

Taking Calibration Readings

It is important to take temperature and conductivity calibration readings with a portable conductivity meter at both the beginning (launchtime) and end of a deployment (readout) because these readings are necessary for data calibration and to compensate for any measurement drift during deployment. The conductivity calibration readings should be the *actual conductivity* without temperature compensation (*not* in specific conductance at 25°C), and should be recorded in a notebook with the time and location of the reading. You will use these readings in the HOBOware Conductivity Assistant to calibrate the readings for the corresponding data series offloaded from the logger.

There are three methods for obtaining accurate calibration readings. The first method involves placing the meter's probe into the water next to the logger. The second method involves placing the logger and meter probe in a field water sample in a jar. In both methods, the conductivity meter probe must be close to the data logger—but not touching—so that it is measuring water at the same conductivity as the logger. The third method involves taking a sample back to the office to measure with a meter there.

If the conductivity in the water where the logger is deployed is stable and it is easy to reach the logger, then you can obtain calibration readings by placing the probe directly into the water next to the logger. However, taking calibration readings some locations, such as in wells, can be difficult because it may be hard to get the meter probe next to the logger. In these instances, you should fill a jar with a water sample from where the logger is deployed to take the calibration readings. To obtain the water sample from a well or stilling well, you can use a bailer with a diameter that is small enough to fit down the well.

Note: Some salt residue may remain on the logger from factory calibration. Carefully rinse the logger in distilled water or clean freshwater to remove any residual salt before taking your first calibration readings.

Method 1:
Taking readings directly in the water (recommended for locations with access for the field meter probe and with conductivity that is stable)

1. If you have just deployed the logger, allow enough time for the logger temperature to stabilize for the best accuracy (approximately 15 minutes).

2. Gently tap the logger to remove any bubbles from the surface. Tug the cable if you cannot reach the logger itself.

3. Measure the temperature and actual conductivity with the field meter, making sure the meter probe readings stabilize per the meter's specification. Record the values, time, and location of the readings in a field notebook for use later in the HOBOware Conductivity Assistant.

Method 2:
Taking readings in a jar (recommended for readings in wells or in water with rapidly changing conductivity, such as areas with saltwater and freshwater mixing)

1. Take a sample of water in a jar that is large enough to hold both the logger and the probe from a portable conductivity meter, leaving an inch of space between the probe and the logger. For wells, use a bailer to obtain the water sample.

2. Leave the logger and the meter probe submerged in this jar of water long enough so they reach temperature equilibrium and the logger has logged at least three readings (allow at least 15 minutes for the best accuracy). (Three readings are necessary because this will help you identify which readings were taken while the logger is in the jar.)

3. Measure the temperature and actual conductivity with the field meter. Record the values, time, and location of the reading in a field notebook for use later in the HOBOware Conductivity Assistant.

4. When using the Conductivity Assistant, look for the spot in the data where there are three similar readings in a row and link the last of those readings to the meter reading. (The time you noted may be slightly different than the logger time so looking for the three similar readings will help isolate the correct reading.) The Conductivity Assistant uses that value to calibrate the specific conductance and salinity readings for that data series.

Method 3:
Taking a sample back to the office in a sealable jar to measure there (recommended for locations with conductivity that is stable when you do not have a field meter or it is not convenient to access the logger)

1. Place a sample of the water taken from next to the logger in a jar and immediately seal it to ensure that none of the water evaporates. This allows the specific conductance and salinity of the sample to be maintained, which in turn results in usable temperature and conductivity readings when you measure it with the meter at a later time.

2. Write down the time you take the sample for use later in the HOBOware Conductivity Assistant.

3. At the office, measure the temperature and actual conductivity of the sample with a meter and write down the values next to the time you noted in step 2.

Note: If you've taken the calibration readings in specific conductivity, you can convert the readings back to actual conductivity. Use the temperature readings from the meter or logger to convert the conductivity reading following the specific conductivity calculation used by your meter (consult the meter documentation). If the meter uses a standard linear compensation, you can use the following formula to convert it. This equation calculates the electrical conductivity (Y_e) from a measured water temperature (T) and from a measured specific conductance at 25°C (C_s) using the linear temperature coefficient entered into the meter.

$$Y_e = C_s * (1 - ((25-T) * a / 100))$$

Where: Y_e = Calculated Electrical Conductivity
T = water temperature in degrees C measured by the meter
C_s = Specific Conductance measured by the meter
a = linear temperature coefficient (% / degrees C) entered into the meter to calculate specific conductance

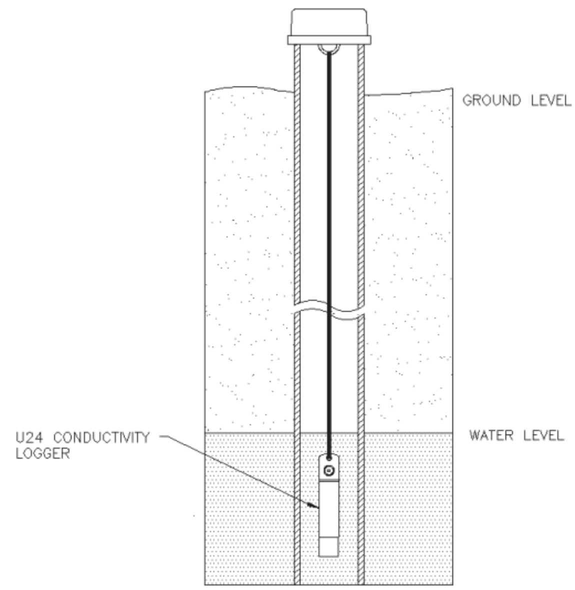
Deploying the Logger

The HOBO U24 Conductivity logger is designed to be easy to deploy in many environments. The small size of the logger is convenient for use in small wells and allows the logger to be mounted and/or hidden in the field. Follow these guidelines when deploying the logger:

- Make sure the logger is located where it will receive a steady flow of the water that is being monitored.
- When deploying the logger in rivers, streams, and ponds, insert the logger in a PVC or ABS pipe if possible. The PVC pipe should have enough holes to ensure good circulation of water.
- To avoid bubbles collecting on the sensor, make sure the sensor face is vertical and avoid sudden temperature changes.
- Do not place any conductive materials or metals within 2.5 cm (1 in.) of the sensor.
- Avoid deploying the logger in freezing water with moving ice.
- Use the included cap to protect the communications window in the logger from fouling and abrasion. Place the protective cap over the communications window before deploying the logger.
- Use the U2X Protective Housing (HOUSING-U2X) for added protection to the logger in harsh environments.

To deploy the logger at each site:

1. Launch the logger with a laptop or shuttle.
2. Take a calibration reading as described on page 4.
3. Deploy the logger in the water (if it hasn't already been placed in the water) following the guidelines recommended above.
4. Repeat steps 1 through 3 for each logger deployed. Be sure to take a new calibration reading for each logger that you deploy.



Reading Out the Logger and Calibrating Data with HOBOware

Your readout and maintenance schedule will be determined by the amount of fouling at the site. To read out the logger in the field:

1. Calibrate the field conductivity meter before using it to take field readings.
2. Measure the actual conductivity and temperature values with the field meter using one of the calibration methods on page 4.
3. Remove the logger from the water (if it hasn't already been removed for the calibration measurement). Remove the logger from the protective housing (if applicable) and remove the protective cap.
4. Read out the data from the logger using a shuttle.
5. Relaunch the logger.
6. Clean the sensor (see *Maintenance* on the next page for more details).
7. Place the protective cap back on the logger and remount the logger inside the protective housing (if applicable).
8. Redeploy the logger in the stream, and take another calibration measurement.

Use HOBOware to calibrate data and convert to specific conductance

1. Offload the most recent data files from the shuttle or loggers to your computer.
2. Open a data file in HOBOware.

3. Use the HOBOware Conductivity Assistant to calibrate the readings and adjust for drift caused by fouling. You will need to enter the field meter conductivity and temperature readings and times from the beginning and, optionally, the end of that segment of the logger's deployment. Refer to the Help for the Conductivity Assistant for more details. Save your changes to a project file.
4. Repeat steps 1 through 3 for all data files.

Maintenance

The logger requires the following periodic maintenance to ensure optimal operation:

- **Clean the sensor.** Mix several drops of dish detergent or biodegradable soap in a cup of tap water with a clean cotton swab. Clean the sensor face using the cotton swab and then rinse the sensor with clean or distilled water. Do not scratch the sensor face with a sharp tool.
- **Check for biofouling.** Biofouling and excessive marine growth on the logger will compromise accuracy. Organisms that grow on the sensor can interfere with the sensor's operation and eventually make the sensor unusable. If the deployment area is prone to biofouling, check the logger periodically for marine growth.
- **Be careful of solvents.** Check a materials compatibility chart before deploying the logger in locations where untested solvents are present. Refer to the specifications for wetted housing materials on page 1.

Battery Guidelines

- **Battery Life.** The battery life of the logger should be three years or more. Actual battery life is a function of the number of deployments, logging interval, and operation/storage temperature of the logger. Frequent deployments with logging intervals of less than one minute, continuous storage/operation at temperatures above 35°C (95°), and keeping the logger connected to the coupler will result in significantly lower battery life. For example, continuous logging at a one-second logging interval will result in a battery life of approximately one month.

  To obtain a three-year battery life, a logging interval of one minute or greater should be used and the logger should be operated and stored at temperatures between 0° and 25°C (32° and 77°F).
- **Battery Voltage.** The logger can report and log its battery voltage. If the battery falls below 3.1 V, the logger will record a "bad battery" event in the datafile. If the datafile contains "bad battery" events, or if logged battery voltage repeatedly falls below 3.3 V, the battery is failing and the logger should be returned to Onset for battery replacement. Note that the logger does not have to be recording the battery channel for it to detect bad battery events. The logger will record these events regardless of what channels are logged.
- **Replacing the Battery.** To have your logger's battery and sensor replaced, contact Onset or your place of purchase for return arrangements. Do not attempt to replace the battery yourself. Severe damage to the logger will result if the case is opened without special tools, and the warranty will be voided.

⚠ **WARNING:** Do not cut open, incinerate, heat above 100°C (212°F), or recharge the lithium battery. The battery may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the battery case. Do not dispose of the logger or battery in fire. Do not expose the contents of the battery to water. Dispose of the battery according to local regulations for lithium batteries.

Appendix F

HOBO® Dissolved Oxygen Logger (U26-001) Manual

HOBO Dissolved Oxygen Logger with Included Calibration Boot and Sponge (Shown Wet in Photo)

HOBO Dissolved Oxygen Logger

U26-001

Included Items:

- Dissolved Oxygen Sensor Cap
- Protective Guard
- Calibration Boot and Sponge

Required Items:

- Coupler (COUPLER-2-C) with USB Optic Base Station (BASE-U-4) *or* HOBO Waterproof Shuttle (U-DTW-1)
- HOBOware Pro 3.3.1 or later

Accessories:

- Replacement Dissolved Oxygen Sensor Cap (U26-RDOB-1)
- Anti-Fouling Guard (U26-GUARD-2)
- Sodium Sulfite (U26-CAL-SOL)

You May Also Need:

- For saltwater, salinity or conductivity measurements are required; HOBO Conductivity/Salinity Logger (U24-002-C) recommended
- For percent saturation, barometric pressure is required; HOBO Water Level Logger (U20-001-0x or U20L-0x) recommended

The HOBO Dissolved Oxygen logger is a standalone logger that uses RDO® Basic Technology to measure dissolved oxygen (DO). The logger has an optical sensor that provides 0.2 mg/L accuracy. The logger also features an easily replaceable sensor cap and an integrated temperature sensor. Using HOBOware® software for logger setup and a HOBO Waterproof Shuttle for quick data offload, this logger is easy to deploy in both freshwater and saltwater environments making it an ideal tool for environmental impact studies as well as ecological and oceanographic research. Using the data offloaded from the logger, the HOBOware Dissolved Oxygen Assistant can calculate percent saturation and salinity-adjusted DO concentration as well as correct for measurement drift from fouling (additional meter or logger measurements required).

Specifications

Dissolved Oxygen

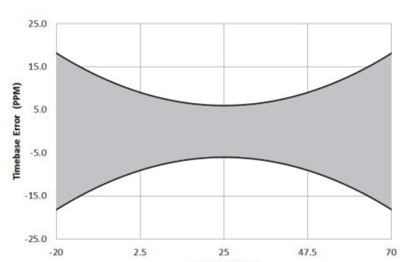
Sensor Type	Optical (dynamic luminescence quenching)
Measurement Range	0 to 30 mg/L
Calibrated Range	0 to 20 mg/L; 0 to 35°C (32 to 95°F)
Accuracy	±0.2 mg/L up to 8 mg/L; ±0.5 mg/L from 8 to 20 mg/L
Resolution	0.02 mg/L
Response Time	To 90% in less than 2 minutes
DO Sensor Cap Life	6 months (cap expires 7 months after initialization)

Temperature

Temperature Measurement/ Operating Range	-5 to 40°C (23 to 104°F), non-freezing
Temperature Accuracy	0.2°C (0.36°F)
Temperature Resolution	0.02°C (0.04°F)
Response Time	To 90% in less than 30 minutes

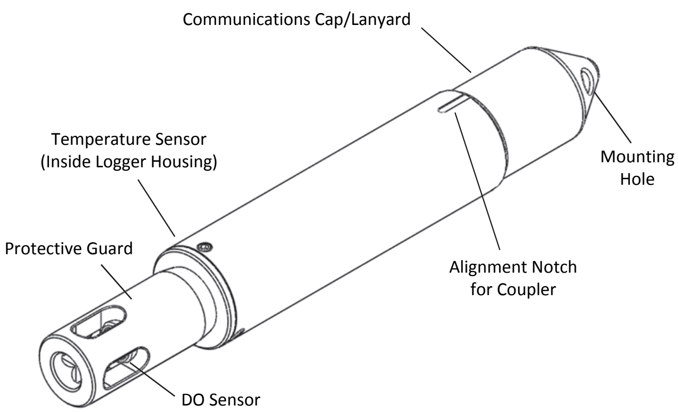
Logger

Memory	21,700 sets of DO and temperature measurements (64 KB total memory); logging stops when memory fills
Logging Rate	1 minute to 18 hours
Time Accuracy	±1 minute per month at 0 to 50°C (32 to 122°F) (see Plot A)
Battery	3.6 V lithium battery; factory replaceable
Battery Life	3 years (at 5 minute logging)
Download Type	Optical
Depth Rating	100 m (328 ft)
Wetted Materials	Black Delrin®, PVC, EPDM o-rings, silicon bronze screws; rated for saltwater use
Size	39.6 mm diameter x 266.7 mm length (1.56 x 10.5 inches); mounting hole 7.88 mm (0.31 inches)
Weight	464 g (16.37 oz)
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).



Plot A: Time Accuracy

Logger Components and Operation



Communications Cap/Lanyard. This removable cap protects the optical communications window. An LED in the communications window of the logger confirms logger operation. When the logger is logging, the LED blinks once every four seconds. The LED also blinks when the logger is recording a sample. When the logger is awaiting a start because it is configured to start "At Interval," "On Date/Time," or "Using Coupler," the LED blinks once every eight seconds until logging begins. See *Connecting the Logger to a Computer or Waterproof Shuttle* for details on using the communications window.

Mounting Hole. Use the hole on the communications cap to mount the logger. See *Deploying the Logger* for more information.

Alignment Notch for Coupler. Use this notch to align the coupler when communicating with the logger. See *Connecting the Logger to a Computer or Waterproof Shuttle* for more information.

DO Sensor. This optical sensor measures dissolved oxygen using RDO® Basic Technology. It is shipped with a red dust cap that must be replaced with a green sensor cap that lasts for six months plus a one-month grace period. See *Installing the Sensor Cap* for more details.

Protective Guard. This removable guard protects the DO sensor. Unscrew it to install or replace the sensor cap as needed. See *Installing the Sensor Cap* for more details.

Temperature Sensor. This built-in sensor (not visible in diagram) measures temperature.

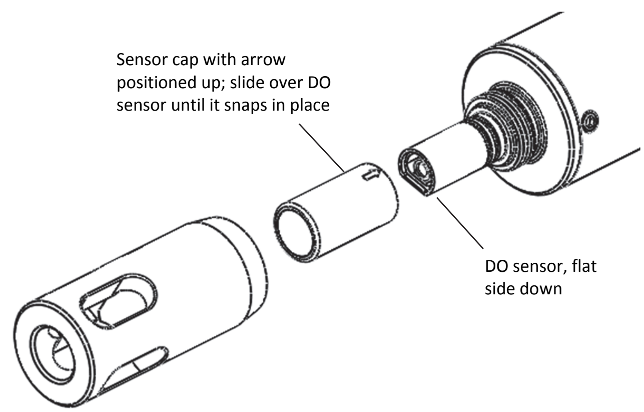
⚠ **WARNING:** This logger can be damaged by mechanical shock. Always handle the logger with care. The logger may be damaged if it is dropped. Use proper packaging when transporting or shipping the logger.

Do not attempt to open the logger case or sensor housing. Disassembling of the logger case or sensor housing will cause serious damage to the sensor and logger electronics. There are no user-serviceable parts inside the case. Contact Onset Technical Support at 1-800-LOGGERS (1-800-564-4377) or an authorized Onset dealer if your logger requires servicing.

Installing the Sensor Cap

The logger ships with a replaceable sensor cap that provides six months of continuous use. Once the cap is initialized, an internal clock within the logger will count down until the sensor cap expiration date. When the sensor cap expires, you will need to replace it with a new cap (U26-RDOB-1). The sensor cap is intended for six months of actual deployment, but the expiration date is seven months from the date the cap was initialized. This allows for any time needed between launching the logger and physically deploying as well as extra time in case you are not able to get the logger after exactly six months of deployment. To install the sensor cap:

1. Unscrew the protective guard covering the DO sensor (see diagram at left).
2. Remove the red dust cap that protects the sensor during shipping.
3. Take the green sensor cap out of the canister.
4. With the flat part of the DO sensor pointing down and the the green sensor cap oriented with the arrow up, slide the sensor cap over the sensor until it snaps in place. The cap should be snug against the logger housing without any gaps.



5. Screw the external protective guard back on until tight.

IMPORTANT: The sensor cap expires 7 months (to the day) after it has been initialized. The logger will record a value of -888 mg/L at each logging interval after the cap has expired. Initialization occurs automatically when the cap is installed while the logger is logging. You can also initialize it from the Status window in HOBOware or when using the Lab Calibration tool. To see when the sensor cap expires after being initialized, check the Status in HOBOware for the expiration date. The cap also has a shelf life; check the "Install By" date printed on the canister.

Connecting the Logger to a Computer or Waterproof Shuttle

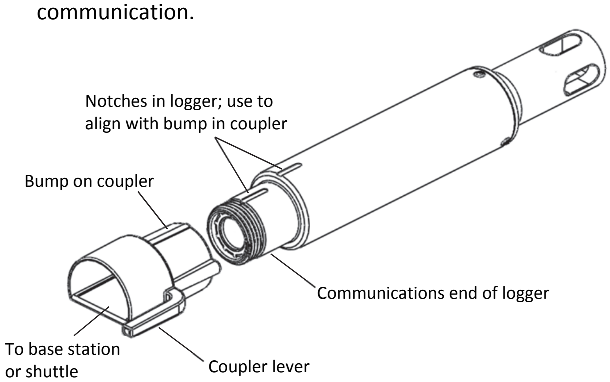
To connect the logger to a computer, use either the Optic USB Base Station (BASE-U-4) or HOBO Waterproof Shuttle (U-DTW-1) with a coupler (COUPLER2-C). To launch and read out the logger in the field, use one of these three methods:

- Laptop computer with Optic USB Base Station (BASE-U-4) and coupler (COUPLER2-C)
- HOBO Waterproof Shuttle (U-DTW-1, Firmware Version 3.2.0 or later) and coupler (COUPLER2-C)

- HOBO U-Shuttle (U-DT-1, Firmware Version 1.16 or later) with Optic USB Base Station and coupler (COUPLER2-C)

> **IMPORTANT**: USB 2.0 specifications do not guarantee operation outside the range of 0°C (32°F) to 50°C (122°F).

1. Follow the instructions that came with your base station or Waterproof Shuttle to attach it to a USB port on the computer.
2. Unscrew the pointed cap on the communications end of the logger.
3. Attach the coupler to the base station or shuttle.
4. Insert the logger into the coupler, aligning the bump/arrow on the coupler with the notches on the logger. Be sure that it is properly seated in the coupler. If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer. **Note**: If you are using the HOBO Waterproof Shuttle as a base station with a computer, briefly press the coupler lever to put the shuttle into base station mode. A green LED on the shuttle or base station indicates good communication.



5. After logger communications are complete, remove the logger from the coupler. Make sure the o-ring is still in the groove inside the cap and then reinstall the communications cap.

> **IMPORTANT**: When connected to a coupler, the logger is "awake" and consumes significantly more power than when it is disconnected and considered "asleep." The logger will automatically "go to sleep" after being left in the coupler for 30 minutes. It will no longer appear as a USB device connected to the computer. If this occurs, remove it from the coupler and start the instructions to connect the logger to a computer or waterproof shuttle over again.

Calibrating the Logger with the Lab Calibration Tool

Use the Lab Calibration tool in HOBOware when you need to calibrate the logger before deploying it or after replacing an expired sensor cap. The tool sets the gain and offset adjustment values for the logger by:

- Restoring logger calibration values to the factory defaults,
- Using your own gain and offset adjustment values, or
- Calculating the values with a 3-step calibration procedure.

In the three-step procedure, the logger is first calibrated to 100% saturation by placing it in water-saturated air. Then, you can calibrate the logger to 0% saturation by placing it in sodium sulfite or another 0% oxygen environment (recommended if the logger will be deployed in water with DO levels of 4 mg/L or less).

> **IMPORTANT**: Lab calibration only affects future launches; any data saved in the logger will be based on the previous calibration values. If the sensor cap is installed and it has not yet been initialized, you will be prompted to do so. Follow the instructions on the screen.

To complete these steps, you will need fresh water, the calibration boot and sponge supplied with the logger, and a source for current barometric pressure at your current location. You will also need sodium sulfite solution and a 7.6 cm (3 inch) beaker if you will be calibrating to 0% saturation.

The fresh water, logger, and sodium sulfite (if applicable) should be left out in the lab where the calibration is being done long enough so that they are at room temperature. If the logger was deployed previously, make sure the sensor is clean and dry (see *Maintenance* for more details). To use the Lab Calibration tool:

1. Connect the logger to the computer as described in the previous section. Stop the logger if it is currently logging or awaiting a coupler or delayed start.
2. From the Device menu, click Lab Calibration.
3. The current gain and offset adjustments are displayed in the top pane of the Lab Calibration window along with the date and time the last lab calibration was completed (if applicable). Completing Steps 1 through 3 in the Lab Calibration tool will result in new gain and offset adjustment values based on the current logger conditions. Continue to the next section for details on how to complete these steps.

   If you already know what the gain and offset values should be (for example, the values from a previous calibration that you want to use again) or want to return to the default factory values, click the "I know my values, skip to Finish" button. This will automatically move you to "Step 3: Finish" in the Lab Calibration window. Either click the "Reset to Factory Defaults" button or type in the desired gain adjustment and offset adjustment values and click the "Send Calibration to the Logger" button. **Note:** If you decide you do not need to change the calibration, click Close to cancel the calibration and revert back to the last saved logger values.

Step 1: 100% Saturation

1. In "Step 1: 100% Saturation" in the Lab Calibration window, enter the barometric pressure for your current location. If the barometric pressure reading has been adjusted for sea level (such as a reading taken from the National Weather Service weather station), select the "If using sea level barometric pressure, enter elevation" checkbox and enter your elevation in either meters or feet.
2. Make sure the logger either has the protective guard or the anti-fouling guard installed (whichever guard you plan to use in the deployment) so that the sensor is covered.

3. Wet the small sponge with fresh water. Squeeze out any excess water.
4. Place the sponge in the end of the calibration boot.
5. Insert the logger in the calibration boot so that there is approximately a 1 cm (0.5 inch) overlap between the end of the boot and the body of the logger. This will ensure there is enough space between the end of the logger and the sponge (the logger should not be pressed up tightly against the sponge).
6. Wait for approximately 15 minutes until the logger reaches temperature equilibrium (and less than 30 minutes so the logger does not go to sleep).
7. Click the “Get DO value from the logger” button to display the 100% saturation results. You can click this button as often as needed. The results are updated each time you click the button. To check for equilibrium, click the “Get DO value from the logger” button several times in a row to check the current “DO Conc from logger at 100% Saturation” value. If the value remains the same or varies very little with each button click, then temperature equilibrium has likely been reached.
8. When you are satisfied with the results displaying in the “Step 1: 100% Saturation” tab, click the Next button to proceed to “Step 2: 0% Saturation.”

Step 2: 0% Saturation (optional)

If the logger will be deployed in water with DO levels greater than 4 mg/L, click the “Skip this Step” button. Otherwise, continue with the following procedure.

1. Make sure the logger either has the protective guard or the anti-fouling guard installed (whichever guard you plan to use in the deployment) so that the sensor is covered.
2. Pour the sodium sulfite into the beaker so that it is about two-thirds full.
3. Place the sensor end of the logger into the solution so that the entire protective guard or anti-fouling guard and at least 2.5 cm (1 inch) of the logger body are submerged in the beaker. Allow it to rest on the bottom of the beaker.
4. Wait for approximately 15 minutes until the logger reaches temperature equilibrium (and less than 30 minutes so the logger does not go to sleep).
5. Click the “Get DO value from the logger” button to display the 0% saturation results. As with the 100% calibration, you can click this button as often as needed. The results are automatically updated each time you click the button. If the value remains the same or varies very little with each button click, then temperature equilibrium has likely been reached.
6. When you are satisfied with the results displaying in the “Step 2: 0% Saturation” tab, click the Next button to proceed to “Step 3: Finish.”

Step 3: Finish

The results from the first two steps are displayed as well as the overall calibration results and the new gain and offset adjustment values. If you are satisfied with the results, click the “Send Calibration to Logger” button. The logger will then be calibrated based on the new values. These values will not take effect until the logger is launched. If you do not want to save these values, click Close to cancel the calibration and revert back to the last saved logger values. Or, click “Reset to Factory Defaults” to return to the original values. If you performed Step 2, then remove the logger from the solution and thoroughly rinse it with fresh water to remove any excess sodium sulfite. See *Maintenance* for additional details on cleaning the logger.

Launching the Logger

After calibrating the logger, it needs to be launched to configure it before taking it to the field for deployment. Once launched, the logger will record two types of data: samples and events. Samples are the sensor measurements recorded at each logging interval. Events are independent occurrences triggered by a logger activity, such as Bad Battery or Host Connected. Events help you determine what was happening while the logger was logging. To launch the logger:

1. With the logger connected to the computer, open HOBOware. From the Device menu, select Launch.
2. Select both the DO and Temperature channels to log. **Note:** HOBOware provides the option of recording the current battery voltage at each logging interval, which is disabled by default. Recording battery life at each logging interval takes up memory and therefore reduces logging duration. It is recommended that you only record battery voltage for diagnostic purposes. Even with the channel disabled, a bad battery event will still be recorded.
3. Select a logging interval.
4. Choose when to start logging and click the Start button.
5. Remove the logger from the coupler and screw the communications cap back on the logger.

IMPORTANT: If this is the first launch with a new sensor cap, the sensor cap will expire six months (plus a one-month grace period) from the time of the first sensor reading. Two caps per year are required for year-round deployment.

Deploying the Logger

The logger is designed to be easy to deploy in many environments. Follow these guidelines when deploying it:

- Remove the calibration boot before deploying the logger.
- Make sure the logger is located where it will receive an unrestricted flow of the water being monitored to the sensor.
- Make sure the logger is fully submerged and not in direct sunlight to minimize temperature changes that are unrelated to water temperature.
- When deploying the logger in rivers, streams, and ponds, insert the logger in a PVC or ABS pipe for protection from debris (if possible). The pipe should have enough holes to ensure good circulation of water to the sensor.
- If possible, position the logger so the sensor face is oriented vertically. After deploying in the water, move the logger around slightly to eliminate any bubbles that may have formed.

- Do not deploy the logger in freezing water with moving ice where the logger could be crushed.
- Use the optional anti-fouling guard to protect against fouling. Unscrew the protective guard and replace it with the anti-fouling guard.
- If fouling is expected during deployment, use field calibration readings from both the beginning and end of the deployment as described in the next section. These readings can then be entered into the HOBOware Dissolved Oxygen Assistant to compensate for any measurement drift due to fouling. Scrub fouling off the logger with a plastic bristle brush.
- When deploying the logger in saltwater with small changes in salinity, you will need a conductivity or salinity value from either a conductivity meter or salinometer to enter in the Dissolved Oxygen Assistant to adjust the data from the logger for salinity. A single meter reading will add less than 1.1% DO error (assuming the conductivity changes are within ±3,000 µS/cm from the calibration point).

  If the conductivity changes, then you will need a data file with salinity or specific conductivity readings for the entire deployment. Consider deploying a HOBO Conductivity logger (U24-002-C) next to this DO logger to use the resulting data file for salinity data. For U24-002-C conductivity readings within a ±30,000 µS/cm range, there will be less than 4% error added to the DO measurements, and for readings over a narrower range, the accuracy will be even better. Refer to the *HOBO Conductivity Logger (U24-002-C) Manual* for more details. For applications that require higher accuracy conductivity data than the U24-002-C can provide, use a third-party conductivity logger.
- To generate a percent saturation series, you will need to deploy a barometric pressure logger (such as a HOBO Water Level Logger, U20-001-0x or U20L-0x) or have access to a nearby weather station to gather barometric pressure data. This data is necessary for the Dissolved Oxygen Assistant to calculate percent saturation.

Taking Field Calibration Readings

If fouling is expected during the deployment, you can take calibration readings at the beginning and end of the deployment to enter in the Dissolved Oxygen Assistant. This will adjust the data from the logger to compensate for any measurement drift due to fouling. There are two methods for taking field calibration readings: the first method involves taking readings using a dissolved oxygen meter or titration while the second method involves calibrating the logger in 100% water-saturated air. The first method is recommended because it is quicker to get the necessary calibration readings; the second method can take 40 minutes or more to achieve equilibrium with temperature extremes.

To Take Calibration Readings Using a DO Meter or Titration:

1. The logger must be logging. Take a DO measurement of the water where the logger is being deployed using either a DO meter or by titration. If using a meter, make sure it is calibrated and allow time for the meter probe to stabilize (this will occur when three meter measurements taken in a row are within your accuracy tolerance).

   If the logger is being deployed in saltwater, adjust the meter measurements for salinity using a meter with both conductivity and DO probes. If the saltwater has a constant salinity, you can use a DO meter where you can enter that salinity value to adjust the readings. If the salinity and/or DO are changing rapidly, then you will need to get a sample of the water in a container large enough for both the logger and meter probe to be completely submerged. Place both devices in the water long enough for them to stabilize and then for the DO logger to log at least two values, and take a concurrent meter reading.
2. Record the reading, date, and time of the measurement in a field notebook.
3. At the end of the deployment, repeat steps 1 and 2.

To Take Calibration Readings Using 100% Water-Saturated Air:

1. The logger must be logging. You will need fresh water, the included calibration boot and sponge, and the current barometric pressure from a HOBO U20 or U20L Water Level logger, a barometer, or a nearby weather station.
2. If the logger has been in salt water, clean the logger body and sensor cap as described in the *Maintenance* section. Make sure the sensor cap is dry before continuing.
3. Make sure the protective guard or anti-fouling guard is installed on the logger.
4. Wet the small sponge with fresh water. Squeeze out any excess water.
5. Place the sponge in the end of the calibration boot.
6. Insert the logger in the calibration boot so that there is approximately a 1 cm (0.5 inch) overlap between the end of the boot and the body of the logger. This will ensure there is enough space between the end of the logger and the sponge (the logger should not be pressed up tightly against the sponge).
7. Allow at least 40 minutes for the logger to reach temperature equilibrium, and then write down the date and time in a field notebook.
8. Write down the barometric pressure at that time (note the elevation if the barometric reading has been adjusted for sea level).
9. Repeat these steps at the end of the deployment.

Reading Out the Logger and Redeploying

Your readout and maintenance schedule will be determined by the amount of fouling at the site. To read out the logger in the field:

1. Take a field calibration reading as described in the *Taking Field Calibration Readings* section.
2. If the logger was in saltwater and you did not deploy a HOBO Conductivity Logger, then use a conductivity meter or salinometer to take a conductivity reading. Write down the reading and the date and time.

3. Remove the logger from the water and read out the data from the logger using a shuttle or computer with a base station.
4. If you are deploying it again, clean the sensor (see *Maintenanc*e for details).
5. Check the expiration date for your cap and make sure it will not expire before the end of your deployment. Replace it if needed.
6. Relaunch the logger if it is not already logging.
7. Take another field calibration reading after the logger is cleaned.
8. Redeploy the logger.

Using the HOBOware Dissolved Oxygen Assistant

Use the Dissolved Oxygen Assistant to obtain accurate Dissolved Oxygen readings if the logger was deployed in a saltwater environment or if percent saturation is required. Also use this assistant if you took field calibration readings. The Dissolved Oxygen Assistant is only available in HOBOware from the Plot Setup window when you open a file from this logger. To use the assistant:

1. Offload the most recent data files from the shuttle or logger to your computer.
2. Open a data file in HOBOware.
3. In the Plot Setup window, select the Dissolved Oxygen Assistant and click Process.
4. In the Dissolved Oxygen Assistant window, enter the salinity, barometric pressure, and field calibration information as needed. Click the Help button in the Dissolved Oxygen Assistant for more details and to learn about the ranges of input data allowed.
5. Plot the data and save it as a project file.

Maintenance

To clean the sensor cap:

1. Remove the protective guard or anti-fouling guard, but leave the sensor cap on the sensor.
2. Rinse the logger with clean water from a squirt bottle or spray bottle.
3. Gently wipe the cap with a soft-bristled brush (such as a toothbrush) or soft cloth if biofouling is present. Use Alconox® to remove grease.
4. If extensive debris or mineral build-up is present, soak the cap end in vinegar for 15 minutes, then soak it in deionized (DI) water for another 15 minutes.
5. If the logger is being immediately redeployed with the same sensor cap, a field calibration is adequate. If a new sensor cap is being installed, a lab calibration with HOBOware is recommended. When storing the logger between deployments, keep it in the calibration boot (wet the small sponge with fresh water, place the sponge in the end of the calibration boot, and then insert the logger in the boot.)

WARNING: Do not use organic solvents; they will damage the sensor. Do not remove the sensor cap from the sensor prior to cleaning with a brush. Only clean the sensor when you replace the sensor cap. See the full instructions that ship with the replacement sensor cap. Do not wet the sensor optical lens area with water or any solution. Remove the cap and gently wipe the window with a soft cloth.

To clean the logger body:

1. Make sure the sensor cap is installed on the logger.
2. Gently scrub the logger body with a plastic bristle brush or nylon dish scrubber.
3. Use Alconox® to remove grease.
4. Soak in vinegar to remove mineral deposits.
5. Rinse the logger with deionized (DI) water.

Battery Guidelines

The battery life of the logger should be three years or more. Actual battery life is a function of the number of deployments, logging interval, and operation/storage temperature of the logger. Frequent deployments with fast logging intervals, continuous storage/operation at temperatures above 35°C (95°), and keeping the logger connected to the coupler will result in significantly lower battery life. For example, the battery may last less than a year with a 1-minute logging interval. To obtain a three-year battery life, a logging interval of five minutes or greater should be used and the logger should be operated and stored at temperatures between 0° and 25°C (32° and 77°F).

The logger can report and log its battery voltage. If the battery falls below 3.2 V, the logger will record a "bad battery" event in the datafile. The logger will record a second "bad battery" event and stop logging when the battery falls below 3.1 V. If the datafile contains "bad battery" events, the logger should be returned to Onset for battery replacement. Note the logger does not have to be recording the battery channel for it to detect bad battery events. The logger will record these events regardless of what channels are logged. To have your logger's battery replaced, contact Onset or your place of purchase for return arrangements. Do not attempt to replace the battery yourself. Severe damage to the logger will result if the case is opened without special tools, and the warranty will be voided.

WARNING: Do not cut open, incinerate, heat above 100°C (212°F), or recharge the lithium battery. The battery may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the battery case. Do not dispose of the logger or battery in fire. Do not expose the contents of the battery to water. Dispose of the battery according to local regulations for lithium batteries.

1-800-LOGGERS (564-4377) • 508-759-9500
www.onsetcomp.com/support/contact

This product has been manufactured by Onset Computer Corporation and in compliance with Onset's ISO 9001:2008 Quality Management System.

15603-G MAN-U26x

Appendix G

HOBO® U20 Water Level Logger (U20-001-0x and U20-001-0x-Ti) Manual

The HOBO U20 Water Level Logger is used for monitoring changing water levels in a wide range of applications including streams, lakes, wetlands, tidal areas, and groundwater. The loggers are typically deployed in existing wells or stilling wells installed specifically for deploying the loggers. This logger features high accuracy at a great price and HOBO ease-of-use, with no cumbersome vent tubes or desiccants to maintain.

The logger uses a maintenance-free absolute pressure sensor and features a durable stainless steel or titanium housing (depending on model) and ceramic pressure sensor. The HOBO Water Level Titanium is recommended for saltwater deployment for recording water levels and temperatures in wetlands and tidal areas. The logger uses precision electronics to measure absolute pressure and temperature and has enough memory to record over 21,700 combined pressure and temperature measurements.

HOBO Water Level Logger

Models:

- U20-001-01 (30-foot depth) and U20-001-01-Ti (30-foot depth/Titanium)
- U20-001-02 (100-foot depth) and U20-001-02-Ti (100-foot depth/Titanium)
- U20-001-03 (250-foot depth) and U20-001-03-Ti (250-foot depth/Titanium)
- U20-001-04 (13-foot depth) and U20-001-04-Ti (13-foot depth/Titanium)

Required Items:

- Coupler (COUPLER-2-B) with USB Optic Base Station (BASE-U-4) *or* HOBO Waterproof Shuttle (U-DTW-1)
- HOBOware® Pro

Accessories:

- Cable (CABLE-1-300 or CABLE-1-50) and Cable Crimp (CABLE-1-CRIMP)
- Replacement Coupler (COUPLER2-B)

Specifications

Pressure (Absolute) and Water Level Measurements U20-001-01 and U20-001-01-Ti

Operation Range	0 to 207 kPa (0 to 30 psia); approximately 0 to 9 m (0 to 30 ft) of water depth at sea level, or 0 to 12 m (0 to 40 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 207 kPa (10 to 30 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	310 kPa (45 psia) or 18 m (60 ft) depth
Water Level Accuracy*	Typical error: ±0.05% FS, 0.5 cm (0.015 ft) water Maximum error: ±0.1% FS, 1.0 cm (0.03 ft) water
Raw Pressure Accuracy**	±0.3% FS, 0.62 kPa (0.09 psi) maximum error
Resolution	<0.02 kPa (0.003 psi), 0.21 cm (0.007 ft) water
Pressure Response Time (90%)***	<1 second; measurement accuracy also depends on temperature response time

Pressure (Absolute) and Water Level Measurements U20-001-02 and U20-001-02-Ti

Operation Range	0 to 400 kPa (0 to 58 psia); approximately 0 to 30.6 m (0 to 100 ft) of water depth at sea level, or 0 to 33.6 m (0 to 111 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 400 kPa (10 to 58 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	500 kPa (72.5 psia) or 40.8 m (134 ft) depth
Water Level Accuracy*	Typical error: ±0.05% FS, 1.5 cm (0.05 ft) water Maximum error: ±0.1% FS, 3 cm (0.1 ft) water
Raw Pressure Accuracy**	±0.3% FS, 1.20 kPa (0.17 psi) maximum error
Resolution	<0.04 kPa (0.006 psi), 0.41 cm (0.013 ft) water
Pressure Response Time (90%)***	<1 second; measurement accuracy also depends on temperature response time

Pressure (Absolute) and Water Level Measurements U20-001-03 and U20-001-03-Ti

Operation Range	0 to 850 kPa (0 to 123.3 psia); approximately 0 to 76.5 m (0 to 251 ft) of water depth at sea level, or 0 to 79.5 m (0 to 262 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 850 kPa (10 to 123.3 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	1200 kPa (174 psia) or 112 m (368 ft) depth
Water Level Accuracy*	Typical error: ±0.05% FS, 3.8 cm (0.125 ft) water Maximum error: ±0.1% FS, 7.6 cm (0.25 ft) water
Raw Pressure Accuracy**	±0.3% FS, 2.55 kPa (0.37 psi) maximum error

Specifications (continued)

Pressure (Absolute) and Water Level Measurements U20-001-03 and U20-001-03-Ti (continued)

Resolution	<0.085 kPa (0.012 psi), 0.87 cm (0.028 ft) water
Pressure Response Time (90%)* **	<1 second; measurement accuracy also depends on temperature response time

Pressure (Absolute) and Water Level Measurements U20-001-04 and U20-001-04-Ti

Operation Range	0 to 145 kPa (0 to 21 psia); approximately 0 to 4 m (0 to 13 ft) of water depth at sea level, or 0 to 7 m (0 to 23 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 145 kPa (10 to 21 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	310 kPa (45 psia) or 18 m (60 ft) depth
Water Level Accuracy*	Typical error: ±0.075% FS, 0.3 cm (0.01 ft) water Maximum error: ±0.15% FS, 0.6 cm (0.02 ft) water
Raw Pressure Accuracy**	±0.3% FS, 0.43 kPa (0.063 psi) maximum error
Resolution	<0.014 kPa (0.002 psi), 0.14 cm (0.005 ft) water
Pressure Response Time (90%)***	<1 second; measurement accuracy also depends on temperature response time

Temperature Measurements (All Models)

Operation Range	-20° to 50°C (-4° to 122°F)
Accuracy	±0.44°C from 0° to 50°C (±0.79°F from 32° to 122°F), see Plot A
Resolution	0.10°C at 25°C (0.18°F at 77°F), see Plot A
Response Time (90%)	5 minutes in water (typical)
Stability (Drift)	0.1°C (0.18°F) per year

Logger

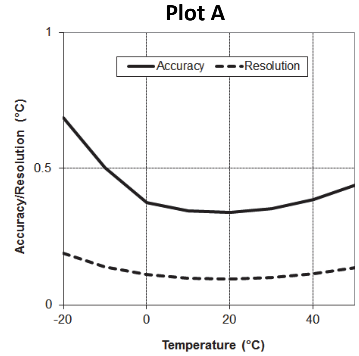
Real-time Clock	± 1 minute per month 0° to 50°C (32° to 122°F)
Battery	2/3 AA, 3.6 Volt lithium, factory-replaceable
Battery Life (Typical Use)	5 years with 1 minute or greater logging interval
Memory (Non-volatile)	64K bytes memory (approx. 21,700 pressure and temperature samples)
Weight	Stainless steel models: approximately 210 g (7.4 oz) Titanium models: approximately 140 g (4.8 oz)
Dimensions	2.46 cm (0.97 inches) diameter, 15 cm (5.9 inches) length; mounting hole 6.3 mm (0.25 inches) diameter
Wetted Materials	Stainless Steel models: 316 stainless steel, Viton® O-rings, acetal cap, ceramic sensor Titanium models: Titanium, Viton O-rings, acetal cap, ceramic sensor
Logging Interval	Fixed-rate or multiple logging intervals, with up to 8 user-defined logging intervals and durations; logging intervals from 1 second to 18 hours. Refer to the HOBOware software manual.
Launch Modes	Immediate start and delayed start
Offload Modes	Offload while logging; stop and offload
Battery Indication	Battery voltage can be viewed in status screen and optionally logged in datafile. Low battery indication in datafile.
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).

* Water Level Accuracy: With accurate reference water level measurement, known water density, accurate Barometric Compensation Assistant data, and a stable temperature environment.

** Raw Pressure Accuracy: Absolute pressure sensor accuracy includes all sensor drift, temperature, and hysteresis-induced errors.

*** Changes in Temperature: Allow 10 minutes in water to achieve full temperature compensation of the pressure sensor. Maximum error due to rapid thermal changes is approximately 0.5%.

Plot A



Software

HOBOware Pro software is required for logger operation. Using a reference water level, HOBOware Pro automatically converts the pressure readings into water level readings. The software also supports compensation for temperature, fluid density, and barometric pressure.

Communication

For launching and reading out the Water Level logger in the field, you can use a laptop computer with HOBOware Pro and an Onset Optic USB Base Station (BASE-U-4), with a coupler (COUPLER2-B) or the HOBO Waterproof Shuttle (U-DTW-1) with a coupler (COUPLER2-B).

The optical interface allows the logger to be offloaded without breaking the integrity of the seals. The USB compatibility allows for easy setup and fast downloads.

Barometric Compensation

The HOBO Water Level Logger records absolute pressure, which is later converted to water level readings by the software. In this application, absolute pressure includes atmospheric pressure and water head. Atmospheric pressure is nominally 100 kPa (14.5 psi) at sea level, but changes with weather and altitude. Left uncompensated, barometric variations could result in errors of 0.6 m (2 ft) or more.

To compensate for barometric pressure changes, you can use the HOBO U20 Water Level Logger as a barometric reference. The barometric reference is typically deployed in the same well or at the same location as the water level of interest, but rather than being placed in the water column, it is deployed above the water in air.

Barometric pressure readings are consistent across a region (except during fast-moving weather events), so you can generally use barometric pressure readings that are taken within 15 km (10 miles) of the logger or more, without significantly degrading the accuracy of the compensation.

Therefore, one U20 or weather station (HOBO U30 or H21 recommended) can be used to compensate all of the water level loggers in an area. The U20-001-01 model with its 0–9m (0–30 ft) range or the U20-001-04 with its 0–4 m (0–13 ft) range are both good barometric references due to their smaller range, temperature-compensated accuracy, and rugged stainless steel case. HOBOware Pro includes a Barometric Compensation Assistant for easy and accurate barometric compensation.

LEDs

A light (LED) in the communications window of the logger confirms logger operation.

The following table explains when the logger blinks during logger operation:

When:	The Light:
The logger is logging	Blinks once every one to four seconds (the shorter the logging interval, the faster the light blinks); blinks when logging a sample
The logger is awaiting a start because it was launched in Start At Interval or Delayed Start mode	Blinks once every eight seconds until logging begins

Calibration

The pressure sensor in each HOBO Water Logger is individually calibrated. During calibration, raw pressure sensor data is collected at multiple pressures and temperatures over the calibrated range of the logger (see the specifications table). This data is used to generate calibration coefficients that are stored in the logger's non-volatile memory. The calibration coefficients are then checked to be sure that the logger meets its stated accuracy over the calibrated range.

The pressure sensor can be used at pressures and temperatures that are outside of the calibrated range, but the accuracy cannot be guaranteed.

Important: Never exceed the burst pressure of the sensor!

Sleep Mode

The logger consumes significantly more power when it is "awake" and connected to a base station or shuttle. To conserve power, the logger will go into a low-power (sleep) mode if there has been no communication with your computer for 30 minutes. To wake up the logger, remove the logger from the coupler, wait a moment, then re-insert the logger.

Sample and Event Logging

The logger can record two types of data: samples and events. Samples are the sensor measurements recorded at each logging interval (for example, the pressure every minute). Events are independent occurrences triggered by a logger activity, such as Bad Battery or Host Connected. Events help you determine what was happening while the logger was logging.

The logger stores 64K of data, and can record over 21,700 samples of pressure and temperature.

Setup

Before you deploy the HOBO U20 Water Level Logger in the field, perform the following steps in the office:

1. Start HOBOware.
2. Connect the logger to the computer. See the next section.
3. Verify the status. Click Status on the toolbar and observe that the absolute pressure is near barometric pressure for the location and the temperature is near the actual temperature.

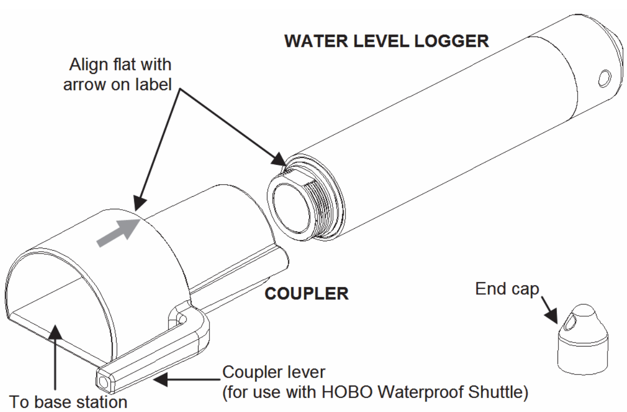
4. Launch the logger. See the *HOBOware User's Guide* for details.
   - Make sure both *Abs. Pressure* and *Temperature* are selected (temperature is required for temperature compensation of pressure).
   - *Logging Battery Voltage* is not essential since you can check the battery voltage using the Status screen at launch or readout of logger.

Connecting the Logger to a Computer

The HOBO Water Level Logger requires a coupler (COUPLER2-B) and USB Optic Base Station (BASE-U-4) or HOBO Waterproof Shuttle (U-DTW-1) to connect to the computer.

1. Follow the instructions that came with your base station or shuttle to attach the base station or shuttle to a USB port on the computer.
2. Unscrew the black plastic end cap from the logger by turning it counter-clockwise.
3. Attach the coupler to the base station or shuttle
4. Insert the logger into the coupler with the flat on the logger aligned with the arrow on the coupler label. Gently twist the logger to be sure that it is properly seated in the coupler (it should not turn).

NOTE: If you are using the Waterproof Shuttle, briefly press the coupler lever to put the shuttle into base station mode.

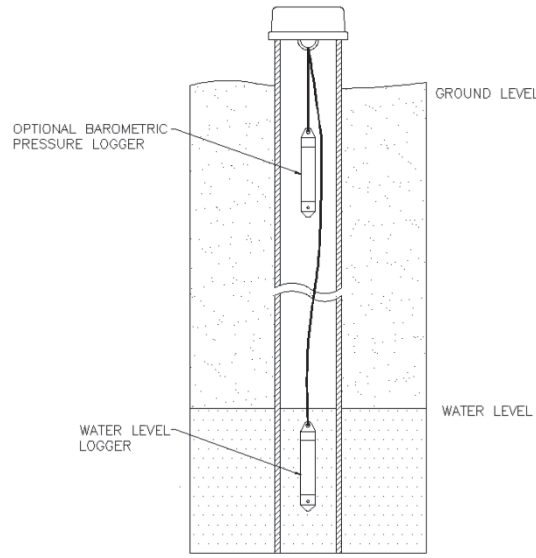


If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer.

Important: USB communications may not function properly at temperatures below 0°C (32°F) or above 50°C (122°F).

Deploying the Logger

The HOBO Water Level Logger is designed to be easy to deploy in many environments. The logger uses an absolute pressure sensor, so no vent tube is required. The small size of the logger is convenient for use in small wells and allows the logger to be mounted and/or hidden in the field.



Deployment Guidelines

Full Temperature Equilibrium

The pressure sensor is temperature compensated over the range of 0° to 40°C (32° to 104°F). To obtain the highest level of accuracy, the logger should be allowed to come to full temperature equilibrium (approximately 20 minutes) before the reference level is recorded.

Sudden Temperature Changes

Sudden temperature changes should be avoided. When deploying a HOBO Water Level Logger for barometric pressure reference, some consideration should be made to minimize the rate of temperature fluctuations. Ideally, the barometric pressure reference logger should be hung several feet below ground level in an observation well where ground temperatures are stable (while making sure the logger remains above the water level). If that is not possible (or if a well is not used), try to put the logger in a location where it will not be subject to rapid daily temperature cycles.

Venting

When deploying a HOBO Water Level logger in a well, make sure the well is vented to the atmosphere. Typically, a small hole can be drilled in the well cap to ensure that the pressure inside and outside the well is at equilibrium. If this is not possible, the barometric pressure reference logger should be used inside the same well.

Wire

Use a no-stretch wire to hang the water level logger. Any change in length of the wire will result in a 1-to-1 corresponding error in the depth measurement. Always pull-test a cable prior to deploying a logger in a well to make sure it does not stretch.

Stilling Well
If you are deploying the logger in a lake, river, or stream, you must first build a stilling well to protect the logger from vibration, shock, and movement.

A simple stilling well can be constructed with PVC or ABS pipe. A properly constructed stilling well helps to protect the logger from currents, wave action, and debris. Suspend the logger in the stilling well so it is always underwater, but not on the bottom to be buried by silt.

For more information, see the Technical Application Note for Constructing a Stilling Well at:
http://www.onsetcomp.com/water_level_stilling_well.html

Burst Pressure
Be very careful not to exceed the burst pressure for the logger. The pressure sensor will burst if the maximum depth is exceeded (see specifications table). The logger should be positioned at a depth where the logger will remain in the water for the duration of the deployment, but not exceed the rated bursting depth.

Deployment Procedure

1. Cut wire to suspend logger.
    a. Measure the physical depth to the surface of the water from the suspension point.
    b. Cut a piece of stranded, stainless steel wire (Teflon coated is best) so that the logger will be deep enough to always be in the water. Estimate the low water level and make the cable length such that the logger will be about 2 feet below that level.
2. Attach the wire to the suspension point and to the logger cap.
3. Relaunch the logger if desired (if a PC or a HOBO U-Shuttle is available).
4. Lower the logger into the well or stilling well.
5. Measure the water depth from the desired reference point (top of pipe, ground level, or sea level).
    - To maximize accuracy, allow 20 minutes after deploying the logger before measuring water depth to allow the logger to reach temperature equilibrium with the water.
    - If the well is too small in diameter to measure the water depth after deployment, measure the water depth before deployment, then deploy the logger immediately and record deployment time.
    - For well deployments: If the water level surface is below the reference point (such as referencing groundwater measurements to the top of the well), record the water level as a negative number. If the water level surface is above the reference point (such as height above sea level), record the water level as a positive number.
    - For lake, stream, and river deployments: If the water level is being referenced to some point above the logger (such as the top of the stilling well), record the water level as a negative number. If the water depth is being referenced to a point below the water surface such as the bottom of the stream, record the water level as a positive number.
6. Record the reference measurement date and time.

Deploying a U20 Logger for Barometric Pressure Data (Optional)

If you are using a U20 logger to record barometric pressure data, install one logger in one of the wells as follows:

1. Cut wire for suspending the logger.
    a. Measure the physical depth to the surface of the water from the suspension point.
    b. Cut a piece of stranded, stainless steel wire (Teflon coated is best) so that the logger will hang about 2 feet below the ground surface but always above the water surface.
2. Attach the wire to the suspension point and to the logger cap.
3. Relaunch the logger if desired (if a PC or a HOBO U-Shuttle is available)
4. Lower the logger into the well or stilling well. Make sure the logger does not go below the water surface.
5. Record the deployment time.

Collecting Data

For reading out the Water Level logger in the field, you can use either of the following:

- Laptop computer with HOBOware Pro and an Optic USB Base Station (BASE-U-4), with a coupler (COUPLER2-B)
- HOBO Waterproof Shuttle (U-DTW-1) with a coupler (COUPLER2-B)

1. Measure the water depth using the original reference point with the correct sign.
2. Record depth and date and time.
3. Pull the logger out of the well.
4. Remove the logger from its cap, leaving the suspension undisturbed.
5. Readout the data using one of the options listed above.
6. Save the data in a test folder location.
7. Redeploy the logger (optional). See below.

Barometric Pressure Data
To read out a U20 logger used for barometric pressure data:

1. Remove the logger from the well.
2. Readout the data using one of the options listed above.
3. Save the data in a test folder location.
4. Redeploy the logger (optional). See the next section.

Redeploying the Logger
If you are redeploying the logger, you must first make sure that it is launched. If you used the HOBO Waterproof Shuttle to offload data, the shuttle automatically performs a synchronized relaunch of the logger so that data is logged on the same measurement intervals. If you wish to change the launch settings, you must launch the logger using HOBOware Pro.

The existing suspension can be reused as long as the water level logger remained in the water and the barometric logger remained out of the water for the entire test interval. Take a new reference reading with the date and time as described in *Collecting Data*. Record this information in your field notebook to use later to calibrate your data, which will zero out any drift error.

Processing Data using Barometric Pressure Data

To determine water level using barometric pressure data, use the **Barometric Compensation Assistant** in HOBOware Pro, as described below.

If you are using barometric pressure data from a HOBO weather station, you can use the data file as if it were U20 barometric data. For data from sources other than Onset products, see *Barometric Data from Other Sources* below.

1. In HOBOware Pro, open the water depth data file. The **Plot Setup** window appears.
2. Uncheck all boxes except *Abs. Pressure*.
3. Run the Barometric Compensation Assistant.
    a. Click the **Process** button.
    b. Select the water density box that best describes the water that you are measuring or enter the actual water density.
    c. Check the *Use a Reference Water Level* box and enter the reference water level that you measured at the beginning of the deployment.
    d. Select the date and time from the pull-down menu that is closest to the recorded date/time for the measurement. If you measured the depth before deployment because of pipe size, then select a date/time after the start of the deployment.
    e. Check *Use Barometric Data file*.
    f. Click the **Choose** button. This will allow you to select the data file to use for barometric pressure compensation.
    g. Select and open the data file.
    h. Click the **Create New Series** button. A new Plot Setup window appears.
4. Select the *Water Level* box and any other series that you want plotted. Click the **Plot** button to obtain a plot of the resulting water level data.

Measurement Error
Measurement error can be caused by manual measurement error, sensor drift, or change in the suspension cable length. To quantify measurement error (which is ideally zero), compare the calculated water level at the end of the plot with the water level measured just before you removed the water level logger.

Barometric Data from Other Sources

Third Party Weather Station or Barometric Logger
If you choose to use barometric pressure from a third party weather station or barometric logger, you need to convert the date, time, and pressure data to a text file with special header requirements. For information on how to set up the text file, see the HOBOware Help or User Guide. It is easiest to do this work in EXCEL and then save it as a text file.

Online Weather Station
If you choose to use barometric pressure from an online weather station, such as the National Weather Service, the measured barometric pressure is modified to be at sea level. This sea level pressure is useable since all pressure offsets are zeroed when you enter the reference measurement.

In the Barometric Compensation Assistant, when you select the Barometric Data File, select the text file that you generated. HOBOware Pro will ask for the data format and data separation characters (tab or comma) and then import the barometric data.

Maintenance

Protecting the Logger

Important: Do not attempt to open the logger housing!
Unscrewing the metal nose cone of the logger will cause serious damage to the pressure sensor and logger electronics. There are no user serviceable parts inside the case. Contact Onset technical support if your logger requires servicing.

This logger can be damaged by shock. Always handle the logger with care. The logger may lose its calibrated accuracy or be damaged if it is dropped. Use proper packaging when transporting or shipping the logger.

Biofouling
Periodically inspect the logger for fouling. Biological growth on the face of the pressure sensor will throw off the pressure sensor's accuracy. Organisms that grow inside the sensor nose cone and on the sensor itself can interfere with the sensor's operation and eventually make the sensor unusable. If the deployment area is prone to biofouling, check the logger periodically for marine growth.

Solvents
Check a materials-compatibility chart before deploying the logger in locations where untested solvents are present.

The logger is shipped with Viton O-rings installed. Viton has an excellent resistance to most solvents and is suitable for deployments in water that contain a mixture of most fuels, solvents and lubricants. However, the Viton O-rings are sensitive to polar solvents (acetone, ketone), ammonia, and brake fluids.

The black acetal cap is provided to help protect the communications window. Acetal is resistant to most solvents, fuels, and lubricants.

The polycarbonate communications window is sealed as an additional barrier to water and dirt entering the logger housing.

Compensating for Drift

All pressure sensors drift over time. The drift for the pressure sensor and electronics in the HOBO Water Level logger is less than 0.3% FS (worst case) per year. In most applications, drift is not a significant source of error, because the offset created by any drift is zeroed out when you take a manual reference level measurement and use the logger software to automatically calculate the level readings relative to the reference measurement. In effect, you are re-zeroing the sensor each time you apply a reference reading to the data file.

Pressure sensor drift matters only when absolute pressure values are needed, or if there are no recent reference level or depth measurements available. For example, if the logger is deployed for one year and no new reference level readings are taken during the deployment, it is possible that the sensor could have drifted as much as 0.3% FS by the end of the deployment.

It is possible to determine the actual amount of drift during a deployment if a reference level is taken at the beginning and the end of a long-term deployment. The results of applying the two different reference levels (once at the beginning of the data file, and again at the end of the data file) can be compared. Any difference between the files indicates the amount of sensor drift (assuming accurate reference levels).

Verifying Accuracy

You can check the *differential accuracy* of your loggers for water level measurements by deploying the loggers at two depths and comparing the difference in level readings. When verifying the accuracy this way, be sure to allow the loggers' temperature to stabilize at each depth. Use the logger software to convert the readings from pressure to level. The level readings should be taken close enough together that the barometric pressure does not change.

You can check the *absolute pressure accuracy* of your HOBO Water Level Logger by comparing its ambient pressure readings to a second HOBO logger. Their readings should be within each other's specified accuracy. Alternatively, you can check the pressure reading against an accurate local barometer. If you use a non-local source of barometric information, such as the NOAA website, adjust for altitude.

Recalibration

If you would like to have your logger's absolute accuracy verified against a NIST standard, or to have your logger recalibrated, contact Onset or your place of purchase for pricing and return arrangements.

The Battery

The battery in the HOBO Water Level Logger is a 3.6 Volt lithium battery.

Battery Life

The battery life of the logger should be about five years or more. Actual battery life is a function of the number of deployments, logging interval, and operation/storage temperature of the logger. Frequent deployments with logging intervals of less than one minute, and continuous storage/operation at temperatures above 35°C will result in significantly lower battery life. For example, continuous logging at a one-second logging interval will result in a battery life of approximately one month.

To obtain a five-year battery life, a logging interval of one minute or greater should be used and the logger should be operated and stored at temperatures between 0° and 25°C (32° and 77°F).

Voltage

The logger can report and log its battery voltage. If the battery falls below 3.1 V, the logger will record a "bad battery" event in the datafile. If the datafile contains "bad battery" events, or if logged battery voltage repeatedly falls below 3.3 V, the battery is failing and the logger should be returned to Onset for battery replacement.

Replacing the Battery

To have your logger's battery replaced, contact Onset or your place of purchase for return arrangements. Do not attempt to replace the battery yourself. Severe damage to the logger will result if the case is opened without special tools, and the warranty will be voided.

⚠ **WARNING:** Do not cut open, incinerate, heat above 100°C (212°F), or recharge the lithium battery. The battery may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the battery case. Do not dispose of the logger or battery in fire. Do not expose the contents of the battery to water. Dispose of the battery according to local regulations for lithium batteries.

ONSET
1-800-LOGGERS (564-4377) • 508-759-9500
www.onsetcomp.com/support/contact

This product has been manufactured by Onset Computer Corporation and in compliance with Onset's ISO 9001:2008 Quality Management System.

Patent #: 6,826,664

12315-H MAN-U20

Appendix H

Standard Operating Procedure
HOBO® U20, U24 and U26 Data Loggers

Table of Contents

Reference Materials

HOBO® Waterproof Shuttle (U-DTW-1) Manual
http://www.onsetcomp.com/files/manual_pdfs/10264-L%20MAN-U-DTW-1.pdf

HOBO® U20 Water Level Logger (U20-001-0x and U20-001-0x-Ti) Manual
http://www.onsetcomp.com/files/manual_pdfs/12315-E-MAN-U20.pdf

HOBO® U24 Conductivity Logger (U24-00x) Manual
http://www.onsetcomp.com/files/manual_pdfs/15070-C-MAN-U24x.pdf

HOBO® Dissolved Oxygen Logger (U26-001) Manual
http://www.onsetcomp.com/files/manual_pdfs/15603-A-MAN-U26x.pdf

HOBOware® User's Guide
http://www.onsetcomp.com/files/manual_pdfs/12730-V%20HOBOware%20User%27s%20Guide.pdf

HOBOware® Pro Dissolved Oxygen Assistant User's Guide
http://www.onsetcomp.com/files/manual_pdfs/15604-C%20Dissolved%20Oxygen%20Assistant%20User%27s%20Guide.pdf

HOBOware® Pro Conductivity Assistant User's Guide
http://www.onsetcomp.com/files/manual_pdfs/Conductivity-Assistant-Users-Guide-15019.pdf

HOBOware® Pro Barometric Compensation Assistant User's Guide
http://www.onsetcomp.com/files/manual_pdfs/Barometric-Compensation-Assistant-Users-Guide-10572.pdf

Supplies

Supplies needed to calibrate, retrieve, or maintain HOBO® data loggers include:

- HOBO® Waterproof Shuttle, Couplers, and associated cords
- Dissolved Oxygen 0mg/L calibration solution
- Lint-free wipes/towels
- Squirt bottles for focused rinsing
- Distilled water
- Alconox detergent
- PPE (e.g., gloves, eye shields)
- Tape measure
- DEP-approved "hand-held" meter/probes for gathering additional instantaneous field data (dissolved oxygen (DO), temperature, and specific conductance) when retrieving data loggers

Calibration, Launch, and Data Logger Deployment

The HOBO Meters Calibration and Deployment Form (included as an **attachment**) should be filled out during calibration, launch, and data logger deployment.

HOBO® Dissolved Oxygen Logger

Please refer to the HOBO® Dissolved Oxygen Logger (U26-001) Manual for details.

1. Install a new sensor cap (if needed).
2. Open the HOBOware Pro software and connect the logger to the computer.
3. Use the Lab Calibration tool in HOBOware®to calibrate the logger before deploying it or after replacing an expired sensor cap.
4. Verify the settings and status of the logger.
5. Launch the logger. Refer to the HOBOware® User's Guide for details.
6. Remove calibration boot before deploying the logger.
7. Deploy logger in accordance with manufacturer specifications.

HOBO® U20 Water Level Logger and HOBO® U24 Conductivity Logger

1. Open the HOBOware Pro software and connect the logger to the computer.
2. Verify the settings and status of the logger.
3. Launch the logger. Refer to the HOBOware® User's Guide for details.
4. Deploy logger in accordance with manufacturer specifications.

Retrieve Data with Waterproof Shuttle

The HOBO® Waterproof Shuttle can be used in the field to read out logger information, and store logger data for subsequent transfer to computer.

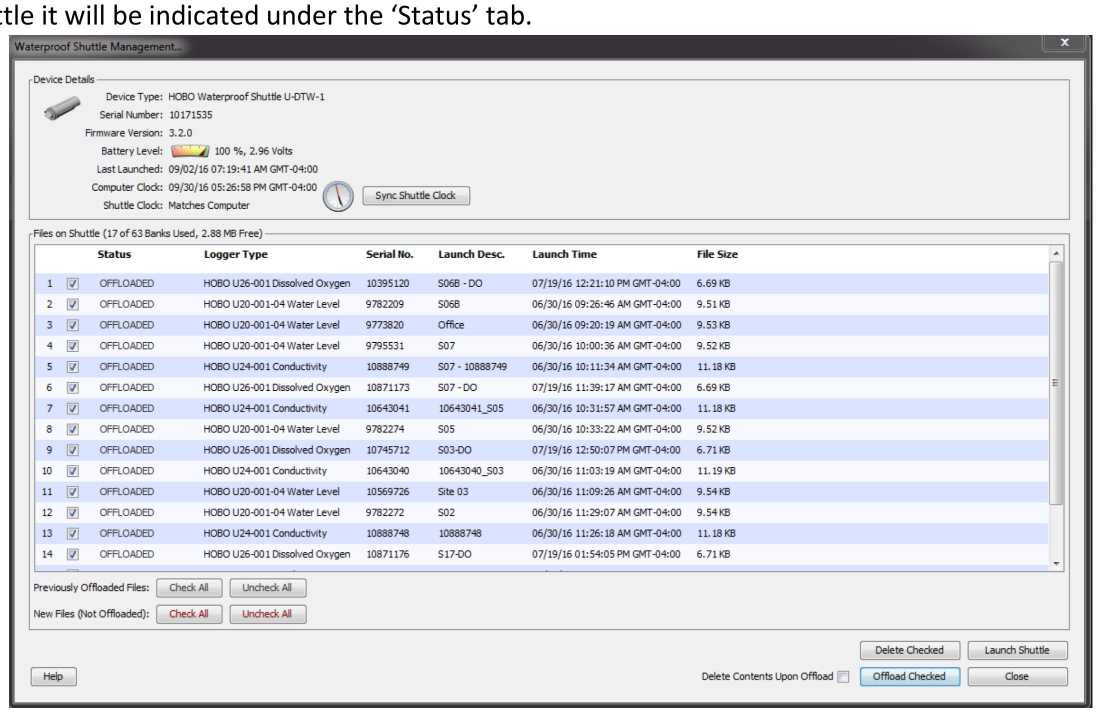
1. Using the DEP-approved "hand-held" meter/probes, measure the following in the stream:
    - Temperature
    - DO mg/L
    - DO%
    - Conductivity

   Record the field measurements and the time(s) the measurements were taken.

2. Measure the water depth (to the nearest hundredth of a foot) at the stilling well housing the HOBO® U20 Water Level Logger. Record the measurement and the time the measurement was taken.
3. Retrieve data logger from stream and clean as needed.
4. Attach the correct coupler for the logger and ensure that it is seated properly.
5. Insert the logger into the coupler and ensure that the optical sensor is lined up properly with the waterproof shuttle.
6. Momentarily press the coupler lever (hard enough so the lever bends) and observe the LED indicator lights on the waterproof shuttle to monitor progress.
    - The amber "Transfer" LED will blink continuously while data transfer and relaunch are in progress.
    - The green "OK" LED blinks when it finishes reading out and relaunching a logger.
    - The red "Fail" LED blinks whenever the shuttle encounters an error condition. Refer to the HOBO® Waterproof Shuttle (U-DTW-1) Manual to troubleshoot possible issues.
7. Remove the logger from the coupler and redeploy data logger in the stream.
   Note: If removing equipment from the stream (for maintenance or end of field season), transport logger to office and connect to HOBOware Pro software to stop logging.

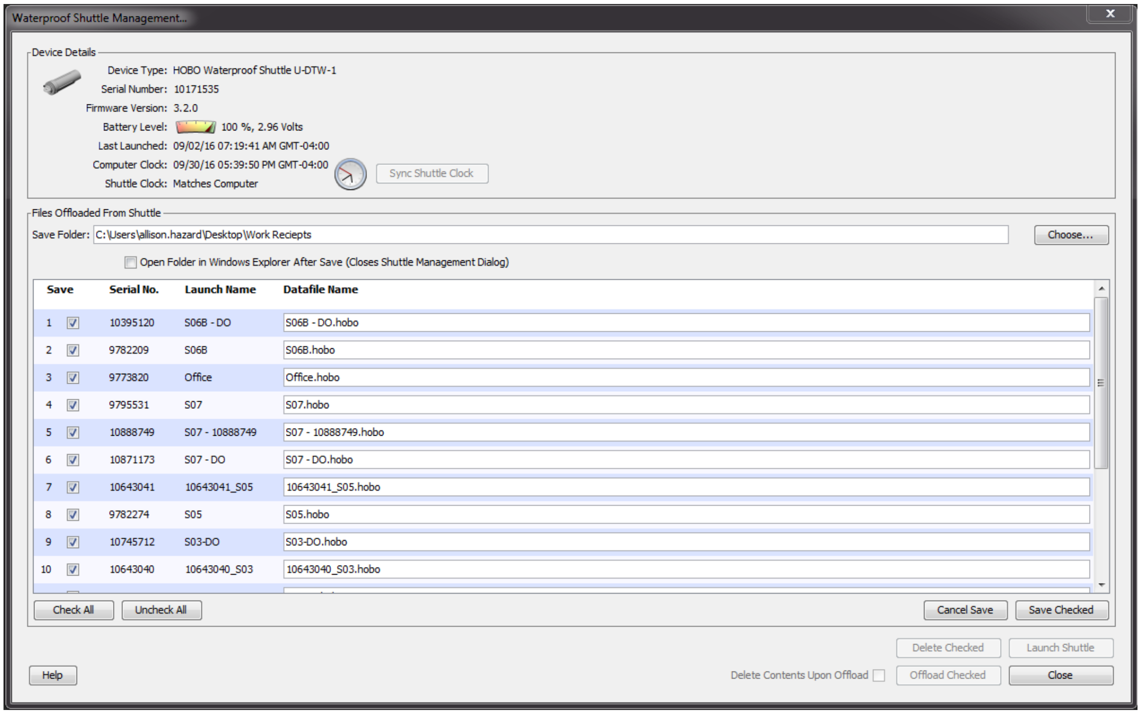
Offloading Data from Waterproof Shuttle

1. Open the HOBOware Pro software and connect shuttle to the computer.
2. Once the device is successfully connected, the HOBOware Pro software will display the name and serial number of the shuttle in the bottom left corner of the screen.
3. Under the **Device** tab, select **Manage Shuttle…**.
4. A window will pop up that lists the files on the shuttle. If a file has already been offloaded from the shuttle it will be indicated under the 'Status' tab.



5. Select the files that are to be offloaded from the shuttle. You may click "**Check All**" near the bottom left corner to select all files, whether previously offloaded or new files.

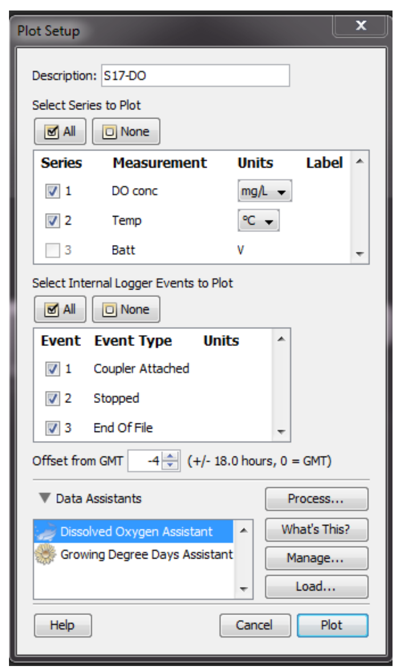
6. Click "**Offload Checked**" in the bottom right corner. The files are individually offloaded and the file names are displayed on the status tab.
7. Once all files are offloaded, choose and select the folder location to save the offloaded files. Data files can be renamed prior to saving to this folder.



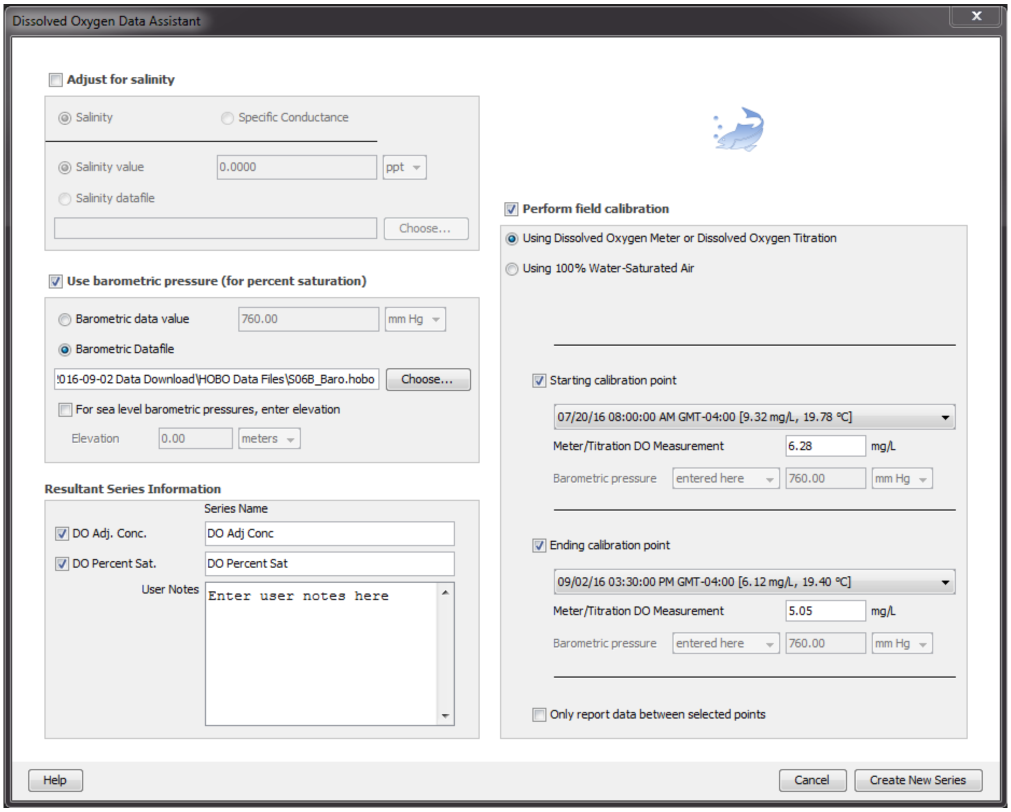
8. Check the files you would like to save and click "**Save Checked**" in the bottom right.

Adjust Dissolved Oxygen (DO) Data

1. Navigate to the saved files offloaded from the shuttle.
2. Open the DO file to be adjusted with the HOBOware Pro software.
3. A **Plot Setup** window will pop up, confirm the following:
   - That **Series 1 (DO conc)** has the units of **mg/L**; and
   - That **Series 2 (Temp)** has the units of **°C**.



4. Under **Data Assistants**, confirm the **Dissolved Oxygen Assistant** is highlighted and click **Process…**. The **Dissolved Oxygen Data Assistant** window will open.

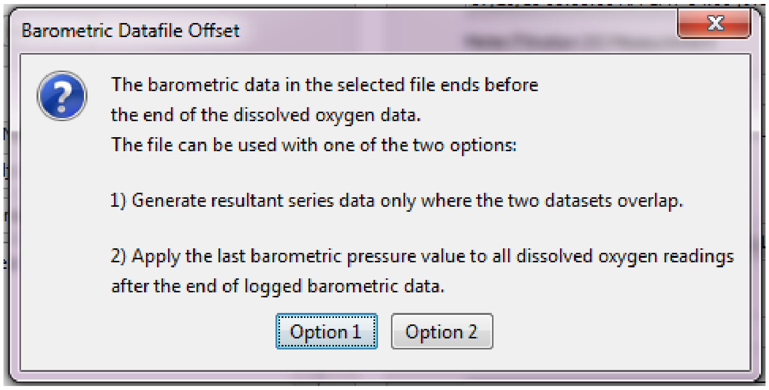


5. Click '**Use barometric pressure (for percent saturation)**.'
6. Click '**Barometric Datafile**.' Choose and navigate to the barometric datafile that should be used and corresponds to the same timeframe as the DO data set.
7. Under '**Resultant Series Information**', confirm that '**DO Adj. Conc.**' and '**DO Percent Sat.'** are checked.
8. Click '**Perform field calibration**.'
9. Click '**Using Dissolved Oxygen Meter or Dissolved Oxygen Titration**.'
10. Confirm that the '**Starting calibration point'** and '**Ending calibration point**' sections are checked. The starting and ending calibration points must be selected with corresponding Meter/Titration DO Measurement.
    - The calibration date and times must be selected and correspond to measurements recorded during field work. Use field notes to find dates/times that correspond for the start and end of the data set. Field notes should include recorded DO measurements and dates/times taken.
    - The field recorded DO values for the start and end calibration points must be entered under the '**Meter/Titration DO Measurement**.'

* *Depending on the DO measurements recorded by the HOBO meter, situations may call for a one-point calibration to adjust the values (e.g., logger stopped logging prior to retrieval or logger recorded zero/negative DO at time of deployment/retrieval). To do such, unclick either the '**Starting calibration point'** or '**Ending calibration point**' depending on field values available. A one-point calibration should only be used if a two-point calibration is not possible.*

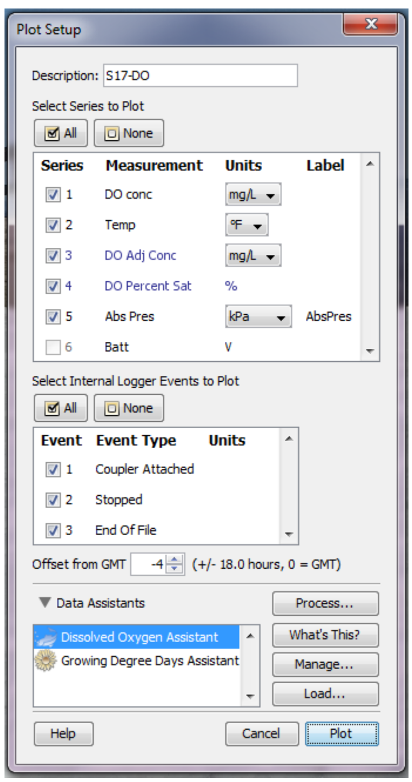
11. Click '**Create New Series**' in the bottom right hand corner.

* *A window may pop-up at this instance if the barometric datafile time range does not cover the entire time range of the DO datafile (entitled **Barometric Datafile Offset**).*

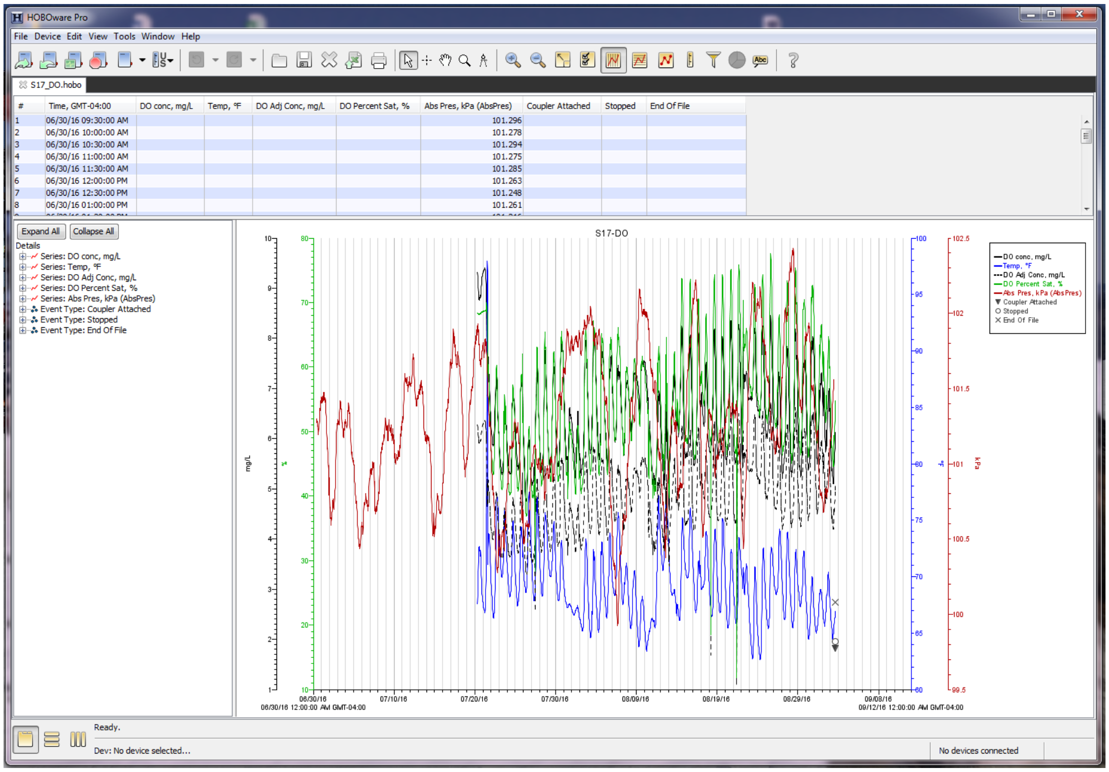


*Select **Option 2**. Note: DO data that is outside of the barometric pressure data file and adjusted based on an estimated barometric readings should be qualified/flagged.*

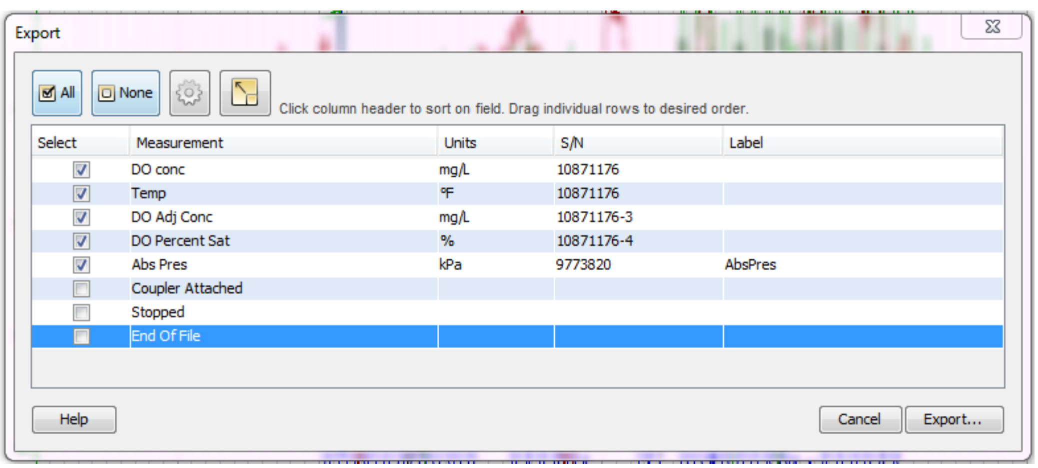
12. The **Plot Setup** window will open again with the new **DO Adj Conc** and **DO Percent Sat** series. In the window, confirm the following:
    - That **Series 1 (DO conc)** has the units of **mg/L**;
    - That **Series 2 (Temp)** has the units of **^{o}C**;
    - That **Series 3 (DO Adj Conc)** has the units of **mg/L**; and
    - That **Series 5 (Abs Pres)** has the units of **kPa**.



13. Click '**Plot**' in the bottom right corner.
14. The DO data file will open in both table and graph form.



15. Under the **File** tab, select **Export Table Data…**
16. In the export window, select and click the **DO conc**, **Temp**, **DO And Conc**, **DO Percent Sat** and **Abs Pres**. Leave the remaining measurements (e.g., **Coupler Attached**, **Coupler Detached**, **Stopped**, **End of File**) unchecked.



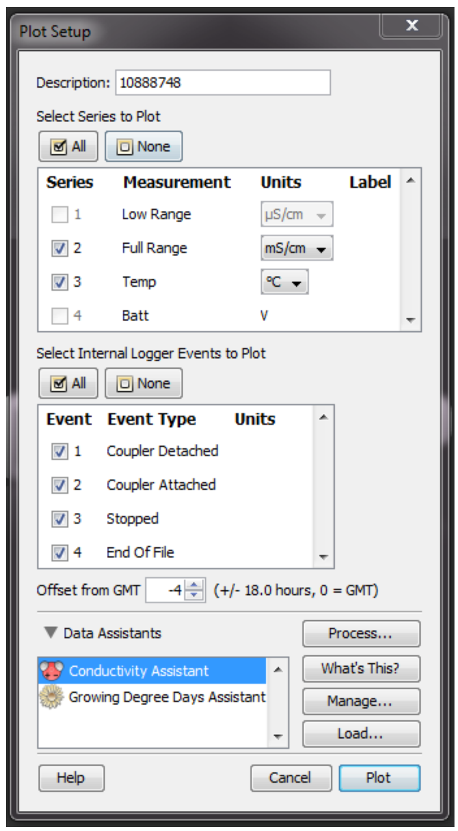
17. Click **Export…**
18. Name the data file and select the location for the saved data file. Click **Save**.

    ** The files will be saved as a .csv file. After the file is saved, it can be opened and resaved as an .xls (excel) file.*

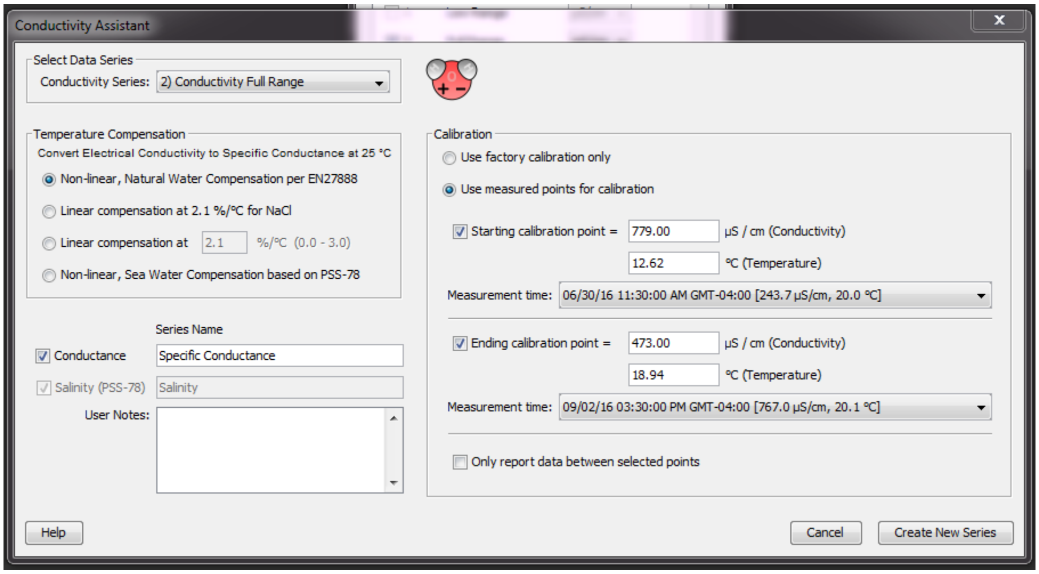
Adjust Conductivity Data

1. Navigate to the saved files offloaded from the shuttle.
2. Open the Conductivity file to be adjusted with the HOBOware Pro software.
3. A **Plot Setup** window will pop up. In the window, confirm the following:
   - That **Series 2 (Full Range)** has the units of **mS/cm**; and
   - That **Series 3 (Temp)** has the units of **°C**.

   ** **Series 1 (Low Range)** is grayed out because the HOBO conductivity logger is programmed to record the Full Range.*



4. Under **Data Assistants**, confirm the **Conductivity Assistant** is highlighted and click **Process…**. The **Conductivity Assistant** window will open.

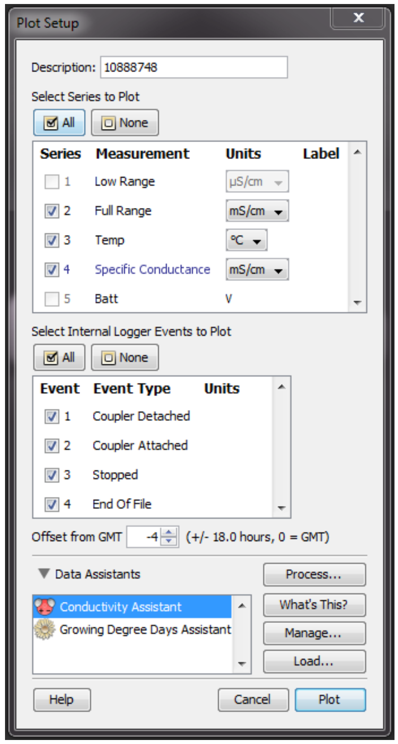


5. Under ‘**Temperature Compensation**’, confirm that ‘**Non-linear, Natural Water Compensation per EN27888**’ is checked.
6. Under ‘**Series Name**’, confirm that ‘**Conductance**’ is checked and is named ‘**Specific Conductance**’.
7. Under ‘**Calibration**’, confirm that ‘**Use measured points for calibration**’ is checked. Click ‘**Starting calibration point’** and ‘**Ending calibration point’**. The starting and ending calibration points must be selected with conductivity, temperature and measurement time.
   - The calibration measurement time (date and time) must be selected and correspond to conductivity measurements recorded during field work. Use field notes to find dates/times that correspond with the start and end of the data set. Field notes should include recorded conductivity measurements and dates/times taken.
   - The field recorded conductivity and temperature values for the starting and ending calibration points must be entered. Make sure the conductivity field measurements, recorded in mS/cm, are converted to µS/cm as required by the software. [1 ms/cm = 1000 µS/cm]

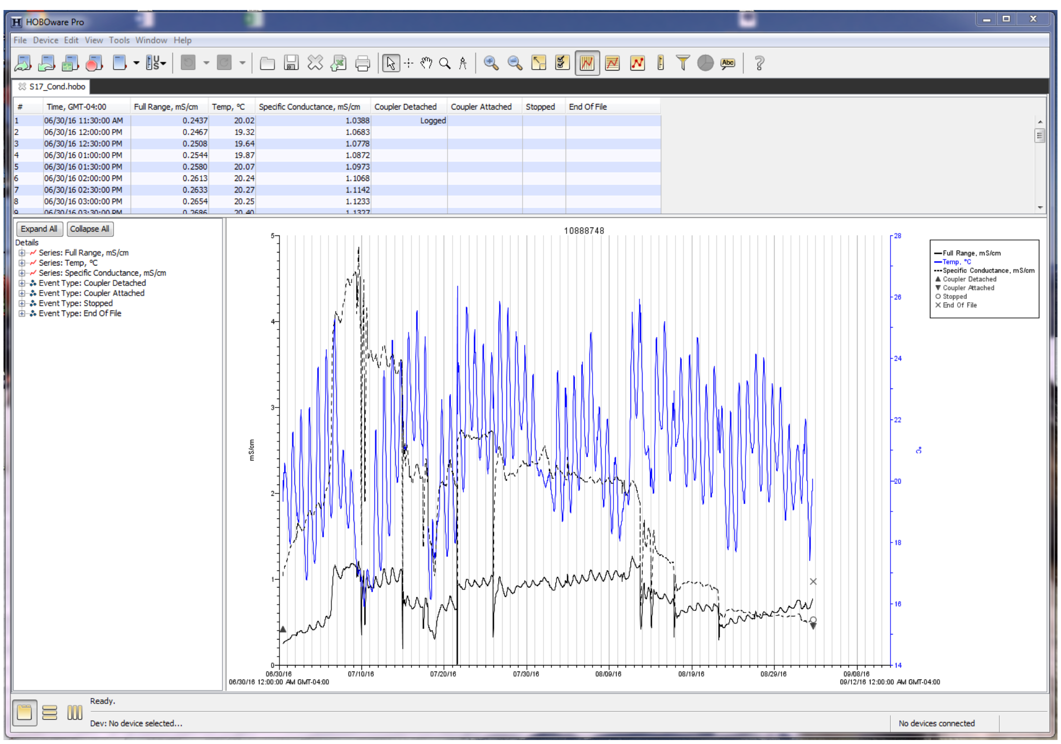
** Depending on the conductivity measurements recorded by the HOBO meter, situations may call for a one-point calibration to calculate specific conductivity (e.g., logger stopped logging prior to retrieval or logger recorded zero/negative conductivity at time of deployment/retrieval). To do such, unclick either the ‘**Starting calibration point’** or ‘**Ending calibration point**’ depending on which field values that may be used. A one-point calibration should only be used if a two-point calibration is not possible.*

8. Click ‘**Create New Series**’ in the bottom right hand corner.
9. The **Plot Setup** window will open again with the new **Specific Conductance** series. In the window, confirm the following:
   - That **Series 2 (Full Range)** has the units of **mS/cm**;
   - That **Series 3 (Temp)** has the units of **^{o}C**; and
   - That **Series 4 (Specific Conductance)** has the units of **mS/cm**.

LONG CREEK
Watershed Management District

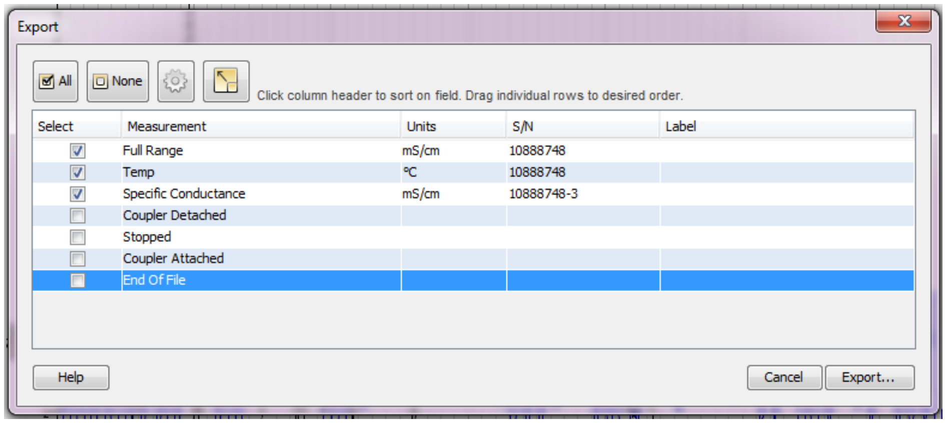


10. Click ‘**Plot**’ in the bottom right hand corner.
11. The Specific Conductance data file will open in both table and graph form.



12. Under the **File** tab, select **Export Table Data…**

13. In the export window, select and click the **Full Range**, **Temp** and **Specific Conductance.** Leave the remaining measurements unclicked (e.g., **Coupler Attached**, **Coupler Detached**, **Stopped**, **End of File**).

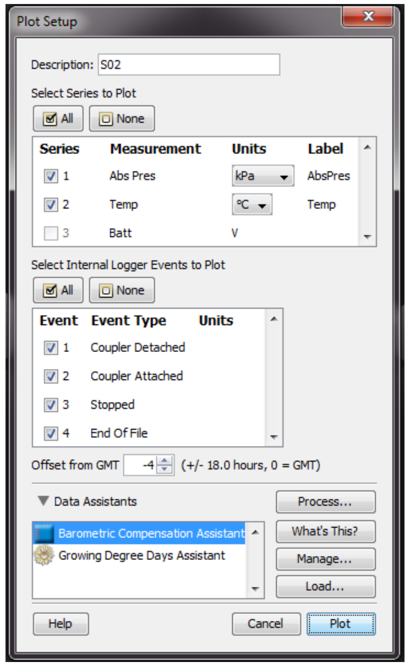


14. Click **Export…**
15. Name the data file and select the location for the saved data file. Click **Save**.

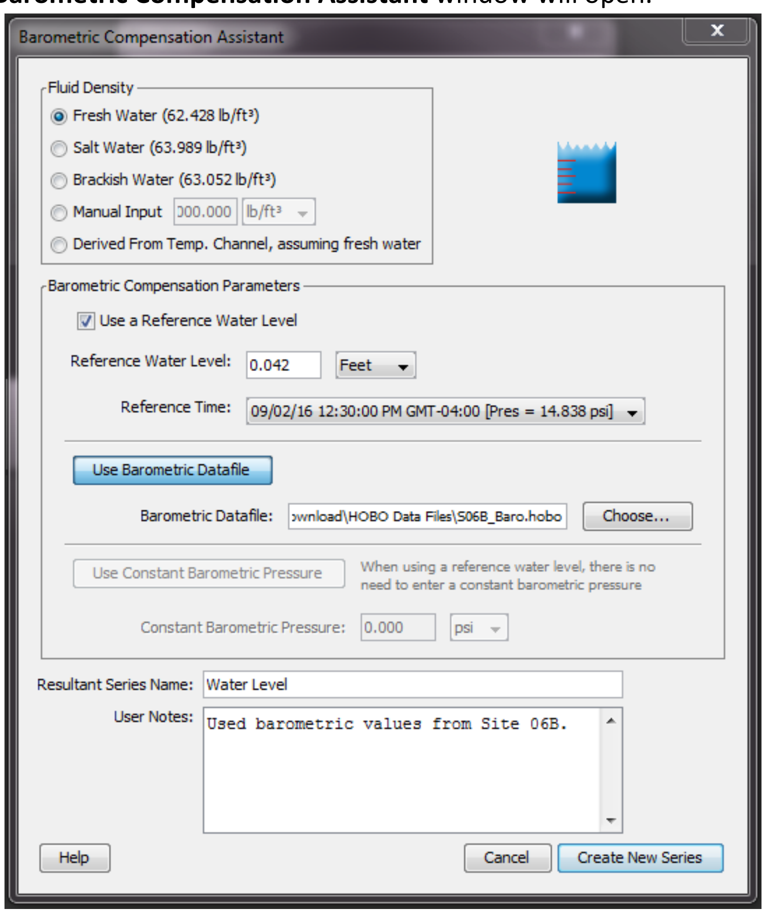
** The files will be saved as a .csv file. After the file is saved, it can be opened and resaved as an .xls (excel) file.*

Adjust Water Level Data

1. Navigate to the saved files offloaded from the shuttle.
2. Open the Water Level file to be adjusted with the HOBOware Pro software.
3. A **Plot Setup** window will pop up. In the window, confirm the following:
   - That **Series 1 (Abs Pres)** has the units of **kPa**; and
   - That **Series 2 (Temp)** has the units of **°C**.



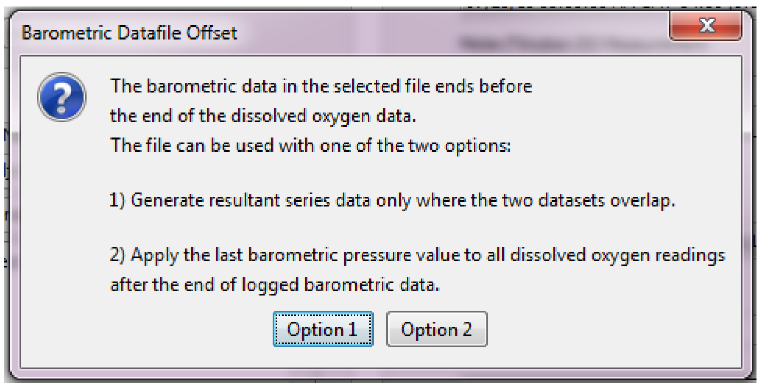
4. Under **Data Assistants**, confirm the **Barometric Compensation Assistant** is highlighted and click **Process….** The **Barometric Compensation Assistant** window will open.



5. Under ‘**Fluid Density**’, confirm that ‘**Fresh Water (62.428 lb/ft^3)**’ is checked.

6. Under '**Barometric Compensation Parameters'**, confirm that '**Use a Reference Water Level**' is checked. The **Reference Water Level** must be selected with corresponding **Reference Time**.
   - The **Reference Water Level** must be selected from a measurement taken with a tape measure at the stilling well at the time of data retrieval. Use field notes to find the recorded water level that corresponds to the start of the data set (a water level recorded at the end of the data set may be used if there was no recorded value at the start of the data set).
7. Click '**Use Barometric Datafile**.' Choose and navigate to the barometric data file that should be used and corresponds to the same timeframe as the level downloaded data set.
8. Enter any user notes, such as the source of the barometric data file and click '**Create New Series**'.

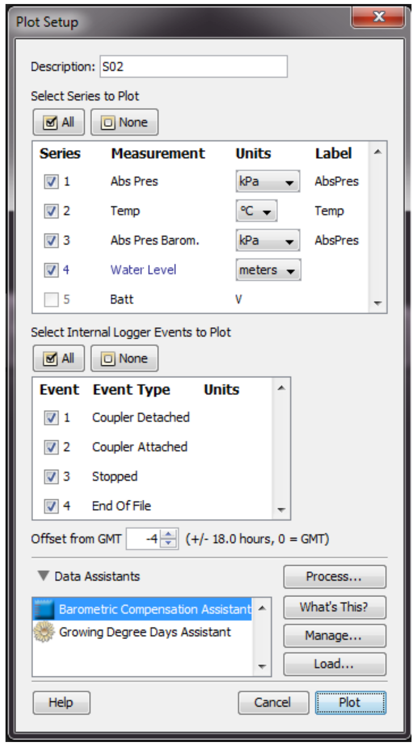
** A window may pop-up at this instance if the barometric data file time range does not cover the entire time range of the level data file (entitled **Barometric Datafile Offset**).*



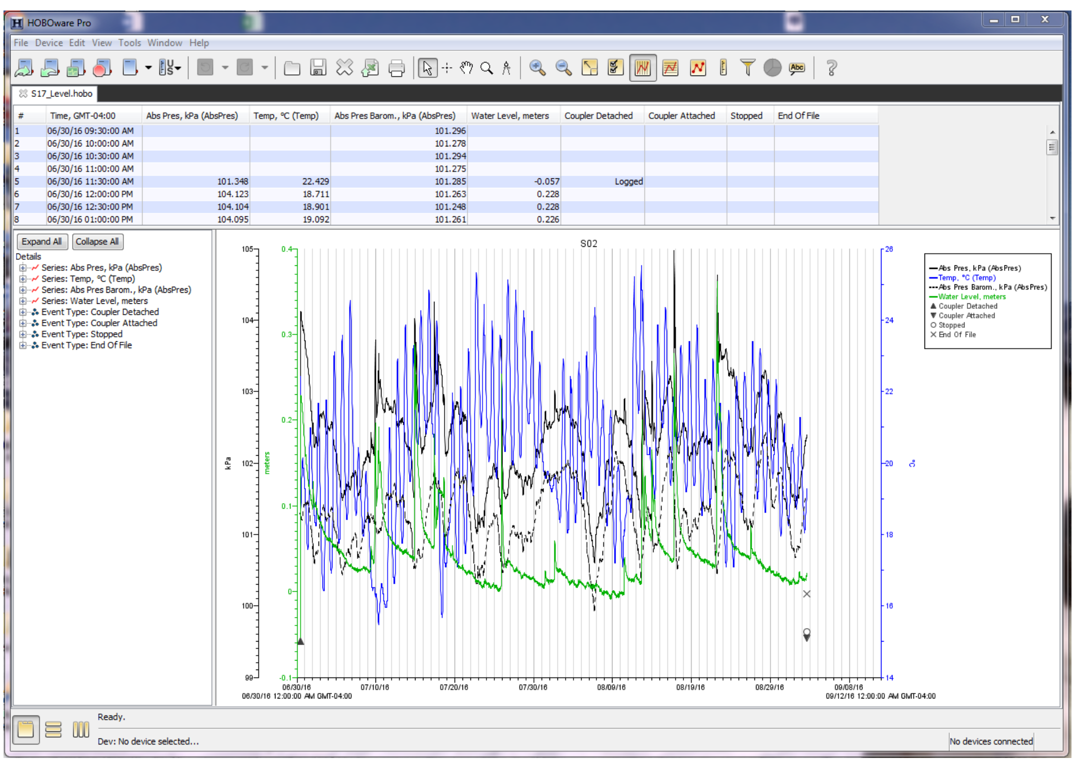
*Select **Option 2**. Note: water level data that is outside of the barometric pressure data file and adjusted based on an estimated barometric readings should be qualified/flagged.*

9. The **Plot Setup** window will open again with the new **Abs Pres Barom.** and **Water Level** series. In the window, confirm the following:
   - That **Series 1 (Abs Pres)** has the units of **kPa**;
   - That **Series 2 (Temp)** has the units of **°C**;
   - That **Series 3** (**Abs Pres Barom.**) has the units of **kPa**; and
   - That **Series 4** (**Water Level**) has the units of **meters**.

Long Creek Watershed Management District

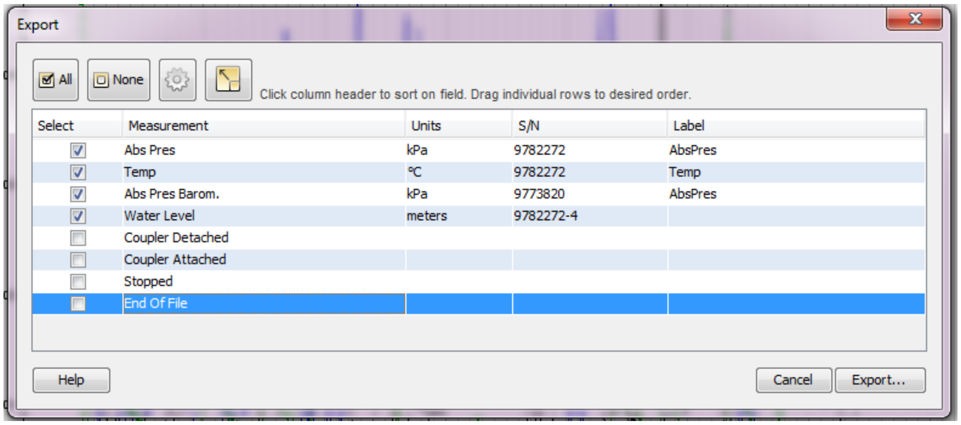


10. Click '**Plot**' in the bottom right.
11. The water level data file will open in both table and graph form.



12. Under the **File** tab, select **Export Table Data…**

13. In the export window, select and click the **Abs Pres**, **Temp**, **Abs Pres Barom.** and **Water Level.** Leave the remaining measurements unclicked (**Coupler Attached**, **Coupler Detached**, **Stopped**, **End of File**, etc).



14. Click **Export…**
15. Name the datafile and select the location for the saved datafile. Click **Save**.

** The files will be saved as a .csv file. After the file is saved, it can be opened and resaved as an .xls (excel) file.*

Data Validation and Management

Data validation requires inspection of the data. Electronic data logger files will undergo a 10% check by someone other than the person that downloaded the files from the loggers.

Inspect the data for obvious discontinuities, missing data periods, and/or outliers (data outside of the expected range). Data that appears suspect will be flagged.

Data will be formatted and uploaded to the LCWMD monitoring database in accordance with the Data Loading Quality Assurance Program Plan dated May 2016.

LONG CREEK HOBO METERS CALIBRATION AND DEPLOYMENT FORM

Site Number:

HOBO U-20, U-24, and U-26 Calibration and Launch

DO loggers were initiated with new sensor caps prior to deployment (circle one): Yes No NA

Date Initiated: Expiration Date:

DO Logger Calibration Date: Time:

Parameter	Measurement	Check as Completed
Dissolved Oxygen	water saturated air (100%)	
Dissolved Oxygen (mg/L)	zero DO solution (mg/L)	

DO Logger launched prior to deployment (circle one): Yes No NA

Date: Time:

Level Logger launched prior to deployment (circle one): Yes No NA

Date: Time:

Specific Conductivity Logger launched prior to deployment (circle one): Yes No NA

Date: Time:

Comments:

Field Installation

Date: Time: Technician:

Weather:

Condition of Stream:

Level Logger:

Benchmark elevation: Length of cord:

Comments:

Field Meter Comparison

Meter make, model, & serial number:

Parameter	Measurement
Temperature (^oC)	
Specific Conductivity (mS/cm)	
Dissolved Oxygen (mg/L)	

Comments:

Appendix I

Technical Application Note for Constructing a Stilling Well

To construct a simple PVC stilling well:
Use PVC Schedule 40 electrical conduit (to withstand UV in an outdoor environment). The biggest advantage of electrical conduit is that electrical elbows are all large-radius turns. Plumbers would call electrical elbows "sweep elbows."

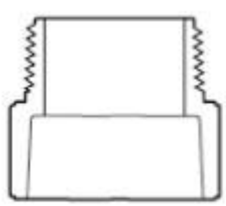
The HOBO® U20 logger's 1x6-inch form factor will fit through 1.5-inch electrical PVC conduit elbows with plenty of clearance (and probably 1.25-inch electrical PVC elbows as well).

You need to cap your stilling well for security. The cap will also serve to keep debris, insects, and small animals out. Regular (potable) water wells require an approved well cap to prevent contaminating the ground water.

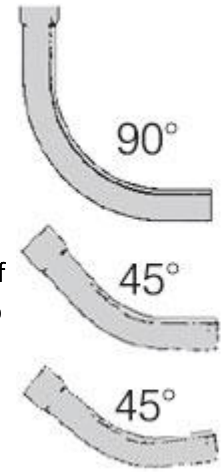
Well caps are usually aluminum or a thermoplastic and include a vent hole screen to equalize any pressure difference between the inside and outside. If your well cap does not have a vent you could remove the O-ring (if any) from the cap or drill a few small holes in the pipe (or cap). This should suffice to equalize pressure in your stilling well. Because the HOBO U20 logger is completely submersible, the casing and cap do not need to extend above the ground or above flood level. Normally you would extend the well casing and cap 6 inches or so above the ground to help keep dirt out of your lock and well. The logger used for barometric correction needs to be mounted higher than flood level.

One nice well cap is the Pro Hydro well cap. http://www.prohydroinc.com/prohydrowellcap.html

You could also use a 2-inch aluminum or PVC locking cap. An example of an aluminum locking-cap with female threads is the 751-202-01.



Thread the cap onto a Schedule 40 2-inch male adapter. You would want to use a pipe joint thread sealant (or slow curing epoxy) that hardens to keep people from un-threading your locking cap (lock-tite in a small blue tube).



Use straight sections of Schedule 40 conduit, making any bends using standard electrical radius elbows. Electrical PVC elbows have a long radius sweep. Gravity will make your logger slide down vertical pipes. If the location of your sensor in the well approaches a horizontal grade, you may need to push your logger through. If you must have push-pull capability, you can install small-diameter vinyl tubing (flexible hose) over your wireline.

End your stilling well with a slotted pipe section or section of PVC with several 1/4" holes drilled into it - maybe with a cap on the end.

For instructions on how to mount a HOBO Water Level Logger in a well see Wireline Mounting a Water Level Logger in a Well

The location of water level loggers in the stream should be “surveyed in” so that if they become damaged or dislodged they can be resituated back to the same location to allow for comparable data sets from year to year. The surveyed “location” might be a reference point on the pipes (stilling wells) in which the loggers are contained at each site. Follow the guidance on how to “survey in” objects (e.g., water level loggers, along with datums and benchmarks) in chapter 5 of Harrelson et al. (1994).

Data Quality

In some cases, water level measured by pressure transducers may not always match exactly water levels that are observed manually by a technician viewing a staff gage at the same site. Under their Methods/Data-Analysis section, Bowden and Clayton (2010) provided an explanation of how they created a regression equation that established the relationship between manually recorded measurements of stage (SM) and water level recording devices (SR) at individual field sites.

References

Bowden, W. B. and M. Clayton. 2010. Vermont Stormwater Flow Monitoring Project – Final Report 2006-2008. University of Vermont, Burlington, VT. Prepared for Vermont Agency of Natural Resources. http://www.uvm.edu/bwrl/vermontflow/ (then click on Digital Archive)

Freeman, L. A., M. C. Carpenter, D. O. Rosenberry, J. P. Rousseau, R. Unger, and J. S. McLean. 2004. Use of Submersible Pressure Transducers in Water-Resources Investigations. U. S. Geological Survey Techniques of Water-Resources Investigations 8-A3. http://pubs.water.usgs.gov/TWRI8a3/

Harrelson, C. C., C. L. Rawlins, and J. P. Potyndy. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: US Dept. of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 pp. http://stream.fs.fed.us/publications/documentsStream.html

Rantz, S. E., and others. 1982. Measurement and Computation of Streamflow: Measurement of Stage and Discharge (Volume 1) and Computation of Discharge (Volume 2). US Geological Survey Water-Supply Paper 2175. http://pubs.usgs.gov/wsp/wsp2175/

2017: Onset HOBO U-20 Water Level Logger Tech Notes
http://www.onsetcomp.com/water_level_stilling_well.html

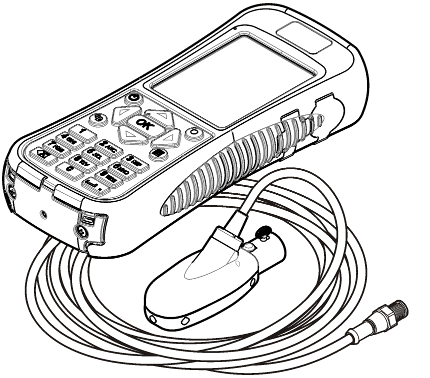
Appendix J

DOC026.52.80210

FH950

07/2012, Edition 3

User Manual



Specifications

Specifications are subject to change without notice.

Sensor specifications

Specification	Details
Velocity measurement	
Method	Electromagnetic
Range	0 to 6.09 m/s (0 to 20 ft/s)
Minimum water depth	3.18 cm (1.25 in.)
Accuracy	±2% of reading ±0.015 m/s (±0.05 ft/s) 0 to 3.04 m/s (0 to 10 ft/s); ± 4% of reading from 3.04 to 4.87 m/s (10 to 16 ft/s)
Resolution	0.01 value < 100; 0.1 value < 1000; 1.0 value ≥ 1000
Zero stability	±0.015 m/s (±0.05 ft/s)
Material	ABS, glass filled
Enclosure rating	IP68
Dimensions (L x W x H)	11.9 x 4.3 x 6.3 cm (4.7 x 1.7 x 2.5 in.)
Cable material	Polyurethane jacketed
Cable lengths	1.5, 6.1, 12.2 and 30.5 m (5, 20, 40 and 100 ft)
Depth measurement	
Method	Diaphragm type: absolute pressure with single point calibration
Accuracy (static)	The larger of ± 2% of reading or ± 0.015 m (± 0.504 inches). Steady state temperature and static non-flowing water.
Range	3.05 m (0-10 ft)
Resolution	0.01 value < 100; 0.1 value < 1000; 1.0 value ≥ 1000

Portable meter specifications

Specification	Details
Pollution degree	2
Protection class	II
Charging temperature	0 to 40 ºC (32 to 104 ºF)
Operating temperature	–20 to 55 ºC (-4 to 131 ºF)
Storage temperature	–20 to 60 ºC (-4 to 140 ºF)
Enclosure rating	IP67
Battery life gauge	Five-segment bar graph
Battery type	Rechargeable lithium ion, 3.7 V, 4.2 Ah
Battery life	18 hours heavy typical day use[1]; 20 ºC (68 ºF)
Battery charger	External Class III power adapter 100–240 VAC, 50–60 Hz, 0.3 A input; 12 VDC, 1.0 A output
Dimensions (L x W x H)	21.8 x 9.3 x 5.3 cm (8.6 x 3.7 x 2.1 in.)

Specification	Details
USB connector	Type Mini-B, 5-pin, rated to IP67 when capped
Material	Polycarbonate with a thermoplastic elastomer (TPE) overmold

[1] Defined as 30 minutes of set up, six 1-hour periods of continuous use with an active sensor and the display at maximum brightness and 30 minutes of sleep mode between use periods, data download and power off.

User interface specifications

Specification	Details
Graphics display	Color, LCD 3.5" QVGA transflective (readable in direct sunlight)
Measurement resolution	0.01 value < 100; 0.1 value < 1000; 1.0 value ≥ 1000
Keypad	Alpha-numeric
Operating modes	Real time, profiling
Profile types	Stream, conduit
Conduit shapes	Circular, rectangular, trapezoidal, 2/3 egg, inverted 2/3 egg
Stream entries	Fixed, non-fixed stations
Noise rejection	User-selectable, 50 Hz or 60 Hz
Units of measure	Velocity: ft/s, m/s, cm/s, mm/s
	Flow: ft^3/sec, million gal/day, gal/day, gal/min, m^3/s, m^3/min, m^3/hour, m^3/day, liters/s, liters/min
	Depth: in., ft, m, cm, mm
Stream flow calculation	Mean-section or mid-section method
Diagnostics	Self test, keypad, display, event log
Conduit profiling methods	0.9 x Vmax, 0.2/0.4/0.8, velocity and level integrator, 2D
Stream profiling methods	1, 2, 3, 5 and 6 point (velocity method - USGS and ISO)
File types	Real-time, profiling, event log
Languages	English, French, Spanish, German, Italian, Dutch, Danish, Swedish, Chinese, Polish, Japanese, Korean, Portuguese, Slovak, Russian, Hungarian, Bulgarian, Romanian, Czech, Turkish, Finnish, Greek

General specifications

Specification	Details
Profiles	Data storage for up to 10 profiles with 32 stations per profile
Maximum number of real-time files	Three each with up to 75 readings captured by the user.
Firmware	The sensor and portable meter are field upgradeable via USB

General information

In no event will the manufacturer be liable for direct, indirect, special, incidental or consequential damages resulting from any defect or omission in this manual. The manufacturer reserves the right to make changes in this manual and the products it describes at any time, without notice or obligation. Revised editions are found on the manufacturer’s website.

Safety information

NOTICE

The manufacturer is not responsible for any damages due to misapplication or misuse of this product including, without limitation, direct, incidental and consequential damages, and disclaims such damages to the full extent permitted under applicable law. The user is solely responsible to identify critical application risks and install appropriate mechanisms to protect processes during a possible equipment malfunction.

Please read this entire manual before unpacking, setting up or operating this equipment. Pay attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

Make sure that the protection provided by this equipment is not impaired. Do not use or install this equipment in any manner other than that specified in this manual.

Use of hazard information

DANGER

Indicates a potentially or imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Indicates a potentially hazardous situation that may result in minor or moderate injury.

NOTICE

Indicates a situation which, if not avoided, may cause damage to the instrument. Information that requires special emphasis.

Precautionary labels

	This symbol, if noted on the instrument, references the instruction manual for operation and/or safety information.
	This symbol indicates the presence of devices sensitive to Electro-static Discharge (ESD) and indicated that care must be taken to prevent damage with the equipment.
	Electrical equipment marked with this symbol may not be disposed of in European public disposal systems after 12 August of 2005. In conformity with European local and national regulations (EU Directive 2002/96/EC), European electrical equipment users must now return old or end-of-life equipment to the Producer for disposal at no charge to the user. ***Note:*** *For return for recycling, please contact the equipment producer or supplier for instructions on how to return end-of-life equipment, producer-supplied electrical accessories, and all auxiliary items for proper disposal.*

Certification

Canadian Radio Interference-Causing Equipment Regulation, IECS-003, Class A:

Supporting test records reside with the manufacturer.

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numèrique de la classe A respecte toutes les exigences du Rëglement sur le matériel brouilleur du Canada.

FCC Part 15, Class "A" Limits

Supporting test records reside with the manufacturer. The device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions:

1. The equipment may not cause harmful interference.
2. The equipment must accept any interference received, including interference that may cause undesired operation.

Changes or modifications to this equipment not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at their expense. The following techniques can be used to reduce interference problems:

1. Disconnect the equipment from its power source to verify that it is or is not the source of the interference.
2. If the equipment is connected to the same outlet as the device experiencing interference, connect the equipment to a different outlet.
3. Move the equipment away from the device receiving the interference.
4. Reposition the receiving antenna for the device receiving the interference.
5. Try combinations of the above.

Product overview

The portable velocity system is used in the field, laboratory and municipalities. Turbulent, noisy and low flows can be measured with this system.

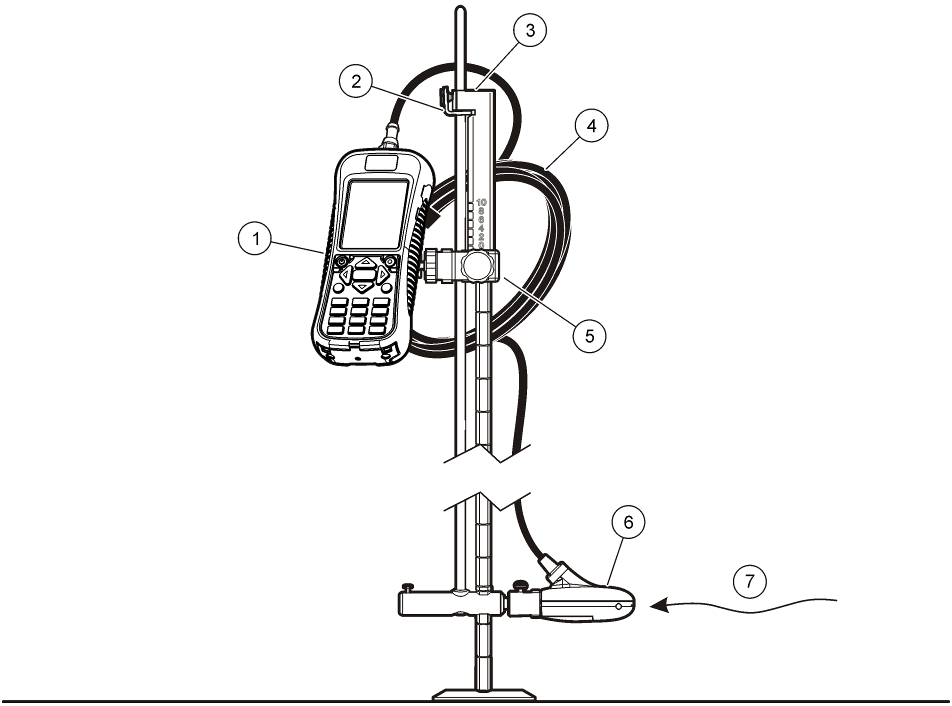
The meter and sensor get velocity information in conduits and streams. These measurements are important for calibration in municipal wastewater industries, as well as for environmental-impact evaluations.

Two types of sensor are available: velocity-only and velocity plus depth. This manual covers both types of sensors. If information applies to a specified type of sensor, this fact is noted in the text.

System overview

An overview of the assembled system is shown in Figure 1. Refer to the documentation supplied with the individual components or accessories for more information.

Figure 1 Assembled components

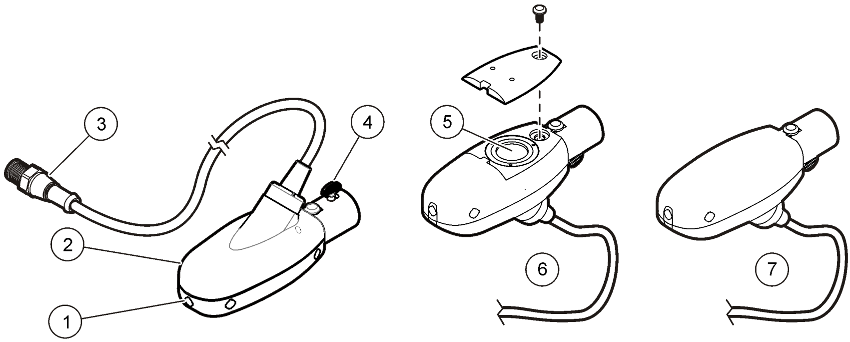


1 Portable meter	**5** Adjustable mount for portable meter
2 Sensor height lock/release device	**6** Sensor assembly
3 Top setting wading rod (optional accessory)	**7** Flow direction
4 Sensor cable	

Sensor overview

Figure 2 shows the main sensor components. Instructions for how to attach the sensor on a standard or top-setting wading rod are supplied with the accessory.

Figure 2 Sensor components

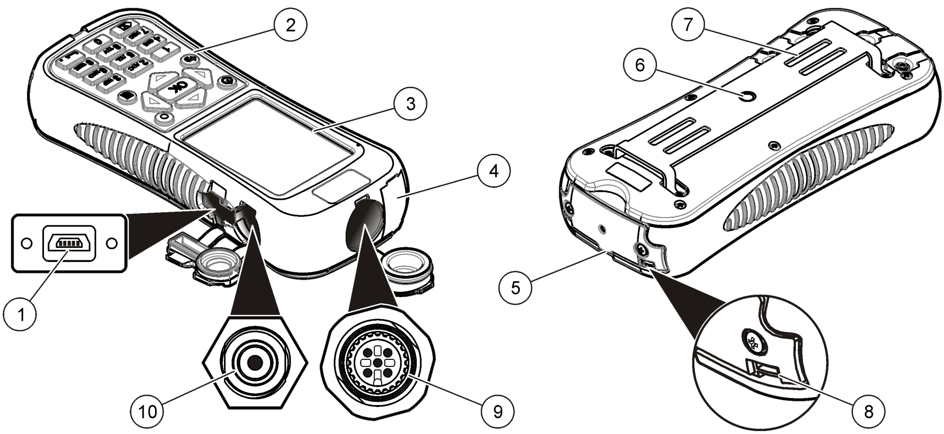


1 Sensor electrodes	**5** Pressure cell (sensors with depth option)
2 Sensor body	**6** Sensor with depth option
3 Sensor connection plug	**7** Sensor without depth option
4 Sensor attachment thumb screw	

Meter overview

Figure 3 shows the features of the meter.

Figure 3 Meter components

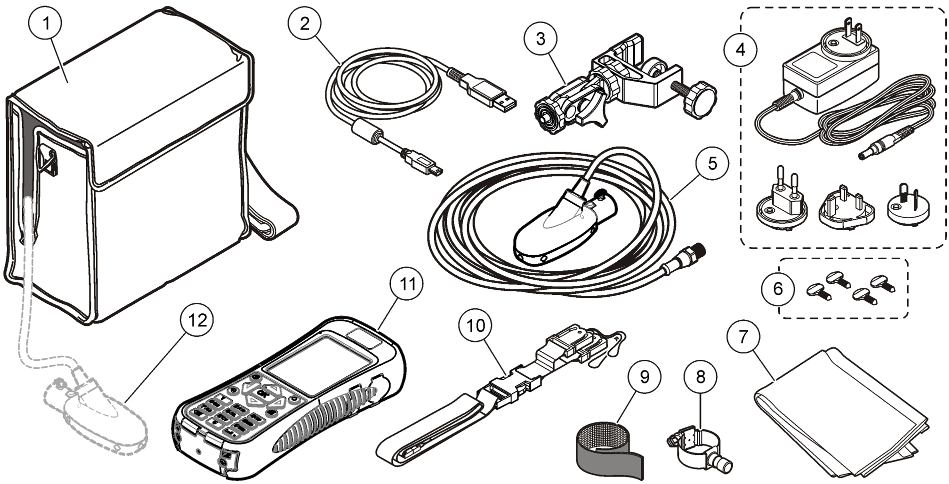


1 USB connection port	**6** Threaded hole for adjustable meter mount
2 Keypad	**7** Slots for velcro or strap attachment
3 Meter display	**8** Slot for neck strap attachment threads (2x)
4 Expansion port (not used)	**9** Sensor connection port
5 Battery compartment cover	**10** Wall-charger connection port

Product components

When purchasing a complete system, refer to Figure 4 to make sure that all components have been received. If any of these items are missing or damaged, contact the manufacturer or a sales representative immediately.

Figure 4 System components



1 Carrying case (with slot for sensor cable)	**7** Cloth to dry the sensor
2 USB communication cable	**8** Universal sensor mount
3 Adjustable portable meter mount	**9** Velcro strap
4 Wall charger and universal plug kit	**10** Lanyard
5 Sensor	**11** Portable meter
6 Extra thumb screws (4x)	**12** Sensor as connected to meter inside case

Installation

Installation with optional accessories

Mount the meter on an optional wading rod for use in low-stage stream environments where the stream can be waded. Optional accessories let the user take measurements from a bridge or cable over a stream. A torpedo shaped weight attached below the sensor keeps the sensor in place when under water. For more information, refer to the documentation supplied with the accessory.

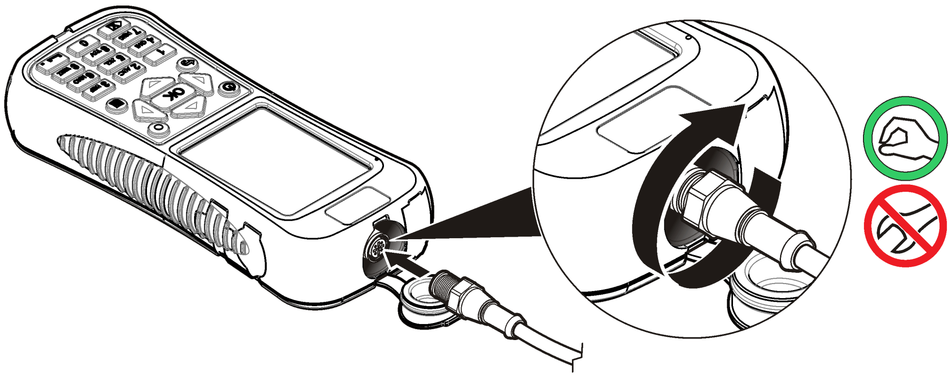
Install the sensor on the universal sensor mount

Use the universal sensor mount to attach the sensor to poles 1 inch or less in diameter. For correct operation and accurate readings, the front of the sensor must be pointed upstream with the electrodes in full contact with the flow.

Note: *Keep the sensor electrodes free from nonconductive substances such as oil and grease. To remove sensor contamination, refer to* *Clean the sensor on page 26.*

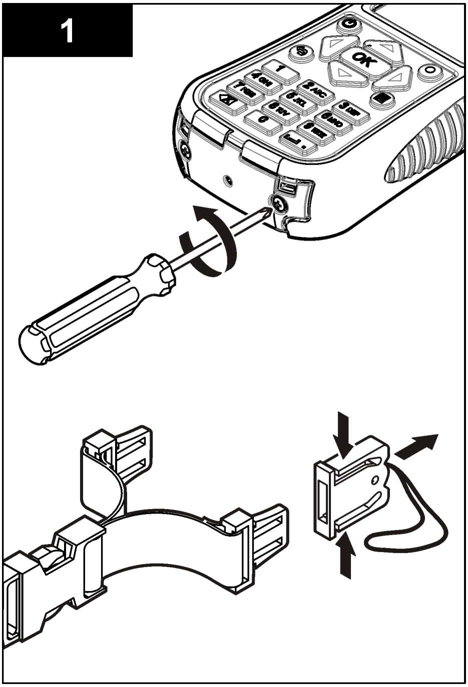
1. The front part of the sensor is round and contains three electrodes. The sensor has a mounting hole in back and a thumbscrew on top. Put the mounting shaft of the universal mount in the mounting hole at the back of the sensor. Make sure that the mounting shaft is completely engaged with the mounting hole and the thumbscrew is engaged with the groove.
2. Hand tighten the thumbscrew.
3. Move a pole 1 inch or less in diameter through the clamp of the universal sensor mount. Tighten the clamp.
   Note: *Instructions for how to mount the sensor on a standard or top setting wading rod are supplied with the accessory.*

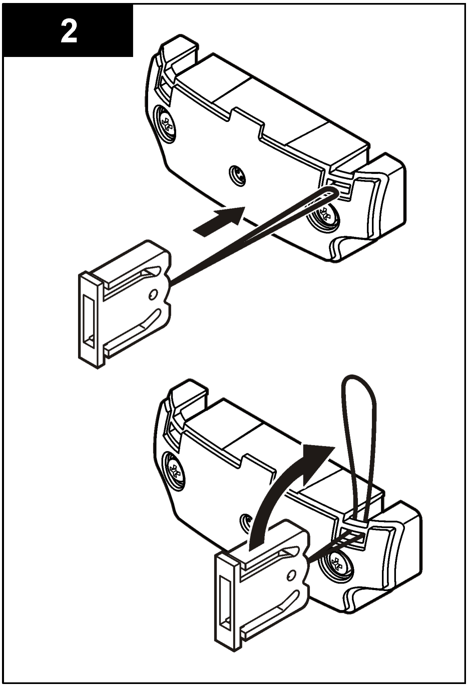
Connect the sensor to the meter

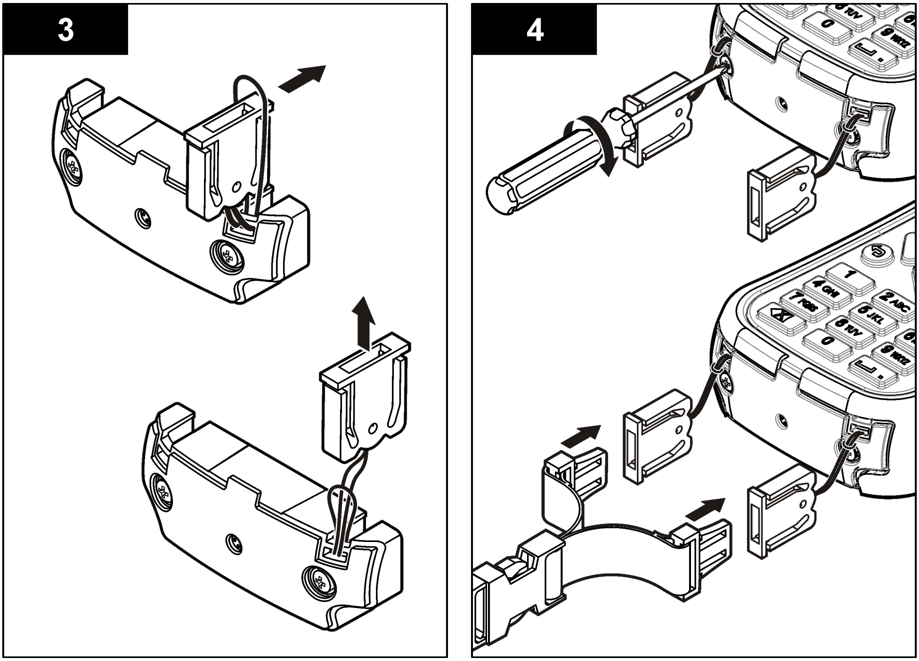


Attach the lanyard

Attach the lanyard to wear the meter safely around the neck.



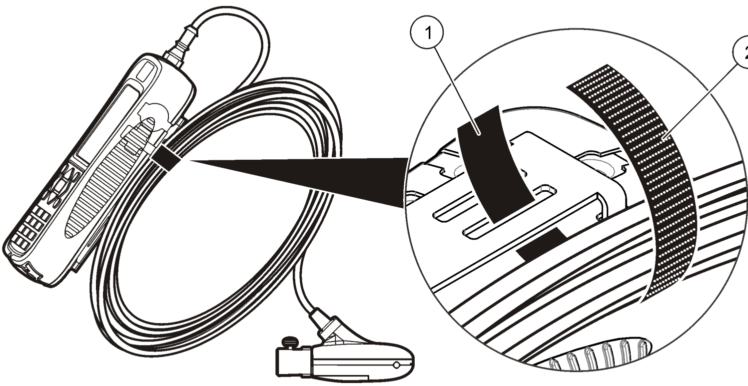




Attach the velcro strap

Use the velcro strap to hold the extra cable. Refer to Figure 5.

Figure 5 Attach the velcro strap



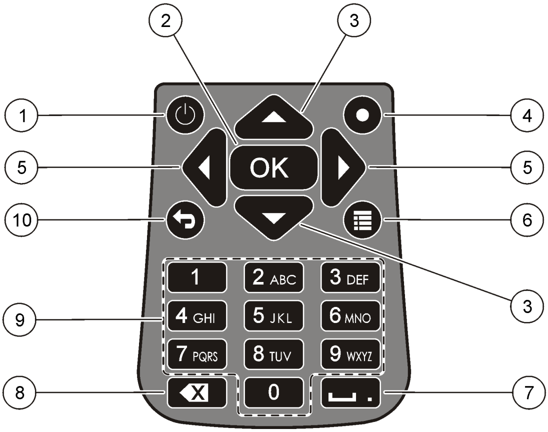
1 Loop side	**2** Hook side

User interface and navigation

Keypad and key functions

Figure 6 shows the meter keypad. Table 1 gives the functions of each key or key type.

Figure 6 Keypad



1 Power On/Off	**6** Main Menu
2 OK	**7** Underscore or decimal
3 Up and Down arrows	**8** Backspace
4 Quick Jump	**9** Alpha-numeric
5 Right and Left arrows	**10** Previous menu

Table 1 Key description

Key	**Description**
Power On/Off	Energizes and de-energizes the meter.
OK	Confirms an entry or highlighted menu option.
Up and Down arrows	Moves up or down in the display. If the cursor is at the top or bottom of the display, the cursor wraps to the bottom or top when the UP or DOWN arrow is pushed.
Quick Jump	In normal operation, this key jumps to the Select conduit shape screen. If the auto-zero feature is disabled, hold this key for five seconds to do a manual zero of the depth sensor. In Real-Time mode, the Quick Jump key toggles between the digital and graph views.
Right and Left arrows	Moves to the right or left in the display.
Main Menu	Moves to the Main Menu from any submenu or screen.
Underscore or decimal	Puts in an underscore or decimal character. In numeric-only fields, this key automatically puts a decimal point in the cursor position.
Backspace	Moves the cursor back one space.
Alpha-numeric	Puts in the key alpha or numeric value. Values are put in the order shown on the key. After 2 seconds, the value shown in the display is stored and the cursor advances.
Previous menu	Moves to the previous screen.

Status bar

A status bar is shown in the top of the display. Descriptions of the information in the status bar are given in Table 2.

Table 2 Status bar indicators

Indicator	Description
Time and Date	Shows the current time and date.
USB	Shows when a USB cable is connected. If a USB cable is connected and this indicator does not show in the status bar, the USB cable is not fully engaged. Make sure that the USB cable is pushed in completely and makes full contact with the connection port.
Conductivity	If the sensor is out of the water and non-conductive, a blue ring appears next to the battery icon. If the sensor is in the water and conductive, the indicator is a solid blue circle.
Battery	A five-bar graph shows the level of charge in the battery.
File access	Shows while the meter gets access to a file.
Auto zero depth indicator	If the depth sensor was zeroed in the last 30 minutes, a solid green circle shows next to the Conductivity indicator. If the depth sensor was not zeroed in the last 30 minutes, this indicator flashes red.

Navigation and Main Menu

Push **OK** to confirm a selected menu option or a value shown in the display. Select More and push **OK** to see additional screens and options if available. Push the Main Menu button to go to the Main Menu from a submenu.

Note: *Some operations cannot be completed unless a sensor is connected to the meter. If these operations are tried when there is no sensor connected, the display shows an error message. Connect a sensor and try the operation again.*

1. **Real time**—Select this option to get real-time velocity and depth information. (A sensor with depth capability is necessary to read depth). An example of a Real Time screen for sensors with velocity only is shown in Figure 7. Real time screens for sensors with both velocity and depth is shown in . The format of the information and options shown depends on the type of sensor used. In Real Time mode, the Quick Jump key toggles between digital and graphic views of Real Time information. The velocity is updated in FPA filter mode according to fixed period averaging time. In RC filter mode, the velocity is updated continuously on the screen every 250 ms.

Option	Description
Capture	Stores the depth and velocity information shown in memory. The information is saved until power is cycled, the memory is saved to a non-volatile real-time file, or the user exits from real-time mode.
Save	Saves captured measurements in the volatile memory to a non-volatile real-time file. A message will show if the number of files is greater than the maximum possible. Files are stored in tab delimited (.tsv) format.
Done or OK	Exits the real-time mode and returns to the Main Menu. If there is unsaved data in volatile memory, a confirmation message asks the user to confirm the exit without saving the data.
Clear	Clears captured measurements from the volatile memory buffer. The user can choose from Clear Last, Clear All or Cancel options.

Option	Description
Setup	Allows the user to modify the main filter parameters and enable and program the Maximum Depth sensor positioning feature. The Maximum depth feature allows a user to enter system parameters for depth measurement in Real Time mode. The user can choose to enter a maximum depth value taken directly with a ruler measurement (manual), or taken indirectly with the depth measurement (automatic). Both methods enable the Maximum Depth sensor positioning feature. In automatic mode setup, the user directly enters the distance from the bottom of the channel to the bottom of the sensor mount (offset). The setup interface will continuously show the current depth value returned by the sensor plus the offset. The meter stores this value as the Maximum Depth when the OK button is pushed. In all other cases, the depth values shown do not include the offset. The Maximum depth feature requires a sensor with velocity plus depth.
Files or View	Shows a summary of each real-time file stored in non-volatile memory. Files can be individually viewed and deleted.

Figure 7 Real time screen

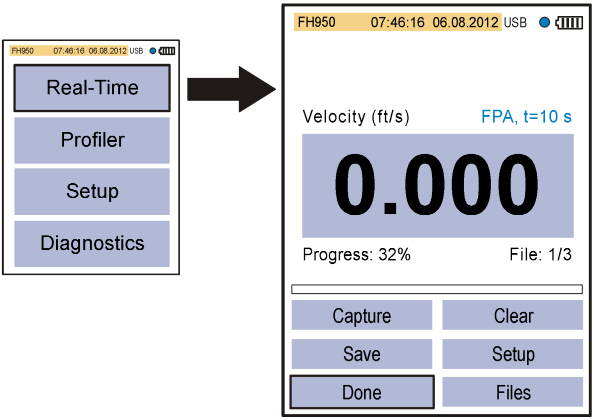
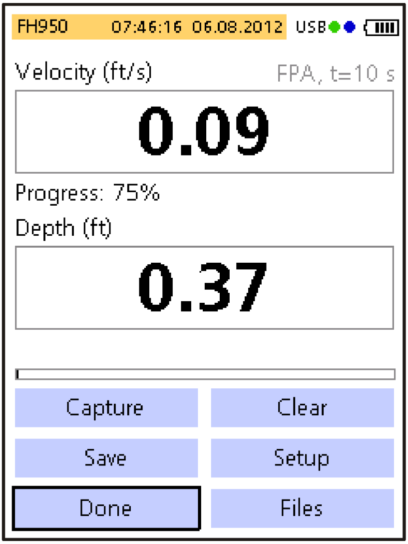


Figure 8 Real time screen for sensor with depth



2. **Profiler—** Select this option to do stream or conduit velocity measurements. The meter shows prompts when user input is necessary. The meter saves up to 10 profiles with up to 32 stations per profile. This number can be greater if data acquisition time is less than the maximum. A percentage of the remaining memory is given in 1% resolution. Refer to the Appendix on page 31 for more information about profiles.

Option	Description
Stream	This option is used to set up a profile for a stream or flowing channel. Do velocity measurements to calculate total discharge based on ISO 748 or USGS standards for Mid-section or Mean-section methods.
Conduit	This option is used to set up a profile for a conduit.
Files	This option is used to view or delete stored files. Files can be deleted all at once or individually.
Setup	This option is used to set up or change the settings for filter parameters and the Maximum Depth feature.

3. **Set up**—Select this option to change general system settings and preferences.

Option	Description
Velocity calibration	Calibrates the sensor. Adds a field offset to the factory calibration. Refer to the Appendix on page 31 for more information.

Option	Description
Filter parameters	Applies a data acquisition filter (Main filter or Pre-filter). The user can select the filter parameters. **Main filter** • Fixed Period Averaging (FPA)—Fixed Period Averaging averages data over a user selectable fixed period of time (1 to 480 seconds). The default is 10 seconds. If the FPA value is 5, the velocity value shown in the display is updated once every 5 seconds. • RCA time constant—The RC filter helps smooth out turbulence through the use of a selected time constant in the filter algorithm. This mode is useful when searching for a maximum velocity, for example in the common 0.9 x Vmax profile method. High RC filter time constants give higher degrees of smoothing. The time constant can be set from 2 to 20 seconds, with a default value of 6. At 1 time constant, the filter settles to approximately 60% of the final value. At 5 time constants, the filter settles to 99.9% of the final value. Thus, if the RC value is set to 2, the final value shows after 10 seconds. **Pre-filter** • Median filter—The filtering process is done in the sensor. The feature can be disabled. However, the recommended (default) value is 5. Enable the feature to enter or change this value.
Wet/dry threshold	Sets the sensor submersion threshold for wet and dry conditions. The default value is 20%. Refer to Wet/Dry threshold on page 33 for more information.
Auto zero depth	Sets the Auto Zero feature to On or Off. If set to On, the instrument does an air calibration when the sensor is removed from the water and is in the air. To do the air calibration, the instrument automatically zeroes the sensor. If set to Off, the user can manually zero the sensor. To do this, remove the sensor from the flow, then push and hold the Quick Jump key for five seconds. When the sensor has been in the flow for 30 minutes, the green circle in the upper right corner goes from green to red. This is a prompt to the user to remove and zero the sensor again.
EMI	Sets the local line frequency for ambient noise rejection to 50 Hz or 60 Hz (default).
Clock	Sets the date and time of the portable meter in 24-hour format. Daylight savings time is not supported.
USB	Sets the USB mode. • Mass Storage (default)—This mode operates like a memory stick or hard drive. Files are read-only. • CDC—This mode is used to update firmware.
Language	Selects the language used in the menus.
Units	Sets the units for velocity, flow and depth measurements. Options are Metric or English (default).
Beeper	On (default) or Off. If set to On, the meter makes an audible tone when the sensor is at the correct depth for applicable profile methods. The meter also makes an audible tone when an inactive button is pushed in any menu. This feature is available only with the optional depth sensor.
Flow calculation	Selects the method of flow calculation for open water segment (stream profiles only). Options are Mean-section or Mid-section. Refer to the Appendix on page 31 for more information.

Option	Description
Station entry	• Fixed—The operator puts in the width of the stream and the number of stations for measurements. The meter divides the cross-section into evenly spaced distances between the station verticals. • Non-fixed (default)—The operator selects the spacing between station verticals. This is the more commonly used option as it lets the operator include obstructions and other restrictions in the cross section.
Restore defaults	Sets all meter options to the factory default values.

4. **Diagnostics—** Select this option to troubleshoot problems with the meter or an attached sensor. For more information about the Diagnostics options, refer to Diagnostics on page 28.

Startup and self-test

DANGER

Chemical or biological hazards. If this instrument is used to monitor a treatment process and/or chemical feed system for which there are regulatory limits and monitoring requirements related to public health, public safety, food or beverage manufacture or processing, it is the responsibility of the user of this instrument to know and abide by any applicable regulation and to have sufficient and appropriate mechanisms in place for compliance with applicable regulations in the event of malfunction of the instrument.

WARNING

Fire and explosion hazards. Do not use or store the instrument in direct sunlight, near a heat source or in high temperature environments such as a closed vehicle in direct sunlight. Failure to take this precaution can make the battery overheat and cause a fire or explosion.

The battery must be installed in the meter and charged before use. For more information about battery installation and replacement, refer to Install or replace the battery on page 27. For information on how to charge the battery, refer to Charge the battery on page 28.

Note: *The meter is not operational while the battery charges.*

1. Push the meter power button until an audible beep is heard.
   The meter does a self test and the display shows the results. If the meter fails the self-test, the display shows FAIL next to the failed parameter. If the sensor fails, attach a different sensor if available.
2. When the self test is complete, push **OK** to go to the Main Menu.
3. To de-energize the meter, push the power button again. In the Confirmation screen, select Yes and push **OK**.
   If the portable meter becomes unresponsive, push and hold the power button for more than 3 seconds to force the power off. Do not force off the power in normal operation or when the file access icon is visible.

Sleep mode

The meter backlight goes dim after 30 seconds of no activity and goes into sleep mode after 60 seconds of no activity. These actions do not occur if the meter is in real-time mode or while the meter is measuring. After 30 minutes in sleep mode, the meter power goes off.

To cancel the sleep mode, push any key. The display brightness goes back to the normal level and all keys go back to their normal functions.

Operation

Stream profiles

Stations and station spacing

For a well-chosen cross-section, division into 25 to 30 partial sections is typically sufficient. If the cross-section is very smooth and the velocity distribution very consistent, it is possible to decrease the number of stations.

Make the distance between the partial stations so that no individual station contains more than 10% of the discharge. The ideal measurement is one in which each partial station contains 5% or less (≤ 5%) of the total discharge, but this is rarely possible when 25 stations are used. Partial stations should not have equal widths across the entire cross-section unless the discharge is well-distributed.

Distances between stations are generally smaller where water depth and flow velocities change significantly. Places where depth and velocities frequently change significantly include bank areas, vertical or steep slopes, ledges in divided cross-sections and transitions from the main stream bed to the foreland. Stations should also be located at points of significant changes in the stream bed profile.

The measurement cross-section must be set at right angles to the direction of flow. Cross-sections must not contain still areas, counter currents or eddies. Do not put the sensor in deep pools, below large inflows, or near ship moorings, ferries or sluices.

Use Table 3 as a guide for the number of stations necessary for an acceptable measurement. The information is based on EN - ISO 748 standards.

Table 3 Number of stations in relation to the waterway width

Feet	Meters	Number of stations
< 1.6	< 0.5	5 to 6
> 1.6 and < 3.3	> 0.5 and < 1	6 to 7
> 3.3 and < 9.8	> 1 and < 3	7 to 12
> 9.8 and < 16.4	> 3 and < 5	13 to 16
> 16.4	≥ 5	≥ 22

Measure velocity

Measurement quality is dependent on the correct selection of a measurement cross-section. Select a section of stream with the following characteristics:

- The flow directions at each measurement point across the stream are parallel to the bank and perpendicular to the cross-section.
- The streambed is stable and free of large rocks, weeds and protruding obstructions such as piers that cause turbulence.

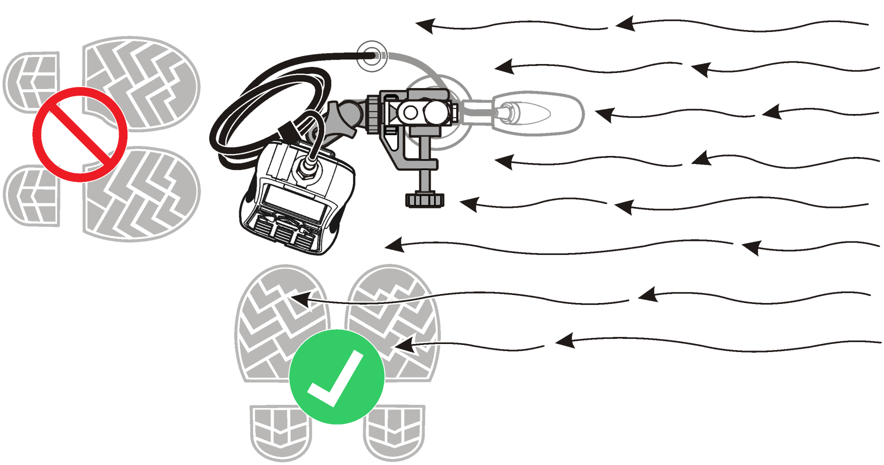
It is often not possible to completely satisfy all of these conditions. Use the criteria to select the best possible section and then select a cross-section.

The general procedure to take velocity measurements in river and stream profiles is described below. Make the first measurement in a stream profile at the top. Make each subsequent measurement below the last one.

- In fixed mode, divide the channel into stations of equal width.
- Conduct a velocity measurement at each station. The portable meter shows and stores the depth and measured velocity information.
- When the stream profile is completed, the meter automatically calculates the total flow.

For accurate measurement results, stand to the side of the instrument. Refer to Figure 9.

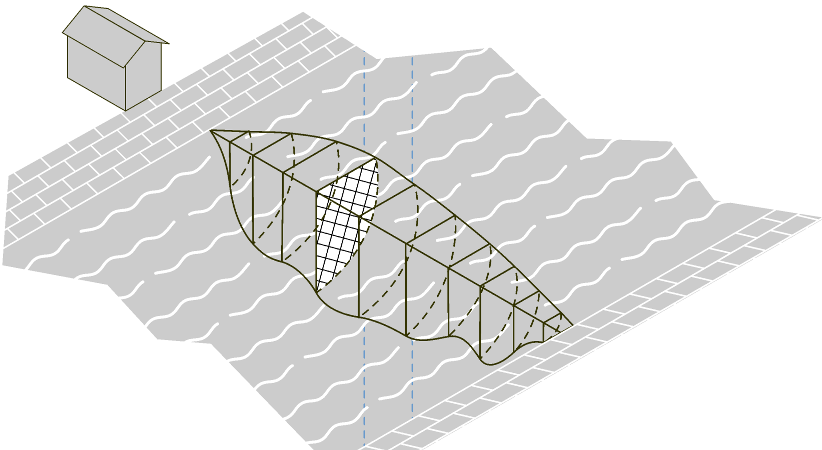
Figure 9 Position of user in the flow



Measure velocities in a cross-section

A typical stream cross-section is shown in Figure 10.

Figure 10 Example of a typical cross section



To measure velocities in a cross-section:

1. In the Main Menu, select Profiler.
2. Enter the Operator name. A list of options will show.

Option	Description
Stream	Used for measurements in a stream profile.
Conduit	Used for measurements in a conduit profile.

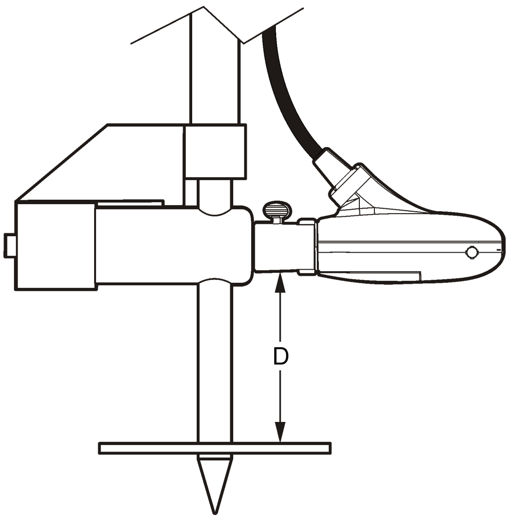
Option	Description
Files	Used to view or delete files.
Setup	Used to set up filter parameters and the Maximum depth feature.

3. Select Setup > Maximum depth. Select Manual or Automatic.

Option	Description
Manual	In this mode, the instrument prompts the user to manually enter the maximum depth of each vertical. This value is normally obtained from a wading rod.
Automatic	In this mode (available only on sensors with the depth option), the instrument uses the pressure transducer to measure the maximum depth at each vertical.

   a. If Automatic is selected, enter the distance from the bottom of the channel to the bottom of the sensor mount.
   b. Put the sensor at the lowest position on the wading rod.
   c. Enter the minimum depth (measured from the bottom) that the sensor can read. Refer to Figure 11.

Figure 11 Minimum depth



4. Select Top or Bottom for the measurement reference then push **OK**.
5. If necessary, change or update the filter parameters in Profiler Setup.
6. In the Profiler menu, select Stream.
7. Enter a name for the stream profile. Make profile names alpha-numeric with a maximum of 11 characters. Push **OK** to save the profile name or select Clear to delete all current stream profile data.
8. Enter the stage reference. This is typically an elevation value from an immovable object such as a survey marker or bridge, etc.

9. In the Station menu, select Edge/Obstruction. Select one of the options.

Option	Description
Left	Select this option if the station is at the left edge of the water or an obstruction (i.e, sandbar, pylon or large boulder).
Right	Use this option if the station is at the right edge of water or an obstruction (i.e., sandbar, pylon or large boulder).
Open water	Use this option to configure the edge as an open water environment (default).

10. Select Distance to Vertical and enter the information.
11. Select Set Depth and enter the information. If at an edge, the meter automatically sets this value to 0.00.
    a. If Manual mode was selected in the Profiler setup, enter the total depth of water at this vertical position.
    b. If Automatic mode was selected in the Profiler setup, push **OK** to set the maximum flow depth at the value shown.
12. If Left or Right was selected in Step 9, enter an edge factor for the vertical. Select a factor from the list or User-defined. For User-defined values, enter a roughness factor between 0.50 (very rough) and 1.00 (smooth). The roughness factor is relevant only for right angled cross sections. It is used as a factor in the calculation of the discharge proportion of edge areas. For example:
    - Smooth edge with no vegetation (e.g., concrete, steel, cement)— 0.8 to 0.9
    - Brick sides with vegetation— 0.7
    - Rough walls with heavy vegetation—0.6 to 0.5
13. Select Measure Velocity. Select the number of points on the vertical to collect.
14. Select a measurement point from the list. Obey the instrument prompts and adjust the sensor to the correct depth. If the sensor has a depth option, adjust the sensor depth until the depth box is green. This means the sensor is in at the correct position.
    ***Note:** Red indicates more adjustment is necessary. Yellow indicates the depth is close to the correct depth.*
15. Select Capture to start the measurement process.
16. If necessary, the setup can be changed and the measurement can be repeated. When the measurement is complete, push **OK** to store the data.
17. Repeat steps 13–16 for the other measurement points on the vertical.
18. When all measurements for the station are complete, select Main or Verify. results. Push **OK** to return to the list of measurement points.

Option	Description
Main	Returns to the station menu.
Verify	Shows the average velocity reading for the station based on the measurement method.

19. Select Next to go to the next station.
20. Repeat steps 10–19 for the remaining stations.
21. When all measurements for all stations in the profile are complete, select Channel Summary to view the results.
    ***Note:** A warning flag will show if the discharge in one or more segments is > 5% of the total discharge.*

Insert or delete a station

Prev, **Next**, **Ins** and **Del** options show at the bottom of the display in the Station screen. **Prev** and **Next** are used to navigate to a previous or subsequent station. **Ins** and **Del** are used to insert or delete a station.

For example, after measurements have been done at 10 stations, a user may wish to insert a new station between stations 3 and 4. The steps below describe how to do this. These steps can be applied in similar situations.

1. Select **Prev** and push **OK** until the display shows the information for Station 3.
2. Select **Ins** and push **OK**.
   The instrument adds a new station named Station 4. Subsequent stations are automatically given new sequential numbers.
3. To delete the current station (when in non-fixed mode), select **Del** and push **OK**.

Conduit profiles

It is possible to use all of the methods for conduit profiles in this section in sites with a typical profile shape and sufficient depth to measure 3-point velocities. The 0.9 x Vmax method can also be used when the depth is not sufficient for multi-point profiles.

Note: *In typical conduit profiles, the first measurement is made at the bottom. Subsequent measurements are made above the one made before. A different procedure may be necessary for some profiles.*

1. In the Main Menu, select Profiler.
2. Enter the operator name.
3. In the list of options, select Conduit.
4. Enter a name for the new Conduit profile.
5. Select the conduit shape.
   Note: *The input screens that show next depend on the shape selected.*
6. Enter values at the screen prompts.
   When the necessary values have been entered, the display shows the Select Method menu.
7. Select a profile method and do the steps for the method.

Option	Description
0.9 x Vmax	The meter calculates flow based on 90% of the fastest velocity. This is the recommended method when the depth is less than 12.7 cm (5 in.) or when the velocity is not stable.
0.2/0.4/0.8	The meter calculates the flow value based on velocity measurements taken at 0.2, 0.4 and 0.8 x the depth. One and two-point versions of this method are also possible.
Vel./Lev. Integ.	The meter integrates 10 separate velocity and level measurements to calculate the flow level.
2D	The sensor collects information while constantly moved through the flow in a specified pattern. The meter calculates the flow value when the user selects Save. This method is recommended for flows where a difference of 30% or more exists between the right and left side velocities.

0.9 x Vmax measurement method

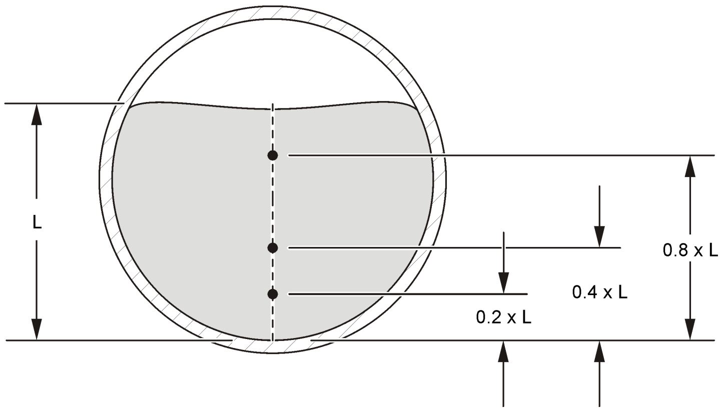
The meter uses the maximum velocity measurement in the conduit and multiplies this value by 0.9 to calculate the total flow.
Note: *The RC filter mode with a value of 2 to 4 seconds is recommended for this method.*

1. In the Select Method menu, select 0.9 x Vmax.
2. With the sensor in the flow, select Measure Velocity to get a velocity measurement.
   The measured values are shown on the graph.
3. Move the sensor until a point of maximum velocity is found, then push **OK**.
   The meter calculates and shows the flow, maximum and average velocity values.
4. Select Save.
   The information is saved to a data file.

0.2/0.4/0.8 method

Do measurements at one, two or three points to calculate an average velocity. Each point represents a percentage of the maximum depth as measured on the center line as shown in Figure 12.

Figure 12 2-4-8 profile



1. In the Select Method menu, select **0.2/0.4/0.8**.
2. Select one of the options.

Option	Description
One point	One-point measurement at 0.4 x maximum depth
Two point	Two-point measurement at 0.2 and 0.8 x maximum depth
Three point	Three-point measurement at 0.2, 0.4 and 0.8 x maximum depth

3. For the selected option, select a measurement point. The meter shows the sensor adjustment information.
4. If necessary, adjust the sensor as necessary.
5. Select Capture.
   The meter gets information from the sensor and shows the velocity value in numerical and graphical form.
6. If necessary, select Setup to change the Y-axis range or the data filter parameters.
7. Push **OK**.
8. Do steps 3–7 for all of the other measurement points then push **OK** to return to the list of measurement points.
9. Select Flow.
10. Select Save to save the information to a data file.

Velocity/Level Integration measurement method

Measurements are done at 10 different depths. The results from all segments are integrated to calculate the flow value.

- Select Prev or Next to go to another measurement.
- Select Main to return to the Select Method menu.

1. In the Select method menu, select Vel./Lev. Integ.
   The display shows the first measurement screen.
2. Select Measure Velocity.
   The sensor depth information is shown.

3. If necessary, adjust the sensor depth as shown.
4. Select Capture.
   The handheld unit gets information from the sensor and shows the average velocity value in numeric and graphical form.
5. If necessary, select Setup to change the Y-axis range in FPA filtering mode, the X and Y-axis range when in RC filtering mode or the data filter parameters.
6. Push **OK** to confirm the information.
7. Select Next. The next measurement screen in the series appears.
8. Do steps 2–7 for the other measurement depths.
9. Select one of the options at the bottom of the screen.

Option	Description
Save	Calculates the current flow value and saves this information to a data file.
Units	Changes the unit type (English or Metric).

2D measurement method

Velocity is measured while the sensor is moved through the flow as shown in Figure 13.

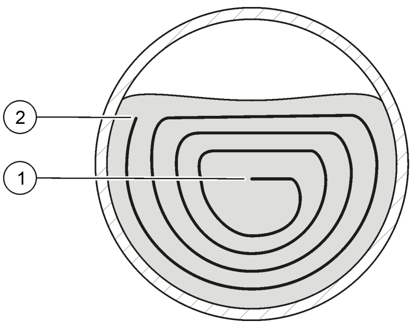
Select Cancel at any time to cancel the measurement and return to the Select Method menu.

***Note:** The RC filter mode with a value of 2 to 4 seconds is recommended for this method.*

1. In the Select method menu, select 2D.
   The sensor depth information is shown.
2. If necessary, adjust the sensor depth.
3. Select Capture. While the sensor collects data, move the sensor through the entire cross-section in the pattern shown in Figure 13.
4. If necessary, select Setup to change the Y-axis range in FPA filtering mode, the X and Y-axis range when in RC filtering mode or the data filter parameters.
5. Push **OK**.
6. Select one of the options shown at the bottom of the screen.

Option	Description
Save	Calculates the current flow value and saves this information to a data file.
Units	Changes the unit type (English or Metric).

Figure 13 Path of the sensor in the flow



1 Start	**2** Finish

Download data

The meter directory is Read Only. In Windows, the meter operates as a mass storage device or removable hard drive.

1. Set the meter to USB Mass Storage mode.
2. To edit the data in a file, drag and drop the file to a laptop or PC. File names are limited to eight characters.
3. Data files are kept in the tab separated variable (.TSV) format. To see files in Microsoft® Excel, double or right-click a file and open the file with Excel.
   Real time files are stored in a directory called RT. Stream and conduit profile files are stored in a directory called P.

Delete data files

1. To delete all files from USB memory:
   a. Go to Main Menu > Diagnostics > Delete Files.
   b. In the confirmation window, select Yes.
   c. Push **OK** once to delete the files, then one more time to return to the previous screen.
2. To delete Real Time files:
   a. Go to Main Menu > Real-Time > Files.
   b. Select Delete All or use the UP or DOWN arrow to select a file in the list.
   c. Push **OK** once to delete the files, then one more time to return to the previous screen.
3. To delete Profiler files:
   a. Go to Main Menu > Profiler > Files.
   b. Select Delete All or use the UP or DOWN arrow to select a file in the list.
   c. Push **OK** once to delete the files, then one more time to return to the previous screen.

Maintenance

Download the PVM utility

The PVM utility is used to update the firmware in the portable meter. The PVM Utility is available at http://www.hach.com or http://www.hachflow.com. Do the steps listed for the selected URL.

1. Go to http://www.hach.com.
2. Search for FH950.
3. Select the product.
4. Click the Downloads tab.
5. Click the download link.
6. Click PVMSetup.msi.
7. Select Save or Run.

1. Go to http://www.hachflow.com.
2. Click Data Management.
3. Click Software Download Center.
4. Click the FH950 link.
5. Click PVMSetup.msi.
6. Select Save or Run.

Update the firmware

***Note:** All data files in mass storage are lost when the firmware is updated. To download data, refer to Download data on page 25.*

The PVM Utility is necessary for this procedure. To download the PVM Utility, refer to Download the PVM utility on page 25.

This is the general procedure to update firmware for the meter and sensor. To update the sensor firmware, the sensor must be connected to the meter.

1. Double-click the PVM Utility desktop icon.
2. Push the power button on the meter. When the meter self-test is complete, push **OK**.
3. In the Main Menu, select Setup, then push **OK**.
4. Select USB>CDC, then push **OK**.
5. Connect the USB cable to the portable meter and the PC.
6. In the PVM Utility window, select Connect.
7. In the drop-down menu, select the PVM (COM X) port, where COM X is the virtual port number assigned to the PVM by Windows. Push **OK**.
8. In the left-side panel, select Firmware Update, then select the Meter or Sensor tab.
9. Select the correct firmware version, then click Start.
   The firmware download starts. A "Firmware update successful" message shows when the download is complete. For meter updates, the instrument display turns off until the instrument completes the update. Then, the instrument automatically resets and powers up again after a few minutes. Do not try to make the instrument power on or off before the update process is complete.
10. In the Main Menu, select Diagnostics > About. Make sure that the firmware versions for both the Handheld Boot and the Handheld Application are correct.

Clean the sensor

⚠ WARNING

Chemical exposure hazard. Obey laboratory safety procedures and wear all of the personal protective equipment appropriate to the chemicals that are handled. Refer to the current material safety data sheets (MSDS) for safety protocols.

Clean the sensor when unexpected increases or decreases in flow or level trends occur and after use in sandy or muddy waterways.

For heavy contamination, soak the sensor in clear water for a few minutes to help make the contamination easy to remove.

Disconnect the sensor from the meter before it is cleaned. Use only solutions listed as acceptable in Table 4 to clean the sensor. For sensors with a pressure cell (i.e., velocity plus depth sensors), make sure the holes for the pressure cell chambers are washed out and clear of contamination. Rinse the sensor with clean water before re-attaching the sensor to the assembly.

Table 4 Acceptable and unacceptable cleaning solutions

Acceptable	Do not use
Dish detergent and water	Concentrated bleach
Window cleaner	Kerosene
Isopropyl alcohol	Gasoline
	Aromatic hydrocarbons

Clean the meter

1. Push the power button to de-energize the meter.
2. Use a clean, moist cloth to clean the meter exterior. Mix the water with a mild detergent if necessary.
3. Dry the meter exterior with a clean cloth. Let the meter dry in air completely before it is energized again.
   Note: *Do not use paper-based cloths to clean the display. This type of cloth can cause damage to the display screen.*

Install or replace the battery

WARNING

Personal injury hazard. This instrument contains one or more batteries. To prevent battery degradation, leakage or explosion, do not use or keep the instrument in places where the temperature is higher than the specified temperature limits of the instrument.

WARNING

Fire and explosion hazards. Battery substitution is not permitted. Use only batteries that are supplied by the instrument manufacturer.

WARNING

Multiple hazards. Do not disassemble the instrument for maintenance. If the internal components must be cleaned or repaired, contact the manufacturer.

NOTICE

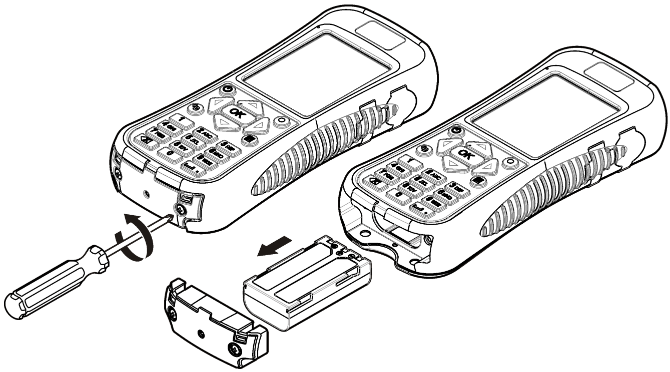
Discard used batteries promptly. Keep used batteries away from children. Do not disassemble the battery or discard the battery in fire.

The instrument is shipped without the battery installed. Order new batteries from the instrument manufacturer. Refer to Replacement parts and accessories on page 29. Recycle or discard used batteries in accordance with local regulations.

Note: *If the instrument must be returned to the factory for repair or maintenance, remove the battery and put the battery in a protective cover before shipment.*

1. If necessary, remove the used battery as shown in Figure 14.
2. Install a new battery in the same location and with the same orientation.
3. Install the battery cover. Make sure that the cover is secure to keep the enclosure rating.
4. Charge the battery if necessary. Refer to Charge the battery on page 28.

Figure 14 Remove the battery



Charge the battery

Make sure that the correct plug-type for the geographic location is installed on the wall charger.

Note: *Battery charger substitution is not permitted. Use only the charger specified in the list of parts and accessories for the instrument. Refer to* Replacement parts and accessories *on page 29.*

A lithium ion battery in the meter supplies power to both the meter and the sensor. Install and charge the battery before the instrument is used.

A full battery charge will supply power to the system for approximately 10–11 hours with constant use. When the level of battery charge drops to 3.4 V or less, the display shows a warning and the meter automatically powers off. The battery must be charged before the unit becomes functional again.

1. Connect the round end of the charger cable to the power jack of the portable meter. Refer to Figure 3 on page 8.
2. Connect the wall charger plug to a power outlet.
   A blue light shows around the charge port while the battery charges. When the charge process is complete, the blue light goes off. A discharged battery gets a full charge in about 8 hours.
   Note: *The meter is not operational while the battery charges. The battery does not charge through the USB cable connection.*

Troubleshooting

Diagnostics

In the Main Menu, select Diagnostics to see information about the meter and do the diagnostic tests in Table 5.

Table 5 Meter diagnostics

Option	Description
About	Shows information about the meter and the sensor. Includes the serial number and the firmware version.
Delete files	Deletes all files from memory to make space for new measurements. Make sure that the data is downloaded to a PC before this option is selected. The system automatically reformats the memory after file deletion.
Sensor	Shows diagnostic information about the sensor.
Self test	Makes the meter do a diagnostic self test.
Key pad test	Does a test of any button to make sure that the button is functional.

Table 5 Meter diagnostics (continued)

Option	Description
Display test	Does a test on the display to make sure that the display is functional.
Event log	Lets the user see, delete or export the event log. Export the event log to make the contents available as an accessible file through USB mass storage. This option is used primarily by factory service.

Troubleshoot errors

The meter and sensor contain no user-serviceable parts. For the errors and messages listed, try the corrective action.

If the problem does not go away or a problem occurs that is not in the list, contact the manufacturer.

Message or problem	Solution
Sensor is not connected	Connect a sensor and try the action again.
Value is out of range	Change the measurement parameters or put in a different value, then try the action again.
Sensor data is known to be not correct or not accurate	Clean the sensor and test.
Sensor is not recognized	Check the sensor connection. Make sure that the lock nut on the connection port is tight (finger-tighten only).
Display is dim or is not visible	Push a key on the keypad.
Data is not available or access to the data is not possible	Make sure that the USB option (Main Menu) is set to Mass Storage.
Meter is unresponsive	Push and hold the power button for at least 3 seconds. This de-energizes the meter. Energize the meter again. ***Note:*** *Do not use this method to power off while in normal operation or if the file access icon is visible in the display.*

Replacement parts and accessories

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Replacement parts

Table 6 Velocity only sensor

Description	Item no.
Sensor with 1.5 m (5 ft) cable	EM950.0005
Sensor with 6.1 m (20 ft) cable	EM950.0020
Sensor with 12.2 m (40 ft) cable	EM950.0040
Sensor with 30.5 m (100 ft) cable	EM950.0100

Table 7 Velocity with depth sensor

Description	Item no.
Sensor with 1.5 m (5 ft) cable	EM950.1005
Sensor with 6.1 m (20 ft) cable	EM950.1020

Table 7 Velocity with depth sensor (continued)

Description	Item no.
Sensor with 12.2 m (40 ft) cable	EM950.1040
Sensor with 30.5 m (100 ft) cable	EM950.1100

Table 8 Handheld meter

Description	Item no.
English/Metric	FH950.1

Accessories

Table 9 Wading rods

Description	Item no.
Standard wading rod kit, English	75002
Standard wading rod kit, Metric (includes the bullet items below)	75002M
• Bottom section for wading rod, English/Metric	43000M/43001M
• Intermediate section for wading rod, English/Metric	43010M/43011M
• Base plate for wading rod, English/Metric	43015M
• Double-end hanger for wading rod, English/Metric	43020M
Top set wading rod kit, English	75013
Top set wading rod kit, Metric	75013M

Table 10 General accessories

Description	Item no.
Absorbent wipe	9073500
Adjustable meter mount	9071700
Battery charger	9072600
Carrying case	9073400
Lanyard, double ended loop	9072700
Lithium ion battery	9113100
Suspension cable kit (includes bulleted items below)[1]	75003
• Sensor mount	42033
• Link connector	43025
• Weight hanger	43030XX01

Table 10 General accessories (continued)

Description	Item no.
• Weight pin	43035M
• 6.8 kg (15 lb) lead weight	43040
Thumb screw kit (includes four thumb screws)	9073200
Universal sensor mount	75015
USB cable	9070800

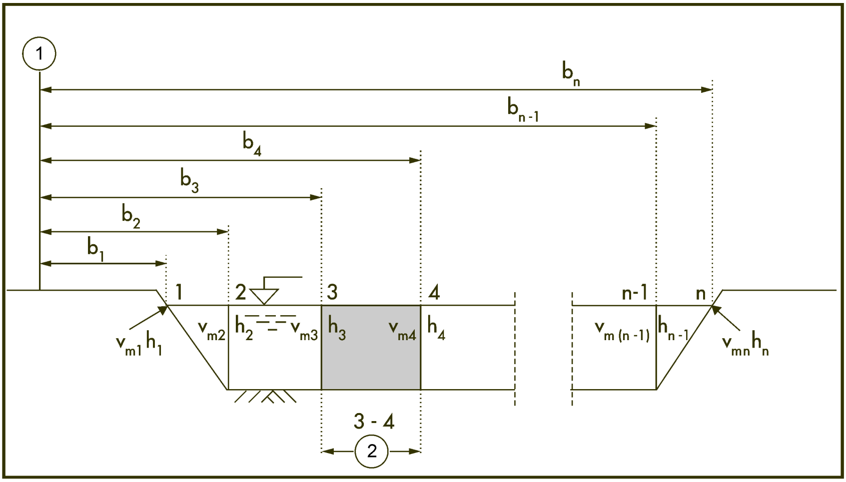
[1] Cable is ordered separately by the foot.

Appendix

Mean-section and Mid-section methods

The user can select the Mean-section or the Mid-section method for flow calculations. The Mean-section method divides the cross-section into individual flow segments. Pairs of adjacent verticals are the limits of the segments. The two edges of the cross-section are given values of 0 for the velocity and depth. The total flow is the sum of the partial flows of all segments. Figure 15 shows the definitions and the equation for the Mean-section method.

Figure 15 Mean-section method



$$q_{3-4} = \left(\frac{V_{m3} + V_{m4}}{2}\right) \times \left(\frac{h_3 + h_4}{2}\right) \times (b_4 - b_3)$$

Where:

V = velocity at vertical

b = distance to vertical from bank

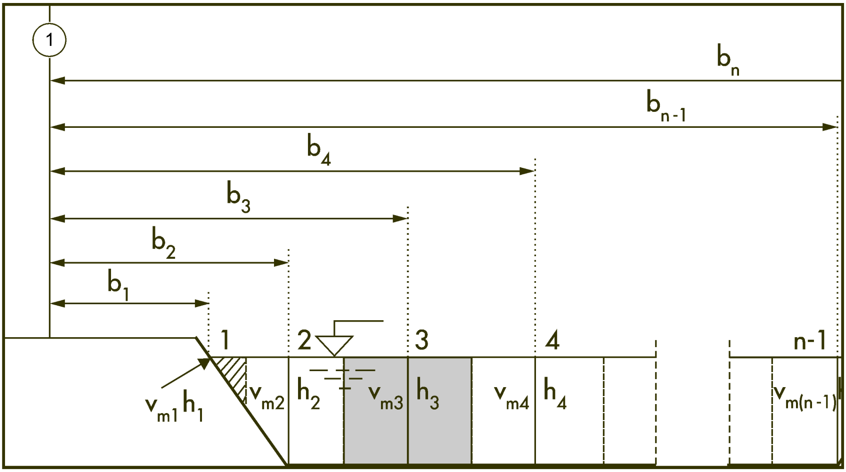
h = depth at vertical

q = flow at vertical

The Mid-section method also divides the cross-section into individual flow segments. With the Mid-section method, the segments are not between verticals but are defined by half of the distance to neighbor verticals in each case. For this reason, the first and last verticals should be as near to the edges as possible (i.e., left edge of water (LEW) and right edge of water (REW)). Boundary conditions dictate the proximity of the first and last vertical to the edge of water.

Experience shows that the Mid-section method gives more exact results compared to the Mean-section method so it is the default setting. Figure 16 shows the definitions and equation for the Mid-section method.

Figure 16 Mid-section method



$$q_3 = V_{m3} \times \left(\frac{(b_3 - b_2) + (b_4 - b_3)}{2} \right) \times h_3$$

Where:

m = station number

n = total number of stations

V = velocity at vertical

b = distance to vertical from bank

h = depth at vertical

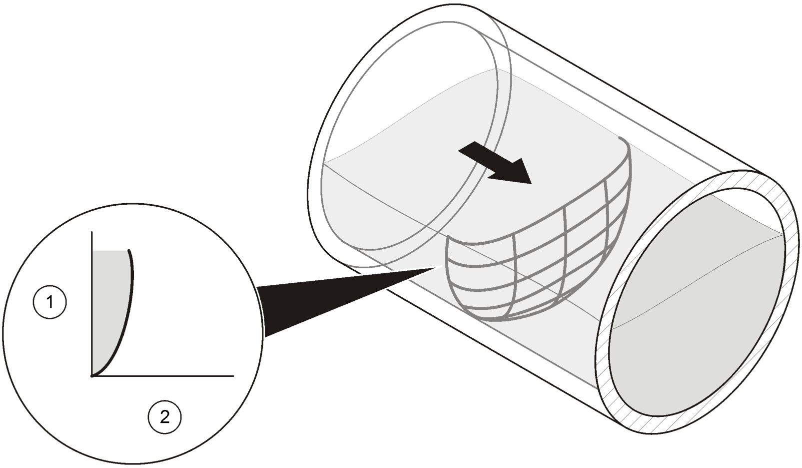
q = flow at vertical

Profiles and measurements

Profiles can be set up for streams or conduits. Figure 17 shows an example of a typical profile shape in a conduit. In a typical profile, velocity is less near a wall or edge than at the center and decreases near the surface. Multiple velocity measurements in the profile are averaged to calculate the total flow. Measurements for conduit profiles are made from the bottom up. Measurements for stream profiles are made from the top down.

In the Main Menu, select Profiler. The meter prompts for the operator name, the type of profile (stream or conduit) and the profile name. Do the instructions for the selected profile type.

Figure 17 Typical profile



1 Depth	**2** Velocity

Site selection

A site with the typical profile shape gives the most accurate results. Visual inspection is typically sufficient to identify problem sites. Use the information in these guidelines to help select the best site.

These guidelines apply to conduit and stream profiles.

- The channel should have as much straight run as possible. If the length of the straight run is limited, the length upstream from the profile should be two times the downstream length.
- The channel should be free of flow disturbances. The site must not have protruding pipe joints, sudden changes in diameter, contributing side-streams, outgoing side-streams or obstructions. Remove all rocks, sediment or other debris from the bottom of the pipe.
- The flow should not have visible swirls, eddies, vortices, back-flow or dead zones.
- Do not select areas immediately downstream from sharp bends or obstructions.
- Do not select areas with converging or diverging flow (approaches to a flume) or vertical drops.
- Do not select areas immediately downstream from sluice gates or places where the channel spills into a body of stationary water.

Do a velocity calibration

Use this feature to remove a velocity offset if necessary. The velocity offset stays active until the meter power is switched off.

1. Collect a bucket of water from the water in the profile area. The bucket must be non-metallic and at least 20.32 cm (8 in.). The water depth must be at least 15.24 cm (6 in.).
2. Put the sensor in the center of the bucket so that it does not touch the sidewall or the bottom of the bucket.
3. Let the water become still.
4. Let the velocity reading stabilize.
5. Select Zero Velocity.

Wet/Dry threshold

The wet/dry threshold is the trigger point for the meter to know when the sensor is in or out of the water. This information is important because if the meter does not know that the sensor is under the surface of the water, the meter sets the velocity value to zero. For a profile or real-time reading, the meter prompts the user to submerge the sensor in the water.

If the specific conductivity of the water being measured is very low, adjust the threshold value for the best performance. Go to Setup Menu>Wet/Dry Threshold.

For troubleshooting, the present reading is used as a guide to set a custom threshold. Get a reading in the water (wet) and then out of the water (dry). The threshold value must be between the wet and dry value. For example, if the actual wet value is 17 and the actual dry value is 2, put in a threshold value half way between 2 and 17. The default value is 20.

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Appendix K

Methods for Biological Sampling and Analysis of Maine's Rivers and Streams

Susan P. Davies
Leonidas Tsomides

DEP LW0387-C2014
Revised April, 2014

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION

METHODS

FOR

BIOLOGICAL SAMPLING AND ANALYSIS OF

MAINE'S RIVERS AND STREAMS

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Bureau of Land and Water Quality
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APPENDICES

FOREWORD

This manual describes the field, laboratory and data preparation methods required by the Maine Department of Environmental Protection to collect and analyze benthic macroinvertebrate samples for the River and Stream Biological Monitoring Program. The biological classification of Maine's inland waters was authorized by the Maine State Legislature with the passage of Public Law 1985 Chapter 698 - The Classification System for Maine Waters. This law states that it is the State's objective "to restore and maintain the chemical, physical and biological integrity" of its waters, and establishes a water quality classification system to enable the State to manage its waters so as to protect their quality. The classification system further establishes minimum standards for each class, which are based on designated uses, and related characteristics of those uses, for each class of water.

Each water quality class contains standards that, among other things, describe the minimum condition of the aquatic life necessary to attain that class. The Maine Department of Environmental Protection (the Department) has developed numeric criteria in support of the narrative aquatic life standards in the Water Quality Classification Law. The Department has collected a large, standardized database consisting of benthic macroinvertebrate samples from above and below all significant licensed discharges in the State, from areas impacted by non-point sources, as well as from relatively unperturbed areas. These sampling locations were chosen to represent the range of water quality conditions in the State. This information has been used to develop numeric criteria which are specific to the natural biotic community potential of the State of Maine (see Davies et al., 1995 and 1999 for a description of the development and application of numeric criteria) and is established in DEP regulation Chapter 579 : Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams.

Standardization of data collection and analytical methods is fundamental to the consistent, unbiased and scientifically sound evaluation of aquatic life impacts. This manual sets forth the standardized practices and procedures used by the Department to acquire or accept benthic macroinvertebrate data for use in regulation, assessment or program development.

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I GENERAL METHODS FOR RIVER AND STREAM AQUATIC LIFE CLASSIFICATION ATTAINMENT EVALUATION

Each water quality class is defined by standards that describe the minimum condition of the aquatic community necessary to attain that class. The benthic macroinvertebrate community is used as an indicator community of the general state of the aquatic life in flowing waters for the purpose of assessment of classification attainment. Standardized sampling techniques and sample analysis are required for assessment of biological attainment of stream water quality classification. This manual presents the standard practices and procedures that have been adopted by the Department to acquire benthic macroinvertebrate data for purposes of aquatic life classification attainment evaluation.

Purpose:

To determine the water quality class attained by a particular river or stream reach in terms of the aquatic life standards set forth in 38 MRSA Sec. 465 (The Classification System for Maine Waters).

Requirements:

All samples of aquatic life that are collected for purposes of classification attainment evaluation, whether collected by the Department or by any party required to make collections by the Department, must be collected, processed and identified in conformance with the standardized methods outlined in this manual. Selection of appropriate sampling sites and micro-habitat to sample, as well as procedures for quantitative analysis of the sample must conform to methods set forth in this manual. Data submitted by any party required to make collections by the Department must be accompanied by a Quality Assurance Plan, approved by the Commissioner.

1. <u>Qualifications of Sampling Personnel</u>

Biological sampling must be performed by a professional aquatic biologist or by qualified personnel under the supervision of a professional aquatic biologist. The professional aquatic biologist must have, as a minimum, a Bachelor of Science degree in biological sciences with aquatic entomology, invertebrate zoology, fisheries or closely related specialization, and greater than 6 months experience working with macroinvertebrate sampling methods and taxonomy. (See also Qualifications of Laboratory Personnel, Sec. II-1.)

2. Apparatus, Equipment, Supplies, Instruments

(1) Sampling devices

a) Rock-filled wire basket introduced substrate

Use: flowing wadeable, eroded, mineral-based bottom rivers and streams.

Description: cylindrical plastic coated or chrome wire, baskets with at least 1.5 cm spaces between wires, a hinged opening, and secure closure (Klemm, D.J. et al, 1990).

Substrate material: clean, washed, bank-run cobble, graded to uniform diameter range of 3.8 to 7.6 cm (1.5 to 3 inches) in size (#2 roofing stone).

Baskets must be filled to 7.25 +/- 0.5 kg (16 lbs +/-1 lb) of substrate material.

b) Rock-filled mesh bag introduced substrate

Use: small flowing streams, too shallow for rock baskets to be fully submerged.

Description: mesh bags of sufficient size to hold 7.25 +/- 0.5 kg of cobble substrate as described above, with at least 2.54 cm aperture mesh, and secure closures.

c) Closing introduced substrate cone

Use: deep, non-wadeable rivers having sufficient flow to have an eroded, mineral based bottom.

Description: cone shaped wire, or plastic coated wire basket filled with substrate material and closed by means of an inverted, weighted funnel (Courtemanch, 1984).

Substrate material: (see above Rock-filled wire basket substrate material).

(2) Sieves, sieve buckets, nets

Samples are concentrated on sieves having a mesh size between 500 - 600 microns (USA Standard Testing Sieve ASTM-E-11 Specification size No. 30 or No. 35).

(3) Optical equipment

a) Binocular microscope: Magnification range from 10x or less to 30x or greater.

b) Compound microscope: Magnification range from 10x to at least 400x; 100x with oil immersion lens is advisable.

3. Sampling Season, Sampler Exposure Period, Placement and Retrieval

(1) Sampling season

The standard sampling season upon which all macroinvertebrate classification criteria are based is the late summer, low flow period (July 1 to September 30). All baseline data for the biological classification program has been collected during this time period. This period often presents conditions of maximal stress to the biological community due to decreased dilution of pollutional material and increased stream water temperatures. Furthermore, because the composition of the benthic macroinvertebrate community changes with season, due to natural life history features, this period defines a standardized seasonal community.

As noted, the Department's linear discriminant models define biological classification criteria derived from a macroinvertebrate community defined by the specific sampling methods and index season under which they were collected. Samples collected at other times of year may yield valuable water quality related information, however classification attainment may not be assigned solely on the basis of results of the linear discriminant models for these non-standard samples.

(2) Exposure period

Standard methods require that substrate samplers be exposed in the water body for a period of 28 days +/- four days within the above-specified sampling season. However, extended exposure periods may be necessary to allow for adequate colonization in the case of assessments of low velocity or impounded habitats. If such conditions exist a 56 days +/- four days exposure period may be used.

(3) Sampler placement

Rock Baskets/Bags

The actual sampler location should be approached so as to avoid any disturbance in, or upstream of, the sampled site. Position baskets in locations of similar habitat characteristics. Orient baskets with the long axis parallel to stream flow. Provide for relocation of baskets by flagging trees in the vicinity and/or by drawing a diagram with appropriate landmarks indicated.

Cones

Cone samplers should be marked with individual marker buoys (milk jugs or other suitable float) leaving about 5 extra feet of line to allow for water level changes and to provide for easy retrieval. They should be placed on the substrate with a minimum of disturbance, in an apex-up position, and located in the approximate middle fifty percent of the channel. (Note however, care should be taken not to create an obstruction to boat traffic.) In areas subject to vandalism, or in rivers having extensive macrophyte beds, it may be necessary to attach the sampler lines to a common anchor and thence to one unobtrusive surface float. Retrieval funnels will not properly close when lines are fouled with drifting macrophytes.

(4) Sampler retrieval

Rock Baskets/ Bags

Baskets are approached from downstream. Excessive accumulations of macrophytes, algae or debris clinging to the outside of the basket should be carefully removed, taking care to avoid jarring the basket itself. An aquatic net or drift net (mesh size 500 - 600 microns) is positioned against the substrate immediately downstream of the basket which is then quickly lifted into the net. The contents of the basket and all net washings are emptied into a sieve bucket (500 - 600 microns); the basket wires are carefully cleaned first, then rocks are hand washed and inspected and returned to the basket. All sieve bucket contents are placed in sample jars. A small amount of stream water and 95% ethyl alcohol is added to yield an approximately 70% solution of alcohol. Especially dense samples should be re-preserved in the laboratory, with fresh 70% ethyl alcohol. Rock baskets should be thoroughly cleaned and allowed to desiccate prior to re-use.

Cones

Cone samplers should be retrieved with the boat anchored directly upstream of the samplers. Once the float is retrieved and removed, the line should be held as vertically as possible while the weighted funnel is released down the line to enclose the cone. Cone and funnel should be retrieved quickly and smoothly from the bottom, and released directly into a sieve bucket or tub. Field processing should then proceed as described above for rock baskets.

4. Site Selection Criteria

Classification criteria apply to a strictly defined sample of the benthic macroinvertebrate community. Habitat type from which the community is obtained is a significant determinant of the make-up of the target community. Benthic macroinvertebrate communities of flowing streams and rivers having a hard, eroded substrate comprise the majority of samples in the baseline data set. This habitat is characteristic of the majority of the river and stream waters of the State. Exceptions to these conditions may require special consideration and the exercise of professional judgment. (Note: See Section III-2. (3) "Classification attainment evaluation of waters subjected to flow regulation" page 13, for procedures relating to the assessment of regulated flow sites.) While it is useful to obtain both an upstream and downstream sample to evaluate the effect of a pollution source, classification attainment evaluation does not require data from a matched reference site in order to arrive at a determination of aquatic life class. Analytical methods for classification attainment evaluation are described in Section III.

(1) Site attributes

a) The area selected should be generally representative of the habitat of the stream reach as a whole;
b) Where there is alternating riffle/pool habitat, the riffle/run is the habitat of choice;
c) A location should be selected where there is a high degree of certainty that the rock basket samples will remain fully submerged even if the water level drops significantly.

(2) Precautions

a) Avoid atypical influences such as bridges, entering culverts, channelized areas such as road crossings, culverts, or obstructions to flow;
b) Avoid bank effects: samplers should be located in the middle 50% of the bank to bank width, or in an area with a flow regime typical of the overall character of the stream segment;
c) Avoid slackwater areas and eddies immediately upstream or downstream of large rocks or debris.

(3) Matching reference and effluent impacted sites

If possible both stream reaches should be viewed prior to selection of sampling sites. Efforts should be made to sample habitats which are comparable in the following characteristics:

a) Water velocity;
b) Substrate composition (i.e., size ranges and proportions of particles making up the substrate);
c) Canopy coverage;
d) Depth;
e) Other upstream influences except the pollution source in question (for example, use caution when one site is just below a lake outfall and the other is not).

(4) Factors to be considered in site selection below point sources

The area of initial dilution of an effluent should be determined by visual observation of the plume pattern; by observations of biotic effects attributable to the plume, if evident (periphyton growth, die-off patterns); and by transects of specific conductance measurements from the outfall, in a downstream direction. The site selected should be in an area where reasonable opportunity for mixing of the effluent has occurred. If a mixing zone has been defined in a license, sampling should occur immediately downstream of it. In cases where the effluent plume channels down one bank for great distances (>1 km), or where localized effluent impact is expected to be severe for a distance beyond the zone of initial dilution, it is advisable to have a sampling site upstream of the source, one or more in the plume, and at least two farther downstream. One downstream site should be located at the point of presumed bank to bank mixing and subsequent sites should be located to assess the extent of impact downstream.

5. <u>Sample Size</u>

The biological community is evaluated on the basis of benthic macroinvertebrates obtained from at least three samplers which yield an average of at least 50 organisms per sampler. Matched upstream and downstream sites must be sampled using identical methods and level of effort, preferably by the same personnel.

Subsampling may be performed on samples if the mean number of organisms in a sampler exceeds 500 and subsampling will yield at least 100 organisms per rock/cone sampler. All samplers in a site should be treated consistently. Subsampling methods are described in Section II-5. Note: Subsampling will reduce sample richness by an indeterminate amount. This may affect the outcome of linear discriminant analysis. See Section III-2. (2).

6. Physical Habitat Evaluation

A field data sheet (Appendix A) is to be completed at the time of sampler placement. This form records site specific information concerning natural variables that may affect community structure. Items addressed include exact site location (latitude and longitude, narrative description of the mapped location and/or a topographic map with site indicated); substrate composition; canopy coverage; land use and terrain characteristics; water velocity, temperature, dates of exposure and investigator name. The form is to be completed by observation as well as instrument measurement of water velocity, specific conductance, dissolved oxygen, global positioning device, temperature, etc.

II LABORATORY METHODS

1. Qualifications of Laboratory Personnel

Sample processing and taxonomy in the laboratory must be performed or supervised by a professional freshwater macroinvertebrate taxonomist who is certified by the Society of Freshwater Science in the identification of eastern US taxa. Certification must include Genus level categories, such as Ephemeroptera, Plecoptera and Trichoptera (EPT), General Arthropods and Chironomidae taxa. Taxonomic data will not be accepted without verification that the supervising laboratory taxonomist has been certified in relevant categories.

2. Sample Preservation, Sorting

All sample material collected in the field, as described in Section I, is preserved in 70% ethyl alcohol. Samples are stored in airtight containers until sorted. Sorting of macroinvertebrates from detritus and debris should follow methods described in Appendix B. One out of every ten samples is evaluated by a biologist for sorting completeness.

After sorting, recommended storage for macroinvertebrates is in 70% ethyl alcohol with 5% glycerin, in vials sealed with tightly fitting rubber stoppers.

3. Sample Labeling

All samples are labeled in the field immediately upon collection. The label must include the following information:

Date of sample retrieval
Waterbody
Town or target discharge
Whether above or below the discharge (if applicable)
Replicate number

4. Sample Log Book

In the laboratory, the samples from each sampled site are to be assigned a sample log number, written on all items generated by the sample (e.g., sample vials, slides, records, count sheets, etc.). Log numbers are sequentially recorded in a master log book. The log book shall also contain site identification, date of placement and retrieval, investigator name, sampler type and any comments regarding sampler retrieval or data quality.

5. Subsampling

(1) Methods

If it is determined that a sample should be subsampled (see criteria in Section I-5 Sample Size) methods of Wrona et al, (1982) are followed. These are summarized below:

a) Fit a plastic or glass Imhoff-type settling cone with an aquarium air stone sealed in the bottom and connected to a compressed air supply.

b) Place the sorted macroinvertebrate sample in the cone and fill the apparatus with water to a total volume of one liter.

c) Agitate gently for 2 to 5 minutes with the air stone.

d) Remove 25% of the sample in 5 aliquots with a wide-mouth 50 ml dipper and combine into one sample vial. The dipper should be submerged and withdrawn over a five second interval.

e) Ascertain whether or not the required 100 organisms have been obtained in the subsample.

f) Indicate clearly on the sample label and on the data sheet the fraction of the sample that the subsample represents.

(2) Precautions

a) Especially large or dense organisms such as crayfish, molluscs or caddisflies with stone cases, which do not suspend randomly in the sample, should not be included in the subsample. They should be counted separately.

b) When removing aliquots, the subsampler should be careful to avoid biased capture of organisms in the cone. Avoid watching the cone as the dipper is withdrawn.

This method has been tested by the Department and has been found to randomly distribute the sample. The five separate counts conform to a Poisson series and thus can be combined into one sample (Elliott, 1979).

(3) Chironomidae subsampling

A subsampling plan for Chironomidae shall be approved by the Department. A Department recommended subsampling plan follows the following criteria:

a) For samples having less than 100 midges, all midges will be identified to genus/species level.

b) For samples having 100 to 199 midges, a subsample of one half (0.5) will be removed by randomly selecting the specimens to be identified and identified to genus/species level. Remaining unsampled midges will be examined for unusual or rare specimens, which will be removed and identified to genus/species level separate from the subsample of the sample.

c) For samples having 200 to 499 midges, a subsample of one quarter (0.25) will be removed by randomly selecting the specimens to be identified and identified to genus/species level. Remaining unsampled midges will be examined for unusual or rare specimens, which will be removed and identified to genus/species level separate from the subsample of the sample.

d) For samples having 500 or more midges, midges will be grouped by genus for those for which it is possible to confidently identify them to genus level without mounting. For remaining midges not grouped by genus, a subsample of 100 specimens will be randomly selected and identified to genus/species level. Remaining unsampled midges will be examined for unusual or rare specimens, which will be removed and identified to genus/species level separate from the subsample of the sample.

e) Reporting of the subsample of the sample will be as follows. Numbers reported on the Excel spreadsheet will be converted to reflect the sample total. Any round-off errors between the subsample total and the sample total will be equalized by adding or deducting the difference from the most numerous taxon. If unusual or rare specimens are removed from the sample following the subsample removal, the conversion of the subsample total to a "partial" sample total will be based on the sample total minus the number of unusual or rare specimens. Following this procedure, the number of unusual or rare specimens will be added to the "partial" sample total to bring it back to the sample total.

6. Sample Taxonomy

All taxonomic data submitted to the Department must be accompanied by the name(s) of the individual(s) actually performing the identifications. A list of taxonomic references used, and a reference collection of organisms must also be submitted (see below).

(1) Taxonomic resolution

Macroinvertebrate organisms are identified to genus in all cases where possible. If generic keys are not available or taxonomic expertise is lacking for a taxon it should be identified to the lowest level possible. Identification of organisms to species is highly recommended whenever possible. Although quantitative analysis of benthic macroinvertebrate samples by the Department is based on counts adjusted to the generic level of resolution, species designations are recorded in the Department database and can contribute to the final stage of data analysis, Professional Judgment Evaluation of the model outcome. This is especially important for Class Insecta. Taxonomists submitting data for use by the Department must use current taxonomic references.

(2) Identification of Chironomidae

Specimens of chironomid midges are identified from slide mounts of the cleared head capsule and body parts. Euparol or Berlese mounting medium is recommended for preparation of slides. CMCP-9 is recommended for the preparation of permanent slide mounts of reference material, for voucher specimens or for permanent collections. These slides should be prepared under a fume hood. Instructions for preparation and slide mounting may be found in Wiederholm, (1983). In samples in which a given taxon is represented by a large number of individuals, the identification to genus may be made from slide mounts of a sufficient proportion of the individuals to give a high degree of certainty that they are all the same (10-50% depending on the distinctiveness of the taxon visible under binocular microscope). A subsampling plan for Chironomidae is described in Section II-5. Each permanent slide mount is to be fully labeled or coded in a manner which positively associates the slide with the sample from which it originated.

(3) Quality control

All organisms and records from any sampling event intended to serve regulatory purposes must be preserved for a period of at least ten years. In the course of identifying taxa collected as part of the Department's biological monitoring program, or in other collection activities, a special reference collection of separate taxa is established. This collection allows subsequent identifications of the same taxon to be confirmed and thus serves to standardize taxonomy for the program.

Each contracted taxonomist, working for the Department or working for anyone submitting data to the Department, will be required to submit a reference collection of taxa identified, as well as a list of the taxonomic references used in the identifications. Organism identifications will be checked against the Department's collection by a Department taxonomist.

III ANALYTICAL METHODS

In general, it is the responsibility of the Department, or its agents, to conduct sampling for the purpose of making decisions on the attainment of water quality classification. Under certain conditions, sampling may be required of applicants for waste discharge licenses, or applicants requiring Section 401 Water Quality Certification. Sampling may be performed by corporations, businesses, organizations or individuals who can demonstrate their qualifications and ability to carry out the Department's sampling and analytical protocol, described in this manual. Such monitoring will be conducted according to a quality assurance plan provided to the Department and approved by the Commissioner.

Classification attainment evaluation is established in DEP regulation Chapter 579: Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams. Davies et al, 1995 details the conceptual and technical basis for the State's application of linear discriminant analysis to assess attainment of aquatic life standards. A synopsis of Chapter 579 follows in this section.

1. Minimum Provisions

Properly collected and analyzed samples that fail to achieve the following criteria are unsuitable for further analysis through the numeric criteria statistical models:

- Total Mean Abundance must be at least *50* individuals (average per basket/bag/cone);

- Generic Richness for three replicate basket/bag/cone samplers must be at least *15*.

Samples not attaining these criteria shall be evaluated by Professional Judgment. A determination will be made whether the affected community requires re-sampling or whether the community demonstrates non-attainment of minimum provisions of the aquatic life standards.

2. Aquatic Life Statistical Decision Models

The four statistical decision models consist of linear discriminant functions developed to use quantitative ecological attributes of the macroinvertebrate community (Appendix C-1) to determine the strength of the association of a test community to any of the water quality classes (Appendix D). The coefficients or weights are calculated using a linear optimization algorithm to minimize the distance, in multivariate space, between sites within a class, and to maximize the distance between sites between classes.

(1) Linear discriminant models

The discriminant function has the form:

$$Z = C + W_1X_1 + W_2X_2 + \ldots W_nX_n$$

Where: Z = discriminant score
C = constant
W_i = the coefficients or weights
X_i = the predictor variable values

Association values are computed, using variable values from a test sample, for each classification using one four-way model and three two-way models. The four-way model uses nine variables pertinent to the evaluation of all classes and provides four initial probabilities that a given site attains one of three classes (A, B, or C), or is in non-attainment (NA) of the minimum criteria for any class. These probabilities have a possible range from 0.0 to 1.0, and are used, after transformation, as variables in each of the three subsequent final decision models. The final decision models (the three, two-way models) are designed to distinguish between a given class and any higher classes as one group and any lower classes as the other group (i.e., Classes A+B+C vs. NA; Classes A+B vs. Class C+NA; Class A vs. Classes B+C+NA). The equations for the final decision models use the predictor variables relevant to the class being tested (Appendix E). The process of determining attainment class using association values is outlined in Appendix F.

(2) Application of professional judgment

Where there is documented evidence of conditions which could result in uncharacteristic findings, allowances may be made to account for those situations by adjusting the classification attainment decision through use of professional judgment as provided in DEP regulation Chapter 579: Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams. The Department may make adjustments to the classification attainment decision based on analytical, biological, and habitat information or may require that additional monitoring of affected waters be conducted prior to issuing a classification attainment decision.

Professional Judgment may be utilized when conditions are found that are atypical to the derivation of the linear discriminant model. Factors that may allow adjustments to the model outcome include but are not limited to:

a) Habitat factors
- Lake outlets
- Impounded waters
- Substrate characteristics
- Tidal waters

b) Sampling factors
- Disturbed samples
- Unusual taxa assemblages
- Human error in sampling

c) Analytical factors
- Subsample vs. whole sample analysis
- Human error in processing

(3) Classification attainment evaluation of waters subjected to flow regulation

The Maine State Legislature, in 38 MRSA Article 4-A Sec. 464 (9)-(10), *The Water Classification Program*, acknowledges that changes to aquatic life and habitat occur as the result of the impoundment of riverine waters and has modified the standards of waters so affected. The habitat and aquatic life criteria of riverine impounded waters of Class A, Class B or Class C are deemed to be met if the impoundment attains the standards of Class C (e.g., maintenance of structure and function of the resident biological community). Impoundments managed as Great Ponds must also attain Class C aquatic life standards. If the actual water quality attains any more stringent characteristic or criterion than the Class C standards dictate, then the waterbody must be managed so as to protect those higher characteristics. Class C standards also apply to the *downstream* waters below certain specified riverine impoundments on the Kennebec River and the Saco River (Wyman Dam, Moosehead East Outlet Dam, West Buxton Dam and Skelton Dam) that are classified as A or B. All other waters subjected to flow regulation are managed according to standards of the water quality classification assigned by the Legislature.

(4) Adjustments of a decision

It is the responsibility of the Department to decide if adjustments of a decision should occur. The following adjustments may be made to correct for these conditions:

a) Resample
The Department may require that additional monitoring of the test community be done before a determination of class attainment can be made, based on documented evidence of specific sampling factors that may have influenced the results.

b) Raise the finding
   i. The Department may raise the classification attainment outcome predicted by the model from non-attainment of any class to indeterminate or to attainment of Class C, based on documented evidence of specific conditions, as defined above.

   ii. The Department may raise the classification attainment outcome predicted by the model from attainment in one class to attainment in the next higher class, based on documented evidence of specific conditions, as defined above.

c) Lower the finding
The Department may decide to lower the classification attainment finding, on the basis of documented, substantive evidence that the narrative aquatic life criteria for the assigned class are not met.

d) Determination of non-attainment: minimum provisions not met
Samples having any of the ecological attributes not attaining the minimum provisions, and where there is no evidence of conditions which could result in uncharacteristic findings, as defined above, must be determined to be in non-attainment of the minimum provisions of the aquatic life criteria for any class.

e) Determination of attainment: minimum provisions not met
Where there is evidence of factors that could result in minimum provisions not being met, professional judgment may be used to make a professional finding of attainment of the aquatic life criteria for any class. Such decisions will be provisional until appropriate resampling is carried out.

(5) Sampling procedures do not conform

For classification attainment evaluation of test communities that do not conform to criteria provided in Section I General Methods, or Section III-1, Minimum Provisions, of this manual, and are therefore not suitable to be run through the linear discriminant models, the Department may make an assessment of classification attainment or aquatic life impact in accordance with the following procedures:

a) Approved assessment plan
A quantitative sampling and data analysis plan must be developed in accordance with methods established in the scientific literature on water pollution biology, and shall be approved by the department.

b) Determination of sampling methods
Sampling methods are determined on a site-specific basis, based on habitat conditions of the sampling site, and the season sampled:

i. Soft-bottomed substrates shall, whenever ecologically appropriate and practical, be sampled by core or dredge of known dimension or volume.

ii. The preferred method for sampling hard-bottomed substrates shall be the rock basket/cone/bag as described in Section I-2.

iii. Other methods may be used where ecologically appropriate and practical.

c) Classification attainment decisions
   Classification attainment decisions may be based on a determination of the degree to which the sampled site conforms to the narrative aquatic life classification criteria provided in 38 MRSA Section 465 and found in Appendix D. The decision is based on established principles of water pollution biology and must be fully documented.

d) Site-specific impact decisions
   Site-specific impact decisions may rely on established methods of analysis of comparative data between a test community and an approved reference community.

e) Determination of detrimental impact
   A determination of detrimental impact to aquatic life of a test community without an approved reference community may be made if it can be documented, based on established methods of the interpretation of macroinvertebrate data, and based on established principles of water pollution biology, that the community fails to demonstrate the ecological attributes of its designated class as defined by the narrative aquatic life standards in the water quality classification law.

Appendix A

Maine DEP Biological Monitoring Unit
Stream Macroinvertebrate Field Data Sheet

Log Number ____________________
Station Number ____________________
Waterbody ____________________
River Basin ____________________
Municipality ____________________
Stream Order ____________________

Directions ____________________
____
____
Lat-Long Coordinates (WGS84, meters)
Latitude ____________________
Longitude ____________________

Type of Sample ____________________
Date Deployed ____________________
Number Deployed ____________________
Date Retrieved ____________________
Number Retrieved ____________________
Agency/Collector(s) ____________________

1. Land Use (500 m radius upstream)
- ☐ Urban
- ☐ Cultivated
- ☐ Pasture
- ☐ Upland hardwood
- ☐ Upland conifer
- ☐ Swamp hardwood
- ☐ Swamp conifer
- ☐ Marsh

2. Terrain (500 m radius upstream)
- ☐ Flat
- ☐ Rolling
- ☐ Hilly
- ☐ Mountains

3. Canopy Cover (upstream view)
- ☐ Dense (75-100% shaded)
- ☐ Partly open (25-75% shaded)
- ☐ Open (0-25% shaded)

(% daily direct sun) ____________

4. Physical Characteristics of Bottom (estimate % of each component over 12 m stretch of site; total = 100%)

[ ] Bedrock
[ ] Boulders (<10")
[ ] Rubble (3" – 10")
[ ] Gravel (1/8" – 3")
[ ] Sand (<1/8")
[ ] Silt-clay-muck
[ ] Detritus

5. Habitat Characteristics (immediate area)

Time ________ AM PM	Time ________ AM PM
Width (m) ________	Width (m) ________
Depth (cm) ________	Depth (cm) ________
Flow (cm/s) ________	Flow (cm/s) ________
Diss. O_2 (ppm) ________	Diss. O_2 (ppm) ________
Temp (°C) ________	Temp (°C) ________
pH ________	pH ________
SPC (µS/cm) ________	SPC (µS/cm) ________
TDS (ppm) ________	TDS (ppm) ________

Temperature Probe # ____________

☐ deployed ☐ retrieved

6. Observations (describe)

Fish ____________________
Algae ____________________
Macrophytes ____________________
Habitat quality ____________________
Dams/impoundments ____________________
Discharges ____________________
Nonpoint stressors ____________________

7. Water Samples
- ☐ Standard
- ☐ Metals
- ☐ Pesticides

Lab Number

8. Photographs

9. Landmarks of Sampler Placement (illustrate or describe landmarks to be used for relocation)

Appendix B

Instructions for Macroinvertebrate Sorters

1. Pick the sample **in small portions** (1-2 TBS of material) at a time.

2. Pick all organisms you can see. If in doubt it's usually best to include it.

3. Some types of samples can be easily floated by adding a saturated solution of Epsom salt or sugar to the water. Maintain the saturated solution for the lab by adding enough salt or sugar to water to maintain a thick layer of crystals on the bottom of the storage jar. Use the supernatant solution for picking. Large numbers of organisms can be removed with a sieve spoon from the water surface. After the floaters have been removed, proceed to pick the rest of the sample as usual. A significant portion of the sample will not float and must be picked out with forceps.

4. The sample can be considered done when a careful 45 second search, after swirling the sample, yields no further organisms.

5. The samples are picked in water but should not remain unpreserved for more than 8 hours. Be certain that the final sample vial is preserved with 70% alcohol and 5% glycerin solution when done.

6. Return the detrital material to the original sample jar and preserve with 70% alcohol.

7. Write on the sample jar label "Picked X1 (your initials)".

8. Include in the vial of organisms a slip of index card label in hard pencil (No. 2) including **all information appearing on the original jar label**:

   Log Number — River
   Date - month/day/year — Location (Town or industry name)
   whether above or below
   Basket or Cone number
   Vial number if more than 1 vial is needed per basket

   ex. Log 621 Sandy R. 9/5/97
   Below Farmington (disturbed)
   Basket 2 vial #1 of 2

9. Complete all samples from one log number before beginning a new log number.

10. Keep a record of samples picked including log number

    Basket number — Time spent per basket
    Your name — Date

Appendix C-1

Methods for the Calculation of Indices and Measures of Community Structure Used in the Linear Discriminant Models

Variable
Number

1 **Total Mean Abundance**

Count all individuals in all replicate samples from one site and divide by the number of replicates to yield mean number of individuals per sample.

2 **Generic Richness**

Count the number of different genera found in all replicates from one site.

Counting rules for Generic Richness:

a) All population counts at the species level will be aggregated to the generic level.

b) A family level identification which includes no more than one taxon identified to the generic level is counted as a separate taxon in generic richness counts.

c) A family level identification with more than one taxon identified to generic level is not counted towards generic richness. Counts are to be divided proportionately among the genera that are present.

d) Higher level taxonomic identifications (Phylum, Class, Order) are not counted toward generic richness unless they are the only representative.

e) Pupae are ignored in all calculations.

3 **Plecoptera Mean Abundance**

Count all individuals from the order Plecoptera in all replicate samplers from one site and divide by the number of replicates to yield mean number of Plecopteran individuals per sampler.

4 **Ephemeroptera Mean Abundance**

Count all individuals from the order Ephemeroptera in all replicate samplers from one site and divide by the number of replicates to yield mean number of Ephemeropteran individuals per sampler.

5 **Shannon-Wiener Generic Diversity (Shannon and Weaver, 1963)**

After adjusting all counts to genus following counting rules in Variable 2:

$$\bar{d} = \frac{c}{N}\left(N \log_{10} N - \sum n_i \log_{10} n_i\right)$$

where: $\bar{d}$ = Shannon-Wiener Diversity
c = 3.321928 (converts base 10 log to base 2)
N = Total abundance of individuals
n_i = Total abundance of individuals in the i^{th} taxon

6 **Hilsenhoff Biotic Index (Hilsenhoff, 1987)**

$$HBI = \sum \frac{n_i a_i}{N}$$

where: HBI = Hilsenhoff Biotic Index
n_i = number of individuals in the i^{th} taxon
a_i = tolerance value assigned to that taxon
N = total number of individuals in sample with tolerance values.

7 **Relative Chironomidae Abundance**

Calculate the mean number of individuals of the family Chironomidae, following counting rules in Variable 4, and divide by total mean abundance (Variable 1).

8 **Relative Diptera Richness**

Count the number of different genera from the Order Diptera, following counting rules in Variable 2, and divide by generic richness (Variable 2).

9 ***Hydropsyche* Mean Abundance**

Count all individuals from the genus *Hydropsyche* in all replicate samplers from one site, and divide by the number of replicates to yield mean number of *Hydropsyche* individuals per sampler.

10 **Probability (A + B + C) from First Stage Model**

Sum of probabilities for Classes A, B, and C from First Stage Model.

11 ***Cheumatopsyche* Mean Abundance**

Count all individuals from the genus *Cheumatopsyche* in all replicate samplers from one site and divide by the number of replicates to yield mean number of *Cheumatopsyche* individuals per sampler.

12 **EPT - Diptera Richness Ratio**

EPT Generic Richness (Variable 19) divided by the number of genera from the order Diptera, following counting rules in Variable 2. If the number of genera of Diptera in the sample is 0, a value of 1 is assigned to the denominator.

13 **Relative Oligochaeta Abundance**

Calculate the mean number of individuals from the Order Oligochaeta, following counting rules in Variable 4, and divide by total mean abundance (Variable 1).

14 **Probability (A + B) from First Stage Model**

Sum of probabilities for Classes A and B from First Stage Model.

15 **Perlidae Mean Abundance (Family Functional Group)**

Count all individuals from the family Perlidae (Appendix C-3) in all replicate samplers from one site and divide by the number of replicates to yield mean number of Perlidae per sampler.

16 **Tanypodinae Mean Abundance (Family Functional Group)**

Count all individuals from the subfamily Tanypodinae (Appendix C-3) in all replicate samplers from one site and divide by the number of replicates to yield mean number of Tanypodinae per sampler.

17 **Chironomini Mean Abundance (Family Functional Group)**

Count all individuals from the tribe Chironomini (Appendix C-3) in all replicate samplers from one site and divide by the number of replicates to yield mean number of Chironomini per sampler.

18 **Relative Ephemeroptera Abundance**

Variable 4 divided by Variable 1.

19 **EPT Generic Richness**

Count the number of different genera from the Order Ephemeroptera (E), Plecoptera (P), and Trichoptera (T) in all replicate samplers, according to counting rules in Variable 2, generic richness.

20 **Variable Reserved**

21 **Sum of Mean Abundances of**: ***Dicrotendipes, Micropsectra, Parachironomus*** **and** ***Helobdella***

Sum the abundance of the 4 genera and divide by the number of replicates (as performed in Variable 4).

22 **Probability of Class A from First Stage Model**

Probability of Class A from First Stage Model.

23 **Relative Plecoptera Richness**

Count number of genera of Order Plecoptera, following counting rules in Variable 2, and divide by generic richness (Variable 2).

24 **Variable Reserved**

25 **Sum of Mean Abundances of** ***Cheumatopsyche, Cricotopus, Tanytarsus*** **and** ***Ablabesmyia***

Sum the number of individuals in each genus in all replicate samplers and divide by the number of replicates (as performed in Variable 4).

26 **Sum of Mean Abundances of** ***Acroneuria*** **and** ***Stenonema***

Sum the number of individuals in each genus in all replicate samplers and divide by the number of replicates (as performed in Variable 4).

27 **Variable Reserved**

28 **Ratio of EP Generic Richness**

Count the number of different genera from the order Ephemeroptera (E), and Plecoptera (P) in all replicate samplers, following counting rules in Variable 2, and divide by 14 (maximum expected for Class A).

29 **Variable Reserved**

30 **Ratio of Class A Indicator Taxa**

Count the number of Class A indicator taxa as listed in Appendix C-2 that are present in the community and divide by 7 (total possible number).

Appendix C-2

Indicator Taxa: Class A

Brachycentrus (Trichoptera: Brachycentridae)
Serratella (Ephemeroptera: Ephemerellidae)
Leucrocuta (Ephemeroptera: Heptageniidae)
Glossosoma (Trichoptera: Glossosomatidae)
Paragnetina (Plecoptera: Perlidae)
Eurylophella (Ephemeroptera: Ephemerellidae)
Psilotreta (Trichoptera: Odontoceridae)

Appendix C-3

Family Functional Groups

PLECOPTERA

Perlidae
Acroneuria
Attaneuria
Beloneuria
Eccoptura
Perlesta
Perlinella
Neoperla
Paragnetina
Agnetina

CHIRONOMIDAE

Tanypodinae
Ablabesmyia
Clinotanypus
Coelotanypus
Conchapelopia
Djalmabatista
Guttipelopia
Hudsonimyia
Labrundinia
Larsia
Meropelopia
Natarsia
Nilotanypus
Paramerina
Pentaneura
Procladius
Psectrotanypus
Rheopelopia
Tanypus
Telopelopia
Thienemannimyia
Trissopelopia
Zavrelimyia

Appendix C-3

Family Functional Group
(continued)

Chironomini
Pseudochironomus
Axarus
Chironomus
Cladopelma
Cryptochironomus
Cryptotendipes
Demicryptochironomus
Dicrotendipes
Einfeldia
Endochironomus
Glyptotendipes
Goeldichironomus
Harnischia
Kiefferulus
Lauterborniella
Microchironomus
Microtendipes
Nilothauma
Pagastiella
Parachironomus
Paracladopelma
Paralauterborniella
Paratendipes
Phaenopsectra
Polypedilum
Robackia
Stelechomyia
Stenochironomus
Stictochironomus
Tribelos
Xenochironomus

Appendix D

MRSA 38, 4-A Sec 464-465

Aquatic Life Standards for the State of Maine

Classification	Biological Standards
AA	No direct discharge of pollutants; aquatic life shall be as naturally occurs.
A	Natural habitat for aquatic life; aquatic life shall be as naturally occurs.
B	Unimpaired habitat for aquatic life; discharges shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community.
C	Habitat for aquatic life; discharges may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community.

Appendix E

Process of Calculating Model Variables and Association Values Using Linear Discriminant Models

Computer calculates model variables (*Var1 – Var30*) using taxa counts from a sample event using procedures described in Appendix C-1.

↓

FIRST STAGE LINEAR DISCRIMINANT MODEL (LDM)
(4-way model: A vs. B vs. C vs. NA)

1. Model calculates Discriminant Score[1] using *Var1 – Var9*.
2. Model uses Discriminant Score to calculate Association Values[1].

Example Results:
probability Class AA/A (*pA1*) = 0.27
probability Class B (*pB1*) = 0.70
probability Class C (*pC1*) = 0.03
probability Non-Attainment (*pNA1*) = 0.00

↓

SECOND STAGE LDM
(2-way model: C or better vs. NA)

1. Model calculates Discriminant Score[1] using *Var10 (pA1+pB1+pC1)* and *Var11 – Var13*.
2. Model uses Discriminant Score to calculate Association Values[1].

Example Results:
probability C or better (*pABC*) = 1.00
probability NA (*pNA*) = 0.00

SECOND STAGE LDM
(2-way model: B or better vs. C, NA)

1. Model calculates Discriminant Score[1] using *Var14 (pA1+pB1)* and *Var15 – Var21*.
2. Model uses Discriminant Score to calculate Association Values[1].

Example Results:
probability B or better (*pAB*) = 1.00
probability C or NA (*pCNA*) = 0.00

SECOND STAGE LDM
(2-way model: A vs. B, C, or NA)

1. Model calculates Discriminant Score[1] using *Var22 (pA1)* and *Var23 – Var30.*
2. Model uses Discriminant Score to calculate Association Values[1].

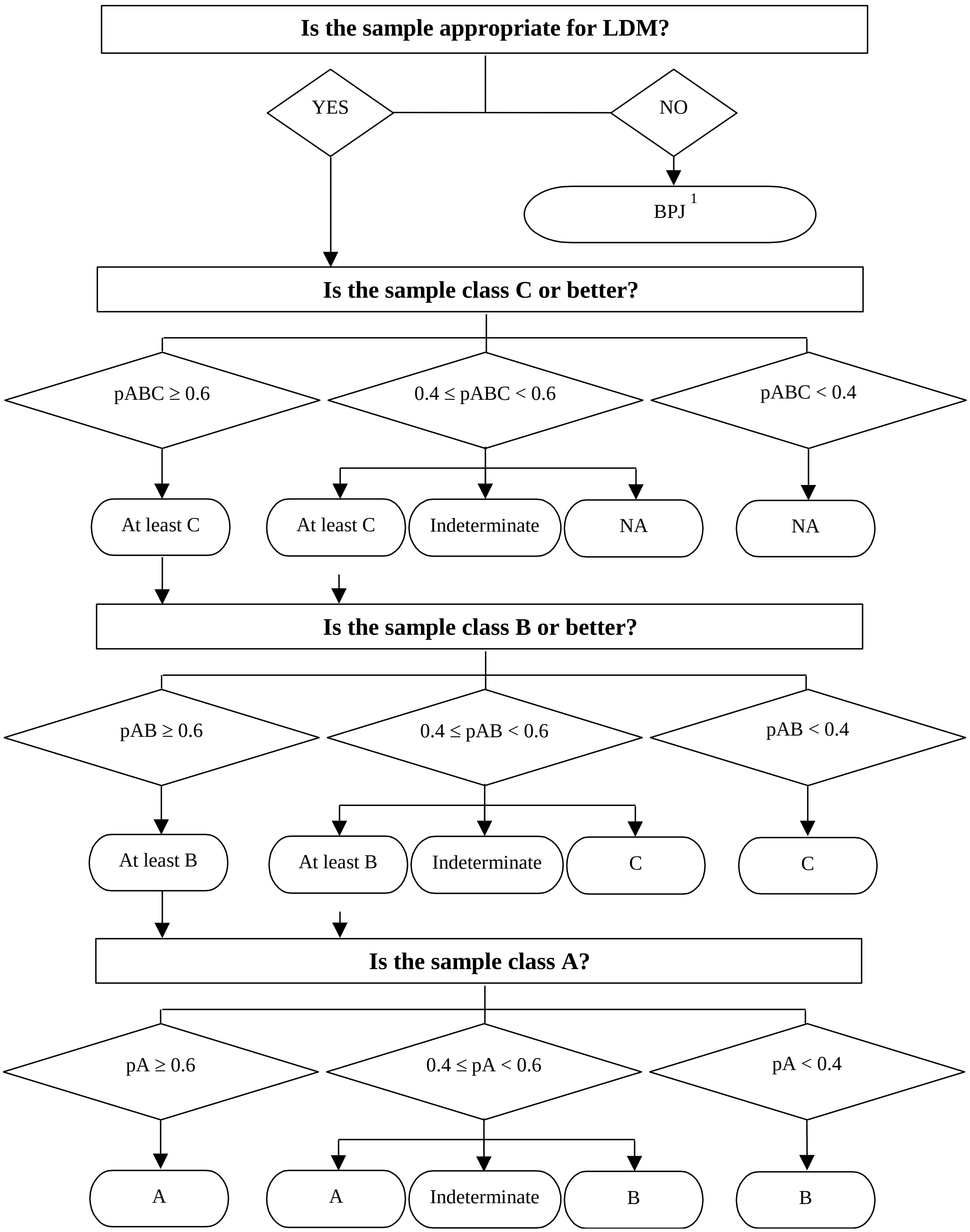
Example Results:
probability AA/A (*pA*) = 0.07
probability B, C, or NA (*pBCNA*) = 0.93

[1] Discriminant Score and Association Values are defined in Section III-2.(1).

Chart by Thomas J. Danielson

Appendix F

Process for Determining Attainment Class Using Association Values



[1] Best Professional Judgment (BPJ) is defined in Section III-2. (2), (4), and (5)

Chart by Thomas J. Danielson

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Appendix L

In Situ Toxicity Study

In situ assessment approaches provide many unique advantages over traditional environmental assessment approaches. Several investigators have demonstrated the usefulness of these approaches for determinations of site toxicity and bioaccumulation of contaminants on aquatic invertebrates (Burton et al. 2005, Clark and Clements 2006).

Potential toxicity of Long Creek-related contaminants on aquatic invertebrates will be assessed at Long Creek study sites and appropriate references site(s) to determine whether spatial (study and reference sites) and temporal (spring and summer exposures) differences exist. This study is experimental and is designed to evaluate the relative aqueous toxicity of Long Creek constituents of concern (i.e., chloride) on chloride-intolerant aquatic invertebrates, such as mayflies (Order: Ephemeroptera). The study design will include the collection of appropriate reference organisms, a seven-day *in situ* exposure period, and an evaluation of the survival of test organisms.

The experimental chambers used for the *in situ* toxicity study will be designed so that the test organisms, contained within the chamber, will be exposed to aqueous conditions at the study sites, while preventing escape of the test organisms and immigration of resident organisms. For example, the *in situ* exposure chambers may be designed and deployed with the following specifications:

- Chamber will be completely sealed except for four holes on the sides, top, and bottom of the chamber to facilitate surface water flow and pore water fluxes.
- Holes will be covered with fine polypropylene or nylon mesh to minimize potential organism escape.
- To facilitate water quality sampling from within the chamber, the chambers may have sampling ports constructed of tubing and pinch clamps/valves. The port for water quality sampling will be covered with fine mesh to prevent organism escape.
- Exposure chambers will be partially embedded 2 to 3 cm in the stream substrate in locations of similar depth, substrate, velocity, and canopy cover, and staked into the substrate to prevent disturbance. Adequate (at least 6 inches) water will be maintained above exposure chambers throughout the exposure period.
- Exposed mesh on the sides and top of the chambers will be monitored daily to prevent clogging during the seven-day experimental period

The study will be conducted in the spring, to evaluate exposure during springmelt conditions, and in late summer, to evaluate exposure during baseflow conditions. Test organisms to be used for the *in situ* toxicity study will be collected from appropriate reference site(s) on the Red Brook (or similar). Non-disruptive sampling techniques will be employed to carefully collect the desired number of test organisms. If the target taxon cannot be collected due to lack of abundance, a similar chloride-intolerant taxon within the same functional feeding group will be collected, as they are available. Invertebrates will be of the same taxon and size where possible. Three composite samples of 10 individuals (n = 10) will be collected, per site, and carefully transported via aerated containers to the selected study sites on Long Creek. Ten test organisms of the same taxon and size will be placed in each exposure chamber, which will then be anchored to the stream-bottom at each study site.

Additionally, a transport control will be established by transporting test organisms via aerated containers back to the reference area where they were collected and deploying them in a manner that is identical to those deployed at the Long Creek study sites. This process will standardize the study methodology between study and reference sites, allowing these organisms to be used as the reference control, appropriately. The transport control test group will be treated the same the other test replicates in terms of test organisms (species, organism size and number) used and exposure conditions. Transport control replicates are collected from the reference site, installed into test chambers and transported with the Long Creek replicates, before being returned to the reference site for the exposure period. The transport control is to evaluate potential effects of sample collection, transport, and exposure conditions (i.e. contained within the test cells). No organisms are collected from Long Creek and transported to the reference site.

Ambient and *in situ* surface water quality parameters (temperature, pH, dissolved oxygen, and specific conductivity) will be monitored daily throughout the seven-day exposure period. The water quality parameter collection will be performed twice a day (once in morning and once in the late afternoon) from a sampling port of each test chamber, in order to determine any potential changes to water quality within the chambers.

Following the seven-day exposure period, the exposure chambers will be removed from the stream and opened so that the contents of the chamber can be examined. All test organisms will be removed from the chamber and determined to be either alive or deceased. If any of the original ten test organisms cannot be found, it will be assumed that these missing individuals expired early in the study and will be considered to be deceased.

Statistical analyses may include a combination of qualitative and quantitative evaluations. As appropriate based on the distribution of the data, analysis of variance (ANOVA) may be conducted to evaluate differences in means of test organism survival between sites as well as seasons. *Post hoc* analysis will be conducted to make comparisons among locations if main effects are significant ($p < 0.05$). To ensure the assumptions of ANOVA are satisfied, probability plots of model residuals will be inspected. Where necessary, data may be transformed to satisfy assumptions of homogeneity of variance.

References

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Appendix M

Sediment Sampling Standard Operating Procedures

Sediment Sampling Procedures

Sediment sampling procedures are summarized in the following steps:

1. Collect surficial sediment samples from the biologically active layer (i.e., top 0 to 6 inches)
4. Document GPS coordinates with sub-meter accuracy using a Trimble ProXRS GPS unit or similar equipment at each location.

The detailed procedures for collecting sediment samples for analytical chemistry and physical parameters are provided below.

Equipment

The following equipment/supplies may be used to collect sediment samples:

- Stainless-steel petite Ponar™
- Stainless-steel spatula
- Stainless-steel bowls and spoons
- Water siphon
- Decontamination supplies
- Sample bottles and labels provided by the laboratory
- Cooler with ice
- Field logbook/field data sheets
- Indelible ink pen
- Sampling location map
- GPS unit
- Camera
- Cellular telephone
- Appropriate health and safety equipment

Decontamination Procedures

Before sampling begins, the sediment sampler, stainless-steel bowls, and spoons will be decontaminated. The equipment will also be decontaminated between sampling locations. The following is a list of equipment/supplies that may be needed to perform decontamination:

- Brushes
- Wash tubs
- Buckets
- Sponges or paper towels
- Alconox detergent (or equivalent)
- 10% Nitric Acid Solution
- Potable tap water
- Organic-free water (deionized or distilled water)
- Hand-held sprayers or spray bottles
- Aluminum foil
- Trash bags
- Plastic sheeting

The following steps will be used to decontaminate the sediment sampler, stainless-steel bowls, and spoons:

1. Dress in suitable safety equipment to reduce personal exposure as required by the health and safety plan (HASP).
2. Scrape off gross quantities of the sampled medium found on equipment at the sampling site.
3. Spray equipment that will not be damaged by water with a solution containing Alconox or low-sudsing detergent along with potable water and scrubbed with a bristle brush or similar utensil.
4. Rinse equipment with tap water.
5. Rinse sampling equipment a second rinse of dilute (10%) nitric acid.
6. Rinse equipment with a deionized or distilled water rinse.

Following decontamination, the sampling equipment will be placed in a clean area and will remain closed to prevent contact with dust and unclean surfaces. If the equipment is not to be used immediately, the equipment will be covered or wrapped in aluminum foil, plastic sheeting or heavy-duty trash bags to minimize potential contamination.

Sediment Collection

Wading will be considered if the water depth is shallow and the substrate is cohesive enough to make wading feasible.

The following procedures will be used during sediment sampling:

1. Record GPS coordinates if not previously recorded.
2. Measure and record water depth.
3. Decontaminate sampling equipment and don a new pair of latex/nitrile gloves.

5. Open stainless-steel petite Ponar and secure trigger bar.
6. Using a secure line, slowly lower the petite Ponar grab through the water column until approximately 1 foot above the sediment surface.
7. Allow petite Ponar grab to free fall the remaining distance to bottom. The petite Ponar will automatically trigger.
8. Slowly retrieve the petite Ponar grab in a controlled manner to minimize sample disturbance or loss of fines.
9. Remove the top of the petite Ponar to siphon excess water.
10. Inspect the sediment grab for the following:
    - Surface sediment is undisturbed and overlying water is present.
    - Sediment level does not touch screen.
    - Sediment grab is even across sampler.
    - Desired sediment penetration depth has been achieved.
    - Sediments did not wash out during sample retrieval.
11. Discard grab if inadequate, being careful not to disturb adjacent sediments at the station.
12. Open petite Ponar grab over stainless-steel bowl, allowing bowl to catch sediment.
13. Repeat the steps for lowering and retrieving the petite Ponar (if necessary) to obtain sufficient quantity of sediment for analysis.

Methods for the collection of AVS/SEM samples are consistent with USEPA guidance on the collection of sediment for AVS analyses (USEPA 2001; USEPA 1994). The following procedures will be used to collect sediment for acid volatile sulfide and simultaneously extractable metals (AVS/SEM) analyses:

1. Follow the procedures outlined in steps 1-11 for collecting sediment.
2. Remove the screens from the top of the Ponar taking care to minimize sediment disturbance.
3. Using a stainless steel trowel scrape the top 1- 2 inches from the undisturbed sediment in the Ponar.
4. Fill the sample jar to the brim, eliminating head space at the top of the jar.
5. Discard remaining sediment.
6. If additional analyses are being performed, repeat the steps for lowering and retrieving the petite Ponar to obtain sufficient quantity of sediment for analysis.

Field Quality Assurance/Quality Control Samples

Field Quality Assurance/Quality Control (QA/QC) samples are designed to help identify and minimize potential sources of sample contamination due to field procedures and to evaluate potential error introduced by sample collection and handling.

Equipment Blank Samples

An equipment rinsate sample of sampling equipment is intended to check if decontamination procedures have been effective. An equipment blank sample will be collected from the decontaminated sampling equipment. The equipment blank water is the same laboratory-demonstrated analyte-free water as the trip blanks. Laboratory supplied organic-free deionized water will be rinsed over the decontaminated sampling apparatus (i.e. sediment bowl, spoon, and sampler) and collected in sample bottles for analysis. The equipment blank sample is assigned a distinct identification number and will be handled, transported, and analyzed in the same manner as the samples acquired that day. One equipment blank will be collected.

Duplicate Samples

Collecting duplicate samples allows for evaluation of natural variability by comparing the analytical results of two samples from the same location. The duplicate sample will be obtained by filling both sets of bottleware simultaneously to check for the natural sample variance and the consistency of field techniques and laboratory analysis. The duplicate sample will be handled in the same manner as the primary sample, assigned a distinct identification number, and shipped to the laboratory along with the primary sample it duplicates. One duplicate sediment sample will be collected.

Matrix Spikes and Matrix Spike Duplicates

MS and MSD samples are prepared at the laboratory by dividing a control sample into two aliquots, then spiking each with identical concentrations of specific analytes. The spike samples are then analyzed separately and the results are compared to evaluate the effects of the sample matrix on the analytical accuracy and precision. The MS/MSD sample will be labeled and shipped to the laboratory along with the primary sample from which it was collected. One MS/MSD sediment sample will be collected.

Sample Identification, Handling, and Chain-of-Custody

Samples will be identified, handled and recorded as described in this sampling guideline. Each sample container will have a sample label affixed to the outside and documentation will be completed in waterproof ink. Each label will be marked using waterproof ink with the following information:

- Project name.
- Sample identification number.
- Date and time of collection.
- Initials of sampling technician.
- Requested analysis.
- Method of preservation.

Sample containers will be packed in bubble wrap to minimize breakage and placed in plastic coolers. Ice will be placed around sample containers and additional cushioning material will be added to the cooler, if necessary. A temperature blank will be included in each cooler. A temperature blank is a vial of water, shipped with samples and used by the laboratory to measure the temperature of the cooler upon receipt at the laboratory. The temperature blank is not analyzed. Paperwork will be put in a "Ziploc" bag and placed on top of the sample containers or taped to the inside lid of the cooler. The cooler will be taped closed and signed custody seals will be affixed to two sides of the cooler. Laboratory address labels will be placed on top of the cooler.

All samples are expected to contain low levels of contamination and will be packaged and shipped as environmental samples in accordance with applicable federal and state regulations. Standard procedures to be followed for shipping environmental samples to the analytical laboratory are outlined below:

- All environmental samples collected will be transported, shipped through Federal Express or equivalent overnight service, or picked up by a lab courier.
- Shipments will be scheduled to meet holding time requirements.

The laboratory will be notified to be prepared to receive a shipment of samples. If the number, type, or date of shipment changes due to site constraints or program changes, the laboratory will be informed.

Sample chain-of-custody procedures will be followed during sample handling activities in both field and laboratory operations. The primary purpose of chain-of-custody procedures is to document the possession of the samples from collection through shipping, storage, and analysis to data reporting and disposal. The Task Manager or his/her designee will be responsible for monitoring compliance with chain-of-custody procedures.

Tracing sample possession will be accomplished by using the COC record (Appendix A). A COC entry will be recorded for every sample and a COC record will accompany every sample shipment to the laboratory. At a minimum, the COC record will contain the following information for each sample:

- Sample number and identification of sampling point.
- Date and time of collection.
- Sample type.
- Number, type, and volume of sample container(s).
- Sample preservative.
- Analysis requested.
- Name, address, and phone number of laboratory or laboratory contact.
- Signature, dates and times of persons in possession.
- Any necessary remarks or special instructions.

Once the COC is complete and the samples are ready for shipment, the COC will be placed inside the shipping container and the container will be sealed. Samples are considered to be in custody if they are within sight of the individual responsible for their security or locked in a secure location. Each person who takes possession of the samples, except the shipping courier, is responsible for sample integrity and safekeeping.

Field Sampling Documentation

Each field activity must be properly documented to facilitate a timely and accurate reconstruction of events in the field.

Field Logbook and Field Data Sheet

The most important aspect of documentation is thorough, organized, and accurate record keeping. All information pertinent to the investigation will be recorded in the Field Logbook and/or Field Data Sheets. Entries will include the following, as applicable:

- Project name and number.
- Sampler's and field personnel names.
- Date and time of sample collection.
- Sample number, location, and depth.
- Sampling method.
- Sampling media.
- Sample type (grab or composite) and approximate quantity recovered.
- Sample physical characteristics.
- Observations at the sampling site such as weather conditions.
- Names and addresses of field contacts.
- Summary of tasks and information concerning sampling changes, scheduling modifications, and change orders dictated by field conditions.

Field investigation situations vary widely. No general rules can include each type of information that must be entered in a logbook for a particular site. Site-specific recording will include sufficient information so that the sampling activity can be reconstructed without relying on the memory of field personnel.

References

USEPA. 2001. Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual. USEPA Office of Water. EPA-823-B-01-002. October 2001.

USEPA. 1994. ARCS Assessment Guidance Document. USEPA Great Lakes National Program Office. EPA-905-B94-002.

Appendix N

LONG CREEK HOBO METERS CALIBRATION AND DEPLOYMENT FORM

Site Number:

HOBO U-20, U-24, and U-26 Calibration and Launch

DO loggers were initiated with new sensor caps prior to deployment (circle one): Yes No NA

Date Initiated: Expiration Date:

DO Logger Calibration Date: Time:

Parameter	Measurement	Check as Completed
Dissolved Oxygen	water saturated air (100%)	
Dissolved Oxygen (mg/L)	zero DO solution (mg/L)	

DO Logger launched prior to deployment (circle one): Yes No NA

Date: Time:

Level Logger launched prior to deployment (circle one): Yes No NA

Date: Time:

Specific Conductivity Logger launched prior to deployment (circle one): Yes No NA

Date: Time:

Comments:

Field Installation

Date: Time: Technician:

Weather:

Condition of Stream:

Level Logger:

Benchmark elevation: Length of cord:

Comments:

Field Meter Comparison

Meter make, model, & serial number:

Parameter	Measurement
Temperature (^{o}C)	
Specific Conductivity (mS/cm)	
Dissolved Oxygen (mg/L)	

Comments:

Appendix O

Flow Measurement Field Sheet

Initial water level at transducer: ___________

Post water level at transducer: ___________

Meter Type: HACH 950

Date: ________________ Time: ________________ Velocity Test: Bucket Zero

Site: ________________ Samplers: ________________

Facing Downstream:

LEW: ________________ REW: ________________ Width: ________________

Reading #	Angle Coeff. (if flow is not straight)	Distance from L bank	Subsection Width (ft)*	Depth (ft)	Velocity	Duplicate Measurement

* Width of each subsection = diff. between preceding and following points / 2

Appendix P

LONG CREEK YSI Pro2030 MULTIMETER CALIBRATION FORM

Calibration

Date:	Time:	Technician(s):
Temperature Check:	NIST:	Meter:
Inspected DO membrane:		Changed membrane:

Barometric Pressure [From NOAA Jetport weather station][1]: inHg

Adjusted Barometric Pressure for Sea Level Correction[2]: mmHg

Parameter	Standard	Pre-Calibration Reading	Check as Completed
Dissolved Oxygen	water saturated air (100%)		
Specific Conductivity	5,000 µs/cm (5.0 ms/cm)		

Comments:

Calibration Check

Technician(s):

Parameter	Standard	Post-Calibration Check	End of Day Check	Acceptable Range
		Time:	Time:	
Specific Conductivity	1,000 µs/cm (1.0 ms/cm)			0.9 - 1.1 ms/cm
Dissolved Oxygen	zero DO solution (mg/L)			< 0.5 mg/L

Comments:

Notes:

1. NOAA Jetport weather station website: www.noaa.gov. Enter zip code 04106.
2. To convert from NOAA sea level corrected values to uncorrected values in units of mmHg, calculate by:
   mmHg = (XX inHg) * (25.4 mmHg/inHg) - 1.5 [3]
3. Assuming local altitude of Portland Jetport is approximately 60 feet above sea level.
4. Calibration check should be within +/-10% of anticipated standard value, with the exception of zero DO solution, which should be <0.5 mg/L.

QA/QC'd By: Date:

Last Updated: 05/31/2017

Appendix Q

Surface Water Sample Data Sheet
Long Creek Watershed Management District

Site ID	**Sample Date/Time**
Sample Event Type (circle one) Melt Baseflow Storm	**Field Sample ID** (follow LOC-MMDDYY-EVENT format)
Sampler Name/Initials	**Duplicate Sample ID** (if collected)
Rain events over previous 48 hours (describe)	**If storm event, date of storm**
	Water Quality Equipment used
Geomorphology or Equipment Condition Notes	

Analyte (check)	Preservative	Notes
◯ TAL Metals		
◯ Indicator Metals (Cu,Ni,Pb,Zn)		
◯ Chloride*		
◯ Hardness		
◯ Orthophosphate		
◯ Total Phosphorus		
◯ Nitrogen (NO_2, NO_3, NH_3)		
◯ PAH		
◯ Other		

*Note: for storm samples, chloride sample should be taken from the stream at the time of sample retrieval.

Water Quality Parameters

Time	Temperature	Dissolved Oxygen		Conductance	Specific Conductance	Notes
	(deg C)	(mg/L)	(Sat %)	(mS/cm)	(mS/cm)	

Laboratory	**Samples submitted** (Date/Initials/Method)

Last Updated: 07/18/17

Appendix R

Page ________ of ________

Chain-of-Custody Record

Bold Fields Required. Please Circle Requested Analysis.

For Lab Use Only

				VOC				SVOC					TCLP	Metals		Inorganics								Micro		Other				
Sample I.D.	**Sampling Date / Time** *If Composite, Indicate Both Start & Finish Date / Time	**Matrix (see below)**	**Grab / *Composite**	524.2 524.2 BTEX 524.2 MTBE only	8260B 624 VTICs 1, 4 Dioxane	8021B BTEX HALOS	8015B GRO MAVPH	8270D 625 SVTICs EDB DBCP ABN A BN PAH	TPH8100 LI L2	8015B DRO MAEPH	PEST 608 PCB 608 PEST 8081A PCB 8082	Oil & Grease 1664 TPH 1664	TCLP 1311 ABN Metals VOC Pest Herb	Dissolved Metals (List Below)	Total Metals (List Below)	TS TSS TDS Spec. Con.	Br Cl F SO_4 NO_2 NO_3 NO_3NO_2	BOD CBOD T. Alk.	TKN NH_3 T. Phos. O. Phos.	pH T. Res. Chlorine	COD Phenols TOC DOC	Total Cyanide Total Sulfide	Reactive Cyanide Reactive Sulfide Flashpoint Ignitability	Total Coliform E. Coli Fecal Coliform	Enterococci Heterotrophic Plate Count				# of Containers	**Notes** MeOH Vial #

Matrix: A-Air; S-Soil; GW-Ground Water; SW-Surface Water; DW-Drinking Water; WW-Waste water

Preservative: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

Project Manager: ____________________

Company: ____________________

Address: ____________________

City: ____________ State: ________ Zip: ________

Phone: ____________________ Ext.: ________

Fax: ____________________

E-Mail: ____________________

Site Name: ____________________

Project #: ____________________

State: NH MA ME VT Other: ____________

Regulatory Program: NPDES: RGP POTW Stormwater or GWP, Oil Fund, Brownfield or Other: ____________

Quote #: ____________ PO #: ____________

Date Needed: ____________________

QA/QC Reporting Level

A B C

or

Presumptive Certainty

Reporting Options

Prelims: Yes or No

If Yes: Fax or PDF

Electronic Options

No Fax E-Mail PDF Equis

Temp. ________ °C

Ice? Yes No

Sampler(s): ____________________

Relinquished By: Date: Time: Received By:

Relinquished By: Date: Time: Received By:

Relinquished By: Date: Time: Received By:

Metals: 8 RCRA 13 PP Fe, Mn Pb, Cu

Other Metals: ____________________

Samples Field Filtered? ☐ **Yes** ☐ **No**

Notes: (ie: Special Detection Limits, Billing Info, If Different)

Site History: ____________________

Suspected Contamination: ____________________

Field Readings: ____________________

Eastern Analytical, Inc.
professional laboratory & drilling services

25 Chenell Drive | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | Fax: 603.228.4591 | E-Mail: customerservice@eailabs.com | www.eailabs.com

(WHITE: Original GREEN: Project Manager)

Appendix S

Long Creek Data Loading Quality Assurance Program Plan

December 2017, Version 1

CONTENTS

APPENDIX

LIST OF TABLES

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

COC	chain of custody
DO	dissolved oxygen
EDD	electronic data deliverable
L	liter(s)
LCWMD	Long Creek Watershed Management District
MDL	Method Detection Limit
MEDEP	Maine Department of Environmental Protection
mg	milligram(s)
NOAA	National Oceanic and Atmospheric Administration
NPS	Non-Point Source Pollution
PAHs	polycyclic aromatic hydrocarbons
PWM	Portland International Jetport
QA	quality assurance
QAPP	Quality Assurance Program (or Project) Plan
QC	quality control
USEPA	United States Environmental Protection Agency

1.0 SCOPE

Data collected in accordance with the Long Creek Monitoring Plan (Monitoring Plan) and Long Creek Quality Assurance Project Plan (Project QAPP) will be processed and loaded into the project water quality monitoring database maintained by LCWMD by the monitoring contractor following the quality assurance (QA)/quality control (QC) protocols outlined below.

The purpose of this Data Loading Quality Assurance Program Plan (Data Loading QAPP) is to define responsibilities for data quality and processes for management of data collected under the Monitoring Plan and Project QAPP.

2.0 DATA SOURCES AND TYPES

2.1 SAMPLING PLAN OVERVIEW

Implementation of the monitoring and assessment program began in June of 2010, and is ongoing. Data collection activities occur under the following programs:

- Grab Sampling for Water Quality Monitoring
- Continuous Sampling for Water Quality Monitoring
- Hydrology and Flow Monitoring
- Weather Monitoring
- Biological Monitoring
- Sediment Investigation

Since 2010, a significant volume of grab sample and continuous sample water quality data have been compiled in the project water quality monitoring database maintained by LCWMD. Grab samples are collected during periodic sampling events conducted in Long Creek under spring-melt, base-flow, and storm-flow conditions.

Water quality field parameters are collected concurrent with each grab sampling event using a hand-held meter. Water quality field parameters are measured with a YSI Pro2030 and include specific conductance, DO, and temperature.

Continuous meter samples for water quality monitoring data are collected using sondes deployed at various locations in Long Creek. Parameters monitored include specific conductance, DO, and temperature. The project uses parameter-specific HOBO® data loggers.

Hydrologic monitoring is performed at several locations along Long Creek to document changes in stream geomorphology and flow. Data collection includes continuous measurements of stream stage (water surface elevation) using *in situ*

HOBO® Level Logger dataloggers, in-field measurements of stage and stream flow (velocity), and measurements of the stream channel.

The National Oceanic and Atmospheric Administration (NOAA) weather station located at the Portland International Jetport is used to monitor temperature, precipitation, and snowfall within the Long Creek Watershed.

Biological monitoring is completed by either the Maine Department of Environmental Protection (MEDEP) or LCWMD twice during a five-year period at specified locations. The MEDEP biological monitoring program consists of benthic macroinvertebrate sampling using rock bags under MEDEP protocols.

2.2 SAMPLE AND FILE NAMING PROTOCOL

Each primary analytical sample collected by the monitoring contractor will be assigned a field sample ID that includes the sample location ID, followed by the six-digit sample collection date, or for stormwater samplers, the assumed date that in-stream Nalgene containers were filled, followed by the flow conditions the sample represents (i.e., MELT for spring-melt conditions, BASE for base-flow conditions, STORM for storm-flow conditions, DRY for stormwater sample containers that are empty, and EFF for effluent samples). For duplicate analytical samples, the same naming protocol will be utilized with the addition of "DUP" at the end of the field sample ID. [S01-061416-STORM; S01-061816-BASE; S01-061816-BASE-DUP]

The field sample IDs of analytical samples will be recorded on the bottleware used to collect the sample, on the associated laboratory COC, and on any field data sheets or field log book used to record field data related to that sample (field water quality measurements, stream height measurements, or site or equipment condition assessments).

In-situ meters will utilize a file naming system that includes the location of meter deployment, and the six-digit launch date of that meter. Additionally, because multiple meters are often deployed at the same location on the same date, to facilitate data management the meter type shall be indicated in the file name, if possible, based on maximum file name characters available.

3.0 LOADING PROCEDURES

3.1 GRAB SAMPLE ANALYTICAL DATA

The Lab Analytical electronic data deliverable (EDD) format, included in the Appendix, will be provided to the monitoring contractor so that analytical data will be delivered in a consistent, easily usable format which will facilitate the data loading process.

Samples will be analyzed by the laboratory, and results will be reported to the monitoring contractor in both an EDD (Maine DEP EGAD EDD is the preferred format) and PDF report with laboratory QA/QC documentation. The report will contain, at a minimum, COC, laboratory narrative with sample receipt information, and batch QC run as part of standard USEPA methodology. Documentation may include:

- dilution tests;
- post-digestion spike addition;
- laboratory control sample (LCS) analysis;
- instrument calibration checks;
- interference checks; and/or
- laboratory or matrix duplicate sample results.

The laboratory results will be reviewed by the monitoring contractor. This review will include:

- a comparison of the COCs to the lab's sample ID, date, and time;
- methods used;
- Method Detection Limits (MDL); and
- completeness of laboratory QA/QC documentation listed above.

The monitoring contractor will format data from the EDD received from the lab into the Lab Analytical EDD in **Appendix A**. The monitoring contractor will conduct a data check comparing results in the EDD to the PDF lab report on a minimum of a 10% of the data reported. If any discrepancies between the electronic data and the PDF lab report are noted, a 100% check will be completed on the data set, and any errors will be corrected in the electronic version. Additionally, a review should be completed to discern the origins of the discrepancies, and either corrective actions applied to the loading process, or errors communicated to the laboratory with a request for corrective action and revised EDD and/or PDF, based on discrepancy source. The monitoring contractor shall also compare the Lab Analytical EDD received from the lab to the EDD format provided and make any necessary changes to the format of the file, or to the valid values contained therein.

Upon completion of QA/QC review, the Lab Analytical EDD will be loaded into the project database by the monitoring contractor. The EDD will be checked during loading for consistency with valid values and format structure included in the EDD format. Errors noted at this time will be corrected by the monitoring contractor in the EDD. If the EDD is error-free, the data will be loaded to the database and as a final QC check, the count of results imported into the database will be checked against the source EDD. All checks will be documented and initials/dates recorded in a standalone spreadsheet maintained by the monitoring contractor. LCWMD will be notified that the EDD has been loaded and data are ready for analysis.

3.2 WATER QUALITY FIELD PARAMETER RESULTS

Water quality field parameter data sheets will be reviewed for completeness and for significant figures/accuracy in reporting. Water quality field parameter data sheets that have been corrected to the appropriate significant figures will have the initials/date of the checker recorded and will be scanned to an electronic PDF. The monitoring contractor will enter the data into the Field Parameter EDD included in the **Appendix B**. One-hundred percent of the water quality field parameter results in the EDD will be checked against the original data. Any edits due to data entry error will be corrected, and the checker's initials and date will be added to the electronic file. Any data that is to be refused based on poor calibration results or meter failure will be flagged, and comments as to the source of the error are noted in the "comments" column.

Upon completion of the QA/QC review, the EDD will be imported into the project database. The EDD will be checked for correct valid values and format structure included in the EDD. Errors noted at this time will be corrected by the monitoring contractor in the EDD. If the EDD is error-free the data will be loaded to the database and as a final QC check, the count of results imported into the database will be checked against the source EDD. All checks will be documented and initials/dates recorded in a standalone spreadsheet maintained by the monitoring contractor. LCWMD will be notified that the EDD has been loaded and data are ready for analysis.

3.3 CONTINUOUS WATER QUALITY METER DATA

Upon collection of continuous water quality meters, the monitoring contractor will download the data file from each meter. Post-calibration results will be checked and documented for each meter at the point of data download, and calibration is completed and recorded prior to equipment redeployment.

Water quality field parameter readings will be measured with the hand-held meter and will be noted in the calibration data sheet. Pre-and post-calibration results will be compared and any data out of calibration limits will be reported to LCWMD in order to determine whether corrective action is required. If needed, data will be adjusted for calibration drift.

Continuous monitoring data downloaded from the HOBO *in-situ* meters that exceeds calibration limits will be uploaded to Hoboware and processed through the

Hoboware Calibration Assistant. The resulting adjusted data file will be exported to a spreadsheet to be converted to the Continuous Water Quality Meter EDD format included in **Appendix C**.

The Continuous Water Quality Meter EDD will be imported into the project database. The EDD will be checked for correct valid values and format structure included in the EDD format. Errors noted at this time will be corrected by the monitoring contractor in the EDD. If the EDD is error-free the data will be loaded to the database and as a final QC check, the count of results imported into the database is checked against the source EDD. All checks will be documented and initials/dates recorded in a standalone spreadsheet maintained by the monitoring contractor. LCWMD will be notified that the EDD has been loaded and data are ready for analysis.

3.3.1 Chloride-Specific Conductance Regression Analysis

Chloride analytical results will be compiled with corresponding specific conductance data collected at the same sample location, at the same date and time, for use in updating a chloride regression chart maintained by LCWMD; this regression chart generates an equation of the relationship between specific conductance and chloride. This equation can then be applied to all specific conductance data collected in the watershed to create calculated chloride results. The resulting calculated chloride values (and the equation used to calculate them) will be added to the project database by the monitoring contractor. When the specific conductance/chloride equation is updated, the calculated chloride results in the database will be recalculated.

3.4 HYDROLOGY AND FLOW MONITORING DATA

3.4.1 HOBO In-Situ Pressure Transducers

Stream stage is measured using *in-situ* HOBO Pressure Transducer meters. Concurrent with each download and redeployment event, a measurement will be made from the water surface to the bottom of stilling well or stream bed, and recorded with measurement time on a field data sheet or in a log book at each location.

Upon collection of the meters, data will be downloaded from each meter and saved.

An additional pressure transducer is maintained in ambient air to record air barometric pressure during pressure transducer deployment; data will be downloaded from the ambient air pressure transducer by the monitoring contractor.

In-stream data files and air data files will be loaded into Hoboware™ to generate a file with barometric pressure data, temperature data, and water column height/stream depth data in the required units. Files will be reviewed for completeness, and checked for invalid results (i.e. meter out of water or buried in sediment) which must be noted in the electronic file.

The monitoring contractor will enter the data into the Pressure Transducer EDD included in the **Appendix D**. The EDD will be imported into the project database. The EDD will be checked for correct valid values and format structure included in the EDD format. Errors noted at this time will be corrected by the monitoring contractor in the EDD. If the EDD is error-free the data will be loaded to the database and as a final QC check, the count of results imported into the database is checked against the source EDD. All checks will be documented and initials/dates recorded in the database. LCWMD will be notified that the EDD has been loaded and data are ready for analysis.

3.4.2 Stream Flow and Cross-Section Data

Stream cross-sections and flow rates are measured periodically using protocols specified in the Monitoring Plan and Project QAPP. Cross-section measurements and flow rates will be recorded in a standalone Microsoft Excel spreadsheet file and QC checked for accuracy of data entry.

Stream discharge data is calculated using stream cross-section and associated flow rates for each flow event and location. Calculated stream discharge data is compared to pressure transducer meter data from the same date/time; these results are used to update a stream height-discharge relationship curve and equation. The stream discharge equation is then used to generate a calculated stream discharge value for all current and historical pressure transducer results.

These calculated values (and the equation used to calculate them) will be added to the Excel file. All checks will be documented and initials/dates recorded in a standalone spreadsheet maintained by the monitoring contractor.

3.5 WEATHER DATA

Meteorological data is collected from the NOAA weather station installed at the Portland International Jetport (PWM) in South Portland, Maine. Parameters collected at the NOAA weather station include temperature (daily maximum, minimum, and average), precipitation (hourly and daily total), and snowfall (daily total).

NOAA weather data is downloaded by the monitoring contractor on a bimonthly basis as it becomes available in an electronic format.[1] The data is manipulated

[1] NOAA historic data website: https://www.ncdc.noaa.gov/cdo-web/search; NOAA discrete data website: https://www7.ncdc.noaa.gov/CDO/cdopoemain.cmd?datasetabbv=DS3505&countryabbv=&georegionabbv=&resolution=40.

electronically to compile required parameters, and results in the required units, provided for in the NOAA Weather EDD in the **Appendix E**.

The NOAA Weather EDD will be imported into the project database. The EDD will be checked for correct valid values and format structure included in the EDD format. Errors noted at this time will be corrected by the monitoring contractor in the EDD. If the EDD is error-free the data will be loaded to the database and as a final QC check, the count of results imported into the database is checked against the source EDD. All checks will be documented and initials/dates recorded in a standalone spreadsheet maintained by the monitoring contractor. LCWMD will be notified that the EDD has been loaded and data are ready for analysis.

4.0 REFERENCES

Management Plan, 2009. *Long Creek Watershed Management Plan*; FB Environmental Associates, Inc.

Monitoring Plan, 2017. *Long Creek Monitoring Plan*; Long Creek Watershed Management District, revised December 2017.

Project QAPP, 2017. *Long Creek Water Quality Monitoring Quality Assurance Project Plan*; Long Creek Watershed Management District, revised December 2017.

Appendix A: Lab Analytical EDD

Lab Analytical EDD

Field Name	Sample Program	Location	Field Sample ID	Sample Date	Sample Time	Source	Lab Sample ID	Sample Type Code	Sample Delivery Group	Lab Batch ID
Data Type	Text	Text	Text	Date	Time	Text	Text	Text	Text	Text
Control (see tabs for Valid Values)	Valid Value	Valid Value	User Defined	MM/DD/YYYY	hh:mm:ss	Valid Value	User Defined	Valid Value	User Defined	User Defined
Nulls allowed?	No	No	No	No	No	No	No	No	Yes	Yes

Field Name	Analytical Method	CAS Number	Parameter	Result	Qualifier	Units	Result Type Code	Detect Flag	Report Detection Limit	Dilution Factor	Matrix
Data Type	Text	Text	Text	Numeric	Text	Text	Text	Text	Numeric	Numeric	Text
Control (see tabs for Valid Values)	User Defined	Valid Value	Valid Value	Number	Valid Value	Valid Value	Valid Value	Valid Value	Number	Number	Valid Value
Nulls allowed?	No	No	No	No	Yes	No	No	No	No	No	No

Field Name	Fraction	Basis	Analysis Date	Analysis Time	Method Detection Limit	Prep Method	Prep Date	Prep Time	Test Batch	Notes	Refuse	Sample Quantitation Limit
Data Type	Text	Text	Date	Time	Numeric	Text	Date	Time	Text	Text	Text	Numeric
Control (see tabs for Valid Values)	Valid Value	Valid Value	MM/DD/YYYY	hh:mm:ss	Number	User Defined	MM/DD/YYYY	hh:mm:ss	User Defined	User Defined	Valid Value	Number
Nulls allowed?	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

Appendix B: Field Parameter EDD

Field Parameter EDD

ID	Field Sample	Sample Date and Time	Location	SDG/FileName	CAS Number	Parameter	Result	Units	Qualifier	Refuse	Notes	Sample_Program

Appendix C: Continuous Water Quality Meter EDD

Continuous Water Quality Meter EDD

Field Name	ID	Location	Sample Date and Ti	Source	SDG/FileName	CAS Number	Parameter	Result	Units	Qualifier	Refuse	Notes
Data Type	Integer	Text	Date	Text	Text	Text	Text	Numeric	Text	Text	Text	Text
Control (see tabs for Valid Values)	User Defined	Valid Value	MM/DD/YYYY	Valid Value	User Defined	Valid Value	Valid Value	Number	Valid Value	Valid Value	Valid Value	User Defined
Nulls allowed?	Yes	No	No	No	No	No	No	No	No	Yes	No	Yes

Appendix D: Pressure Transducer EDD

Pressure Transducer EDD

Field Name	ID	Location	Sample Date and Ti	Source	SDG/FileName	CAS Number	Parameter	Result	Units	Qualifier	Refuse	Notes
Data Type	Integer	Text	Date	Text	Text	Text	Text	Numeric	Text	Text	Text	Text
Control (see tabs for Valid Values)	User Defined	Valid Value	MM/DD/YYYY	Valid Value	User Defined	Valid Value	Valid Value	Number	Valid Value	Valid Value	Valid Value	User Defined
Nulls allowed?	Yes	No	No	No	No	No	No	No	No	Yes	No	Yes

Appendix E: NOAA Weather EDD

NOAA Weather EDD

Field Name	ID	Location	Sample Date	Sample Time	CAS Number	Parameter	Result	Units	Method	Source	Notes
Data Type	Integer	Text	Date	Time	Text	Text	Numeric	Text	Text	Text	Text
Control (see tabs for Valid Values)	User Defined	Valid Value	MM/DD/YYYY	hh:mm:ss	Valid Value	Valid Value	Number	Valid Value	Valid Value	Valid Value	User Defined
Nulls allowed?	Yes	No	No	No	No	No	No	No	No	No	Yes