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Addendum to Quality Assurance Project Plan

Hangman Creek Watershed Dissolved Oxygen and pH Total Maximum Daily Load

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Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search Study ID JJOY0005.

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Addendum to
Quality Assurance Project Plan

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April 2016

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Signatures are not available on the Internet version.
EAP: Environmental Assessment Program
WQP: Water Quality Program

Note: The decimal numbers in the headings in this document correspond to the numbers in the headings used in QAPPs. Only relevant sections are included. This is why some numbers are missing, and why, for instance, the text begins at 3.0.

3.0 Background

In 2008-2009, the Washington State Department of Ecology (Ecology) undertook a data collection effort in order to establish Total Maximum Daily Loads (TMDL) for dissolved oxygen and pH in the Hangman Creek watershed, located south of Spokane in Eastern Washington (Joy, 2008). After these data were collected, it was determined that the data would be insufficient to complete the TMDLs, primarily because:

- The original modeling strategy on which the two summertime synoptic surveys were based proved insufficient for Hangman Creek, due to the extremely slow water movement and long travel times at low flow. A new strategy is needed.
- The TMDL on Hangman Creek is also going to need to address watershed nonpoint loading of nutrients in order to meet the load allocation for phosphorus at the mouth of Hangman Creek. This load allocation was set by the *Spokane River and Lake Spokane Dissolved Oxygen TMDL* (Moore and Ross, 2010). A sub-watershed level analysis of nonpoint nutrient sources was outside the scope of the 2008-2009 study.

Ecology is currently targeting a follow-up data collection effort for 2017 to fill data gaps to complete the TMDLs for dissolved oxygen and pH in the Hangman Creek watershed. A Quality Assurance Project Plan (QAPP) will be written prior to that data collection. This QAPP addendum addresses two reconnaissance sampling tasks that will be conducted during spring 2016, in preparation for the larger sampling effort the following year.

4.0 Project Description

4.1 Project goals

The goal of the activities described in this QAPP addendum is to provide additional information needed to plan for the larger-scale data collection effort in 2017, as well as to accomplish some tasks which there likely will not be time to fit in during 2017.

4.2 Project objectives

The above stated goals will be fulfilled by meeting the following two objectives.

Comparison of equal width increment depth integrated vs. grab sampling

We plan to conduct a small-scale side-by-side comparison of equal width increment depth integrated vs. grab sampling techniques. Equal width increment depth integrated sampling is used by the USGS to accurately characterize sediment concentrations in streams where suspended sediment concentrations may vary laterally and/or vertically through the water column. However, it is significantly more time-consuming than grab sampling. Ecology used equal width increment depth integrated sampling during 2008-2009 whenever elevated sediment conditions were present.

Hallock (2005) compared data collected by the USGS, which uses equal width integrated sampling, to data collected by Ecology's ambient monitoring program, which uses grab sampling. One of the compared sites was the Palouse River at Hooper. The Palouse River drains the same ecoregion as much of Hangman Creek, and it is likely that the sediment types of the two systems are very similar. The comparison found that a bias was present for some parameters, particularly sediment concentration. However, the comparison had two confounding factors. First, the comparison was between USGS and Ecology data sets as a whole, rather than side-by-side comparisons; Ecology and USGS did not sample on the same dates. Second, USGS uses a different laboratory method (Suspended Sediment Concentration, SSC) than Ecology (Total Suspended Solids, TSS), and SSC is known to produce higher results than TSS. Therefore it is not possible to be sure whether the bias observed between USGS and Ecology datasets was due to differences in field method or lab method.

We plan to sample four locations in the Hangman watershed, three times each, during runoff conditions in spring 2016. At each location, two sample sets will be collected, one using equal width increment depth integrated sampling, and one using grab sampling. Although this will result in a small number (12) of sample pairs for comparison, the side-by-side nature of the samples as well as consistency in laboratory procedures will help make this a useful comparison. Two parameters will be included, total suspended solids (TSS) and total phosphorus (TP). Sampling events will be targeted to a range of spring runoff flow conditions in order to capture as wide a range of conditions as possible given the size constraints of this study.

Longitudinal float survey

We plan to float Hangman Creek from the Idaho/Washington state line to the mouth, as well as Rock Creek from the North Fork Rock Creek confluence to the mouth. The main purpose of this is to collect a continuous longitudinal series of depth data in order to characterize channel geometry. Temperature, conductivity, pH, and dissolved oxygen data will also be collected.

There are two reasons for collecting this data during 2016 rather than 2017. First, there likely will not be enough time during 2017 to conduct a float in between sampling activities. Second, we will probably be requesting a groundwater study for 2017 to characterize a large groundwater input in the bottom several miles of Hangman Creek. Longitudinal temperature and conductivity data collected during the float will be of great assistance in pinpointing areas of groundwater inflow in order to help locate piezometers.

4.6 Tasks required

The following is a brief summary of required tasks.

- Collection of total suspended solids and total phosphorus data at four locations in the Hangman Creek watershed, three times during the spring runoff period of 2016. At each visit, two sample sets will be collected, one using equal width increment depth integrated sampling and one using grab sampling.
- Float Hangman Creek from the Idaho/Washington state line to the mouth, and Rock Creek from the North Fork Rock Creek confluence to mouth. Drag a Hydrolab® MiniSonde in order to collect depth, temperature, conductivity, pH, and dissolved oxygen data along the length of both streams.

4.7 Practical constraints

Both the sampling method comparison and float survey tasks are streamflow-sensitive. Ideally, the sampling method comparison will be done across a range of springtime flows. This includes high flows, when the highest concentrations of sediment typically occur. If a rain event producing such a flow condition does not occur during the project timeframe, this could limit the ability to compare equal width increment depth integrated and grab sample results at higher sediment concentrations.

The longitudinal float survey requires a specific set of flow conditions which normally occur for a short period of time during April and/or May. If these float conditions do not occur and persist for the amount of time necessary to complete the float survey (probably 2 weeks), that could limit the ability to complete the survey.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 1. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Elaine Snouwaert Water Quality Program Eastern Regional Office Phone: 509-329-3503	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Tighe Stuart Eastern Regional Office Eastern Operations Section Phone: 509-329-3476	Project Manager	Writes the QAPP. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Leads field surveys.
Jim Ross Eastern Regional Office Eastern Operations Section Phone: 509-329-3425	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Tom Mackie Central Regional Office Eastern Operations Section Phone: 509-454-4244	Section Manager for the Project Manager and Study Area	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Joel Bird Manchester Environmental Laboratory Phone: 360-871-8801	Director	Reviews and approves the final QAPP.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

EAP: Environmental Assessment Program
EIM: Environmental Information Management database
QAPP: Quality Assurance Project Plan

5.4 Project schedule

Table 2 shows schedule details.

Table 2. Proposed schedule for completing field and laboratory work and data entry into EIM.

Field and laboratory work	Due date	Lead staff
Field work completed	May 2016	Tighe Stuart
Laboratory analyses completed	June 2016	
Environmental Information System (EIM) database		
EIM Study ID	JJOY0005	
Product	Due date	Lead staff
EIM data loaded	August 2016	TBD (ERO EAP)
EIM quality assurance	September 2016	TBD (ERO EAP)
EIM complete	October 2016	TBD (ERO EAP)
Final report		
There will be no final report specific to this QAPP addendum. Rather, the data collected will be included in the TMDL report that will be written after the main data collection effort in 2017. As appropriate, results will also be included in the QAPP that will be written before the main data collection effort in 2017.		

5.6 Budget and funding

The estimated laboratory budget and number of lab samples are shown in Table 3. All samples for this project will be analyzed by Ecology's Manchester Environmental Laboratory (MEL).

Table 3. Laboratory budget.

Parameter	Number of Samples	Number of QA Samples	Total Number of Samples	Cost Per Sample	MEL Subtotal
Total suspended solids	24	4	28	$12	$336
Total phosphorus	24	4	28	$20	$560
				Total for study:	$896

6.0 Quality Objectives

6.2 Measurement Quality Objectives

All measurement quality objectives (MQOs) are the same as originally specified in Joy (2008). Table 4 provides quality control requirements for one additional parameter that was not included in the 2008-2009 data collection.

Table 4. Quality control requirement for additional parameter not included in original study.

Parameter	Method	Calibration drift zero check
Depth	Hydrolab®	±0.05 meters

GPS location data recorded by the Hydrolab® Surveyor® will be assessed visually. GIS will be used to compare locations to orthophoto imagery, to ensure that locations plot correctly along the creek.

6.2.2 Targets for Comparability, Representativeness, and Completeness

6.2.2.1 Comparability

To ensure comparability, field measurements will follow approved Environmental Assessment Program SOPs. These are listed in section 8.1.

6.2.2.2 Representativeness

The sampling method comparison is intended to cover a range of spring runoff flow conditions, which will ideally lead to a range of spring runoff sediment and total phosphorus concentrations. By representing a wide range of conditions, this comparison can avoid pitfalls associated with applying results from one set of conditions to a different set of conditions.

The longitudinal float survey will represent one set of medium-flow, mid- to late-springtime conditions. This is acceptable for depth data, since the modeling use of this data accounts for changes in depth corresponding to different flow conditions. (The modeling approach will be described in the QAPP preceding the main sampling effort in 2017.) The other parameters collected during the float survey will mainly be used to identify areas of groundwater influence. Therefore, it is not critically important for these parameters to represent any specific set of conditions.

6.2.2.3 Completeness

EPA has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system (Lombard and Kirchmer, 2004). The goal for this study is to (1) correctly collect and analyze 100% of the samples for each of the sites in the sampling method comparison, and (2) to float the entire Washington portion of Hangman Creek and the entire portion Rock Creek below the North Fork/South Fork confluence. However, problems occasionally arise during data collection that cannot be controlled; thus, a completeness of 95% is acceptable. Potential problems are site access problems, sample container shortages, and hydrolab equipment failures.

7.0 Sampling Process Design (Experimental Design)

7.1 Study Design

7.1.1 Field measurements

A Hydrolab® MiniSonde® will be used to collect depth, temperature, conductivity, pH, and dissolved oxygen continuously (logging every 30 seconds as watercraft progresses downstream). Data will be collected along the length of Hangman Creek from the Idaho/Washington state line to mouth and along Rock Creek from the North Fork Rock Creek confluence to the mouth.

The float survey will occur during April or May of 2016. Timing will be linked to streamflow, targeting a flow condition of approximately 100 cfs at the USGS gage at the mouth of Hangman Creek (USGS site 12424000). It is estimated that staff can cover 10-15 miles per day during the float and that it will take approximately two work weeks to float the entire proposed distance.

7.1.2 Sampling location and frequency

Sampling to compare equal width increment depth integrated vs. grab sampling will be conducted at four sites in the Hangman Creek watershed:

- Hangman Creek at mouth
- Hangman Creek at Duncan
- Rock Creek at mouth
- Hangman Creek at Idaho/Washington state line near Tekoa

Sampling will occur three times in 2016 as follows:

- Late March
- Early April
- Late April or early May

7.1.3 Parameters to be determined

Depth float

- Depth
- Temperature
- Conductivity
- pH
- dissolved oxygen
- GPS location (latitude and longitude)

Equal width increment depth integrated vs. grab sampling comparison

- Total suspended solids
- Total phosphorus

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

Standard operating procedures (SOPs) to be used are the same as in Joy (2008). This includes use of the USGS (2006) procedure for equal width increment depth integrated sampling.

An SOP is currently under review for conducting longitudinal depth surveys from small watercraft. The provisional SOP will be followed, and it is included as Appendix A to this document.

8.3 Invasive species evaluation

The Hangman Creek watershed is in an area of moderate concern. This means that invasive species such as New Zealand mud snails, which are particularly hard to clean off equipment and are especially disruptive to native ecological communities, have not been found in this area. Sampling crews will follow SOP EAP070, Minimizing the Spread of Aquatic Invasive Species.

10.0 Quality Control (QC) Procedures

Table 5 shows the QC requirements for laboratory samples for this addendum. It is not necessary to take replicate measurements of Hydrolab® parameters during a depth float; quality of most of these parameters will be evaluated using calibration end checks. The depth probe will be zeroed at the put-in site, and will be zero checked and re-zeroed if necessary every 2-3 hours throughout the float. All zero checks will be recorded in a field notebook.

Table 5. Summary of laboratory quality control samples and intervals.

Parameter	Field Blanks	Field Replicates	Lab Check Standard	Lab Method Blanks	Lab Replicates	Matrix Spikes
Total Suspended Solids	n/a	4/project*	1/run	1/run	1/20 samples	1/20 samples
Total Phosphorus	n/a	4/project*	1/run	1/run	1/20 samples	1/20 samples

*2 replicates each for equal width increment depth integrated and grab sample methods

Field replicates will be used to assess the variability *within* each sampling method (equal width increment depth integrated and grab). The side-by-side comparisons will be used to assess the variability *between* methods and particularly to look for bias. Any bias detected will be compared to the variability within methods to assess the likelihood that bias is due to difference in sampling method. The presence and/or amount of bias seen between sampling methods will be used to determine whether it is necessary to use equal width increment depth integrated sampling during the upcoming data collection effort in 2017.

14.0 Data Quality (Usability) Assessment

After all laboratory and field data are verified, the project manager will thoroughly examine the data package, using statistics and professional judgment, to determine if MQOs have been met. The project manager will examine the entire data package to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. If the criteria have not been met, the project manager will decide if affected data should be qualified or rejected based upon the decision criteria from the QAPP. The project manager will decide how any qualified data will be used in the technical analysis.

Particular attention will be paid to the representativeness of samples collected to compare equal width increment depth integrated and grab sample methods. The range of total suspended solids and total phosphorus results will be compared with existing ambient data collected from the Hangman Creek watershed to determine if these samples adequately represent a wide range of conditions.

15.0 References

Hallock, D., 2005. A Comparison of Water Quality Data Collected from Two Washington Rivers by the Department of Ecology and the U.S. Geological Survey. Publication No. 05-03-009. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/publications/summarypages/0503009.html

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Appendix A. Longitudinal Depth Data Collection

Note: The following is a provisional standard operation procedure (SOP) which is currently under review by Ecology quality assurance staff. It is included here for reference as these procedures will be followed while carrying out the activities described in this QAPP addendum.

Environmental Assessment Program

Standard Operating Procedure for Collection of Longitudinal Stream Depth Profiles

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for Collection of Longitudinal Stream Depth Profiles using a small watercraft such as a canoe, kayak, or raft.

1.2 Stream water quality models, such as those used for Total Maximum Daily Load (TMDL) studies, depend on having an accurate representation of channel geometry, including depth, width, and velocity. Channel survey techniques utilized only at selected locations often do not provide an adequate characterization of depth. In many streams, depth can vary greatly within small distances, and the use of a supposed "average" depth condition in a variable system can greatly confound modeling efforts. This SOP provides a method for collecting a continuous depth profile along the length of a stream (longitudinally).

1.3 This technique also has other applications. For example, continuous profiles of temperature, conductivity, and dissolved oxygen can also be collected simultaneously, and this data can be used to pinpoint springs and groundwater inputs.

2.0 Applicability

2.1 This SOP should be followed when collecting a longitudinal profile of stream depth from a small watercraft such as a canoe, kayak, or raft. It is intended primarily for use on creeks and small to medium-sized rivers.

3.0 Definitions

3.1 Longitudinal – data along the length of a stream

3.2 GPS – Geographic Positioning System

3.3 PVC – Polyvinyl chloride

4.0 Personnel Qualifications/Responsibilities

4.1 This type of field work requires two technicians to safely perform.

4.2 Staff performing this task need to be trained and have experience using Hydrolab® multiprobes. (See SOP EAP033, Hydrolab DataSonde® and MiniSonde® Multiprobes.) Hydrolab experience should include creating and downloading log files.

4.3 Staff performing this task need to be experienced in using whatever type of small watercraft is selected and have the ability to use the craft safely in challenging situations.

5.0 Equipment, Reagents, and Supplies

5.1 Canoe, Kayak, or Raft

5.2 Small outboard motor (optional, more commonly used with raft)

5.3 Paddles or oars

5.4 Personal floatation devices (PFDs)

5.5 Hydrolab Tow Setup:

5.5.1 Hydrolab MiniSonde® equipped with depth sensor (preferably a smaller-range depth sensor, such as 25m with a minimum of 0.01m resolution)

5.5.2 Screw-on weighted sensor cage for MiniSonde®

5.5.3 Hydrolab Surveyor® deck unit equipped with GPS and internal memory, fully charged. EAP has two of these deck units, one at HQ and one at ERO. As of 2014, Hach® no longer offers the GPS option on Surveyors. However, the new surveyor HL will include this option.

5.5.4 GPS receiver antenna to plug into deck unit

5.5.5 10-meter Hydrolab cable (note that normal Hydrolab cables are only 5 meters)

5.5.6 "Split" or "Y" Hydrolab cable, which connects to the deck unit, to the 10-meter Hydrolab cable, and to the external battery

5.5.7 "Double serial" Hydrolab cable, for connecting deck unit to laptop

5.5.8 Hydrolab external 12-V battery

5.5.9 Hydrolab accessories, such as repair toolkit and calibration standards

5.5.10 Wooden "clamp block" with wing nuts, for securing tension in the length of Hydrolab cable that is inside the PVC tube

5.6 Alternate Tow Setup:

5.6.1 Pressure transducer/logger (submerged at stream bottom) – minimum <0.3 ft accuracy (Figure 4 – left)

5.6.2 Pressure transducer/logger with barometric pressure (in boat) (Figure 4 – right)

5.6.3 Optional: Fast response temperature logger – minimum <0.3°C accuracy; <20 sec response time (Figure 5)

5.6.4 GPS device with route tracking capability

5.6.5 Well vented plastic container for barometric pressure transducer

5.7 20-ft PVC tube, which generally consists of two 10-ft sections that screw together in the middle

5.8 Flared PVC cage with holes drilled in sides, which screws into lower end of 20-ft tube

5.9 PVC repair materials in case of PVC breakage at remote location. This should include spare PVC fittings, PVC primer and glue, and a hacksaw.

5.10 Rope for attaching upper end of 20-ft PVC tube to watercraft

5.11 Foam weather-stripping

5.12 Duct tape (copious quantities)

5.13 Electric tape

5.14 1-gallon Ziploc bags

5.15 Cooler or other object to function as desk (optional, depends on watercraft being used)

5.16 Dry bag

5.17 Rite-in-the-rain notebook and pencils

5.18 Laptop computer equipped with HyperTerminal, TerraTerm, or equivalent communications software. (Only needed for downloading data after the float)

5.19 High quality ("hiccup" free) Serial-to-USB adapter (if laptop does not have a serial port)

6.0 Summary of Procedure

6.1 Important considerations before embarking on float

6.1.1 *Watercraft selection*. For most streams, and particularly those that tend to be shallow and rocky, a plastic canoe is ideal. Plastic canoes are relatively light, can handle a large amount of scraping against rocky substrate, and have adequate space to store and set up equipment. However, canoes are not very stable and do not handle well at all in fast-moving water, whitewater, standing waves, etc. For larger or faster streams, where stability may be an issue, but where shallow riffles with rocks (which might tear a raft) are not expected to be an issue, a raft may be a better choice. Kayaks have also been used successfully. Note that this protocol requires carrying electrical equipment, not all of which is waterproof, inside the craft. Therefore, capsizing may well lead to a loss of equipment and/or data, and is to be avoided.

6.1.2 *Flow conditions.* Some streams are floatable across a variety of flow conditions. In these streams, the float may be timed for a flow condition that is closest to what is desired for modeling purposes, e.g. low flow conditions. Some streams are only floatable during certain specific flow conditions. For example, some streams may be very unsafe to float during high-flow conditions, but too shallow to float at low flow. In such streams there may be a medium-flow condition that is low enough to be safe, but high enough to avoid excessive "getting out and push" over shallow sections. Some streams may never be safe to float.

6.1.3 *Distance that can be covered*. On most streams, it is possible to float 10 miles in a long day, sometimes more. However on streams with many obstacles that require portaging or pushing, the distance that can be covered in a day may be less than 10 miles.

6.1.4 *Tow setup selection*. Two options are available: (1) Hydrolab multiparameter sonde or (2) Pressure transducers with separate temperature logger.

6.1.4.1 *Hydrolab sonde:* Advantages of this setup are: (1) all parameters are displayed live on the surveyor, allowing the operator to troubleshoot potential sensor issues; (2) The GPS and water quality data are automatically synced and download on to one file; (3) Water quality parameters such as specific conductance, dissolved oxygen, and pH are available to provide additional information about potential groundwater inputs. The disadvantages are: (1) the sonde is not designed for this type of deployment, and even with protective measures, damage to equipment may occur; replacement or repair is expensive; (2) an external power source is required, which adds weight to the craft and could be damaged if craft capsizes or takes on water.

6.1.4.2 *Pressure transducer:* Advantages of this setup are: (1) Highly accurate depth data; (2) No need for external power source; (3) The equipment is rugged and relatively inexpensive to replace; (4) a smaller diameter, more flexible PVC can be used in the setup. The disadvantages are: (1) the data is logged with no display, user must remove from tow pipe and download to view data; (2) times and logging intervals on the pressure transducer, temperature logger, and GPS unit must be synchronized before survey and data from all three sources must be combined later.

6.2 Equipment set-up – Hydrolab Sonde

6.2.1 Calibrate conventional parameters on Hydrolab miniSonde®. (See EAP SOP033, Hydrolab DataSonde® and MiniSonde® Multiprobes.) This step is optional for only depth data but not for any other parameters. However, it is highly recommended to go ahead and calibrate dissolved oxygen, pH, and conductivity, as these data often turn out to be useful. Make sure the MiniSonde has 8 fresh AA batteries in it.

6.2.2 At the put-in site, within easy carrying distance of water, assemble the PVC equipment that rides behind the watercraft and carries the MiniSonde along the channel bottom. Attach the two 10-ft sections that form the 20-ft length of pipe that separate the watercraft from the cage. These two sections have a threaded connection that can be twisted together. Then attach the PVC cage to the end away from the watercraft. This also has a threaded connection. Figure 1 shows how the PVC setup should look. However, do not rope the front end of the pipe to the watercraft yet.

Figure 1. PVC assembly for carrying Hydrolab MiniSonde® along streambed behind small watercraft.

6.2.3 Feed the 10-m Hydrolab cable through the PVC assembly so that the underwater connection is sticking out through the end of the PVC cage, and the serial end is sticking out the end of the pipe near the watercraft.

6.2.4 Attach the MiniSonde to the underwater end of the cable using the threaded connector. Remove the calibration cup from the MiniSonde and replace it with the weighted Hydrolab cage if you have not already done so.

6.2.4 Wrap the O-ring joints on the MiniSonde several times with electric tape. (If you hold the MiniSonde with the probes facing down, there is one joint just above where the weighted cage screws on, and another at the lower edge of the battery case.) Alternately, wrap the entire MiniSonde (except of course the weighted cage) with electric tape.

6.2.6 Wrap the MiniSonde (except of course the weighted cage) in weather stripping. Wrap the weather stripping around the MiniSonde in a spiral pattern. Note that you do not want to entirely cover the MiniSonde in weather stripping—three or four wraps to span the length of the MiniSonde is about right. The thickness of weather stripping to use for this depends on the amount of airspace between the MiniSonde body and the inside of the upper (skinny) part of the PVC cage. If you cannot get the MiniSonde all the way into the PVC cage, try using thinner weather stripping or wrapping fewer times. If the MiniSonde is loose or wiggles in the PVC cage, try thicker weather stripping or wrapping more times.

6.2.7 Insert the MiniSonde into the PVC cage. This is generally a two-person job. One person inserts the MiniSonde (with weather stripping) into the PVC cage using a twisting motion. The weather stripping essentially functions as screw threads, and the MiniSonde gets screwed into the cage. The other person stands at the opposite end of the PVC pipe holds the Hydrolab cable, keeping a bit of tension in it. Figure 2 shows how the MiniSonde inside the PVC cage looks once this is done.

Figure 2. Hydrolab MiniSonde® properly seated inside PVC cage.

6.2.8 Making sure that the length of Hydrolab cable inside the PVC pipe is taut, attach the wooden clamp block to the cable such that the block rests against the end of the pipe and prevents the cable inside the pipe from going slack. Notice that there are two things that prevent the MiniSonde from sliding out of the PVC cage during the float: (1) the weather stripping and (2) the tension in the Hydrolab cable, anchored by the clamp block.

6.2.9 Connect the front end of the PVC pipe to the stern of the watercraft with rope, leaving some slack. See Figure 1.

6.2.10 Connect the Hydrolab electronics. The serial connection at the upper end of the 10m cable (the end now sticking out of the PVC tube, near the watercraft) connects to the corresponding end of the "split" cable. The round connecter end of the split cable connects to the 12V Hydrolab battery. The remaining serial connector on the split cable connects to the deck unit. The GPS antenna plugs into the round port next to the serial port on the deck unit. Figure 3 shows a schematic of how the electronics connect.

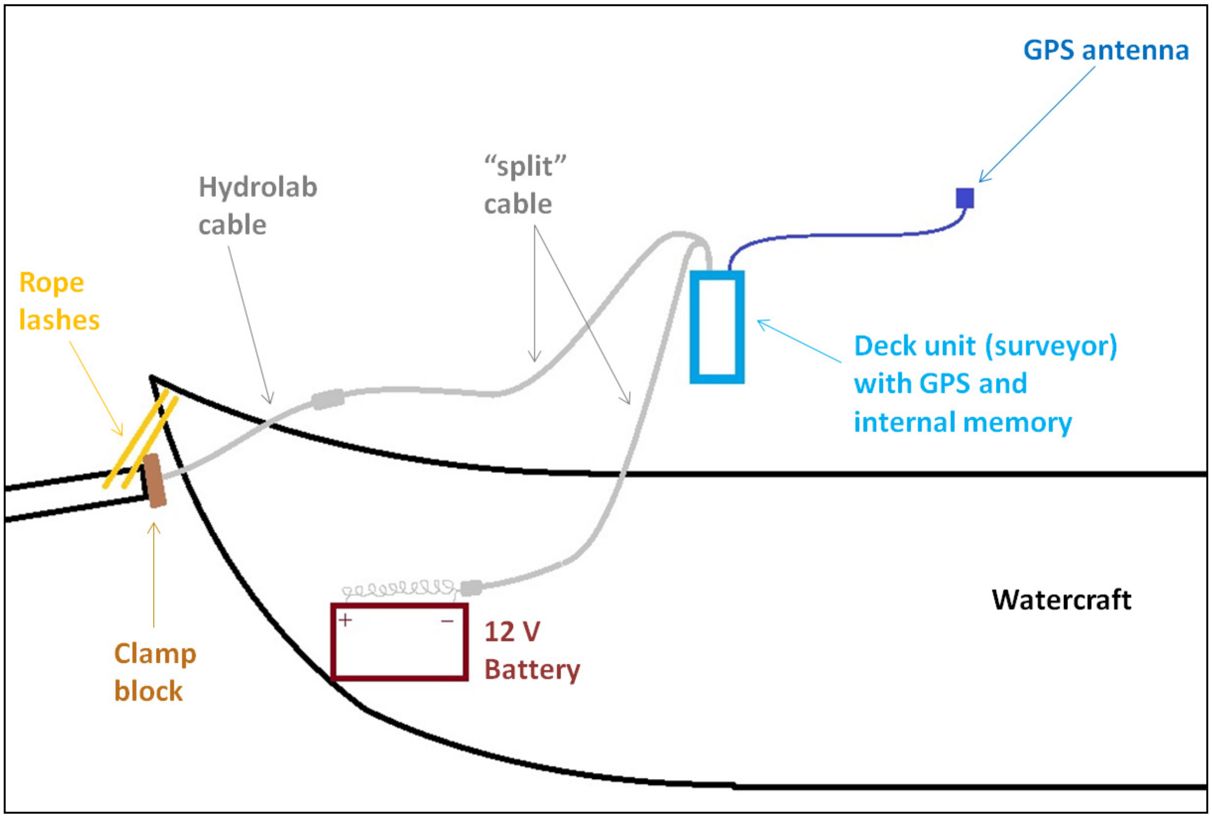

Figure 3. Arrangement of Hydrolab cables and electronics at the stern of the watercraft.

6.2.11 Cover all PVC joints and sharp edges with copious amounts of duct tape. Figures 1 and 2 show how this will look. The purpose of this is to prevent blunt or sharp PVC edges from catching on sharp rocks while being dragged along the streambed.

6.2.12 Turn on Surveyor deck unit. Disable automatic time-out for display and for total shut-down. Set up the tabular display on the deck unit so that it includes D/TSvr4, IBVSvr4 (Internal Battery Voltage), XBVSvr4 (External Battery Voltage), Latitude DMS, LongitudeDMS, Depth in meters, and any other parameters you desire to log. Ensure that all parameters being sent from the MiniSonde are displaying values correctly. Ensure that LatitudeDMS and LongitudeDMS are displaying, and are correctly defining your location. Ensure that XBV reads somewhere near 12 volts, which indicates that the external battery is connected and working properly.

6.2.13 Once you have confirmed that the external 12V Hydrolab battery is working properly, make a semi-watertight pouch for the battery. This is done using two 1-gallon Ziploc bags. Making sure the battery is in its padded cloth carrying case, and that the top flap is velcroed down, insert one end of the battery into one of the Ziploc bags, as far as it will go. Cover the other end with the other bag, overlapping the bags as much as possible. Stuff the battery cable into the bag, to the point where the connection between the battery cable and the split cable is inside the bag. Then wrap duct tape around the whole thing, so that all the joints between the bags are covered, and only the split cable is sticking out of the pouch. Then place the pouch in a dry bag, securely close the dry bag so only the cable is sticking out of it, and put the dry bag in a secure place in the stern of the watercraft where the cable will reach. Note that the purpose of all this is to protect the battery from water splashing into the watercraft. This will probably not save your equipment if you capsize.

6.2.14 Set up log file, using the controls on the Surveyor. Note that unlike most Hydrolab deployments, where the log file is stored in the sonde, in this case the log file needs to be stored in the deck unit. It is suggested to use a logging interval of 30 seconds, which is the smallest logging interval the surveyor will accept.

6.2.15 If you are not already there, move the watercraft to the edge of the water and prepare to launch. It may be convenient to set a cooler or other object in front of the person sitting in the stern for use as a desk, and to secure the deck unit and GPS antenna to this surface with duct tape.

6.2.16 The very last thing to do before launching is to zero the depth probe. Make sure the PVC pipe and cage assembly are laid out flat behind the watercraft, with the MiniSonde sitting out of the water. The deck unit commands for zeroing the depth probe are the same as for calibrating any other parameter.

6.3 Equipment setup – pressure transducer

6.3.1 Calibrate pressure transducers (Figure 4), one for water depth and one for barometric pressure, following manufacturer's instructions and SOP EAP074: Standard Operating Procedure for the use of Submersible Pressure Transducers During Groundwater Studies (Sinclair and Pitz, 2010).

Figure 4. (Left) example of basic pressure transducer with adequate vertical accuracy for stream bottom deployment. (Right) example of pressure transducer with barometric pressure for use in watercraft (or bottom).

6.3.2 Perform a calibration check on temperature logger (Figure 5) following SOP EAP044: Standard Operating Procedure for continuous temperature monitoring of fresh water rivers and streams conducted in a Total Maximum Daily Load (TMDL) project for stream temperature (Bilhimer and Stohr, 2009).

Figure 5. Example of fast-response temperature logger with external probe.

6.3.3 Synchronize depth and temperature logger times with computer system time. If computer is not connected to a network, verify that system time is accurate, using world atomic clock (can be found on the internet). Set up all three loggers with exact same start time and logging interval. A minimum of 30 second logging interval is recommended to accurately capture changes in depth and temperature.

6.3.4 Prepare GPS unit: (1) make sure two sets of batteries are fully charged, store spare batteries in dry bag; (2) make sure that GPS device system time is synchronized with laptop or computer system time used to set the time on depth and temperature loggers; (3) turn on GPS connection and establish satellite connection, verify that connection has been established and coordinates change with movement; (4) open GPS software, save and name new file, and begin route tracking (as boat begins to move downstream verify that route tracking is working properly). If possible, set route tracking interval to match logger recording interval.

6.3.5 Assemble PVC equipment following section 6.2.2.

6.3.6 Feed a steel cable or rope through the PVC assembly so that the one end is sticking out through the end of the PVC cage, and one end is sticking out the end of the pipe near the watercraft.

6.3.7 Attach one pressure transducer and the temperature logger to the underwater end of the cable/rope. Attach temperature logger first with probe facing back up the PVC pipe. Use a small loop of wire to connect pressure transducer to end of safety line. Cover any exposed wire that is near or touching the loggers with electrical tape.

6.3.8 Wrap the entire body of the loggers in electrical tape. Do not cover the hole in the transducer or external probe on the temperature logger. Wrap each sensor with enough weather stripping to fit snugly in the PVC cage assembly; apply weather stripping on top of electrical tape.

6.3.9 Insert loggers into PVC cage (temperature first, then depth) similar to section 6.2.7

6.3.10 Attach PVC pipe to watercraft, following section 6.2.9, then attach logger safety line to watercraft.

6.3.11 Cover all PVC joints and sharp edges with duct tape following 6.2.11.

6.3.12 Place barometric pressure transducer inside well-vented container and attach securely somewhere inside the watercraft.

6.3.13 Move the watercraft to the edge of the water and prepare to launch

6.3.14 Move the PVC cage out above the water, where the depth is several feet deep. Gently release cage at surface. If the cage sinks quickly, then the setup likely has negative or neutral buoyancy and is float-ready. If the cage sinks slowly or floats, the buoyancy needs to be reduced. Two options to adjust are: (1) drill additional pressure relief holes in the submerged PVC pipe above the cage; (2) add additional weight inside the pipe. You can do this by placing steel rebar inside, but this requires placing a crossbolt through the pipe to prevent the rebar from sliding down to the sensors.

6.3.15 After launching, pay close attention to the look and feel of the PVC cage. Ideally you should be able to feel the cage gently bouncing on the bottom. The goal is to optimize the buoyancy of your equipment setup so that the cage stays on the bottom but doesn't provide a lot of drag on the watercraft and can easily move over objects on the streambed. Faster moving water will require more weight (less buoyancy) and slower moving waters will require less weight (more buoyancy).

6.4 Floating

6.4.1 Navigate the watercraft down the stream channel, trying to stay in the thalweg as much as possible.

6.4.2 Avoid letting the PVC cage track beside or ahead of the watercraft. This places stress on the PVC joints and can damage the PVC setup. In wadeable areas, step out of the watercraft and reposition the cage behind the watercraft. In non-wadeable areas, paddle to the nearest stream bank and reposition the cage there.

6.4.3 In areas with visual evidence of GW input (seeps, orange staining, etc.) or in large pools, allow the watercraft to drift slowly to thoroughly characterize the depth and water quality of these features.

6.4.4 Periodically check the GPS coordinates to verify that they are changing, a connection is still established, and the route is still tracking. For pressure transducer setup, make sure to save the GPS file frequently to avoid potential data loss.

6.4.5 Every couple of hours, or if there has been a significant change in elevation, stop and pull the cage containing the MiniSonde out of the water. Check to make sure that the depth still reads 0.00 when the MiniSonde is out of the water. If not, make a note and re-zero the probe. Inspect all equipment and re-tape any joints where the duct tape has worn down.

6.5 For Hydrolab setup, after the float, connect the deck unit to the laptop using the "double serial" cable. Download the log file from the deck unit to the laptop using an Xmodem transfer. This will require use of TeraTerm, HyperTerminal, or other similar communications software on the laptop.

6.6 For pressure transducer setup, after the float, save the GPS file and then disconnect device. Remove the loggers and download to laptop or field PC using appropriate docking stations or equipment cables. If floating multiple days, download the loggers each evening to safeguard against data loss. Data from the barometric pressure transducer are used to correct the unvented transducer on the stream bottom. Most equipment software is set up to allow for easy correction of this data. For details on manual correction see SOP EAP074 (Sinclair and Pitz, 2010).

7.0 Records Management

7.1 Keep all notes in a Rite-in-the-Rain notebook. These notes should include depth probe calibration checks, observations, pictures taken, or any other ancillary data collected.

7.2 By far the most important record generated during the float is the log file that is recorded on the deck unit. After the log file is downloaded to the laptop, this log file should be placed on a shared drive location. An original, unedited version of the log file should always be retained, and any data calculations should be made in a copy.

7.3 As of 2014, it is not possible to enter float data into EIM. This is because EIM accepts discrete or continuous data that is linked to particular locations. This procedure generates data that is "spatially continuous," consisting of a dense series of points that define locations along the length of a stream, each with attached data values. This type of data set is not compatible with the format of EIM.

8.0 Quality Control and Quality Assurance Section

8.1 The depth probe used by Hydrolab MiniSondes is an unvented probe. This means that it is sensitive to changes in barometric pressure and elevation. It is important to realize that calibrating or zeroing this probe at the OC and then driving to the put-in site will most likely result in a calibration shift. That is why this SOP specifies that the probe is to be zeroed at the launch site, immediately prior to launch. Any time the zero point is checked and/or the probe is re-zeroed during the float, a note should be made and retained.

8.2 All other parameters that are being logged should be calibrated prior to the float, and checked afterward, per SOP EAP033.

8.3 If dissolved oxygen data is to be used, then either (1) an LDO probe needs to be used; or (2) the circulator needs to be turned on to use a Clark cell probe. Note that circulator use during a float can be problematic because of the tendency of the magnetic circulator paddle to pick up iron shards from the streambed. On the other hand, LDO probes have a greater power draw than Clark cell probes, which could be an issue, since the sonde is continuously powered up during the float. If dissolved oxygen data is to be used for model calibration, regulatory, or other uses that require accuracy better than ~1 mg/L, then a few Winkler dissolved oxygen samples should be taken alongside the probe measurements. See SOP EAP023, Collection and Analysis of Dissolved Oxygen (Winkler Method).

8.4 A common source of data loss during depth floats is Hydrolab power failure. The MiniSonde and the deck unit are powered up continuously for the duration of the float, creating significant power needs. The best approach to avoid power loss is to make sure that (1) there are fresh AA batteries installed in the MiniSonde; (2) the deck unit is fully charged; and (3) the external battery is fully charged and all connections are good. This way, even if one battery/set of batteries fails, the equipment can continue to operate on the remaining power sources at least for a little while.

8.5 High aeration caused by rapids can interfere with the accuracy of the depth probes. Areas of high aeration/whitewater should be recorded in field notes, and depth data from these areas should be reviewed to make sure it makes sense.

9.0 Safety

9.1 A personal floatation device (PFD) must be worn. (Ecology, 2012)

9.2 Collecting a longitudinal stream depth profile can involve a variety of hazards and challenges. The streams and rivers where Ecology needs to collect depth data are often “off the beaten path.” There is no guarantee that a given stream or river will be logistically feasible or safe to float. Streams and rivers can contain numerous obstacles and hazards, such as:

- Larger-than-expected rapids
- Waterfalls – although large waterfalls are usually named, mapped, and well-known, smaller waterfalls and steps several feet high can often exist without being well documented. In certain geological regions, such as the channeled scablands of Eastern Washington, waterfalls can exist at surprising locations on otherwise low-gradient streams.
- Bridges too low for staff in a watercraft to duck under
- Logs across the channel, especially “spanners” in the air that may be too low to duck under
- Tree foliage that overhangs the channel, possibly creating “strainers” that could catch or capsize a watercraft
- Sharp corners in high-velocity rapids that can throw the watercraft violently against the outside bank
- Boulders that sit just below the water surface
- Barbed-wire fences strung low across the stream
- Electric fences strung low across the stream

- Rocks and shallow riffles that the watercraft can get hung up on, requiring staff to get out and push
- Stoppers or "keepers" where re-circulating current can trap the watercraft or boater; avoid whitewater where the rapids resemble a frowning mouth.
- Landowner confrontations. In Washington, the bedlands of rivers and streams which are defined as "navigable" are generally publically owned, either to the Line of Navigability or to the Line of Ordinary High Water (DNR, 2010). However, there are exceptions. It is the responsibility of staff to make sure they either stay on public lands or have permission to be on any private lands. When floating on publically owned streams, staff should be aware that some adjacent landowners may not know that the stream is publically owned, and confrontations are still a possibility.

9.3 If staff are not intimately acquainted with the stream that is to be floated, then good reconnaissance is a very important safety step. This should include driving along the stream to get an idea of what the stream is like and look for hazards. Reconnaissance should also include familiarization with streamflow patterns. USGS gaging stations generally have records of individual streamflow measurements along with continuous flow data. These individual streamflow measurements usually contain ancillary data such as channel depth and channel velocity. These records can be used to get an idea of what depth and velocities might be expected at a given streamflow. This can help guide decisions about what flow conditions to float at. Also, it is strongly recommended that staff conduct a "virtual fly-over" using online or GIS orthophotos. This should be done at a resolution of about 1:1000, slowly scrolling along the course of the stream to be floated. This "virtual fly-over" can often identify hazards such as logjams and waterfalls.

9.5 Ultimately the decision about which stream reaches are safe to float, and at what streamflow conditions, is a complex one. The use of common sense is recommended.

9.6 Refer to attached MSDS sheets if using PVC purple primer and PVC glue.

10.0 References

10.1 Ecology, 2012. Environmental Assessment Program Safety Manual. Washington State Department of Ecology, Olympia, WA.

10.2 Bilhimer, D. and A. Stohr, 2009. Standard Operating Procedures for continuous temperature monitoring of fresh water rivers and streams conducted in a Total Maximum Daily Load (TMDL) project for stream temperature. EAP SOP 044. Washington State Department of Ecology, Olympia, WA.

10.3 DNR, 2010. Boundaries of State-owned aquatic lands. Fact Sheet. Washington State Department of Natural Resources, Olympia, WA. http://www.dnr.wa.gov/Publications/aqr_aquatic_land_boundaries.pdf

10.4 Sinclair, K. and C. Pitz, 2010. Standard Operating Procedure for the use of Submersible Pressure Transducers During Groundwater Studies. SOP EAP074. Washington State Department of Ecology, Olympia, WA.

10.5 Swanson, T. Standard Operating Procedures for Hydrolab DataSonde and MiniSonde Multiprobes. SOP EAP033. Washington State Department of Ecology, Olympia, WA.

10.6 Ward, W. and N. Mathieu. Standard Operating Procedures for the Collection and Analysis of Dissolved Oxygen (Winkler Method). SOP EAP023. Washington State Department of Ecology, Olympia, WA.