National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Upper Columbia Basin Network
Integrated Water Quality Monitoring Protocol

Standard Operating Procedures Version 1.8
(Appendix A to Narrative Version 1.0)

Natural Resource Report NPS/UCBN/NRR(DRAFT)—2013/XXX



ON THE COVER
North Fork Big Hole River, Big Hole National Battlefield
NPS photo

Upper Columbia Basin Network
Integrated Water Quality Monitoring Protocol

Standard Operating Procedures Version 1.8
(Appendix A to Narrative Version 1.0)



Natural Resource Report NPS/UCBN/NRR(DRAFT)—2013/XXX

Eric N. Starkey
Biological Technician
National Park Service
Moscow, ID 83844-1136

Lisa K. Garrett
Network Coordinator
National Park Service
Moscow, ID 83844-1136

Thomas J. Rodhouse
Ecologist
National Park Service
Bend, OR 97701

Gordon H. Dicus
Data Manager
National Park Service
Moscow, ID 83844-1136

R. Kirk Steinhorst, Ph.D.
Department of Statistics
University of Idaho
Moscow, ID 83844

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2. Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D. Klemm, J.M. Lazorchak, F.H. McCormick, S.A. Peterson, P.L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, DC, EPA/620/R-06/003.
3. Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.
4. Garmin. 2005. GPSMAP 76CSx Owner's Manuel. Garmin International, Olathe, KS. Available online at http://www.garmin.com/products/manual.jsp?product=010-00469-00
5. Lane, S.L., and Fay, R.G., October 1997, Safety in field activities: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A9, accessed January 2008 at http://pubs.water.usgs.gov/twri9A9/
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Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 1: Preparations and Equipment Set-up Prior to the Field Season

Version 1.1, February 2013

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0
1.0	February 2013	UCBN-Aquatic Biologist	Updates to multiprobe housing construction. Changes to macroinvertebrate site selection/setup. Addition of external power source directions. Updated safety section.	Updates reflect changes to procedures	1.1

Note: This SOP describes the step-by-step procedures for preparing for field work and for constructing, preparing, and organizing field equipment prior to the initiation of personnel training and entry into the field. Field time is expensive and adequate field and equipment preparation is crucial to a successful monitoring program.

Suggested Reading

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Starkey, E. N., T. J. Rodhouse, G. H. Dicus, L. K. Garrett, K. M. Irvine, and E. K. Archer. 2011. Upper Columbia Basin Network stream channel characteristics monitoring protocol: Standard operating procedures version 1.0 (Appendix A to Narrative Version 1.0). Natural Resource Report NPS/UCBN/NRR—2011/340.A. National Park Service, Fort Collins, CO.

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Annual Review

Key network and park staff should conduct an annual review of the protocol and SOPs prior to spring preparations. This is a central element to season close-out procedures. Review should include training and field procedures, data management, analysis, and reporting, as well as fundamental design issues. Most importantly, careful consideration should be made of the resulting analyses and the overall confidence in results. The adequacy of sampling effort must be evaluated. Any necessary changes should be made to the protocol and SOPs with enough time to circulate updated material to key staff.

Procedures

Scheduling and Organizing Field Work

The UCBN and its constituent parks are unable to maintain a large field staff for financial and logistical reasons. This combined with the remote and widely dispersed nature of the network, as well as the demands from other vital signs monitoring efforts, requires that the field portion of the integrated water quality monitoring program be sustained by the project lead, UCBN staff, and park resource managers. This fact mandates that field work should be scheduled well in advance of the May-October sampling window, and scheduling efforts should begin no later than the previous January. The project lead will coordinate this planning with park resource managers and UCBN staff. While park resource managers will assume primary responsibility for multiprobe calibration and data retrieval, the network will provide additional support in this area, and will be responsible for training, multiprobe installation / removal, and macroinvertebrate collection. In some cases, the natural resource manager may be unable to assume primary responsibility for the multiprobe. If this should occur the UCBN project leader will make arrangements with the Network Coordinator to hire seasonal help or contract for multiprobe calibration and data retrieval. A minimum of two people are necessary to complete multiprobe installation and macroinvertebrate sampling in a reasonable amount of time.

Supplies for Construction and Preparation

The following equipment should be assembled each spring, and sufficient time allowed to construct and/or order replacement equipment. Water quality field equipment will be checked out/in of the UCBN office by the protocol lead. Each park will require one multiprobe set up/calibration supplies and adequate supplies for all macroinvertebrate reaches to be sampled. The number of macroinvertebrate reaches will vary with the available stream length (see the Benthic Macroinvertebrate Sample Collection SOP #7).

Macroinvertebrate Equipment:

These are the supplies that should be gathered/made prior to sample collection. For equipment needed during sample collection see SOP #7. Note that macroinvertebrates are now collected as part of the stream channel characteristics monitoring protocol (Starkey et al. 2011).

- Sample Reach Layout
    - Aluminum tags (labeled with the cite number and bottom/top of reach) Note these tags are to be installed during stream channel characteristics monitoring and should not be re-marked for macroinvertebrate sampling. (2 tags/sample reach).

- Flagging pins (for stream channel transects-See Starkey et al. 2011)
- 50 m tape measure (1)
- GRTS generated sampling points loaded in GPS unit

- Sample Collection –
  - 95% ethanol, in a proper container (2 gal)
  - Blank labels to affix to sample jar (6 to 8 / park)
  - Blank labels printed on waterproof paper for inside of sample jars (6 to 8 /park)
  - Sample collection form / data sheet (6 to 8 / park)
  - Field Safety Notebook
  - List of GRTS generated or other site coordinates

Multiprobe Equipment:

- Initial installation/housing construction
  - ½-inch rebar, 5’ (3)
  - Cable padlock –for locking the housing(1)
  - Padlock - for attaching security cable (2)
  - Security cable – 1/8-inch (1)
  - PVC pipe 5’ section (4” diameter, schedule 40) (1)
  - PVC flanged end cap (4” diameter, schedule 40) (1)
  - 5-inch long ½-inch carriage bolt (1)
  - Flat washers (2) inside diameter ¼-inch, (2) inside diameter ½-inch
  - 2 ½” long, ¼-inch stainless steel eyebolt (1)
  - Stainless steel bolt snap (1)
  - Stainless steel band clamps (3)
  - 5/16-inch drill bit
  - ½-inch drill bit
  - 2-inch hole-saw drill bit
  - Flathead screwdriver to adjust band clamp
  - T-Post driver/3 pound sledge hammer
  - Drill
  - Handsaw
  - Optional for construction of housing extension (for use in deep pools)
    - PVC pipe 5’ section (4” diameter, schedule 40) (1)
    - PVC straight connectors 4” diameter (2)
- Initial installation/external power source construction
  - Adapter (Hach Company Cat. No. 011530HY) (1)
  - External Power Adapter Cable (Hach Company Cat. No. 013170HY) (1)
  - Detachable calibration cable (15 m preferred) (Hach Company Cat. No. 015XXX) (1)
  - PVC pipe 8’ section (¾” diameter)
  - PVC pipe (2” diameter) length depends on distance between battery box and multiprobe housing.
  - PVC electrical conduit 8’ (2” diameter, schedule 80) (1)
  - PCV connectors ¾-inch
    - 90° corners (4)

        - Ts (3)
        - 45° (1)
    - PVC cleaner and glue
    - Battery box (8 gallon, ActionPacker® Cargo Box / Bin Rubbermaid)
    - Deep cycle battery
    - Solar 12V battery trickle charger such as http://www.northerntool.com/shop/tools/product_200578631_200578631 (accessed 02/14/2013)
    - Alligator clips (2)- one black (-) one red (+)
    - Camouflage green paint (1 spray can)
    - ¼ -inch wing nuts (4)
    - 2 ½-inch long ¼ -inch machine screws, Philips head (2)
    - ¼ -inch flat washers (4)
    - T-post (1)
    - T-post driver (1)
    - 2 padlocks-same key (for battery box)
    - Copper scrub pads

- Maintenance / Data retrieval
    - Brush (1)
    - Dish soap
    - New AA batteries (8)
    - Cotton swabs
    - Lint free towels
    - Deionized water
    - Wash bottle
    - Laptop computer or PDA
    - Detachable calibration cable
    - MS5 calibration cup
- Calibration (See the Multiprobe Site Revisit SOP #6).

Multiprobe Site Selection –Preliminary reconnaissance

Multiprobe site selection will be determined using the criteria established by Wagner et al. (2006) and White (1999). In preparation for the field season, it is necessary to adequately search for prime multiprobe installation locations. This reconnaissance should be conducted during base flow conditions, the year prior to the scheduled monitoring. Overall, the UCBN seeks to balance the need for a representative location within each stream, with factors such as stream stages, channel morphology, water velocity, potential for debris damage, and logistics. Multiprobe site selection is discussed in more detail in SOP #5.

Multiprobe Housing Construction and Preparation

The methods for housing construction outlined below are based on construction techniques used by the Southeast Coast Inventory and Monitoring Network (DiDonato, et al. 2006), and information provided in the Hydrolab MS5 User Manual (HACH Environmental 2006).

The housing containing the Hydrolab MS5 Water Quality Multiprobe is made from 4-inch diameter schedule 40 PVC pipe, which will be attached to 3 metal posts within the stream channel or on the bank. Typically multiprobes are attached to bridges or other permanent structures to help prevent theft, washouts or damage from drifting debris. However, very few of these structures exist in UCBN parks and water quality information taken near permanent structures may not be representative of overall stream conditions. As a result, multiprobes will be attached to metal posts in a location found to be representative of water chemistry within the reach. The multiprobe, will be suspended such that the sensors are ≈ 30.5 cm (1 ft) from the bottom of the housing to prevent contact with sediment. At most locations the multiprobe cannot be higher in the water column, because aerial exposure may occur during low flow conditions. Each multiprobe housing is capped with a PVC flanged end-cap and locked with a cable padlock. The entire housing is also affixed to a permanent or semi permanent location on the bank using a cable and lock.

PVC pipe can be purchased from most hardware stores in 3.05 m (10 ft) sections and will need to be cut into 1.52 m (5 ft) sections. Generally a handsaw works best to cut PVC pipe. Drill one ½" hole through the entire pipe 30.5 cm (1 ft) from one end. A 5-inch stainless steel carriage bolt will be inserted through this hole to serve as the rest for the multiprobe so it will remain 30.5 cm (1 ft) from the sediment. Next, with a 2-inch hole-saw drill bit, drill a series of 2 inch diameter holes around the pipe and extending 46 cm (1.5 ft) above the carriage bolt (Figure 1). These holes will allow water to mix easily and pass through the pipe. Several other ½-inch holes should be drilled throughout the rest of the pipe to ensure the mixing of water. Place the end cap on and drill a ½-inch hole through the end cap and the pipe, across the diameter of the pipe, so that the end cap can be locked with a cable padlock. If using an external power source, a notch should be cut in the pipe and flanged end cap to allow the calibration/power cable to enter the housing (Figure 2).

The Southeast Coast Network operating procedure suggests the use of a flanged end-cap because it is easy to remove and provides a good location for an eye bolt from which to hang the multiprobe (note that the eye bolt is only used with a multiprobe operated by internal AA batteries). Drill a 5/16-inch hole in the cap, just off center, to prevent interference with the locking mechanism. Then, insert a ¼-inch stainless steel eye bolt and washer from the bottom of the cap (Figures 3 and 4). It is advisable to damage the threads to prevent the nut from being removed and subsequent multiprobe loss. An eye bolt should also be inserted into the multiprobes mooring fixture (Figure 5). This eyebolt will allow the multiprobe to be suspended from a cable attached to the cap (internal power option). The cable should be made from braided nylon line, which has had the ends melted to prevent fraying. The line should be tied to a long bolt stainless steel snap hook, with a clinch knot. This end will be attached to the multiprobe and will allow for easy removal during calibration. It is advisable to paint the housing a non-descript color to prevent vandalism. In addition, a white line should be painted on the housing that indicates when the sensors are in danger of drying out.



Figure 1. Photo of the series of holes drilled in the multiprobe housing to allow water to mix easily.



Figure 2. Flanged end cap and housing with notch to accommodate external power source cable.



Figure 3. Flanged end cap top view (DiDonato, et al. (2006).



Figure 4. Flanged end cap bottom view (DiDonato, et al. 2006).

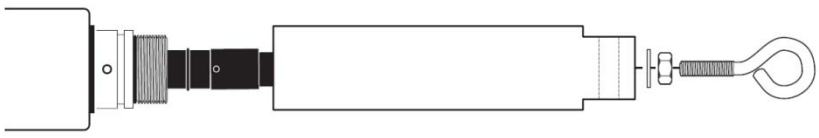


Figure 5. Mooring fixture with eye bolt (HACH 2006).

Recommended Multiprobe Housing Options

External Power Source: In addition to the standard multiprobe housing setup above, the UCBN recommends the use of an external power source for multiprobes that are to be deployed longer than 20 days. Deployment intervals over 20 days usually result in the depletion of internal battery power (8-AA) and reduction of data quality and utility. One external power source that has been reliably used since 2010 is a deep cycle battery maintained by a solar trickle charger (Figure 6). Initial costs of setup are quickly recovered by avoiding the purchase of AA batteries and additional site visits/travel time. Note that if vandalism is a concern this design may need to be modified.



Figure 6. External power source/multiprobe configuration.

Solar trickle charger frame: A PVC frame should be constructed to fit the solar trickle charger. The exact design may differ slightly due to varying types of solar trickle chargers; however, it is important that the frame provides adequate support even during high winds. After dry fitting, all PVC connections should be cleaned and glued. Following construction of the frame and attachment of the trickle charger, 2- ¼-inch holes should be drilled in the stem of the frame so that it can be attached to the vertical support using 2 ½-inch long ¼ -inch machine screws and wing nuts (Figure 7).



Figure 7. Solar trickle charger and PVC frame attached to vertical support. Note placement of PVC connectors and bolts.

Vertical Support: The vertical support is constructed of PVC electrical conduit (2" diameter, schedule 80). A 1 inch hole should be drilled near the base of the vertical support such that wiring from the solar panel can be fed down the top end of the conduit and exit the hole near the battery box (Figures 6 and 7). This electrical conduit is placed over a T-post driven into the ground (Figure 6).

Electrical Connections: A small hole (2.5 cm X 1.9 cm) should be cut in the battery box, just below the handles. The position and diameter of the hole are important in order to limit the entry of rain water, rodents and insects. The trickle charger cable should pass from the vertical support, through the hole in the battery box and be connected to the posts on the deep cycle battery. The battery adapter cable (Figure 8) should be modified such that it can be connected to the battery using alligator clips. As shown in figure 8, the battery adapter cable should be connected to the external power adapter cable, which should subsequently be connected to the detachable calibration cable. After these connections have been made, the calibration cable should be fed from the battery box down a PVC pipe (2" diameter) towards the multiprobe housing. This step will help avoid damage to the calibration cable by rodents as it runs between the battery box and multiprobe housing. The ends of the PVC pipe should be blocked with copper scrub pads. If there is exposed cable between the battery box and the PVC pipe it should be wrapped with copper mesh. The external power source and calibration cable is now ready to be connected to the multiprobe. Make sure to close and lock the lid to the battery box.

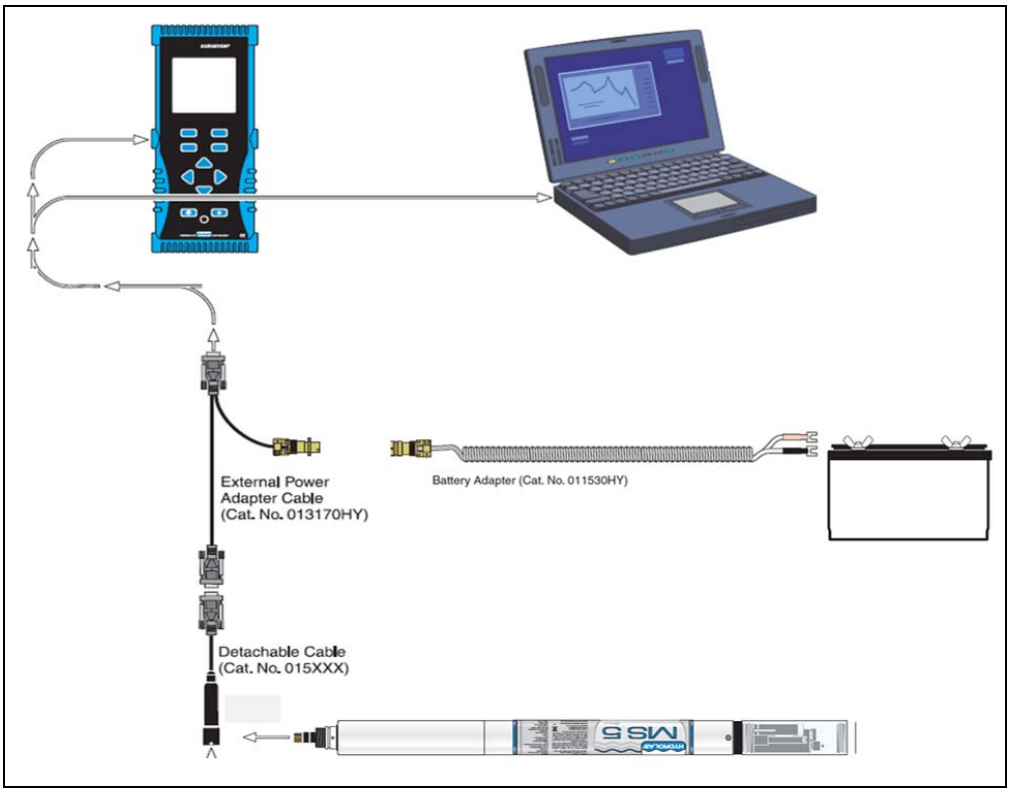


Figure 8. Cables required to connect a Hach brand Hydrolab MS-5 to an external power source. Modified from Hach Environmental 2006.

Multiprobe Housing Extension: If the multiprobe is to be deployed in a deep pool, or where access may be limited due to high flow, it may be necessary to extend the length of the housing from 1.5 m (5 foot) to 3.1 m (10 feet). This extension can be made by using a 1.52 m (5 ft) section of 4-inch schedule 40 PVC, a straight coupling and PVC glue. The coupling should be glued to the new section of PVC such that it can be joined with the 5foot long housing as constructed above. In addition, new holes should be drilled in the PVC pipe so that the flanged end cap can be locked and a notch should be cut to accommodate an external power source. DO NOT glue the PVC coupling to both the extension and the housing. The extension will only be dry fitted to the existing housing. This arrangement makes transport to the site easier and allows the housing to be used as a 5 or 10 foot segment depending upon site requirements.

Multiprobe Housing Installation

Shallow/Low Flow Configuration

Once a representative location has been established (SOP 5), three 1.5 m (5 ft) ½-inch rebar posts should be driven at least 30.5 cm (1 ft) into the substrate, so that when they are pulled together they form a tripod of three supports for the 1.5 m (5 ft) PVC housing (Figures 9 and 10). Three band clamps should be used to fasten the pipe to the rebar posts. This design should allow the housing to "break away" from the installation location during high flow events, yet remain attached to the bank via a security cable. In addition, this design is easily reconfigured to accommodate low flow conditions. Note that it is best to use rebar in gravel to coble substrates and 2 T-posts in soft silty or clay substrates (Figure 12).



Figure 9. Rebar posts for multiprobe housing support.



Figure 10. Multiprobe housing attached to rebar posts. Note the security cable attached to the bank.

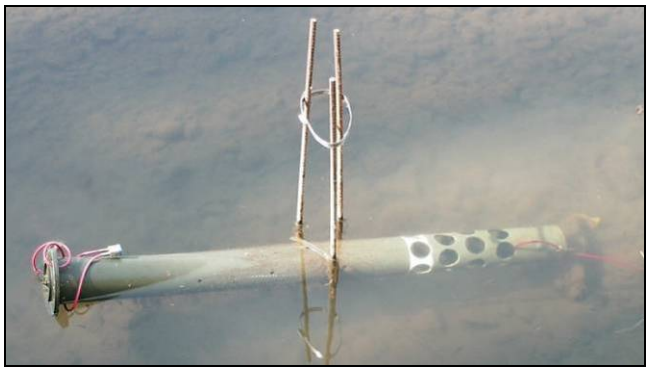


Figure 11. Alternative configuration of the multiprobe housing during low flow conditions.



Figure 12. Multiprobe housing attached to T-posts. Soft substrate is not optimal for rebar supports.

Deep Water/High Flow Configuration

Once a representative location has been established (SOP 5), two T-posts should be driven into the bank near the water's edge so that they will support the PVC housing (Figures 13 and 14). The two sections of the 3.1 m (10ft) housing should be joined by dry fitting the housing with the extension. Use a mallet and board to tap the two segments together. Two additional T-Posts should be fastened to each side of the housing so that the ends of the posts extend approximately 47 cm (1.5 ft) from the end of the pipe. (Figures 13 and 14). Three band clamps should be used to fasten the T-posts to the housing.

The housing should then be positioned in between the T-posts driven into the bank. The housing should be hit with a mallet to drive the lower T-posts into the stream substrate. Once in position, the upper portion of the housing should be affixed to the T-posts on the bank using band clamps. In areas that are expected to experience high flows, the T-Posts positioned in the stream may need to be driven directly into the substrate.

This design will allow the housing and multiprobe to be accessed from the bank, even in deep pools or high flows. An example of this design is shown in Figures 13-15)

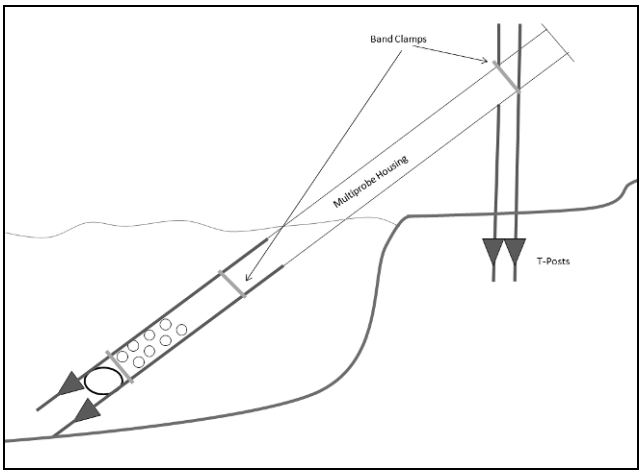


Figure 13. Deep water multiprobe housing configuration.



Figure 14. Multiprobe housing with extension deployed in a deep pool. Note the position of T-posts on the bank and attached to the housing.



Figure 15. Multiprobe housing with extension and external power source.

Multiprobe Pre-mobilization Calibration/Error Check

Prior to the field season each spring, the multiprobe should be prepared for deployment. These pre-mobilization activities involve general maintenance, calibration and error checks that will help ensure quality data collection. General pre-mobilization activities are outlined below and are more fully outlined in SOP #6 Multiprobe Site Revisit. The procedures for pre-mobilization calibration are the same as the calibration procedures in the field but instead are conducted in the lab/office. Note that all calibrations and error checks should be recorded on a UCBN Calibration and Maintenance Log sheet (Appendix 5).

1. Clean the sensors and multiprobe with soapy water as outlined in the "Cleaning" section of SOP #6.
2. Conduct other maintenance as outlined in the "Other Maintenance" section of SOP #6
    a. Install new batteries
    b. Lubricate all O-rings
3. Calibrate each sensor as outlined in the "Calibration" section of SOP #6 - Calibration failure likely indicates a faulty sensor. If the problem persists contact Hach Technical Assistance (1-800-949-3766).
    a. Specific Conductance
    b. Dissolved Oxygen
    c. pH
    d. Turbidity
4. Pre-mobilization error check - this error check should be performed in the same manner as the "Calibration Drift Check" in the Multiprobe Site Revisit SOP #6. The only difference is that it is done after the calibration instead of before. Make sure that all standard solution readings fall within the calibration criteria given in Table 4 of SOP #6. If standard solutions measurements do not fall within the accepted criteria the faulty sensor should be re-calibrated and checked again. If the sensor fails a second time call Hach Technical Assistance.
5. Note that dissolved oxygen will need to be re-calibrated at the deployment location due to differences in barometric pressure caused by change in altitude.
6. Determine QA/QC data quality indicators. As described in the QA/QC SOP #12
    a. Method Detection Limit (MDL) – Turbidity
    b. Minimum Level of quantitation (ML) – Turbidity

Other Multiprobe Preparations

Calibration and Maintenance Log

Each multiprobe should have a unique Calibration and Maintenance Log Book, to reflect maintenance over the life of the instrument. The log book is a critical part of both water quality data management and multiprobe maintenance, for this reason all information should be kept up to date.

The Calibration and Maintenance Log Book should be a 1-inch or larger, 3-ring notebook with a clear cover. The cover of the notebook should indicate the following:

- UCBN Calibration and Maintenance Log for Multiprobe #
- The make and model (e.g. Hach MS5 Hydrolab)

- Serial number for the multiprobe.

The inside cover of the notebook should list the following

- Make and model of the multiprobe
- Serial number of the multiprobe
- Serial number for each sensor (this should be updated if sensors are changed).

The rest of the notebook should be divided into sections that contain the following:

- General workflow for a water quality site revisit
- List of standard solutions and calibration criteria for each parameter
- UCBN Calibration and Maintenance Log Sheets (Blank sheets for site revisits and completed sheets from previous deployments)
- UCBN Site Inspection Summary Forms – printed after data has been processed from a deployment period.
- Log of other maintenance/calibration issues (e.g. repairs, calibration failure, etc.)
- Multiprobe and Sensors User Manuals
- Dissolved Oxygen Solubility Table
- MSDS – for calibration standard solutions

The Calibration and Maintenance Log Book should be retained during the field season by the person conducting multiprobe site revisits. After the field season has been completed the log book should be kept in the UCBN office. Note that copies of all UCBN Calibration and Maintenance Log sheets should be made after each deployment and placed in a different location.

Macroinvertebrate Sample Reach Selection

In 2010 the collection of benthic macroinvertebrates became part of the stream channel characteristics monitoring protocol. With the exception of Little Cottonwood Creek at CRMO, streams sampled under the stream channel protocol are the same as those sampled for integrated water quality monitoring. The method of sample reach selection reflects methods for stream channel reach delineation (Heitke et al. 2008, Starkey et al. 2011, Archer et al. 2012). For Little Cottonwood Creek at CRMO the macroinvertebrate sample reach will begin (bottom of reach) at the previous X-Site (see this SOP v 1.0 and SOP #7 v 1.0).

The stream selection criteria as defined by PIBO specify that the preferred sample reaches have "unconstrained valley bottoms with gradients less than 3 percent and have wadeable channels with bankfull widths between 1 and 15 m." Streams with gradients over 3 percent or with bankfull widths over 15 m will still be sampled; however, the data may not be comparable to other reaches sampled by PIBO.

The location of the first sample reach will be determined by moving upstream from the park boundary until the sample crew identifies the first pool tail. Reach length is a function of the average bankfull width, such that as width increases so does the total reach length, with a minimum reach length of 160 m and a maximum reach length of 480 m. A minimum of 21 [stream channel] transects are sampled within each reach and the top of the reach "is located at the first pool tail encountered after the 21st transect (Heitke et al. 2008)." Transects will continue to be established until a pool tail is identified or 25 transects have been sampled. A more detailed

description of reach and transect establishment can be found in Heitke et al. (2008), and Kershner et al. (2004). Pools are clearly defined in the "Pools" section of the PIBO Sampling Protocol for Stream Channel Attributes (Heitke et al. 2008). Subsequent sample reaches within the park will be determined by moving upstream from a previous sample reach until another pool tail is identified.

The top and bottom of each sample reach will be permanently marked using a 1 inch by 3 inch piece of aluminum with PIBO EM scratched into them (Figure 16). The top of the reach will be labeled as TR and the bottom of the reach as BR. In subsequent years, during sample reach revisits, field crews will navigate back to the same sample reach using a reach description, photographs, topographic map and UTM coordinates. At CRMO where no stream channel characteristic monitoring occurs, the X-Site will be marked with BR.



Figure 16. Close up of a reach marker.

Note that the average bankfull width of each sample reach will help determine how many sample reaches fit within the park boundary. Ideally each stream will have 6 sample reaches; however, this may not be possible due to stream segments that are too short for 6 reaches. A reach is defined as a function of the average bankfull width, such that as width increases so does the total reach length, with a minimum reach length of 160 m and a maximum reach length of 480 m. When the total stream length within a park will accommodate 6 reaches, sample locations will be selected by moving upstream from the park boundary until the sample crew identifies the first pool tail. Subsequent sample reaches within the park will be determined by moving upstream from a previous sample reach until another pool tail is identified.

In cases where total stream length will accommodate more than 6 reaches these reach locations may be identified using a GRTS spatially-balanced sample. Generation of these points is outlined in SOP #4. When the stream length within the park cannot accommodate 6 sites the UCBN will position sample locations to maximize the number of sample reaches within the park. It is important to estimate the number of reaches that will fit within a park stream segment prior to conducting field work. Table 1 shows stream length as estimated using NAIP imagery.

Table 1. Stream length within the boundaries of each park as identified using NAIP imagery. Actual sample area may differ due to varying hydrologic conditions.

Park	Stream	Maximum Length (m)
BIHO	North Fork Big Hole River	3389
CIRO	Almo Creek	4545
	Main Circle Creek	1333
	North Fork Circle Creek	1294
	South Fork Circle Creek	1066
CRMO	Little Cottonwood Creek	2762
JODA	Bridge Creek	6033
	John Day River	10694
	Rock Creek	2370
NEPE	Jim Ford Creek	1258
	Lapwai Creek	374
WHMI	Doan Creek	529
	Mill Creek	151

Additional Macroinvertebrate Sample Reaches

As mentioned in the Stream Channel Characteristics Narrative (Starkey et al. 2011), the PIBO program collects benthic macroinvertebrates as part of its assessment of stream channel characteristics. For this reason samples collected by the PIBO program will fulfill the requirements of both the stream channel and water quality protocols. In some streams, the number of sample reaches for the assessment of stream channel characteristics fall below the minimum desired samples for macroinvertebrates (6 sample reaches). In these cases, additional samples will be collected by the PIBO program. These additional macroinvertebrate sample locations will be determined by moving upstream from a previous sample reach until another pool tail is identified. Note that additional macroinvertebrate reaches should fall above the most upstream stream-channel sample reach, and should be permanently marked as described above.

Macroinvertebrate Field Work Preparation

Sample Reach Markers

New reach markers should be made and placed only if a macroinvertebrate site has not been previously marked as part of the stream channel characteristics monitoring protocol. Prepare new markers by scratching the site number and TR (top of reach) or BR (bottom of reach) into a 1 inch by 3 inch piece of aluminum. Placement of these site markers is covered in SOP #7 and in Starkey et al. 2011.

Composite Sample Labels

Sample labels for the outside of sample jars should be printed in advance and contain the following information:

- Sample ID including Site Number / Stream Name
- Date of collection
- Type of sampler and mesh size used
- Collector's initials
- Number of Jars

In addition, Rite-In-The-Rain paper should be cut into 4 x 4 cm squares. This paper label will need to be filled out with the above information and will be inserted in the jar with its contents. Note that the labels that will be attached to the sample jar will have information recorded in ink and permanent marker, and the label that is placed inside the jar MUST be filled out in pencil! If the inner label is not filled out in pencil alcohol will cause ink to dissipate and no information will remain. In the same way care should be taken not to spill alcohol on the outer label, if this occurs the jar should be dried and the information re-written immediately and covered with a clear tape strip.

Navigation and Field Data Management Equipment

- When establishing new sample locations that are not co-located with stream channel characteristics monitoring, development of a new set of randomly generated sampling points must be conducted following the procedures described in SOP #4, and a digital text file (.txt) created with the Site ID and UTM coordinates. This list will then be uploaded to each GPS unit following procedures outlined in SOP #3. GPS preplanning also includes review of satellite availability for the duration of the scheduled sampling window, and is described in SOP #3. In some parks riparian vegetation and low valleys may make satellite reception difficult, but generally, enough satellites are available to have a relative location error less than 10 m (30 ft). Make necessary schedule changes if an unusually poor arrangement of satellites is scheduled during the sampling window. Data entry forms should be revised and printed, with extra copies available. Back-up GPS units should also be available and have all necessary files pre-loaded.

- Be sure to completely charge all GPS units, as well as backup batteries, prior to departure for the field.

- Paper data sheets and composite sample labels should be prepared and printed to Rite-in-the-Rain paper. Data sheets should include the following: Macroinvertebrate Site Verification/Establishment Form, Macroinvertebrate Sample Collection Form, and Field Sample Shipment Packing/Tracking Form. All of these datasheets are found on the DVD in the back of this document.

Macroinvertebrate Sample Reach Setup

Sample reach setup/establishment is discussed in more detail in the Benthic Macroinvertebrate Sampling SOP #7.

Safety Preparations

Safety is an important, but easily overlooked consideration. The safety information (SOP #13) should be reviewed before any field activity occurs. All information in the field safety notebook should be updated and reviewed. This includes appropriate Job Hazard Analysis, contact phone numbers, Chemical Material Safety Data Sheet (MSDS), and the Medical Information for Office Personnel form. Make sure all persons in the field know where vehicle keys are to be stored during field operations, the location of the nearest pay phone and/or cellular phone coverage opportunity, and emergency contact and operation procedures for NPS staff.

In addition, prior to the start of each field season, certain safety documents must be reviewed, signed, and returned to the park contact and the network coordinator. These documents include: an official travel checklist, fieldwork itinerary forms that outline when and where field operations will take place, readiness review documents that detail necessary safety topics that have been prepared for the field season, and job hazard analyses (JHAs) that highlight some of the individual risks associated with fieldwork and ways to mitigate those risks. A CRMO specific backcountry travel SOP is required for anyone performing fieldwork in CRMO. These documents are included in the appendices.

Miscellaneous Preparatory Notes:

1. Analysis and reporting of previous year's data is necessary before starting a new field effort. This is covered in SOP #10, data management, and SOP #11, data analysis and reporting.
2. Prepare a realistic schedule of events in advance of sampling, and circulate to resource managers in each park. Each year prior to multiprobe deployment, training or training updates should be conducted with resource managers as a QA/QC measure.
3. Inventory and order fresh calibration standards prior to the start of field work each year. Necessary standards are given in SOP #6.

Literature Cited

Archer, E. K., R. A. Scully, R. Henderson, B. B. Roper, and J. D. Heitke. 2012. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp.

DiDonato, E.M., C. Wright, and B. Huston. 2006. Core Parameter Fixed-Station Water Quality Monitoring (Draft). Natural Resource Report NPS/SER/SECN/NRR—2007/xxx. National Park Service, Southeast Coast Network, Atlanta, Georgia.

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Starkey, E. N., T. J. Rodhouse, G. H. Dicus, L. K. Garrett, K. M. Irvine, and E. K. Archer. 2011. Upper Columbia Basin Network stream channel characteristics monitoring protocol: Standard operating procedures version 1.0 (Appendix A to Narrative Version 1.0). Natural Resource Report NPS/UCBN/NRR—2011/340.A. National Park Service, Fort Collins, CO.

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

White, E.T.1999, Automated water quality monitoring field manual: British Columbia, Canada, Ministry of the Environment Lands and Parks, Water Management Branch for the Aquatic Inventory Task Force Resources Inventory Committee, version 1.0 [June 8, 1999], 73 p.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 2: Training Field Personnel

Version 1.1, February 2013

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0
1.0	February 2013	UCBN-Aquatic Biologist	Addition of safety section	Updates to SOP 13 and changes in procedures necessitated updates.	1.1

Note: This SOP describes the step-by-step procedures for organizing and training field personnel. Note that none of these SOPs are meant to be stand-alone training manuals replacing the thorough documentation available for GPS, PDA and multiprobe hardware and software. Training personnel should refer to these SOPs as a guide, and seek out additional information in the suggested references and through hands-on training courses provided by NPS and outside vendors.

Suggested Reading

Archer, E. K., R. A. Scully, R. Henderson, B. B. Roper, and J. D. Heitke. 2012. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp.

Garmin. 2005. GPSMAP 76CSx Owner's Manuel. Garmin International, Olathe, KS. Available online at http://www.garmin.com/products/manual.jsp?product=010-00469-00

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Procedures

Multiprobe Operation

Initial installation and multiprobe calibration will be conducted by the UCBN Integrated Water Quality Monitoring project leader and temporary field staff. Subsequent data retrieval and multiprobe calibration/maintenance will be performed by the UCBN Integrated Water Quality Project Leader, NPS resource managers, and/or other temporary field staff. As a result it's necessary to annually train resource managers and other field personnel in proper calibration and maintenance methods. In general the most effective technique for multiprobe calibration training is a hands-on demonstration. This demonstration will follow the procedures outlined in the Hydrolab MS5 user manual (located on the CD attached to the back page of this report) and the Multiprobe Site Revisit SOP. A copy of the HACH manual and SOPs will be provided to resource managers and can serve as a quick reference if they encounter difficulties during multiprobe operation. During training, field personnel will perform calibration techniques with the water quality project leader to address any issues or questions. Training will occur each spring prior to multiprobe deployment. Each year, field personnel that are responsible for calibration and data retrieval will be updated on procedures. Training is a critical aspect of the UCBN's water quality monitoring program because a well trained staff helps ensure the collection of quality data, and is part of QA/QC.

Topics to be covered by training include:

- Multiprobe housing maintenance
- Multiprobe calibration of five core parameters: dissolved oxygen, pH, turbidity, conductivity, and temperature
- Data retrieval
- Use of Hydras 3 LT software

Macroinvertebrate Sampling

Sampling for macroinvertebrates will be conducted June through October of each year by the stream channel characteristics monitoring field crew or the water quality project leader. It is important that field personnel be instructed on the proper U.S. Forest Service PIBO-EM procedures (Archer et al. 2011) to ensure that data from multiple years is comparable. The best way to train personnel on these procedures is to demonstrate the procedure in the field after they have read SOP #7. Training may also take the form of participation in the PIBO-EM's week long training camp held each year prior to field work. Training of other NPS staff will last an hour or two and should be conducted on site.

Topics to be covered by training include:

- PIBO site layout
- PIBO benthic macroinvertebrate sampling
- Sample Locations
- D-Frame Net use
- Sieving sample
- Debris removal
- Preserving sample

Safety

Field crews and park staff that will assist with monitoring will be briefed on safety procedures and hazards prior to field work. Briefings will occur in the office and during tailgate safety talks each site visit. Required reading is the job hazard analysis and other pertinent hazards listed on the field description form in Appendix 3 and the Field Safety Notebook. Recommended reading is the Safety SOP #13.

Other Training

Site photographs will be taken during macroinvertebrate sampling. In addition photographs will be taken of the multiprobe site after multiprobe deployment. All field personnel assisting in field operations should be trained on how to use a digital camera and record pictures from designated photo monitoring points. This procedure is more thoroughly covered in SOP #7.

Literature Cited

Archer, E. K., R. A. Scully, R. Henderson, B. B. Roper, and J. D. Heitke. 2012. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp.

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D. Klemm, J. M. Lazorchak, F. H. McCormick, S. A. Peterson, P. L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, DC, EPA/620/R-06/003.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 3: Finding GPS Waypoints

Version 1.0, January 2009

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0

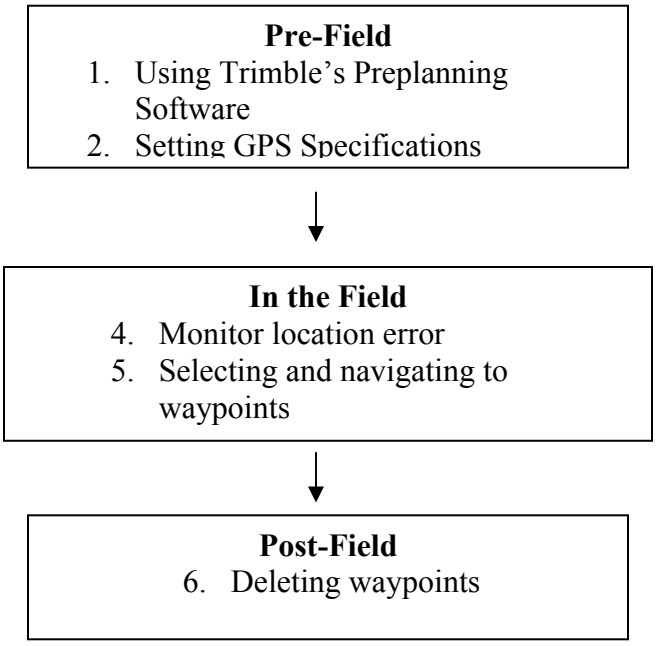
Suggested Reading

Garmin. 2005. GPSMAP 76CSx Owner's Manuel. Garmin International, Olathe, KS. Available online at http://www.garmin.com/products/manual.jsp?product=010-00469-00

Introduction

The purpose of this SOP is to describe the procedures necessary to navigate to waypoints using GPS units, particularly Garmin Map 76CSx. Information on GPS specifications and settings are also included. This is not intended as a substitute user's guide for GPS units. Please consult the appropriate user's guide for more detailed information on unit functionality.

The following flowchart provides a general overview of steps addressed in this SOP:



Pre-Field

Preparation is key to successful field work, particularly when that field work relies on GPS data collection or navigation. The baseline GPS constellation consists of 24 satellites that orbit the earth approximately every 12 hours. The position and time signals transmitted by these satellites are used by GPS receivers to triangulate a location on Earth. While this process is subject to various sources of error, pre-planning can minimize the impacts.

Using Trimble's Preplanning Software

Trimble offers a free stand-alone program that determines visibility for GPS, GLONASS, and WAAS satellites. The software can be downloaded from http://www.trimble.com/planningsoftware.html. Make sure to also download the Ephemeris file (current.ssf).

1) Use the Station Editor to select the location, date, and time of data collection (See Figure 17).

2) Import current .ssf file and check the satellite information. Select those satellites of interest. Default is all.

3) Create graphs.

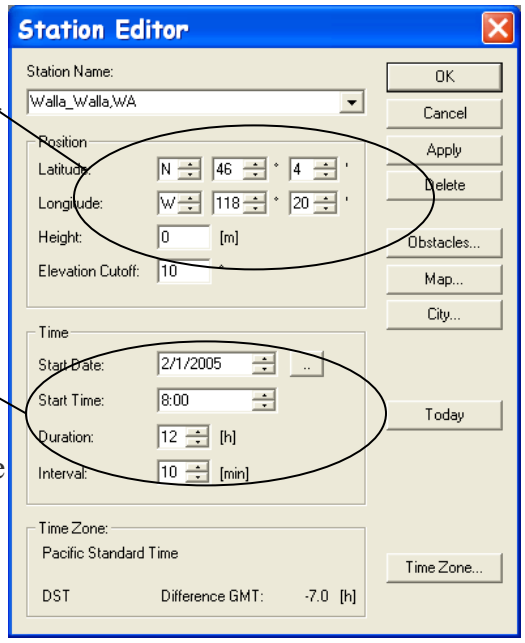


Figure 17. Station Editor in Trimble's preplanning software highlighting position and time.

Look for the time of day when the most satellites are available and the PDOP (Position Dilution of Precision) is lowest. PDOP is the measurement of error introduced by satellite orientation or geometry and can be easily minimized through the timing of field data collection.

Setting GPS Specifications

Verify Time: Time synchronization of the GPS receiver and GPS satellites is critical for the most accurate data collection and navigation. With Garmin MAP76CSx, use the Time Setup Menu to set the time format, zone, and to conform to Daylight Savings Time.

Verify Projection and Datum: All GPS positioning information is referenced to the World Geodetic System 1984 (WGS84) datum. While the difference between WGS84 and NAD83 is minimal (< 1m), best practice is to navigate and collect data in WGS 84. In the case of UCBN water quality sampling refer to Table 2 to select the correct UTM Zone for the park of interest. Note that streams for JODA fall in 2 different UTM Zones. With Garmin MAP76CSx, use the Units Setup Menu to select the position format and map datum.

Table 2. UTM Zones for parks in the UCBN

Park	UTM Zone
NEPE	11
WHMI	11
BIHO	12
CIRO	12
CRMO	12
HAFO	11
JODA	
John Day River	11
Rock Creek	11
Bridge Creek	10

Enable WAAS: Enabling WAAS (Wide Area Augmentation System) allows for real-time correction of GPS coordinates as long as the WAAS satellites are in view. Due to the fixed position of these satellites over the equator, signal reception is best in open areas with a clear view of the southern sky. With Garmin MAP76CSx, use the System Setup Menu to enable WAAS.

Calibrate the Compass: The internal compass in the Garmin MAP76CSx should be calibrated prior to each use for increased accuracy in navigation. Use the Calibration Setup Menu to calibrate the compass. Follow the directions on screen.

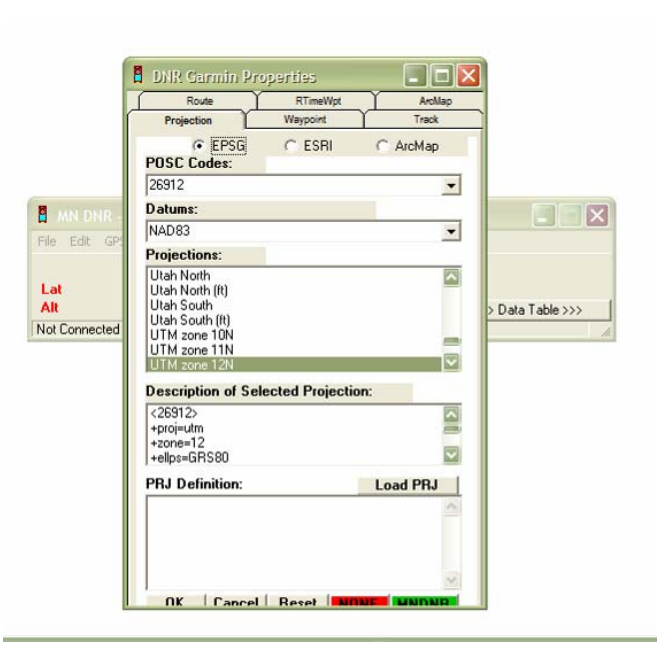
Batteries: Lastly, fully charge the AA batteries and remember to take spares! The Garmin Map76 units tend to fail on battery power quickly and without warning.

Loading Waypoints

Following the water quality monitoring GRTS protocol, random sample points are generated using ArcGIS 9.1 and exported to a shape or dBase file. Uploading these locations to the Garmin Map76CSx as waypoints is simplified by using DNRGarmin, a freeware program developed and maintained by the Minnesota Department of Natural Resources. The program can be downloaded from http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html. The site has information on the application including installation guidelines and documentation.

To upload waypoints to the Garmin Map76CSx, connect the GPS unit to the PC and open DNRGarmin. DNRGarmin should display your GPS unit and say connect. If it does not, go to GPS and open port.

Use the File Menu to set the correct projection (i.e. Zone 11 for HAFO points and Zone 12 for BIHO points both with the datum as WGS84) (Figure 18). Next go to load data in the File Menu and select your shapefile or dBase file of interest. You can delete and or edit points, add comments, etc. if necessary (Figure 19). Use the GPS Menu to open the port to the GPS unit. Then, use the Waypoint Menu to upload the points to the GPS unit.



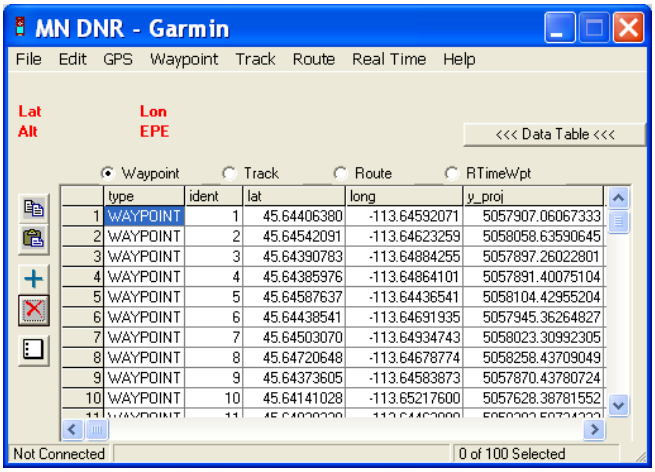


Figure 18 (left). Screenshot from DNRGarmin used to set the correct map projection.
Figure 19 (right). Screenshot from DNRGarmin used to view and upload selected waypoints.

In the Field

Monitoring Location Error

Ideally, you would be able to set thresholds for the maximum PDOP allowed as well as the minimum number of satellites. While you cannot set these values in the Garmin MAP76CSx, you can monitor the satellite strength and relative location error by using the Satellite Main Page.

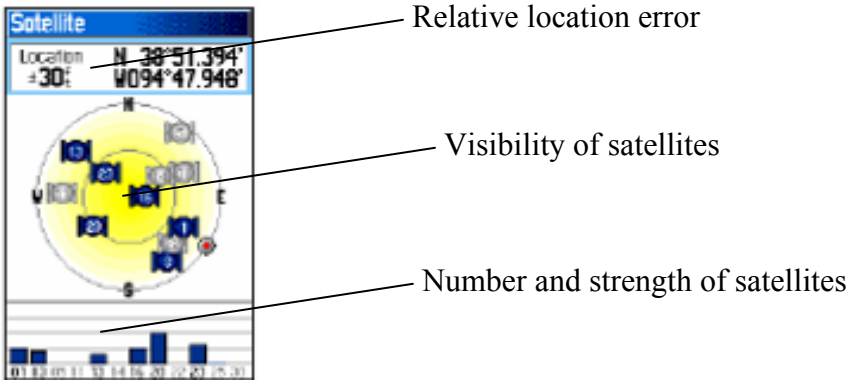


Figure 20. Screenshot from GPS unit for satellite information.

These values should all be monitored frequently during data collection and navigation (see Figure 20). The maximum relative location error allowed should be set prior to beginning field work. For the water quality monitoring protocol, the maximum location error allowed is 30 ft (10m). If a GPS unit is used that allows for user-defined PDOP thresholds, the maximum PDOP should be set at 6.

Selecting and Navigating to Waypoints

With Garmin Map76CSx, use the Find Menu to search for a waypoint of interest. Select 'Find by Name' and scroll to the point ID of interest. Conversely, you can select the waypoints icon and scroll to the Point ID of interest. Note that often the menu is set to 'Find by Nearest' and if no point are near, no points will be displayed. To change this setting, go to the waypoint menu, push the menu button, and select 'Find by Name.'

Once selected, the items information page for the waypoint opens, allowing you to show the item on the map (by selecting Map) or create a route to the point (select GoTo). Select GoTo to navigate to the point. You can use the 'Page' button to switch through various pages, select the Compass page (Figure 21) and, holding the GPS level, walk in the direction indicated by the compass until the 'Dist to Dest' window reads zero.

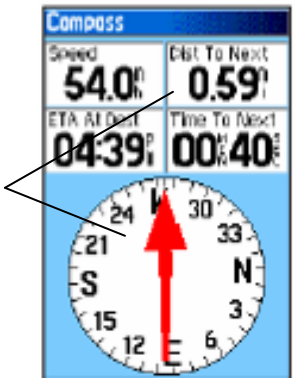


Figure 21. Screenshot from GPS unit compass page for navigation to a waypoint.

After the Field

Delete Waypoints

After completion of fieldwork, with permission of the project leader, delete any waypoints on the GPS units. Go to the Find Waypoints page, select Menu – Delete – All waypoints. Remove batteries from units before any long-term winter storage to prevent corrosion and leakage.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 4: Drawing a GRTS Sample

Version 1.0, January 2009

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0

Note: This SOP describes the step-by-step procedures for drawing an unstratified equal-probability generalized random tessellation stratified (GRTS) spatially-balanced sample of survey points along UCBN streams. This procedure is based on instruction outlined by the EPA EMAP monitoring and design analysis team available at: http://www.epa.gov/nheerl/arm/. Implementation of the GRTS algorithm requires competency in the R statistical language and software environment, an open source version of S-Plus. R is a powerful system for statistical computations and graphics, which runs on Windows, Unix, and Mac computers. R is a combination of a statistics package and a programming language. It can be downloaded for free from http://www.r-project.org/ . The R Wiki provides an online forum http://wiki.rproject.org/rwiki/doku.php and documentation. R is the analytical environment of choice for the Upper Columbia Basin Network. Drawing spatially-balanced samples also requires competency in ESRI's ArcGIS or ArcView GIS software in order to manipulate shapefiles required as input and ouput data sources for the GRTS routine in R. An alternative approach to drawing a spatially-balanced sample, the reversed randomized quadrant-recursive raster (RRQRR), can also be accomplished directly in ArcGIS using an Arc Toolbox extension available from http://www.nrel.colostate.edu/projects/starmap/rrqrr_index.htm.

Suggested Reading

Crawley, M.J. 2005. Statistics: an introduction using R. John Wiley and Sons, Ltd. West Sussek, England.

Kincaid, T. 2007. User guide for spsurvey, version 1.6 probability survey design and analysis functions. Version 1.6 January 18, 2007. Available at: http://www.epa.gov/nheerl/arm/documents/design_doc/User%20Guide%20for%20spsurvey%201.6.pdf.

Maindonald, J., and W.J. Braun. 2007. Data analysis and graphics using R – an example-based approach. Cambridge University Press, UK.

Stevens, D.L. and A.R. Olsen. 2003. Variance estimation for spatially-balanced samples of environmental resources. Environmetrics **14**: 593-610.

Stevens, D.L., and A.R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association **99**: 262-278.

Theobald, D.M., D.L. Stevens Jr., D. White, N.S. Urquhart, A.R. Olsen, and J.B. Norman. 2007. Using GIS to generate spatially balanced random survey designs for natural resource applications. Environmental Management **40**:134-146.

Preparations

In order to generate a GRTS sample, ArcView or ArcGIS must be installed and running, as well as R statistical software. The *spsurvey* and *sp* packages must be downloaded from the EPA EMAP website (http://www.epa.gov/nheerl/arm/analysispages/software.htm) and installed in the appropriate R library. The *Tinn-R* text editor available from this same website can be used for manipulating the R scripts, or the script feature available in R can be used (File > New script).

Procedures

Generating Spatially-Balanced Sample Locations

1) Begin by organizing a working directory (e.g. C:\GRTS\temp), and placing the target stream shapefile (all files including .shp,.dbf, and .prj extensions) in the appropriate subfolder. The stream shapefile should be accurate and projected in UTM NAD 83. In some cases, an accurate shapefile will need to be created by screen digitizing a new linear feature on an appropriate base image such as a NAIP photograph. Be careful to account for park boundaries and non-NPS inholdings. Complete stream coverages for UCBN parks are in the process of being acquired or created and are stored on the Network's network attached storage (NAS) server located at UCBN headquarters.

2) In the RGui screen, change the working directory to C:\GRTS\temp (or an appropriate alternative). Open an existing GRTS script in R (or *Tinn-R*). If no GRTS script is available, the example in step X below can be copied and saved into the text editor and edited as necessary. Examples are also available from the EPA EMAP website.

3) In RGui, load the *spsurvey* package (Packages > Load Package)

4) R code example for drawing a GRTS sample. This sample can be copied and saved directly into the R script text editor, modified as necessary, and executed by highlighting desired sections of code, and keying "ctrl-shift" and then "r" on the computer keyboard.

```
************************************************************
# File: UCBNriparian_Rcode_GRTS_unstratified_eqprob_20071227.txt
# Purpose: Example linear unstratified equal probability GRTS survey
# designs for Bridge Cr., Painted Hills Unit, JODA
# Contact: Tom Rodhouse, UCBN Ecologist, Tom_Rodhouse@nps.gov
# Date: December 27, 2007

# Load the spsurvey library

library(spsurvey)

# Equal probability GRTS survey design, example sample size = 10,
# example oversample = 25 [for equal probability designs, the use of
the
# oversample feature is not necessary, an equivalent would be to set
# Panel_1=35 in the Equaldsgn list below]

# Create the design list
```

```
Equaldsgn <- list(None=list(panel=c(Panel_1=10),
seltype="Equal",over=25))

# Create the GRTS survey design

Equalsites <- grts(design=Equaldsgn,
                   DesignID="Site",
                   type.frame="linear",
                   src.frame="shapefile",
                   in.shape="BridgeCr",
                   prjfilename="BridgeCr",
                   out.shape="Bridge_grts10_25_NAD83")

print(dsgnsum(Equalsites))
**********************************************************
```

5) In ArcGIS (or ArcView), add the output file (e.g. Bridge_grts10_25.shp) to an open park map project to display the sample locations. View the associated .dbf table to ensure everything worked as expected. Note that UTM coordinates are already included in the .dbf.

6) **Note:** In order to maintain the desirable properties of the GRTS sample (e.g. spatial balance), sites need to be included in the sample in the same order as is presented in the .dbf list. The points are also given a site ID as a feature of the `grts()` function in R, and the ID order should be followed. For example, if 6 sites are needed for a macroinvertebrate sample, but the 2nd and 3rd sites are inaccessible, then sites 1, 4-8 should be used (Figure 22). If additional sites are needed in the future, then site 9 should be the first choice, followed by 10, 11, and so on. This will be important for integrating the water quality and riparian vegetation monitoring designs.

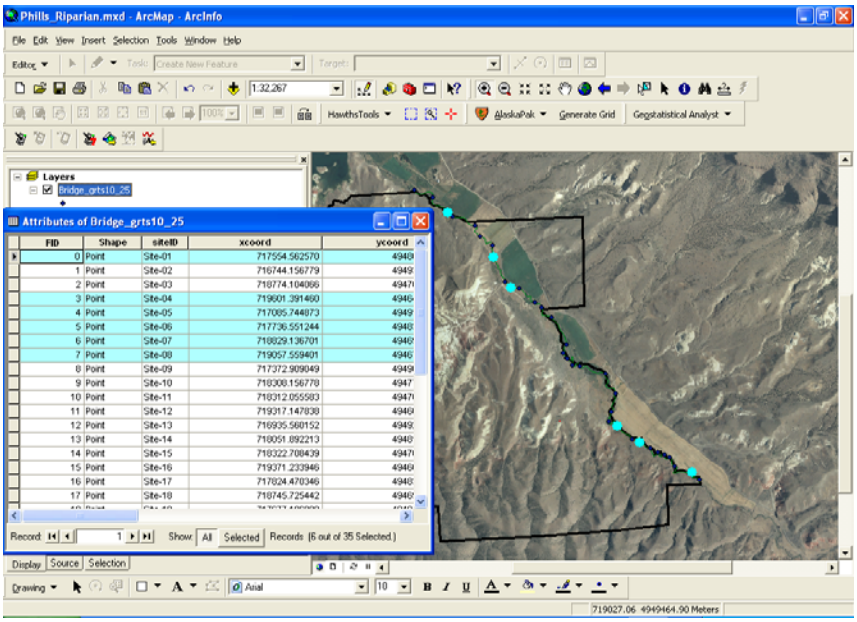


Figure 22. An ArcGIS screenshot illustrating the Bridge_grts10_25_NAD83 shapefile along Bridge Creek in the Painted Hills Unit of JODA with the sites 1 and 4-8 selected.

7) Note that NPS and UCBN standards require that spatial data be projected in the North American Datum 1983 (NAD 83). However, the native datum for GPS satellites is the World Geodetic Survey 1984 (WGS 84), and coordinates output for uploading into GPS units should be in this datum. This requires that the shapefile be reprojected and X and Y coordinates added again (a second step), or that the data frame environment for the .mxd is in WGS 84 to begin with. Note that the example output shapefile name in step 4 above specifies the datum. Careful attention should be paid to this issue to avoid confusion. Fortunately there is very little difference between the two projections. Spatial data and maps produced for archiving, analysis, and reporting should be projected in NAD 83.

8) Export the output table (e.g. BridgeCr_grts10_25_NAD83.dbf) and update the water quality monitoring project Access database.

9) Finally, import the master sampling location list, as a text file (e.g. BridgeCr_grts10_25_NAD83.txt), to GPS waypoints following procedures outlined in SOP #3, Finding GPS Waypoints.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 5: Multiprobe Site Selection – Cross Section Survey

Version 1.0, January 2009

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Note: This SOP describes the step-by-step procedures for determining if the multiprobe monitoring location is representative of the stream segment within the UCBN Park.

Suggested Reading

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Overview

Multiprobe site selection is an important aspect of the integrated water quality monitoring protocol in that it determines if water chemistry data is representative of the entire stream segment within each UCBN Park. Without proper placement of the multiprobe the data collected has limited value for assessment of status and trend of water quality within UCBN Parks.

Multiprobe site selection is determined using the criteria established by Wagner et al. (2006) and White (1999). Overall, the UCBN seeks to balance the need for a representative location within each stream, with factors such as stream stages, channel morphology, water velocity, potential for debris damage, and logistics (Table 3).

Table 3. Factors for consideration in the placement and installation of continuous waterquality monitoring systems (Wagner et al. 2006).

Site characteristics
Potential for water quality measurements at the site to be representative of the location being monitored.
Degree of cross-section variation and vertical stratification.
A channel configuration that may pose unique constraints.
Range of stream stage (from low flow to flood) that can be expected.
Water velocity.
Presence of turbulence that will affect water quality measurements.
Conditions that may enhance the rate of fouling, such as excessive fine sediments, algae, or invertebrates.
Range of values for water quality field parameters.
Need for protection from high-water debris damage.
Need for protection from vandalism.
Monitor installation
Type of state or local permits required before installation can begin.
Safety hazards relevant to monitor construction and installation.
Optimal type and design of installation.
Consideration of unique difficulties or costs of installation.
Logistics (maintenance requirements)
Accessibility of site, including parking or boat access.
Safe and adequate space in which to perform maintenance.
Presence of conditions that increase the frequency of servicing intervals needed to meet data-quality objectives.
For stream sites, proximity to an adequate location for making cross-section measurements.
Accessibility and safety of the site during extreme events (for example, floods or high winds).
Availability of electrical power or telephone service.
Need for real-time reporting.

Within the area immediately downstream of the last (most downstream) macroinvertebrate reach, the factors in Table 3 will be assessed to determine the best multiprobe site. Assessment of cross-section and stream segment variation will be determined using a survey of water quality parameters. This survey will consist of measurements taken at the proposed multiprobe site,

across a transect at the proposed multiprobe site, and at three subsequent transects upstream (Figure 23).

The distance between the proposed multiprobe site and the most upstream transect will be 40 times the mean wetted width. Therefore, the distance between the transects is the total reach length divided by 3. Each transect will be subdivided into 10 equal-width increments. The core water chemistry parameters will be recorded once a minute for 10 minutes at the proposed multiprobe site and once at each equal-width increment along the transects during the cross section survey.

Note that the UCBN is using a modified Equal-Width Increment Method. The parameter values and associated variability among transects will be compared to the proposed multiprobe site with an ANOVA or a Kruskal-Wallis test. If the proposed multiprobe site is not significantly different from the other transects it will be assumed that the multiprobe site is reasonably representative of the stream segment within the park.

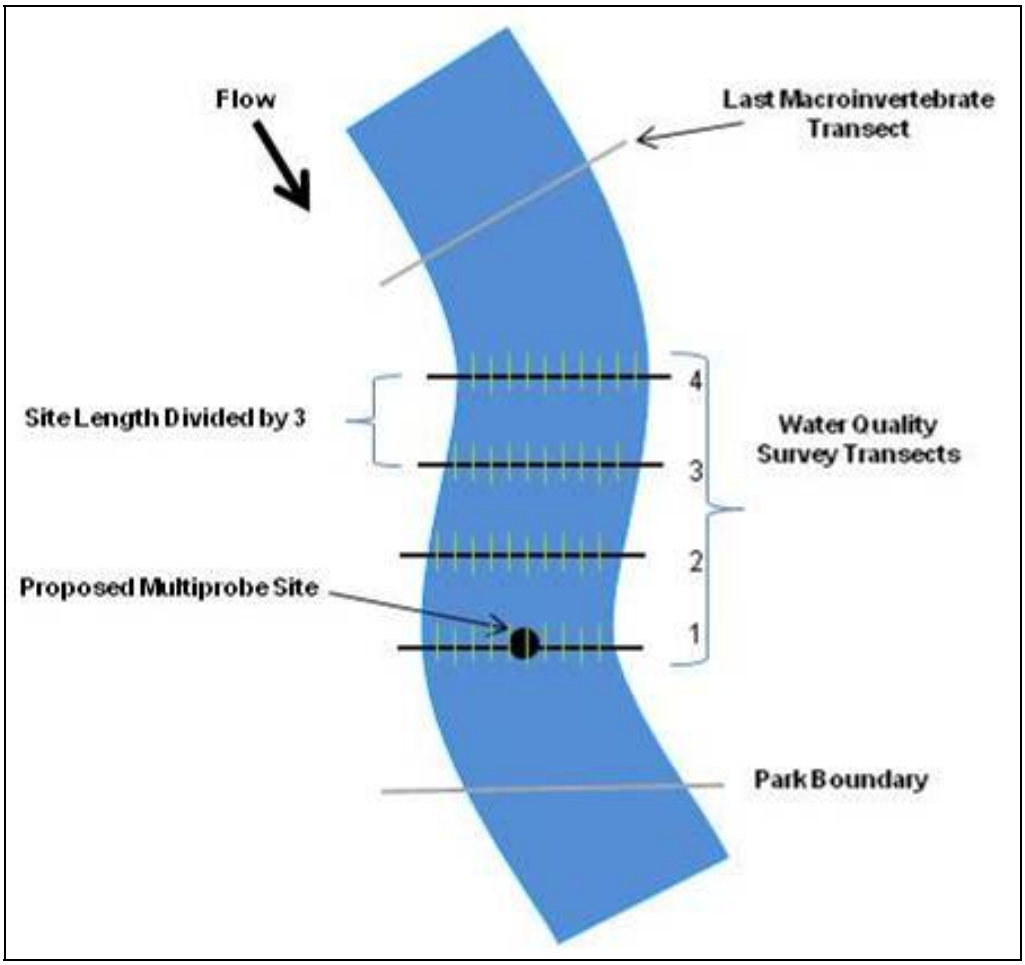


Figure 23. Multiprobe site selection survey transects. Measurements will be recorded using a modified Equal-Width Increments Method and data will be recorded at 10 locations across each transect. (Wagner et al. 2006).

Procedures

Site Selection

Initially, a location for deployment of the water quality multiprobe should be determined by visual assessment of the factors listed in Table 3. These factors include the need for a representative location within each stream, stream stages, channel morphology, water velocity, potential for debris damage, and logistics. In general, a location that would be ideal for measuring stream discharge is an ideal location for the placement of a multiprobe. Overall, an appropriate site will have easy access, smooth flowing water, water deep enough for multiprobe sensor submersion, and stable substrate. In most parks, the UCBN will establish multiprobe sites near the downstream boundary of each park. This will give the UCBN the best understanding of water conditions in the park. When a site has been selected it will be checked for representativeness with a Cross-Section Survey.

Cross-Section Survey

Cross-Section Surveys will help the UCBN determine if the conditions at the multiprobe site are representative of conditions throughout a park's stream segment. The UCBN will use a modified Equal-Width Increments survey design. The USGS uses the Equal-Width Increments design but calculates an area-weighted value for each parameter at each measurement location (Wagner et al. 2006, Wilde and Radtke 2005). For simplicity and comparison with one fixed site (the proposed multiprobe site) the UCBN will not be calculating area-weighted values.

Modified Equal-Width Increment Design

1) **Wetted Width:** Initially the average wetted width should be determined. The average wetted width times 40 will determine the length of the Cross-Section Survey (site). The distance between transects will be the site length divided by 3. Record these values on the UCBN Cross-Section Survey Form (Appendix 5). Use pin flags to temporarily mark the position of each transect.
2) **Proposed Multiprobe Site**: Next, the multiprobe should be deployed at the proposed site for 10 minutes. During this time period the multiprobe should be connected to the Archer unit and Hydras 3 Pocket PC. Values for each parameter should be recorded each minute on the UCBN Cross-Section Survey Form.
3) **Transect 1:** Transect 1 is located perpendicular to the flow at the proposed multiprobe site (Figure 23). The wetted width should be determined and divided into 10 equal-width increments (record these on the datasheet). Starting from the left bank (facing downstream), the procedure for each increment is as follows.
    a. Go to the first of 10 equal increments and measure the total depth. Divide the total depth in half to determine where the water chemistry measurement should be taken. Record both of these values under the "Total Depth" and "Depth of Measurement (50% of total)" columns.
    b. The multiprobe should be lowered to 50% of the total depth and held in the water for one minute to equilibrate. At the end of one minute a reading should be recorded for each parameter (see the Cross-Section Survey Form in Appendix 5).
    c. Repeat a and b for the remaining 9 increments along transect 1.

4) **Transects 2-4:** Move to the next transect and stretch the tape measure from the left bank to the right bank. Record core parameter values at each of the 10 increments in the same way as transect 1 (step 3).
5) **Evaluation of the Cross-Section Survey:**
    a. For each parameter within a transect the median value should be determined and recorded on the UCBN Cross-Section Survey Form.
    b. After the field assessment, the data should be statistically analyzed to determine if the multiprobe site is representative of conditions upstream (± 10%). An ANOVA or a Kruskal-Wallace Test are likely the best methods for this analysis. Specific Conductance (µS/cm) should be the primary parameter used to evaluate cross-section surveys since it is less variable than other core parameters and should accurately reflect stream mixing. Secondary parameters such as pH and dissolved oxygen are important, but due to their inherent variability will not be the primary means of evaluating the Cross-Section Survey.

If the proposed multiprobe site is found to be representative, the multiprobe housing can be installed. If the proposed site is found to be un-representative, the results of the survey may help indicate a more appropriate location for the multiprobe. Once a new proposed site is found a new Cross-Section Survey should be conducted. It is important to note that data from the monitoring site will not be corrected based on data gathered during the Cross-Section Survey. The variability of streams in time and space precludes such corrections and is not suggested by the USGS.

The USGS advocates at least two Cross-Section Surveys per year. Given that most UCBN streams are small and relatively stable, it is likely that two surveys per year will be adequate (May, and October). However, the North Fork of the Big Hole River in BIHO is known to shift on a regular basis, and other streams may change significantly with hydrologic events. If changes in stream morphology are noted that could change the representativeness of the multiprobe site, a new Cross-Section Survey should be conducted.

Literature Cited

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Wilde, F.D., and Radtke, D.B., 2005, General information and guidelines: U.S. Geological Survey Techniques of Water Resources Investigations, book 9, chap. A6, section 6.0, 36 p.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 6: Multiprobe Site Revisit

Version 1.1, June 2011

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	June 2011	Eric Starkey	Revisions to recovery of multiprobe and fouling check due to the use of an external power source. Additional step in the calibration of turbidity (use of 20 NTU standard)	Necessary for cooperators and park staff that service water quality instrumentation.	1.1

Note: This SOP describes the step-by-step procedures to download data, error check, calibrate and re-deploy the integrated water quality multiprobe. This SOP is likely to be updated frequently within the first 3 years of water quality monitoring due to changes in best practices suggested by field experience, the Hach Company and USGS.

Suggested Reading

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

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Overview

Water quality multiprobes or Hydrolabs are complex instruments that require maintenance and calibration on a regular basis. Despite the need for frequent visits, the exact timing of maintenance and calibration is varies due to field conditions. Factors affecting the timing of site revisits include; sensor fouling, water levels, battery life and data storage capacity. After 3 years of monitoring streams across the network, the UCBN has established that it is optimal to schedule a site revisit every 30-35 days if using an external power source such as a solar panel/battery. If the multiprobe is being powered by internal batteries, return site visits should occur as frequent as every 20 days. In addition to extending the site revisit interval, the solar panel/battery combination has eliminated data gaps caused by low battery power. These revisit intervals should serve as a guide to servicing multiprobes, but site specific conditions may warrant deviations from this schedule in any given year. With this in mind, the following is a guide to the proper procedures for each multiprobe site revisit.

Procedures

Materials Required for Site Revisit

Each time the multiprobe is serviced it will require a substantial amount of supplies and equipment, for data download, cleaning and calibration. These supplies will be provided by UCBN and stored in a clear plastic container in each park. When supplies run low the person responsible for multiprobe maintenance should notify UCBN personnel that more supplies are needed.

- Multiprobe retrieval
    - Keys for cable lock and battery box (if applicable)
    - Hammer
- Data retrieval
    - PDA with 9 pin port or laptop computer
    - Hydras 3 or Hydras for PDA's
    - Detachable calibration cable
- Maintenance
    - Calibration stand with clamp
    - Soft brush (1)
    - Dish soap
    - Spray bottle with soapy water
    - New AA batteries (16)
    - Cotton swabs
    - Deionized water
    - MS5 calibration cup
- Calibration
    - Bucket
    - Calibration stand with clamp
    - Container for waste standard solutions
    - Standard solutions
        - Conductivity

        - 100 µS/cm
        - 1412 µS/cm
    - pH
        - 4 pH Units
        - 7 pH Units
        - 10 pH Units
    - pH Reference Electrolyte
    - pH small Teflon junction
    - Turbidity
        - Deinoized water
        - 20 NTU
        - 100 NTU
  - NIST traceable thermometer
  - Handheld barometer
  - Handheld multiparameter water chemistry meter equipped at minimum with Temperature, Dissolved oxygen, Conductivity, and pH sensors (i.e. YSI #556).
  - Watch
  - PDA with 9 pin port or laptop computer
  - Hydras 3 or Hydras for PDA's
  - Detachable calibration cable
  - Multiprobe Maintenance/Calibration Log Book
  - Datasheets
    - Paper- Maintenance/Calibration Log Sheet
  - Hach Hydrolab User Manual and Calibration Instructions
  - Pencil
- Miscellaneous Field Equipment
  - Park Radio
  - Topographic map of park and aerial imagery
  - First Aid Kit
  - Water Jug
  - Sun screen
  - Field safety notebook
  - Bug repellent

General Workflow

1. Recovery of Multiprobe
2. Attachment of Calibration Cable / Connection to Archer Unit
3. Fouling Check
4. Data Download
5. General Maintenance
6. Calibration Drift Check
7. Calibration (if necessary)
8. Final Readings
9. Log File Setup
10. Re-Deployment

Recovery of Multiprobe

The water quality multiprobe will have been deployed for approximately one month prior to the site revisit. On the previous deployment the instrument will have been locked in the housing with a cable padlock. Each park will be supplied with the keys for the cable padlock, security cable, and external battery box. An extra set of keys will be kept in the UCBN office. As you approach the housing please take note of any debris on the housing or vandalism. The UCBN requests pictures of anything that might have affected data collection or the security of the multiprobe.

Multiprobe with External Power Source

When using an external power source such as a solar panel and battery it is possible to connect to the multiprobe without removing it from the housing. This prevents the removal of algae and sediment from the sensors prior to the assessment of fouling error. As a result, the use of an external power source provides the most accurate assessment of data quality.

Note that the calibration cable is already connected to the multiprobe and to the battery via an External Power Adapter Cable (Hach Company Cat. No. 013170HY) and Battery Adapter (Hach Company Cat. No. 011530HY). The external power adapter cable has a 9 pin connection to which the Archer Field PC can be connected (see Figure 24 and the "Connecting to Hydras" section below).

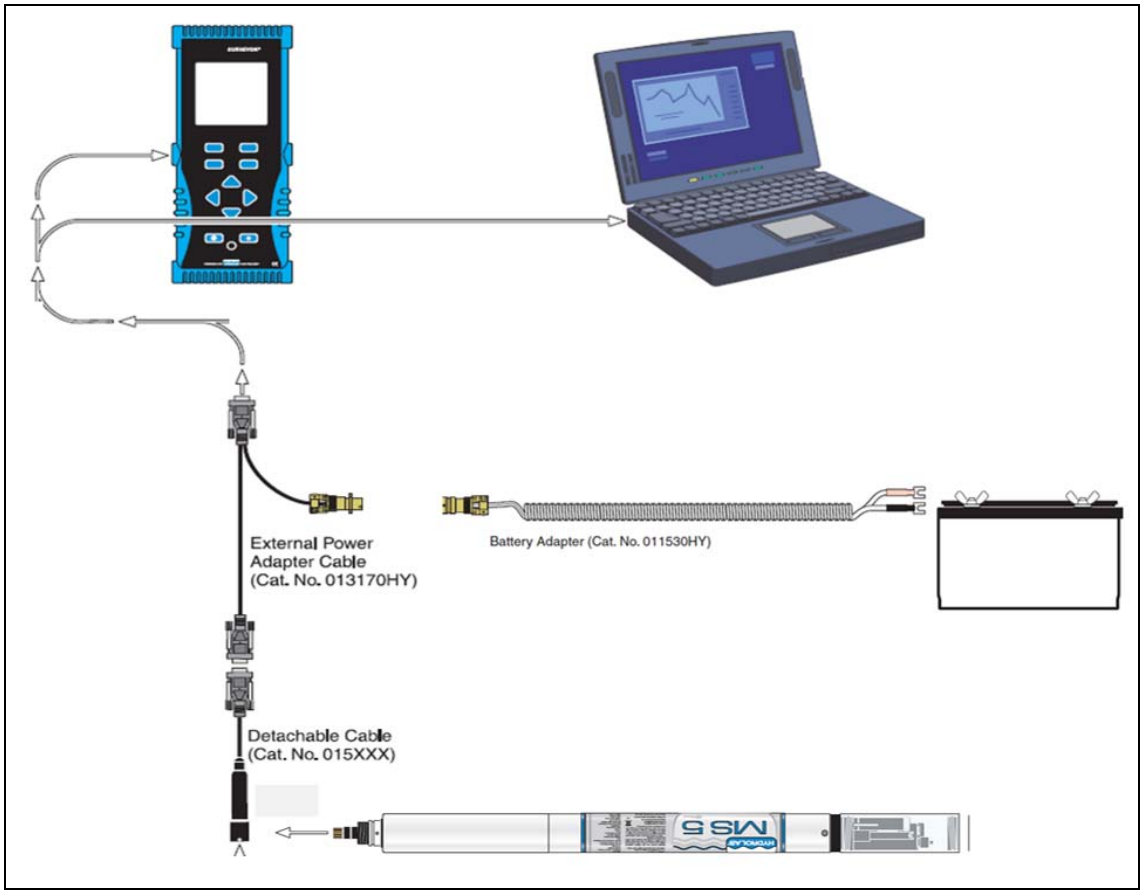


Figure 24. Cables required to connect a Hach brand Hydrolab MS-5 to an external power source. Modified from Hach Environmental 2006.

Multiprobe with Internal Power Source

If the multiprobe is powered with internal batteries, it is necessary to remove the multiprobe from the housing in order to attach the calibration cable. Make sure to gently remove the instrument from the water/housing and connect the calibration cable. It is important to minimize disturbance of the fouling on the sensors. If fouling is removed it will greatly affect the assessment of the fouling error. To remove the multiprobe from the housing gently tap upwards on the flange until the cap becomes loose. The multiprobe is suspended from the cap by a cable or rope, after the multiprobe has been removed unclip the snap hook and remove the mooring fixture. Make sure to keep the mooring fixture in a safe place until you re-deploy the multiprobe. Attach the calibration cable and prepare for the fouling and calibration drift error checks.

Attachment of the Calibration Cable

Remove the 9-pin connector cap (Figure 25) and attach the calibration cable. Note that the 9-pin connector cap may be difficult to remove. Pull straight up and the cap will come off. Make sure the calibration cable is fastened securely and sealed properly, if not water may leak into the connection and damage the Hydrolab. When the calibration cable is connected, gently lower the multiprobe back into the housing, being careful not to disturb any fouling. This will not harm the cable or the multiprobe as long as you have connected it and tightened it properly.



Figure 25. Remove the nine-pin connection cap before attaching the calibration cable.

Connecting to Hydras

Hydras is the program provided by the Hach Company that allows for data download and calibration. Hydras comes in two formats, one for standard PC computers and the other for PDA's equipped with a 9-pin connection. The PC version of Hydras has more capabilities than the PDA version and should be used for setup and lab calibrations. In the field the UCBN will be using an Archer unit to download data and calibrate the multiprobe. After the multiprobe is connected to the calibration cable it should be plugged into the Archer unit. The 9-pin connection is located on the side of the Archer unit just below the buttons (Figure 26). When the calibration cable is connected, the multiprobe will beep once. Make sure to secure the 9-pin connection by tightening the screws. Once you have connected the multiprobe, follow the steps below for successful multiprobe operation.



Figure 26. The Archer Field PC with 9-pin communication port.

1. Turn on the Archer unit by pressing the button with this symbol (φ) in the lower right hand corner of the Archer unit.
2. Remove stylus from upper left hand back corner of Archer unit.
3. Use stylus to tap on upper left hand corner of screen on windows icon.
4. Scroll down pop-up window menu and tap on **"Hydras 3 Pocket for Hydrolab"** to open program.
5. Click **"Connect"** on Hydras 3 program screen. You will hear a "beep" that indicates that the Hydrolab is connected and receiving information from the Archer unit.
6. Prior to conducting the fouling check and downloading data, you should check to see if there is enough battery power to complete the fouling check (>5% internal battery power). Click on **"Online Monitoring"** and then **"Start"** the internal battery power should be displayed in the statistics window. See Figures 29 and 30. If there is insufficient battery power, replace them according to the instructions given in the general maintenance section of this SOP.

Data Download

The recovery of data from prior deployments is a critical step to help the UCBN determine the status and trends of water quality. The calibration cable and Archer Unit should still be attached to the multiprobe. If the Archer unit is not connected see the "Attachment of the Calibration Cable" and "Connecting to Hydras" section in this SOP.

Saving the file

1. On the main Hydras screen click on **"Log Files."** A list of log files should appear.
2. Select the log file with the most recent date and for the stream in which the multiprobe has been deployed.
3. After selecting the log file, the download and disable option should be available from the buttons near the bottom of the screen. Click "**To Disable"** then click **"Download"** (Figure 27).



Figure 27. Selection of a log file in Hydras.



Figure 28. Screen to save a log file.

4. A new window will appear with a preview of the log file. Click **"Save"** at the bottom of the screen.
5. The next screen will have the current name for the log file (Figure 28). This name should be modified to reflect when the log period ended. For example the file name might read NEPE_Lapwai_20080402. The file name should include the park abbreviation, the stream and the beginning date. During the data download, the file name should be modified to reflect the end of the deployment. If the log period ended on April 18, 2008 the file name would be, NEPE_Lapwai_20080402_20080418. **Adding the end date is critical!** Please remember to complete this step. **Make sure to record the log file name in the "Data Download" section on the "UCBN Multiprobe Calibration/Maintenance Log."**

6. On the same screen under the **"Folders"** pull down menu, select Water_Quality_Log-Files.
7. Under **"Location"** make sure **"Main Memory"** is selected.
8. When finished click **"Save."** You will be directed back to the log file preview. Click **"OK"** in the upper right hand corner.
9. To ensure the file has been saved, click the Windows **"Start"** menu and click the icon for **"File Explorer."**
10. Click the **"Water_Quality_Log-Files"** folder and check for the new log file.
11. If the log file has been saved correctly click the **X** to close the File Explorer window. You should now be back to the **"Log Files"** screen. Click **"OK"** to return to the main Hydras menu.

Fouling Check

Fouling error is the error in measurements caused by biological growth and/or sediments on the sensors. You will need to obtain current readings from the stream before and after you have cleaned it. While it seems repetitive to take stream measurements before cleaning and after cleaning, these measures allow for the calculation of fouling error. "The observed difference between the initial sensor reading and the cleaned-sensor readings (in stream water) is a result of fouling" (Wagner et al. 2006). The fouling error will be used for data corrections and for the assessment of data quality.

Stream Reading Before Cleaning

1. If you have removed the multiprobe from the housing, make sure it has been gently placed back into the housing, being careful not to disturb any fouling.
2. Place the handheld multiparameter field meter (Temperature, dissolved oxygen, pH, and specific conductance sensors) in the water near the multiprobe housing. If a handheld field meter is not available place a NIST traceable thermometer in the water near the multiprobe housing. It works well to hang the thermometer from the multiprobe housing.
    a. A field meter is used to evaluate the amount of environmental change that has occurred in between the time "before cleaning" measures are recorded and "after cleaning." Ideally a handheld multiparameter field meter should be used as it allows for more accurate assessment of data quality and correction for fouling.
3. The Hydras program should still be open on the Archer unit. If not open Hydras and connect to the multiprobe.
4. On the main Hydras menu click **"Monitor."**
5. A new screen will appear with three tabs along the bottom: (Figure 29) **"Time Series" "Depth Profile"** and **"Manual Mode."**

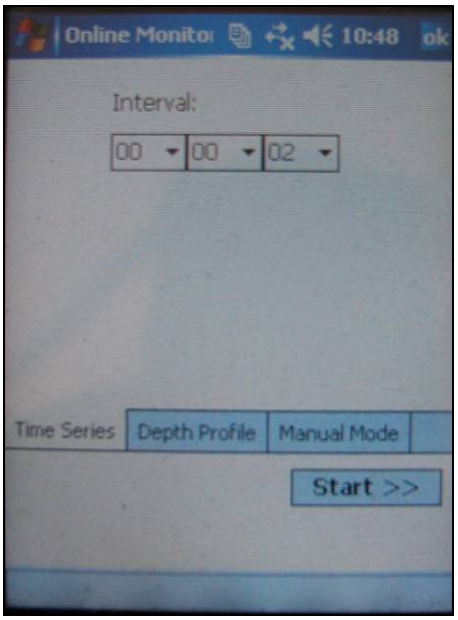


Figure 29. Online Monitoring Screen.

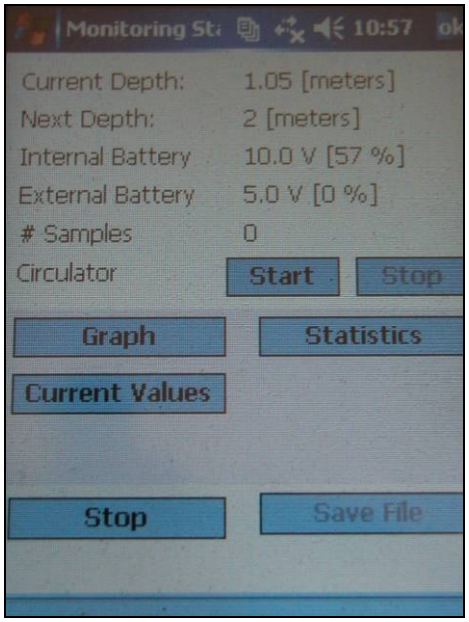


Figure 30. Monitoring Statistics Screen.

7. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button.
8. In the Monitoring Statistics Screen you will press the **"Current Values"** button.
9. Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add."** There should be five parameters; Temp., SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the calibration/maintenance log sheet.
10. Wait for the readings to stabilize. Record the value for each parameter in the **"Before Cleaning" – "Recorded/Live Monitor Reading"** column.
11. Check the field meter and record the values for each parameter in the **"Before Cleaning" – "Field Meter Reading"** column. If you do not have a field meter, check the temperature on the NIST traceable thermometer and record it in the **"Before Cleaning" – "Field Meter Reading"** column.
12. In the Dissolved Oxygen field make sure to record the barometric pressure.
    a. If a handheld barometer is available, record the current barometric pressure "inHg." This value will need to be converted to mmHg using the following equation:

$$\frac{ABS\ \text{inHg}}{0.0393701} = ABS\ \text{mmHg}$$

Where:

ABS inHG = The absolute barometric pressure from the handheld barometer (inHg)
ABS mmHg = The absolute barometric pressure (mmHg)

    b. If no barometer is available check the nearest weather station before you service the instrument for barometric pressure in mbar (Weather Bureau station is preferred http://www.wrh.noaa.gov/otx/). You will first need to convert from mbar to mmHg.

$$0.75 \times BPmbar = BPmmHg$$

Weather stations report a corrected barometric pressure, which is barometric pressure at sea level (BP). To convert the barometric pressure at sea level to barometric pressure at altitude BP' Use the following equation:

$$BP' = BP - 2.5\left(\frac{A_{ft}}{100}\right)$$

Where:

BP' = Barometric pressure at altitude mmHg
BP = Barometric pressure at sea level mmHg
A_{ft} = Altitude in feet

13. You will need to stop monitoring after recording parameter values by pressing **"OK"** in the upper right hand corner of the statistics screen and then pressing **"Stop"** at the bottom of the monitoring screen. Press **"OK"** again. You do not need to save the associated text file so press **"No."** Start up Hydras 3 again.

Cleaning

1. Remove the multiprobe from the housing and place it in the calibration stand with the sensors pointing up.
2. Carefully remove the sensor guard.
3. On page 3 of the UCBN Multiprobe Calibration/Maintenance Log record the type and degree of fouling found on the sensors and sensor guard.
4. Spray the multiprobe case and sensors with the soap and water from the spray bottle.
5. Gently scrub the sensors with a soft brush to loosen any fouling. Be careful not to scrub the L.D.O. sensor or the pH sensor use a cotton swab instead of the brush. These components are especially easy to damage. If fouling will not loosen on the sensors try using a cotton swab. After the sensors have been scrubbed, clean the outside of the multiprobe with a soft brush.
6. Rinse the entire multiprobe with clean tap water or stream water. Use a cup or the bucket to pour stream water over the multiprobe while it is in the calibration stand. Make sure to rinse the sensors thoroughly.
7. After rinsing with stream water, gently rinse the sensors with de-ionized water.
8. Replace the sensor guard and remove the multiprobe from the calibration stand.
9. Prior to placing the multiprobe back in the housing make sure has been scrubbed inside and out with the brush. It will take a minute for the debris and turbidity to clear the housing.

Stream Reading After Cleaning

1. Lower the multiprobe into the housing by holding onto the calibration cable, this will not harm the cable or the multiprobe as long as you have connected it and tightened it properly.
2. The Hydras program should still be open on the Archer unit. If it is not, open Hydras and connect to the multiprobe.
3. On the main Hydras menu click **"Monitor."**
4. A new screen will appear with three tabs along the bottom: (Figure 29) **"Time Series" "Depth Profile"** and **"Manual Mode."**
5. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button.
6. In the Monitoring Statistics Screen you will press the **"Current Values"** button.
7. (Skip if parameters are already listed.) Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add."** There should be 5 parameters, Temp., SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the Calibration/Maintenance Log Sheet.
8. Wait for the readings to stabilize. Record the value for each parameter in the **"After Cleaning" – "Recorded/Live Monitor Reading"** column.
9. Check the field meter and record the values for each parameter in the **"After Cleaning" – "Field Meter Reading"** column. If you do not have a field meter, check the temperature on the NIST traceable thermometer and record it in the **"After Cleaning" – "Field Meter Reading"** column.
10. You will need to stop monitoring after recording parameter values by pressing **"OK"** in the upper right hand corner of the statistics screen and then pressing **"Stop"** at the bottom

of the monitoring screen. Press **"OK"** again. You do not need to save the associated text file so press **"No."** Start up Hydras 3 again.

11. After recording the stream measurements before and after cleaning you can proceed with other maintenance and the calibration drift checks.

Other Maintenance

After the fouling error checks you will need to prepare for the calibration drift error check and calibration of each sensor. In most cases, if using internal batteries, they will be very low after the deployment period and should be replaced before the fouling check and calibration. In addition it is important to make sure the multiprobe battery compartment is water tight. All O-rings need to be lubricated before the battery compartment is closed.

Battery Replacement (only if using internal batteries)

1. Grasp the middle of the multiprobe with your left hand (near the Hydrolab label) and grasp the upper portion of the multiprobe above the label with your right.
2. You should be able to twist the upper portion counter clockwise to open the battery compartment.
3. Remove all batteries and replace with new NON-RECHARGABLE AA batteries of the same brand.
4. Make sure to **INSTALL THE BATTERIES CORRECTLY!** There is a diagram inside the battery compartment. If the batteries are not replaced correctly the multiprobe will be **DAMAGED!!!** You should double check the orientation of each battery as you replace them. This is **VERY IMPORTANT!!**

O-Ring Maintenance/Replacement of Battery Compartment Cover

1. When all batteries have been replaced you should lubricate the four O-rings that seal the housing. Two O-rings are located near the cable attachment and two are located near the Hydrolab label. O-rings should be lubricated with the silicon grease supplied by the UCBN (Figure 31).
2. Replace the battery compartment cover by placing it back into position and pushing down slightly until the cover slides just past the first O-ring (you may need to push down rather hard to clear the first O-ring).
3. After clearing the first O-ring you should be able to tighten the cover by twisting it clockwise until it is seated against the lowest O-ring.



Figure 31. Water quality multiprobe with open battery compartment. Note the O-rings located at the red arrows.

Calibration Drift Check

Calibration drift error is the error in measurements caused by changes in the sensors due to electronic drift over time. You will need to obtain readings of standard solutions (solutions of a known value) for each parameter. These measures allow for the calculation of calibration drift error. "The difference between the cleaned-sensor readings in calibration standard solutions and the expected reading in these solutions is the result of sensor calibration drift error" (Wagner et al. 2006). Calibration drift error values will be used for data correction, assessment of data quality, and sensor trouble shooting. In addition, the amount of calibration drift will determine if re-calibration is necessary. **If drift is under the calibration criteria, no calibration will be necessary.**

Standard Solution Readings

During the process of recording standard solution readings you will evaluate one parameter at a time starting with Temperature (Table 4). As you evaluate each parameter, and if it is found to be outside of the calibration criteria, it will need to be recalibrated before checking subsequent parameters.

1. Remove the multiprobe from the housing and place it in the calibration stand with the sensors pointing up.
2. Carefully remove the sensor guard and replace it with the calibration cup.
3. Fill the calibration cup with 2 inches of de-ionized water. Replace the calibration cup top and tighten.
4. Gently swirl the de-ionized water around to rinse the sensors of all stream water. Make sure the water comes in contact with each sensor. Empty and repeat step 3.
5. Empty the de-ionized water from the calibration cup, remove the cup and dry the sensors with a paper towel, and/or a cotton swab. Make sure not to damage the L.D.O. or the pH sensor. Replace the calibration cup.
6. Fill the calibration cup ¼ of the way with one of the standards listed in Table 4. **Make sure to follow the order of parameters in Table 4 and on the datasheet.** Place the cap on the calibration cup and tighten.

Table 4. Standard solutions that should be measured to determine calibration drift. Note the calibration criteria for each parameter.

Calibration Drift Checks

Parameter	Checked against	Parameters to select on Archer	Calibration Criteria	Maximum allowable limits for WQ sensor values
Temp	NIST Thermometer	Temp[°C]	> ± 0.2 °C when checked with another meter. > ± 0.5 °C when checked with NIST thermometer.	± 2.0 °C
Specific Cond.	100 µS/cm	SpCond [µS/cm]	± 5 µS/cm or ± 3%	± 30 %
	1412 µS/cm std.	SpCond [µS/cm]	± 5 µS/cm or ± 3%	± 30 %
D.O.	Air Sat. Water 100%	LDO%[SAT]	> ± 0.3 mg/L	The greater of ± 2.0 mg/L or 20%
pH	4.0	pH [Units]	>0.2 pH units	± 2 pH units
	7.0	pH [Units]	>0.2 pH units	± 2 pH units
	10.0	pH [Units]	>0.2 pH units	± 2 pH units
Turbidity	De-ionized water	Turbidity [NTU]	The greater of ± 0.5 turbidity units or ±5%	The greater of 3.0 TU or ± 30 %
	20 NTU	Turbidity [NTU]	The greater of ± 0.5 turbidity units or ±5%	The greater of 3.0 TU or ± 30 %
	100 NTU	Turbidity [NTU	The greater of ± 0.5 turbidity units or ±5%	The greater of 3.0 TU or ± 30 %
Battery	N/A	Internal-Battery [%Left]	Must be replaced before Calibration	

7. Gently swirl the standard around to ensure that the sensors are rinsed with the standard solution.
8. Empty the calibration cup. (Repeat steps 7 and 8 twice). **Steps 3-7 are critical for an accurate assessment of sensor drift.**
9. Now fill the calibration cup with the appropriate calibration standard (i.e. the same as used in step 7) so that the sensor is covered. Loosely cap the calibration cup for each standard except for dissolved oxygen. For dissolved oxygen you should place the cap upside down on the calibration cup. **In addition, make sure to follow the procedures for saturating the water with dissolved oxygen. This procedure is outlined in the Calibration section of this SOP.**
    a. **In addition, for the DO drift check, record the DO saturation value from the DO Solubility Table in the Calibration and Maintenance Log.** To do this you will need to know the barometric pressure and the current water temperature. Record the appropriate value in mg/L on the log sheet.
10. On the main Hydras menu click **"Monitor."**
11. A new screen will appear with three tabs along the bottom (Figure 29) **"Time Series," "Depth Profile"** and **"Manual Mode."**
12. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button.
13. In the next window you will press the **"Current Values"** button.
14. Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add"**. There should be five parameters, Temp.,

SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the Calibration/Maintenance Log Sheet.

15. After readings have stabilized (approx. 1 min.) you will want to look at the reading for a given parameter and determine if the reading falls within the calibration criteria given in Table 4 and on the "UCBN Multiprobe Calibration/Maintenance Log" listed in the "Calibration Drift Check" section for each parameter.
16. During the calibration drift checks you will need record each parameters reading on the "UCBN Multiprobe Calibration/Maintenance Log" in the "Calibration Drift Check" section for each parameter.
17. Check if the readings are outside of the calibration criteria listed on the Calibration/Maintenance Log. If they are outside the range you will need to re-calibrate that parameter. The recalibration of the parameter should be conducted immediately after the calibration drift check for the individual parameter. For example, if the calibration check in a standard solution of pH 7.0 measures 7.3 it is outside of the calibration criteria (> 0.2 pH units). Therefore, the instrument will need to be calibrated before you can proceed with the calibration drift checks for other parameters (i.e., Turbidity, DO, etc.) To conduct the calibration of each parameter see the "Calibration" section in this SOP.
18. Make sure to record the barometric pressure during the dissolved oxygen calibration check. This is the same value you will use to re-calibrate the sensor.

    a. If a handheld barometer is available record the current barometric pressure inHg. This value will need to be converted to mmHg using the following equation.

$$\frac{ABS\ \text{inHg}}{0.0393701} = ABS\ \text{mmHg}$$

    Where:

    ABS inHG = The absolute barometric pressure from the handheld barometer (inHg)

    ABS mmHg = The absolute barometric pressure (mmHg)

    b. If no barometer is available check the nearest weather station before you service the instrument for barometric pressure in mbar (Weather Bureau station is preferred http://www.wrh.noaa.gov/otx/). You will first need to convert from mbar to mmHg.

$$0.75 \times BPmbar = BPmmHg$$

    Weather stations report a corrected barometric pressure, barometric pressure at sea level (BP). To convert the barometric pressure at sea level to barometric pressure at altitude BP' Use the following equation:

$$BP' = BP - 2.5\left(\frac{A_{ft}}{100}\right)$$

Where:

BP' = Barometric pressure at altitude mmHg
BP = Barometric pressure at sea level mmHg
A_{ft} = Altitude in feet

19. You will need to stop monitoring after each parameter by pressing **"OK"** in the upper right hand corner of the statistics screen and then pressing **"Stop"** at the bottom of the monitoring screen. Press **"OK"** again. You do not need to save the associated text file so press **"No."** Start up Hydras 3 again. You should still be connected so you just need to press on **"Monitoring**" and set your interval for the next parameter.
20. Repeat steps #3-19 until all 9 parameters have been recorded for the pre-calibration error check. Calibration should be conducted, and then a post-calibration error check should be completed using the same steps, and the same datasheet "UCBN Multiprobe Calibration/Maintenance Log."

Calibration

The process of calibration is one of the most important steps during the multiprobe site revisit in that it ensures that the data collected during the deployment period represents actual conditions. Quality calibration depends on following the calibration guidelines established by the Hach Company. Much of the information contained in this section comes directly from the Hach Hydrolab MS5 User Manual (HACH Environmental. 2006) and the HACH Calibration Video Transcripts (http://www.hydrolab.com/web/ott_hach.nsf/id/pa_videos_and_transcripts.html Accessed on May 6, 2011). The calibration videos on the Hach website are an invaluable tool for anyone that will be conducting calibrations. Each video contains information not found in the user manual.

All sensors must be calibrated separately, with different standard solutions. In some cases multiple standard solutions are used to generate calibration points for a single parameter. This is done so that the sensor is calibrated for both high and low concentrations. For example, the pH calibration uses a standard solution of 7 pH units to establish the first calibration point and a standard solution of 10 pH units to establish the second point.

Each calibration requires that the sensor be clean and free from any contaminates. If the sensor is cleaned properly the calibration will be successful 9 out of 10 times. If cleaning procedures are not followed, erroneous readings and calibration failure may occur. Proper cleaning and rinsing is described in the following sections.

Make sure to calibrate the sensors in the same order as they are listed on the data sheet and in this SOP. The order has been predetermined to help reduce the possibility of cross contaminations caused by standard solutions.

Temperature Sensor

The temperature sensor is factory-set and does not require recalibration. However, if this sensor does malfunction it will have a negative impact on all of the other sensors because they adjust readings based on the temperature. If any discrepancy between the NIST traceable thermometer and the temperature sensor are noted, the multiprobe will need to be serviced by the Hach company.

Specific Conductance *– Modified from the HACH Calibration Video Transcript*

"The conductivity sensor measures the ability of water to conduct electricity across a set distance between graphite conductors of a known size. When the conductivity is known, the salinity and total dissolved solids can be calculated and displayed (Hach Environmental 2006)."

"The only maintenance required is cleaning of the probe's cell and body. Debris, organisms, and other contaminants in the sensor cell will have a negative impact on the accuracy and stability of the readings. The inside of the cell should be cleaned out after every deployment with a cotton swab or small brush. Additionally, prior to calibration of conductivity, all sensors should be cleaned. Any residue or debris on the sensors may contaminate the conductivity standards and change their value, resulting in an inaccurate calibration (Hach Environmental 2006)."

1. Attach the Hydrolab to the Archer unit using the cable provided with a 9-pin connector.

2. Turn on the Archer unit by pressing the button with this symbol (φ) in the lower right hand corner of the Archer unit.
3. Remove the stylus from upper left hand back corner of Archer unit.
4. Use the stylus to tap on upper left hand corner of screen on the Windows **"Start"** icon.
5. Scroll down the pop-up window menu and tap on **"Hydras 3 Pocket for Hydrolab"** to open program.
6. Click on **"Connect"** on the Hydras 3 program screen. You will hear a "beep" that indicates that the Hydrolab is connected and receiving information from the Archer unit.
7. When the Hydrolab finishes its initialization, click the **"Calibration"** tab, then click the **"SpCond [µS/cm]"** tab.
8. You will see the current conductivity reading and the current temperature.
9. The first calibration point is done with a dry sensor to establish a zero point. Rinse the sensors with de-ionized water and dry them thoroughly. Be sure the inside of the conductivity cell is dry. It is best to use cotton swabs to do this.
10. Replace the calibration cup.
11. In the box on the Hydras screen, type a value of **"0"** and click **"Calibrate"**. A **"Calibration successful"** message will appear.
12. Fill the storage cup about 25% with a conductivity standard higher than the highest expected value of the water at your deployment site. For the UCBN we will use a 1412 µS/cm standard.
13. Screw the cap on and shake vigorously for six seconds. Discard the standard.
14. Fill the cup with the calibration standard again, this time so the conductivity cell is completely submerged.
15. Wait one minute for the readings to stabilize.
16. When the readings are stable, type the labeled value of the standard into the box and click the **"Calibrate"** button. This labeled value is on the bottle of calibration standard.
17. A **"Calibration successful"** message will appear.
18. Pour the used standard solution into the "Waste Calibration Standard" bottle that was provided by the UCBN. When this bottle is full please let UCBN know so it can be picked up and disposed of properly.

Congratulations you have calibrated the first sensor!

Luminescent Dissolved Oxygen (LDO) –
Modified from the HACH Calibration Video Transcript

"The Hach LDO probe measures the oxygen dissolved in water by flashing a blue light on the sensor cap coated with a luminescent material and measuring the time it takes for the sensor to return red light. More oxygen in the water causes a shorter time delay" (Hach Environmental 2006).

"The Hach LDO probe is nearly maintenance free. To ensure accurate readings and long sensor life, the probe should be kept clean. After each deployment, the sensor should be cleaned with a cotton swab or soft brush and soapy water to remove any oils or organisms. Organisms living on the sensor will consume or produce oxygen and change the readings. Hard scrubbing will remove the black coating from the outside of the sensor cap. If more than half of the coating is removed, the cap must be replaced. If deposits on the sensor are difficult to remove, soak the sensor in warm fresh water until the deposits soften. NEVER use organic solvents such as acetone or methanol on any part of the sensor or cap. When the sensors are clean, the LDO is ready to calibrate" (Hach Environmental 2006).

"The LDO sensor compensates for the temperature of the water. **To perform an accurate calibration it is important that the temperature of the water remain constant during the procedure. The easiest way to do this is to allow the water used for calibration to sit overnight in an open container until it equilibrates to room temperature.** If the temperature changes by more than 0.5 °C during calibration, dissolved oxygen measurements may be inaccurate and the sensor will need to be recalibrated when the temperature of the water stabilizes. For this reason, the calibration should also not be done in direct sunlight" (Hach Environmental 2006).

1. Make sure the sensor has been cleaned with a soft brush or cotton swab.
2. Use a handheld barometer or local weather station to determine the barometric pressure at the deployment site. This barometric pressure will be used to re-calibrate the LDO sensor.

    a. If a handheld barometer is available record the current barometric pressure inHg. This value will need to be converted to mmHg using the following equation.

$$\frac{ABS\ \text{inHg}}{0.0393701} = ABS\ \text{mmHg}$$

    Where:

    ABS inHG = The absolute barometric pressure from the handheld barometer (inHg)

    ABS mmHg = The absolute barometric pressure (mmHg)

    b. If no barometer is available check the nearest weather station before you service the instrument for barometric pressure in mbar (Weather Bureau station is preferred http://www.wrh.noaa.gov/otx/). You will first need to convert from mbar to mmHg.

$$0.75 \times BPmbar = BPmmHg$$

Weather stations report a corrected barometric pressure, barometric pressure at sea level (BP). To convert the barometric pressure at sea level to barometric pressure at altitude BP' Use the following equation:

$$BP' = BP - 2.5\left(\frac{A_{ft}}{100}\right)$$

Where:

BP' = Barometric pressure at altitude mmHg
BP = Barometric pressure at sea level mmHg
A_{ft} = Altitude in feet

3. Attach the Hydrolab to Archer Unit using cable provided with 9-pin connector.
4. Stand the Hydrolab so the sensors are pointed upwards with the storage cup attached.
5. Turn on the Archer unit by pressing the button with this symbol (φ) in the lower right hand corner of the Archer unit.
6. Remove stylus from upper left hand back corner of Archer unit.
7. Use stylus to tap on upper left hand corner of screen on **Windows start icon**.
8. Scroll down the pop-up window menu and tap on **"Hydras 3 Pocket for Hydrolab"** to open program.
9. Click on **"Connect"** on the Hydras 3 program screen. You will hear a "beep" that indicates that the Hydrolab is connected and receiving information from the Archer unit.
10. Add about one liter of **room temperature** de-ionized water (or clean tap water with a conductivity of less than 500 µS/cm) to a clean one gallon jug. Shake the jug very vigorously for 40 seconds.
11. Fill the storage cup over the sensors to the bottom of the threads and place the storage cap on upside-down. Do not screw the cap on.
12. When the sonde is ready to operate, click the **"Calibration"** tab.
13. Select the **"LDO (%Sat)"** tab.
14. Wait for the current value and temperature readings to stabilize. If the LDO cap was stored wet this should happen very quickly. A dry cap may take several minutes to stabilize.
15. Enter the current absolute barometric pressure in mm/Hg in the box.
16. Click **"Calibrate"**.
17. A **"Calibration Successful"** message will be displayed.
18. Record the DO saturation value from the DO Solubility Table in the Calibration and Maintenance Log. To do this you will need to know the barometric pressure and the current water temperature. Copy the appropriate value in mg/L. This is the same value used to determine if the instrument exceeds the calibration criteria.

Verification of LDO Calibration: If LDO calibration is conducted with a PC instead of an Archer Unit it is possible to verify the success of the calibration by following the next set of steps. **If calibration was conducted with an Archer Unit move on to the next parameter. Note that the symbols < and > designate commands to be pressed on the keyboard.**

1. Click the red **"X"** in the upper right corner and close the calibration window.
2. In the Connection window click the button labeled **"Terminal mode."**
3. Using the arrow keys, highlight **"Login"** and press <**Enter>.**
4. Highlight **"Level 3"** and press <**Enter>.**
5. Type the password and press **<Enter>.** The default is **"Hydrolab"** and it is case sensitive.
6. Use the arrow keys to highlight **"Setup"** and press <**Enter>**.
7. Highlight **"Sensors"** and press **<Enter>.**
8. Highlight **"LDO"** and press **<Enter>.**
9. Highlight **"LDO % SAT"** and press **<Enter>.**
10. Read the Scale Factor. A valid calibration will produce a Scale Factor between 0.5 and 1.5. Values outside of these parameters may indicate a problem with the sensor or electronics. DO NOT type a new value for the Scale Factor. This will invalidate the calibration and cause the sensor to take incorrect readings!
11. Press **<Esc>** after you have verified that the Scale Factor is acceptable.
12. Your LDO is now calibrated and ready to deploy.

pH *– Modified from the HACH Calibration Video Transcript*

"The pH sensor consists of two electrodes: The Measuring Electrode is surrounded by a glass bulb, The Reference Electrode is surrounded by an electrolyte solution and is separated from the water sample by a porous junction. By measuring the electrical potential between these two electrodes, the sensor can determine the Hydrogen ion activity and calculate the pH for a given water sample" (Hach Environmental 2006).

"In order to give consistently accurate readings, the pH sensor should be maintained on a regular basis. Oils, sediment, and biological contaminants on the bulb or reference junction will result in errant readings or a very slow response. Leaching or dilution of the electrolyte solution in the reference will cause the readings to drift over time" (Hach Environmental 2006).

"The glass bulb is very thin and fragile. Care should always be taken not to damage it when servicing the instrument. The sensor should be cleaned with a cotton swab or soft brush and soapy water.

The reference junction is a threaded cap with a sleeve of porous Teflon in the center. The Teflon allows the reference electrolyte to make an electrical connection to the sample water while preventing them from mixing freely. If it becomes clogged or dirty, replace it" (Hach Environmental 2006).

1. **VERY CAREFULLY** clean the glass bulb with a cotton swab and a mild soap. The bulb is made from extremely thin glass and is very fragile.
2. Replace the reference junction if it is visibly fouled. Water with strong biological activity tends to foul the junction more rapidly.
3. Replace the electrolyte solution regularly. Water with very low levels of dissolved solids or high flow rates will leach the salts out of the solution and dilute it more quickly. Your specific water conditions will determine how frequently this should be done.
4. Use of the salt tablets from the maintenance kit will keep the electrolyte solution saturated for longer periods of time.
5. The pH sensor should not be allowed to dry out for extended periods. When not in use, store the sensor in pH 4 buffer, or alternatively, clean tap water.
6. **DO NOT store the sensor in de-ionized water or sample water.** DI water will damage the sensor bulb, and the organisms in sample water will foul the bulb and junction.

Replacing the Teflon Reference Junction

1. Turn the junction counter clock-wise to unscrew it from the base; you will need a flat screwdriver to do this.
2. With the junction off, pour the old electrolyte solution out and replace it with fresh solution.

   ***Make sure the new electrolyte solution is clear!** If it is grey or milky-looking, it is bad and should not be used. Re-deployment is acceptable but will have a negative impact on the pH data quality. Reorder the solution as soon as possible.**
3. Add a salt tablet to the reference electrolyte in the sensor . This will maintain the saturation level of the electrolyte as the salt slowly leaches through the Teflon junction.
4. Fill the reference until the electrolyte forms a slight dome over the top.

5. Gently place the new junction into the top of the reference tube so that no air remains inside, and turn it clock-wise until the O-ring is sealed tightly. As you tighten you will see a small amount of electrolyte and possibly bubbles being forced out of the junction. This is the air being purged from inside the junction. If this purging effect does not occur, the junction may be clogged and must be replaced.
6. The pH sensor is now ready to be calibrated.

Calibration of the pH sensor

1. Attach the Hydrolab to the Archer unit using cable provided with 9-pin connector.
2. Turn on the Archer unit by pressing the button with this symbol (φ) in the lower right hand corner of the Archer unit.
3. Remove stylus from upper left hand back corner of Archer unit.
4. Use stylus to tap on upper left hand corner of screen on the **Windows start icon**.
5. Scroll down the pop-up window menu and tap on **"Hydras 3 Pocket for Hydrolab"** to open program.
6. Click on **"Connect"** on the Hydras 3 program screen. You will hear a "beep" that indicates that the Hydrolab is connected and receiving information from the Archer unit.
7. When the Hydrolab finishes its initialization, click the **"Calibration"** tab, then select pH units and click **"Select"** near the bottom of the screen.
8. You will see the current pH value, the date and time, and the current temperature.
9. **Rinse and dry the sensors (Very important!)** and attach the storage/calibration cup. Fill the cup about 25% with pH buffer 7 and screw on the storage cap. Shake for 6 seconds.
10. Remove the storage cap and pour the buffer 7 out.
11. Fill the cup with buffer 7 again, this time over the top of the pH sensor.
12. Wait one minute for the readings to stabilize.
13. When the readings are stable, type a value of 7.00 into the box, or the standard value adjusted for temperature***** and click **"Calibrate"**. ***The corrected values are listed on the pH at temperature table in the calibration and maintenance log notebook or can be calculated with the pH/D.O. calculator Excel file on the pda.**
14. A **"Calibration Successful"** message will appear. If the pH readings continue to drift for an extended period of time, or jump up and down, the sensor may need to be cleaned or replaced.
15. Pour the buffer 7 out, rinse the sensors with deionized water, and dry them.
16. Fill the cup about 25% with pH 10 buffer solution.
17. Screw on the storage cap and shake for 6 seconds. Remove the storage cap and pour the buffer 10 solution out.
18. Fill the cup with pH 10 buffer solution again, this time over the top of the pH sensor.
19. Wait one minute for the readings to stabilize.
20. When the reading stabilizes, type the labeled value of the solution into the box, adjusted for temperature, and click **"Calibrate"**. A **"Calibration Successful"** message will appear. If the pH readings continue to drift for an extended period of time or jump up and down, the sensor may need to be cleaned or replaced.
21. The pH sensor is now calibrated.

"If desired, a linearity test may be performed with a buffer opposite that used for pH slope calibration. For example, if pH 10 was used to calibrate, check with pH 4, or if pH 4 was used to

calibrate, check with pH 10. Repeat the process used for the previous calibration with the opposing buffer solution, but **do not** click the calibrate button again" (Hach Environmental 2006).

Self-cleaning Turbidity - *Modified from the HACH Calibration Video Transcript*

"The Hydrolab Self Cleaning Turbidity sensor measures the intensity of light scattered by particles in the water sample at 90 degrees from an infrared light source and reports that value in NTUs. In order to take an accurate measurement of the scattered light, the sensor requires an unobstructed view of the water extending approximately 1 inch (25.4 mm) from the end of the sensor. To keep the optics clean there is a motorized pad that can be set to wipe from 1 to 9 times before taking a measurement depending on the degree of sensor fouling expected. The 'X' version also features an extended brush for removing debris from the other sensors" (Hach Environmental 2006).

"The Self Cleaning Turbidity sensor is almost completely maintenance free. When the cleaning pad becomes fouled, simply replace it using the hex wrench provided. The cleaning pad set screw should be tightened against the flat side of the shaft. **DO NOT rotate the wiper by hand or operate the wiper when the sensor is dry**. Both of these actions can damage the gear assembly inside the motor" (Hach Environmental 2006).

The Self Cleaning Turbidity sensor uses scattered light to report the concentration of suspended particles in water, so it is important to clean the instrument as thoroughly as possible prior to calibration.

1. Use a soft brush and mild soap to remove dirt and debris from all of the sensors and the inside of the storage cup. Rinse the storage cup and sensors until they are free of soap and dirt, then **dry with lint free towels**.
2. Change the wiper if necessary. Use the supplied Allen wrench to remove the set screw holding the wiper onto the motor shaft. Position a new wiper on the motor shaft and tighten the set screw. More details are provided in the Hach Self Cleaning Turbidity manual.
3. Attach the Hydrolab to the Archer unit using the cable provided with a 9-pin connector.
4. Turn on the Archer unit by pressing the button with this symbol (φ) in the lower right hand corner of the Archer unit.
5. **Zero Point Calibration** – With the sensors pointed upwards, fill the storage cup approximately 75% with de-ionized water or <0.1 NTU StablCal and screw the storage cap on tightly.
6. Slowly turn the Hydrolab over so the sensors point downwards.
7. Remove stylus from upper left hand back corner of Archer unit.
8. Use the stylus to tap on upper left hand corner of the screen on the Windows start icon.
9. Scroll down the pop-up window menu and tap on **"Hydras 3 Pocket for Hydrolab"** to open program.
10. Click on **"Connect"** on the Hydras 3 program screen. You will hear a "beep" that indicates that the Hydrolab is connected and receiving information from the Archer unit.
11. When the Hydrolab finishes its initialization, click the **"Calibration"** tab, then select **"Turbidity [rev]"**
12. Verify that the value in the box is **"1"** and click the **"Calibrate"** button.
13. The wiper should make one complete revolution, removing any air bubbles from the optics.
14. Click the **"OK"** button in the **"Calibration Successful"** window.
15. Click the **"Calibration"** tab, then select **"Turbidity [NTU]."** There are two boxes on this page.
16. In the box labeled **"Turbidity [Point]"** enter a **"1."**
17. In the box labeled **"Turbidity [NTU]"** enter a value of 0.3 to 0.6 depending on the cleanliness of the sensors.

18. When the readings at the top of the page are stable, click **"Calibrate."**
19. Click the **"OK"** button in the **"Calibration Successful"** window.
20. **High-End Calibration** – The high-end calibration point should be a value higher than the highest value anticipated at the deployment site. The standard factory high point is 100 NTU.
21. Pour the de-ionized water out of the storage cup and dry the sensors again.
22. Gently swirl or invert the bottle of 100NTU StablCal for two to three minutes to mix the suspension. **DO NOT shake the bottle of StablCal!** This will suspend air bubbles in the solution and change the turbidity of the standard.
23. Pour the StablCal into the storage cup until it is about 25% filled. Screw the cap on tightly and shake the Hydrolab. Remove the cap and pour the solution out.
24. Gently pour StablCal into the storage cup again, this time filling the cup to 75%. Screw the cap on and gently turn the sonde over so the sensors are pointing downward. The end of the Self Cleaning Turbidity sensor should be fully submerged.
25. Again, in Hydras, click on the **"Calibration"** tab, and then click on **"Turbidity [rev]."** Verify that the value in the box is **"1"** and click the **"Calibrate"** button. The wiper should make one complete revolution, removing any air bubbles from the optics.
26. Click the **"OK"** button in the **"Calibration Successful"** window.
27. From the main Hydras menu click the **"Calibration"** tab, and then select **"Turbidity [NTU.]"** There are two boxes on this page.
28. In the box labeled **"Turbidity [Point]"** enter a **"2."**
29. In the box labeled **"Turbidity [NTU]"** enter a value of **"100".**
30. When the readings at the top of the page are stable, click **"Calibrate"**.
31. Click the **"OK"** button in the **"Calibration Successful"** window.
32. The Self Cleaning Turbidity sensor is now calibrated.

Post-Calibration Final Readings

After the calibration drift error check and/or calibration of all sensors, the multiprobe should be deployed briefly in the stream next to a field meter or checked against standard solutions. The final readings allow the multiprobe to be "double checked" before it is re-deployed. Ideally the multiprobe will be checked against a field meter and not in standard solutions. A field meter is a meter that was calibrated in lab conditions and is used to verify that multiprobe measurements reflect actual stream conditions. The final readings should be recorded in the "Final Readings" section on the "UCBN Multiprobe Calibration/Maintenance Log." **If a field meter is not available final readings should be determined by placing the sensors in standard solutions**, **in the same manner as when they were assessed for calibration drift**. A list of standards that you should use for final readings is provided in Table 5. The type of standard used for the final readings should be recorded next to the multiprobe (monitor) readings on the UCBN Multiprobe Calibration/Maintenance Log. Make sure to note if final readings were taken in the stream or with standard solutions.

Final Readings in the Stream

If a field meter is available, the multiprobe should be placed in the stream next to the field meter. After values on the multiprobe and field meter have stabilized the values for each parameter should be recorded on the UCBN Multiprobe Calibration/Maintenance Log in the "Final Readings" section. Readings should be recorded for both the field meter and the multiprobe.

1. Do not disconnect the calibration cable/Archer unit from the multiprobe.

2. Remove the calibration cup from the multiprobe and attach the sensor guard.
3. Place the multiprobe in the stream adjacent to the field meter.
4. Wait several minutes for the readings on the multiprobe to stabilize.
5. On the main Hydras menu click **"Monitor."**
6. A new screen will appear with three tabs along the bottom: (Figure 29) **"Time Series," "Depth Profile,"** and **"Manual Mode."**
7. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button.
8. In the next window you will press the **"Current Values"** button.
9. Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add"**. There should be five parameters: Temp., SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the Calibration/Maintenance Log Sheet.
10. Wait for the readings to stabilize. Record the value for each parameter in the appropriate blank in the "Final Readings" section. You should also record the readings for each value from the field meter and record these values in the "Final Readings" section. After you have recorded all of the parameters look at the calibration criteria listed in Table 5. The values recorded by the multiprobe should be very close to the field meter. If the readings are not within the limits, or very close, the sensor should be re-calibrated again or the sensor may be faulty and should be replaced.
11. You will need to stop monitoring after each parameter by pressing **"OK"** in the upper right hand corner of the statistics screen and then pressing **"Stop"** at the bottom of the monitoring screen. Press **"OK"** again. You do not need to save the associated text file so press **"No."** Start up Hydras 3 again. You should still be connected so you just need to press on **"Monitoring"** and set your interval for the next parameter.

Final Readings in Standard Solutions

If no field meter is available, final readings should be taken in standard solutions. While this is not the preferred method it, will serve the same function as a double check using a field meter. It is important to note on the Calibration/Maintenance Log that the final readings were not taken using a field meter. In addition, the type of standards used for the comparison should also be recorded.

1. Fill the calibration cup with 2 inches of de-ionized water. Replace the calibration cup top and tighten.
2. Gently swirl the de-ionized water around to rinse the sensors of all stream water. Make sure the water comes in contact with each sensor.
3. Empty the de-ionized water from the calibration cup, remove the cup and dry the sensors with a paper towel and/or a cotton swab. Make sure not to damage the L.D.O. or the pH sensor. Replace the calibration cup.
4. Fill the calibration cup ¼ of the way with one of the standards listed in Table 5. Place the cap on the calibration cup and tighten.

Table 5. List of standard solutions for final readings after calibration.

FINAL READINGS IN STANDARD SOLUTIONS				
Parameter	**Checked against**	**Parameters to select on Archer**	**Calibration Criteria**	**Maximum allowable limits for WQ sensor values**
Temp	**NIST Thermometer**	**Temp[°C]**	**> ± 0.2 °C when checked with another meter. > ± 0.5 °C when checked with NIST thermometer.**	**± 2.0 °C**
Specific Cond.	**1412 µS/cm std.**	**SpCond [µS/cm]**	**± 5 µS/cm or ± 3%**	**± 30 %**
pH	**7.0**	**pH [Units]**	**>0.2 pH units**	**± 2 pH units**
D.O.	**Air Sat. Water 100%**	**LDO%[SAT]**	**> ± 0.3 mg/L**	**The greater of ± 2.0 mg/L or 20%**
Turbidity	**100 NTU**	**Turbidity [NTU]**	**The greater of ± 0.5 turbidity units or ±5%**	**The greater of 3.0 TU or ± 30 %**
Battery	**N/A**	**Internal-Battery [%Left]**	**Should have ≈ 95% remaining**	

5. Gently swirl the standard around to ensure that the sensors are rinsed with the standard solution.
6. Empty the calibration cup.
7. Now fill the calibration cup with the appropriate calibration standard so that the sensor is covered. Loosely cap the calibration cup for each standard except for dissolved oxygen. For dissolved oxygen you should place the cap upside down on the calibration cup.
8. On the main Hydras menu click **"Monitor."**
9. A new screen will appear with three tabs along the bottom: (Figure 29) **"Time Series," "Depth Profile,"** and **"Manual Mode."**
10. Make sure you are on the **"Time Series"** tab, and then specify the interval of samples. For our purposes you should specify 2 seconds. Press the **"Start"** button.
11. In the next window you will press the **"Current Values"** button.
12. Individually select each of the parameters listed on the "UCBN Multiprobe Calibration/Maintenance Log" and click **"Add."** There should be five parameters: Temp., SC (specific conductivity), D.O. (dissolved oxygen), pH, and Turbidity. **Make sure to select the correct units**. It is easiest to select and add the parameters in the same order as listed on the Calibration/Maintenance Log Sheet.
13. Wait for the readings to stabilize. Record the value for each parameter in the appropriate blank in the "Final Readings" section. You should also record the readings for each value from the field meter and record these values in the "Final Readings" section. After you have recorded all of the parameters look at the calibration criteria listed in Table 5. The values recorded by the multiprobe should be very close to the field meter. If the readings are not within the limits, or very close, the sensor should be re-calibrated again or the sensor may be faulty.
14. As in the calibration check, make sure to record the barometric pressure and temperature during the dissolved oxygen check.
15. You will need to stop monitoring after each parameter by pressing **"OK"** in the upper right hand corner of the statistics screen and then pressing **"Stop"** at the bottom of the

monitoring screen. Press **"OK"** again. You do not need to save the associated text file so press **"No."** Start up Hydras 3 again. You should still be connected so you just need to press on **"Monitoring"** and set your interval for the next parameter.

16. Repeat steps #4-15 until all 5 parameters have been recorded for the final readings.

If values are observed outside of the acceptable range during the final readings the sensor may have been fouled during the calibration procedure, may be low on batteries or requires maintenance. The first step in trouble shooting should be to check the batteries. If the batteries have been replaced or have ≥ 95 % remaining then you should try re-calibrating the suspect sensor. If neither of these two options works to fix erroneous readings you should contact the UCBN Water Quality Project Lead (208-885-3010) and/or Hach Technical Assistance (1-800-949-3766).

Re-deployment

After the multiprobe has been error checked it will need to be set up to collect data during the next deployment period. To do this, a new log file will need to be created.

Creating/Enabling a Log File

1. **Quickly double check the amount of battery remaining. If the batteries are less than 95%, replace them.**
    a. To check battery power, go to the main Hydras screen and click **"Monitoring."**
    b. Set the interval for 2 seconds. Click **"Start"**
    c. Check the **"Internal Battery"** reading (Volts and %) Record these values on the log sheet.
2. From the main Hydras menu click **"Log Files."**
3. The next screen will allow you to create a new log file. Make sure not to delete the templates for each park (Figure 32). Click **"New."**

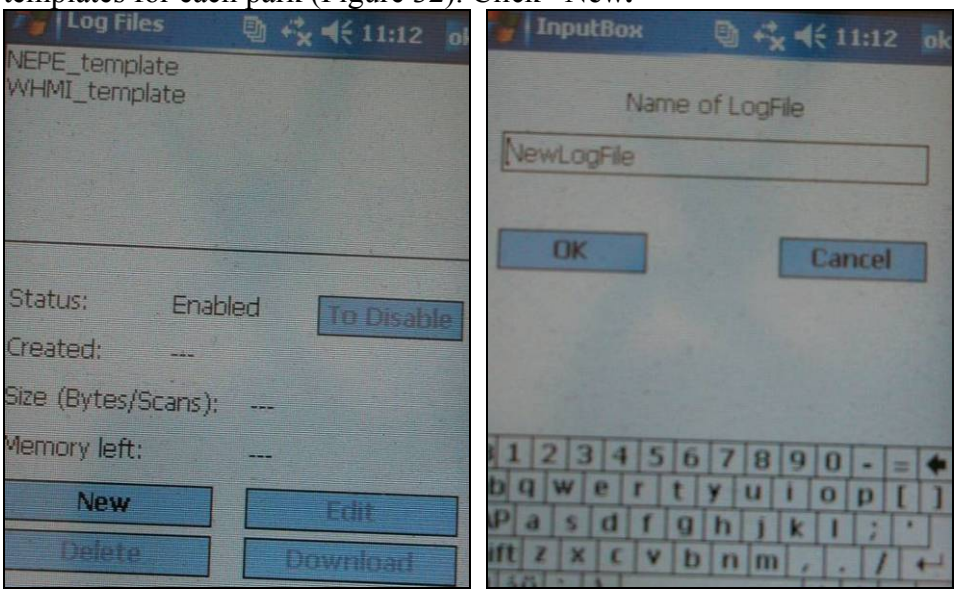


Figure 32. (left) The Log Files screen allows the user to create a new log file for the next deployment period.
Figure 33. (right) The Input Box screen is used to name the new log file.

4. On the Input Box screen (Figure 33) enter the new file name for the log file. Remember the file naming convention used when you downloaded the data from the previous deployment. For example the file name might read NEPE_Lapwai_20080402. The file name should include the park abbreviation, the stream and the beginning date. During the next data download the file name will be modified to reflect the end of the deployment. Make sure to record the new log files name in the "Deployment" section of the "UCBN Multiprobe Calibration/Maintenance Log." This is important in case a different person services the multiprobe on the next visit.
5. After you name the file click **"OK."**
6. After a few seconds the Log File Setup screen will appear. This screen allows the user to specify the sensors start and stop times, measuring interval, sensor warm up period, and the measured parameters.
7. To avoid confusion about what parameters and intervals to select a template has been created and pre-loaded on each Archer unit.
8. On the bottom of the Log File Setup screen click **"Templates", "Load"** and then the appropriate template for the park being monitored or for the multiprobe number (UCBN label on the instrument) (Figure 34).

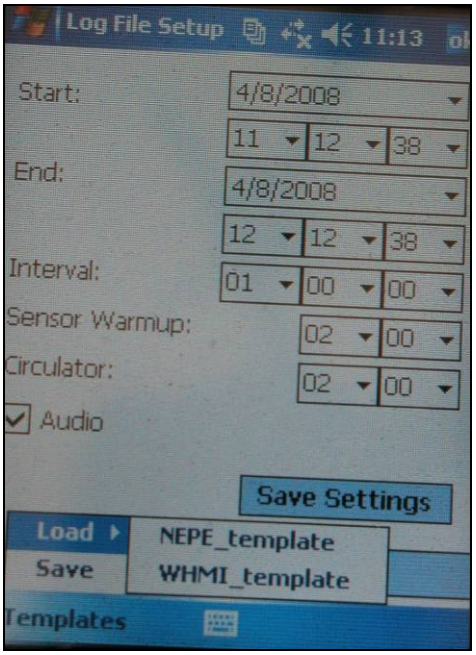


Figure 34. Log File Setup Screen "General" tab.

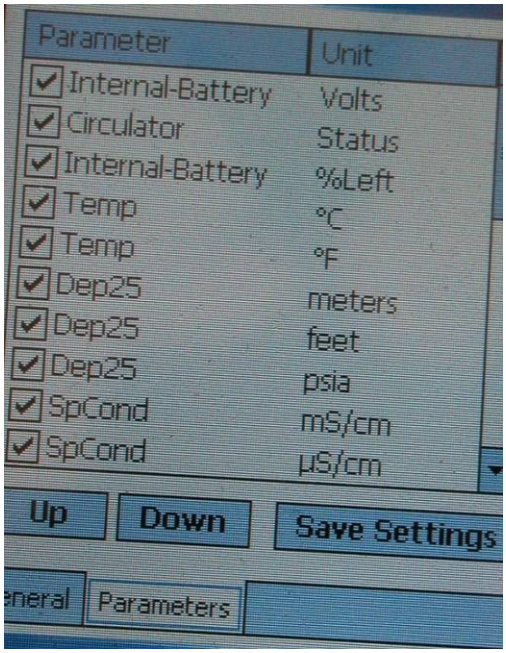


Figure 35. Log File Setup Screen "Parameters" tab.

9. The template will automatically populate the Parameters, Interval, Sensor Warm Up and Circulator fields with the correct values; however, you will need to update the start and end dates and times. **Note that if you are using an external power source you may need to manually select "External Battery- Volts" and "External Battery- %Left" from the "Parameters" tab.**
10. On the **"General"** tab in the **"Start"** field enter the current date.

11. In the **"Start"** field enter the time you want the multiprobe to begin taking measurements. Make sure to set this time for when the multiprobe will be secured in the housing and when you will no longer be in the stream. **When in doubt add at least 15 minutes to the current time. Make sure to record the deployment time in the log book.**
12. In the **"End"** field enter the expected return date. This will be a bit tricky to decide when you will revisit the site, especially given the variable nature of field work. However, you should enter a date at least one month away from the current date. The reason for this is that if field conditions do not allow you to revisit the site, data will be collected until the batteries run out.
13. Double check that the following is correctly entered on the Log File Setup **"General"** tab:
    a. Interval: 1 hour
    b. Sensor Warm-up: 2 minutes
    c. Circulator: 2 minutes
    d. Audio: Off or Un-checked
14. Click on the **"Parameters"** tab (Figure 35).
15. Double check that the following parameters are selected:
    a. Internal Battery –Volts (if applicable)
    b. External Battery- Volts (if applicable)
    c. Circulator - Status
    d. Internal Battery - %Left (if applicable)
    e. External Battery- %Left (if applicable)
    f. Temp - °C
    g. Temp - °F
    h. Dep25 – meters (Hydrolab 064 only)
    i. Dep25 – feet (Hydrolab 064 only)
    j. Dep25 – psia (Hydrolab 064 only)
    k. SpCond – mS/cm
    l. SpCond - µS/cm
    m. Res – KÛ-cm
    n. Sal – ppt
    o. TDS – g/l
    p. pH – units
    q. ORP – mV
    r. Turbidity – Rev
    s. Turbidity – NTU
    t. Turbidity – Volts
    u. LDO% - Sat
    v. LDO – mg/l
    w. LDO _BP – mmHg
    x. Date-Time – seconds
16. **The following should NOT be selected.**
    a. Temp - °K
    b. DepthX – volts
    c. DepthY - mvolts

17. When you have double checked all parameters, dates and times click **"Save Settings."** After saving there will be a short delay before you are returned to the Log File Screen.
18. Select the newly created log file. Make sure to double check the name and write it down on the data sheet.
19. Click **"To Enable."**
20. The multiprobe log file has been created and should actively monitor data beginning at the time you specified. **Make sure to deploy the multiprobe and exit the stream before monitoring begins.**
21. **Double check that the ENTIRE multiprobe calibration/maintenance log sheet is complete.**
22. Go to the main Hydras menu and select **"Disconnect."** You will be asked if you really want to disconnect click **"Yes."**

Deployment

External Power Source:

1. The calibration cable should remain attached to the multiprobe and battery.
2. Disconnect the Archer unit from the external power adapter cable.
3. Double check all connections and look for signs of rodent damage to the calibration cable.
4. Lower the multiprobe into the housing by holding onto the calibration cable.
5. Align the security cable holes in the cap with the holes in the housing.
6. Gently tap the top of the cap until it is seated against the top of the multiprobe housing or the cable lock holes are aligned.
7. Fasten the cable lock as shown in Figures 38(a) and 38(b).
8. Double check that the security cable is locked.
9. Coil extra calibration cable into the battery box.
10. Replace the lid on the battery box and secure it with locks.

Internal Power Source:

1. Disconnect the calibration cable from the multiprobe and the Archer unit. Loosely coil the cable so it is no smaller than 15” in diameter.
2. Re-attach the 9 pin connector cap. Make sure to purge all air from the cap by pressing in on the rubber sleeve near the multiprobe (Figure 36).



Figure 36. Replace the nine-pin connection cap before attaching the mooring fixture.

3. Re-attach the mooring fixture, making sure that it is seated against the O-ring.
4. Attach the snap hook located under the housing cap to the mooring fixture.
5. Grasp the multiprobe in your left hand and the housing cap in your right and slowly lower the multiprobe into the housing (Figure 37).



Figure 37. Proper arrangement of the multiprobe cap, snap hook, mooring fixture, multiprobe and multiprobe housing.

6. Align the security cable holes in the cap with the holes in the housing.
7. Gently tap the top of the cap until it is seated against the top of the multiprobe housing or the cable lock holes are aligned.
8. Fasten the cable lock as shown in Figures 38(a) and 38(b).
9. Double check that the security cable is locked.

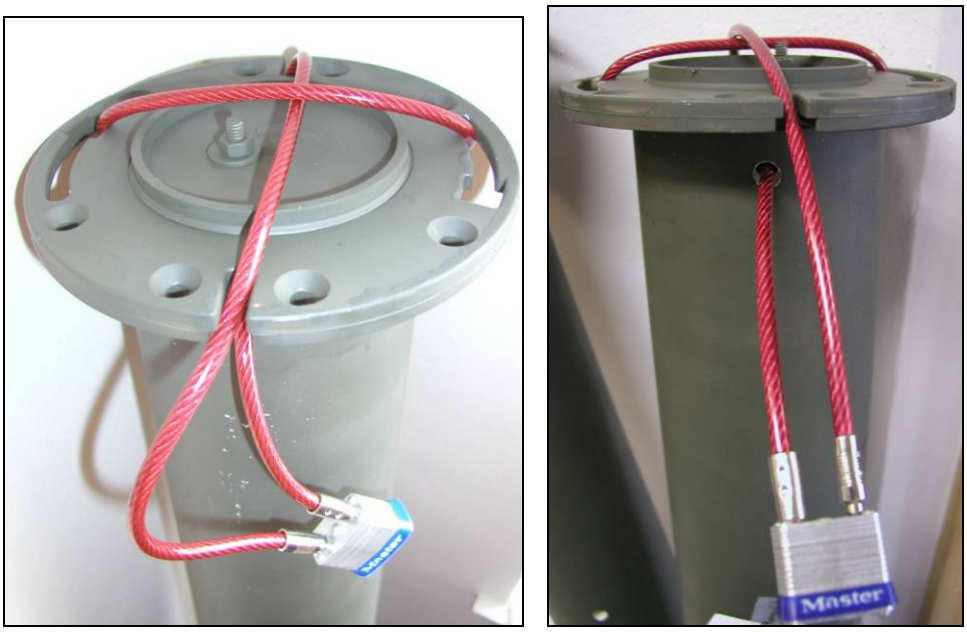


Figure 38(a) 38 (b) Proper arrangement of the cable lock. Note that the cable passes through the housing and cap.

Transfer of files to UCBN

After maintenance, calibration, and re-deployment, the downloaded data should be transferred from the Archer unit onto a PC that is capable of printing and has an internet connection. In addition, the PC must have Microsoft Active Sync version 4.5 or higher. Microsoft Active Sync can be provided by the UCBN.

1. Connect the Archer unit to the PC by attaching the USB cable to port B on the side of the unit just below the buttons. Port B is on the left side of the 9-pin connection (Figure 26). Plug the other side into the computer's USB slot. When the connection has been made, Microsoft Active Sync will automatically detect the unit.
2. When Active Sync is connected, click **"Explore."** This will open the Mobile Device window which will allow you to navigate to different folders on the Archer unit (Figure 39).

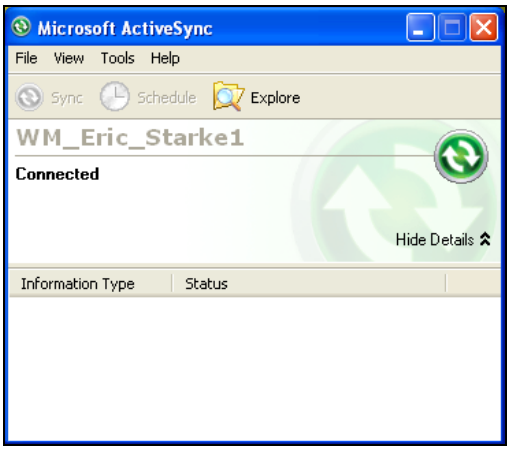


Figure 39. Microsoft Active Sync window.

3. Navigate to the correct folder containing the downloaded data.
4. Copy the correct file to your computer. Make sure the data remains on the Archer unit. Only UCBN personnel should remove deployment records from the Archer unit.
5. On the PC open the data file and print a copy. The paper version should be stored at the park with the maintenance/calibration log book.
6. Attach the electronic file to an email and send it to the UCBN water quality project lead as soon as possible.

Post Revisit

1. Transfer all datasheets to the UCBN

   After the multiprobe has been re-deployed it is up to the Integrated Water Quality Protocol cooperator and UCBN staff to ensure that all datasheets, electronic or paper, are transferred to the UCBN Water Quality Project Lead. All log files and datasheets should be transferred via email or ground mail within a week of the multiprobe site revisit. **It is critical to transfer data to UCBN staff as soon as possible so any problems with the multiprobe can be fixed!** For more on transferring files to UCBN see the Recovery of Multiprobe Section at the beginning of this SOP.

2. Notify the UCBN if any standard solutions are running low

   To avoid costly gaps in data, it is crucial that the UCBN be aware of standard solution levels. If you are low on standard solutions let the UCBN Project Lead know immediately so more can be ordered.

3. Check on the Water Quality Multiprobe

   UCBN Cooperators should check on the multiprobe at least once a week. The multiprobe sensors are very fragile and susceptible to desiccation.
   IF THE SENSORS DRY OUT THEY WILL NEED TO BE REPLACED! Please check on the multiprobe at least once a week to avoid the cost of replacing the sensors. IF THE WATER IS NEAR THE WHITE LINE ON

THE HOUSING THE HYDROLAB SHOULD BE REMOVED OR RECONFIGURED (Figure 40).



Figure 40. Multiprobe housing. The white line indicates low water. If the water level reaches the white line, the sensors have one inch of water covering them. Remove the multiprobe if water reaches this line.

If you are in doubt of water levels, remove the sensor from the stream, conduct fouling and drift error checks and download the data from the last deployment. Place the multiprobe in its calibration/storage cup with ¼ inch of pH 4 standard and store it in the office. Call the Integrated Water Quality Project Lead to discuss relocating the multiprobe.

Storage/End of Season Procedures

If the multiprobe is removed for storage during low water or at the end of the sampling season it should undergo routine maintenance and error checks. In addition, it should be prepared as follows before it is stored in a hard-sided case.

1. Scrubbed clean with a brush and soap and water
2. All O-rings lubricated
3. Batteries removed
4. The storage cup filled with ¼ inch of pH 4 buffer solution
5. The communication cable should be scrubbed with soap and water and rinsed
6. Coil the communication cable in a coil greater than 15” in diameter

If the multiprobe has been operated using an external power source such as a solar panel and battery, these items should be serviced before storage.

1. Remove any debris found in the battery box (grass, soil, etc.)
2. Disconnect the external power adapter and battery adapter from the calibration cable and battery. Coil all 3 cables and leave them in the same box.
3. Place the locks inside of the box

4. Remove the solar panel from the PVC post.
5. Wipe the dust off of the solar panel and coil the cable. (Keep the battery clips attached to the cable)

Conclusion

By the time you have made it to this point in the SOP you have successfully serviced and re-deployed the UCBN water quality multiprobe. Thanks for taking the time to download data, error check and calibrate. The long term data gained by continuous monitoring helps to determine the status and trend of water quality in each park. You have directly contributed to a better understanding of surface water in the National Park system. Thanks for your help! Keep up the good work!

Literature Cited

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 7: Benthic Macroinvertebrate Sample Collection

Version 2.0, February 2013

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	February 2013	UCBN-Aquatic Biologist	Switched from EPA EMAP sample methods to those used by the USFS-PIBO program.	Benthic macroinvertebrate collection is now an integrated part of stream channel sampling conducted by the USFS-PIBO program.	2.0

Note: This SOP describes the step-by-step procedures for benthic macroinvertebrate sample reach delineation and collection. These procedures have been excerpted from or have been modified from the United States Forest Service-PIBO Programs Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes (Archer et al. 2012, Heitke et al. 2008). The original sampling design for this SOP (v1.0) was modified from the EPA's Environmental Monitoring and Assessment Programs – Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams (2006).

Suggested Reading

Archer, E. K., R. A. Scully, R. Henderson, B. B. Roper, and J. D. Heitke. 2012. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp.

Heitke, J. D., E. J. Archer, D.D Dugaw, B. A. Bouwes, E. A. Archer, R. C. Henderson, and J. L. Kershner. 2008. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp.

Peck, D. V., A. T. Herlihy, B. H. Hill, R. M. Hughes, P. R. Kaufmann, D. Klemm, J. M. Lazorchak, F. H. McCormick, S. A. Peterson, P. L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, DC, EPA/620/R-06/003.

Introduction and Background

In 2009, this SOPs (v1.0) sampling methods were based on the EPA's Environmental Monitoring and Assessment Programs (EMAP) – Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams (Peck et al. 2006). Streams in Big Hole National Battlefield (BIHO) City of Rocks National Reserve (CIRO), Nez Perce National Historical Park (NEPE), and Whitman Mission National Historical Site (WHMI) were sampled in 2008 and 2009 following these methods. Subsequently in 2010, the UCBN began stream channel characteristics monitoring following the United States Forest Service PACFISH/INFISH Effectiveness Monitoring (PIBO-EM) Program's protocol (Archer et al. 2012, Heitke et al. 2008). Part of PIBO's assessment of stream channel characteristics is the collection of benthic macroinvertebrates. The PIBO protocol calls for the collection of macroinvertebrates from 4 fast water habitats, rather than along transects, regardless of habitat type, as in the EMAP protocol. The PIBO program monitors stream channel characteristics in selected UCBN streams via an inter-agency agreement with the UCBN and collects macroinvertebrates following their methods. Rather than duplicate efforts by sampling again following EMAP methods the UCBN decided to adopt PIBO methods for all of the streams monitored under the integrated water quality and stream channel characteristics protocols. In addition to cost savings, these methods offer benefits including; facilitating the use of Observed/Expected (O/E) ratios, more consistent application of indices used by states, and potential to compare data to other sites sampled by PIBO. As a result, this SOP has been modified to reflect the change in collection procedures.

Benthic Macroinvertebrate Index Period

Streams will be sampled using a three-year rotating panel design (Table 6). During sample years, each stream will be sampled during the index period recommended by Hayslip (2007) and Montana DEQ (2006). This index period for streams in Idaho, Oregon, and Washington is between July 1st and October 15th and in Montana is between June 21st and September 21st. The major reason for sampling within this index period is that typically State DEQs and federal agencies such as the EPA have developed multimetric indices and established reference conditions based on data collected during these time periods. In addition, sampling during this time period will help ensure data collected by the UCBN is integrable with other regional data sources. It has also been suggested that sampling during this time period is advantageous because benthic macroinvertebrates reach their maximum representation, and that there has been an adequate amount of time for the instream environment to stabilize following high spring flows (Hayslip 2006). Sampling outside of the index period may occur in locations where surface flow generally ceases prior to the index period identified in Table 6 (CIRO and CRMO).

Table 6. Three-year rotating panel design schedule for selected UCBN streams.

Park	Waterbody	Index Period (1)	Index Period (2)	Index Period (3)
NEPE	Jim Ford Creek	July 1 – October 15, 2014	July 1 – October 15, 2017	July 1 – October 15, 2020
	Lapwai Creek	July 1 – October 15, 2014	July 1 – October 15, 2017	July 1 – October 15, 2020
WHMI	Mill Creek	July 1 – October 15, 2014	July 1 – October 15, 2017	July 1 – October 15, 2020
	Doan Creek	July 1 – October 15, 2014	July 1 – October 15, 2017	July 1 – October 15, 2020
BIHO	NF Big Hole River	June 21 - September 21, 2015	June 21 - September 21, 2018	June 21 - September 21, 2021
CIRO	Circle Creek	July 1 – October 15, 2015	July 1 – October 15, 2018	July 1 – October 15, 2021
	Almo Creek	July 1 – October 15, 2015	July 1 – October 15, 2018	July 1 – October 15, 2021
JODA	John Day River	July 1 – October 15, 2013	July 1 – October 15, 2016	July 1 – October 15, 2019
	Rock Creek	July 1 – October 15, 2013	July 1 – October 15, 2016	July 1 – October 15, 2019
	Bridge Creek	July 1 – October 15, 2013	July 1 – October 15, 2016	July 1 – October 15, 2019
CRMO	Little Cottonwood Cr.	July 1 – October 15, 2013	July 1 – October 15, 2016	July 1 – October 15, 2019

Procedures

Field Operations Overview

The benthic macroinvertebrate sample collection protocol is intended to be conducted by a one or two-person field crew. Upon arrival, the stream segment should be verified using maps, aerial photos or other means.

Streams that are included in the UCBN's stream channel characteristics monitoring protocol have established benthic macroinvertebrate sample reaches (all streams in Table 6 except at CRMO). These reaches have been sampled following the PIBO macroinvertebrate protocol and will be re-sampled on the same rotating panel shown in Table 6. No stream channel characteristics monitoring occur at CRMO, therefore a benthic macroinvertebrate reach has been established, with the bottom of the reach (BR) starting at the X-site as defined in this SOP v1.0.

If new sample reaches are to be established, the protocol lead must determine how many sample reaches will fit within the park boundaries. In some cases, where stream length allows, sample reach locations will be pre-defined using a generalized random tessellation stratified (GRTS) spatially-balanced sample (SOP #4).
Starting with the most downstream sample reach, the field crew will permanently mark the bottom (downstream) and top (upstream) of each sample reach. Reaches will subsequently be sampled for benthic macroinvertebrates following the revisit schedule as outline in Table 6. Permanent markers also serve to monument stream channel characteristics and riparian monitoring sites (see Starkey et al. 2011)This general work flow is outlined in Figure 41 and the estimated times for completion of each task is given in Table 7.

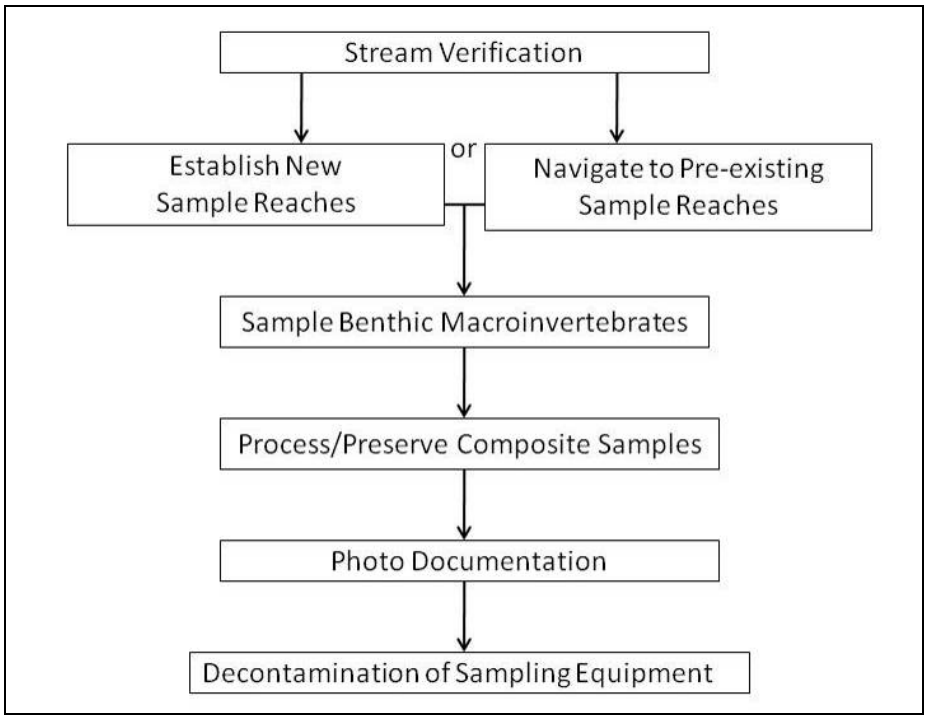


Figure 41. General workflow for benthic macroinvertebrate sampling.

Table 7. Estimated time requirements for benthic macroinvertebrate sampling activities.

Activity	Number of Personnel Required	Estimated Time Required
Initial procedures: Stream verification/determination of mean wetted width	2	0.25 hr
Delineation of sample reach	2	0.25 hr/reach
Reach photos / collection of GPS waypoint	1	0.25 hr/reach
Sampling/Sorting benthic macroinvertebrates	2	1.5 hr/reach
Sample tracking and packing	1	0.25 hr/reach
	Summary	**2.25 hrs/reach** **0.75 hrs for initial procedure**

Stream Verification and Sampling Status

Upon arrival, field personnel must verify that they are in the correct sampling location. Most UCBN parks are relatively small and have streams that are readily identifiable/easy to access. Verification of the stream should be done with topographic maps, aerial photos, previously recorded GPS coordinates or personal communication with National Park Service staff. New site information should be recorded on the UCBN Site Verification/Establishment Form (Appendix 5) or as part of the stream channel characteristics monitoring data. One verification form is required for each macroinvertebrate sample reach not part of stream channel characteristics monitoring, although the method of verification will likely be the same for all sampled reaches within a give park (Starkey et al. 2011).

In addition to verifying the sample reach, field personnel should determine the sampling status of the stream and record flow severity. An effort has been made to eliminate non-sampleable streams from integrated water quality monitoring; however, on occasion environmental conditions may prevent the sampling of streams. Streams will be classified as "sampleable" and "non-sampleable." After the stream/reach has been classified as sampleable or non-sampleable it will be further defined as: wadeable, partial, wadeable interrupted, altered, dry, or high water. Flow severity will be evaluated visually using Water Resource Division descriptions (Table 8).

Table 8. Flow severity descriptions as developed by the Water Resource Division.

Flow Severity (circle one)	**Description as defined by WRD**
Dry	No visible water in stream (typical of dry period for an ephemeral/intermittent stream
No Flow	Discrete pools of water with no apparent connecting flow (at surface)
Low	Base flow for a stream of flow within roughly 10% to 20% of base flow condition
Normal	When stream flow is considered normal (greatest time that stream is characterized by this in terms of flow quantity, level, or general range of flow during a falling or rising hydroperiod, but above base flow).
Above Normal	Bank full flow or approaching bank full (generally within upper 20% of bank full conditions)
Flood	Flow extends outside normal bank full conditions or spreads across floodplain

Sample Reach Establishment

As noted above, in 2010 the collection of benthic macroinvertebrates became part of the stream channel characteristics monitoring protocol. With the exception of Little Cottonwood Creek at CRMO, streams sampled under the stream channel protocol are the same as those sampled for integrated water quality monitoring. The method of sample reach establishment below reflects methods for stream channel reach delineation (Heitke et al. 2008, Starkey et al. 2011, Archer et al. 2012). For Little Cottonwood Creek at CRMO the macroinvertebrate sample reach will begin (bottom of reach) at the previous X-Site (see this SOP v 1.0).

The stream selection criteria as defined by PIBO specify that the preferred sample reaches have "unconstrained valley bottoms with gradients less than 3 percent and have wadeable channels with bankfull widths between 1 and 15 m." Streams with gradients over 3 percent or with bankfull widths over 15 m will still be sampled; however, the data may not be comparable to other reaches sampled by PIBO.

The location of the first sample reach will be determined by moving upstream from the park boundary until the sample crew identifies the first pool tail (Figure 6). Reach length is a function of the average bankfull width, such that as width increases so does the total reach length, with a minimum reach length of 160 m and a maximum reach length of 480 m. A minimum of 21 [stream channel] transects are sampled within each reach (Figure 42) and the top of the reach "is located at the first pool tail encountered after the 21st transect (Heitke et al. 2008)." Transects will continue to be established until a pool tail is identified or 25 transects have been sampled. A more detailed description of reach and transect establishment can be found in Heitke et al. (2008), and Kershner et al. (2004). Pools are clearly defined in the "Pools" section of the PIBO Sampling Protocol for Stream Channel Attributes (Heitke et al. 2008). Subsequent sample reaches within the park will be determined by moving upstream from a previous sample reach until another pool tail is identified.

The top and bottom of each sample reach will be permanently marked using a 1 inch by 3 inch piece of aluminum with PIBO EM scratched into them (Figures 43 and 44). The top of the reach will be labeled as TR and the bottom of the reach as BR. In subsequent years, during sample reach revisits, field crews will navigate back to the same sample reach using a reach description, photographs, topographic map and UTM coordinates. At CRMO where no stream channel characteristic monitoring occurs, the X-Site will be marked with BR.

Note that the average bankfull width of each sample reach will help determine how many sample reaches fit within the park boundary. Ideally each stream will have 6 sample reaches; however, this may not be possible due to stream segments that are too short for 6 reaches. A reach is defined as a function of the average bankfull width, such that as width increases so does the total reach length, with a minimum reach length of 160 m and a maximum reach length of 480 m. When the total stream length within a park will accommodate 6 reaches, sample locations will be selected by moving upstream from the park boundary until the sample crew identifies the first pool tail. Subsequent sample reaches within the park will be determined by moving upstream from a previous sample reach until another pool tail is identified.

In cases where total stream length will accommodate more than 6 reaches these reach locations may be identified using a GRTS spatially-balanced sample. Generation of these points is outlined in SOP #4. When the stream length within the park cannot accommodate 6 sites the UCBN will position sample locations to maximize the number of sample reaches within the park. It is important to estimate the number of reaches that will fit within a park stream segment prior to conducting field work. Table 9 shows stream length as estimated using NAIP imagery.

Table 9. Stream length within the boundaries of each park as identified using NAIP imagery. Actual sample area may differ due to varying hydrologic conditions.

Park	Stream	Maximum Length (m)
BIHO	North Fork Big Hole River	3389
CIRO	Almo Creek	4545
	Main Circle Creek	1333
	North Fork Circle Creek	1294
	South Fork Circle Creek	1066
CRMO	Little Cottonwood Creek	2762
JODA	Bridge Creek	6033
	John Day River	10694
	Rock Creek	2370
NEPE	Jim Ford Creek	1258
	Lapwai Creek	374
WHMI	Doan Creek	529
	Mill Creek	151

Additional Macroinvertebrate Sample Reaches

As mentioned in the Stream Channel Characteristics Narrative (Starkey et al. 2011), the PIBO program collects benthic macroinvertebrates as part of its assessment of stream channel characteristics. For this reason samples collected by the PIBO program will fulfill the requirements of both the stream channel and water quality protocols. In some streams, the number of sample reaches for the assessment of stream channel characteristics fall below the minimum desired samples for macroinvertebrates (6 sample reaches). In these cases, additional samples will be collected by the PIBO program (Table 9). These additional macroinvertebrate sample locations will be determined by moving upstream from a previous sample reach until another pool tail is identified. Note that additional macroinvertebrate reaches should fall above the most upstream stream-channel sample reach, and should be permanently marked as described above.

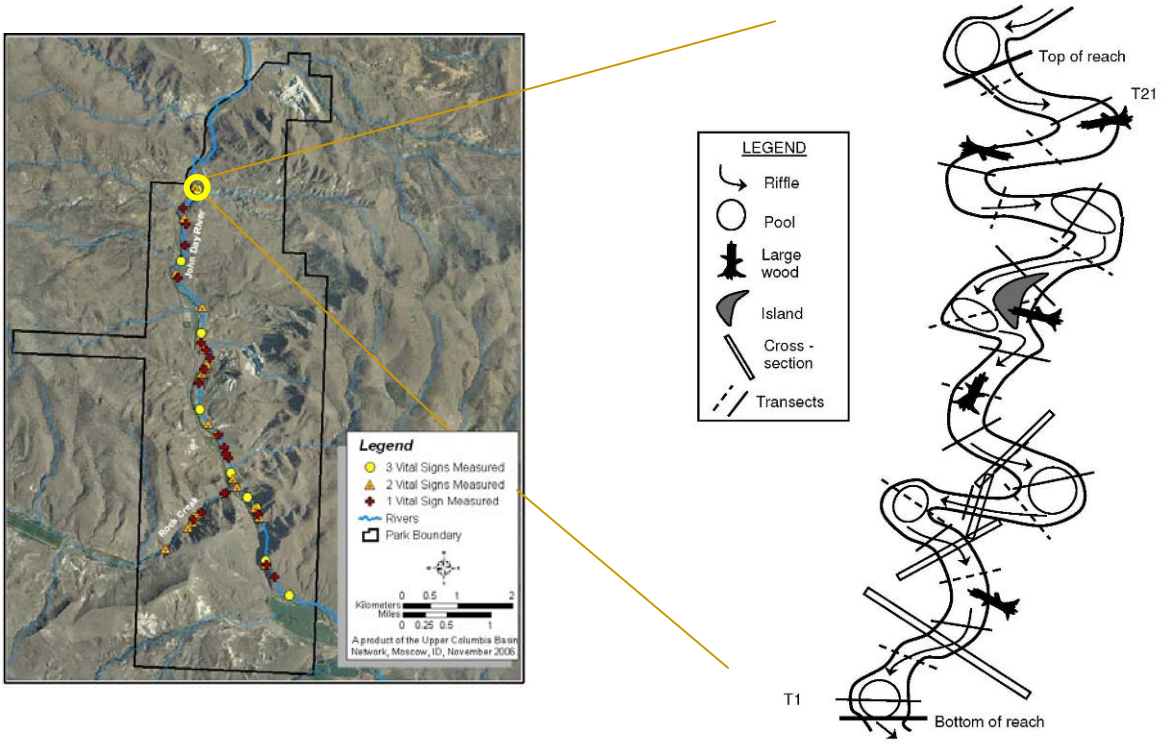


Figure 42. Example of stream channel reach selection and co-location of macroinvertebrates, and integrated riparian sampling locations on the John Day River. The reach overview indicates the position of the reach relative to pools (directly from the PIBO Sampling Protocol for Stream Channel Attributes Heitke et al. 2008).



Figure 43. Member of the PIBO field crew.



Figure 44. Close up of reach marker.

Benthic Macroinvertebrate Sample Collection

"Benthic invertebrates inhabit the sediment or live on the bottom substrates of streams. Benthic macroinvertebrate assemblages in streams reflect overall biological integrity of the benthic community. Monitoring these assemblages is useful in assessing the status of the water body and detecting trend in ecological condition. Benthic communities respond to a wide array of stressors in different ways so that it is often possible to determine the type of stress that has affected a macroinvertebrate community (e.g., Klemm et al., 1990). Because many macroinvertebrates have relatively long life cycles of a year or more and are relatively immobile, macroinvertebrate community structure is a function of present or past conditions" (Peck et al. 2001).

The following procedures are directly excerpted or modified from Effectiveness Monitoring for Streams and Riparian Areas: Sampling Protocol for Stream Channel Attributes (Archer et al. 2012).

If there is an aquatic invasive in the sample, collect an additional sample of the invasive see: Aquatic Invasive Procedures in the next section for specific instructions on creating a label and the descriptions of invasive species.

Special situations:

- Collect macroinvertebrates (bugs) in sites with beaver dams, see 'Appendix B (Archer et al. 2012): Sampling Sites with Beaver Activity' pg 89 in (Archer et al. 2012) (*simply stated we want bugs collected DS from dams)*
- Collect bugs in sites with partial flow. The rule is, if there is enough water in any part of the reach to move bugs into the net, collect them in those areas - see Appendix C (Archer et al. 2012): 'Sampling When There Isn't Flowing Water throughout the Site' pg 95 (Archer et al. 2012)

Sampling Overview:

- Collect bugs from the **first 4 riffle / runs** (fast-water habitat) upstream from your BR.
- Collect bugs at **2 locations in within each riffle / runs, for a total of 8 samples**
- Determine each bug net placement using random numbers.
    - Generate 2 pairs of random numbers 1 - 9 on the data logger.
    - The first number in each pair (multiplied by 10) represents the percent upstream along the habitat unit's length.
    - The second number in each pair represents the percent of the stream's width from river left (RL) looking downstream.
    - Repeat this process to locate the second sampling location.
    - Take samples where the length and width distances intersect (estimate by eye).
    - If it is not possible to collect bugs at one of these locations (log in the way, too deep, cannot seal bottom of net, etc.), generate an additional set of random numbers and sample the new location.
- NOTE: If no fast-water habitats occur, take the samples from shallow, slow-water habitat units.

How to collect bugs at each net placement:

1. Collect samples using a Fixed Area Design (0.72 m2) 500 µm mesh net from fast water habitats.
2. Place the kick net so the mouth if facing into the flow of water. If there is no detectable flow, orient the net to most easily facilitate washing benthic material into the net.
3. Collect invertebrates from within the sampling frame in front of the net.
    a. Work from the upstream edge of the sampling plot backward and carefully pick up and rub stones directly in front of the net to remove attached organisms.
    b. Quickly inspect each stone to make sure you have dislodged everything and then set it aside. If a rock is lodged in the stream bottom, rub it a few times concentrating on any cracks or indentations.
    c. After removing all large stones, disturb small substrates (i.e. sand or gravel) to a depth of about 10 cm by raking and stirring with your hands.
    d. Continue this process until you can see no additional organisms or organic matter being washed into the net.
    e. After completing the sample, hold the net vertically (cup down!) and rinse material into the bottom of the cup.
    f. If a substantial amount of material is in the net, empty the net into the 14-liter bucket for processing before continuing to the next sample location. Otherwise, move to the next sample location and repeat the above procedure to create a composite sample.
4. Field processing requires a 14-liter bucket, a white plastic washtub, and a 500 µm sieve. Use the bucket to decant organisms from inorganic substrates into the sieve. Use the washtub to transfer stream water into the bucket and then to visually inspect inorganic residue for heavy organisms that were not decanted.
5. Continue this process until all 8 samples have been collected and placed in the bucket. Make sure you thoroughly wash organisms from the net by vigorously pouring water down the net and into the cup. If the net has a cup at the end, remove the cup over the top of the bucket and wash it out.
6. Remove and release all vertebrates, including fish and amphibians.
7. Collect all aquatic invasive in a separate jar. See the species of interest and collection protocol on pg 108 (Archer et al. 2012) also in the section below.

Sample Processing

8. Add water to the bucket and decant invertebrates and organic matter from the sample by stirring the contents of the bucket and then pouring suspended material through the 500-µm sieve. Repeat this process until no additional material can be decanted. Transfer the material in the sieve (invertebrates and organic matter) into the 2-liter sample jar with a small spoon and then wash any remaining material in the sieve into the jar with a squirt bottle. Place the inorganic residue remaining in the bucket into the plastic washtub and cover with water to a depth of 1 cm. Inspect the gravel on the bottom of the tub for any cased caddis flies or other organisms that might remain. Remove any remaining organisms by hand and place in the sample jar.
9. Once all samples have been processed, fill the jars (no headspace) with 95% EtOH. It is very important that sufficient ethanol be used, or the organisms will not be properly preserved.

10. Immediately label the jars inside and outside (as in Figure 45). Cover the outside label with clear tape. The label inside of the jar should be on waterproof paper and include the same information as listed on the outside label. Preserve this composite sample in 1 or more sample jars depending on the amount of material collected. If there are multiple jars, label them as 1 of 2 and 2 of 2, etc. and then tape them together.
11. Replace the cap on each jar. Slowly tip the jar to a horizontal position, and then gently rotate the jar to mix the preservative. Do not invert or shake the jar. After mixing, seal each jar with plastic tape.
12. Store labeled composite samples in a container with absorbent material that is suitable for use with 95% ethanol until transport or shipment to the contracted identification laboratory.

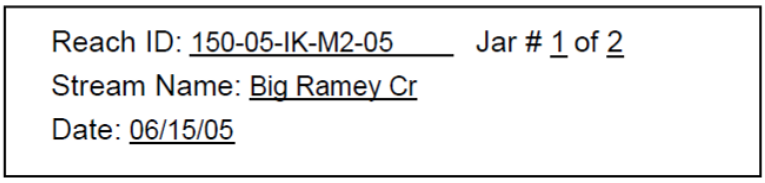


Figure 45. Example of macroinvertebrate label.

13. Record the number of bug jars on Form 1 and in the data logger (during stream channel monitoring) OR on the UCBN Field Sample Shipment Packing/Tracking Form (Appendix 5).
14. If the sample reach is only being sampled for benthic macroinvertebrates, continue with the procedure for photo documentation at each sample reach. If the sample reach is being sampled as part of the stream channel characteristics protocol, continue as outlined in Archer et al. 2012.

Aquatic Invasive Protocol

Invasive species pose a threat to biological diversity. PIBO's spatial scale offers an opportunity to detect the spread of aquatic invasive species in the Columbia and Missouri river basin. That being said PIBO crews also pose a potential threat as a vector by which aquatic invasive could be transported. According to the literature most likely mechanism for spreading invasive species is contaminated equipment. Following is our collection protocols for aquatic invasive species see gear decontamination protocol.

Collection and recording of aquatic invasive species

If you find one any of the following aquatic invasives in your bug sample or during any other sampling task such as collecting pebbles, cross sections, etc… collect an additional specimen. **Do not mix your invasive samples with your marcoinvertebrates samples**.

Store the specimen according to the PIBO protocol for macroinvertebrate samples (above), include on the labels -"invasive sample" see Figure 46, on Form 1 (Archer 2012) make a comment, mark the number of invasive samples collected in the logger. The number of bug jars on Form 1 and in the logger will not change. At the end of hitch record on the macroinvertebrate summary sheet the number of aquatic invasive samples collected at each reach. At the bunkhouse

place the specimen in a box designated by your supervisor for aquatic invasive specimens. **Do not mix your invasive samples with your marcoinvertebrates samples.**

Reach ID: 150-05-IK-M2-12 Jar # 1 of 2
Stream Name: Big Ramey Cr **INVASIVE SAMPLE**
Date: 06/15/05

Figure 46. Example of aquatic invasive label.

Aquatic Invasive Species of Focus
PIBO is focusing on the following aquatic invasive found in the river systems of our study area (Figure 47).

Crayfish: Collect all crayfish because they can be difficult to identify in the field.

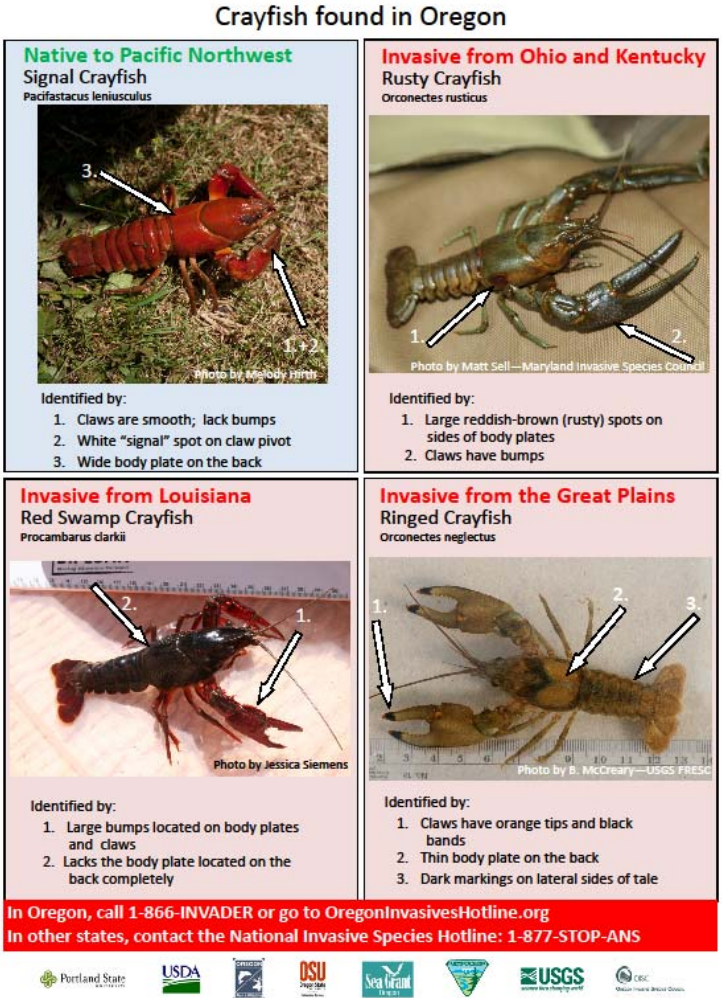


Figure 47. Descriptions of crayfish found in the PIBO study area. Collect all crayfish to eliminate incorrect identification in the field.

Didymosphenia geminata: "didymo" or "rock snot" (Figure 48)
D. geminate is a freshwater alga found in North American streams and rivers. It forms a mat of alga covering the stream bed. Collect a sample if found in the reach so the specimen can be verified in Logan.

Field descriptions according to the EPA: In the field, D. geminata can be easily confused with other stalk-forming diatom species. In particular, the visual appearance of D. geminata is very similar to its closest relatives, Cymbella mexicana and C. mexicana var. janischii. However, D. geminata is distinctive to the touch. When D. geminata stalks are pulled apart, there is some resistance and the stalks feel like wet cotton balls. Other diatom species have no such resistance, and they are slimy and slippery when the stalks are pulled apart. The field identification of D. geminata can be divided into four stages of colony growth and appearance:

1. **Initial colony growth** – As the diatom cells attach to a rocky (or other)substrate and begin to produce stalks, the colonies appear as small, circular clumps that range from 2 – 10 mm. The growths are visible to the naked eye, and are light tan to brown in color. The clumps are soft and feel like a cotton ball when they are pulled apart. They are not slimy or slippery. This stage is common during the late winter or following periods of high flow, but can occur at any time of year, depending on the region.

2. **Colony expansion** – As the colonies grow, they merge together and may cover the substrate completely. Colonies attached to plant stems form rope-like strands. As several small colonies coalesce and stalk production increases, the clumps become thicker. The colonies are frequently 1-2 cm in thickness, but may be greater. The coverage on the streambed may be patchy, or the substrate across a transect may be completely covered.

3. **Stalk proliferation** - Under periods of low flow or with favorable growth conditions, the colonies have the opportunity to form blooms. The cells produce excessive amounts of stalk many times the length of the microscopic cells. As the stalks lengthen, they form ropy strands and are white in color. Some reports describe the strands as tissue, fiberglass, toilet paper, or sheepskins.

4. **Colony senescence** – Although the cells may die, the stalks persist on the stream substrate or stranded above the stream wetted zone. The stalks may persist for 2 months, or more. Stalks may change in color as they trap fine sediment and dry. The microscopic cells may no longer be living, or present, in the aging stalk masses.



Figure 48. D. geminate colony.

Potamopyrgus antipodarum: New Zealand mudsnail (Figure 49)

Field Identification: Potamopyrgus antipodarum is usually 4 to 6 mm. Shell color vary from gray to dark brown to light brown. They have elongated shells with 7-8 whorls separate by deep groves. (http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=1008, May 2012)



Figure 49. Potamopyrgus antipodarum, New Zealand Mudsnail

Invasive Species References

A rough field guide for identification of D.geminata. Environmental Protection Agency Region 8. www.epa.gov/region8/water/didymosphenia/didymo_field_guide.pdf. Viewed 10 May 2012.

Crayfish Found In Oregon. State of Oregon Department of Fish and Wildlife. www.dfw.state.or.us/conservationstrategy/invasive_species/docs/Crayfish_Comparison.pdf. Revision October 2011. Viewed 10 May 2012.

Benson, A.J., R.M. Kipp, J. Larson, and A. Fusaro. 2012. *Potamopyrgus antipodarum*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=1008 Revision Date: 2/15/2012. Viewed 10 May 2012.

Spaulding SA and Elwell L. 2007. *Increase in nuisance blooms and geographic expansion of the freshwater diatom Didymosphenia geminata: recommendations for response*. Denver, CO: US Environmental Protection Agency Region 8. Open File Report 2007-1425. www.epa.gov/region8/water/didymosphenia/. Viewed 10 May 2012.

Photo Point Establishment and Photo Documentation

The main purpose of photo documentation in this water quality protocol is for site verification and use as a visual aid to complement future channel morphology measurements. Photo points for the integrated water quality monitoring will be established for each former X-site location (center of each EMAP reach see v1.0) or at the bottom of sample reaches (BR) as outline in the stream channel characteristics monitoring protocol (Starkey et al. 2011). The X-site will be marked with permanent stakes on both the left and right bank, and the photo point will be centered between these two permanent markers. For photo procedures related to the stream channel characteristics monitoring protocol please see Starkey et al. 2011, or Archer 2012. During stream channel monitoring a photo log will be maintained for each sample reach (Form 4) see Starkey et al. 2011.

Procedure

1. To locate a new photo point, go through the steps outlined in the Sample Reach Establishment section above. Once a new sample reach has been established proceed to the bottom of the reach and take photos as described below.

2. To relocate a historic camera station (field seasons 2008 and 2009), prepare a copy of the original photograph and include it in the field notebook along with site descriptions. A metric tape measure should be stretched between the two X-site permanent stakes. When the tape measure has been secured on both sides of the stream the center point should be found. At this point a photo label should be prepared on a white 8.5 X 11 inch piece of paper or on a dry erase board. This label should include the following information: Park abbreviation, stream name, site(reach) number, date, direction abbreviation, and center/photo point location. Appropriate direction abbreviations are: UP for upstream, DWN for downstream and L or R for left and right bank. GPS locations do not need to be taken at the photo point, although the location of center should be noted in the photo label. An example of information to be included in the photo label is given in Figure 50. For all X-Site locations there should be 4 photos: upstream, downstream, and left and right bank. Remember that the left bank is considered the bank on your left when facing downstream. The photo label should be visible in each photo, although the label should not obstruct the view of the stream and riparian vegetation.

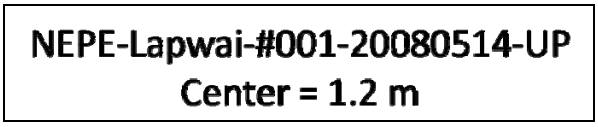


Figure 50. Example of a photo point label.

Post Sampling Activities

Transfer of Composite Samples to Identification Lab

The UCBN will contract out all sample identification to a qualified laboratory specializing in benthic macroinvertebrates. It is important to have all composite samples labeled with an external adhesive label as well as a matching internal waterproof label. Prior to the transfer of samples from the UCBN to the lab the UCBN Field Sample Shipment Packing/Tracking Form

must be completed. A completed example is shown in Figure 54 and a blank form is provided in Appendix 5 and on the DVD in the back of this document.

Decontamination of Sampling Equipment

The UCBN seeks to prevent the introduction and dispersal of aquatic invasive species to waterbodies. Therefore the UCBN requires all equipment used during macroinvertebrate sampling to be decontaminated prior to entering another waterbody. The procedures for proper equipment decontamination are given in SOP #8.

Supply List

Navigation and Recording Equipment:

- GPS unit with pre-loaded sampling location waypoints (UCBN supplied, or comparable unit)
- Weatherized field data entry forms and maps (e.g. Rite-in-the-Rain paper)
- Backup copies of data sheets
- Mechanical pencils and clip board
- Extra batteries

Sample Collection

- D-frame net 500 mμ mesh and 1 spare
- Bucket (2)
- Sieve with 500 mμ mesh (2)
- Watchmaker's forceps
- Wash bottle labeled "stream water"
- Sample jars, HDPE plastic with screw caps, 1-L capacity, suitable for use with ethanol (6 to 8 / park)
- 95% ethanol, in a proper container (2 gal)
- Rubber gloves (optional)
- Cooler for transporting ethanol and samples
- Blank labels to be put on sample jar (6 to 8 / park)
- Blank labels on waterproof paper for inside of sample jars (6 to 8 /park)
- Sample collection form / data sheet (6 to 8 / park)
- Permanent marker (2)
- Clear tape strips (1 box)
- Plastic electrical tape (2 rolls)
- Scissors (1)
- Pocket knife (1)
- Felt soled chest waders (1 per person)
- Benthic Macroinvertebrate Sample Collection SOP #7
- Field Safety Notebook
- List of site coordinates

Sample Reach Layout

- Rebar #4 (1.27 cm or ½-inch) cut into 30.48 cm (1foot) stakes (up to 3 stakes/sample reach to monument top and bottom of reach)
- Engraved plastic caps for ½-inch rebar (up to 3 caps/sample reach)
- Aluminum tags (to monument top and bottom of reach)
- Flagging pins
- Small sledge hammer
- 50 m tape measure (1)
- GRTS generated sampling points loaded in GPS unit
- Calculator

Miscellaneous Field Equipment:

- Park Radio
- Topographic map of park and aerial imagery
- First Aid Kit
- Water Jug
- Sun screen
- Field safety notebook
- Bug repellent

Example Datasheets

UCBN Macroinvertebrate Site Verification / Establishment Form
Page 1 of 3
Updated 02/13/2013

Park abbreviation:	Date (mm/dd/yyyy):	UCBN Staff (Initials):
Stream:		
Site ID:		(denote sites sampled by PIBO vs UCBN only)

Stream / River Verification Information

Stream /River Verified by (X all that apply)	GPS ☐ Local Contact Topo Map ☐ Other ☐(Describe here): Not Verified (Explain in comments)☐

GPS Coordinates of X-Site or Bottom of Reach: (Left bank facing downstream, centered over permanent marker) *WGS84 datum*	**Relative Location Error (ft /m)**

Mean Wetted Width (m): **Measurements:**		**Total Length of PIBO Reach (m):** (minimum reach length of 160 m and a maximum reach length of 480 m – see established site descriptions for PIBO reaches)
		Distance Between Transects (m):
		(based on width category- see established site descriptions for PIBO reaches)

Has the X-site or bottom of reach been permanently marked? Yes / No

Have all other transects been permanently marked on the left bank? Yes / No

Photo point location(s): (circle applicable location)

X-Site (m from left bank):
(stretch tape measure between X-site markers, the center between the markers is the photo point)

Bottom of Stream Channel Characteristics Monitoring Reach:
Note that stream reaches sampled as part of the stream channel characteristics monitoring protocol will document photos on "Form 4 Photo Log"

Photo of upstream, downstream, left and right bank? Yes / No

Site Description:

General Directions to X-Site or Bottom of Reach Marker:

Figure 51. Page 1 of the UCBN Macroinvertebrate Site Verification/Establishment Form

UCBN Site Verification / Establishment Form
Page 2 of 3

Did you sample this site?

Yes ☐	No ☐
if yes check one below	if no check one below
☐ Wadeable – Continuous water, greater than 50% wadeable	☐ Dry –Visited
☐ Partial – Sampled by wading (Explain in comments)	☐ Dry – Not visited
☐ Wadeable Interrupted – Not continuous water along each reach	☐ High water
☐ Altered – Stream/River present but not as on map	☐ Unable to reach site (Explain in comments)
	☐ Unsafe to reach site (Explain in comments)

Flow Severity (circle one)	Description as defined by WRD
Dry	No visible water in stream (typical of dry period for an ephemeral/intermittent stream
No Flow	Discrete pools of water with no apparent connecting flow (at surface)
Low	Base flow for a stream of flow within roughly 10% to 20% of base flow condition
Normal	When stream flow is considered normal (greatest time that stream is characterized by this in terms of flow quantity, level, or general range of flow during a falling or rising hydroperiod, but above base flow).
Above Normal	Bank full flow or approaching bank full (generally within upper 20% of bank full conditions)
Flood	Flow extends outside normal bank full conditions or spreads across floodplain

Personnel	
Name	Duties

General Comments:

Figure 52. Page 2 of the UCBN Macroinvertebrate Site Verification/Establishment Form.

UCBN Site Verification / Establishment Form
Page 3 of 3
Updated 02/13/2013

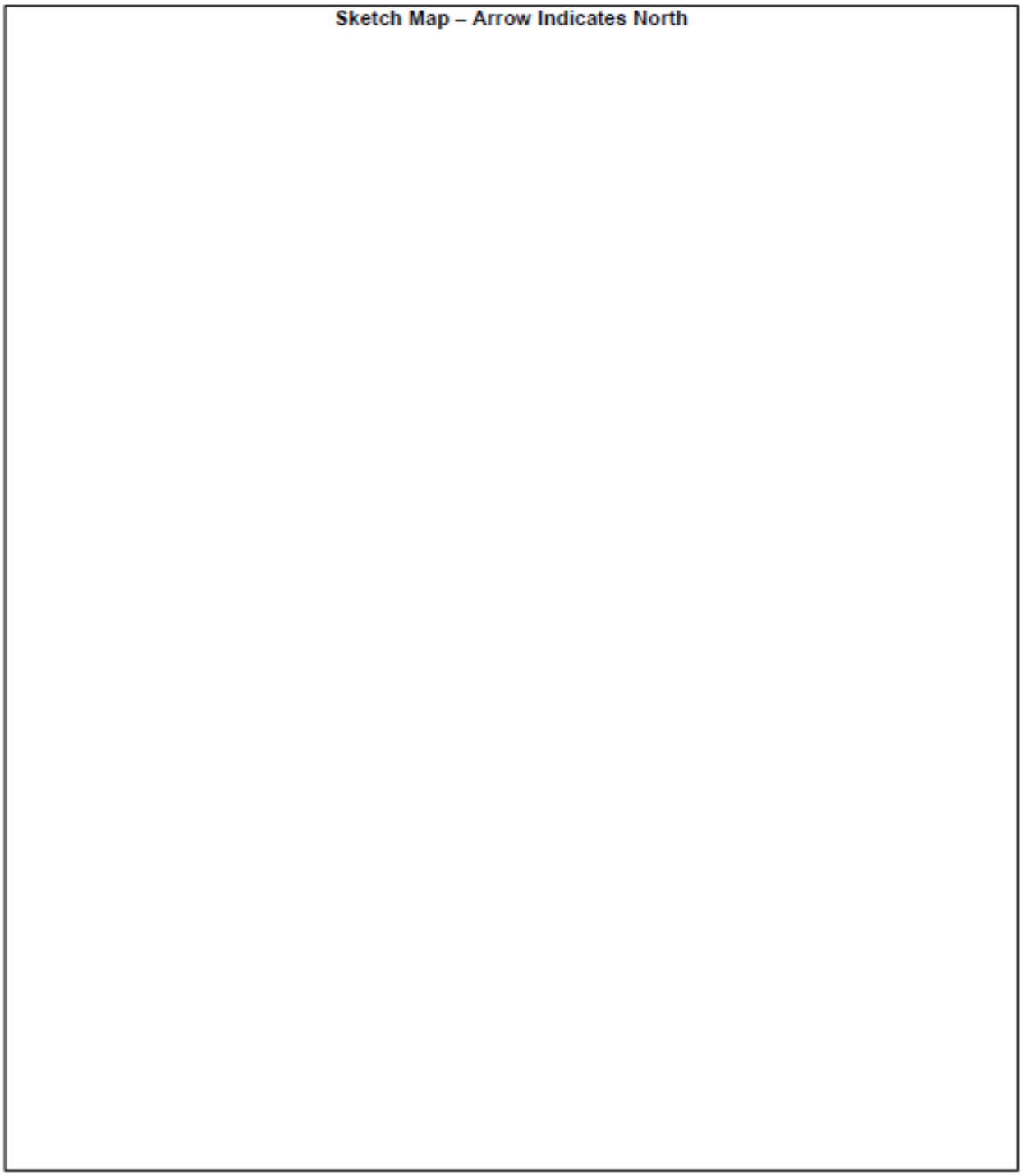


Figure 53. Page 3 of the UCBN Macroinvertebrate Site Verification/Establishment Form.

5226.1

UCBN FIELD SAMPLE SHIPMENT PACKING/TRACKING FORM

* Use separate tracking form for each park*

This form is to be returned to UCBN when samples have been received and checked for condition.

*Park abbreviation: NEPE	Sample Date (mm/dd/yyyy): 07/22, 07/23 2008	UCBN Staff (Initials): ES
Stream: Lapwai and Jim Ford Creek		

Shipping Method: Hand Delivered Tracking Number: —	UCBN Contact Name: Eric Starkey Phone: 208-885-3010 Fax: Email: estarkey@uidaho.edu	Date Sent: 8/7/08

Site ID	Sample ID	Sample Type	# of Jars	Comments (Sample condition and other comments here)
NEPE-Lapwai-001	NEPE-Lapwai-001-	Benthos - reach wide	1	5226.1-1 OK
NEPE-Jimford-001	NEPE-Jimfork-001	Benthos - reach wide	1	5226.1-2 OK
NEPE-Jimford-002	NEPE-Jimfork-002	Benthos - reach wide	1	5226.1-3 OK
NEPE-Jimford-003	NEPE-Jimford-003	Benthos - reach wide	1	5226.1_4 OK
NEPE-Jimford-004	NEPE-Jimford-004	Benthos - reach wide	1	5226.1_5 OK
NEPE-Jimford-005	NEPE-Jimford-005	Benthos - reach wide	1	5226.1-6 OK
NEPE-Jimford-006	NEPE-Jimford-006	Benthos - reach wide	1	5226.1-7 OK
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		

Lab Contact	Date Received	Condition Codes
Name: SHONDA McGRAW Phone: (208) 882-2588 (x30) Fax: (208) 883-4288 Email: smcgraw@ecanalysts.com	8/7/08 -SJMcGraw	C = Cracked Jar L = Leaking ML = Missing Label NP = Not Preserved OK = Seems fine

Return tracking form to UCBN when Lab has received and checked samples for condition

Relinquished: SJMcGraw 10/17/08

Figure 54. UCBN Field Sample Shipment Packing/Tracking Form for NEPE benthic macroinvertebrate samples.

UCBN Macroinvertebrate Site Revisit Form

Park abbreviation:	Date (mm/dd/yyyy):	UCBN Staff (Initials):
Stream:		
Site ID:		

Stream / River Revisit Information

Site Description:
(To be filled in before traveling to site)

General Directions to X-Site/Bottom of Reach Marker:
(To be filled in before traveling to site)

GPS Coordinates of X-Site or Bottom of Reach:
(To be filled in before traveling to site)
WGS84 datum

Stream /River Verified by (X all that apply) GPS ☐ Site Marker ☐ Topo Map ☐

Are all bottom and top of reach markers remaining? Yes / No

If transect markers are missing which ones were replaced: (describe)

Photo point location (m from left bank):
NOTE: photos are now taken as part of the stream channel characteristics and riparian condition monitoring protocols at BIHO, CIRO, JODA, NEPE, WHMI). Site photos should be taken as described below for sites at CRMO.

(stretch tape measure between X-site (bottom of reach) markers, the center between the markers is the photo point)

Photo of upstream, downstream, left and right bank? Yes / No

Did you sample this site?

Yes ☐
if yes check one below
- ☐ Wadeable – Continuous water, greater than 50% wadeable
- ☐ Partial – Sampled by wading (Explain in comments)
- ☐ Wadeable Interrupted – Not continuous water along each reach
- ☐ Altered – Stream/River present but not as on map

No ☐
if no check one below
- ☐ Dry –Visited
- ☐ Dry – Not visited
- ☐ High water
- ☐ Unable to reach site (Explain in comments)
- ☐ Unsafe to reach site (Explain in comments)

Updated on 02/11/2013

Figure 55. UCBN Macroinvertebrate Site Revisit Form page 1.

UCBN Macroinvertebrate Site Revisit Form

Flow Severity (circle one)	Description as defined by WRD
Dry	No visible water in stream (typical of dry period for an ephemeral/intermittent stream
No Flow	Discrete pools of water with no apparent connecting flow (at surface)
Low	Base flow for a stream of flow within roughly 10% to 20% of base flow condition
Normal	When stream flow is considered normal (greatest time that stream is characterized by this in terms of flow quantity, level, or general range of flow during a falling or rising hydroperiod, but above base flow).
Above Normal	Bank full flow or approaching bank full (generally within upper 20% of bank full conditions)
Flood	Flow extends outside normal bank full conditions or spreads across floodplain

General Comments:

Sketch Map – Arrow Indicates North

Personnel	
Name	**Duties**

Updated on 02/11/2013

Figure 56. UCBN Macroinvertebrate Site Revisit Form page 2.

Literature Cited

Archer, E. K., R. A. Scully, R. Henderson, B. B. Roper, and J. D. Heitke. 2012. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp.

Hayslip, Gretchen, editor. 2007. Methods for the collection and analysis of benthic macroinvertebrate assemblages in wadeable streams of the Pacific Northwest. Pacific Northwest Aquatic Monitoring Partnership, Cook, WA.

Heitke, J. D., E. J. Archer, D.D Dugaw, B. A. Bouwes, E. A. Archer, R. C. Henderson, and J. L. Kershner. 2008. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp.

Kershner, J. L., E. K. Archer, M. C. Coles-Ritchie, E. R. Cowley, R. C. Henderson, K. Kratz, C. M. Quimby, D. L. Turner, D. L. Ulmer, and M. R. Vinson. 2004. Guide to effective monitoring of aquatic and riparian resources. General Technical Report RMRS-GTR-121. USDA Forest Service, Rocky Mountain Research Station. Fort Collins, CO.

Klemm, D. J., P. A. Lewis, F. Fulk, J. M. Lazorchak. 1990. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. EPA/600/4-90/030. U.S. Environmental Protection Agency, Cincinnati, OH.

Montana Department of Environmental Quality (DEQ). 2006. Sample Collection, Sorting, and Taxonomic Identification of Benthic Macroinvertebrates. Water Quality Planning Bureau. Standard Operation Procedure (WQPBWQM-009).

Peck, D. V., A. T. Herlihy, B. H. Hill, R. M. Hughes, P. R. Kaufmann, D. Klemm, J. M. Lazorchak, F. H. McCormick, S. A. Peterson, P. L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, DC.

Peck, D.V., J.M. Lazorchak, and D.J. Klemm (editors). 2001. Unpublished draft. Environmental Monitoring and Assessment Program -Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. EPA/XXX/X-XX/XXXX. U.S. Environmental Protection Agency, Washington, D.C.

Starkey, E. N., T. J. Rodhouse, G. H. Dicus, L. K. Garrett, K. M. Irvine, and E. K. Archer. 2011. Upper Columbia Basin Network stream channel characteristics monitoring protocol: Standard operating procedures version 1.0 (Appendix A to Narrative Version 1.0). Natural Resource Report NPS/UCBN/NRR—2011/340.A. National Park Service, Fort Collins, CO.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 8: Decontamination of Equipment for Aquatic Invasive Species

Version 1.0, January 2009

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Note: This SOP describes the step-by-step procedures for decontamination of all water quality monitoring equipment. Decontamination will help prevent the spread of aquatic invasive species from one sample location to another. Procedures have been modified from the Great Lakes Network Large Rivers Water Quality Monitoring Protocol (2005). This SOP does not address terrestrial invasive species that may be encountered in the riparian areas.

Suggested Reading

Elias, J. 2005. Standard operating procedure #5, Decontamination of equipment to remove exotic species. *in* Magdalene S., D.R. Engstrom, and J. Elias. 2007. Large rivers water quality monitoring protocol, Version 1.0. National Park Service, Great Lakes Network, Ashland, Wisconsin.

Idaho Invasive Species Council Technical Committee. 2007. Idaho Aquatic Nuisance Species Plan. http://www.anstaskforce.gov/State%20Plans/Idaho_ANS_Plan_2007.pdf

Meacham, P. 2001. Washington State Aquatic Nuisance Species Management Plan. http://wdfw.wa.gov/fish/nuisxsum.htm

Montana Aquatic Nuisance Species (ANS) Technical Committee. 2002. Montana Aquatic Nuisance Species Management Plan. http://water.montana.edu/pdfs/MTaliens-FINAL_PLAN.pdf

Overview

Aquatic invasive species (AIS) are an issue of concern throughout the United States and within the Upper Columbia Basin Network. The UCBN will be monitoring water quality in diverse watersheds across 4 states; therefore, it is important to take a pro-active approach to preventing the spread of AIS between waterbodies.

Aquatic invasive species threaten aquatic ecosystems by disrupting community composition, outcompeting native species, and altering food chains. The ecologic and economic damages caused by the most serious aquatic invasive species top $8.9 billion/year and this cost continues to rise (Pimentel 2003). The states of Idaho, Montana, Oregon, and Washington all have distinct aquatic invasive species issues which are outlined in their respective Aquatic Nuisance Species Management Plan. These plans are listed under the Suggested Readings heading on the first page of this SOP. The Water Quality Project Leader is responsible for reviewing each state's Aquatic Nuisance Species Management Plan and educating the field crew about threats in each region. This SOP identifies the most likely AIS threats and addresses general decontamination procedures. In the future, if an explicit species threat develops, more specific procedures will be implemented.

Existing and Potential Aquatic Invasive Species Threats

Idaho

Idaho has fewer known invasive species than many other western states, yet it faces a serious threat of invasion due to interstate travel from one waterbody to another. The primary concern for invasive introduction comes from recreational use by anglers and boaters who frequent multiple waterbodies. Another, more specific source for invasion is barge traffic on the Snake River, near the port of Lewiston. The port of Lewiston is 465 miles upstream from the Pacific Ocean, which makes it the farthest inland sea port on the west coast. As a result, traffic entering this area has the potential to bring invasive species from miles downstream. Other threats to Idaho state waters include fish culture and aquarists.

Table 10 lists high priority aquatic nuisance species currently known to be in the state of Idaho and Table 11 lists the high priority aquatic nuisance species not currently found in Idaho. These lists serve as a general guide for AIS that may be encountered during work in Idaho but may not be all inclusive. For this reason the Water Quality Project Lead should be aware of changes in AIS status in and around UCBN parks.

Parks affected in Idaho include: City of Rocks National Reserve (CIRO), Craters of the Moon National Monument and Preserve (CRMO), Hagerman Fossil Beds National Monument (HAFO), and Nez Perce National Historical Park (NEPE).

Table 10. High priority aquatic nuisance species **known to be in Idaho** (Idaho Invasive Species Council Technical Committee 2007).

Scientific Name	Common Name
Animals	
Corbicula fluminea	Asian clam
Potamopyrgus antipodarum	New Zealand mudsnail
Myxobolus cerebralis	Whirling disease
Plants	
Potamogeton crispus	Curly leaf pondweed
Myriophyllum spicatum	Eurasian watermilfoil
Myriophyllum aquaticum	Parrot feather milfoil
Lythrum salicaria	Purple loosestrife
Tamaricaceae spp.	Saltcedar
Iris pseudacorus	Yellow flag iris

Table 11. High priority aquatic nuisance species **not currently found in the state of Idaho**, but likely to have a detrimental effect if introduced (Idaho Invasive Species Council Technical Committee 2007).

Scientific Name	Common Name
Animals	
Rhinogobius brunneus	Amur goby
Mylopharyngodon piceus, Hypophthalmichthys molitrix, H.nobilis, Ctenopharyngodon idella	Asian Carp (black, silver, bighead, grass (fertile variety))
Gymnocephalus cernuus	Eurasian ruffe
Myocastor coypus	Nutria
Neogobius melanostomus	Round goby
Orconectes rusticus	Rusty crayfish
Channa argus, C. maculata, C. marulius, C. micropeltes	Snakehead fish, sp.
Bythotrephes cederstroemii / Bythotrephes longimanus	Spiney/fishhook water flea
	Viral hemorrhagic septicemia
Dreissena polymorpha / Dreissena rostriformis bugensis	Zebra mussel/Quagga mussel
Plants	
Egeria sp.	Brazilian elodea
Cabomba sp.	Carolina fanwort
Hydrocharis morsus-ranae	Frog's bit / European frogbit
Hydrilla verticillata	Hydrilla
Eichhornia sp.	Water hyacinth
Trapa natans	Water-chestnut

Montana

In Montana the primary vector for introduction and transport of aquatic invasive species (AIS) is recreational anglers and boat users. Another potential source of introductions are fish culture and aquarists. In addition, water diversions increase the connectivity of waterbodies and raise the likelihood of spreading AIS once they are established. Montana classifies AIS threats into 4 distinct classes depending on if they are currently established within the state and the degree to which management actions can control AIS. Tables 12 and 13 list and explain the classification of AIS. These lists serve as a general guide for AIS that may be encountered during work in Montana but may not be all inclusive. For this reason, the Water Quality Project Lead should be aware of changes in AIS status in and around UCBN parks.

Parks affected in Montana include Big Hole National Battlefield (BIHO).

Table 12. Priority Class 2* and Class 4** AIS for Montana

Scientific Name	Common Name	Class
Animals		
Rana catesbeiana	Bullfrog	4
Aeromonas salmonicida	Furunculosis (Bacteria)	4
Potamopyrgus antipodarum	New Zealand mudsnail	2
Oncorhynchus mykiss, Salvelinus fontinalis, Salvelinus namaycush, Salmo trutta, Micropterus spp., Sander vitreus, Esox lucius, etc.	Non-indigenous fishes (i.e., rainbow, brook, lake and brown trout, bass, walleye, Northern pike, and other warmwater fish species)	4
Myxobolus cerebralis	Whirling disease	2
Plants		
Potamogeton crispus	Curly leaf pondweed	4
Butomus umbellatus	Flowering rush	4
Lythrum salicaria	Purple loosestrife	4
Tamaricaceae spp.	Saltcedar	4
Iris pseudacorus	Yellow flag iris	4

***** Priority Class 2 species are **present and established in Montana and have the potential to spread in Montana** and there are limited or no known management strategies for these species (Montana Aquatic Nuisance Species (ANS) Technical Committee 2002).

** Priority Class 4 species are **present and have the potential to spread in Montana,** but there are management strategies available for these species (Montana Aquatic Nuisance Species (ANS) Technical Committee 2002).

Table 13. Priority Class 1* and Class 3** AIS for Montana.

Scientific Name	Common Name	Class
Animals		
Mylopharyngodon piceus, Hypophthalmichthys molitrix, H.nobilis, Ctenopharyngodon idella	Asian Carp (black, silver, bighead, grass (fertile variety))	1
Gymnocephalus cernuus	Eurasian ruffe	1
None Specified	Hematopoietic Necrosis (IHN)Virus	1
None Specified	Heterosporosis (Parasite)	1
Myocastor coypus	Nutria	1
Neogobius melanostomus	Round goby	1
Orconectes rusticus	Rusty crayfish	1
Bythotrephes cederstroemii	Spiney water flea	1
Tinca tinca	Tench	1
Stizostedion lucioperca	Zander	1
Dreissena polymorpha	Zebra mussel	1
Bothriocephalus acheilognathi	Asian tapeworm	3
Plants		
Egeria sp.	Brazilian elodea	1
Myriophyllum spicatum	Eurasian watermilfoil	3
Hydrilla verticillata	Hydrilla	1

*Priority Class 1 species are **not known to be present in Montana, but have a high potential to invade** and there are limited or no known management strategies for these species (Montana Aquatic Nuisance Species (ANS) Technical Committee 2002).

Priority Class 3 species are **not known to be established in Montana and have a high potential for invasion and appropriate management techniques are available (Montana Aquatic Nuisance Species (ANS) Technical Committee 2002).

Oregon

The Oregon Aquatic Nuisance Species Plan does not designate specific threats to aquatic resources but rather lists all non-indigenous species existing in Oregon, Oregon species introduced outside of their historic range, and non-indigenous species prohibited by state programs. Many of the AIS listed by Idaho's Aquatic Nuisance Species Plan are the same as those listed as non-indigenous by Oregon. For this reason the UCBN will operate on the premise that threats to freshwater are similar to those found in Idaho. These threats can be found in Tables 10 and 11 under the Idaho section of this SOP.

Parks affected in Oregon include: John Day Fossil Beds National Monument (JODA)

Washington

The primary mechanisms of AIS introduction in the state of Washington are: aquarium trade, biological control, transport via vessel fouling and ballast water discharge, recreational boating and fishing, research activities, and movement of nonnative species through channels, canals and locks. Washington classifies AIS threats into 4 distinct classes depending on if they are currently established within the state and the degree to which management actions can control AIS. Tables 14 and 15 list and explain the classification of AIS. These lists serve as a general guide for AIS that may be encountered during work in Washington but may not be all inclusive. For this reason, the Water Quality Project Lead should be aware of changes in AIS status in and around UCBN parks.

Parks affected in Washington include: Whitman Mission National Historical Site (WHMI), and Lake Roosevelt National Recreational Area (LARO).

Table 14. Includes freshwater class1* and class 4** aquatic invasive species.

Scientific Name	Common Name	Class
Animals		
Gymnocephalus cernuus	Eurasian ruffe	1
Eriocheir spp.	Mitten crab	1
Neogobius melanostomus	Round goby	1
Bythotrephes cederstroemi	Spiny water flea	1
Dreissena polymorpha	Zebra mussel	1
Plants		
Salvinia molesta	Giant salvinia	4
Hydrilla verticillata	Hydrilla	1
Eichornia crassipes	Water hyacinth	1
Trapa natans	Water-chestnut	1

*Management Class 1 - Management activities focus on preventing the introduction and eradicating pioneering populations of nonnative plant and animal species that currently **are not present in the state, or that have limited populations within state waters**.

Management Class 4 - This group consists of nonnative species that **are not present in Washington for which we lack adequate information to understand their potential to be invasive,

or their interaction and effects on native species. These species warrant further evaluation and research to ascertain the potential for impact and control. Until information is available that would place them in management class two or three, they are treated as management class 1 species.

Table 15. Freshwater class 2* and 3* aquatic invasive species.

Scientific Name	Common Name	Class
Animals		
Procambarus clarkii	Louisiana red swamp crayfish	2
Potamopyrgus antipodarum	New Zealand mudsnail	2
Corbicula fluminea	Asian clam	3
	Nonnative amphibians	3
	Nonnative fish	3
Plants		
Egeria densa	Brazilian elodea	2
Phragmites australis	Common reed	2
Myriophyllum spicatum	Eurasian watermilfoil	2
Myriophyllum aquaticum	Parrot feather milfoil	2
Lythrum salicaria	Purple loosestrife	2
Tamarix ramosissima	Saltcedar	2

*Management Class 2 - Management activities focus on mitigating the impact, controlling population size and preventing dispersal to other water bodies of nonnative plant or animal species that are present and established in Washington. This class **includes nonnative species approved for import and managed under other regulations** - such as aquacultural species.

** Management Class 3 **- Includes nonnative species that are established throughout Washington and that have an impact, but for which there are no available or appropriate management techniques.** These species warrant further evaluation and research to ascertain the potential for impact and control, and to prevent establishment in new waterbodies.

Procedures

Before any waterbody can be entered for sampling purposes all equipment must be decontaminated to remove exotic species. Decontamination should be conducted as soon as a waterbody has been sampled, and before sampling occurs in another waterbody. These procedures are to be followed in all waters, not only those with current AIS issues. To prevent any introductions/dispersal of aquatic invasive species (AIS) all UCBN waterbodies are assumed to be infested.

The following procedures have been directly taken or modified from the Great Lakes Network Standard operating procedure #5, Decontamination of Equipment to Remove Exotic Species (Elias 2005).

1.0 Procedure at non-remote locations, when tap water is available

1.1 When finished at a segment of river that is known or suspected to be infested with exotic species:

- remove or rinse mud, plant material, mussels, and other visible organic material from boat/canoe, paddles/oars, waders, boots, and all sampling equipment;
- soak all nets, waders, and boots in a 2% Sparquat 256 solution for 10 minutes or spray a 10% Sparquat 256 solution on equipment and let stand for 5 minutes; Sparquat is preferred over bleach since it is less harsh on nets and wader material.
- thoroughly rinse disinfectant solution off sampling equipment;
- let equipment dry for 10 days. If it is not possible to let equipment dry, follow the procedure outlined in section 1.2.

1.2 Before entering a new segment of the river that is not known to contain exotic species:

- on vegetated land, use hose with spray nozzle and scrub brush to rinse and scrub with tap water and scrub-brush all sampling equipment, boat/canoe, paddles/oars, boots; discard water on land, away from the bank of the river, avoiding impervious surfaces and slopes where rinse water might run directly into the river;
- use a bottle or toilet brush on a rope to clean the inside of the continuous water quality monitor housing;
- pay particular attention to ropes, cracks, and crevices in equipment, and rinse well;
- visually inspect all gear to verify that all equipment and gear has been cleaned and rinsed.

2.0 Procedure at remote locations, when tap water is not available

2.1 When finished at a segment of river that is known or suspected to be infested with exotic species:

- remove and rinse mud, plant material, mussels, and other visible organic material; boat/canoe, paddles/oars, waders, boots, and all sampling equipment;
- run hand up and down ropes attached to all equipment and anchor to dislodge mud, plant material, and organisms;
- pay particular attention to cracks and crevices in equipment when rinsing;
- visually inspect all gear to verify that all equipment and gear has been cleaned and rinsed;
- let equipment dry for 10 days. If it is not possible to let equipment dry, follow the procedure outlined in section 2.2.

2.2 Before entering a new segment of the river that is not known to contain exotic species:

- use a clean and dry container, such as a bucket to collect river water;
- on vegetated land away from the bank of the river, rinse and scrub with (clean) scrub-brush all sampling equipment, boat/canoe, paddles/oars, boots, etc. Avoid rinsing on impervious surfaces or slopes where rinse water might run directly into the river;
- use a bottle or toilet brush on a rope to clean the inside of the continuous water quality monitor housing;
- pay particular attention to ropes, cracks, and crevices in equipment, and rinse well;
- visually inspect all gear to verify that all equipment and gear has been cleaned and rinsed.

3.0 Regardless of Remoteness

- When possible, avoid using boats and other equipment on both infested and un-infested waters. Designate a set of equipment for both types of waters.
- Always begin sampling with waterbodies not known to harbor exotic species; sample waterbodies known or suspected to contain exotic species last.
- Thoroughly clean or disinfect all equipment between use in infested and un-infested waters.
- Use a 2-10% Sparquat 256 or bleach solution as a disinfectant. Sparquat is preferred as it is less harsh on equipment. Sparquat is available as a commercial cleaner manufactured by the Spartan Chemical Company, Inc.
- When possible, allow boat/canoe and paddles/oars to dry for five days and all other sampling equipment such as nets, waders, and boots to dry for 10 days after sampling a water body known to be infested with AIS.

Literature Cited

Elias, J. 2005. Standard operating procedure #5, Decontamination of equipment to remove exotic species. *in* Magdalene S., D.R. Engstrom, and J. Elias. 2007. Large rivers water quality monitoring protocol, Version 1.0. National Park Service, Great Lakes Network, Ashland, Wisconsin.

Idaho Invasive Species Council Technical Committee. 2007. Idaho Aquatic Nuisance Species Plan. http://www.anstaskforce.gov/State%20Plans/Idaho_ANS_Plan_2007.pdf

Meacham, P. 2001. Washington State Aquatic Nuisance Species Management Plan. http://wdfw.wa.gov/fish/nuisxsum.htm

Montana Aquatic Nuisance Species (ANS) Technical Committee. 2002. Montana Aquatic Nuisance Species Management Plan. http://water.montana.edu/pdfs/MTaliens-FINAL_PLAN.pdf

Pimentel, D., 2003. Economic and Ecological Costs Associated with Aquatic Invasive Species. Proceedings of the Aquatic Invaders of the Delaware Estuary Symposium, Malvern, Pennsylvania, May 20, 2003, pp. 3-5.

Standard Operating Procedure (SOP) 9: Continuous Water Quality Record Processing

Version 1.1, June 2011

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	June 2011	Eric Starkey	Updates to site inspection summary worksheet section. These changes reflect the use of a field meter during the assessment of sensor fouling. Updates to workflow and AQUARIUS toolbox arrangement.	New methods insure better evaluation of data quality and record maintenance within AQUARIUS software.	1.1

Note: This SOP describes the step-by-step procedures for processing continuous water quality monitoring log files (records) after they have been successfully downloaded from the multiprobe and transferred to the UCBN with the accompanying Calibration/Maintenance Log. The UCBN has successfully used Aquarius Time-Series Software to meet its water quality record processing needs but its use does not constitute an endorsement by the U.S. Government.

Required Reading

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Overview

This SOP is meant to be a guide for processing records (log files) from continuous water quality monitoring stations within the UCBN. Currently all water quality monitoring in the UCBN is conducted with Hach MS5 Hydrolabs also referred to as multiprobes. It is important that all multiprobe calibration and maintenance procedures be followed from SOP #6. Processing of log files that have been improperly configured or downloaded from incorrectly serviced multiprobes will not be covered by this SOP. In addition, it is not advisable to process water quality log files without knowledge of monitoring locations and general knowledge of water chemistry daily cycles and parameter relationships. At a minimum it is required that personnel read the Record Computation section of Wagner et al. 2006 (pages 22-35) prior to processing water quality records. This guidance document provides an excellent introduction to data corrections for fouling and calibration drift. It should be noted that the information contained in Wagner 2006 focuses on the use of ADAPS which is the program the USGS uses for record computation.

In June 2008 the UCBN worked closely with the National Park Service-Water Resource Division to purchase and pilot test Aquarius Time-Series Software produced by the Aquatic Informatics Company in Vancouver, British Columbia. During pilot testing this software greatly streamlined record processing and allowed the UCBN to track data corrections and deletions. The UCBN anticipates continued use of this software; as a result, this SOP focuses on the procedures necessary to process records in Aquarius Time Series Software. It should be noted that Aquarius time series software may not directly meet every need but the data can be easily exported for subsequent analysis in other programs. The UCBN has successfully used Aquarius to meet its water quality record processing needs but its use does not constitute an endorsement by the U.S. Government.

Pre-Processing Requirements

After UCBN personnel have completed a multiprobe site revisit the Water Quality Project Lead should have the following prior to record processing:

- Access to discharge information from the nearest United States Geological Survey (USGS) gage.
- Access to weather information from the nearest National Weather Service station.
- Log file from the multiprobe (Comma delimited text file) with appropriate naming convention and parameters (see SOP #6).
- Completed UCBN Calibration and Maintenance Log for the same deployment period as the log file (See example at the end of this SOP).
- UCBN Site Inspection Summary Form in MS Excel (on the DVD in the back of this document.)
- Aquarius Time Series Software– standard version, Release 2.7 or newer.

General Workflow

1. Enter data into Site Inspection Summary Worksheet
2. Import log file to Aquarius Time Series Software
3. Signal trimming
4. Threshold flagging
5. Data correction/deletion of erroneous data

6. Data grading
7. Signal joining
8. Graphing/Descriptive Statistics
9. Export

Site Inspection Summary Worksheet

The site inspection summary worksheet was developed to aid in the assessment of data quality and corrections for calibration drift and fouling. The UCBN is using data correction and grading criteria established and used by the United States Geological Survey (USGS) (Wagner et al. 2006). The site inspection summary worksheet follows the design of the USGS - QW Ultimate Worksheet v.2.51.

Procedure

1. User Input

The off-white cells within the site inspection summary will require user input (Figure 57). All of these values have been recorded on the UCBN Calibration and Maintenance Log for the given deployment period. It is important to note that all other cells have been locked to prevent accidental changes. The water quality project lead should be notified if changes are required. Currently, the UCBN deploys a field meter during the assessment of sensor fouling. Readings from the field meter allow for the subtraction of changes in environmental conditions between measures taken before and after sensors are cleaned. If no field meter is used, cells within the site inspection summary worksheet that perform calculations with field meter data should be edited. The specific cells that require changes are marked in the spreadsheet with comments (cells marked with a red triangle). When all data has been entered, the user should double check the fouling and drift error as described below.

UCBN Site Inspection Summary

Version 2.5 03/30/2010

*Field meter readings measure environmental change during the site visit. Corresponding cells should only be used if a field meter is available during site revisits. If no field meter is used see comments in D13, I13, D19, and K15. Data grades and correction criteria are based on Wagner et al. 2006.

Requires User Input
Automatically Calculated
No Input Required
Correction Condition
Data Rating
For DO% Saturation Correction

Park Abbreviation	JODA	Stream	John Day River	Date of Revisit	11/4/2010
Deployment Start Date	9/29/2010	Deployment End Date	11/4/2010	Field Meter (Y/N)	Y
Julian date	2010272		2010308		

Multiprobe Fouling

	Before Cleaning		After Cleaning					
	Time	8:22	Time	8:40				
Parameter	Recorded/Live Monitor Reading	Field Meter Reading*	Recorded/Live Monitor Reading	Field Meter Reading*	Fouling Correction (without field meter)	% Fouling Correction Where Needed	Fouling Correction (with field meter)*	Fouling PD, aka. Systematic Error/Bias
Temp (°C)	9.1	9.19	9.03	9.13	-0.07		-0.01	-0.769230769
SC (µS/cm)	261.4	272	265.2	270	3.8	1.453710788	5.8	1.453710788
DO (mg/L)	10.2	9.87	10.31	10.22	0.11	3.259024311	-0.24	1.078431373
pH (units)	8.19	8.21	8.29	8.25	0.1		0.06	1.221001221
Turbidity (NTU)	2974	N/A	4	N/A	-2970	-99.86550101	no field meter	-99.86550101
Dissolved Oxygen Saturation Table Reading (mg/L)	10.74	10.72	10.76	10.73				

Figure 57. Site Inspection Summary Worksheet v2.5 -fouling input. Note the Fouling Correction field in blue.

2. Assessment of Fouling Error

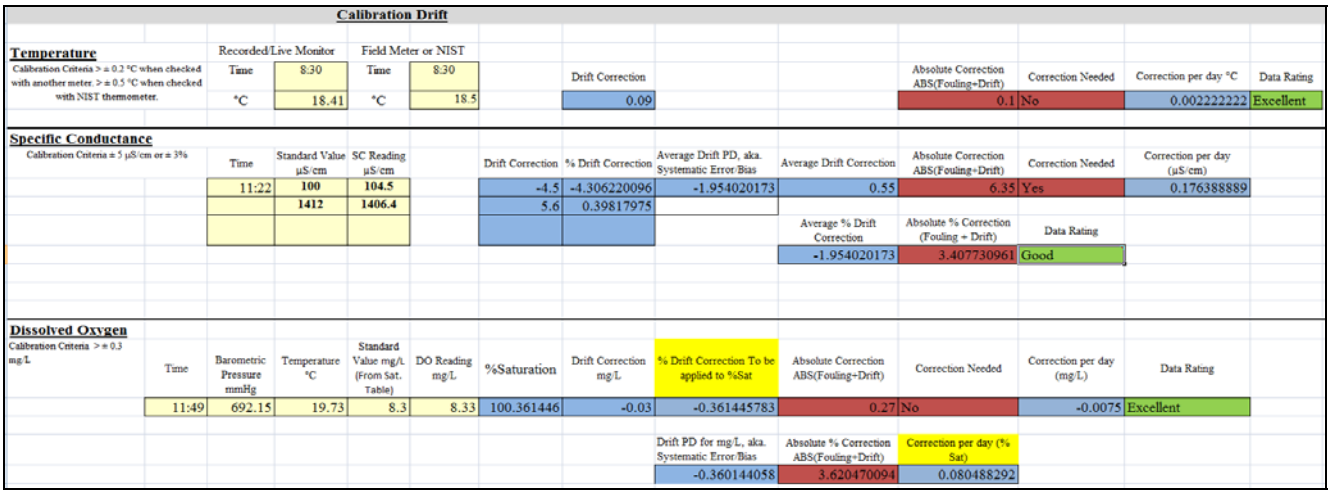
Fouling error is the error in measurements caused by biological growth and/or sediments on the sensors. "The observed difference between the initial sensor reading and the cleaned-sensor readings (in stream water) is a result of fouling" (Wagner et al. 2006). After all the cells have been filled in with the appropriate data, the amount of fouling is indicated in cells colored blue (Figure 57). It is important to note that these values will only be applied as a correction if the absolute value of fouling and drift error exceeds the calibration criteria listed in Table 16. Double check all fouling correction values to make sure they reflect the original Calibration and Maintenance Log. It is especially important to check the degree of fouling reported on each sensor (page 3 of multiprobe calibration/maintenance log sheet). If very little fouling was indicated yet fouling error is high, it may indicate that the sensor is faulty. The calibration drift error will also reflect problematic sensors. Note that the "Field Meter Reading" cells will remain blank unless a field meter is used to evaluate changes in environmental conditions during fouling assessment.

Table 16. Criteria for water-quality data corrections, modified from Wagner et al. 2006.

Parameter	**Data Correction Criteria** (Apply correction when the sum of the absolute values for fouling and calibration drift error exceeds the value listed.)
Temperature	± 0.2 °C when checked with another meter ± 0.5 °C when checked with NIST thermometer
Specific Conductance	± 5 µS/cm or ± 3% of the measured value, whichever is greater
Dissolved Oxygen	± 0.3 mg/L
pH	0.2 pH units
Turbidity	± 0.5 turbidity units or ±5% of the measured value, whichever is greater

3. Assessment of Calibration Drift Error

Calibration drift error is the error in measurements caused by changes in the sensors due to electronic drift over time. "The difference between the cleaned-sensor readings in calibration standard solutions and the expected reading in these solutions is the result of sensor calibration drift error" (Wagner et al. 2006). After all the cells have been filled in with the appropriate data, the degree of calibration drift is indicated in cells colored blue. The "Average Drift Correction" field is important since it will be used to determine if a correction needs to be applied (Figure 58). **Note that the UCBN will be applying a correction if the combined absolute value of the fouling and the average drift correction error exceed the calibration criteria.** It is also important to quickly check the "Absolute Correction" field against the data correction criteria given in Table 16. If the summary worksheet indicates it is necessary, corrections will be applied within the Aquarius software package.



Calibration Drift

Temperature

Calibration Criteria > ± 0.2 °C when checked with another meter. > ± 0.5 °C when checked with NIST thermometer.

	Recorded/Live Monitor		Field Meter or NIST		Drift Correction	Absolute Correction ABS(Fouling+Drift)	Correction Needed	Correction per day °C	Data Rating
Time	8:30		Time	8:30					
°C	18.41		°C	18.5	0.09	0.1	No	0.002222222	Excellent

Specific Conductance

Calibration Criteria ± 5 µS/cm or ± 3%

Time	Standard Value µS/cm	SC Reading µS/cm	Drift Correction	% Drift Correction	Average Drift PD, aka. Systematic Error/Bias	Average Drift Correction	Absolute Correction ABS(Fouling+Drift)	Correction Needed	Correction per day (µS/cm)
11:22	100	104.5	-4.5	-4.306220096	-1.954020173	0.55	6.35	Yes	0.176388889
	1412	1406.4	5.6	0.39817975					

Average % Drift Correction	Absolute % Correction (Fouling + Drift)	Data Rating
-1.954020173	3.407730961	Good

Dissolved Oxygen

Calibration Criteria > ± 0.3 mg/L

Time	Barometric Pressure mmHg	Temperature °C	Standard Value mg/L (From Sat. Table)	DO Reading mg/L	%Saturation	Drift Correction mg/L	% Drift Correction To be applied to %Sat	Absolute Correction ABS(Fouling+Drift)	Correction Needed	Correction per day (mg/L)	Data Rating
11:49	692.15	19.73	8.3	8.33	100.361446	-0.03	-0.361445783	0.27	No	-0.0075	Excellent

Drift PD for mg/L, aka. Systematic Error/Bias	Absolute % Correction ABS(Fouling+Drift)	Correction per day (% Sat)
-0.360144058	3.620470094	0.080488292

Figure 58. Site Inspection Summary worksheet-v2.5: calibration drift assessment for Temp., Sp. Cond., and D.O. Note the Average Drift Correction, Absolute Correction and the Correction Needed fields highlighted in red.

4. Data Grading

After all cells have been populated with data from the Calibration and Maintenance Log, data ratings/grades will be generated in the green boxes (Figure 58). The ratings in these cells are determined using the absolute correction mentioned in the previous section and a standard set of accuracy ratings developed by the USGS (Table 17).

It is important to review data grades relative to notes on the Calibration and Maintenance Log Sheet and fouling error. This is an important step because these ratings, on occasion, may not accurately portray the quality of data due to specific field conditions. For example, if actual water temperature changes during the fouling error check procedure, it might cause an artificially high fouling error. As a result, the data rating may be reported as "poor" when, in fact, the rating should have been "good." This data rating may need to be adjusted based on professional judgment. This simple example highlights several important points. First, it shows the importance of a field meter or at a minimum, a NIST thermometer to track actual conditions during calibration. Second, it highlights the importance of the professional judgment needed to process water quality records. Data ratings (grades) will be applied to the data within the Aquarius software package as described in the next section. **If a data rating is suspected of being incorrect and will be recorded in Aquarius differently than the generated rating (in the site inspection summary worksheet), the modification should be noted in the comments filed and within Aquarius when the data grade is applied.**

Table 17. USGS accuracy ratings of continuous water-quality records or "data grade" (modified from Wagner et al. 2006).

Measured field parameter	**Rating of accuracy (data grade)** (Based on combined fouling and calibration drift corrections applied to the record.)			
	Excellent	**Good**	**Fair**	**Poor**
Water Temperature	≤ ± 0.2 °C	>± 0.2-0.5 °C	>± 0.5-0.8 °C	>± 0.8 °C
Specific Conductance	≤ ± 3%	>± 3-10%	>± 10-15%	>± 15%
Dissolved Oxygen	≤ ± 0.3 mg/L or ≤ ± 5%, whichever is greater	>±0.3-0.5 mg/L or >±5-10%, whichever is greater	>± 0.5-0.8 mg/L or >± 10-15%, whichever is greater	>± 0.8 mg/L or >± 15%, whichever is greater
pH	≤ ± 0.2 units	>± 0.2-0.5 units	>± 0.5-0.8 units	>± 0.8 units
Turbidity	≤ ± 0.5 NTU or ≤ ± 5%, whichever is greater	>± 0.5-1.0 NTU or >± 5-10%, whichever is greater	>± 1.0-1.5 NTU or >± 10-15%, whichever is greater	>± 1.5 NTU or >± 15%, whichever is greater

5. Print the Site Inspection Summary

After the Site Inspection Summary has been carefully reviewed, it should be printed and 3-hole punched and included in the Calibration and Maintenance Log Book. These summaries may be referred to months or years after the initial processing of data. It is best to place the Site Inspection Summary Worksheet immediately following the Corresponding Calibration and Maintenance Log sheet.

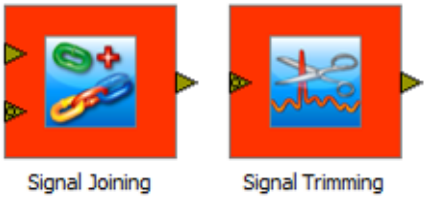
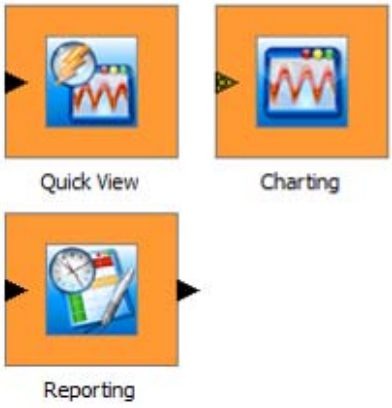
Record Processing in Aquarius

Introduction to Aquarius Software

Aquarius Time Series software is a unique workspace in that it relies on a series of toolboxes that can be dragged onto the workspace (whiteboard) and connected to each other or wired together in a variety of ways. While this system sounds complex, it adds great flexibility to the ways data can be processed and viewed. The UCBN will be using the standard version (Release 2.7 or newer) of this software, which has fewer features than the professional version, but more than adequately meets the networks needs. The best way to learn how to operate Aquarius is by using the training videos and user manual, both of which can be found by clicking the "Help" menu within Aquarius or by going to http://support.aquaticinformatics.com/.

The primary toolboxes you should be familiar with prior to starting record processing in Aquarius are listed in Table 18. It is advisable to setup a workspace and explore the functionality of each toolbox prior to loading the UCBN Aquarius Workflow and importing new data. In addition, the Aquatic Informatics Company offers live, online training upon request.

Table 18. Primary toolboxes used to process water quality monitoring data in the UCBN.

Data input 	Data pre-processing 
Flagging and QA/QC 	Correction 
Visualization and reporting 	Math and statistics 
	Data output 

UCBN General Whiteboard/Workflow Setup

The UCBN has developed a general whiteboard or workflow that should be used to process each parks water quality data. This whiteboard should accommodate up to 6 months of continuous water quality data. Data from continuous monitors should be processed immediately following the deployment period (monthly). Whiteboards will likely need to be modified or re-arranged to address differences in data from various parks or monitoring concerns. All major changes to the workflow should be revised in this SOP. Figure 59 shows the general workflow for each parameter. Note that each row represents one deployment interval and has a corresponding Calibration and Maintenance Log. Each deployment period's data is processed individually and then joined to form a continuous signal. This signal can then be flagged for values over regulatory thresholds and wired into a descriptive statistics toolbox and/or a graphing toolbox. An example whiteboard is provided on the DVD in the back of this document.

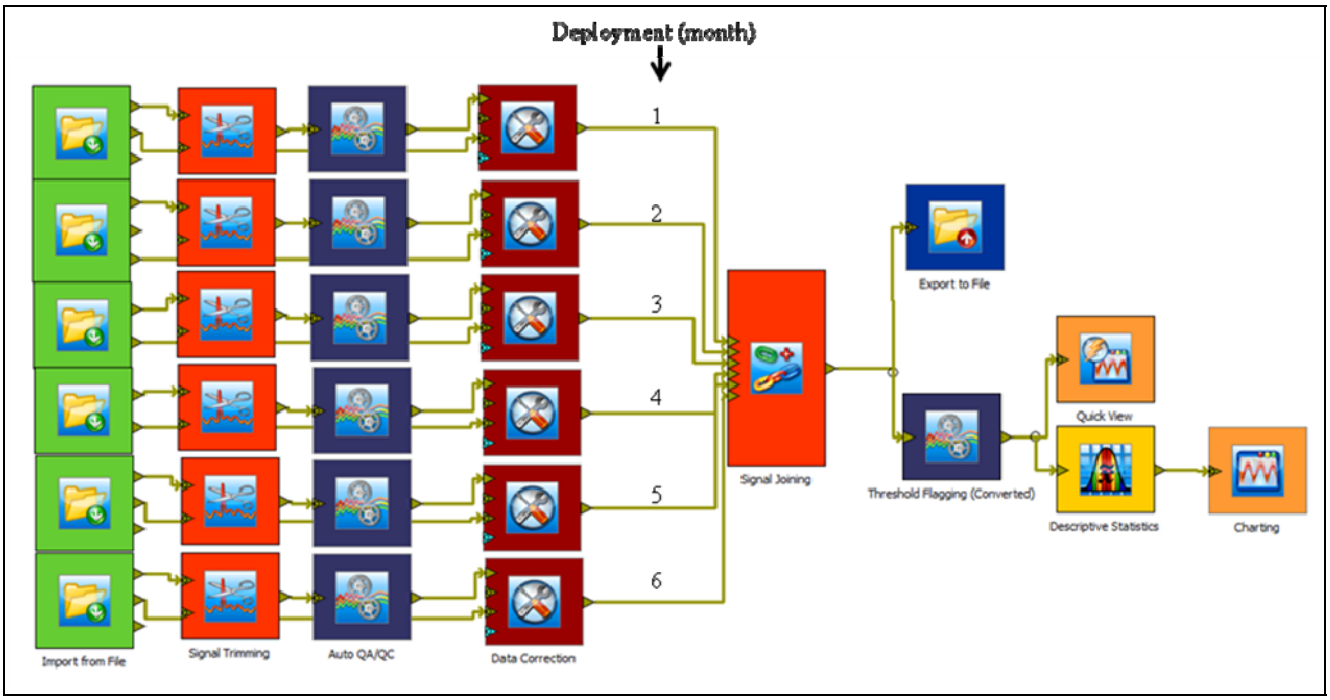


Figure 59. General workflow for one core water quality parameter. Note that each row corresponds to a specific deployment period (approx. 1 month). This workflow should be repeated for each of the five core parameters (Temperature, Specific Conductance, Dissolved Oxygen, pH, and Turbidity).

Procedure

Importing from a File

When the Hydrolab is re-deployed it is important that the log file be configured in a consistent format (See SOP #6). Consistent formatting will greatly reduce the time and effort required to successfully import data to Aquarius. Note that the same configuration file will be used to import each parameter (i.e. one configuration file / whiteboard).

1. **If you have an existing whiteboard skip to #3**. Setup the whiteboard as illustrated in Figure 59 this design should be repeated for each core parameter (Temperature,

Specific Conductance, Dissolved Oxygen, pH, and Turbidity). In other words, you should have five groups that look exactly like the general workflow in Figure 59. A separate whiteboard is necessary for each stream/monitoring station. Note that you will not be able to wire toolboxes together until data has been imported.

2. Double click the top most **"Import from file"** toolbox. An Import from File Toolbox window will appear (Figure 60).

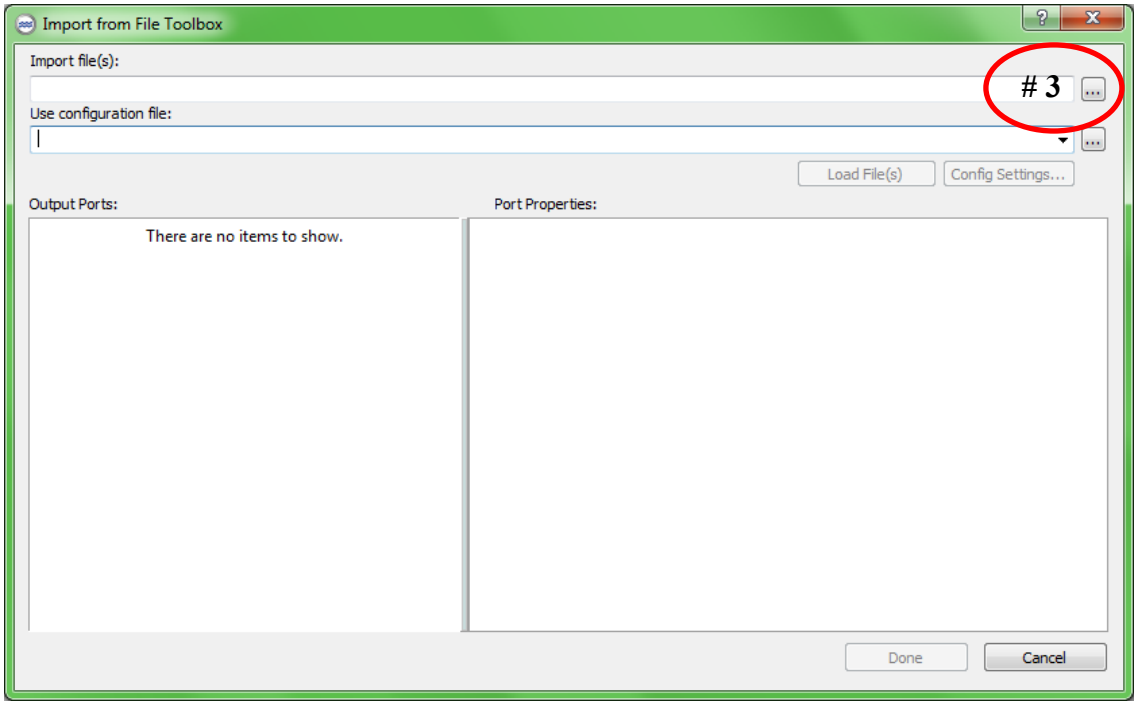


Figure 60. Import from File Toolbox.

3. If you have already imported data from this monitoring station, skip to the *Import from File Using an Existing Configuration* section. If you are importing data that came from a new station click the ellipsis next to **"Import File."** Then select the log file (.txt) for the deployment period you wish to process.
4. After you have selected the file, you will return to the Import from file toolbox, click **"Config Settings…"**
5. The "Import from File Wizard" should appear (Figure 61). Make sure the **"Time Series"** radio button is selected. Click **"Next."**

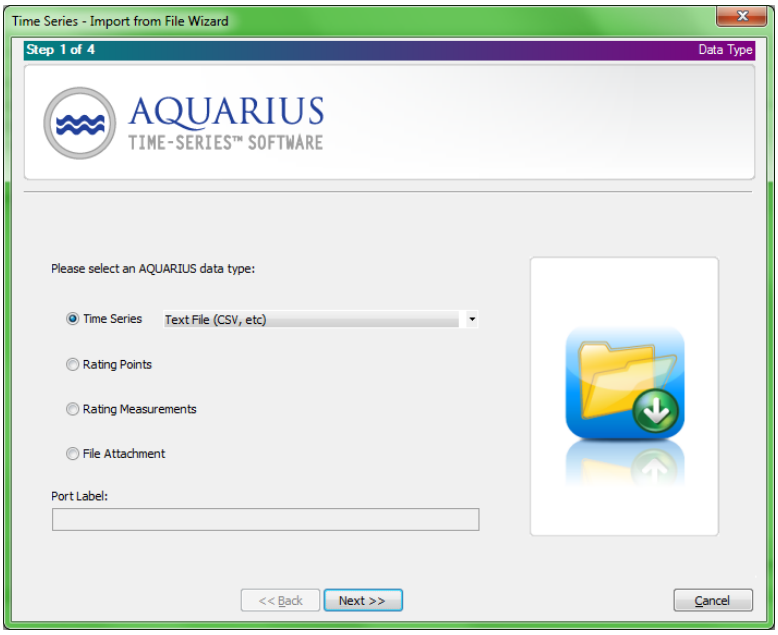


Figure 61. Import from File Wizard step 1. Select the appropriate data type.

6. The "Import from File Wizard" step 2 window should appear (Figure 62). In this step you will need to specify what Aquarius should import and what should be ignored. First, **change the** "**Start import at row" field to 14** this will eliminate the miscellaneous header rows. Note that the number of headers may vary with different multiprobe manufactures. **Make sure the delimiter is set as Comma**. Click **"Next."**

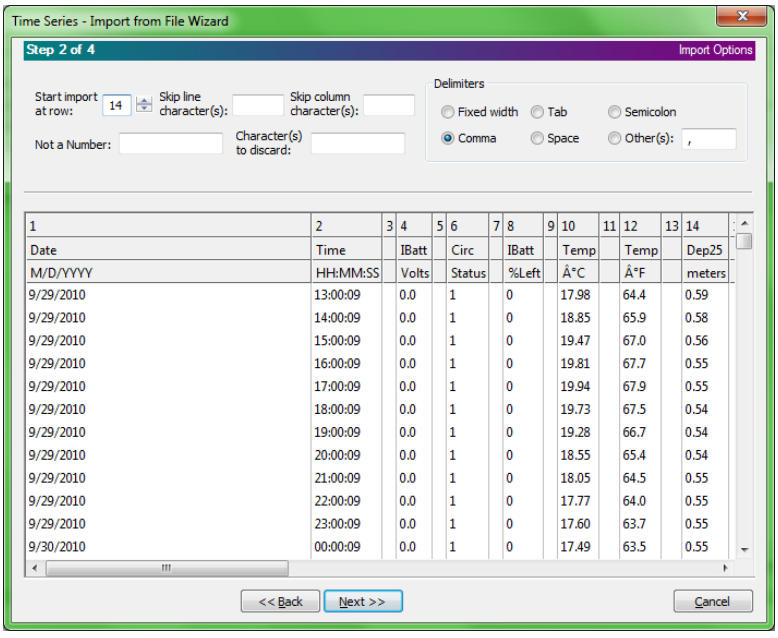


Figure 62. Import from File Wizard step 2. Specify what data Aquarius should import.

7. The “Import from File Wizard” step 3 window should appear (Figure 63).In this step you define what each column of data means, and eliminate columns without data. Select Column 1**-Date.** The Date/Time field should now be active, click the radio button next to **“Date/Time”**. Enter or select the correct format for the date (**mm/dd/yyyy**). Next, select Column 2–**Time**. Again, the Date/Time field should be active. Enter or select the correct time format (**HH:MM:SS**). Notice that time designations use capital letters while the date uses lower case. After selecting the correct time format, specify the correct time zone for the monitoring site. Most UCBN sites and monitoring will occur in **PDT (Pacific Daylight Time UTC -07:00) or MDT (Mountain Daylight Time UTC -06:00).**

   Select columns with missing data or data that will never be used for analysis or QA/QC. After selecting a column you do not wish to import, select the **“Do not import column (skip)”** radio button. If you are unsure if a column will be useful, it is better to go ahead and import it. You can discard extra columns later. If you have skipped a column and wish to undo your selection, highlight the skipped column and select **“Data.”**

   Next, select columns with the data you intend to import. After selecting a column you should define the parameter using the **“Parameter”** drop down menu. After you choose a parameter the “Units” will be automatically selected based on the default settings. If the default is not correct you can manually select the correct unit from the **“Units”** drop down menu. In the step 3 window, you should also define the **“Gap Tolerance.”** The gap tolerance for most UCBN continuous monitoring is 60 minutes, any gap longer than 60 minutes will be treated as missing data.

   After selecting each column, click the **“Grade”** dropdown menu and give each column a grade of **“0-UNDEF”** meaning that it has not been defined (it will be graded in a later step). Also click the **“Approval”** dropdown menu and select **“1-Working”** this signifies that the data is undergoing processing. After the data has been reviewed and assigned a grade, the approval code can be changed to **“Approved”** (note that this will occur in a later step)**.**

   Notice that this window also allows you to edit the name and the units of each column. It is especially important to delete characters that may have been added to your units (Figure 63 i.e., Â°C, delete Â). **The configuration done in this step is very important since it will help you import future data with only a few clicks of the mouse.** Click **“Next.”** Note that all of the above must be defined before the “Next” button will be active.

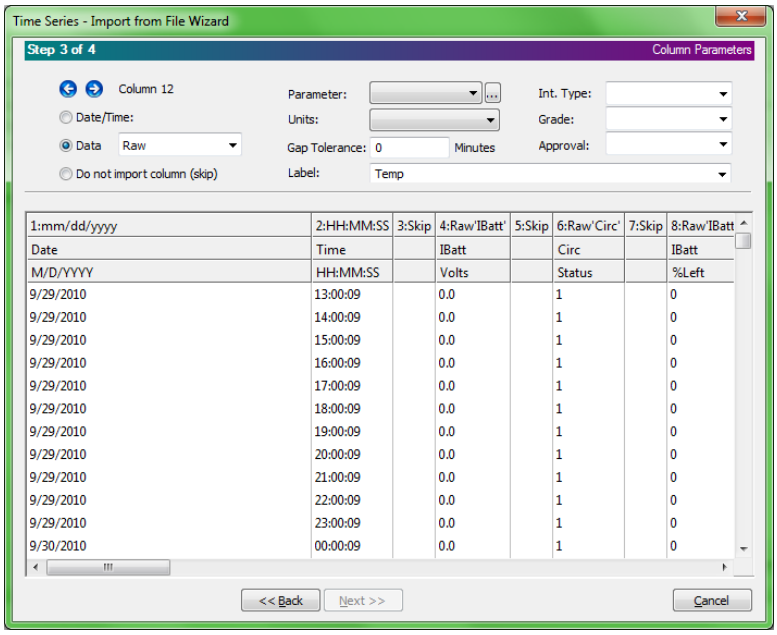


Figure 63. Import from File Wizard step 3. Specify the date and time formats.

8. The "Import from File Wizard" step 4 window should appear (Figure 64). In this window you will be given the option to save your configuration for future use. If you save your configuration you won't need to complete the setup procedure each time you import data. It is a good idea to establish a configuration file for each multiprobe/park since each instrument may have unique sensors, log file headers, etc. Make sure the **"Apply Gap Processing Tolerance"** radio button is selected. Check the **"Save Configuration"** box. Name the configuration file something that will be useful to future users. For example, the Hydrolab deployed at Nez Perce National Historical Park (NEPE) is number #054 so its configuration file name is **NEPE_054_Configuration.txt.cfg**. As long as the Hydrolab is programmed the same at each deployment, this log file can be used to quickly import data. Click **"Finish."**

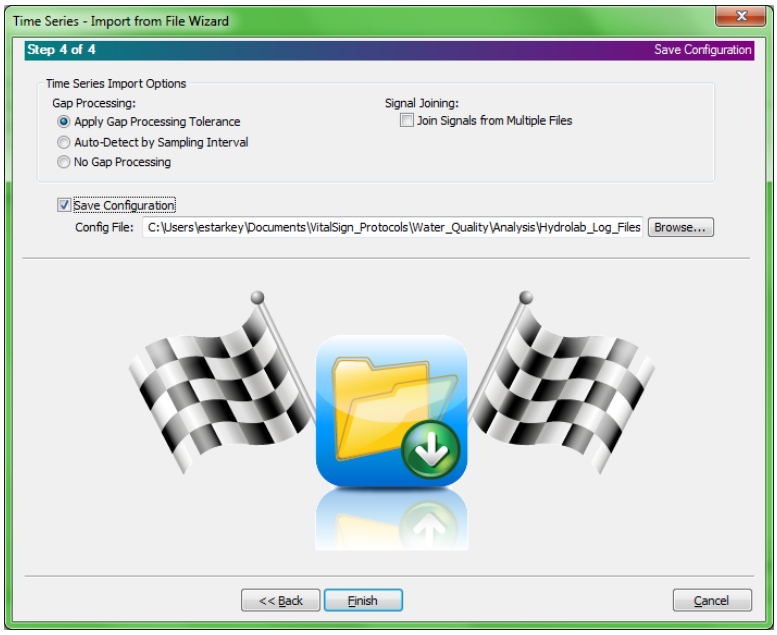


Figure 64. Import from File Wizard step 4. Check the box to save the configuration file.

9. You will now see the original "Import from File Toolbox" except the "Output ports" field has been populated (Figure 65). These are the parameters you selected to import. Given that we are processing our data parameter by parameter you should **delete any ports that are not of interest.** To delete ports select the port and press **<Delete>** on the keyboard. You can also **re-arrange these ports** to make wiring the toolboxes less cluttered. It is useful to keep the parameter of interest and either the "% Internal Battery" or "Internal Battery Volts" output ports (use "% External if the multiprobe is powered by a solar panel/external battery). This will help you determine when a sensor stopped working due to low battery power. **If you accidently delete the parameter port you needed you must completely re-load the data.** This should not be a problem if you saved the configuration file. See the next section to re-load your data with a configuration file. Click **"Done."**

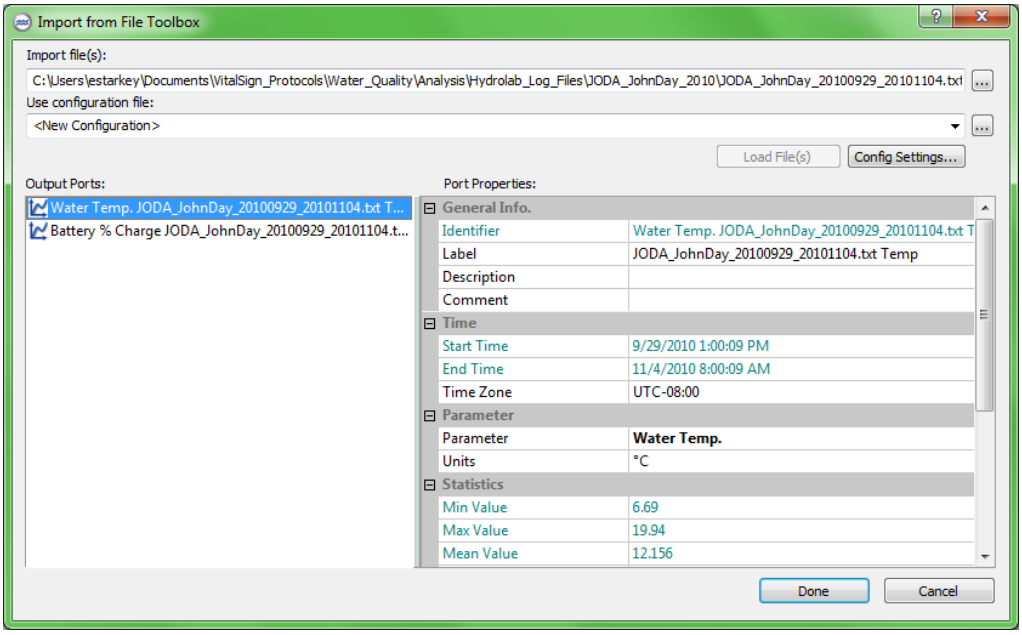


Figure 65. Populated Import from File Toolbox.

Import from File Using an Existing Configuration (Skip if you have just created a new file)

1. Double click on the **"Import from File"** toolbox.
2. Click the ellipsis next to **"Import File."** Then select the log file (.txt) for the deployment period you wish to process (Figure 65).
3. Click the ellipsis next to **"Use configuration file"** navigate to the configuration file (.cfg) that corresponds to the data you are importing (see previous section). Note that there should be a unique configuration file for each multiprobe/stream. Click **"Open."**
4. Next, click **"Load."**
5. You will now see the original "Import from File Toolbox" except the "Output ports" and "Port properties" fields have been populated (Figure 65). These are the parameters you selected to import. Given that we are processing our data parameter by parameter you should **delete any ports that are not of interest.** To delete ports select the port and press **<Delete>** on the keyboard. You can also **re-arrange these ports** to make wiring the toolboxes less cluttered. It is useful to keep the parameter of interest and either the "% Internal Battery" or "Internal Battery Volts" output ports (use "% External if the multiprobe is powered by a solar panel/external battery). This will help you determine when a sensor stopped working due to low battery power. **If you accidently delete the parameter port you needed you must completely re-load the data.** This should not be a problem if you saved the configuration file.

Signal Trimming

The Signal Trimming toolbox allows you to remove outliers, trim dates, interpolate small gaps, etc. This toolbox is very helpful in some situations and can greatly speed up the processing of a record (Figure 66 and 67). The "Signal Trimming Toolbox" should be placed before the "Auto QA/QC" and "Data Correction" Toolboxes.

Note the following about the signal trimming toolbox: "The Signal Trimming Toolbox performs special corrections on one or more input signals and creates a new output signal for each one. It works as follows: Corrected data from input + new corrections = New raw data in output. The original raw data and correction history are not preserved, so using this toolbox on previously corrected signals in not recommended." For this reason, this toolbox should always immediately follow the input from file toolbox.

1. After successfully loading one parameter and % battery, your "Import from File Toolbox" should have two triangular output ports. **Click on the first output port (►) and drag a wire to the input port on the "Signal Trimming" toolbox** (Figure 66). Next**, connect the second output port (should be % battery) to the surrogate signal input port labeled with an "O" on the "Data Correction" toolbox.** You can tell which output port is which by placing the mouse cursor over the port and waiting for several seconds to see a dialog box that describes the data. The data you imported is now connected to the signal trimming toolbox.

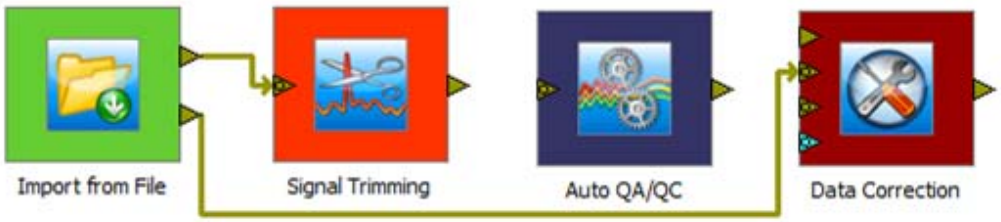


Figure 66. "Import from File" toolbox successfully connected to the "Signal Trimming" and "Data Correction" toolboxes.

2. Double click the **"Signal Trimming"** toolbox.
3. If the data **does not require trimming** Click **"Run"** and to return to the whiteboard click **"OK"** (Figure 67).
4. If the data **does require trimming,** enter the values and/or date range you wish to **keep**. Everything outside of the range you specify will be trimmed.
5. Click **"Apply"** then click **"Run"** and to return to the whiteboard click **"OK."**
6. You should now have an active output port on the "Signal Trimming" toolbox.

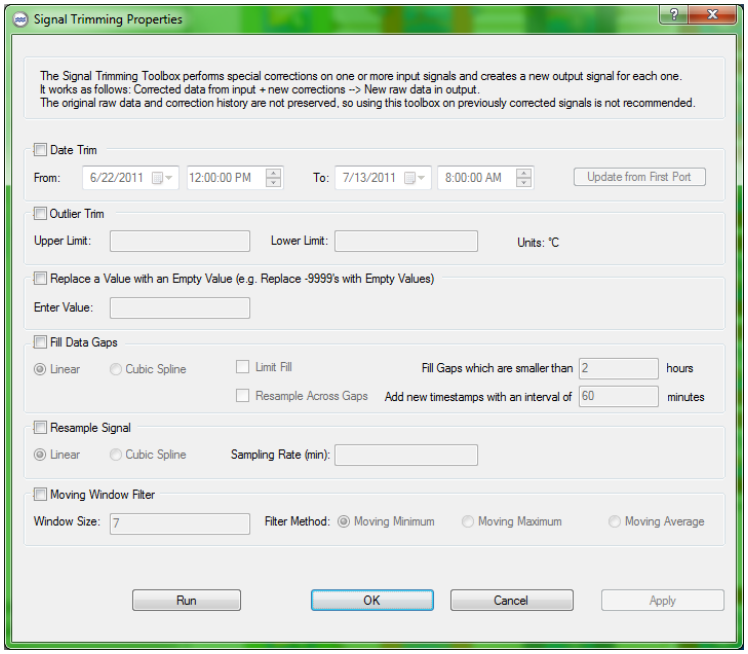


Figure 67. Signal Trimming toolbox – Properties window.

Auto QA/QC

The "Auto QA/QC" toolbox allows the user to automatically flag data that exceeds a specified threshold or rate of change. Individual data points that have been flagged using this toolbox can be viewed in the "Quick View" toolbox and the "Data Correction" toolbox. In addition, options under the "Correctives" tab (Figure 68) allow for the automatic removal and correction of flagged data. This toolbox can also be used to assist in the identification of outliers. Basic steps for running data through this toolbox are:

1. Wire the **"Signal Trimming"** toolbox to the auto QA/QC input port.
2. Double click the **"Auto QA/QC"** toolbox.
3. When the toolbox first opens you will notice that the fields in the **"Input Port View"** (left column in Figure 68) are populated with data. The **"Output Port View"** will remain empty until you run the toolbox.
   Enter any data flagging thresholds or correctives (center column Figure 68). Exact thresholds depend on the parameter, time of year, and monitoring station. For this reason, professional judgment should be used to determine appropriate thresholds and corrective measures. Threshold flagging allows the user to input values that should be flagged for review or that exceed a specified criteria. This function is especially useful for indicating values that fall above state DEQ regulatory thresholds.

   When in doubt, it may be easier to visually identify outliers and other data anomalies in the subsequent "Data Correction" toolbox.
4. Once all thresholds and correctives have been input, click the **"Run Toolbox"**  button. The **"Output Port View"** should now be populated (right column Figure 68). This view allows you to quickly see how many flags have been applied and other summary information about the output signal.
5. Click the **"Save Output Port and Exit"** button  to exit the "Auto QA/QC" toolbox.

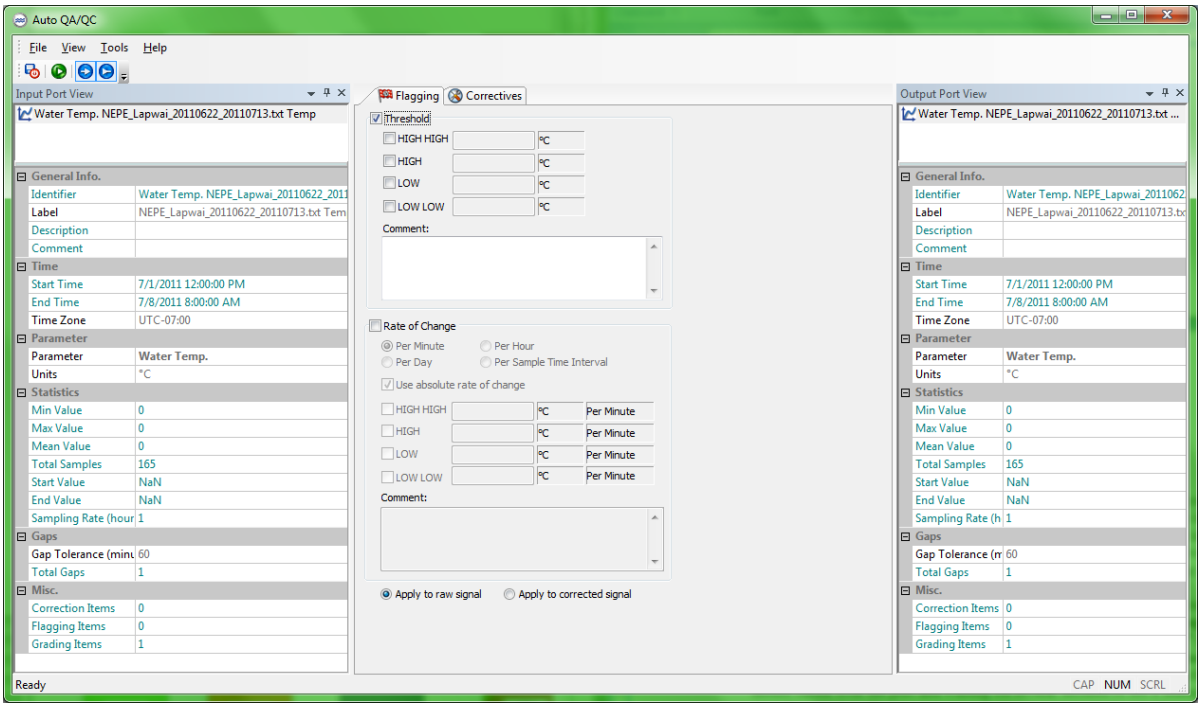


Figure 68. The "Auto QA/QC" toolbox – Flagging tab.

Data Corrections

In Aquarius v 2.7 data corrections and data grading are completed in the same toolbox. For information on data grading refer to the next section. To complete data corrections you should have prior knowledge about the deployment location (i.e., discharge, weather, basin geology, etc.). This knowledge will allow you to interpret the data and look for false spikes/outliners versus real spikes. Some parameters may be interpreted more easily by looking at several parameters simultaneously (i.e., dissolved oxygen, water temperature). Removal of false spikes and corrections relies on professional judgment.

1. Wire the **"Auto QA/QC"** toolbox to the **"Data Corrections"** toolbox. Also make sure to connect any other parameters of interest to the surrogate signal input port. Surrogate signals can aid in the interpretation of data. Several examples of when surrogate signals are useful include:
    a. Data for a specific parameter may show erratic readings near the end of a deployment but the cause may be unknown. If you look at the time series for the parameter and % battery power (surrogate signal) you may be able to tell if the erratic readings are associated with low battery power.
    b. If you notice a large spike in turbidity that you suspect might be erroneous, you might want to view specific conductance or stream discharge as surrogate signals. The surrogate signals may help determine if the spike was due to actual conditions in the stream or sensor fouling.

2. Double click on the **"Data Correction"** Toolbox. You will see the data correction window open with a graph of the parameter you loaded (Figure 69). If you connected a surrogate signal it will be graphed below the main time series. Next, you should look at

your data and visually determine which values are suspected outliers or erroneous data. Outliers that have not been removed in the "Auto QA/QC" toolbox should be removed here manually (as described in step 3).

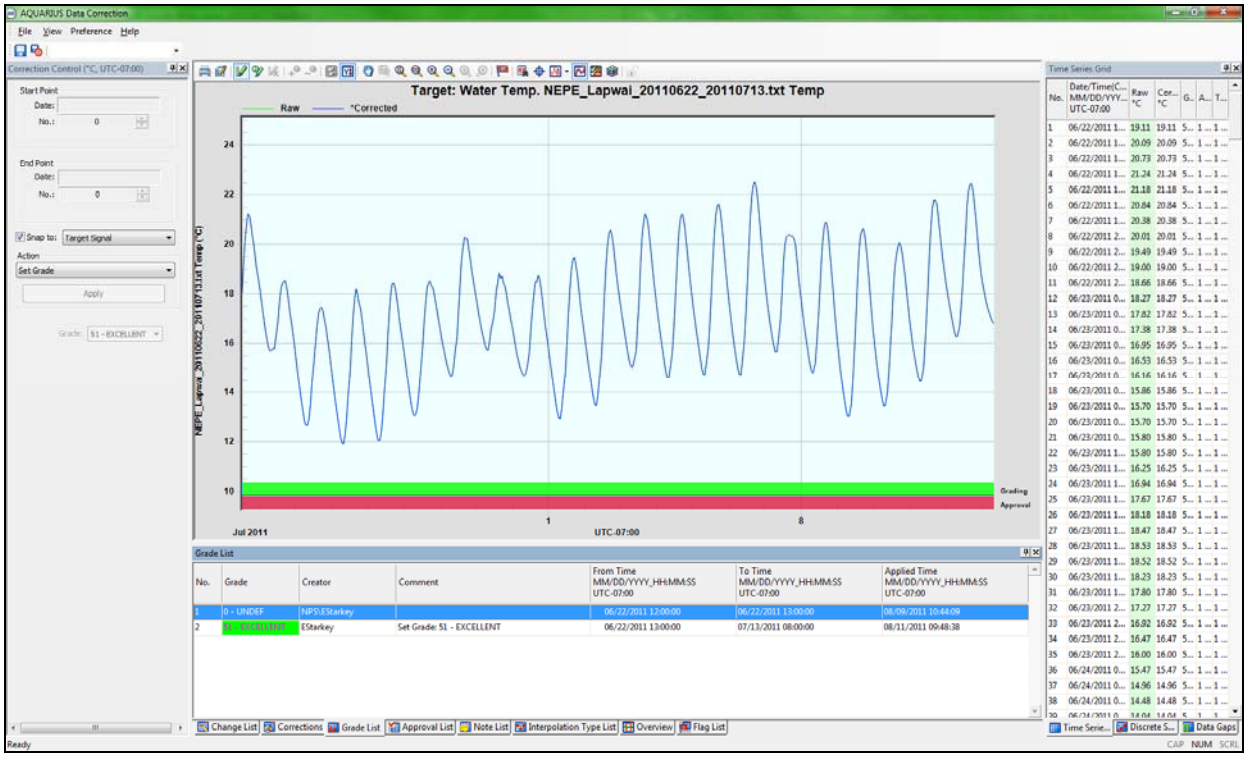


Figure 69. Data Correction toolbox. Graph of raw temperature data.

Delete Region – Note: within Aquarius the data is never permanently deleted, it is removed from the working or "Corrected" copy of the data. A correction history log tracks all changes made to the corrected data.

3. To remove data points (outliers, erroneous data, etc.) click the **"Mark Region"**  tool from the toolbar and **highlight the section of data you wish to remove. Double check you have selected the correct region.** It is useful to zoom in on the specific segment you want to remove. You can also make sure you have selected the correct data by checking the time series plot on the right side of the window (Figure 69). **Click the drop down menu under "Action"** (left side in the Correction Control pane). **Select "Delete Region" then click "Apply"** under the drop down menu**.** An "Apply Correction" window will open (Figure 70).

4. **Fill out the** "**Apply Correction"** window (Figure 70). Make sure to add a comment describing the reason you have removed the data. This comment can be saved to the list for future use. If you have already added comments to the list they can be selected from the "Saved Comments" box. All deletions/corrections are logged in the correction history manager. If you have made an error these deletions can be un-done from the correction

history tab at the bottom of the data correction window. Reasons for deletion might include a low battery, sensor spikes, etc.

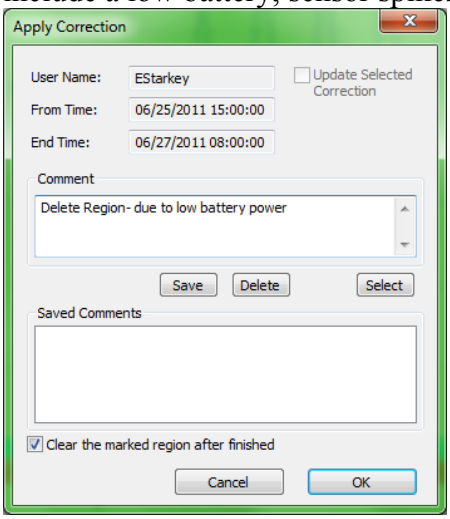


Figure 70. Apply Correction window.

Fouling and Drift Corrections

5. **Skip this step if no correction is necessary** (see the Site Inspection Summary Worksheet that you completed for the deployment period you are processing). Applying drift and fouling corrections is done by highlighting the entire data set. Note that the UCBN is applying a pro-rated correction for the entire deployment period (back to the previous calibration). **Click the "Mark All Region" icon**  from the toolbar to select the entire time period. Next, **click the drop down menu under "Action"** (left side in the Correction Control pane). **Select "Drift Correction."** If needed, enter the **calibration drift** (aka sensor drift) and **fouling drift**. These can be found on the site inspection summary worksheet. Make sure to **include a negative sign if necessary. Click "Apply"** under the drop down menu**.** The "Apply Correction" window will appear. The amount of correction applied will automatically be listed in the comment field. Make sure to **add additional comments if necessary** (Figure 70). Click **"OK."** You will now see a second signal within the graph, this is the corrected data.
6. Note that this toolbox is also the place to make other corrections such as: offset, percent, multi-point, and clock drift. These types of corrections are described in the Aquarius data correction toolbox manual. This manual can be found by going to the Help menu within the Data Correction toolbox.
7. After double checking that all corrections have been made you should continue with data grading (see next section). Do not close the "Data Correction" toolbox.

Data Grading

The ability to grade or assign a quality rating to data is now built into the "Data Correction" toolbox. Data grades are indicated by the color below the time series graph and by the "Grade" column in the time series grid (Figure 71).

1. The **"Data Correction"** toolbox should still be open following data corrections. If the "Data Correction" toolbox is not open, follow steps 1 and 2 from the Data Correction section above.
2. Note that the UCBN is applying a data grade for the entire deployment period (back to the previous calibration). **Click the "Mark All Region" icon** from the toolbar to select the entire time period. Next, **click the drop down menu under "Action"** (left side in the Correction Control pane). **Select "Set Grade."**
3. Next, **select the appropriate data grade from the "Grade" drop down menu.** These data grades are listed on the Site Inspection Summary Worksheet and are based on the USGS rating criteria found in Wagner et al. 2006 and in Table 17 in this SOP. **Click "Apply."**
4. The "Set Grade" window will appear (Figure 72). Add any necessary comments in the comments field. **Click "OK."**
5. After double checking that all corrections have been made you should continue by setting the approval code (see next section). Do not close the "Data Correction" toolbox.

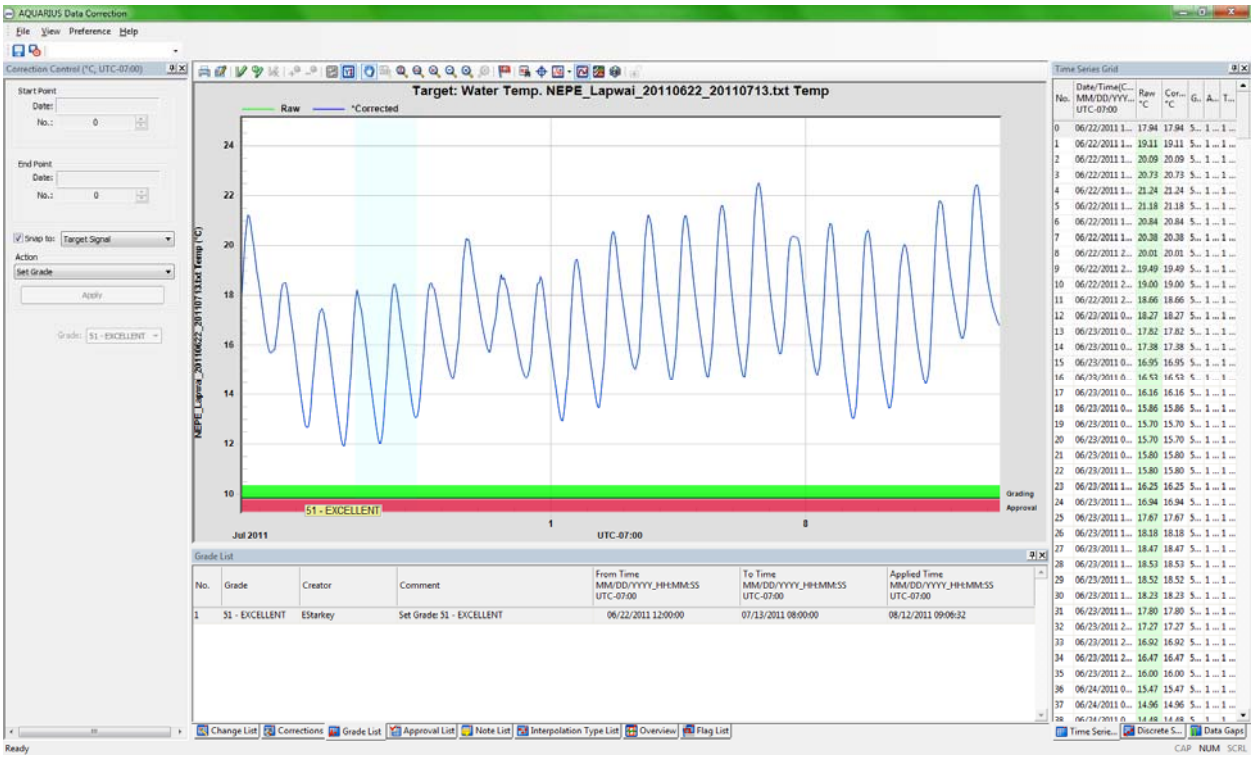


Figure 71. Data Correction Toolbox indicating the data grade for temperature data collected at Nez Perce National Historical Park (NEPE).

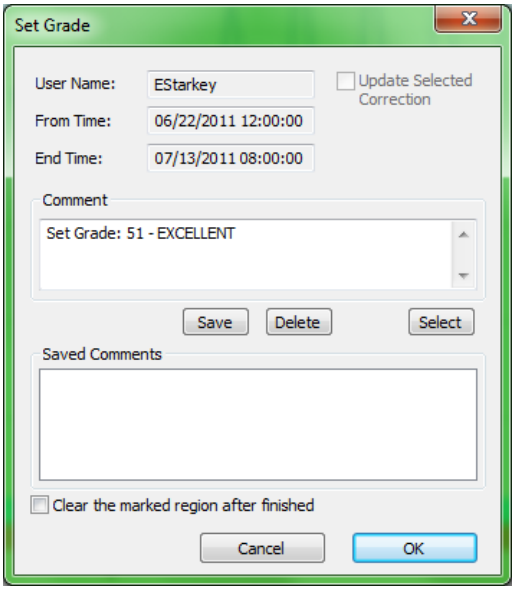


Figure 72. Set Grade window.

Approval Codes

Approval codes are a relatively new feature in Aquarius and help define the status of the data relative to data processing. In other words, is the data "working", "in review", or "approved." These categories help with quality assurance and are especially important if multiple users will be reviewing and processing the data. For example a hydrologic technician could enter and process the data in Aquarius and set the approval code as "in review." After the data has been checked by a supervisor the approval code could be switch to "approved." Note that the approval codes can be changed to meet individual user needs. For instance, rather than "working" the user might want the approval code to read "provisional." The process for changing the approval codes can be found in the Aquarius Help Manual under the heading "Aquarius Local Data Manager." The help manual is available from the Help menu.

1. The **"Data Correction"** toolbox should still be open following data grading. If the "Data Correction" toolbox is not open, follow steps 1 and 2 from the Data Correction section above.
2. Click the **"Mark Region"**  tool from the toolbar and **highlight the section of data to which you would like to set the approval code. If you wish to set the same approval code for the entire deployment period use the "Mark All Region" tool**  **to select the entire data range.**
3. Next, **click the drop down menu under "Action"** (left side in the Correction Control pane). **Select "Set Approval."**
4. Next, **select the appropriate approval code from the "Approval" drop down menu.** The assigned approval code depends on the data's status. Use the following as a guide to choosing an approval code.
    a. Working = The data has been imported to Aquarius but have not been reviewed, error checked, corrected, or graded.

b. In Review = The data is being processed and checked for errors and outliers. The data may have been corrected and graded but have not been double checked by a supervisor or subsequent analysis.
c. Approved = The data have been corrected, graded, and error checked. The data is certified and ready for export and analysis.

5. After double checking the approval code, data grade, and data corrections click the **"Save data to output ports and exit"** icon  . You should now have one active output port on the "Data Correction" toolbox.

Signal Joining

The "Signal Joining" toolbox allows you to join the signals from multiple deployment periods. Joining signals allows the user to perform descriptive statistic functions on the entire season's dataset or on a monthly basis. **Note that signal joining requires multiple signals. If you have only one signal you will need to bypass this step and wire the output port from the Data Correction toolbox directly to the input port on the Descriptive Statistics toolbox.**

1. **Connect multiple deployment signals to the signal joining input ports.** If you need additional input ports, right click on the "Signal Joining" toolbox and select **"Properties Pane."** Change the number of input ports. If you have more input ports than signals the toolbox will not function.
2. Double click the **"Signal Joining" t**oolbox.
3. The "Signal Joining" window will appear (Figure 73). Each signal (deployment period) will appear as a different color on the graph. Make sure the check boxes are selected under **"Include Corrections?"** in the "Signal Joining Properties" section of the Time Series Manager pane.

4. Click the **"Save data to output ports and exit"** icon  on the toolbar. You should now have one active output port on the "Signal Joining" toolbox.

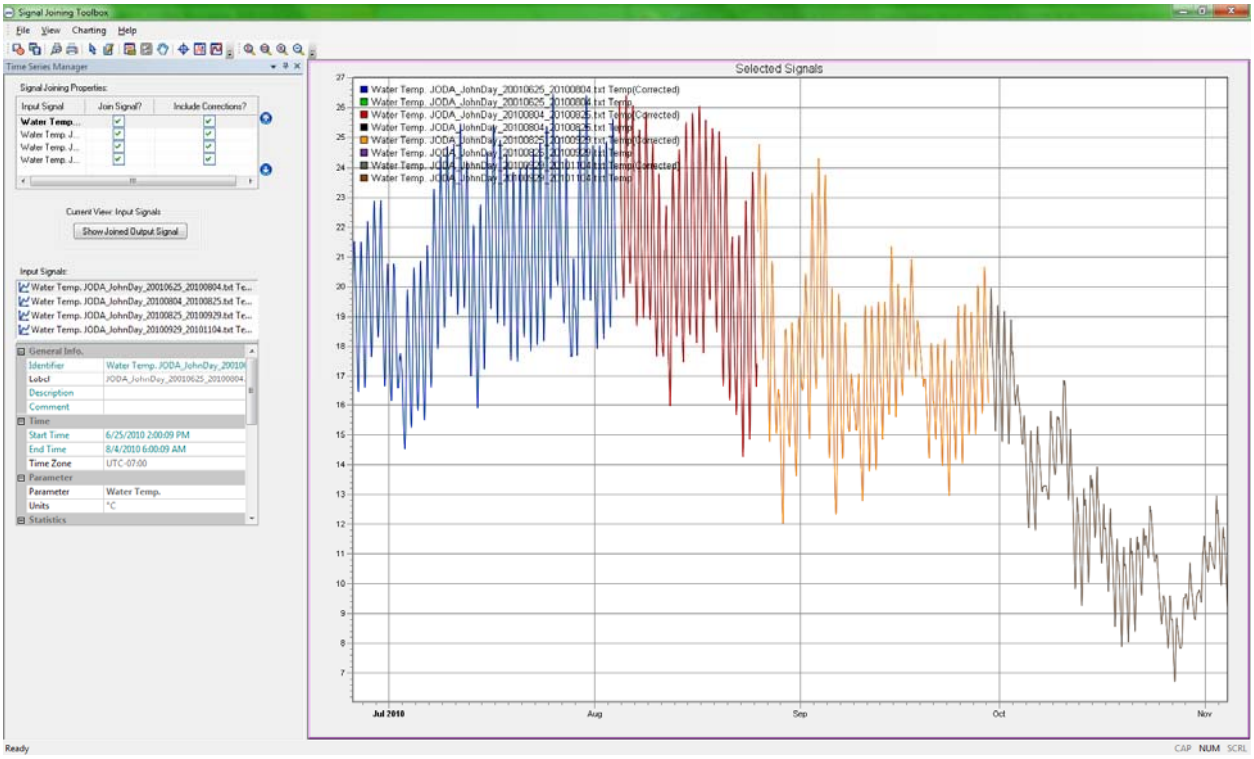


Figure 73. Signal Joining Toolbox-multiple (monthly) temperature signals.

Graphing

There are two toolboxes that allow the user to produce a graph suitable for export to a publication. The "Quick View" toolbox is the easiest to use, yet it does not have the flexibility of the "Charting" toolbox. The user can decide which toolbox best meets his/her graphical needs. It is important to note that a user can either graph the entire set of raw or corrected data, or can analyze the data with the "Descriptive Statistics" toolbox first and subsequently graph summarized data (i.e., daily max, min, mean). The order of operations depends on the user's specific needs.

Quick View:

1. **Connect the "Signal Joining" toolbox to the "Quick View" toolbox,** OR **right click the** "**Signal Joining" output port, and select "Quick View"** (if you choose this option skip to step 3)**.**
2. Double click the **"Quick View"** toolbox.
3. The "Quick View" graphing window should open. You can zoom to specific dates or graph the entire time period. Graph options can be edited by going to the **Charting menu**, then by clicking **"Properties."**
4. For reports, it is best to change the grid lines to black and the frame to white.
5. Threshold flags initially established in the "Auto QA/QC" toolbox (prior to data correction) are not maintained after the data has been processed in the "Data Correction" toolbox. If you would like to view threshold flags after the signal has been joined, you must connect the **"Signal Joining"** toolbox to another **"Auto QA/QC"** toolbox and re-enter the flagging thresholds (see the Auto QA/QC section above). The "Auto QA/QC" toolbox can then be connected to the "Quick View" toolbox.
6. To view the threshold flags within the quick view window, click the **"Select Active Flag"** icon  from the toolbar. Then choose the threshold rule you established in the "Auto QA/QC" toolbox.
7. To export the graph go to the **"File" menu** and select **"Save Chart Image."**

Charting:

1. **Connect the "Signal Joining" toolbox to the "Charting" toolbox.**
2. Double click the **"Charting" toolbox.**
3. The "Charting" window should open. It will automatically graph both the raw and corrected data. The raw or corrected the signals can be turned on and off by going to the **"Chart" menu** and selecting **"Show/Hide Series."**
4. To customize the chart, go to the **"View" menu** and select **"Chart Options"**
5. If you want to add an additional Y axis, go to the "Chart" menu and select **"Multiple Y-Axis."**
6. Note that no threshold flagging option is available from this toolbox.
7. After you have formatted the graph, you can save the settings as a template for future use. This will help you produce standardized looking graphs for each parameter. To save the template go to the **"File" menu** and select **"Save as Template."**
8. To export the graph go to the **"File" menu** and select **"Save Chart Image."**
9. **NOTE: If you close the Charting toolbox you will lose your graph!**

Descriptive Statistics

1. **Connect the "Signal Joining" toolbox to the "Descriptive Statistics Toolbox."**
2. Specify the time period and the types of statistics you would like to report by filling in the appropriate fields and by checking the appropriate boxes. Note that by checking the left box next to each statistic you will generate an output port. For example, if both boxes were checked next to mean, minimum and maximum, and the time period was set at "daily," it would generate three output ports. These output ports would contain the daily mean, minimum and maximum. This is important because those values could then be graphed using the "Quick View" or the "Charting Toolbox."
3. It is also possible to specify thresholds within this toolbox and calculate the "number of days" the parameter exceeded the threshold. It is important to note that the "Days Above" and "Days Below" values are calculated based on the number of hours the parameter exceeded the threshold and not the actual number of days the parameter peaked above or below that threshold. For example (Figures 74 and 75), if dissolved oxygen was below 6.0 mg/L during 8 samples (1 sample/hour) Aquarius would say that it was below the threshold 0.333 days (8-hourly samples/24hrs). Dissolved oxygen was actually below the threshold on 4 separate days. **This is important to take into account when compiling annual reports.**
4. Within the Input Time Series Binning Control pane it is also possible to specify that you would like run statistics on days with a specify grade and data coverage. These settings are described in detail in the Aquarius user manual. This manual can be accessed by clicking on the Help menu and selecting "Descriptive Statistics Toolbox Manual."
5. Click **"Compute"** and the results will be displayed within the same window.
6. If you wish to save the results to the output port click the icon **"Save Data to Output Ports and Exit"**  .

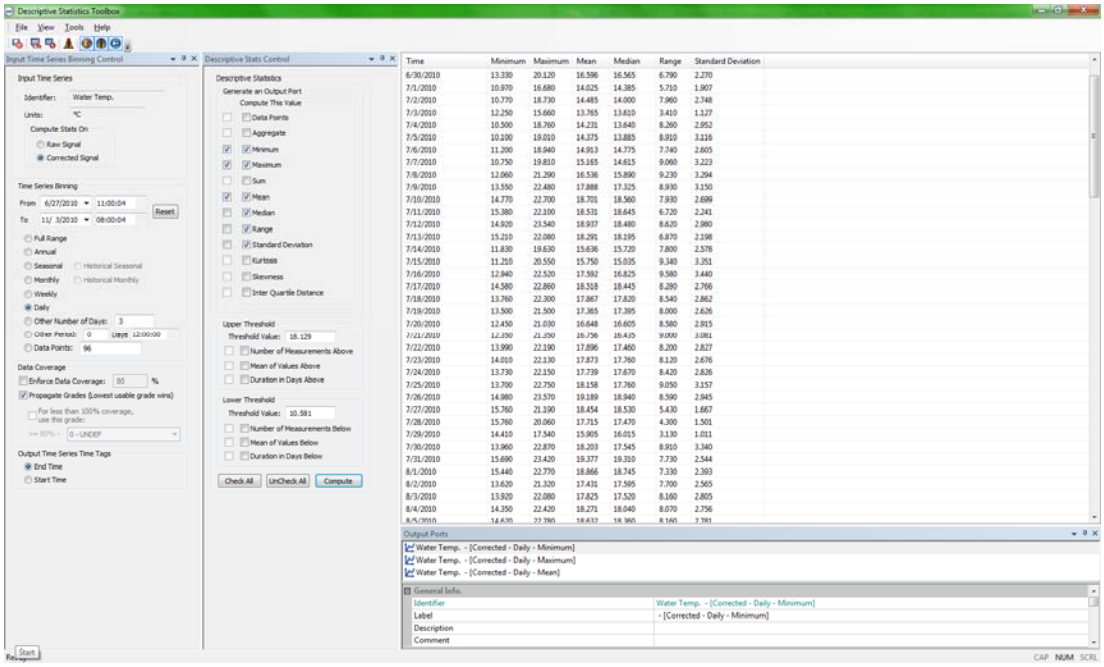


Figure 74. Descriptive Statistics Toolbox.

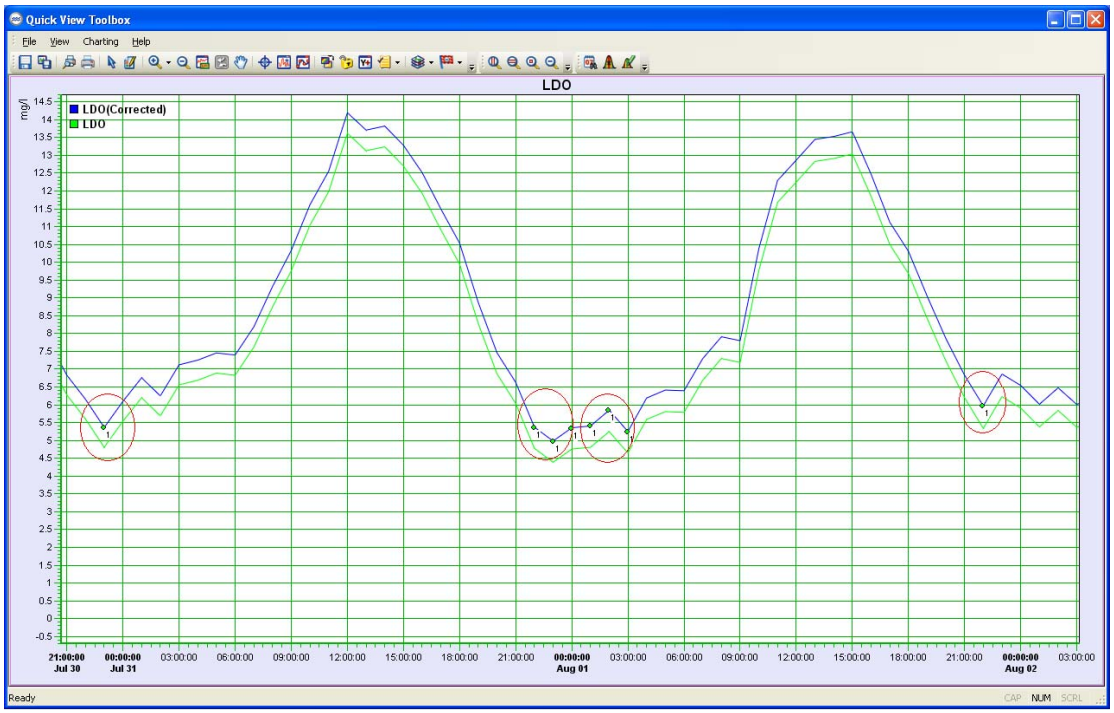


Figure 75. Illustration of threshold flagging for dissolved oxygen. Values below 6.0 mg/L are flagged with green dots. Red circles indicate the days when dissolved oxygen was below 6.0 mg/L.

Export

At the end of each season, the following should be exported and saved on the UCBN server:

1. AOP file for each parameter – Aquarius specific file (carries all data corrections and grading)
2. Corrected data file (will include all parameters) – CSV format
3. Correction history file for each parameter – CSV format
4. Data grade/rating file for each parameter- CSV format

Other files that do not require export but should be copied and saved on the UCBN server include:

1. Workstation file for each monitoring station – Aquarius specific file
2. Configuration file for each monitoring station- Aquarius specific file
3. Site inspection summary worksheets for each deployment/station- MS Excel

The procedure for exporting the AOP and corrected data files listed above is:

1. Wire the **"Signal Joining"** toolbox for each parameter to the **"Export to File"** toolbox. Adjust the number of input ports on the "Export to File" toolbox by right clicking the toolbox and selecting **"Properties Pane."** Once this pane opens, change the number of input ports to match the number of parameters on your whiteboard.
2. Double click the **"Export to File"** toolbox. The Export to File window will open (Figure 76).

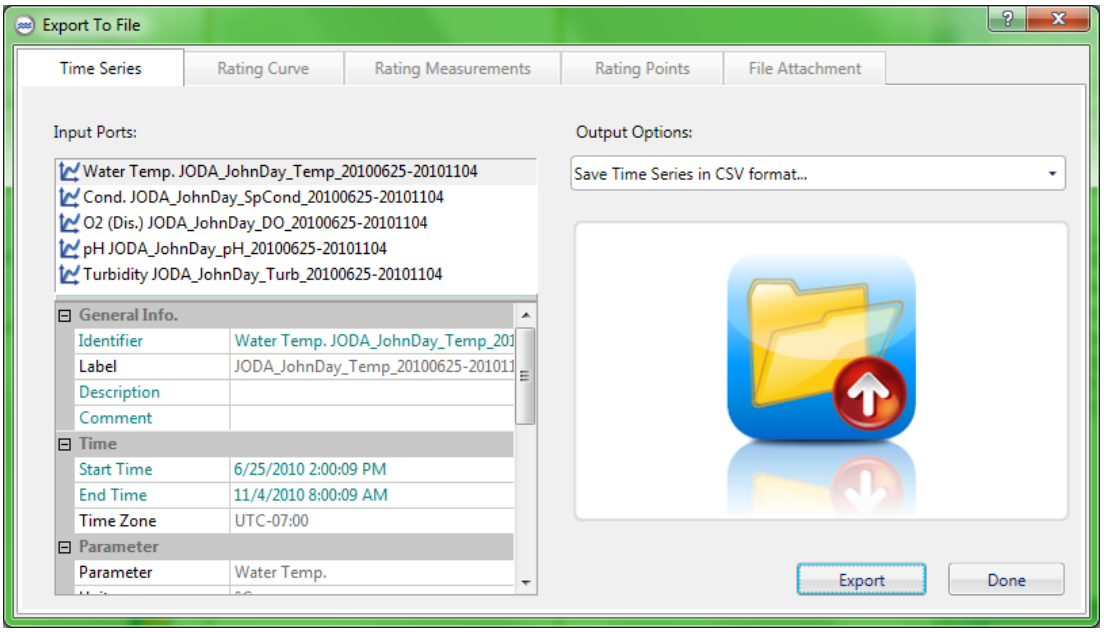


Figure 76. Export to File Toolbox.

3. Make sure all of the parameters are listed in the "Input Ports" box.
4. **Click on the first parameter in the list of input ports.**

AOP File:

5. To export the AOP file select **"Save Selected Time Series in AOP Format"** from the drop down menu under **"Output Options."** Then click **"Export."** Save the AOP file using established naming conventions (e.g. Water Temp. JODA_BridgeCreek_Temp_20100626-20101103). This step will need to be
6. Repeat steps 4 and 5 for each parameter until all AOP files have been exported.

Corrected/Raw Data File:

7. To export the corrected/raw data file select **"Save Time Series in CSV Format"** from the drop down menu under **"Output Options."** Then click **"Export."** The "Export to CSV" window will appear (Figure 77).
8. Select the radio button for **"Entire Range.**
9. **Select the first parameter from the list on the left**. When you have selected the first parameter, the "Available Columns" box should be populated.
10. **Select each column under the "Raw Data" tab and click "Add."** This column will become part of the data that will be exported.
11. **Click the "Corrected Data" tab**
12. Again, select the fist parameter from the list on the left. When you have selected the first parameter the "Available Columns" box should again be populated. This time with the corrected data.
13. **Select each column under the "Corrected Data" tab and click "Add".** This column will become part of the exported data.

14. When all columns for both raw and corrected data have been added, Click the checkboxes next to **"Append Time Series Statistics" and "Append Metadata Glossary."**
15. To avoid this process in the future, save these settings as a configuration file by clicking **"Save Config."**
16. Next, click **"Export"** and save the CSV file using established naming conventions (e.g. JODA_BridgeCreek_Output_All_Data_2010).
17. When finished, Click **"Done"**

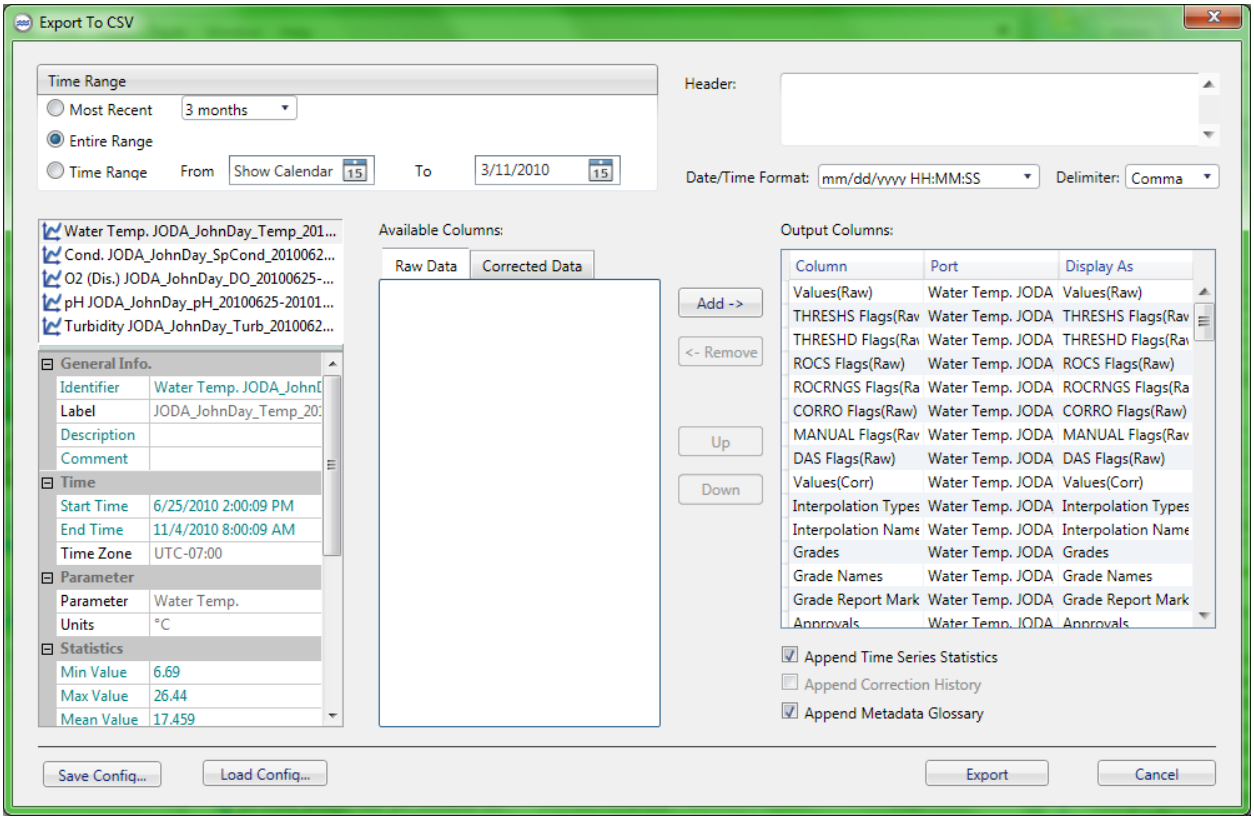


Figure 77. Export to CSV window.

Correction History File:

1. Connect the **"Signal Joining"** toolbox for a single parameter to a new **"Data Correction"** toolbox.
2. Double click the **"Data Correction"** toolbox. The data correction window should open.
3. Check that the entire season's worth of data is displayed in the graph. Below the graph should be a series of colors indicating each deployment periods data grade.
4. Go to the "File" menu. Select **"Export Corrections List."** Save the file using established naming conventions (e.g.JODA_JohnDay_001_Correction_history_of_SpCond_2010).
5. Repeat steps 1-4 for each parameter.
6. Do not close this toolbox and continue by exporting the data grade/rating file.

Data Grade/Rating File:

1. After exporting the correction history file, you should still be within the **"Data Correction"** toolbox for a given parameter
2. Go to the "File" menu. Select **"Export Grade List."** Save the file using established naming conventions (e.g. JODA_JohnDay_001_Grade_List_SpCond_2010)
3. Repeat steps 1 and 2 for each parameter.
4. When finished, click the icon **"Save Data to Output Ports and Exit"**  .

After export these files can be packaged and processed using an Access database and subsequently uploaded to NPSTORET. The Aquatic Informatics Company is working with NPS–Water Resource Division to add functions to Aquarius Time Series Software that may allow for direct export to NPSTORET. This functionality will eliminate the need for an intermediate Access database.

Other Notes

It is important to save the whiteboard for future use. The naming convention for whiteboards should indicate the Park, Stream and last date of modification (e.g., NEPE_Lapwai_Workstation_20081103.aqw). If multiple Hydrolabs are deployed within the same stream it may be necessary to add the instrument or station number to the file name.

Example Calibration and Maintenance Log

UCBN Multiprobe Calibration/Maintenance Log

Park abbreviation NEPE **Stream** Lapwai **Site ID** 01 **Multiprobe Number** 54
Monitor Inspected By ES **Date (mm/dd/yyyy)** 07/13/2011 **Time** 8:25 **(MST / PST)**
Gage Ht _____ **(Rising, Falling, Steady, Peak)** **Channel Conditions** Stable
Monitor Make/Model HACH MS5 **Monitor Serial No.** 703000450286
Field Meter Make/Model YSI 556 **Field Meter Serial No.** _____
Weather Cold (Cool) Warm Hot Rain Mist Sleet Snow Humid Dry Cloudy Pt Cloudy (Overcast) Clear Windy Gusty Breeze Calm
Comments:

Data Download

Did you download data from the past deployment? (Y) N
Log file name: NEPE-Lapwai-20110622-2011 0713 including site name, begin and end date (YYYYMMDD)
i.e. WHMI_Mill_20080422_20080520
Ending Battery 11.7 volts 96 % Remaining

Multiprobe Fouling Checks

	Before Cleaning Time 8:32				After Cleaning Time 8:57			
Parameter	Recorded/Live Monitor Reading		Field Meter Reading		Recorded/Live Monitor Reading		Field Meter Reading	
Temp (°C)	16.79°		16.82°		16.79		16.82	
SC (µS/cm)	282.0		284		286.2		284	
DO (mg/L, % Sat)	94.6 %Sat	D.O. Table mg/l	97 %Sat	D.O. Table mg/l	97.9 %Sat	D.O. Table mg/l	99.3 %Sat	D.O. Table mg/l
	8.91 mg/L	9.38	9.4 mg/L	9.37	9.20 mg/L	9.38	9.63 mg/L	9.37
	Water Temperature 16.79 °C		Barometric Pressure 736.59 mmHg		Water Temperature 16.79 °C		Barometric Pressure 736.59 mmHg	
pH (units)	8.16		7.96		8.29		7.88	
Turbidity (NTU FNU)	17.6		—		3.0		—	

Calibration Drift Checks

Temperature
Calibration Criteria > ± 0.2 °C when checked with another meter. > ± 0.5 °C when checked with NIST thermometer.

Recorded/Live Monitor Reading Time 9:09	Field Meter or NIST Reading Time 9:09	Difference Monitor – Field Meter or Thermometer	Field Meter 2-pt check Date —
19.99°	20.0°	0.01	—

Comments:

Specific Conductance
Calibration Criteria ± 5 µS/cm or ± 3%

Standard Value	Standard Lot No.	Standard Type KCl; NaCl	Expiration Date	Calibration Check Time 9:15 Standard Temp.°C	SC Reading µS/cm	%Error	Recalibration Time 9:30 Standard Temp.°C	SC Reading µS/cm	%Error
100	A0246	NaCl	Aug-11	20.49	104.2	4.2	—	—	—
1412	A0246	KCl	Aug-11	20.76	1413.5	0.106	20.78	1412	0
0	—	—	—				19.98°	0	—

Reading in air = 0 (should be zero)

Comments:

Last updated on: 10/14/2010

Example Calibration and Maintenance Log (continued)

Dissolved Oxygen Calibration Criteria > ± 0.3 mg/L			Calibration Check Time 9:37				Recalibration Time ____						
Temp °C	Barometric Pressure mm Hg	DO Table Reading mg/L	Salinity Corr. Factor	DO Reading	Error %	Reading in zero DO solution	Temp °C	Barometric Pressure mm Hg	DO Table Reading mg/L	Salinity Corr. Factor	DO Reading	Error %	Readi in zero DO solution
19.02	737.87	8.97	—	98.3 %Sat 8.81 mg/L	1.78	—	19.02	737.87	8.97	—	99.8 %Sat 8.97 mg/L	0	—

Altitude:	Salinity:	Salinity correction applied? Y (N)	DO Charge: (Clark cell sensor)	DO Gain: (Clark cell sensor)	Date Barometer Calibrated:
—	—		—	—	—

Comments:	Did you use a handheld barometer or a weather station to determine barometric pressure? (circle one) **Handheld** **Weather Station** (location)

pH Calibration Criteria >0.2 pH units				Calibration Check Time 9:49			Recalibration Time 10:12				
pH Buffer	Theoretical pH from Table on Cal. Stand.	Buffer Lot No.	Buffer Expiration Date	Temp °C	pH Reading	Error %	Temp °C	pH Reading	Error %	Slope	Millivolts
pH 7	7.02	A9328 → A1046	Nov-11 → Apr-13	20.10	7.09	0.9	20.10	7.02	0	—	—
pH 4	4.0	A9022	Jan-13	19.94	3.83	4.25	—	—	—	—	—
pH 10	10.05	A0049	Feb-11	20.01	10.33	2.78	19.95	10.05	0	—	—

Comments:

Turbidity Calibration Criteria: The greater of 0.5 TU or ± 5%				Calibration Check Time 10:37			Recalibration Time 11:00		
Stock Turbidity Standard	Lot no.	Exp. Date	Concentration	Temp °C	Reading (NTU/FNU)	Error %	Temp °C	Reading (NTU/FNU)	Error %
Zero Standard or <0.1 NTU	DO	—	0	20.84	0.1	0.1	21	0.3	0.3
Standard 1	A0229	Aug-12	20	21.08	20.3	1.5	—	—	—
Standard 2	A0202	Jul-12	100	21.62	99.9	0.1	21.87	100	0
Standard 3	—	—	—	—	—	—	—	—	—

Turbidity Sensor Limits:	Comments:

Final Readings In Stream / Standard Solution		**Time** 11:11
Parameter	Recorded/Live Monitor Reading	Field Meter Reading/Standard Value
Temp (°C)	20.94	21
SC (µS/cm)	1411.3	1412
DO (% Sat. and mg/L)	100.4 % Sat. 8.68 mg/L	8.64 D.O. Table mg/l
Barometric Pressure (mmHg)	736.59	736.59
pH (units)	21.58° - 7.01	7.01
Turbidity (NTU FNU)	100	100

Example Calibration and Maintenance Log (continued)

Maintenance Record For Multiprobe

Sensors cleaned? (Yes) No

Fouling Presence: Record type of fouling AND amount (e.g. A, E, / H)
Type: A = algae, E = eggs, F = fish, S=sediment, O = other, N = none / Amount: H = heavy, M = moderate, L = light, N = none

O= caddisflies

Sonde / Guard ASOM DO Probe ASOM External Screen ASOM

pH Probe ASOM Temp / Cond ASOM Turbidity ASOM

Sensors changed?	Temp	Yes	(No)	Sensor ID_____
	SC	Yes	(No)	Sensor ID_____
	DO	Yes	(No)	Sensor ID_____
	pH	Yes	(No)	Sensor ID_____
	Turbidity	Yes	(No)	Sensor ID_____
	Sonde changed?	Yes	(No)	New Sonde No._____ Old Sonde No._____
pH Teflon junction changed?		Yes	(No)	Type of fouling_____
pH reference electrolyte changed?		Yes	(No)	
LDO cap changed?		Yes	(No)	Type of fouling_____
Lubricate O-rings?		Yes	(No)	
Changed O-rings?		Yes	(No)	
Wiper Parks 180 deg from Optics?		(Yes)	No	
Wiper replaced?		Yes	(No)	Type of fouling_____
Clock Set		Yes	(No)	
Battery changed prior to deployment?		Yes	(No)	_____volts _____% Remaining

Deployment

Name of the new log file: NEPE-Lapwai-20110713 (i.e. WHMI_Mill_20080521)

Time of deployment: 17:00

Housing Locked? (Yes) No

Security Cable Locked? (Yes) No

Field Meter

	Make/Model	Serial No.	Correction Factor Applied?
Multiprobe/Sonde/Meter			None Yes No
Temp			None Yes No
Conductivity			None Yes No
pH			None Yes No
DO			None Yes No
Turbidity			None Yes No
Other			None Yes No

Comments/Observations:

UCBN Office: 208-885-3010 or 208-885-3684
HACH Technical Assistance 1-800-949-3766

Last updated on: 10/14/2010

Example Calibration and Maintenance Log (continued)

Useful Equations

$$\%\ Error = \left(\frac{Reading - Standard\ Value}{Standard\ Value}\right) \times 100$$

To determine the current barometric pressure in mmHg record the current absolute (ABS) barometric pressure from the handheld barometer (inHg). Then divide by the constant 0.0393701.

29.05 : 737.87

$$\frac{ABS\ \text{inHg}}{0.0393701} = ABS\ \text{mmHg}$$

29 = 736.59

If no barometer is available check the nearest weather station (Weather Bureau station is preferred http://www.wrh.noaa.gov/otx/) for barometric pressure in mbar. You will first need to convert from mbar to mmHg.

$$0.75 \times BPmbar = BPmmHg$$

Weather stations report a corrected barometric pressure, barometric pressure at sea level (BP). To convert the barometric pressure at sea level to barometric pressure at altitude BP' Use the following equation:

$$BP' = BP - 2.5\left(\frac{A_{ft}}{100}\right)$$

Where:
BP' = Barometric pressure at altitude mmHg
BP = Barometric pressure at sea level mmHg
A_{ft} = Altitude in feet

$\frac{104.2 - 100}{100} = 0.042 \times 100 = 4.2$

$\frac{1413.5 - 1412}{1412} = 0.00106 \times 100 = 0.106$

Page 4 of 4

Last updated on: 10/14/2010

Literature Cited

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, B.A. Smith. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 10: Data Management

Version 1.0, January 2009

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0

Note: This SOP provides documentation for the integrated water quality monitoring project database and provides instructions for the development, maintenance, archiving, and distribution of the database or datasets.

Suggested Reading

Dicus, G.H. and L.K. Garrett. 2007. Upper Columbia Basin Network Data Management Plan. National Park Service Upper Columbia Basin Network Inventory and Monitoring Program. Moscow, ID

Garrett, L.K., T.J. Rodhouse, G.H. Dicus, C.C. Caudill, and M. R. Shardlow. 2007. Upper Columbia Basin Network vital signs monitoring plan. Natural Resource Report NPS/ UCBN/NRR—2007/002. National Park Service, Fort Collins, CO.

National Park Service. 2006. Natural Resource Database Template Version 3.1 documentation. Natural Resource Program Center, Office of Inventory, Monitoring, and Evaluation, Fort Collins, CO.

Overview

An integrated water quality monitoring project database, UCBN_IWQ_vX_X.mdb, has been developed within Microsoft Access. The database will store core water quality data (water chemistry data from multiprobe data loggers), macroinvertebrate assemblage structure data (from in-stream kick samples), and stream cross sectional survey measurements. There is very limited need for direct data entry into this database; instead emphasis is placed on importing data processed within other software applications, and on output procedures to format data for export to national databases (e.g., NPStoret) and for data analysis and reporting requirements. Data to be imported into the UCBN IWQ database will consist of Microsoft Excel files generated from the Aquarius Time Series software (see SOP 9 – Continuous Water Quality Record Processing) and delivered from the laboratory responsible for macroinvertebrate sample identifications (see SOP 7 – Benthic Macroinvertebrate Sample Collection). The UCBN IWQ database uses automated data import routines to import records from these standardized MS Excel files into the database tables. The only direct data entry required is for the site inspection summary worksheet (see SOP 9), and the stream cross sectional survey measurements (see SOP 5 – Multiprobe Site Selection – Cross Section Survey). The UCBN IWQ database presents a user-friendly "switchboard" menu where the various data import, data entry, and data export forms are available (Figure 78)

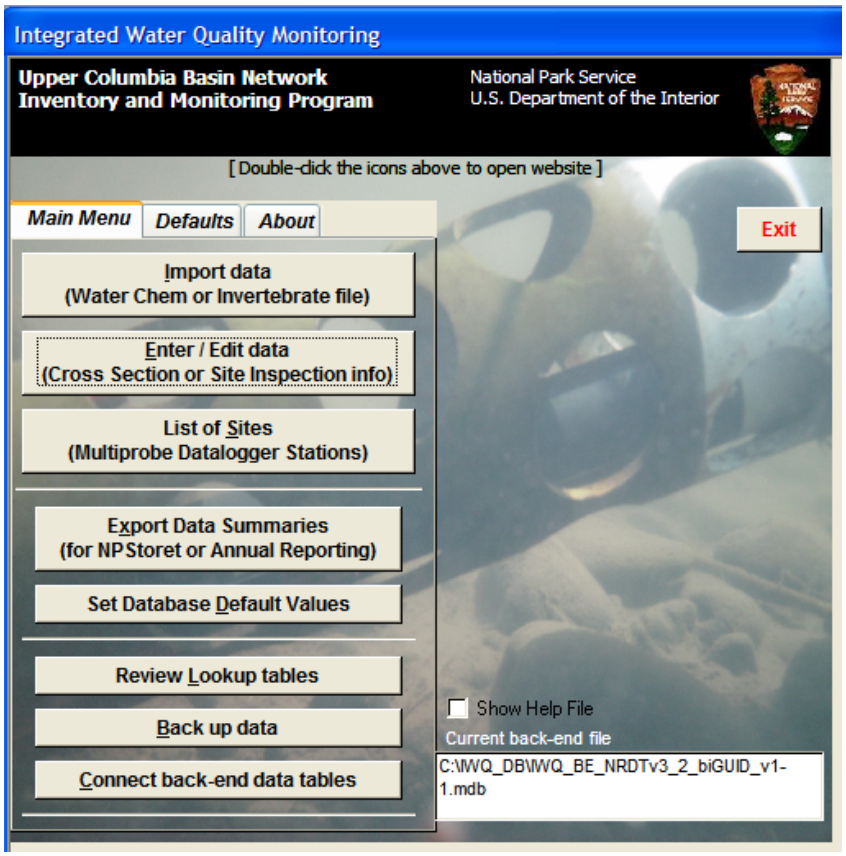


Figure 78. Screen shot of the UCBN Integrated Water Quality database front end.

Database Model

The UCBN WQ database structure conforms to the standards of version 3.2 of the Natural Resource Database Template (NRDT), and consists of a user interface front-end (holding data entry forms, data import and export procedures, and data summary queries) that is linked to a back-end database file (holding the core data tables for the integrated water quality protocol), an integrated UCBN data dictionary database file (holding various lookup tables shared across all UCBN protocols), and an integrated UCBN species database file (holding UCBN species data, from the NPSpecies database, also shared across all UCBN protocols). A logical data model for the integrated water quality protocol can be depicted as a collection of linked core data tables (Figure 79). In the context of the integrated water quality protocol, a site is a reach within a waterbody occurring within or immediately adjacent to a park boundary. A location is a point location (with specific X and Y coordinates) either where a multiprobe data logger has been deployed or representing the mid-point (X-site) of a reach within which macroinvertebrates have been sampled. An event is a sampling visit to a location – that is, either a site visit to calibrate and download data from a multiprobe data logger, or a site visit to collect macroinvertebrates, or a site visit to collect cross section transect data at a multiprobe location. All data associated with a sampling event are stored in the remaining core tables.

This set of core integrated water quality protocol tables is supported by a suite of lookup tables. These protocol-specific lookup tables provide the criteria for applying instrument drift corrections and correction ratings to multiprobe data; define the codes applied to cross section substrate size classes, vegetation types, vegetation cover classes, and riparian disturbance factors; and define the abundance, richness, diversity, community composition, functional group, and index measures applied in laboratory results from the macroinvertebrate samples. Each record within these lookup tables is associated with a particular version of the integrated water quality protocol, as is each event record, which allows changes to multiprobe data correction criteria, code definitions, or lab measures to be incorporated into the database and linked to individual records depending on the protocol version specified by the database user at the time of data import or entry. Lookup tables containing general information applicable to multiple UCBN protocols, such as park unit codes, coordinate systems, coordinate units, datums, UTM zones, and contacts (or observers), are stored in the integrated UCBN data dictionary database. The integrated UCBN species file contains lookup data for all species known to occur in UCBN parks (drawn from the NPSpecies database); in addition, linkages between specific UCBN protocols and species allow data entry species pick-list fields to be narrowed down to only those species associated with a given protocol. These integrated back-end database files allow for centralized record management, and facilitate distribution of updated versions of the integrated back-end files to project leaders and technicians using distributed versions of protocol databases.

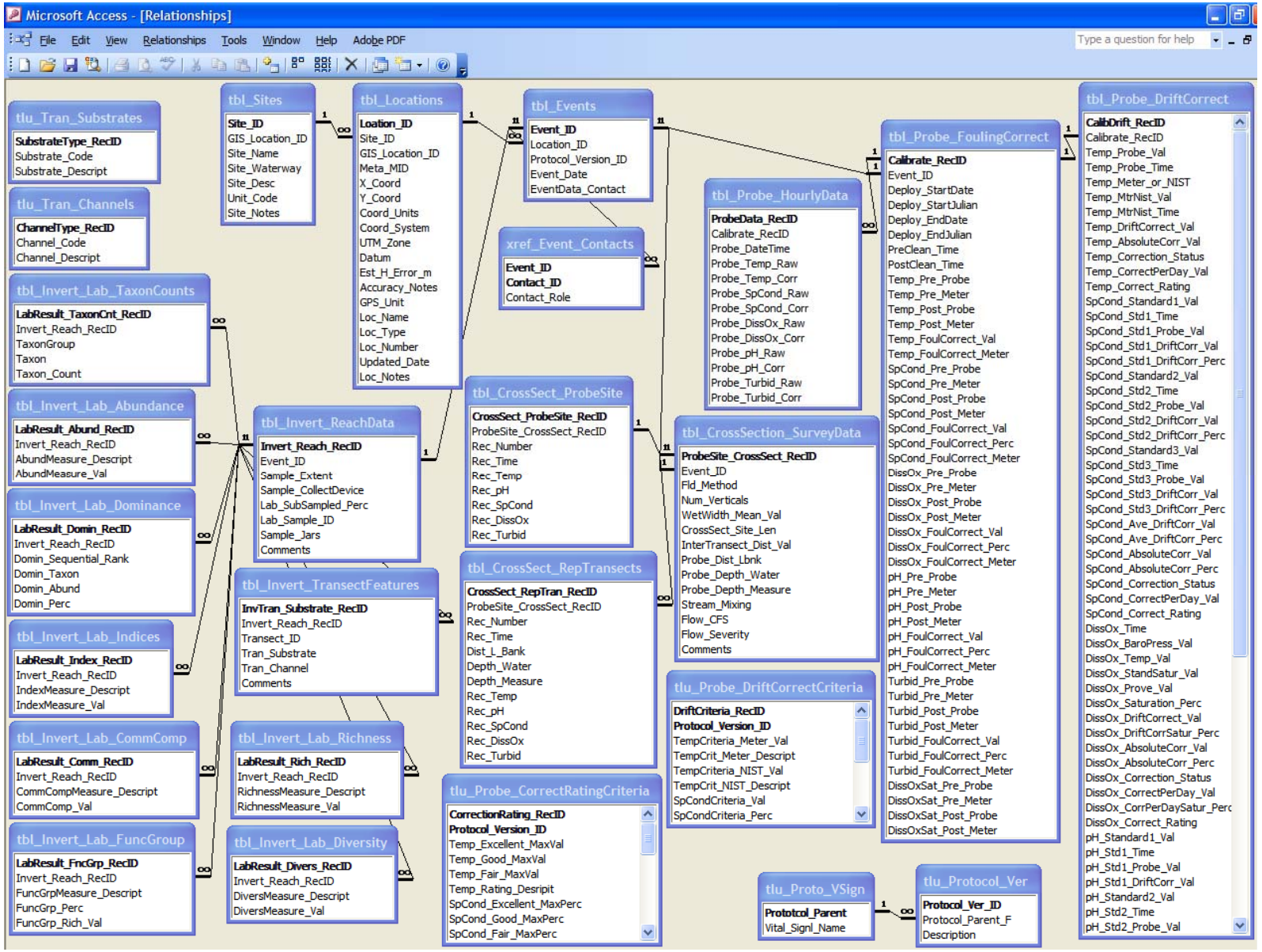


Figure 79. A logical data model for the UCBN Integrated Water Quality monitoring protocol.

Data Dictionary

The data dictionary (Appendix 6) provides a description for every table contained in the UCBN Integrated Water Quality database back-end file, and, for each table, provides each field name, the field type, the field size, and the field description.

Data Import

Multiprobe data logger records are imported into the UCBN WQ database from MS Excel files generated from the Aquarius Time Series software (see SOP 9). Record processing within Aquarius requires the application of calibration data from the site inspection summary worksheet which is manually entered into the UCBN WQ database. Macroinvertebrate data is imported into the UCBN WQ database from MS Excel files generated by the contracted laboratory that processes the invertebrate samples. These data import processes are handled by automated procedures developed within MS Access code modules, and require only that the user ensure that the MS Excel files are in the appropriate format and that the correct MS Excel file name is provided when importing data into the UCBN WQ database. Quality assurance components to check for missing data or illogical combinations have been built-in to these data import procedures, and will be improved upon in future versions of the database.

Quality Review

After the data have been entered and processed, they need to be reviewed by the Project Leader for quality, completeness, and logical consistency. The UCBN WQ database facilitates this process by providing queries that check for data integrity, data outliers and missing values, and illogical values. The user may then fix these problems and document the fixes. If errors and/or inconsistencies cannot be corrected, the resulting errors or inconsistencies are then documented and included in the metadata and certification report.

Metadata Procedures

Data documentation is a critical step toward ensuring that data sets are useable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, and condition of data. Additionally, metadata provide the means to catalog data sets within intranet and internet systems, making data available to a broad range of potential users. Metadata for all UCBN monitoring data will conform to Federal Geographic Data Committee (FGDC) and NPS guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized. For long-term projects such as this one, metadata creation is the most time consuming the first time it is developed – after which most information remains static from one year to the next. Metadata records in subsequent years will need to be updated to reflect current publications, references, taxonomic conventions, contact information, data disposition and quality, and to describe any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for metadata development and posting are outlined in the UCBN Data Management Plan. In general, the Project Leader and the Data Manager (or Data Technician) will work together to create and update an FGDC- and NPS-compliant metadata record in XML format. The Project Leader should update the metadata content as changes to the protocol are made, and each year as additional data are accumulated. Any edits within the document will be tracked so that any changes are obvious to those who will use it to update the XML metadata file. At the conclusion of the field season, the Project Leader will be responsible for providing a completed, up-to-date metadata interview form to the Data Manager. The Data Manager will facilitate metadata development by creating and parsing metadata records, and by posting such records to national clearinghouses as described below.

Sensitive Information

Part of metadata development includes determining whether or not the data include any sensitive information, which includes specific locations of rare, threatened, or endangered species. Prior to completing metadata, the Project Leader and Park Resource Manager should work together to identify any sensitive information in the data. Their findings should be documented and communicated to the Data Manager. We do not anticipate that sensitive information will be present in the water quality monitoring program at this time.

Data Certification and Delivery

Data certification is a benchmark in the project data management process that indicates that 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks; and 3) that they are appropriately documented and in a condition for archiving, posting, and distribution. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may not have been detected during quality assurance reviews.

To ensure that only data of the highest possible quality are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Project Leader is primarily responsible for completing certification. The completed form, certified data, and updated metadata should be delivered to the Data Manager as outlined in the following steps and in Table 19.

Data Certification Steps

To package the certification materials for delivery, the Project Leader should follow these steps:

1) After the quality review has been completed, open the back-end working database file and compact it (in Microsoft Access, Tools > Database Utilities > Compact and Repair Database). This will make the file size much smaller.

2) Create a compressed file (using WinZip® or similar software) and add the back-end database file to that file. Note: The front-end application does not contain project data and as such should not be included in the delivery file.

3) Add the completed metadata to the compressed file.

4) Add the completed certification report to the compressed file.

5) Add any geospatial data files that aren't already in the possession of the Data Manager.

6) All file names – except for image files and geospatial data files – should include the assigned UCBN project code, in addition to the year or span of years for the data being certified. For example: IWQ_2008_certified.mdb, IWQ_2008_cert_report.doc.

7) The compressed file may then be submitted to the UCBN Data Manager.

Upon receiving the certification materials, the Data Manager will check them in, store them in the UCBN Digital Library, upload the certified data to the master project database, and update the project GIS data sets with any geospatial data that are submitted. Upon notification that the year's data have been uploaded and processed successfully, the Project Leader may then proceed with data summarization, analysis and reporting.

Data Archiving

The water quality component of the Natural Resource Challenge (NRC) requires that Networks archive all physical, chemical, and biological water quality data collected with NRC water quality funds in the National Park Service's STORET database maintained by the NPS Water Resources Division (WRD). All water quality data collected by the UCBN will be managed according to guidelines from the NPS Water Resources Division (WRD). This includes facilitating the transfer of park and network water quality into suitable NPSTORET format, as dictated by WRD. UCBN data management staff will transfer all network water quality data, in an NPSTORET-compatible format, at least annually to WRD for upload to the STORET database Figure 80). Although WRD's data dissemination needs dictate a monthly schedule for uploads to their data warehouse, UCBN data collection and summation activities will be on an annual schedule requiring data uploads to the master WRD database only once a year.

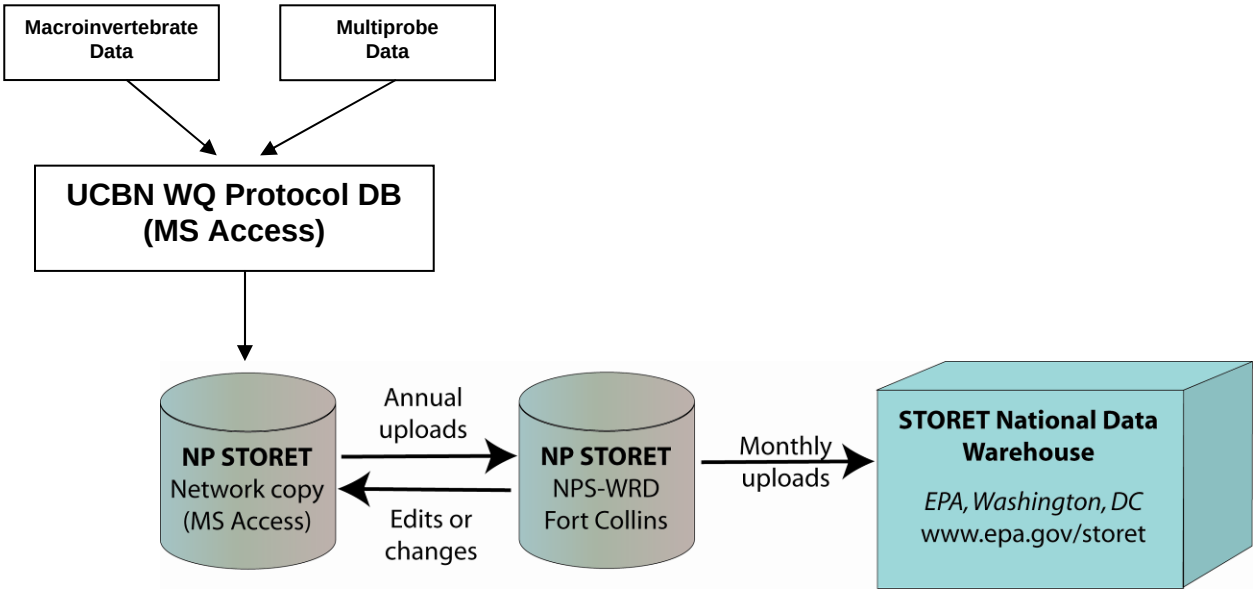


Figure 80. Data flow diagram for water quality data.

Upon certification, data and reports will be archived on the UCBN Network Attached Storage (NAS) unit, posted to the UCBN website, and posted to the national web-accessible secure databases hosted by the NPS Washington Areas Support Office (WASO) or National I&M program. These include:

NatureBib – the master database for natural resource bibliographic references.

NPSpecies – the master database for biodiversity information including species occurrences and physical or written evidence for the occurrence (i.e., references, vouchers, and observations).

NPS Data Store – a centralized data repository with a graphical search interface.

NPSTORET – a centralized data repository developed and maintained by NPS as a database to house ambient water quality data collected by Networks.

STORET – a centralized data repository developed and maintained by EPA as a database to house ambient water quality data collected by states, federal agencies, volunteer monitoring groups, and other entities.

A review of archive and expendable data products will be undertaken by the Project Leader and Data Manager during season close-out each year. An example of an expendable data product is an intermediate draft of an annual report that was saved during report preparation.

Directory Structure

The following directory structure will be used to store and archive all information related to the integrated water quality monitoring project on the UCBN Network Attached Storage (NAS) drive. This is a generic structure that should provide a foundation and a minimum standard of organization and consistency. The goal is to organize all project materials in an efficient hierarchical structure that reflects the life cycle and workflow of the project. Toward this goal, all subfolders are organized into four primary project folders that reflect life cycle stages (initiate, plan, implement, and close). Additional subfolders may be added as needed, but a strong emphasis must be placed on keeping the structure as simple and logical as possible. The four primary project folders and their standard subfolders are presented below.

\Initiate – Store information about the initiation of the project here, including proposals, contract agreements, relevant e-mails, etc.

\Agreements_Contracts
\Meetings_Correspondence
\Proposals

\Plan – Store information about the planning phase of the project here, including monitoring objectives, protocol development summaries, conceptual models, protocol and SOP drafts, study plans, and research permits.

\Conceptual_Models
\Data_Mng_Models
\Equipment
\Meetings_Correspondence
\Monitoring_Objectives
\Protocol_Develop_Summary
\Protocol_SOP_Drafts
\Research_Permits
\Study_Plans

\Implement – Store information about the implementation phase of the project here, including data management documents and draft products, data analysis documents and draft products, project photos, and relevant correspondence.

\Data_Analysis
\Data_Management

\Data_Dictionary
\PDA_Forms
\Database_Working
\Download_Files
\GPS_Files
\Datalogger_Files
\GIS_Data_Working
\Map_Products
\Templates
\Features
\Geodatabases
\Meetings_Coorespondence
\Photos
\Final
\Originals
\Working

\Close – Store finalized documents and products from the close-out phase of the project (on either an annual basis or a final project close-out basis) here, including final reports, certified data and GIS products, and presentations.

\Certified_Data_GIS_Metadata
\Final_Reports
\Annual_Reports
\Investigator_Annual_Reports
\Protocol_SOP_Final
\Other_Final_Deliverables
\Presentations

Schedule for Data Management Tasks

Table 19. Yearly integrated water quality data management task list. This table identifies tasks by project stage, indicates who is responsible for the task, and establishes the timing for its execution.

Project Stage	Task Description	Responsibility	Timing
Preparation	Notify Data manager of needs (field maps, GPS support, training)	Project Leader	ASAP, before Feb 1
	Prepare and print field maps and field forms	Project Leader/Data Manager	by April 1
	Provide database/GPS training as needed	Data Manager	by April 1
	Train field crew in EMAP field sampling protocols/Multiprobe calibration techniques	Project Leader/Field Leader/Data Manager	Early April
Data acquisition	Place multiprobe in streams for continuous monthly monitoring (after spring high flow)	Project Leader and/or Field Leader	May/June
	Collect macroinvertebrate sample	Project Leader and/or Field Leader	June - October
	Download multiprobe data monthly and review for completeness and accuracy	Field Leader/Park resource managers	Monthly
Data entry & processing	Import multiprobe data to Aquarius software for processing, and import resulting Excel files to UCBN WQ database	Project Leader and/or Technician	Monthly
Quality review	Quality review and data validation of multiprobe data using database tools	Project Leader/Data Manager	Monthly
Metadata	Identify any sensitive information contained in the data set	Project Leader	After each season
	Update project metadata records	Project Leader/Data Manager	November
Data certification	Certify the season's data	Project Leader/Data Manager	November
Data delivery	Deliver certified data and updated metadata to data manager	Project Leader	November
	Upload certified data into master project database, store data files in UCBN Digital Library [1]	Project Leader	November
	Notify Project Leader of uploaded data ready for analysis and reporting	Data Manager	November
	Update project GIS data sets, layers and associated metadata records	Data Manager	November
	Finalize and parse metadata records, store in UCBN Digital Library [1]	Data Manager	By Dec 1

Table 19 (continued). Yearly integrated water quality data management task list. This table identifies tasks by project stage, indicates who is responsible for the task, and establishes the timing for its execution.

Project Stage	Task Description	Responsibility	Timing
Data analysis	Status and trend analyses	Project Leader/Data Analyst	December
Product development	Acquire the proper report template from the NPS website, create annual report	Data Analyst	Dec – Jan
	Screen all reports and data products for sensitive information	Data Manager / Data Analyst	Dec – Jan
	Submit draft report to Network Coordinator for review	Data Manager / Data Analyst	Jan
	Review report for formatting and completeness, notify Project Leader of approval or need for changes	Network Coordinator	Jan
	Upload completed report to UCBN Digital Library[1] submissions folder, notify Data Manager	Project Leader	Feb
	Deliver other products according to the delivery schedule and instructions	Project Leader	Feb
Posting & distribution	Submit metadata to NR-GIS Data Store [2]	Data Manager	Feb
	Create NatureBib [3] record, post reports to NPS clearinghouse	Data Manager	Feb
	Update NPSpecies [4] records according to data observations	Data Manager	Feb
	Submit certified data and GIS data sets to NR-GIS Data Store [2]	Data Manager	Feb
Archival & records management	Store finished products in UCBN Digital Library [1]	Data Manager	Feb
	Review, clean up and store and/or dispose of project files according to NPS Director's Order #19 [5]	Project Leader	Feb
Season close-out	Meet to discuss the recent field season, and document any needed changes to field sampling protocols or the working database	Project Leader, Park Resource Managers, and Data Manager	Jan – Feb
	Discuss and document needed changes to analysis and reporting procedures	Project Leader, Park Resource Managers, and Data Manager	Jan - Feb

[1] The UCBN Digital Library is a hierarchical digital filing system stored on the UCBN file server. Network users have read-only access to these files, except where information sensitivity may preclude general access.

[2] NR-GIS Metadata and Data Store is a clearinghouse for natural resource data and metadata (http://science.nature.nps.gov/nrdata). Only non-sensitive information is posted to NR-GIS Metadata and Data Store. Refer to the protocol section on sensitive information for details.

[3] NatureBib is the NPS bibliographic database (http://www.nature.nps.gov/nrbib/index.htm). This application has the capability of storing and providing public access to image data (e.g., PDF files) associated with each record.
[4] NPSpecies is the NPS database and application for maintaining park-specific species lists and observation data (http://science.nature.nps.gov/im/apps/npspp/index.htm).
[5] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at:
http://www.nps.gov/refdesk/DOrders/DOrder19.html

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 11: Data Analysis and Reporting

Version 1.1, February 2013

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0
1.0	February 2013	UCBN- Eric Starkey	Updates to Table 20- Regulatory thresholds for UCBN streams. Updated resource brief example in Figure 85.	Outdated standards	1.1

Note: This SOP describes details of the recommended analytical approaches and reporting guidelines for the UCBN Integrated Water Quality monitoring program.

Suggested Reading

Allan, J.D. 1995. Stream ecology: structure and function of running waters. Chapman and Hall. London.

Starkey, E. N., L. K. Garrett, T. J. Rodhouse, G. H. Dicus, and R. K. Steinhorst. 2009. Integrated Water Quality Monitoring Protocol Narrative, Upper Columbia Basin Network. Natural Resource Report NPS/PWR/UCBN/NRR—2008/00xx. National Park Service, Fort Collins, Colorado.

Hayslip, G., editor. 2007. Methods for the collection and analysis of benthic macroinvertebrate assemblages in wadeable streams of the Pacific Northwest. Pacific Northwest Aquatic Monitoring Partnership, Cook, Washington.

Helsel, D.R., and R.M. Hirsch. 2002. Statistical methods in water resources: Techniques of water-resources investigations of the United States. Geological Survey Book 4: Hydrologic Analysis and Interpretation Chapter A3.

van Belle, G. and J.P. Hughes. 1984. Nonparametric Tests for Trend in Water Quality. Water Resources Research **20**:127-136.

Analytical Procedures

The statistical methods outlined below, particularly those assessing trend, may be implemented using the statistical freeware R, an open source version of S-Plus. R is a powerful system for statistical computations and graphics, which runs on Windows, Unix, and Mac computers. R is a combination of a statistics package and a programming language. It can be downloaded for free from http://www.r-project.org/ . The R Wiki provides an online forum http://wiki.rproject.org/rwiki/doku.php and documentation. R is the analytical environment of choice for the Upper Columbia Basin Network however; some of the initial power analyses for this protocol were completed in SAS by a University of Idaho consulting statistician.

Overview

Data analysis and reporting consists of two primary tasks: calculating summary statistics and describing trend, and preparing reports. Annual reports will include summary statistics while 5-year reports will include analyses of trends and recalculation of power analyses after pilot data is available. The procedures for each major monitoring component — core water quality and macroinvertebrates—are described below.

Data Analysis Procedures for Multiprobe Core Parameters

Multiprobe data will be used to examine patterns of status, variability, and trend in core water quality parameters with respect to established water quality criteria (Table 20).

Once multiprobe data have been acquired, quality checked, and submitted to the UCBN Data Manager, the Project Lead and Data Manager will collaboratively generate report tables with descriptive statistics using automated scripts that will ensure quality control of the analysis. Analyses may be undertaken in a database program (e.g., Microsoft Access) or data may be uploaded and analyzed using a script within R or other suitable software package. Regardless, the scripts used to calculate summary statistics will be included in a revision to this SOP following testing and implementation.

Table 20. Regulatory thresholds for UCBN streams. Thresholds are set by state DEQs and consequently differ considerably among parks

Park	Waterbody	Temperature	pH	Dissolved Oxygen	Conductivity/TDS	Turbidity
BIHO	Big Hole River	"A 1ºF (0.56ºC) maximum increase above naturally occurring water temperature is allowed"	6.0-8.5; < 0.5 unit human induced change; Maintain >7.0 if naturally > 7.0	Daily minimum > 8.0 mg/L; 7-d mean > 9.5 mg/L (Early life stage- applicable 16 July to 30 Sept.) 1-day minimum >4.0 mg/L; 7-d mean minimum > 5.0 mg/L; 30 day mean >6.5 mg/L (Other life stages applicable to data collected 20 June to 15 July and 1 Oct. to 17 Oct.)	Not designated	"No increase above natural turbidity is allowed"
CIRO	Circle Creek/Almo Creek	MDMT < 22 C; MDAT < 19 C	6.5-9.0	> 6.0 mg/L	Not designated	< 50 NTU (instaneous); < 25 for 10 consecutive days
JODA	Bridge Creek, John Day River, Rock Creek	7 day average < 18 °C (salmon/trout rearing/migration)	6.5-9.0	> 6.5 mg/L instantaneous (cool water, non-spawning)	TDS < 500 mg/L	< 10% cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity
NEPE	Jim Ford Creek, Lapwai Creek	MDMT < 22 C; MDAT < 19 C	6.5-9.0	> 6.0 mg/L	Not designated	< 50 NTU (instaneous); < 25 for 10 consecutive days
WHMI	Doan Creek, Mill Creek	7-DADMax <16 °C	6.5-8.5 with < 0.5 unit human-induced change	>9.5 mg/L Minimum Daily Minimum	Not designated	< 5 NTU increase above background when background NTU < 50, < 10% increase when background NTU > 50

Notes: MDMT – Maximium Daily Maximum Temperature, MDAT – Maximum Daily Average Temperature, 7-DADMax: 7-d average daily maximum

Status of Core Water Quality Parameters

Seasonal and annual patterns in the mean and variability of core water quality parameters will be reported in tabular form following the format in Table 21. The proportion of observations in exceedance is calculated using DEQ regulatory thresholds from Table 19.

Table 21: Summary of descriptive statistics for core water quality parameters for a spring and late summer sampling period at Lapwai Creek, 2007 (NEPE).

Season		Temp (°C)	pH	Conduct.	Turbidity (NTU)	DO (mg L^{-1})
Spring	N	390	390	390	390	390
(4/16-4/24)	Mean	9.528	7.988	151.056	32.167	10.690
	Standard Dev	1.909	0.179	7.824	143.163	0.552
	Median	9.42	7.9	151	0	10.68
	Minimum	5.64	7.79	136	0	9.41
	Maximum	14.21	8.46	171	1530	11.92
	C.V.	0.200	0.022	0.052	4.451	0.052
	% exceedance	0	0	0	10%	0
Late Summer	N of cases	1138	1138	1138	1138	1138
(9/18-9/30)	Mean	13.756	8.579	255.002	2.976	10.871
	Standard Dev	2.371	0.492	40.415	89.134	1.900
	Median	13.66	8.79	259	0	11.53
	Minimum	8.61	5.98	0	0	7.2
	Maximum	15.51	9.19	276	3000	15.52
	C.V.	0.172	0.057	0.158	29.953	0.175
	% exceedance	0	0	0	0.20%	0

In addition to tabular summaries, plots of time series and exceedance conditions for each parameter will quickly convey status. Figures 81 and 82 provide examples for turbidity and dissolved oxygen for Lapwai Creek.

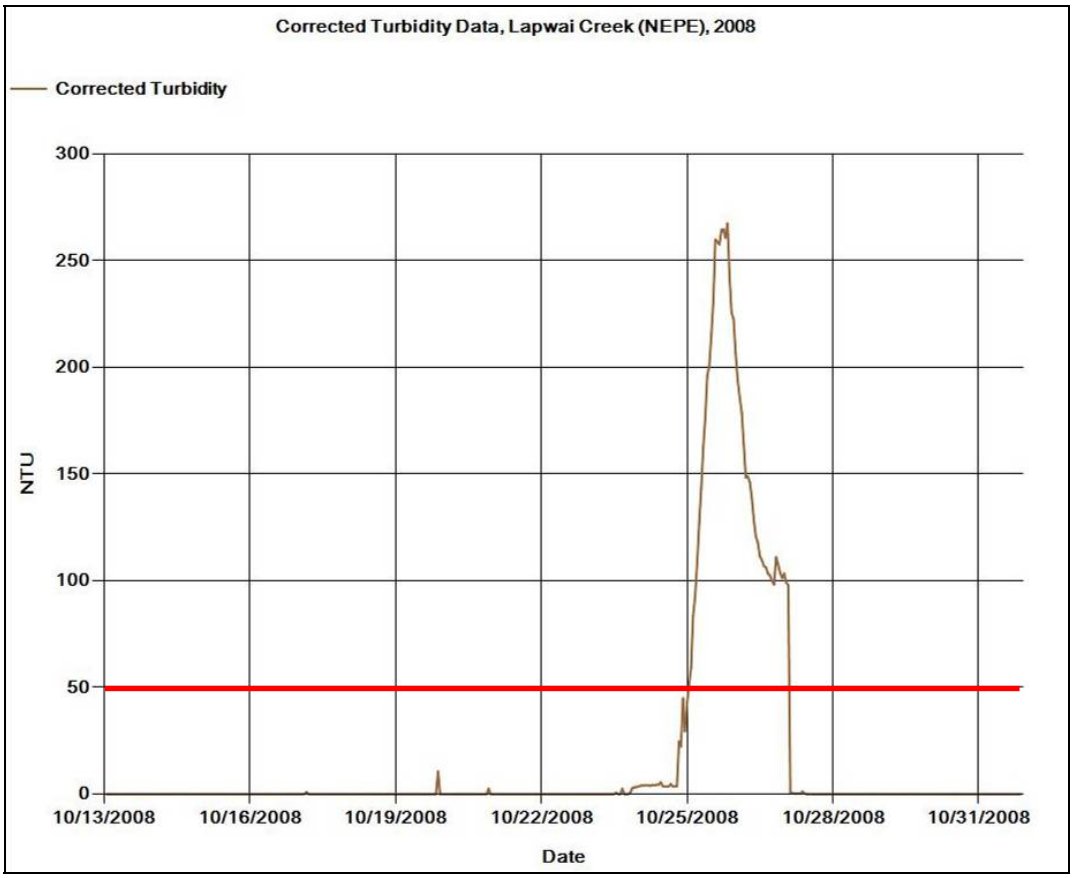


Figure 81. Example summary plots of corrected turbidity data collected using a Hydrolab MS-5 multiprobe at Lapwai Creek (NEPE) during 2008. The red line indicates the regulatory threshold set by the DEQ (50 NTU). Note that the spike in turbidity between October 24th and 27th corresponded to a large rain event within the basin.

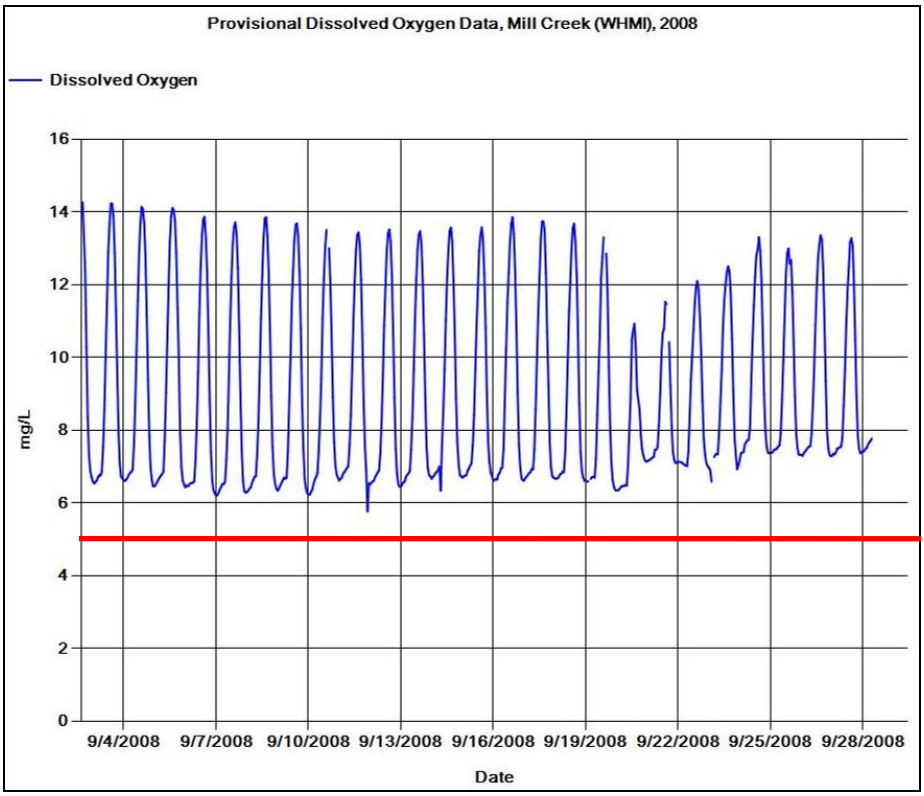


Figure 82. Example summary plots of provisional dissolved oxygen data collected using a Hydrolab MS-5 multiprobe at Mill Creek (WHMI) during 2008. The red line indicates the regulatory threshold set by the DEQ (5.0 mg/L).

Annual reports will include short narratives highlighting conditions that are out of bounds for state criteria, other major results and recommendations for future monitoring.

Trend in Core Water Quality Parameters

Long-term trend is measured on a scale of years and may be blocked by months. Trend analysis will use a repeated measures analysis with months as the sampling units (blocks) and years as the repeated measures (treatments). Each year we will obtain one replicate reading for each month (May thru October). For example, at Lapwai Creek we will obtain six observations per year. The long-term monitoring data table consists of readings arranged in years and months. The parametric analysis of simple repeated measures of monthly data over years is equivalent to a randomized complete block ANOVA (van Belle and Hughes 1984). One can also use the seasonal Mann-Kendall test (Helsel and Hirsch 2002). Tests for linear trend in each core water quality parameter will be conducted once every five years. If we consider only the first and last years of data, we can test for a step trend using the Wilcoxon signed rank test.
The means table appears below, where μ is the unknown population mean and subscripts represent year and month, respectively:

YR/Month	$Month_1$	$Month_2$	…	$Month_s$
$Year_1$	μ_{11}		…	μ_{1S}
$Year_2$	μ_{21}		…	μ_{2S}
:	:	:		:
$Year_t$	μ_{t1}		…	μ_{tS}

Power Analysis of Core Water Quality Parameters

We evaluated our ability to detect a $\pm$20% change in the means of core parameters over 10 years with 80% power and 5% acceptable false-change error (α or Type I error). The null hypothesis is that the monthly means do not change monotonically over time at a rate greater than expected from natural variability. There are two alternative hypotheses, 1) the μ's may change linearly over the 10 years (an 0.02 annual rate of linear change) or 2) there is a step change from year 1 to year 10. In the linear case, the pattern of means in the above table would increase or decrease by 2% each year. Using average monthly temperature for Lapwai Creek as an example, we used sample means from recent years for March (spring), June (summer), September (fall), and December (winter) to give us realistic values for initial conditions (μ_{11}, μ_{12}, μ_{13}, and μ_{14}) (see tables below).

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1998	.	.	.	.	.	.	15.1	14.2	16.9	21.8	20.3	17.7
2000	.	.	.	.	.	.	12.0	14.2	17.4	19.4	18.9	15.0
2001	.	7.3	4.7	.	.	.	.	.	.	.	.	.
2002	11.1	.	.	4.7	4.4	5.0	8.7	13.1	16.6	20.5	17.8	15.0
2003	.	.	.	.	.	.	.	.	17.6	19.8	18.6	15.0

We then increased each μ_{ij} by 2% per year within each month to create a table of μ_{ij}'s consistent with the linear alternative hypothesis. As a result, the means for year 10 are 20% higher than year 1.

Obs	MAR	JUN	SEP	DEC
1	5.00000	17.1200	15.6700	4.74000
2	5.11111	17.5004	16.0182	4.84533
3	5.22222	17.8809	16.3664	4.95067
4	5.33333	18.2613	16.7147	5.05600
5	5.44444	18.6418	17.0629	5.16133
6	5.55556	19.0222	17.4111	5.26667
7	5.66667	19.4027	17.7593	5.37200
8	5.77778	19.7831	18.1076	5.47733
9	5.88889	20.1636	18.4558	5.58267
10	6.00000	20.5440	18.8040	5.68800

We estimated the standard deviation by calculating the square root of the mean square error. Using the SAS function *proc glmpower* with $\alpha = 0.05$, the μ_{ij}'s in the table above, SD=1.1, and an overall sample size of 40, we obtained a power of 0.96. That is, we have a 96% chance of detecting an increase of 20% in temperature by the end of 10 years. If we use the Mann-Kendall test, we would need about 10% more data, i.e., another year (Irwin 2008)

Preliminary power analyses using multiprobe data from Lapwai Creek for two seasons (April and September 2007) are detailed below (Table 22). The results suggest power to detect a 20% linear change in core water quality parameters will be quite good for most parameters (mean temperature = 0.90; minimum temperature = 0.74; specific conductivity = 0.99; dissolved oxygen = 0.99). Higher variability in maximum temperature, and very high variability in turbidity resulted in lower or poor power for these two parameters (maximum temperature = 0.49; turbidity = 0.06). While the power to detect long term trends (defined as 20% change over 10 years) in turbidity was poor, the importance of sedimentation as an impairment in some UCBN streams (e.g., John Day River) justifies estimating this parameter for both status and trend. Graphical tools, such as is illustrated in Figure 81, can be very effective in describing turbidity dynamics over time, as can alternative summaries, such as the number of times turbidity exceeds the threshold criterion over a period of time.

Table 22. Power analyses results for four core parameters for Lapwai Creek at Nez Perce National Historical Park for April and September 2007.

Lapwai Creek	April	September	σ	Power
Avg temp	$\mu_{11} = 9.66$	$\mu_{12} = 12.79$	1.35	0.9
Min temp	$\mu_{11} = 7.85$	$\mu_{12} = 10.4$	1.36	0.74
Max temp	$\mu_{11} = 11.58$	$\mu_{12} = 15.31$	2.69	0.49
SC	$\mu_{11} = 152.8$	$\mu_{12} = 261.7$	8.55	0.99
Turbidity	$\mu_{11} = 34.4$	$\mu_{12} = 1.0$	25	0.06
Dissolved oxygen	$\mu_{11} = 10.63$	$\mu_{12} = 10.33$	0.55	0.99

Data Analysis Procedures for Macroinvertebrate Data

Macroinvertebrate Status

Each year, a multimetric approach will be used to determine and summarize the status of macroinvertebrate assemblages and water quality relative to reference sites. The UCBN will follow the general procedures for multimetric index development established by Jessup et al. (2006) and Barbour et al. (1999). Figure 83 illustrates the flow of information when using indices in the analysis of macroinvertebrate data.

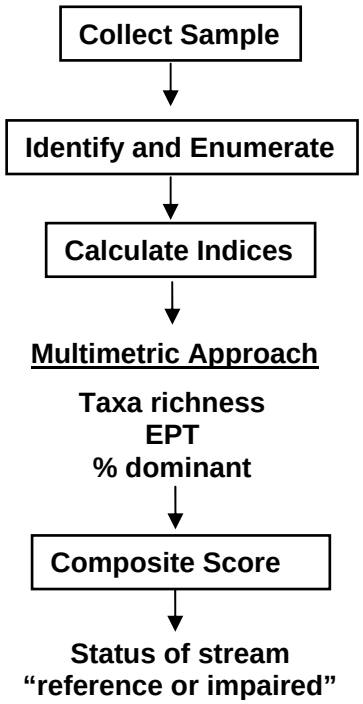


Figure 83. Conceptual model illustrating the flow of information when using indices in the analysis of macroinvertebrate data.

Multimetric indices include attributes of the assemblage thought to reflect biodiversity (taxon richness; number of Ephemeroptera, Plecoptera, Trichoptera taxa [EPT taxa; mayfly, stonefly, caddisfly taxa]), sensitivity to organic pollution (Hilsenhoff Biotic Index [HBI]), community evenness (% dominant taxon), trophic structure (% predators, % shredders), or other functional groupings (e.g., % burrowers) (Barbour et al. 1999, Karr and Chu 1999). The observed multimetric value for each index is compared to threshold or benchmark values for regional streams, when available. An overall composite index estimates overall water quality. Examination of individual metrics or indices can provide clues to the causes of assemblage shifts. For instance, shifts in HBI values could indicate changes in pollutant sources because this metric includes tolerance values for organic pollutants, while a shift in the percent predators could indicate a shift in the food web resulting from changing land use surrounding a stream. Table 23 lists the metrics that are currently used by state and federal agencies within the UCBN region. Metrics for the integrated water quality protocol will be selected after consultation with

the EPA, state DEQ, and macroinvertebrate taxonomists based on utility, robustness and comparability.

As indicated by Barbour et al. (1999) metrics should have a high degree of utility, in that they are ecologically relevant to the community of interest, are sensitive to stressors, and provide a response that can be separated from natural variation. The metrics that are chosen should also be robust and respond in a relatively predictive manor to stressors such that a suite of metrics become a reliable diagnostic tool. Having metrics that are similar to those used by state and federal agencies will allow our data to be easily integrated with other monitoring activities. Furthermore, by selecting similar metrics we will be able to use established reference sites for comparison to UCBN monitoring locations. After calculating individual metrics, a composite score is calculated. This composite score is compared to those for streams identified prior to analysis as "reference or impacted" based on watershed condition and impairments to water quality. Reference and impacted sites will be determined based on information provided by state and federal agencies in the UCBN region. As reference sites are developed and become available for UCBN waterbodies, comparisons will be made with reference sites at the end of each collection season.

Figure 84 illustrates a hypothetical example of macroinvertebrate data analysis using a multimetric approach. Sample data (blue circles) are compared to a distribution of values observed for many samples (box plots) taken from reference and impacted streams in the same region (mountainous streams in western Montana). The individual scores for replicate samples are shown adjacent to the mean and a confidence interval to the right. These hypothetical data indicate that the stream was in a reference or unimpacted condition. Each year a similar graph will be constructed for each park, in addition to tables that list individual metric scores.

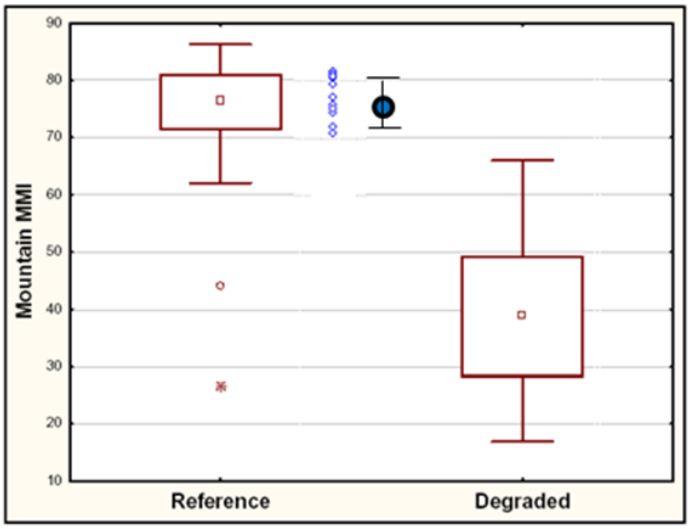


Figure 84. Hypothetical examples of macroinvertebrate data analysis using a multimetric approach. Sample data (blue circles) are compared to a distribution of values observed for many samples (box plots) taken from reference and impacted streams in the same region (mountainous streams in western Montana). Figures modified from Jessup et al. (2006).

Table 23. Candidate metrics for macroinvertebrate multimetric analysis (modified after Barbour et al. 1999; Grafe 2002; Wiseman 2003; OWEB 1999; Montana DEQ 2006). Potential metrics for UCBN water quality monitoring program are highlighted in grey.

Metric	Definition	Predicted Response to Increasing Perturbation	State / Federal Agencies Using Metric
Richness measures			
Total Taxa	Number of distinct taxa in the macroinvertebrate assemblage	-	MT, ID, WA, OR, EPA
EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	-	MT, WA, EPA
Ephemeroptera taxa	Number of mayfly taxa	-	MT, ID, WA, OR, EPA
Plecoptera taxa	Number of stonefly taxa	-	MT, ID, WA, OR, EPA
Trichoptera taxa	Number of caddisfly taxa	-	ID, WA, OR, EPA
Sensitive Taxa	This is the number of taxa identified that are known to be very sensitive to stream disturbance. (OR)	-	OR

Sediment Sensitive Taxa (OR)	Some taxa are known to be very sensitive to inputs of fine sediment. The presence of one or more of these taxa indicates that fine sediments are probably not a major concern. (OR)	-	OR
Composition measures			
%EPT	Percent of the sample that is mayfly, stonefly, and caddisfly larvae.	-	MT, WA, OR, EPA
% Ephemeroptera	Percent of sample that is mayfly nymphs	-	WA, OR, EPA
% Plecoptera	Percent of sample that is stonefly nymphs	-	ID
%Chironomidae	Percent of sample of the midge family of flies	+	WA, MT
% Tanypodinae	Percent of the individuals in the sample that are in the subfamily Tanypodinae (Diptera: Chironomidae)	-	MT
% Crustacea & Mollusca	Percent of the individuals in the sample that are Crustacea or Mollusca	+/-	MT
Tolerance/Intolerance measures			
Number of Tolerant Organisms (0-1)	Taxa richness of those organisms considered to be most sensitive to perturbation (with a tolerance value of 0 or 1)	+	EPA
Number of Intolerant Organisms (0-3)	Taxa richness of those organisms considered to be sensitive to perturbation (with a tolerance value of 0 to 3)	-	WA
Hilsenhoff Biotic Index (HBI)	Abundance-weighted average tolerance of	+	MT, ID, WA, OR

	organisms to pollution. Originally designed to evaluate organic pollution (Hilsenhoff 1987).		
% Tolerant Organisms	Percent of sample considered to be tolerant of various types of perturbation (with tolerance values of 7 to 10)	+	WA, OR, EPA
% Sediment Tolerant Taxa	This is the percent of the invertebrate community made up of taxa tolerant to fine sediments (OWEB, 2001).	+	OR
Feeding measures			
% Filterers / Collectors	Percent of individuals that scavenge or filter organic matter	+/-	MT, WA, EPA
% Grazers	Percent of individuals that graze upon periphyton	-	EPA
Scraper taxa	Number of taxa that scrape periphyton from substrates	-	ID
% Scrapers	Percent of sample that are scrapers	-	MT, WA, EPA
% Predators	Percent of the sample that are predators but not omnivores	+/-	MT, WA
Habitat measures			
Number of Clinger taxa	Number of taxa that have fixed retreats or adaptations for attaching surfaces in flowing water.	-	ID, EPA
% Clingers	Percent of sample that are clingers	-	WA, EPA
% Burrower	Percent of the taxa in the sample that burrow in soft sediments	+	MT

Diversity measures			
Shannon-Wiener Index	A measure of the heterogeneity of the community or of the diversity of dominant taxa (Shannon and Weaver 1949)	-	None
Simpson's Index	The probability of randomly and independently selecting the same taxa from the sample twice (Simpson 1949)	+	None
% Dominant Taxon/Dominant 5 Idaho	Percent of sample in the single most abundant taxon. Also calculated as dominant two, three, five, or 10 taxa.	+	ID, OR,EPA
Voltinism measures			
Semi-voltine taxa (long lived richness, WA)	Number of taxa that have aquatic life cycles lasting more than one year.	-	WA

Macroinvertebrate Trend Analysis

Trend in macroinvertebrate assemblage structure will be evaluated after the first 2 sampling rotations and after each rotation thereafter. Two-sample tests (step trend *sensu* Helsel and Hirsch 2002) such as the *t*-test and Wilcoxon rank-sum test may be used to detect statistically significant changes between any two sampling periods. However, given up to 6 replicates per sampling period, power will be restricted to detect only large changes. Once several years of sample data become available, linear trends in measures such as % EPT as a function of time can also be evaluated (Helsel and Hirsch 2002). Simple graphical tools to display biologically important changes in macroinvertebrate indicators over time will also be very powerful.

Macroinvertebrate Power Analysis

Currently, assessing statistical power for macroinvertebrate indices is difficult for UCBN streams because within-site and interannual estimates of variability in macroinvertebrate assemblage structure are not yet available. Available data from regional streams suggests that increasing sample size (e.g., number of replicates/site) decreases variability and improves the probability of detecting uncommon or rare species. For example, in Wyoming streams, increasing the number of samples at each location asymptotically reduces the mean change in taxa richness between samples (Gary Lester, EcoAnalysts, Inc., personal communication). The data from Wyoming suggests that six replicates per stream should provide a reasonable trade-off between cost and power. After the first rotation of sampling, the sampling design for macroinvertebrates will be revisited to estimate power using estimates of variability obtained from the first samples. In particular the evaluation will examine whether it is reasonable to reduce the number of replicates per stream and use these sample resources to increase the spatial extent (add more streams) or temporal frequency of macroinvertebrate sampling (e.g., move to a 2 year rotating panel).

Reporting

A summary report will be produced annually, with a more detailed status and trend report produced every five years. The annual summary will:

- List project personnel and their roles.
- List locations sampled during the current year.
- Provide a summary history of the macroinvertebrate samples taken during each year of monitoring and mean monthly calculations for core water chemistry parameters by location and park.
- Provide descriptive summaries for each core water quality parameter at each sampling location plotted against the DEQ regulatory threshold.
- Provide trend estimates for each core water quality parameter after five years.
- Provide macroinvertebrate metrics at the end of each sampling season.
- Provide macroinvertebrate trend analysis after the first two sampling rotations.
- Evaluate data quality and identify any data quality concerns and/or deviations from protocols that affect data quality and interpretability.
- Evaluate and identify suggested or required changes to the protocol.

The annual summary will be developed following the standards for the Natural Resource Technical Report series (http://www.nature.nps.gov/publications/NRPM/index.cfm). This report will be assigned a report series number following peer-review and will be posted to the NRTR series website (http://www.nature.nps.gov/publications/NRPM/nrtr.cfm). A one to two page resource brief will be prepared annually for interpretive staff and the public, and will be provided to park interpretive staff for distribution to interested visitors. Figure 85 illustrates the resource brief template currently in use by the UCBN for Integrated Water Quality Monitoring. An NPS template for producing maps with ESRI ArcGIS or ArcView software is available at http://imgis.nps.gov/templates.html. The proportion of observations above or below the DEQ regulatory threshold will be reported annually in the resource brief along with any unusual observations (new taxa, high flow events, invasive species, etc.). Data from annual monitoring efforts will be used to populate and update the Natural Resource Summary Tables maintained by each park in the Network.

A more in-depth analysis and report will be produced approximately every five years, or as the importance of emerging information warrants. This report will provide greater analytical and interpretive detail, and will evaluate the relevance of findings to long-term management and restoration goals. The report should also evaluate operational aspects of the monitoring program, such as whether the sampling period remains appropriate.

The 5-year status and trend report should use the NPS Natural Resource Publications Natural Resource Technical Report (NRTR) template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. This template, guidelines for its use and documentation of the NPS publication standards are available at the following address: http://www.nature.nps.gov/publications/NRPM/index.cfm.

Upper Columbia Basin Network
Inventory and Monitoring

National Park Service
U.S. Department of Interior

Water Quality Monitoring in Nez Perce National Historical Park (NEPE) - Spalding

Importance

Freshwater habitats are diverse and productive ecosystems, providing habitat for aquatic plant, invertebrate, and vertebrate species including many fishes and birds. Rivers and streams are intimately connected to riparian zones, providing habitat for many specialist species. Additionally, most upland animals rely on aquatic habitats to one degree or another.

Water resources in the semi-arid west have been strongly affected by human activity, and many Upper Columbia Basin Network (UCBN) streams and rivers are listed by states as impaired for one or more parameters. Most UCBN waterbodies and many aquatic resources, such as migratory fish, are strongly influenced by activities in the larger watersheds outside park boundaries. Understanding the current status of freshwater ecosystems will help guide management and restoration efforts and provide insight into ecosystem change in a landscape with shifting climate and dynamic human influences.



Lapwai Creek looking downstream from the water quality monitoring station, August 2011.

Status of Lapwai Creek in NEPE - Spalding

Threats to water resources in NEPE have been listed as: point and non-point discharge from upstream sources, agriculture, logging, grazing, recreation, highway runoff and urbanization. In 2010, Lapwai Creek was listed as a category 3 water by the state of Idaho meaning that it had not been assessed to determine if it meets state water quality standards ([a] ID DEQ 2011). In 1998, Lapwai Creek was on the 303(d) list for pollution problems related to: bacteria, flow alteration, habitat alteration, nutrients, sediment, dissolved oxygen and temperature. In 2011, the UCBN monitored 5 core water chemistry parameters in Lapwai Creek including: dissolved oxygen, pH, specific conductance, temperature, and turbidity. Each parameter was evaluated hourly between the months of June and November using a continuous water quality monitor. In addition, aquatic macroinvertebrates were collected according to United States Forest Service (USFS) - PACFISH/INFISH Biological Opinion Effectiveness Monitoring (PIBO-EM) Program protocol. For more on macroinvertebrates please see the integrated water quality annual report for NEPE on the UCBN website listed below:

- Water temperature exceeded the state standard designated for cold water aquatic life (MDMT <22 °C and MDAT< 19 °C) during 27% and 17% of observations respectively. These data suggest the need for an increase in stream shading via riparian vegetation basin wide.
- pH levels exceeded the upper criteria of 9.0 pH units during 14% of observations and may indicate pollution from an upstream source.

UCBN water quality monitoring is conducted on a 3 year rotating panel. Lapwai Creek will be sampled for water chemistry and macroinvertebrates again in 2014.The following table is a summary of findings from 2011 monitoring along with state regulatory thresholds for Lapwai Creek.

Lapwai Creek Water Chemistry Summary 2011

Measure	*Current Condition (June-November, 2011)*	*State DEQ Thresholds[b]*	*% Exceedance[c]*
Temperature	*MDMT=24.31 °C	*MDMT<22 °C	27%
(*MDMT, **MDAT)	**MDAT=21.04 °C	**MDAT<19 °C	17%
Specific Conductance (mean)	273.19 µS/cm	N/A	N/A
Dissolved Oxygen (mean daily min)	8.24 mg/L	>6.0 mg/L	0%
pH (mean daily max)	9.0 pH Units	9.0 pH Units, Max	14%
pH (mean daily min)	7.9 pH Units	6.5 pH Units, Min	0%
Turbidity (mean daily max)	104.4[d]	< 50 NTU over background (instantaneous) < 25 for 10 consecutive days	Insufficient data
E. coli	46.7 MPN/100 ml	< 406 *E. coli*/100 ml	0%
Fecal Coliform	22 MPN/100 ml	< 500 cfu/100 ml	0%

**MDMT – Maximum Daily Maximum Temperature, **MDAT – Maximum Daily Average Temperature, [a] Idaho Department of Environmental Quality. 2011. Idaho Department of Environmental Quality. Final 2010 Integrated Report. Boise, ID: Idaho Department of Environmental Quality. [b] Criteria for cold water life designation. [c] Proportion of samples above water quality standard. [d] Mean daily max based on 2 months of data due to poor data quality.*

Upper Columbia Basin Network
105 East 2nd St., Suite #7
Moscow, ID 83843
http://science.nature.nps.gov/im/units/ucbn/monitor/waterquality/waterquality.cfm

November 2011

Figure 85. Resource brief template for annual vital signs reporting to park staff and the public.

Schedule for Monitoring Project Deliverables

Table 24. Schedule for integrated water quality monitoring project deliverables.

Deliverable Product	Primary Responsibility	Target Date	Destination(s)
Raw data files	Field Leader	November of each year	UCBN Digital Library [1]
Certified working database and geospatial data with draft metadata	Project Leader with Data Manager assistance	December 15	Master project database and GIS data sets, copy to UCBN Digital Library [1], and NR-GIS Metadata and Data Store [2]
Full metadata (parsed XML)	Data Manager	January 15	NR-GIS Metadata and Data Store [2], UCBN Digital Library [1]
Resource Brief	Project Leader	February 1 of following year	UCBN website
Annual report (for internal purposes)	Project Leader	March 1 of following year	NatureBib [3], UCBN Digital Library [1], printout to local park collections
5-year analysis report	Project Leader	Every 5 years by March 1 of 6th year	NatureBib [3], UCBN Digital Library [1], printout to local park collections
Other publications	Network Coordinator, Project Leader, Data Manager	As completed	NatureBib [3], UCBN Digital Library [1], printout to local park collections
Other records	Network Coordinator, Project Leader	Review for retention every December	Retain according to NPS Director's Order #19 [4]

[1] The UCBN Digital Library is a hierarchical digital filing system stored on the UCBN file server. Network users have read-only access to these files, except where information sensitivity may preclude general access.
[2] NR-GIS Metadata and Data Store is a clearinghouse for natural resource data and metadata (http://science.nature.nps.gov/nrdata). Only non-sensitive information is posted to NR-GIS Metadata and Data Store. Refer to the protocol section on sensitive information for details.
[3] NatureBib is the NPS bibliographic database (http://www.nature.nps.gov/nrbib/index.htm). This application has the capability of storing and providing public access to image data (e.g., PDF files) associated with each record.
[4] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://www.nps.gov/refdesk/DOrders/DOrder19.html

Literature Cited

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, 2nd edition. EPA 841-B-99-002. U.S. E.P.A.,Washington, D.C.

Grafe, C. S. (ed.). 2002. Idaho River Ecological Assessment Framework: an Integrated Approach. Idaho Department of Environmental Quality; Boise, ID.

Helsel, D. R., and R. M. Hirsch. 2002. Statistical methods in water resources: Techniques of water-resources investigations of the United States Geological Survey. Book 4: Hydrologic Analysis and Interpretation Chapter A3.

Irwin, R .J. 2008. Draft Part B lite QA/QC Review Checklist for Aquatic Vital Sign Monitoring Protocols and SOPs, National Park Service, Water Resources Division. Fort Collins, CO. http://www.nature.nps.gov/water/Vital_Signs_Guidance/Guidance_Documents/PartBLite.pdf)

Jessup B., C. Hawkins, J. Stribling. 2006. Biological indicators of stream condition in Montana using benthic macroinvertebrates. October 4. Prepared for Montana Department of Environmental Quality, Helena, MT. 76 p.

Karr, J. R., and E. W. Chu. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington, D.C.

Montana Department of Environmental Quality (DEQ). 2006. Sample Collection, Sorting, and Taxonomic Identification of Benthic Macroinvertebrates. Water Quality Planning Bureau. Standard Operation Procedure (WQPBWQM-009).

OWEB. 1999. Water Quality Monitoring Technical Guide Book. Oregon's Watershed Enhancement Board. Salem, OR.

van Belle, G. and J.P. Hughes. 1984. Nonparametric Tests for Trend in Water Quality. Water Resources Research **20:**127-136.

Wiseman, C.D. 2003. Multi-Metric Index Development for Biological Monitoring in Washington State Streams. No. 03-03-035 Washington Department of Ecology. Olympia WA.

Standard Operating Procedure (SOP) 12: Quality Assurance/Quality Control

Version 1.0, January 2009

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0

Note: This SOP describes the step-by-step QA/QC procedures for ensuring that data collected by the UCBN integrated water quality monitoring program is of known quality, pertinent to monitoring objectives, and will be useful to future investigations. The general content and format of this SOP is based on the NCPN- Quality Assurance Project Plan (QAPP) SOP#7, Part B lite (Irwin, 2008) and the EPA's National Coastal Assessment Quality Assurance Project Plan 2001-2004.

Suggested Reading

Irwin, R .J. 2008. Draft Part B lite QA/QC Review Checklist for Aquatic Vital Sign Monitoring Protocols and SOPs, National Park Service, Water Resources Division. Fort Collins, CO. http://www.nature.nps.gov/water/Vital_Signs_Guidance/Guidance_Documents/PartBLite.pdf

U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan 2001-2004. United States Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL.EPA/620/R-01/002.

Sharrow, D., D. Thoma, K. Wynn, M. Beer. 2007. Water Quality Vital Signs Monitoring Protocol for Park Units in the Northern Colorado Plateau Network (NCPN). Moab, UT

Introduction

Quality Assurance and Quality Control are important aspects of the UCBN integrated water quality monitoring protocol in order to establish and maintain high standards of data collection and maintenance. These QA/QC standards will ensure that data is of known quality, pertinent to UCBN integrated water quality monitoring objectives, and will be useful to future investigations.

The overarching programmatic goal of the UCBN integrated water quality monitoring program is to obtain information that will aid in informed management decisions pertaining to improved water quality within UCBN parks. Park managers have committed to improving the water quality of impaired waters by adopting the NPS Government Performance Results Act (GPRA) goal that 99.3% of streams and rivers managed by NPS will meet State and Federal water quality standards. Most UCBN waters do not meet standards and are listed on 303(d) lists. Park managers would also like to be able to demonstrate and maintain high water quality where it exists. The NPS should be leading the way in high water quality regardless of beneficial uses, i.e. consideration should be given to water resources for their intrinsic value alone.

Given the lack of available data on water quality in UCBN parks, the following fundamental questions drive much of the UCBN's inquiry into water quality:

- Are 303(d) listed waterbodies in the UCBN including those with established TMDLs improving over time?
- What is the status and long term trend of core water quality parameters (temperature, pH, conductivity, dissolved oxygen, and turbidity) in or near select UCBN waterbodies?
- What is the status of aquatic macroinvertebrate abundance and assemblage composition in selected UCBN lotic waterbodies?
- Do aquatic macroinvertebrate assemblages sampled within the UCBN indicate "pristine" or "reference" conditions according to regional criteria established by EPA and the states of Idaho, Montana, Oregon, and Washington?
- Do aquatic macroinvertebrate assemblages sampled within the UCBN indicate polluted or otherwise impaired water quality?
- What are the long-term trends in aquatic macroinvertebrate abundance and assemblage composition within selected UCBN lotic waterbodies?

The objectives and sampling design were developed through a process that involved site reconnaissance, pilot data collection and analysis, and thoughtful consideration of budget and Network information requirements. The protocol team consisted of this document's authors, as well as park resource management staff.

We note that, while the aim of the sampling design is to provide optimal statistical robustness and scientific rigor, other considerations including personnel safety, fiscal and logistical constraints, and the ability to integrate data with other vital signs must be considered. In addition, the water bodies of most UCBN parks are diverse and the most efficient sampling design will

differ among parks. Water quality sampling in UCBN parks will be at targeted index sites. Probabilistic sampling will be used, where stream length will allow, for macroinvertebrate sampling to provide stream-wide inferences about the status and trend in assemblage composition and structure.

QA/QC issues related to water chemistry and macroinvertebrates are addressed in two separate sections within this SOP (Measurement Quality Objectives (MQOs) for Water Chemistry and Measurement Quality Objectives (MQOs) for Macroinvertebrates).

Measurement Quality Objectives (MQOs) for Water Chemistry

From the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

This section is intended to demonstrate how this project generates data of known and documented quality, resulting in complete, accurate and transferable information. Data credibility necessary for the intended uses will be achieved when it is:

1. Consistent over time and consistent between staff members
2. Collected and analyzed using standardized and acceptable techniques
3. Comparable to data collected in other assessments using the same methods
4. Used appropriately to make decisions based on sound statistics

Data Quality Objectives (DQOs)

Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

These are the quantitative and qualitative terms that describe how good data need to be in order to meet project objectives. DQOs for water chemistry data are discussed in detail below and are listed by NPS WRD as:

1. Target population
2. Representativeness
3. Completeness
4. Data comparability
5. Measurement sensitivity and detection limits
6. Measurement precision as repeatability
7. Measurement systematic error/bias

Target Population

The initial target population for the integrated water quality monitoring protocol was defined as representative UCBN waterbodies. Due to logistical constraints it is not possible to sample all UCBN waterbodies; as a result the water quality monitoring sample population is defined as representative UCBN wadeable streams with permanent water sampled between the months of May and October.

Representativeness

Spatial: The UCBN seeks to balance the need for a representative location within each stream with factors such as: stream stages, channel morphology, water velocity, potential for debris damage, and logistics. Within the area immediately downstream of the last (most downstream) macroinvertebrate reach, the above mentioned factors will be assessed to help determine the best multiprobe site (SOP #5). In addition, cross-section and stream segment variation will be determined using a survey of water quality parameters. This survey will consist of measurements taken at the proposed multiprobe site, across a transect at the proposed multiprobe site and at 3 subsequent transects upstream. These values and associated variability among transects will be compared to the proposed multiprobe site. If the proposed multiprobe site values are not significantly different from the other transects it will be inferred that the multiprobe site is

reasonably representative of the stream segment within the park. Having stated this, caution should be exercised when making comparisons to other streams within and outside of UCBN parks, due to the longitudinal and spatial variability of streams. For more details about the cross section survey see SOP #5.

Temporal: Annual and daily variations in water chemistry conditions are inherent in any aquatic system; however, in order to assess the status of streams in UCBN parks it is important to account for this variation. To address variation in water chemistry values the UCBN will be using continuous multiparameter water quality monitors. These multiprobes will record core water quality values every hour, 24 hours a day May through October. It is anticipated that this time period will be adequate to determine overall trends in water chemistry. Logistical constraints such as ice and high flows will prevent deployment of the multiprobes between the months of November and April. Due to this restriction, statements regarding the status of water chemistry between November and April will be avoided. Despite the 6 month gap in water quality data; the fine temporal resolution obtained from these multiprobes is advantageous in that it gives a better "picture" of the stream than the relatively coarse information obtained from grab samples. Monthly calibrations and error checks will ensure quality data throughout the deployment period (SOP #6).

Completeness

Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

Given the objectives of the UCBN integrated water quality monitoring protocol it is extremely important that samples be collected during the entire deployment period (May-October). However, it is not reasonable to expect that all sites will be accessible during this period especially given high water levels in May. In addition, erroneous data caused by low battery power will be removed from any analysis. Given our minimum detectable differences and calculated statistical power, 90% completeness should insure large enough sample sizes to meet objectives outlined in the protocol narrative and at the beginning of this SOP. That being said, every effort will be made to achieve 100% completion of data collection and analysis, but realistically some data may be missed in the monthly deployments. To decrease the number of samples lost due to low battery power, multiprobes will be serviced approximately every 28 days, just prior to battery failure. Some error in core parameters and laboratory analysis is also expected that will result in un-usable data.

Data Comparability

The UCBN seeks to have water quality data that is easily integrated with data obtained by other agencies and projects. Data that is easily integrated will facilitate a greater understanding of watershed issues, problems and conditions. This will be accomplished by adopting sample designs comparable to that of the United States Geological Survey (USGS). Site selection, sampling frequency, calibration criteria, and correction criteria will all follow guidelines recommended by the USGS (Wagner et al. 2006). By adopting a similar sample design and calibration methods, data should be easily compared with data collected outside NPS boundaries.

In addition, the UCBN will be monitoring a set of rather ubiquitous core parameters (Temperature, pH, Specific Conductance, Dissolved Oxygen, and Turbidity). These parameters are widely reported and have broad utility for interpreting water quality.

Measurement Sensitivity and Detection Limits

Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007).

The low-level method detection limits (MDL) and minimum level of quantitation (ML) are the terms used to describe the smallest presence that can be observed and the accurate quantity of an analyte of interest. They are important concepts in water quality data reporting and analysis for many reasons especially when considering chronic low level pollution that is near the detection limits of analysis methods (Irwin 2008). These values will be updated / reported at least once per year or when methods change and become part of the permanent data record (Sharrow et al. 2007). Values below the MDL and ML will be reported as "present less than quantification limit" or as "non-detectable." The only parameter that occurs at levels near the lower detection limit is turbidity. For this reason MDL and ML will not be determined for temperature, pH, specific conductance, or dissolved oxygen. Instead, these measures will have associated "alternative measurement sensitivity +" as described below.

The UCBN will be using the HACH Hydrolab MS5 for continuous water quality monitoring. The range, accuracy and resolution of each sensor as provided by HACH are given in Table 24. This should not be confused with the alternative measurement sensitivity + described below.

Table 25. Range, Accuracy and Resolution of the HACH Hydrolab MS5 multiprobe sensors as defined by the HACH Company.

Sensor	Range	Accuracy	Resolution
Temperature	-5 to 50 °C	± 0.10 °C	0.01 °C
Specific Conductance	0 to 100 mS/cm	± 1% of reading; ± 0.001 mS/cm	0.0001 units
pH	0 to 14 units	± 0.2 units	0.01 units
Hach LDO (dissolved oxygen)	0-20 mg/L	± 0.01 mg/L for 0-8 mg/L; ± 0.02 mg /L for greater than 8mg/L	0.01 or 0.1 mg/L
Self-cleaning Turbidity	0 to 3000 NTU	± 1% up to 100 NTU, ± 3% up to 100-400 NTU, ± 5% from 400-3000 NTU	0.1, up to 400 NTU; 1.0m, 400-3000

Table 26. Comparison table for QC data quality indicators used by the UCBN (Modified from Irwin 2008).

Metric Acronym	Purpose	Metric + Brief STORET Note	Minimum Frequency of Reporting	Description	Sample Size	Equation
MDL: For Control of Very Low Level Sensitivity. This is the standard MDL	EPA, State, and some USGS labs Low Level Sensitivity as Detection Limits (Usually Lab)	Method Detection Level. Put MDL in the detection limit field. If the result is <MDL, STORET Detection Condition is "Not Detected."	1/year or when methods change	Lowest value that can be differentiated from zero, the lower Semi-Quantitative Type of Detection Limit, Based on Short Term Data	Seven	Obtain MDL from laboratory, For field work calculate as 3.134*SD of a blank or very low signal solution
ML: Higher than This, Values are Quantitative	EPA and State Quantitative Sensitivity as Detection Limits (Usually Lab)	Minimum level of quantitation, In STORET, record at LQL	1/year or when methods change	Lowest Quantitative Value Above the ML values are quantitative	Based on Single MDL	3.18 * (MDL)
AMS: Lowest Change Possibly Real	Sensitivity (Usually Field, or Whenever MDL is NA)	Alternative Measurement Sensitivity, For ± STORET "analytical procedure description" field	Beginning and end of field seasons	Determines instrument noise in both directions (up or down). How big of a change is real?	7 measurements from the same field sample	3.708*SD, where SD = Sample Standard Deviation
AMS+: Total Variability of Close Replicates	AMS+ (Usually Field, or Whenever MDL is NA)	Alternative Measurement Sensitivity+, Record In STORET as Stated Above if no other form of AMS is reported	Beginning and end of field seasons	Includes instrument noise and natural heterogeneity	7 measurements of nearby but not identical samples, in-situ for sondes only	SD * 3.708
RPD: QC Precision+ Control	Precision+ (Usually for Field Measurements Only)	Relative Percent Difference. In STORET include both values RPD was based on and optionally include RPD as a comment.	1 for every deployment period, and at the beginning and end of each field season, lab or field. Done Instead of Precision or in Addition to Precision	Variability of repeated measures (precision+) + = potentially some additional true variability (two samples not one)	2 (1 Comparison of two values, measurements of two samples collected in close proximity but not one sample)	RPD = $\left[\frac{S_1 - S_2}{(S_1 + S_2)/}\right.$
PD: QC Bias Control	Bias (Lab and Field)	Percent difference: In STORET include both values PD was based on and optionally include PD as a comment, Choose Reference Sample or Field Spike	1 for fouling bias and 1for drift bias, for each parameter, every deployment period. In the field.	Difference Between Measured Result and Expected Result Based on a Reference Sample Standard or a Spike	2 (1 Comparison of two values, one of which is a known correct (or expected) value and the other is the measurement result	PD = [Y - X) / X] * 100, where X is the known (usually "correct" or "expected") or spiked amount, and Y is the measured concentration.

Method Detection Limit (MDL):
The Method Detection Limit (MDL) is the lowest value that can be distinguished from zero. The UCBN will determine MDL for Turbidity each year or more frequently as personnel or methods change. MDL will be based on seven measures of a very low concentration sample (near 0.1 NTU).

> To determine the MDL, at least seven replicate samples with a concentration of the pollutant of interest near the estimated detection capabilities of the method are analyzed. The standard deviation among the replicate measurements is determined and multiplied by the upper (one-sided) critical t-value for n-1 degrees of freedom (in the case of 7 replicates, the multiplier is 3.143, which is the value for 6 degrees of freedom) (Irwin, 2008)

MDLs for each multiprobe will be reported when data is uploaded to NPSTORET. MDL's for the 2008 pilot season are given in Tables 29 and 30.

Minimum Level of Quantitation (ML):
The minimum level of quantitation (ML) is the lowest value that can be reliably measured (Sharrow et al. 2007). Within NPSTORET, minimum level of quantitation (ML) is synonymous with "lower quantitation limit" (LQL). The UCBN will determine ML by multiplying the MDL by 3.18 (Irwin, 2008). The ML will be calculated annually for turbidity and not other parameters since they do not approach the lower detection limits. MLs will be reported for each multiprobe when data is uploaded to NPSTORET. MLs for the 2008 pilot season are given in Tables 29 and 30.

Alternative Measurement Sensitivity Plus (AMS+):
Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

In the range of quantitative values where low level detection limits are not an issue, measurement sensitivity is determined by evaluating the variability of repeated measurements on an environmental sample. Over time, AMS+ can be used to bound measurement uncertainty on each single data point (when 7 measurements are made on the same environmental sample). It includes instrument noise and natural heterogeneity (Sharrow et al. 2007). AMS+ will be based on 7 measurements of nearby but not identical samples, in-situ for sondes (Irwin 2008). In other words, the UCBN will take 1 discreet measure (for each core parameter) every minute for 7 minutes during initial site selection procedures (SOP #5). These 7 measures will then be used to calculate AMS+. Specifically AMS+ is calculated as the standard deviation of the 7 measurements times 3.708, where 3.708 is the 99% confidence middle (two-sided) t-value for sample size 7. AMS+ will be determined at the beginning and end of each sample season and will correspond to pre- and post-season cross section surveys (See SOP #5). AMS+ values will be reported for each parameter when data is uploaded to NPSTORET. AMS+ values for the 2008 pilot season are given in Tables 29 and 30.

Measurement Precision/Repeatability

Relative Percent Difference (RPD) – Precision Plus:
Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

Precision Plus (reported as RPD in NPSTORET) is the variability of repeated measures of two samples collected in close proximity. It is a less rigorous measure of sensitivity than AMS (sample size 2 rather than 7), but is used more frequently to ensure measurements are in 'control' especially in laboratory analyses where 7 duplicates are not always practical (Sharrow et al. 2007). RPD is calculated as:

$$\left[\frac{S_1 - S_2}{(S_1 + S_2)/2}\right] \times 100$$

S_1 = the larger test result value
S_2 = the smaller test result value

The UCBN will calculate RPD based on data obtained during the monthly calibration/error check procedure outlined in SOP#6. Immediately after each parameter is re-calibrated it is placed in a standard solution to verify successful calibration. This measured value is recorded on the Calibration and Maintenance Log sheet. After all parameters have been re-calibrated, all sensors are error checked by placing them in corresponding standard solutions (SOP #6). The value obtained immediately following the calibration and during the final readings will be used as S_1 and S_2. As the UCBN transitions to checking calibrations against a calibrated field meter, RPD will be calculated based on data collected in-situ. In addition, RPD will be calculated at the beginning and end of the sample season using data from the cross-section survey (SOP #5), where two separate values (i.e., minute 1 and minute 2) will be used as S_1 and S_2.

Measurement Systematic Error/Bias

Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

Systematic error/bias is the systematic or persistent distortion of a measurement process that causes errors in only one direction (usually high or low). Results for systematic error/bias are usually expressed as a % recovery with the correct or expected answer being considered 100%, with an acceptable range between 90-110% for core parameters (Sharrow et al. 2007, Irwin 2008). During each monthly site revisit/calibration the UCBN will determine the amount of error caused by fouling and calibration drift as described in the Multiprobe Site Revisit SOP #6 and the Continuous Water Quality Record Processing SOP #9. The raw values for systematic error/bias will be recorded in the corresponding site inspection summary form as "drift correction" and "fouling correction." Percent difference will be calculated for each parameter based on data obtained during assessment of fouling and drift corrections as: PD = [Y - X) / X] * 100.

PD for Fouling

X = the concentration after fouling has been removed from the sensors

Y = the concentration in stream water before fouling has been removed from the sensors

PD for Drift

X= the known concentration of a standard solution

Y = the measured concentration of the standard solution

The result will be two percent difference values for each parameter for each month (deployment interval), one that accounts for % drift and the other for % fouling.

When data is processed for analysis and before it is uploaded to NPSTORET it will be corrected to account for fouling and drift error. Data correction will only occur if drift and fouling corrections fall outside of pre-defined criteria (Table 27). The process of data correction is more thoroughly discussed in SOP #9.

Besides percent difference (PD), the degree of data bias will be reflected in the grade or rating that data will receive based on the amount of correction that has been applied. Rating criteria are listed in Table 28. and more thoroughly discussed in the record processing SOP #9. Data grades will be applied on a monthly (deployment period basis).

Table 27. Criteria for water quality data corrections, modified from Wagner et al. 2006.

Parameter	**Calibration / Data Correction Criteria** (Apply correction when the sum of the absolute values for fouling and calibration drift error exceeds the value listed.)
Temperature	± 0.2 °C when checked with another meter ± 0.5 °C when checked with NIST thermometer
Specific Conductance	± 5 µS/cm or ± 3% of the measured value, whichever is greater
Dissolved Oxygen	± 0.3 mg/L
pH	0.2 pH units
Turbidity	± 0.5 turbidity units or ±5% of the measured value, whichever is greater

Table 28. USGS accuracy ratings of continuous water-quality records or "data grade" (modified from Wagner et al. 2006).

Measured field parameter	**Rating of accuracy (data grade)** (Based on combined fouling and calibration drift corrections applied to the record.)			
	Excellent	**Good**	**Fair**	**Poor**
Water Temperature	≤ ± 0.2 °C	>± 0.2-0.5 °C	>± 0.5-0.8 °C	>± 0.8 °C
Specific Conductance	≤ ± 3%	>± 3-10%	>± 10-15%	>± 15%
Dissolved Oxygen	≤ ± 0.3 mg/L or ≤ ± 5%, whichever is greater	>±0.3-0.5 mg/L or >±5-10%, whichever is greater	>± 0.5-0.8 mg/L or >± 10-15%, whichever is greater	>± 0.8 mg/L or >± 15%, whichever is greater
pH	≤ ± 0.2 units	>± 0.2-0.5 units	>± 0.5-0.8 units	>± 0.8 units
Turbidity	≤ ± 0.5 NTU or ≤ ± 5%, whichever is greater	>± 0.5-1.0 NTU or >± 5-10%, whichever is greater	>± 1.0-1.5 NTU or >± 10-15%, whichever is greater	>± 1.5 NTU or >± 15%, whichever is greater

Pre/Post Mobilization Check to Minimize Bias:
Pre and post deployment calibration and error checks will be conducted in the UCBN office to ensure all sensors are functional and ready for the field season (See SOP #1 and 6). During pre and post-mobilization calibrations all sensors must calibrate and remain within the calibration criteria during error checks as defined in Table 27 and in SOP #6. The calibration criteria used by the UCBN are the same standards used by the USGS as defined in (Wagner et al. 2006). MDL will be determined for turbidity during the pre-mobilization check. Should any sensors fail to calibrate, or measurements of standard solutions consistently fall outside of the calibration criteria it will be returned to the HACH Company to be serviced. These calibrations and maintenance service will be documented in the Calibration and Maintenance Log Book.

Field Calibration to Minimize Bias:
After deployment, the multiprobe will be calibrated monthly, preferably on the stream bank in the morning; the calibration will be documented in the Calibration and Maintenance Log Book. All calibrations follow the HACH MS5 user manual and guidelines established by the USGS. Temperature is a fixed function set by the manufacturer and cannot be adjusted in the field; the instrument reading is verified against a hand- held laboratory thermometer. Calibration of the luminescent dissolved oxygen (LDO) sensor is based on using a water-saturated air environment as the standard; for pH, a three point calibration curve is established with standard buffer solution of pH 4, 7 and 10; the specific conductance probe is calibrated using a two point calibration, in air (zero) and using a standard solution of 1,412 µs/cm; the self cleaning turbidity sensor is calibrated using a <0.1 and 100 NTU standard solution. Details of field calibrations are more thoroughly discussed in SOP #6. In general, if measures of standard solutions fall outside of the calibration criteria as defined by Wagner et al. (2006) the sensor will need to be re-calibrated; or, if values consistently fall outside of the criteria or exceed the maximum allowable limits (SOP #6) it will need to be returned to the manufacture for repair. Consistent staff training (SOP #2) and strict adherence to the procedures in SOP #6 will help limit bias caused by personnel.

Summary of QA/QC Values Required for Water Chemistry Each Field Season

1. MDLs – Method Detection Limit, for turbidity sensors on each multiprobe. MDL is determined in the lab/office each year with a low signal standard.
2. ML – Minimum Level of Quantitation, for turbidity sensor on each multiprobe. ML is calculated with the MDL.
3. AMS + Alternative Measurement Sensitivity Plus, for all core parameters except turbidity (Temperature, pH, Dissolved Oxygen, Specific Conductance) at the beginning and end of the sample season. AMS+ is based on data from the cross section survey conducted at the start and finish of each sample season.
4. RPD – Relative Percent Difference, also known as precision. RPD is based on data collected during each calibration and during the cross section survey at the start and finish of each sample season.
5. PD – Percent Difference or Bias is based on data collected during each calibration throughout the deployment period (May-October). Two PD values will be reported for each parameter for each month (deployment interval), one that accounts for % drift and the other for % fouling.

Note that these values should be uploaded to NPSTORET in accordance with the guidelines in the data management SOP #10 and also included as an appendix in the annual report for each monitoring season.

Table 29. QC data quality indicators for 2008 pilot season at NEPE, Lapwai Creek, Hydrolab 054, Station #NEPE 001.

STORET Name	Units	Detection Range Description from Manufacture	Method Detection Limit (MDL)	Minimum Level of Quantination (ML)	Alternative Measurement Sensitivity Plus (AMS+) Beginning of Season	Alternative Measurement Sensitivity Plus (AMS+) End of Season	Precision+ (RPD) Beginning of Season	Precision+ (RPD) End of Season
Temperature, water	deg C	-5 to 50°C	N/A	N/A	0.14	0.09	0.06	0.11
Specific Conductance	µS/cm	0 to 100,000 µS/cm	N/A	N/A	1	0.9	0.07	0.09
Dissolved Oxygen	mg/L	0-20 mg/L	N/A	N/A	0.04	0.08	0.1	0.08
pH	pH units	0-14 Units	N/A	N/A	0.04	0.07	0.12	0
Turbidity	NTU	0-3000 NTU	0.2	0.6	N/A	N/A	0	66.67

Table 30. QC data quality indicators for 2008 pilot season at WHMI, Mill Creek, Hydrolab 064, Station #WHMI 001.

STORET Name	Units	Detection Range Description from Manufacture	Method Detection Limit (MDL)	Minimum Level of Quantination (ML)	Alternative Measurement Sensitivity Plus (AMS+) Beginning of Season	Alternative Measurement Sensitivity Plus (AMS+) End of Season	Precision+ (RPD) Beginning of Season	Precision+ (RPD) End of Season
Temperature, water	deg C	-5 to 50°C	N/A	N/A	0.12	0.03	0.13	0.1
Specific Conductance	µS/cm	0 to 100,000 µS/cm	N/A	N/A	0.9	2.4	0.08	0.47
Dissolved Oxygen	mg/L	0-20 mg/L	N/A	N/A	0.06	0.12	0	0.84
pH	pH units	0-14 Units	N/A	N/A	0.07	0.04	0	0.24
Turbidity	NTU	0-3000 NTU	0.2	0.6	N/A	N/A	0	0

Measurement Quality Objectives (MQOs) for Macroinvertebrates

From the NCPN Quality Assurance Project Plan (Sharrow et al. 2007)

This section is intended to demonstrate how this project generates data of known and documented quality, resulting in complete, accurate and transferable information. Data credibility necessary for the intended uses will be achieved when it is:

1. consistent over time and consistent between staff members
2. collected and analyzed using standardized and acceptable techniques
3. comparable to data collected in other assessments using the same methods
4. used appropriately to make decisions based on sound statistics

Data Quality Objectives (DQOs)

These are the quantitative and qualitative terms that describe how good data need to be in order to meet project objectives (Sharrow et al. 2007). These DQOs are discussed in more detail below:

1. Target population
2. Representativeness
3. Completeness
4. Data comparability
5. Measurement sensitivity and detection limits
6. Measurement precision as repeatability
7. Measurement systematic error/bias

Target Population

The target population and sample population are defined as the macroinvertebrate community in targeted or probabilistic UCBN aquatic sampling sites.

Representativeness

Spatial:

Macroinvertebrate samples will be collected along 11 equally spaced transects at 25%, 50% or 75% of the wetted width, as designated by EMAP protocol and in SOP #7. The placement of sample locations will be done in two ways and will rely on the length of the stream segment within the UCBN park. When the total stream length within a park will accommodate 6 reaches, reach locations will be randomly selected using a GRTS spatially-balanced sample (SOP #4). When the stream length within the park cannot accommodate 6 sites, the UCBN will position sample locations to maximize the number of sample reaches within the park. These two methods will be used to maximize the number of samples in small stream segments and to maximize independent samples in larger streams. Both methods should ensure data is representative of the stream segment within the park.

Temporal:
Macroinvertebrates will be sampled during the index periods suggested by Hayslip (2007) and Montana DEQ (2006). This index period for streams in Idaho, Oregon, and Washington is between July 1st and October 15th and in Montana is between June 21st and September 21st. The major reason for sampling within this index period is that typically State DEQs and federal agencies such as the EPA have developed multimetric indices and established reference conditions based on data collected during these time periods. In addition, sampling during this time period will help ensure data collected by the UCBN is integrable with other regional data sources. It has also been suggested that sampling during this time period is advantageous because benthic macroinvertebrates reach their maximum representation, and that there has been an adequate amount of time for the instream environment to stabilize following high spring flows (Hayslip 2006).

Completeness

Modified from the NCPN Quality Assurance Project Plan (Sharrow et al. 2007).

Given the objectives of the UCBN integrated water quality monitoring protocol, it is extremely important that all samples be collected during the index period. However, it is not reasonable to expect that all sites will be accessible during this period, especially given potential high water levels caused by rain events or potential lack of water caused by drought. Given our calculated statistical power, 95% completeness should insure large enough sample sizes to meet objectives outlined in the protocol narrative and at the beginning of this SOP. That being said, every effort will be made to achieve 100% completion of data collection and analysis, but realistically some data may be missed.

Data Comparability

UCBN macroinvertebrate protocol for macroinvertebrate collection and identification is consistent with the EPA's Environmental Monitoring and Assessment Program (EMAP) and the Rapid Bioassessment Protocol for Use in Wadeable Streams and Rivers. Therefore, all data obtained by the UCBN will be of the same quality and caliber as data collected by the EPA and will allow for comparisons to other data collected in the watershed.

Measurement Sensitivity and Detection Limits

The UCBN's ability to detect status and trend largely depends on the amount of variability in macroinvertebrate assemblage structure. Available data from regional streams suggests that increasing sample size (e.g., number of replicates/site) decreases variability and improves the probability of detecting uncommon or rare species. However, without information on macroinvertebrate community structure from each park, it is difficult to determine the variability associated with each stream. After the first rotation of sampling the UCBN will more clearly understand the variability in each system and subsequently define the integrated water quality program's sensitivity and detection limits.

Measurement Precision as Repeatability

To ensure precision and reproducibility of data collected in the field, each person assisting in the collection of macroinvertebrates must have been trained on how to conduct macroinvertebrate sampling according to EMAP. Consistent techniques and sample effort are required and will be monitored closely by the project lead. In the lab it is expected that all technicians and taxonomists will adhere to the QA/QC guidelines established by the EPA-EMAP protocols and to the guidance given in the Macroinvertebrate Lab QA/QC section of this SOP.

Measurement Systematic Error/Bias

Systematic error and bias will be monitored in the field and laboratory. In the field, systematic error will be monitored by timing of sample effort, and use of standardized techniques. If techniques or sample effort vary from the accepted EMAP protocol, the sample will be abandoned and re-sampled in accordance with EMAP protocol.

Laboratory systematic error and bias will be monitored by the senior taxonomist who is responsible for double checking technician sorting and identification. More specific QA/QC details are listed below in the Macroinvertebrate Lab QA/QC section of this SOP.

Macroinvertebrate Field QA/QC Guidelines

Field QA/QC is based on section 7 "Benthic Macroinvertebrate Protocols" of the Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (Barbour, et al. 1999), and the National Coastal Assessment Quality Assurance Project Plan (US EPA 2001). Several quality control (QC) procedures will be implemented in the field to ensure consistent collection of high quality data.

From the Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (US EPA 1999):

- Sample labels must be properly completed, including the sample identification code, date, stream name, sampling location, and collector's name, and placed into the sample container. The outside of the container should be labeled with the same information. Chain-of-custody forms, if needed, must include the same information as the sample container labels.
- After sampling has been completed at a given site, all nets, pans, etc. that have come in contact with the sample should be rinsed thoroughly, examined carefully, and picked free of organisms or debris. Any additional organisms found should be placed into the sample containers. The equipment should then be decontaminated by rinsing it in a 10% Sparquat 256 solution as outlined in the sampling equipment decontamination SOP #8.
- Replicate (1 duplicate sample) 10% of the sites to evaluate precision or repeatability of the sampling technique or the collection team.

Modified from the National Coastal Assessment Quality Assurance Project Plan (US EPA 2001):

- UCBN field crews will record most of their raw field data on hardcopy data sheets. Some crews may also use instrumentation with self-contained data logging capabilities (e.g., Archer field PC, Dell Pocket PC) that store values in electronic format which can be downloaded later as electronic files. To maintain uniformity across samples, the template for field data sheets will be designed by UCBN personnel to systematically query the crew for all pertinent information required to document the conditions and activities performed for a sample collection. All pertinent field data will eventually be transcribed into an electronic format standardized for each park so that the data can be transmitted to the regional data collection node; therefore the field sheets and electronic tables should closely resemble one another.
- The UCBN, Integrated Water Quality Monitoring Program project leader will supply site identity codes for each EMAP reach within UCBN parks. This site code will contain the 4 letter park abbreviation, stream name, reach number and the sample date, for example, NEPE-Lapwai-#001-20080514. This site identity code will be included on all sample labels and other information related to the stream reach.
- All hardcopies of data sheets should be transferred to electronic copies as soon as possible. In addition, all data that has been transferred from paper to electronic should be double checked by other UCBN personnel.

Macroinvertebrate Lab QA/QC Guidelines

Laboratory quality assurance and quality control are based on section 3 "Benthic Macroinvertebrate Methods" of the EMAP-Laboratory Methods Manual for Estuaries (US EPA. 1995). The standard for laboratory QA/QC will be these guidelines and those established by the Pacific Northwest Aquatic Monitoring Partnership (PNAMP). The following information has been modified directly from the original documents to fit UCBN's freshwater needs. **Laboratories contracted to conduct sample identification must follow the guidelines listed below and/or the most current EPA QA/QC guidelines for wadeable streams.**

Various quality control (QC) procedures will be implemented to ensure consistent production of high quality data. In addition to the QC procedures included above, the following procedures will be periodically conducted as part of data quality control.

Sorting:

- A minimum of 10% of all samples sorted by each technician will be re-sorted to monitor technician performance and provide feedback necessary to maintain acceptable standards. Re-sorts will be conducted on a regular basis on batches of 10 samples, and all results will be documented and recorded in the QA/QC logbook for the laboratory.
- The QC re-sort procedure is designed to provide effective and continuous monitoring of sorting efficiency. The minimum acceptable sorting efficiency is 90%; however, sorting efficiencies are expected to be greater than 95%.
- Samples sorted by a particular technician will be randomly selected for re-sorting from a sample batch.
- The archived sample residues will be retrieved and the sample number will be recorded in the QC log book.
- The residue will be re-sorted.
- Sorting efficiency (%) will be calculated using the following formula:

$$\frac{\#\textit{organisms originally sorted}}{\#\textit{organisms originally sorted} + \textit{additional found in resort}} \times 100$$

- The results of sample re-sorts may require that certain actions be taken for specific technicians. If sorting efficiency is greater than 95%, no action will be required. If sorting efficiency is 90 to 95%, the technician will be retrained and problem areas identified. Laboratory personnel and supervisors must be particularly sensitive to systematic errors (i.e., consistent failure to represent specific taxonomic groups) that may suggest the need for further training. Re-sort efficiencies below 90% will require re-sorting all samples in that batch and continuous monitoring of that technician to improve efficiency.
- If sorting efficiency is less than 90%, organisms found in the re-sort will be added to the original data sheet and placed in the appropriate biomass group vial. If sorting

efficiency is 90% or greater, the results will be recorded in the QC log book; however, the organisms should be kept separate from the original sample.

- If a sample batch fails to meet the 90% efficiency sorting criteria, all samples within the batch will be re-sorted. An additional sample from the batch will be randomly selected and used to check the sorting efficiency of the re-sorted batch.
- After re-sorting, and if quality control criteria are met, sample residues may be discarded.
- Re-sort results will be summarized for each technician on a QC re-sort summary sheet.

Species Identification and Enumeration:

- Most organisms are identified to the lowest practical level (generally genus or species) by a qualified taxonomist. Midges (Diptera: Chironomidae) are mounted on slides in an appropriate medium and identified using a compound microscope. Each taxon found in a sample is recorded and enumerated in a laboratory bench notebook or log and then transcribed to the laboratory bench sheet for subsequent reports. Any difficulties encountered during identification (e.g., missing gills) are noted on these sheets.
- Only senior taxonomists are qualified to complete identification quality control checks. A minimum of 10% of all samples processed by each taxonomic technician will be checked to verify the accuracy of species identifications and enumerations. This control check establishes the level of accuracy with which identification and counts are performed and offers feedback to taxonomists in the laboratory to maintain a high standard of accuracy. Samples will never be rechecked by the technician who originally processed the sample.
- Approximately 10% of each sample batch will be checked. A sample batch consists of 10 samples and ideally is made of samples from the same watershed. Rechecks will be performed in a timely manner so that data entry may proceed.
- The vials containing specimens from the randomly selected sample will be retrieved along with the original species identification sheet and information will be recorded in the QC log book.
- The specimens in each vial will be re-identified and enumerated.
- As each taxon is identified and counted, results will be compared to the original data sheet. Discrepancies will be double-checked to verify that the final results are correct.
- Following re-identification, specimens will be returned to the original vials and set aside.
- When the entire sample has been re-identified, the total number of errors will be computed. The total number of errors will be based upon the number of misidentifications and miscounts. Numerically, accuracy will be represented in the following manner:

$$\frac{Total\ \#\ of\ \ organisms\ in\ QC\ recount - total\ \#\ of\ \ errors^{*}}{Total\ \#\ of\ \ organisms\ in\ QC\ recount} \times 100$$

* Three types of errors are included in the total number of errors:
  1) Counting errors (for example, counting 11 *Gemma gemma* as 10)
  2) Identification errors (for example, identifying a *Nucula annulata* specimen as *Nucula proxima*, where both are present)
  3) Unrecorded taxa errors (for example, not identifying *Phoronis* spp. when it is present)

- For the UCBN Integrated Water Quality Monitoring Program, the minimum acceptable taxonomic efficiency will be 90%. If taxonomic efficiency is greater than 95%, no action will be required. If taxonomic efficiency is 90 to 95%, the taxonomist will be consulted and problem areas will be identified. Taxonomists and laboratory supervisors must be particularly sensitive to systematic errors (i.e., repeated errors for specific taxonomic groups) that may suggest the need for further training. Taxonomic efficiencies below 90% will require re-identifying and enumerating all samples in that sample batch and additional monitoring of the taxonomist to improve efficiency.
- Any species identification changes resulting from quality assurance procedures will be recorded on the original data sheet; however, the numerical count for each taxonomic group will not be corrected unless the overall accuracy for the sample is below 90%.
- Treatment of the results of quality control audits are illustrated in the following examples.
  - Example 1: Ten *Mulinia lateralis* individuals were recounted as eleven. The sample had a greater than 90% overall efficiency, therefore, the original count of ten *Mulinia* would be recorded.
  - Example 2: One individual of the species *Prionospio steenstrupi* was misidentified as *Streblospio benedicti*. On the final data sheet, one *Prionospio steenstrupi* and no *Streblospio benedicti* would be recorded.
  - Example 3: Ten *Nucula annulata* and no *Nucula proxima* were originally recorded. During the QA/QC check, one *N. annulata* was found to be *N. proxima.* Providing the overall efficiency was greater than 90%, nine *N. annulata* and one *N. proxima* would be recorded on the final data sheet.
  - Example 4: Five *Nucula annulata* and ten *Mulinia lateralis* were originally recorded. During the QA/QC check, one *M. lateralis* was found to be a *N. annulata*. Providing the overall efficiency was greater than 90%, six *N. annulata* and nine *M. lateralis* would be recorded on the final data sheet.
  - Example 5: One Onuphidae spp. (juvenile) was recorded on original data sheet. During the QA/QC check, this individual was not found. On the final data sheet, one Onuphidae spp. (juvenile) would be recorded.
  - Example 6: Terebellidae spp. (juvenile) was found in the annelid fragment category during the QA/QC check. No Terebellidae were previously recorded on the data sheet. On the final data sheet, one Terebellidae spp. would be recorded.
- The results from all QC rechecks of species identification and enumeration will be recorded in the QC log book that will become a part of the documentation for the UCBN Integrated Water Quality Monitoring Program.

- All corrections to data sheets will be initialed and dated by the person making the changes.

Taxonomic Reference Collection:

- Taxonomic identifications should be consistent within a given laboratory and with the identifications of other regional laboratories. Consistent identifications are achieved by implementing the procedures described above and by maintaining informal interaction among the taxonomists working on each major group.
- A voucher specimen collection should be established by each laboratory processing UCBN samples. This collection should consist of representative specimens of each species identified in samples from all UCBN parks. For some species, it may be appropriate to include in the voucher specimen collection individuals sampled from different geographical locations (i.e., UCBN parks).
- New species added to a laboratory's voucher specimen collection should be sent to recognized experts for verification of the laboratory's taxonomic identifications. The verified specimens should then be placed in a permanent taxonomic reference collection. The reference collection should be used to train new taxonomists. Participation of the laboratory staff in a regional taxonomic standardization program (if available) is recommended, to ensure regional consistency and accuracy of identification.
- All specimens in the reference collection should be preserved in 70% ethanol in labeled vials that are segregated by species and sample. More than one specimen may be in each vial. The labels placed in these vials should be made of waterproof, 100-percent rag paper and filled out using a pencil. Paper with less than 100-percent rag content or that is not waterproofed will disintegrate in the 70-percent alcohol mixture. It is important to complete these labels because future workers may not be familiar with details of the work in progress.
- To reduce evaporation of alcohol, the lids of vials and jars can be sealed with plastic tape wrapped in a clockwise direction. The species (and other taxonomic designation) should be written clearly on the outside and on an internal label. Reference specimens should be archived alphabetically within major taxonomic groups.
- Reference collections are invaluable and should be retained at the location where the identifications were performed. In no instance should this collection be destroyed. A single person should be identified as curator of the reference collection and should be responsible for its integrity. Its upkeep will require periodic checking to ensure that alcohol levels are adequate. When refilling the jars, it is advisable to use full-strength alcohol (i.e., 95 percent), because alcohol tends to evaporate more rapidly than water in a 70-percent solution.
- The laboratory will maintain a log pertaining to the taxonomic reference collection. This log will contain the species name, the name and affiliation of the person who originated the reference sample, the location of the reference sample, the status of the sample if it has been loaned to outside experts, and information about the confirmation

of identification by outside experts. The log may also contain references to pertinent literature describing the species in the reference sample.

Data Handling and Reporting

QA/QC information for data handling, reporting and management are contained within the data management SOP #10.

Literature Cited

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.

Hayslip, Gretchen, editor. 2007. Methods for the collection and analysis of benthic macroinvertebrate assemblages in wadeable streams of the Pacific Northwest. Pacific Northwest Aquatic Monitoring Partnership, Cook, Washington.

Irwin, R .J. 2008. Draft Part B lite QA/QC Review Checklist for Aquatic Vital Sign Monitoring Protocols and SOPs, National Park Service, Water Resources Division. Fort Collins, CO. http://www.nature.nps.gov/water/Vital_Signs_Guidance/Guidance_Documents/PartBLite.pdf

Montana Department of Environmental Quality (DEQ). 2006. Sample Collection, Sorting, and Taxonomic Identification of Benthic Macroinvertebrates. Water Quality Planning Bureau. Standard Operation Procedure (WQPBWQM-009).

Sharrow, D., D. Thoma, K. Wynn, M. Beer. 2007. Water Quality Vital Signs Monitoring Protocol for Park Units in the Northern Colorado Plateau Network (NCPN). Moab, UT.

U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan 2001-2004. United States Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL.EPA/620/R-01/002.

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 13:

Field Safety for Water Quality Sampling

Adapted from
Water Quality Vital Signs Monitoring Protocol for
Park Units in the Northern Colorado Plateau Network, SOP #1
and
Freshwater Quality Monitoring Protocol for
San Francisco Area Network, SOP #2

Version 1.1, February 2013

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0
1.0	February 2013	UCBN- Eric Starkey	Updates to JHA (see appendix 3) and addition of regional safety guidelines that require readiness review, field itinerary, and travel forms be completed prior to fieldwork	Updates following UCBN safety plan and regional guidelines	1.1

Note: This Standard Operating Procedure (SOP) describes procedures for conducting field and laboratory aspects of water quality monitoring in a safe manner, recognizing that certain hazards are inherent in the field and laboratory environments. This is done through a process to (1) identify hazards associated with field and laboratory settings and (2) develop approaches to reduce or mitigate those hazards.The primary tool used to promote safe conduct is the Job Hazard Analysis. This approach is consistent with NPS Directors Order 50 and Reference Manual 50B for Occupational Heath and Safety.

Suggested Reading

Lane, S.L., and Fay, R.G., October 1997, Safety in field activities: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A9, accessed 15 January 2008 at http://pubs.water.usgs.gov/twri9A9/

Introduction and Objectives

Encountering hazardous situations is inherent in water quality monitoring activities thus staff needs to be aware of these and adjust approaches accordingly so that high quality monitoring can be conducted without injury or property damage.

The objectives for the UCBN water quality monitoring program and the specific objectives for operations under this SOP are:

- To monitor water quality conditions, including accessing monitoring sites, making field measurements, gathering, processing and analyzing water quality samples in a manner where hazardous conditions are recognized and measures are taken to minimize the risk of personnel injury.

- To maintain a high quality monitoring effort, avoiding missed data collection and undue expense due to personnel injury or property damage.

Some hazardous conditions are inherent in all monitoring activities being undertaken by UCBN staff, whereas others are specific to individual sites. Examples include exposure to winter and summer weather, highway driving, use of hazardous chemicals, and specific hazards associated with accessing individual sites. Therefore, two similar procedures will be used. First, a Job Hazard Analysis will be developed for water quality monitoring and will include hazards associated with each park where monitoring will be conducted. Second, hazards associated with specific sampling sites will be identified in the Field Site Description for each site. These are similar in that they both improve operational safety through identifying hazardous conditions to NPS staff and technicians, and develop approaches to avoid or mitigate the hazards.

In addition, prior to the start of each field season, certain safety documents must be reviewed, signed, and returned to the park contact and the network coordinator. These documents include: an official travel checklist, fieldwork itinerary forms that outline when and where field operations will take place, readiness review documents that detail necessary safety topics that have been prepared for the field season, and job hazard analyses (JHAs) that highlight some of the individual risks associated with fieldwork and ways to mitigate those risks. A CRMO specific backcountry travel SOP is required for anyone performing fieldwork in CRMO. These documents are included in the appendices.

Risks Inherent in Water Quality Monitoring

Risks inherent in water quality monitoring in general, and specifically to monitoring the sites selected in UCBN parks, include:

Working alone – Field staff will often work alone when traveling to and from remote sites and when making measurements and collecting samples in the field. As a result, particular attention must be given to safety and communication.

Long road trips – Travel between parks will require long road trips at all times of the year and under varied weather and road conditions.

Backcountry roads and trails – Accessing water quality sample sites may require travel on secondary roads that are graveled or dirt, and some sites require hiking. The unsurfaced roads can become impassible during wet weather, and may remain muddy for several days after snowmelt. Hiking is generally done on established trails that vary in difficulty and condition.

Activities in and on the water - Sample collection will require entering the main current in streams. Extra care is necessary when wading because many streams are swift and stream bottoms can be loose or slippery, and water temperatures can be near freezing in winter. Precautions are needed to (1) recognize and avoid risks, (2) use proper techniques to avoid accidents, and (3) be properly equipped for self-rescue. It is recognized that some sites will not be accessible during periods of bad weather. If there is any doubt, the correct decision is to forgo sampling until another day. The USGS Field Manual (Lane and Fay 1997) chapter 9 gives excellent guidance for safety precautions working on, in and near water. A copy is located in the Field Safety Notebook.

Varied weather conditions – The UCBN region is characterized by weather conditions that vary considerably through the seasons, day-to-day, and even hour-by-hour. Snow, wind and temperatures below 0°F occur in the winter, and summer temperatures may be above 100°F. As a result, field work requires preparation for this range of conditions. Hypothermia and heat-related injury are possible and occasional discomfort is certain.

Use of hazardous materials – Some of the reagents used are hazardous and require proper storage, handling, disposal and personal safety gear including eye and skin protection.

Field Safety Notebook

A notebook containing information related to water quality monitoring safety will be prepared and maintained in the UCBN office and will be carried when sampling activities occur. Copies of information contained in this notebook will be provided to park resource managers during multiprobe data retrieval training. This notebook is intended to facilitate review of safety

information, and provide concise information for use during an emergency. The following is a list of items to be included in the Water Quality Field Safety Notebook (Appendix 3).

- UCBN - Field Safety for Water Quality Sampling SOP #13
- Field Site Descriptions (Appendix 3)
- Job Hazard Analysis (JHA) (Appendix 3)
- Material Safety Data Sheets (MSDS) for chemicals
- Emergency Contact Information
- Emergency Evacuation Instructions (Appendix 3)
- USGS Field Manual- Chapter 9 –Safety in Field Activities
- Medical Information for Office Personnel (Appendix 3)
- Readiness Review Forms (Appendix 3)
- Travel Checklist (Appendix 3)
- Field Itineraries (Appendix 3)

Job Hazard Analysis

The UCBN water quality project lead will, in conjunction with his/her supervisor (and, if appropriate, other knowledgeable persons), develop a Job Hazard Analysis (JHA) of the task to be performed within each park. At the beginning of each sampling season all personnel will review the appropriate JHA and make modifications as necessary. The procedure to be used for writing a JHA is presented in NPS Reference Manual #50B, Occupational Safety and Health Program. (NPS 1999).

- A list of suggested hazards to be included and expanded upon is presented in Table 31.
- A completed JHA for NEPE Water Quality Field Work is presented in Appendix 3. This JHA was developed based on the San Francisco Area Networks, Freshwater Quality Protocol SOP #2.
- All JHA sheets will be included in the water quality Field Safety Notebook.

Table 31. Suggested topics to be addressed in a Job Hazard Analysis

General Job Activity	Basic Job Step	Potential Hazards
All Field Activities	Environmental Conditions	Temperature and Sun Exposure
		Adverse Weather (rain, snow, lightning and wind)
		Hazardous Animals, Plants, People
Accessing Sites	Highway Driving	Varied Road Conditions Fatigue Behavior of other Drivers Animals and other Obstructions
	Driving on	Rough and Rutted Roads

	Unimproved Roads	Muddy Roads
		Narrow Roads with Poor Visibility
	Winter Driving	Slippery Roads and Poor Visibility
	Hiking	Steep/Slippery Terrain, Undergrowth, Rocky Slopes
Sample Collection	Wading	Swift Currents and Deep Water
		Flood Flows
		Cold Water and Ice
		Contaminated Water
	Walking on Stream Banks	Slick Footing
		Adjacent Swift Currents and Deep Water
Sample Processing	Acidifying Samples	Exposure to Acid
	Filtering Samples	Mechanical Pumps

Field Site Description

A record of site locations and specific hazards that might be present will be developed in Field Site Descriptions that are kept as a reference for field staff in the field folder that accompanies resource managers in the field vehicle. An example is given in Appendix 3. This will serve as a reference and reminder for existing and new staff. The procedure for completing field site descriptions is outlined in the EMAP field operations manuals (Peck et. al. 2006).

Routine and Emergency Communication

Having established lines of communication and a Check-in/Check-out procedure are essential to ensure timely assistance can be provided in case of a mishap or delay. This will be particularly important since UCBN field staff will often work alone. A routine will be established where UCBN field staff will contact park staff to notify them of the time and location of work in each park using email or other written forms of communication (field itinerary forms and readiness review). In addition, it is required to leave a written/approved travel plan (field itinerary form Appendix 3) with UCBN staff or other NPS staff. This plan should include the time and location of work and return times. National Park Service park managers and UCBN staff should be notified if plans have been modified. Emergency and field operations contact information for each park will be included in the Field Safety Notebook and on the field itinerary forms for each park/visit.

UCBN field staff may have a field radio programmed for the applicable radio frequencies used by each district where they will be working. An exception would be parks that have reliable cellular phone coverage. UCBN field staff will also carry back-up means of emergency communication when practical, including a cellular phone and a signal mirror.

Chemical Storage and Use

Chemicals must be stored according to their Material Safety Data Sheet (MSDS) information. The MSDS sheets for all of the chemicals are kept in a clearly marked folder in the UCBN office and in the Field Safety Notebook.

A list of all the chemicals must be posted on the outside of the cabinet door or wherever they are stored (Table 32). This is done for the following reasons: (1) Emergency personnel are able to identify the contents in case of an emergency and (2) People who are sensitive to certain materials are able to avoid exposure. The list of chemicals should include: the name of the chemical, the number of that chemical in storage, and the number of that chemical that has been used (including anything that has been opened). One list must be in the lab and copies of this list must be given to the Project leader and Network Coordinator.

Table 32. Example chemical list to be posted on chemical cabinet.

Water Quality Chemical List		
Solution	**Size**	**Number in Cabinet**
pH Buffer Solution 4	500ml	1
pH Buffer Solution 7	500ml	1
pH Buffer Solution 10	500ml	1
Deionized Water	4 L	1
Conductivity Standard 100	1 L	1
Conductivity Standard 1412	1 L	1
pH Electrode Solution	500ml	2
Stablcal Formazin Standard <0.1 NTU	500 ml	2 (1 exp)
Stablcal Formazin Standard 100 NTU	500 ml	2 (1 exp)
Clorox Bleach	1 L	1
70% Ethanol	2 L	1
Unless otherwise noted all chemicals are in main cabinet for storage.		

Procedures for Safety Preparation

The following should be completed before traveling into the field to sample:

1. Completion of a Readiness Review
2. Completion of a Field Itinerary Form (trip plan)
3. Completion of the Official Vehicle Travel Checklist
4. Completion and review of Job Hazard Analysis (JHA)
5. Review and update emergency contact information
6. Update and double check contents of Field Safety Notebook
7. Completion of Medical Information for Office Personnel form
8. Completion of CPR / First Aid Training
9. Review all protective equipment to ensure it is in working order and present
10. Check weather and stream conditions
11. Notify park managers and UCBN Coordinator of changes to itinerary
12. Tailgate safety meeting just prior to field work to address changing conditions/hazards

Required/Recommended Personal Protective Equipment

Required
Eye Protection (safety glasses or goggles)- while working with water chemistry standards
Felt sole (or similar) waders (chest, hip, neoprene)- when working in areas with coarse gravel.
Felt sole (or similar) wading boots-when working in areas with coarse gravel.
Latex gloves- while working with water chemistry standards.
Personal Flotation Device (PFD) – Life Jacket
First Aid Kit

Recommended
Bug spray
Compass / GPS Unit
Cotton gloves / wool gloves
First Aid Kit
Flashlight
Forceps / vial
Life Preserver
Maps
Neoprene gloves
Park radio
Personal water bottles
Polarized sunglasses
Rope
Safety glasses
Shovel
Sturdy work boots
Sun hat
Sunscreen
Survival kit
Technu (poison oak/ ivy cleanser)
Wading Belt
Warm clothing / hat

Literature Cited

Cooprider, M.A. 2005. Personnel Training and Safety, Version 1.01, Standard Operating Procedure #2. *In* San Francisco Area Network Freshwater Quality Monitoring Protocol, Version 2.01, Appendix H-SOPs, National Park Service, San Francisco Bay Area Network, CA. 51 pp. Plus appendices

National Park Service (NPS). 1999. Director's Order #50b and Reference Manual #50b Occupational Safety and Health Program.

Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D. Klemm, J.M. Lazorchak, F.H. McCormick, S.A. Peterson, P.L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, DC, EPA/620/R-06/003.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 14: Post Field Season Activities

Version 1.0, January 2009

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0

Note: This SOP describes the step-by-step procedures for equipment maintenance and storage after each field season.

Suggested Reading

HACH Environmental. 2006. Hydrolab DS5x, DS5, and MS5 Water Quality Multiprobes – User Manual. v.3

Peck, D. V., A. T. Herlihy, B. H. Hill, R. M. Hughes, P. R. Kaufmann, D. Klemm, J. M. Lazorchak, F. H. McCormick, S. A. Peterson, P. L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, DC, EPA/620/R-06/003.

Overview

Following the macroinvertebrate and multiprobe field work, all equipment will be stored in the UCBN headquarters. Non-electrical equipment, including nets, stakes, buckets, etc. should be stored in well-marked plastic bins. Some of this equipment may be used by other UCBN protocols, so thorough organization and documentation of equipment will be important. Electronic equipment, including; GPS units, multiprobes, and Archer units, should have the batteries removed during the winter months to prevent corrosion and leaking, and will be stored in plastic bins in the UCBN office. Multiprobes will be cleaned and stored in a hard plastic case, such as a Pelican case, to prevent any damage to the sondes.

Procedures

Removal of Multiprobe Housing

Each season the multiprobe housing should be removed from the water quality monitoring station. It is important to remove this housing for several reasons. First, removal will facilitate thorough cleaning and repair. Second, removal will prevent loss of the housing during typical fall and spring high flow events. Third, the absence of the housing will prevent vandalism during the off season when UCBN personnel and park managers will not frequent the site.

Equipment Cleaning/Storage

It is important to clean all equipment, to reduce the risk of transferring invasive species and pathogens, and to have equipment ready for the next sampling season.

Multiprobe:

- After the last deployment for the season the instrument should be error checked/re-calibrated according to the guidelines in the Multiprobe Site Revisit SOP #6. If faulty/excessively warn sensors are noted they should be re-ordered and installed.
- The water quality multiprobe should be cleaned according to manufacture guidelines given in the HACH Hydrolab MS5 user manual. Generally this means cleaning the external surface of the multiprobe with a clean brush, soap and water. After washing with soap rinse the multiprobe with clean tap water and allow the outside (NOT the sensors) to dry. The sensors should be placed in the calibration/storage cup with one ½ inch of pH 4 buffer solution. This buffer solution will prevent desiccation, biological growth and damage to the pH sensor. It is important to note that the sensors should never be stored in de-ionized water.
- All sealing surfaces such as O-rings should be lubricated using silicone grease.
- Remove batteries
- The multiprobe should be stored in a plastic case in the UCBN office to prevent damage and to prevent the water in the storage cup from freezing.

- The cable should be stored in the same case as the multiprobe, and should be in coils of at least 15cm (6 inches) in diameter. If cable is coiled tighter that 15cm in diameter it will be damaged.

Multiprobe Housing:

- The multiprobe housing should be scrubbed thoroughly with a clean brush, soap and water, and if necessary a 10% bleach or Sparquat 256 solution. A toilet brush works well to reach inside the housing.
- The locks should all be lubricated with oil to prevent corrosion and make them easy to use in the spring.
- If necessary new band clamps should be purchased for the re-attachment of the housing in the spring.

Macroinvertebrate Equipment:

- In general the UCBN will follow guidelines established for equipment care after each stream visit, as established by the EPA-EMAP protocol (Peck et al. 2006).
- At a minimum all macroinvertebrate equipment; nets, sieves, buckets etc. should be soaked in a 10% Sparquat 256 or bleach solution for 10 minutes, or should be sprayed with a 50% solution and left to stand for 5 minutes. After soaking or being sprayed with bleach, the equipment should be thoroughly rinsed with fresh tap water. Each piece of equipment should be allowed to dry in direct sunlight (84°F) for at least 4 hours.
- Torn nets should be repaired if possible, and replaced if damage will create a potential for sample bias.
- Macroinvertebrate gear will be stored in a plastic container in the UCBN office.

Electronic Equipment:

- All electronic equipment should have pertinent data removed and stored as a hard copy or on a computer.
- Batteries should be removed.
- Electronics should be wiped down according to manufacture instructions to remove dust.

Consumable Materials Inventory

At the end of each field season a list should be prepared detailing the amount of consumable materials remaining and how much material should be ordered in the spring. Consumable materials include items such as: 95% alcohol, calibration standards, and batteries. This inventory should be conducted by the project leader and filed in the UCBN office to speed ordering of supplies in the spring.

Seasonal Summary

To adequately prepare for the following sampling season, notes should be taken on where improvements to the sampling protocol or data sheets can be made, records kept on the condition

of each multiprobe, and notes of any other problems or issues that occurred during the field season. In addition, all items listed on the UCBN Integrated Water Quality Season Closeout Checklist (Appendix 5) and Project Data Certification Form must be completed and filed with the data manager.

Integrated Water Quality Monitoring Protocol

Standard Operating Procedure (SOP) 15: Administrative Record/Protocol Revision

Version 1.1, February 2013

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	January 2009	UCBN	Revision following peer review		1.0
1.0	February 2013	UCBN-Aquatic Biologist	Updated following revisions to other SOPs	Track SOP updates	1.1

Note: This SOP describes the recommended protocol revision practices and provides a history and documentation of the protocol development and revision process.

Procedures

This monitoring protocol is an actively evaluated and updated document that reflects the latest procedures of the monitoring program. Revisions are expected, and can involve only minor changes with little overall impact or occasional major revisions and course corrections. Evaluation and revision of the protocol is directed by the project leader on an annual basis in association with season close-out. The narrative as well as each SOP has a revision history log whereby changes can be recorded. Older versions of the narrative and SOPs should be archived to ensure proper legacy of past work is maintained. Each revision will require the updating of the version number. Minor changes are recorded as decimal numbers (e.g., 1.0, 1.1, 1.2, etc…). Major changes are recorded as a change in the primary number of the protocol version (e.g., 1.0, 2.0, 3.0, etc…). In some cases, major revisions to the protocol may prompt the need for additional peer-review. The project leader and Network Coordinator will coordinate this with the Regional I&M Program Coordinator.

Administrative Record and Revision History Log

Table 33. Protocol administrative record and revision history log. This table summarizes the major events leading to the development and revision of the UCBN integrated water quality monitoring protocol (version 1.8).

Date	Development Step	Documentation
April 2005	Hired Chris Caudill, University of Idaho Research Scientist, to compile the historic and current status of monitoring in UCBN waterbodies.	UCBN Phase I report
June 2005	Chris Caudill reviewed and certified the NPSpecies fish inventory review for UCBN parks.	NPSpecies fish inventory certification
October 2005	Initial protocol development summaries developed for water chemistry, surface water dynamics, channel/streambank morphology, and macroinvertebrates.	PDS available from UCBN
March 2006-December 2006	Chris Caudill, University of Idaho Research Scientist, worked part-time on development of the monitoring protocol and contributed to the water quality components of the draft monitoring plan.	December 2006 draft monitoring plan submitted
June-September 2007	One HACH multiprobe was purchased and preliminary measurements were taken at Lapwai Creek for use in an initial power analyses.	Water Quality Resource Brief available from UCBN
October 2007	Additional HACH multiprobe purchased for 2008.	

December 2007	Hired Eric Starkey, aquatic biotechnician, to work with Lisa Garrett, UCBN Coordinator, to finish writing the water quality monitoring protocol.	Draft water quality protocol available from UCBN
January 2008	Internal review of protocol conducted by Kirk Steinhorst (statistician), Tom Rodhouse (ecologist), and Gordon Dicus (data manager).	Comments available from UCBN
February 2008	Draft of integrated water quality monitoring protocol version 1.0 complete, submitted for peer review with the NPS Water Resources Division. **NRR series ID assigned.**	
February 2008	Eric Starkey attended the Water Resource Professional Meeting to determine how other I&M Networks structure water quality monitoring protocols and manage water quality data. Eric identified ways to improve lab/field calibrations, and QA/QC procedures. These improvements were incorporated into the final protocol.	
April 2008	Eric Starkey attended USGS training entitled "Guidelines and Standard Procedures for Continuous Water Quality Monitors: Station Operation, Record Computation, and Data Reporting" lead by Rick Wagner. This course provided valuable information on multiprobe installation, calibration technique, calibration criteria, data ratings, interpretation of time series data and cross section surveys. Knowledge gained in this course lead to the development of SOPs detailing cross section surveys, multiprobe site revisits, and record processing. These SOP's were not included in the draft submitted for peer review in February 2008. Guidance from Rick Wagner helped standardize parts of the UCBN water quality protocol with USGS procedure. Rick Wagner and Hydrologist Brett Smith suggested that the UCBN investigate the use of Aquarius Time Series Software by the Aquatic Informatics company to manage water quality data.	Meeting notes available from UCBN
May 2008	Eric Starkey provided hands on water quality monitoring training for resource managers at NEPE (Jason Lyon) and WHMI (Roger Trick). This training provided an opportunity for resource managers to learn how to conduct calibrations and routine maintenance on continuous water quality monitoring instruments. In addition, training provided a means of testing the Multiprobe Site Revisit SOP.	
May-November 2008	Pilot field season. Water chemistry data was collected hourly between the months of May and November at NEPE–Lapwai Creek and WHMI-Mill Creek. Macroinvertebrates were collected at NEPE-Lapwai and Jim Ford Creeks and WHMI-Mill Creek. Experience from the first field season helped guide revisions of the peer reviewed draft protocol.	2008 Water Quality Annual Report and Resource Brief

June-July 2008	Eric Starkey conducted water quality site reconnaissance at BIHO, CIRO, CRMO, and JODA. Assessment of potential monitoring locations helped guide revisions to SOPs on water chemistry site selection and macroinvertebrate sample procedures.	Integrated Water Quality Site Reconnaissance Notebook, available from UCBN
June-August 2008	Eric Starkey and Lisa Garrett worked with Pete Penoyer and Water Resource Division (WRD) to facilitate the purchase of Aquarius Time Series Software by the Aquatic Informatics Company. Aquatic Informatics agreed to reduce the purchase price from $5,000 to $2,500 and WRD agreed to purchase the program with the understanding that the UCBN would pilot test the software. The purchase date for Aquarius Time Series Standard was August 2008	
June 2008	Integrated Water Quality Monitoring Protocol approved pending minor revisions.	
August-December 2008	Revision of Integrated Water Quality Monitoring Protocol	
September 2008	Additional HACH multiprobe purchased by WHMI for network wide use.	
January 2009	Internal review of protocol conducted by Lisa Garrett (Network Coordinator), Kirk Steinhorst (statistician), Tom Rodhouse (ecologist), and Gordon Dicus (data manager).	
February 2009	Final draft of integrated water quality monitoring protocol version 1.0 complete, submitted for peer review with the NPS Water Resources Division.	
August 2009	Protocol version 1.0 approval by NPS Water Resources Division. Minor revisions completed. **Original series ID number and date maintained (February 2008).**	Final water quality protocol available from UCBN v 1.0
February 2013	Protocol SOPs # 1, 2, 6, 7, 9, 11, 13, and 15 were updated by Eric Starkey (Aquatic Biologist). Updates were to add clarity to procedures and to reflect lessons learned since the implementation of the approved protocol in 2009. In addition, changes to SOP 7 were due to the integration of benthic macroinvertebrate sample collection with the UCBN stream channel characteristics monitoring protocol.	Water quality protocol available from UCBN v 1.8

UCBN Protocol Development Summary

Protocol: Integrated Water Quality

Parks Where Protocol Will Be Implemented:
BIHO, CIRO, CRMO, JODA, NEPE, and WHMI

Justification/Issues being addressed:
Monitoring of NPS water resources has been identified as a core objective of the national I&M program, as well as by the UCBN. Several UCBN parks have identified water quality improvement-related land health goals for performance reporting purposes. All Network waters assessed by state DEQ agencies are on 303(d) lists for impairment of at least one parameter, and the riparian and wetland areas supported by Network waterbodies are foci for biological invasions and other management challenges. Several parks have begun concerted riparian and stream channel restoration projects.

Although the UCBN contains more than 34 rivers, streams, ponds, and reservoirs within park boundaries, water resources actually represent a very small percentage of total land cover, except in the case of LARO. Unlike many water resources in the National Park system, most UCBN parks and waterbodies are only small proportions of their watersheds. Consequently, water quality and aquatic resources are strongly affected by activities outside of the park boundaries, and NPS management authority and capability for water quality improvement in waterbodies that pass through the parks is minimal. However, aquatic environments are disproportionately important in terms of biodiversity, biological productivity, and many other ecosystem functions and values. The UCBN has prioritized three water quality vital signs, surface water dynamics, aquatic macroinvertebrates, and water chemistry, and is committed to implementing a modest integrated water quality monitoring program that address those vital signs.

Water quantity and flow regime have overriding influence on stream channel morphology and stream and riparian biota. The strong alteration of flow regimes by human activity in the UCBN has altered biotic communities and ecosystem processes. UCBN parks are small relative to their watershed areas and few contain established flow monitoring sites within their boundaries. Consequently, future revisions to the integrated water quality monitoring protocol will include the monitoring of stream flow and compilation of data available from stations within and outside of UCBN unit boundaries. Aquatic macroinvertebrates are good indicators of ecosystem condition because they occur in all waterbodies, integrate point, nonpoint, pulse, and press disturbances, are trophically diverse, and are less mobile than fishes. Macroinvertebrate communities are also affected both by conditions in local stream reaches and those within the watershed. The sampling of aquatic macroinvertebrates is relatively effective and efficient compared to other biotic indicators (e.g., algae and fish), and hence, is relatively cost-effective. Water chemistry and temperature have strong effects on aquatic biota. Consequently, direct and indirect human alteration of stream water chemistry and temperature is associated with altered biotic communities and ecosystem processes. Because of the direct relationship between water

chemistry and biota, water chemistry is typically a central component of any water quality monitoring program. More recently, monitoring of stream water temperatures has increased because of concerns over cold-water fish habitat (primarily salmonid fishes), the recognized influence of land- and water-use on stream thermal regime, and the need for baseline temperature information to monitor effects of climate change. For example, temperature was selected as one of two key parameters for monitoring in the John Day Basin by the NOAA research, monitoring, and effectiveness program and its partners.

The water monitoring protocol will be a single, integrated protocol because sampling locations and personnel will greatly overlap. Macroinvertebrates will be sampled directly from select UCBN waterbodies, and water chemistry will be monitored by sampling select waterbodies for a set of core water quality parameters using continuous water quality monitoring probes ("multiprobes"; temperature, pH, specific conductance, dissolved oxygen, and turbidity).

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- Are the core water quality parameters of streams in the UCBN with established TMDLs selected for sampling improving over time?
- What is the status and long-term trend of core water quality parameters (temperature, pH, conductivity, dissolved oxygen, and turbidity) in UCBN streams selected for sampling?
- What is the status and long term trend in aquatic macroinvertebrate abundance and assemblage composition in selected UCBN streams?
- Do aquatic macroinvertebrate assemblages sampled within UCBN streams indicate polluted or otherwise impaired water quality?
- Do aquatic macroinvertebrate assemblages sampled within UCBN streams indicate "pristine" or "reference" conditions according to regional criteria established by EPA and the states of Idaho, Oregon, Montana, and Washington?

Monitoring objectives addressed by this protocol include:

- Determine status and long term trend in key water quality parameters for selected streams within UCBN park units. ***Justification:*** *Water quality has strong effects on aquatic biota, but both vary through time as a result of natural and human-induced causes. Understanding the patterns of variability among years is critical to detecting long-term trends.*

- Determine status and trend in aquatic macroinvertebrate abundance, assemblage composition, and functional feeding group composition in wadeable streams within the UCBN. ***Justification:*** *Aquatic macroinvertebrates are good indicators of ecosystem condition because they occur in all waterbodies, integrate point, nonpoint, pulse, and press disturbances, are trophically diverse, and are less mobile than fishes. Macroinvertebrate communities are also affected both by conditions in local stream reaches and those within the*

watershed. Macroinvertebrate communities are also affected both by conditions in local stream reaches and those within the watershed.

Basic Approach:
The monitoring protocol will specify criteria for selecting suitable sites (i.e., maximum distance from UCBN park boundary, etc.). Data analysis, statistical testing, and data summarization and reporting protocols will be specified and SOPs will include examples. SOPs specifying statistical comparisons will include tests of long term changes in and status of macroinvertebrate assemblage structure.

Macroinvertebrate biomonitoring protocols are well developed and SOPs will be adapted from existing protocols developed by the EPA and the states of Idaho, Oregon and Washington, and other NPS monitoring Networks. Therefore, protocol development will not require field research and will primarily consist of writing protocols to meet NPS standards and to make existing national and regional protocols specific to UCBN parks. Site selection will be specified and will include protocols for selecting, permanently marking, photographing, and determining site coordinates using GPS. The type(s) of sampling device, size, and mesh size will be specified following consultation with local experts (EcoAnalysts, Moscow ID, Idaho DEQ, etc). Sample frequency and timing will be conducted using a rotating basin design, where one-third of UCBN waterbodies are sampled each year, resulting in the sampling of each unit every 3 years. Protocols will specify the frequency and sampling within year, and samples will be taken during index periods suggested by Hayslip (2007) and Montana DEQ (2006); June through October. SOPs will also describe field sampling, sample preservation, processing, and archiving, field and laboratory data collection (including sample data sheets), data storage, sharing, and database management, and will include an SOP to ensure QA/QC. Following the first round of sampling, protocols for data summaries and statistical power analyses will be specified to determine the primary sources of variation in aquatic community structure and whether sampling levels are sufficient to meet monitoring goals. Additional SOPs will recommend potential sampling regime modifications, protocols for data analysis, including methods for testing for long-term trends, and suggested data summary and reporting formats.

Water chemistry and temperature data will be evaluated to determine the best sites for monitoring. The UCBN seeks to balance the need for a representative location within each stream, with factors such as: stream stages, channel morphology, water velocity, potential for debris damage, and logistics. The reasoning for specific site selection will be fully documented. Data analysis, statistical testing, and data summarization and reporting protocols will be specified and SOPs will include examples. SOPs specifying statistical comparisons will include tests of long term change in the magnitude and variability in parameters, and will emphasize reporting of trends in 303(d) listed streams.

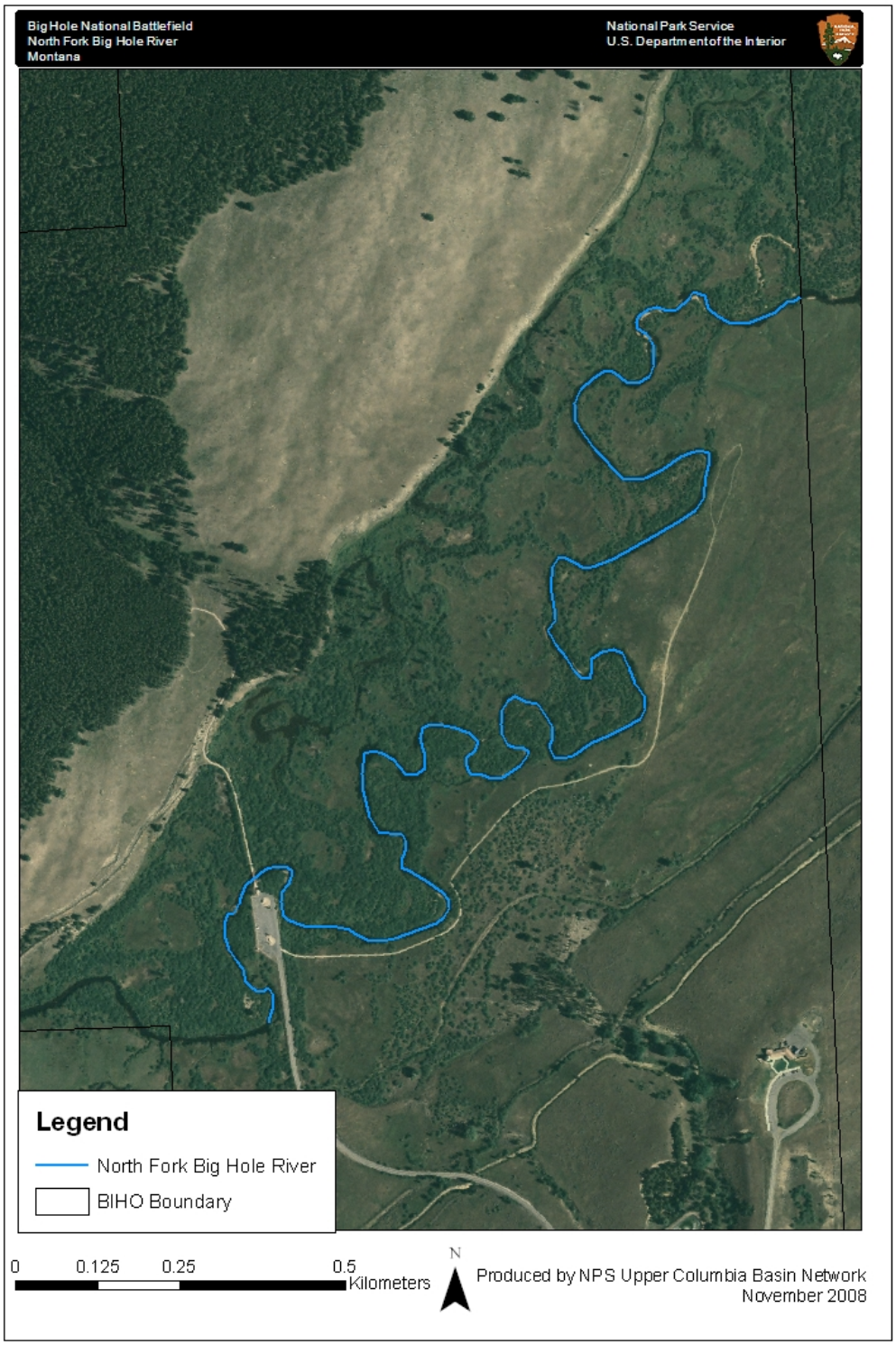
The use of continuous water quality monitors (multiprobes) will allow water quality data for a core set of parameter to be determined at high resolution from selected UCBN waterbodies. The core parameters will be measured every hour by the multiprobe. Probes will be deployed in each

stream from May through the end of October to characterize daily, weekly, seasonal, and interannual patterns in mean parameter values and variability. SOPs will describe multiprobe transport, calibration/maintenance, storage, data retrieval, analysis, and archiving. Data analysis, statistical testing, and data summarization and reporting protocols will be specified and SOPs will include examples. SOPs outlining data screening and QA/QC protocols will be included, as well as procedures for revising monitoring protocols and documenting any changes.

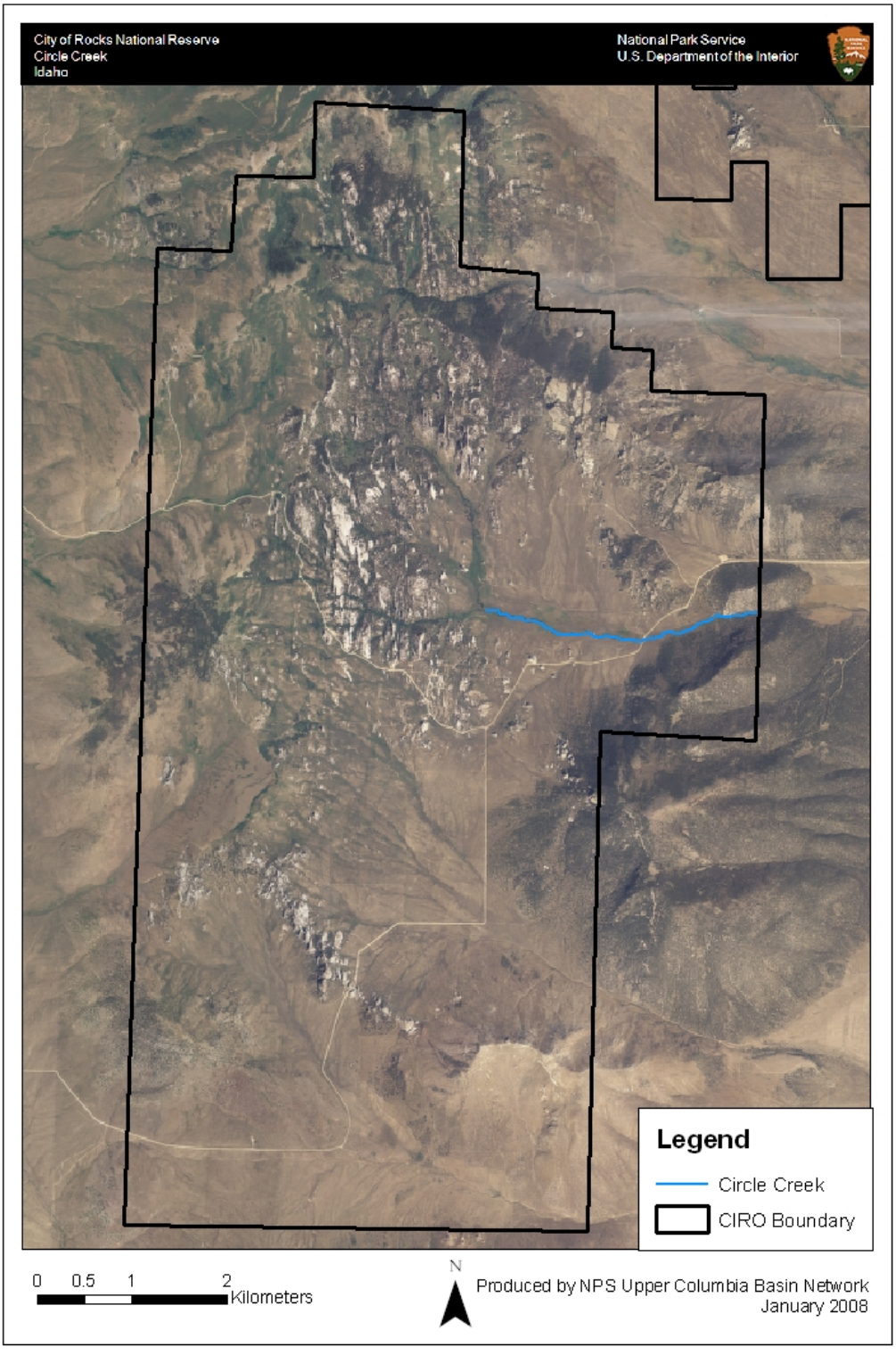
NPS Project Leader:
Eric Starkey, 208-885-3010

Development Schedule, and Expected Interim Products:
A draft monitoring protocol was submitted to NPS Water Resource Division for review in January 2008. Upon return of the protocol from peer review, comments and revisions were incorporated into the final Integrated Water Quality Monitoring Protocol.

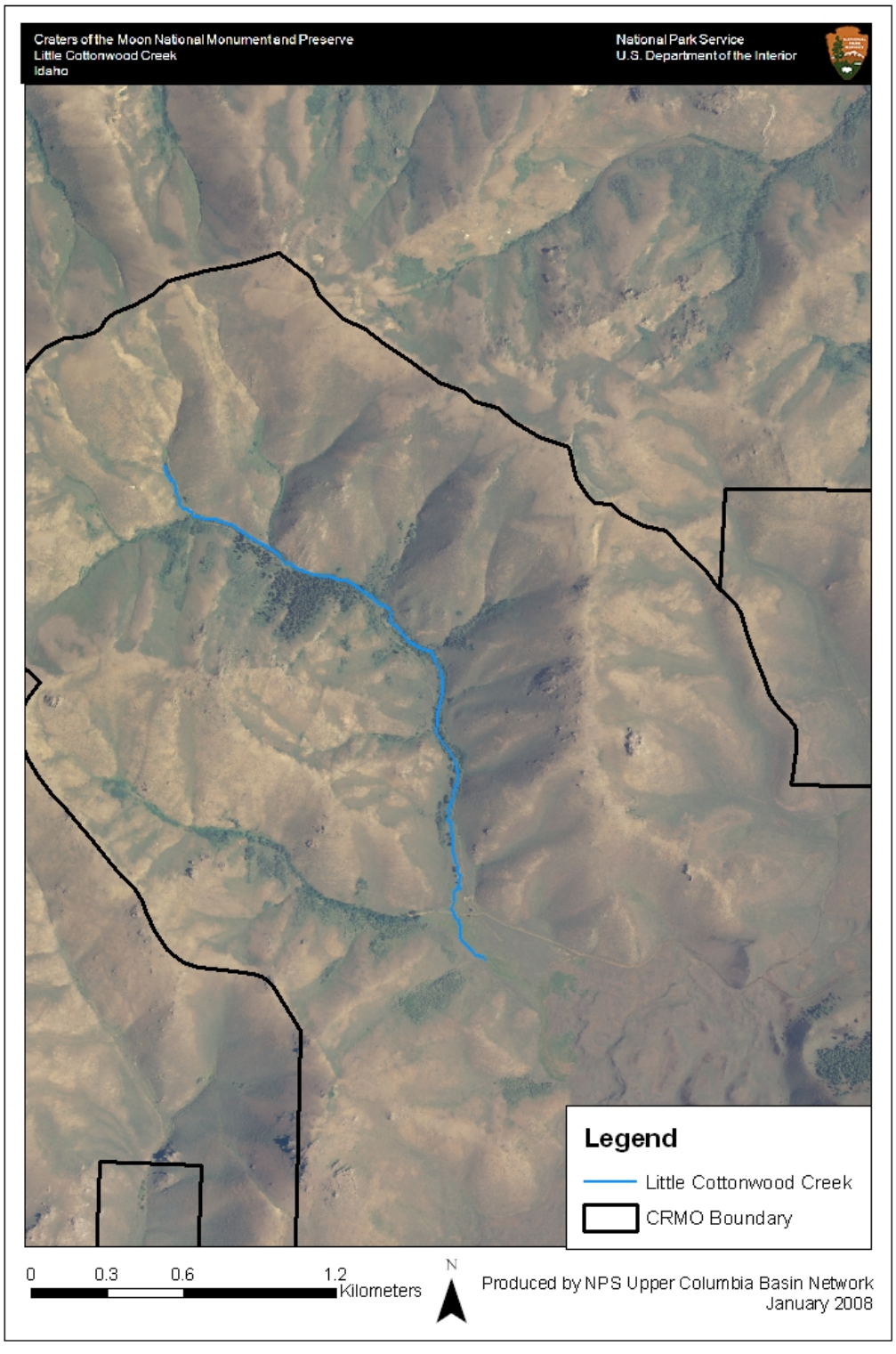
Appendix 1. UCBN Stream Maps



Appendix 1. UCBN Stream Maps (continued)



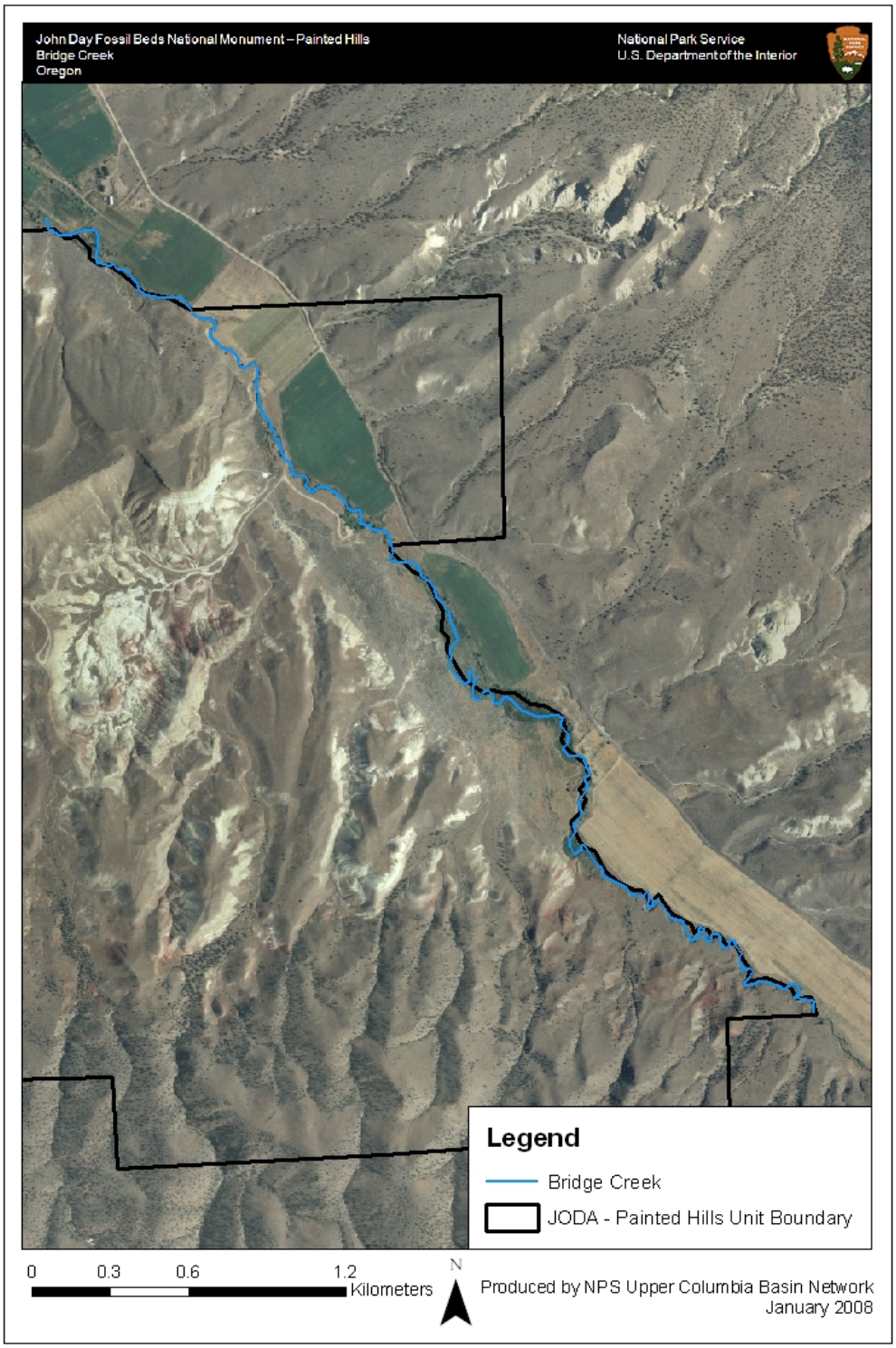
Appendix 1. UCBN Stream Maps (continued)



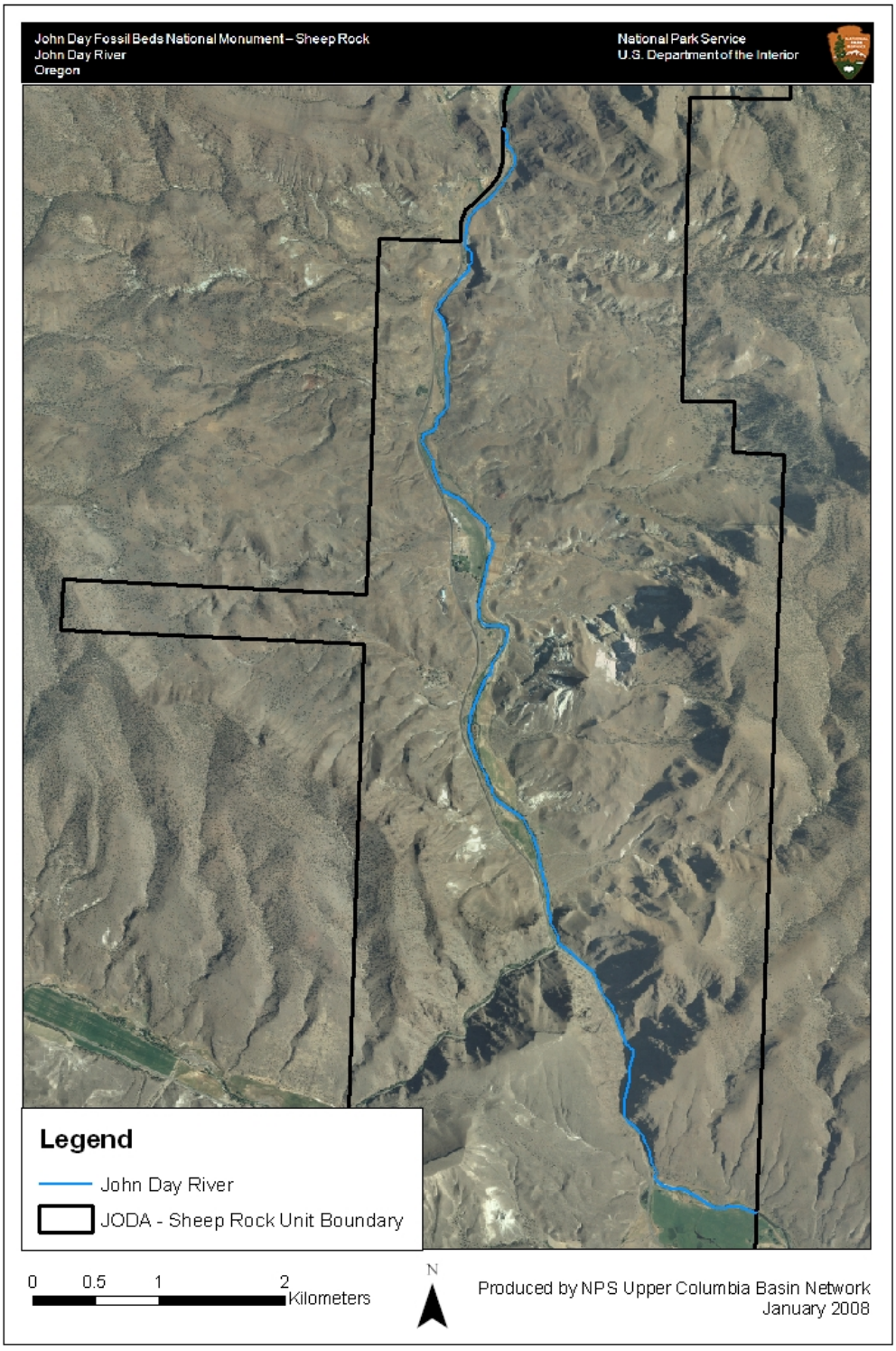
Appendix 1. UCBN Stream Maps (continued)



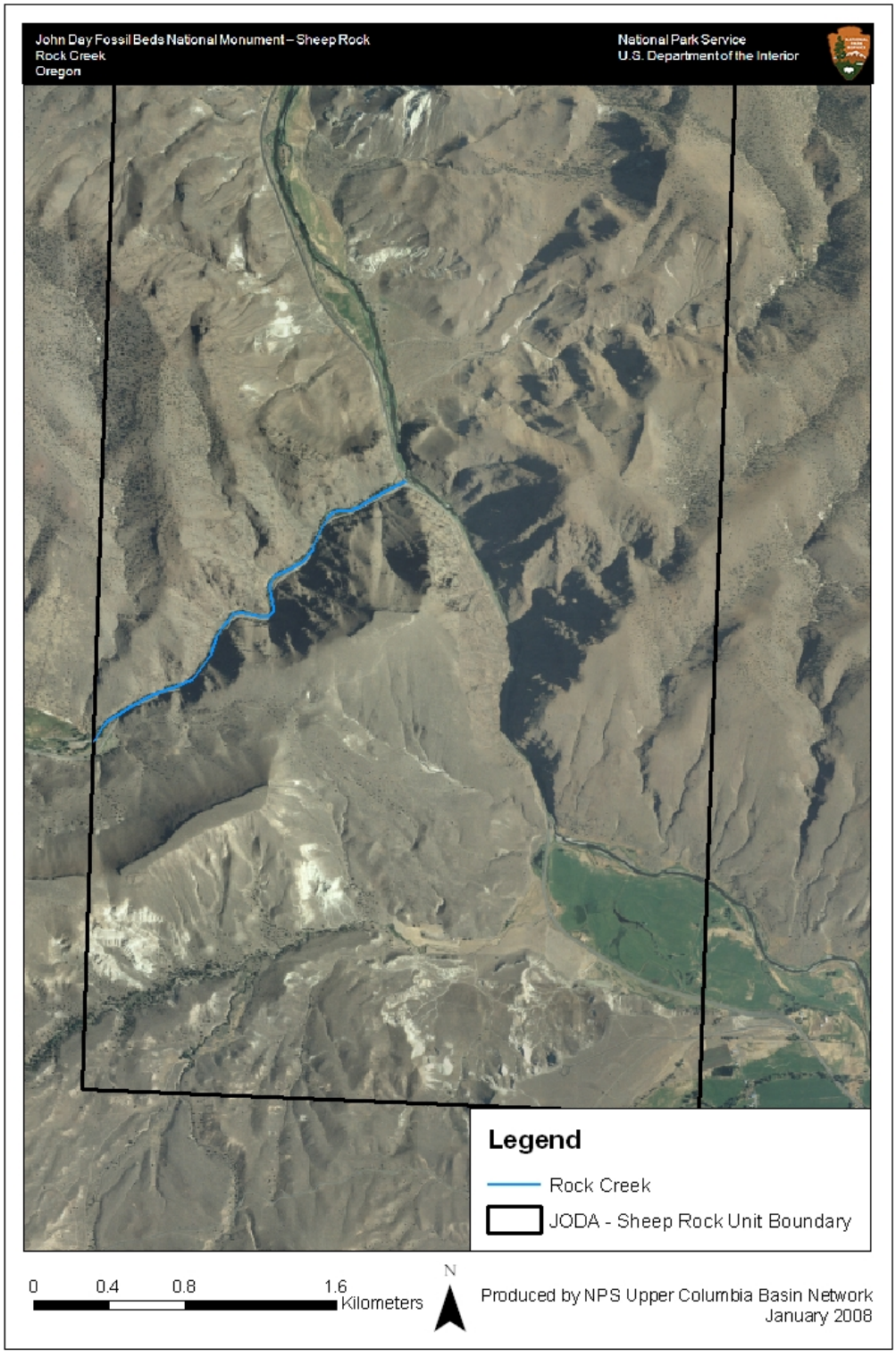
Appendix 1. UCBN Stream Maps (continued)



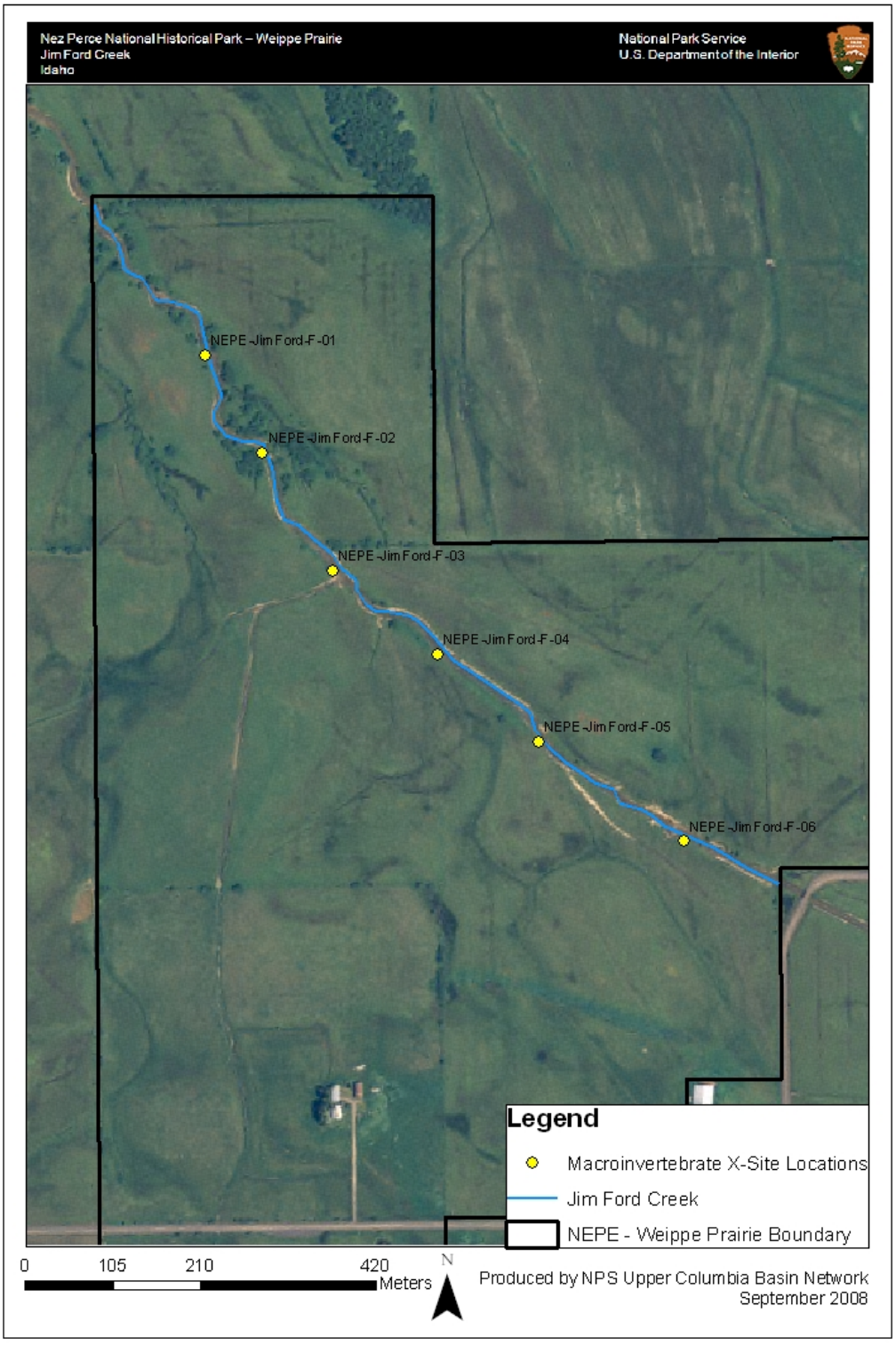
Appendix 1. UCBN Stream Maps (continued)



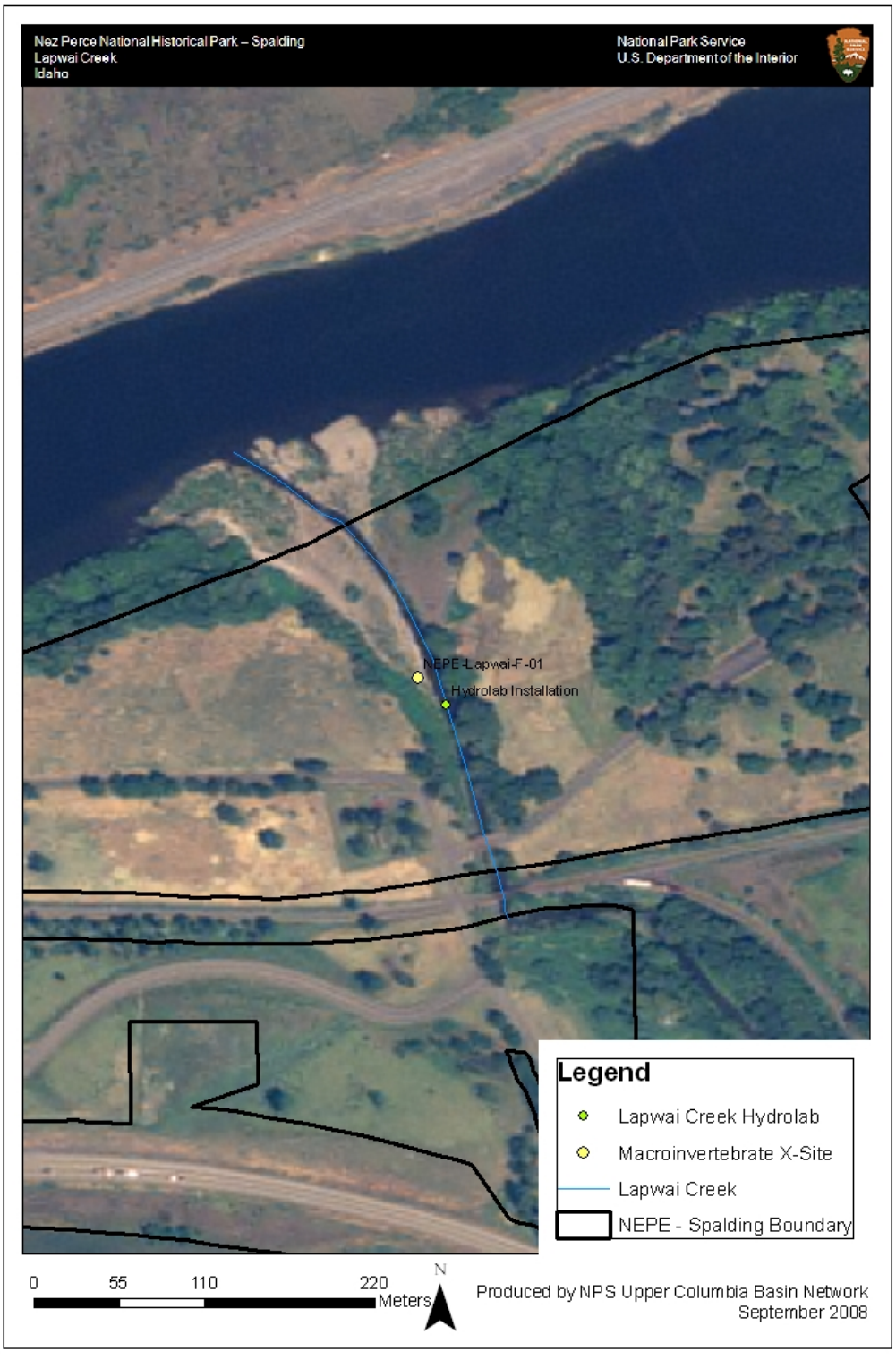
Appendix 1. UCBN Stream Maps (continued)



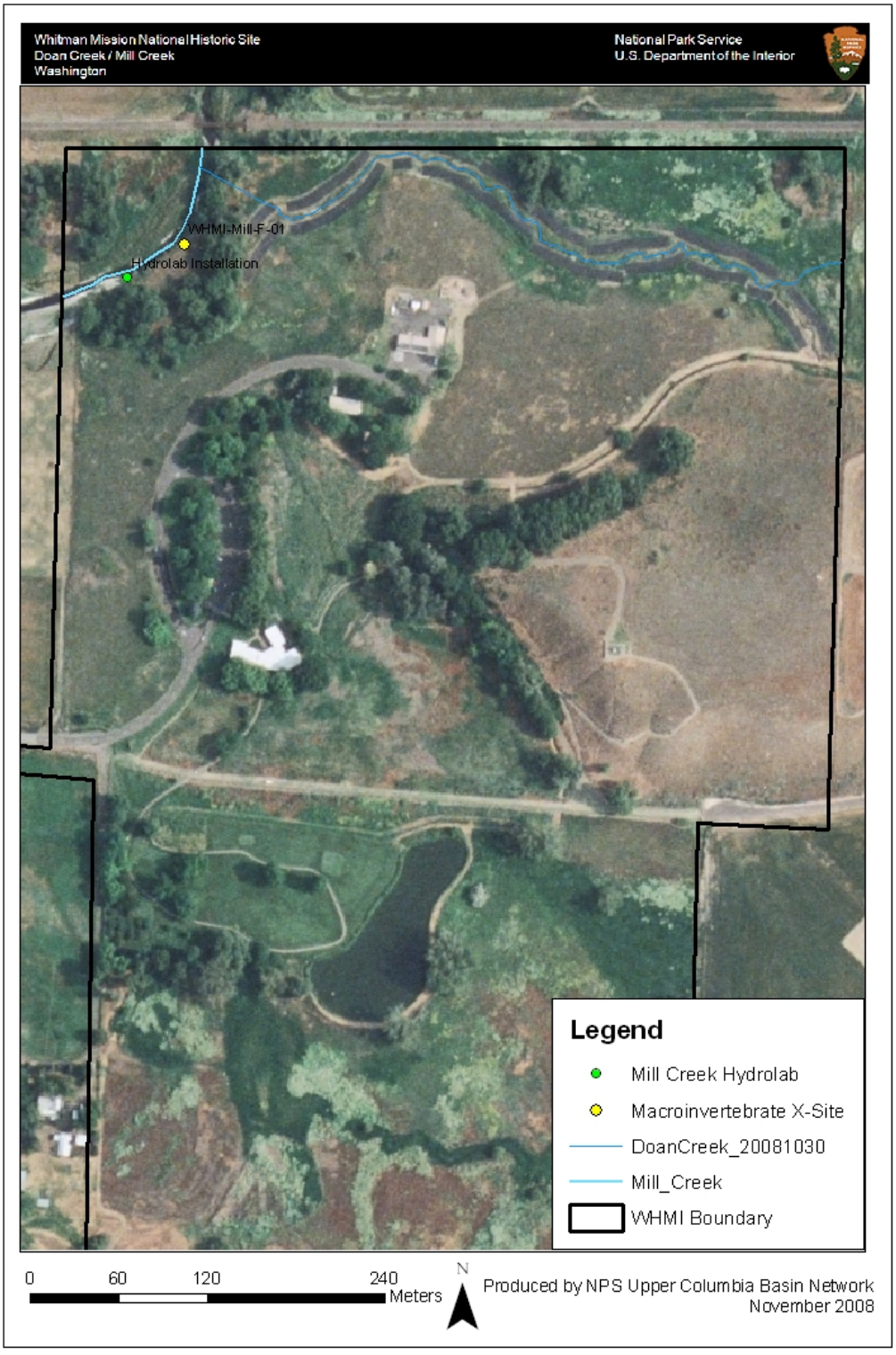
Appendix 1. UCBN Stream Maps (continued)



Appendix 1. UCBN Stream Maps (continued)



Appendix 1. UCBN Stream Maps (continued)



Appendix 2. Sources for UCBN Water Quality Data

State Water Resource Monitoring Programs: State programs include 303(d) assessments, monitoring of surface water quality, and in most of the states, an aquatic macroinvertebrate monitoring program.

Idaho: http://www.deq.idaho.gov/water/index.cfm

Montana: http://www.deq.state.mt.us/wqinfo/index.asp

Oregon: http://www.oregon.gov/DEQ/WQ/

Washington: http://www.ecy.wa.gov/programs/wq/wqhome.html

Updating 303(d) status:
In recent years, states have been combining the 303(d) and 305(b) reports into a single Integrated Report. These are available online.

Idaho's 2002 and 2008 Integrated report can be found at:

http://www.deq.idaho.gov/water/data_reports/surface_water/monitoring/2008.cfm

Montana's 2004 Integrated report can be found at:
http://www.deq.state.mt.us/wqinfo/303_d/303d_information.asp

Oregon's Integrated Report for 2004/2006 can be found at:
http://www.deq.state.or.us/wq/assessment/rpt0406.htm

Washington's 2002/2004 Integrated Report was approved by EPA on 4 November, 2005:
http://www.ecy.wa.gov/programs/wq/303d/2002/2002-index.html

Tribal Water Resource Monitoring Programs: The Nez Perce Tribe has a water resource monitoring program: http://www.nezperce.org/Programs/water_resources_program.htm

Pacific Northwest Aquatic Monitoring Program (PNAMP):"The purpose of the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is to provide a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs. Improved communication, shared resources and data, and compatible monitoring efforts provide increased scientific credibility, cost-effective use of limited funds and greater accountability to stakeholders. PNAMP provides leadership through the development and the advancement of recommendations and agency level agreements that are considered for adoption by the participating agencies." http://www.pnamp.org

Appendix 2. Sources for UCBN Water Quality Data (continued)

StreamNet: "StreamNet is a cooperative venture of the Pacific Northwest's fish and wildlife agencies and tribes and is administered by the Pacific States Marine Fisheries Commission. We provide data and data services in support of the region's Fish and Wildlife Program and other efforts to manage and restore the region's aquatic resources"(www.streamnet.org). StreamNet is primarily a repository for fish surveys, though it is also as contains habitat data.

USGS National Ambient Water Quality Assessment (NAWQA):

As described by Fuhrer et al. (2004):

> "In 1991, the U.S. Congress began to appropriate funds to the USGS to conduct the National Water-Quality Assessment (NAWQA) Program. Since that time, NAWQA has evaluated the quality of streams, ground water, and aquatic ecosystems in more than 50 major river basins and aquifer systems across the Nation, referred to as "Study Units." As indicated on the map, timing of the assessments varies within the program's rotational design: about one-third of all Study Units are intensively investigated for 3 to 4 years, which is followed by 6 to 7 years of low-level monitoring.
>
> In 2001, the NAWQA Program entered its second decade of investigations and an intensive reassessment of water conditions was begun to determine trends, based on 10 years of comparable monitoring data collected at selected streams and ground-water sites. The next 10 years of study also will fill critical gaps in characterizing water-quality conditions, and increase understanding of processes that control water-quality conditions, which will better establish critical links among sources of contaminants, their transport through the hydrologic system, and the potential effects of contaminants on ecological health and on the quality of drinking water."

Three NAWQA study basins fall within the UCBN boundary. The Upper Snake River Basin study unit (Clark et al. 1998) includes HAFO, CIRO, and CRMO. The Yakima (Fuhrer et al. 2004) and Central Columbia Plateau (Williamson 1998) study basins do not encompass any UCBN Units, but provide good overviews of water resource trends and issues in the region. Resampling of most basins is currently underway and the program should be monitored for the addition of study basins that include UCBN units. More detail on the program, including links to the data storage warehouse can be found at http://water.usgs.gov/nawqa/nawqa_sumr.html .

NPS Water Resources Division (WRD): WRD maintains the NPSTORET database and also maintains a list of 303(d) status for park water bodies nationwide that is updated periodically. The 303(d) list can be accessed through the NPS intranet at:
http://www1.nrintra.nps.gov/wrd/DUI/index.cfm

Appendix 3. Field Safety Notebook

Medical Information for Office Personnel

Employee name: _____ Home phone: _____

Treatment preference: medical _____ other (specify) _____

Doctor: _____ Phone: _____

Other emergency contact: _____ Phone: _____

Allergies and other medical conditions	Medications being taken	Medications to avoid

Relevant medical history:

Allergies and other medical conditions:

Special instructions:

Emergency Evacuation Instructions
NEPE – Spalding Area – Lapwai Creek

Be prepared to provide the following information:

1. **Nature of the accident or injury.**
   a. **Follow the SAMPLE and SOAP guidelines the back of this sheet.**
2. **Type of assistance needed, if any (ground, air, or water evacuation).**
3. **Location of accident or injury, best access route into the worksite (road name/number), i identifiable ground/air landmarks.**
4. **Radio frequencies.**
5. **Contact person.**
6. **Local hazards to ground vehicles or aviation.**
7. **Weather conditions (wind speed & direction, visibility, temperature).**
8. **Topography.**
9. **Number of individuals to be transported.**
10. **Estimated weight of individuals for air/water evacuation.**

Local Emergency Contact	**Phone Number**
Lapwai Police Department	208-843-2212 Or 911
Latah County Sheriff	208-882-2216 Or 911
NEPE - Park Ranger - Idaho Unit Manager - Scott Eckberg	208 843-7051
NEPE - Integrated Resources Program Manager – Jason Lyon	208 843-7017
UCBN Office	
Gordon Dicus – Program Manager	208-885-3684
UCBN data manager	208-885-3022
Eric Starkey- UCBN Aquatic Biologist	208-885-3010

Nearest Hospital

St Joseph Reg. Medical Center
415 Sixth Street
Lewiston, ID83501-0816
Phone: 208-743-2511

Route to Nearest Hospital:

Directions		**Distance**
Total Est. Time: 16 minutes	**Total Est. Distance:** 11.98 miles	
1:	Start out going NORTH on US-95 N toward SPALDING MILL RD.	8.8 miles
2:	US-95 N becomes US-12 W.	2.4 miles
3:	Turn RIGHT onto D ST / US-12 W.	0.1 miles
4:	Turn LEFT onto 9TH ST.	0.3 miles
5:	Turn RIGHT onto 5TH AVE.	0.1 miles
6:	Turn RIGHT onto 6TH ST.	<0.1 miles
7:	End at **415 6th St** Lewiston, ID 83501-2431, US	

1. **DO NOT PANIC**
2. **Make sure area is safe for you and victim**
3. **Do not move victim, unless necessary to avoid further injury**
4. **Stabilize victim and treat for shock**
    a. **Stop bleeding (apply pressure) use first aid kit (gloves, gauze, etc.)**
    b. **Make sure victim is lying down**
    c. **Elevate feet**
    d. **Cover with coat / blankets**
5. **Call / Radio for emergency help**
    a. **Provide the information listed at the top of this sheet**
    b. **Do not leave victim unless contact cannot be made**
6. **Remain with victim until help arrives or stabilize victim's condition before you go for help.**
7. **If with other group members consider evacuation of individual using stretcher or other techniques.**

The following is taken from Tilton, Buck. 2007. Backcountry first aid and extended care. National Outdoor Leadership School. 5th ed. Falcon Guides. Helena, MT.

SAMPLE History

The Sample Questions

S for symptoms: pain, nausea, lightheadedness, and other things you cannot see.
A for allergies: any known allergic reactions? What happens
M for medications: Anything legal or illegal? Why? How much?
P for pertinent medical history: Anything like this happen before? Currently under a physician's care for anything?
L for last intake and output: When was food or drink last taken? How much? When were the most recent urination and defecation? Were they normal?
E for events: What led up to the accident or illness? Why did it happen?

SOAP: The Written Report

This information should be given to emergency personnel and retained for records.

S for subjective summary: A summary of who the patient is (including age and sex), what the patient complains of, and what happened to the patient.
O for objective / observations: Observations and results of patient exam, vital signs and **SAMPLE** history.
A for assessment: What you think is wrong.
P for plan: What you are going to do immediately for the patient and the answer to the evacuation question- stay or go, fast or slow? A part of every plan is to monitor the patient for changes and developing needs.

Field Site Descriptions/Hazards

The following site descriptions describe the location and hazards for water quality monitoring stations; however, unless otherwise stated, it should be assumed that similar hazards also apply to benthic macroinvertebrate sample sites.

Site ID	Lat.	Long.	General Description	Potential Hazards
BIHO NF Big Hole River WQ Station 001	45.65166414	-113.64428200	The Hydrolab was deployed approximately 100 meters upstream from the bridge over the North Fork Big Hole River and 40m west of the lower parking lot.	Traffic in the parking lot, biting mosquitoes, high water, deep pool just downstream of deployment location, sharp beaver chewed willow stakes, heavy willow cover, and extreme cold during fall samples.
CIRO- NF Circle Creek WQ Station 001	42.090693	-113.707035	The Hydrolab was deployed just upstream of where Stripe Rock Trail crosses North Fork Circle Creek. See the trail map of City of Rocks at http://www.nps.gov/ciro/planyourvisit/upload/CIRO-Trail-Map-11-24-10-4.pdf Stream is moderately incised with steep banks.	Uneven trail/2-track road on the hike in, rattlesnake encounters on trail and in riparian area, steep banks, potential encounters with cattle, and extremes in air temperature.
CIRO- SF Circle Creek WQ Station 001	42.077681	-113.707022	The Hydrolab was deployed just downstream of where Box Top Trail crosses South Fork Circle Creek. See the trail map of City of Rocks at http://www.nps.gov/ciro/planyourvisit/upload/CIRO-Trail-Map-11-24-10-4.pdf	Uneven trail on the hike in, potential rattlesnake encounters on trail and in riparian area, steep banks, and extremes in air temperature.
CIRO- Circle Creek WQ Station 001	42.076254	-113.680830	The Hydrolab was deployed ~150 m downstream of where Circle Creek flows under City of Rocks Road. Follow the equestrian trail to the east towards monitoring station. Stream is very incised with steep banks and sharp drop offs.	Traffic/parking along City of Rocks road, equestrian traffic on trail, uneven trail, very steep and potentially unstable banks, potential encounters with cattle, potential rattlesnake encounters on trail and in riparian area, and extremes in air temperature.
CIRO/CRSP- Almo Creek WQ Station 001	42.126794	-113.659879	The Hydrolab was deployed just to the North of the fence line North of the "ranch house". Access is from the parking lot ~300m south of site.	Traffic along the road and in parking lot, uneven/rocky banks, and potential rattlesnake encounters on trail and in riparian area.

Field Site Descriptions/Hazards (continued)

CRMO- L.Cottonwood Creek WQ Station 001	43.48793970	-113.59347828	The Hydrolab was deployed 580 m upstream from where the 2-track road crosses the creek. The stream lies in a steep valley and is relatively high gradient.	Narrow 2-track road requires high clearance vehicle. If fire danger exists it is best to hike in from field station. Uneven terrain, must traverse steep hillside to access the stream, loose soil/substrate, potential rattlesnake encounters on trail and in riparian area, thick riparian vegetation, and extremes in air temperature.
JODA- Bridge Creek WQ Station 001	44.65517177	-120.25189075	The Hydrolab was deployed approximately 75 m downstream of the picnic area /visitor information kiosk.	Traffic in the parking lot, steep potentially unstable banks, potential rattlesnake encounters, and extreme heat midsummer.
JODA- John Day River WQ Station 001	44.56650180	-119.64642028	The Hydrolab was deployed approximately 1.6 km downstream of the Cant ranch house and approximately 200 m downstream of the first parking area north of the Cant ranch	Traffic in the parking lot and on highway, large cobble-boulder substrate in stream is difficult to traverse, potential rattlesnake encounters, extreme heat midsummer, and deep water/high flow during cross section survey.
NEPE- Jim Ford Creek WQ Station 001	46.35429603	-115.91867957	The Hydrolab was deployed approximately 200 m downstream of the bridge (Larson or Prairie Road) over Jim Ford Creek	Traffic along the county road, several downed fences are a tripping hazard, slick clay/hard pan substrate, biting mosquitoes, and a deep pool near the bridge.
NEPE- Lapwai Creek WQ Station 001	46.44935628	-116.81816423	The Hydrolab was deployed in the same location as in 2008, approximately 100 meters downstream from the railroad bridge.	Traffic in the parking lot, very slick cobble substrate, potential rattlesnake encounters, ticks, extreme heat midsummer, and high flow in spring.
WHMI- Doan Creek WQ Station 001	46.044167	-118.463377	The Hydrolab was deployed approximately 100 m upstream from the mouth of Doan Creek.	Traffic in the parking lot, and ticks.
WHMI- Mill Creek WQ Station 001	46.04366488	-118.46517032	The Hydrolab was deployed approximately 150 m downstream from the railroad bridge/northern park boundary.	Traffic in the parking lot, ticks, poison ivy, thick black berry thickets in riparian area, high flow in spring.

Job Hazard Analysis

U.S. Department of Interior National Park Service	WORK PROJECT/ACTIVITY UCBN Integrated Water Quality Monitoring	LOCATION Upper Columbia Basin Network Parks	UNIT
JOB HAZARD ANALYSIS (JHA)	**DEVELOPED BY** **Eric Starkey**	**JOB TITLE** **Aquatic Biologist**	**DATE PREPARED** **9 April 2012**

APPROVED BY: DATE:

Required and/or Recommended Personal Protective Equipment:

RECOMMENDED

Bug spray	Polarized sunglasses
Compass / GPS Unit	Rope
Cotton gloves / wool gloves	Safety glasses
First Aid Kit	Shovel
Flashlight	Sturdy work boots
Forceps / vial	Sun hat
Life Preserver	Sunscreen
Maps	Survival kit
Neoprene gloves	Technu (poison oak/ ivy cleanser)
Park radio	Wading Belt
Personal water bottles	Warm clothing / hat

REQUIRED

Eye Protection (safety glasses or goggles)- while working with water chemistry standards
Felt sole (or similar) waders (chest, hip, neoprene)- when working in areas with coarse gravel.
Felt sole (or similar) wading boots-when working in areas with coarse gravel.
Latex gloves- while working with water chemistry standards.
Personal Flotation Device (PFD) – Life Jacket
First Aid Kit

TASKS/PROCEDURES	HAZARDS	ABATEMENT ACTIONS Engineering Controls* Substitution* Administrative Controls* Personal Protection Equipment
All Tasks and Procedures	**Unfamiliarity**	**All people (permanent, seasonal, VIPs) involved in any project should receive a general orientation and tailgate safety session specific to the task prior to beginning of work.**
1. Driving to and from remote field sites	1a. Narrow roads with bumpy or "washboard" surfaces	WEAR SEATBELTS AT ALL TIMES WHEN VEHICLE IS MOVING 1a. Maintain a safe speed (this may be below the legal speed limit) for the road conditions; stay clear to the right, especially on curves, drive with headlights on at all times; when turning around on mountain roads always "face the danger" (versus backing toward the cliff edge, e.g.); the passenger should get out and spot for driver when backing up.
	1b. Driving with limited visibility	1b. Maintain windshield cleaner fluid level and clean both sides of windows regularly (remember back window); slow down; if blinded by sun or dust, proceed slowly or pullover and wait for hazard to pass; keep to the right hand side of the road and drive with your lights on.
	1c. Sharp rocks on edge or in middle of road	1c. Get out and move sharp rocks out of the way, reduce speed substantially in places with large amounts of rockfall; make sure tires are properly inflated and check tread and walls regularly for damage; make sure tire jack fits the vehicle and all parts are in the vehicle.
	1d. Large animals crossing or standing in roads	1d. Slow down where animals might be present to allow for reaction time; do not swerve abruptly to avoid hitting an animal, if necessary it's better to ride out the impact.
	1e. Fatigue at night and after a long shift in the field	1e. Be aware of signs of fatigue- pull over and rest! Take a short nap, eat a snack or have a partner drive; do not take chances by continuing to drive; communicate with your field partner.
	1f. Storm conditions – wind, lightning, muddy/ slippery roads	1f. Keep informed on the current weather- check www.weather.com or www.wrh.noaa.gov; if winds exceed 15 mph, or the excessive wind category on Beaufort scale (tree tops swaying, twigs and leaves falling, etc.), do not travel into the field; avoid going to the field if lightning is present and avoid using radios; drive slowly when roads are muddy and slippery or snow covered, check with geologists if you are uncertain of back road conditions; avoid wet clay roads as much as possible, these roads can fail after storms, especially in spring, maintain a slow speed when driving on these roads!; if you damage waterbars make sure you repair them immediately.
	1g. Fallen trees on road	1g. For small trees, try and remove tree or cut with a handsaw and remove portion of tree; for large trees, notify support crew to remove tree.

	1h. Others driving on the road	1h. Do not assume you are the only one on the road behind locked gates (day or night), people from other agencies use these roads; be alert to the idea that others may be coming in from the field in the early a.m. - drive slow and keep right!; if you encounter an unusual situation, contact your partner to inform and notify the supervisor or park ranger- avoid confrontational situations with visitors- let the proper authorities handle it!
	1i. Dry vegetation on or near road	1i. Dry vegetation especially on 2-track roads has the potential to ignite from hot engines and exhaust. Pay attention to fire conditions and consult with park staff prior to driving on un-paved surfaces in the park. It is advisable to carry a fire extinguisher and in some locations (CRMO) also a backpack sprayer.
2. Check in with Park/Communication	2a. No one available in the park office	2a. Attempt to call park contacts using a phone or radio. If no one responds, check in with the UCBN supervisor/program manager to let them know you have arrived at your destination.
	2b. Unable to reach a radio repeater in a remote location	2b. Make sure radio is charged- try to contact someone on the radio to inform him/her of your predicament; if you are unable to reach a repeater from your location climb upslope toward a ridgetop or knoll and try again; try at regular intervals, meandering around may help in getting a signal; Use cell phone in vehicle (while stopped), as this may be more reliable for communication in remote locations.
3. Hiking	3a. Steep, rugged, and slippery terrain	3a. Assess terrain conditions to find safe route and modify sampling plans to avoid unsafe areas; proper footwear is VERY important- wear boots with slip-resistant soles with tops well above the ankle, broken in before the field season, plus wool socks, NO TENNIS SHOES; if wearing wading boots be cognizant that they are slippery on grass and mud, carry supplies in backpack, make sure pack is comfortable and secure, waist belt recommended; take care when walking on hardwood leaf litter and on wet ground; maintain an erect posture when contouring steep slopes; avoid walking below another person due to the potential for rocks to dislodge from above; Use caution when crossing large and/or wet logs and fences.
	3b. Undergrowth	3b. Wear safety glasses (or other glasses) when hiking in brushy areas to protect eyes from protruding objects.
	3c. Stream crossing	3c. Wear proper slip-resistant footwear and life jacket. Unfasten backpack hip belt before crossing. Cross streams only if you are sure they are safely wadeable. Cross in shallow relatively calm area with limited obstacles (boulders, logs, etc.). Use a walking stick or pole to balance and check for deep pools. Cross at a slight downstream angle to avoid fighting the current.
	3d. Fence crossing	3d. Fences may be crossed during the course of work. When possible use gates (leave them open or closed depending on how you find them) if no gate is available cross under or over with caution.

4. Encountering noxious plants, animals, disease, and people	4a. Poison ivy	4a. Make sure you can identify poison ivy in all its growth forms, foliage, bare twigs, and berries (the plant is toxic in winter when foliage is absent!); wear long sleeves; avoid sitting with arms resting on knees; use Technu lotion (or something similar) to prevent exposure; wash with soap immediately after returning from the field; bring an extra set of clothes and shoes to change into after coming out of field; wash field clothes separately from other laundry.
	4b. Bees/Wasps/Hornets	4b. Determine if any field crew are allergic to bee stings. Notify other crew members and the supervisor if you know you are allergic to bee stings; ensure that individual carries prescribed medication to prevent anaphylactic shock; carry a bee sting kit or Benadryl or other antihistamine; be aware of the ground where you step- some hornets build nests in the ground at the base of trees or shrubs, or in rotten logs- watch for bees buzzing in and out of holes or around ground level; if possible, flag a nest so future surveyors won't run into it.
	4c. Ticks	4c. If bitten by a tick, remove it (grasp tick with tweezers at head and pull straight out); fill out an accident report as soon as you remove the tick. In the event that symptoms of Lyme disease appear the accident report will be of assistance.
	4d. Scorpions	4d. Inspect items left lying on the ground, e.g., clothing, for scorpions prior to putting them on
	4e. Mosquitoes	4e. Wear bug repellent and long sleeve shirt to prevent bites; be aware of West Nile Virus symptoms.
	4f. Rattlesnakes	4f. Avoid rattlesnakes by inspecting the ground near logs before stepping over them; avoid placing hands on rock ledges or other natural hoists without visually inspecting them first; in the unlikely event you're bitten by a rattlesnake, stay calm, sit still, and call and wait for help.
	4g. Mountain lions	4g. Avoid mountain lions; if you encounter a lion that doesn't run from you- leave the area; if attacked- fight back!
	4h. Disease (bubonic plague and Hanta Virus)	4h. Stay away from dead rodents and rodent feces, especially in closed buildings.
	4i. Encounters with strangers	4i. Report uncomfortable encounters with strangers in the park to a supervisor as soon as possible; report apparent illegal activity to a park ranger, do not get into a confrontation with visitors in the park.
5. Exposure to environmental variables	5a. Treatment of general injuries	5a. All NPS field staff and contractors should have current first aid and CPR certification.
	5b. Hypothermia	5b. Always anticipate bad weather and dress accordingly, or carry warm clothes with you; always travel in pairs as a minimum; keep clothing as dry as possible; eat high energy nutritional supplements between meals; cover the head and neck to prevent heat loss; keep active to maintain the body's metabolism; drink plenty of liquids to prevent

		dehydration, although an individual does not "feel" thirsty; drink warm liquids not cold; understand the effects of cold and wind; most hypothermia cases develop between 30□F and 50□F. If someone falls in cold water they need to get dry and warm as soon as possible. If possible, leave the field quickly and get inside a heated vehicle or building. Cover the victim with blankets or sleeping bags. Call emergency services if necessary.
	5c. Hyperthermia	5c. Hyperthermia may occur during high temperatures, monitor for dehydration, heat exhaustion, heat cramps, and heat stroke; symptoms include nausea, headache, and flushed, red skin; drink plenty of cold/cool water (even when you are not thirsty); as heat increases, take frequent breaks in cool locations; wear a light shirt.
	5d. Giardia	5d. Giardia is caused by drinking contaminated water- carry plenty of water on outings; also carry water treatment tablets; consider all streams contaminated. Take care not to get stream water on your water bottle. Wash your hands before eating.
	5e. Sunburn	5e. Much of the work takes place in full sunlight (macroinvertebrate sampling, multiprobe installation/calibration, etc.) so to prevent sunburn, use 30+ or greater SFP sunscreen and lip balm; and wear a hat, sunglasses, and shirt.
6. General work in or near streams	6a. Working near unstable, steep, deep channels, swift flows.	6a. Reconnoiter to familiarize yourself with stream and adjacent reach; know the current and projected flow conditions from weather forecasts and stream gauge information; familiarize yourself with work area prior to fieldwork; review maps and aerial photos to determine access points, reference points, and potential evacuation points; develop evacuation plans for remote stream sites and make sure you leave a trip plan with supervisors (written plan is preferred).
	6b. Giardia	6b. Refer to 5d.
	6c. Sunburn	6c. Refer to 5e.
	6d. Undergrowth	6d. Refer to 3b.
7. Aquatic surveys, water quality sampling, macroinvertebrate sampling, habitat monitoring	7a. Wading/walking in and across streams and other aquatic areas	7a. Wear proper waders, felt-soled, chest or hip boots for conditions. When using waders, wear wading belt or similar. Purchase and use waders with felt soles or retrofitted with anti-slip devices. In cold weather, wear neoprene waders or wear warm, preferably polyester garments with standard waders. Use walking stick to improve stability in current. Walk slowly and carefully. Work in teams of two or more and within sight of one another. Cross-stream at shallow riffles, and avoid deep, swift areas. When wading in aquatic sites with deep, fine sediments, test fine sediment depths with wading rod before entering. Do not enter when fine sediment depths extend above knee Consult weather forecast each morning or call local observer to determine stream and flow conditions. Avoid wet logs and slippery rocks. **All people should be CPR and**

		First Aid Certified. Carry a means of communication (e.g., cell phone or radio).
	7b. Crossing debris jams	7b. Avoid crossing debris jams when possible. If there is no other route, determine the safest route along the creek; either climbing around on either side of the banks, or by going under and/or on top of the jam. When crossing you should be in sight of your coworkers in case anything should occur. Free both hands to assist with climbing jams. If crossing under and/or on top of the jam, be cognizant of its structural integrity. Walk or crawl on the larger key pieces/logs in the jam as smaller woody pieces are more prone to shift, break, or completely give way. Usually, the larger pieces are the most stable and structurally sound. The same is true for any handholds you may use when climbing the jam. If unsure, do not put all your weight on a piece at once, be slow and maintain your handholds if possible. Avoid slick wet logs without bark and if cold, be aware of ice that may be on their surfaces. DO NOT JUMP onto log pieces.
	7c. Drowning	7c. Wear proper protective/floatation gear (life vests, water repellent clothing) at all times; work in pairs or teams; consult flow gauge to determine stream safety level; it is advisable for those conducting aquatic work to be able to swim; if swept away, point feet downstream(to avoid rocks and other debris), swim towards the bank.
	7d. Hypothermia	7d. Refer to 5b.
	7e. Giardia	7e. Refer to 5d.
	7f. Sunburn	7f. Refer to 5e.
8. Calibration of water quality multiprobe	8.a Chemical exposure (burns, eye and skin irritation)	8a. Wear protective equipment including; gloves, eye protection, long sleeve shirt, pants, shoes. If exposure occurs, consult the Material Safety Data Sheet, which is located in the field safety notebook and box of water quality standards. Contact emergency personnel if required. It is advisable to wash hands after calibration of water quality multiprobe.
9. Fixing macroinvertebrate samples	9a. Alcohol spill	Pack 95% alcohol in container with appropriate absorptive material; to prevent fire clean spills immediately with appropriate absorptive material; avoid sources of ignition.
	9b. Eye and skin exposure	Rinse affected area with water; consult physician if necessary.

HA Instructions	Emergency Evacuation Instructions
The JHA shall identify the location of the work project or activity, the name of employee(s) involved in the process, the date(s) of acknowledgment, and the name of the appropriate supervisor approving the JHA. The supervisor acknowledges that employees have read and understand the contents, have received the required training, and are qualified to perform the work project or activity. **Identify all tasks and procedures associated with the work project or activity that have potential to cause injury or illness to personnel and damage to property or material. Include emergency evacuation procedures (EEP).** **Identify all known or suspect hazards associated with each respective task/procedure listed. For example:** **a. Research past accidents/incidents.** **b. Research the Health and Safety Code, or other appropriate literature.** **c. Discuss the work project/activity with participants.** **d. Observe the work project/activity.** **e. A combination of the above.**	**Work supervisors and crewmembers are responsible for developing and discussing field emergency evacuation procedures (EEP) and alternatives in the event a person(s) becomes seriously ill or injured at the worksite.** **Be prepared to provide the following information:** **a. Nature of the accident or injury (avoid using victim's name).** **b. Type of assistance needed, if any (ground, air, or water evacuation).** **c. Location of accident or injury, best access route into the worksite (road name/number), Identifiable ground/air landmarks.** **d. Radio frequencies.** **e. Contact person.** **f. Local hazards to ground vehicles or aviation.** **g. Weather conditions (wind speed & direction, visibility, temperature).** **h. Topography.** **i. Number of individuals to be transported.** **j. Estimated weight of individuals for air/water evacuation.** **The items listed above serve only as guidelines for the development of emergency evacuation procedures.**
Identify appropriate actions to reduce or eliminate the hazards identified. Abatement measures listed below are in the order of the preferred abatement method: **a. Engineering Controls (the most desirable method of abatement). For example, ergonomically designed tools, equipment, and Furniture.** **b. Substitution. For example, switching to high flash point, non-toxic solvents.** **c. Administrative Controls. For example, limiting exposure by reducing the work schedule; establishing appropriate procedures and practices.** **d. PPE (least desirable method of abatement). For example, using hearing protection when working with or close to portable machines (chain saws, rock drills, and portable water pumps).** **e. A combination of the above.** **Copy of the JHA as justification for purchase orders when procuring PPE.**	**JHA and Emergency Evacuation Procedures Acknowledgment** **We, the undersigned work leader and crewmembers, acknowledge participation in the development of this JHA (as applicable) and accompanying emergency evacuation procedures. We have thoroughly discussed and understand the provisions of each of these documents:** **PRINT NAME** **SIGNATURE** **DATE** _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____

Pacific West Region Inventory and Monitoring Program
Protocol Readiness Review Certification

Monitoring Protocol: Integrated Water Quality

Park and Network: Big Hole National Battlefield (BIHO), Upper Columbia Basin Network (UCBN)

Date: 7/13/2012

We confirm that the above named monitoring protocol has sufficient resources and support to implement with full consideration for safety, field logistics, and supervisory oversight. All relevant Inventory and Monitoring Program and park personnel have been informed of, understand, and concur with safety plans, procedures, and responsibilities, and will effectively communicate, supervise, and execute these measures through the Inventory and Monitoring Program, Inventory and Monitoring Network, and park lines of authority. Park staff and Inventory and Monitoring personnel have jointly identified the key groups and individuals that will contribute and participate to ensure safe implementation of the protocol.

Our Readiness Review assessed the following components of protocol implementation and safety:

- Operations planning and field logistics
- Training requirements
- Risk management
- Awareness of and consistency with park safety protocols and emergency procedures
- Supervisory oversight
- Communications
-

We certify that each above component has been fully addressed and will be properly implemented and supported prior to initiating and while conducting protocol field work (including pilot data collection or other field work before a protocol is finalized).

Signatures:

Park Superintendent	Name	Park/Network	Date
I&M Network Program Manager	Name	Park/Network	Date
Protocol Field Supervisor/Manager	Name	Park/Network	Date

Copies of this certification must be provided to the I&M Network Board of Directors Chair and to the Regional I&M Program Manager. The signed original is retained by the I&M Network Program Manager.

Protocol/Field Work Readiness Review-Assessment Components
Supplement to Protocol Readiness Review Certification

Monitoring Protocol: Integrated Water Quality Monitoring
Park and Network: Big Hole National Battlefield (BIHO), Upper Columbia Basin Network (UCBN)
Date: 7/13/2012

Readiness Review Component Details
Describe how the protocol and implementation address the following:

- ***Operations planning and field logistics***

  A detailed field itinerary form will be submitted to the UCBN Program Manager and Park Contact at least one week prior to planned trip. The itinerary will include: a brief description of field work, dates of field work, transportation arrangements, primary and secondary park contact information, list of participants, detailed daily description of field work, location of field work, risk assessment, and items to be completed prior to field work. Signed field itinerary forms are posted on the UCBN server.

  Check in procedures with park staff are outlined in the field itinerary form. Standard UCBN procedure calls for check in with the park upon arrival and daily check in upon completion of field work each day (timing identified in the field itinerary form).

  Job Hazard Analysis forms are completed and sent to the parks prior to field work. These are also posted on the UCBN server.

  Integrated Water Quality Monitoring protocol SOP # 13 "Field Safety for Water Quality" lists the procedures for safety preparation prior to field work. Steps include:

  13. Completion and review of Job Hazard Analysis (JHA)
  14. Review and update emergency contact information
  15. Update and double check contents of Field Safety Notebook
  16. Completion of Medical Information for Office Personnel form
  17. Completion of CPR / First Aid Training
  18. Review all protective equipment to ensure it is in working order and present
  19. Check weather and stream conditions
  20. File a trip plan
      a. Notify park managers
      b. Leave plan with UCBN Coordinator and NPS staff

- ***Training requirements***

  The approved UCBN Integrated Water Quality Monitoring protocol SOPs will serve as the training manual for water quality monitoring. See SOP #2 "Training Field Personnel" and SOP #13 "Field Safety for Water Quality".

  In addition, daily tailgate safety meetings are held to address changing conditions.

  It is advisable that all UCBN staff in the field have recent CPR and first aid training.

  During initial check in with parks safety concerns and special conditions are discussed with park staff.

- ***Risk management***

  Job Hazard Analysis forms are completed and sent to the parks prior to field work. These are also posted on the UCBN server. Daily tailgate safety meetings are held to address changing conditions. During initial check in with parks safety concerns and special conditions are discussed with park staff.

  All participants are to understand that safety is our first priority.

  The UCBN aquatic biologist completed first aid and CPR training at NEPE in 2012. In addition, the UCBN aquatic biologist also completed a GSA endorsed defensive driving course in 2011.

  Risks and risk mitigation are also discussed in SOP#13 field safety for water quality.

  As outlined in the UCBN water quality protocol, the field safety notebook contains the following:
  - UCBN - Field Safety for Water Quality Sampling SOP #13
  - Field Site Descriptions
  - Job Hazard Analysis (JHA) for each park to be sampled
  - Material Safety Data Sheets (MSDS) for chemicals
  - Emergency Contact Information
  - Emergency Evacuation Instructions
  - USGS Field Manual- Chapter 9 –Safety in Field Activities
  - Medical Information for Office Personnel

- ***Awareness of and consistency with park safety protocols and emergency procedures***

The park is involved in the review of the UCBN field itinerary forms. Special safety protocols and emergency procedures are discussed at this time and during the initial check in with park staff.

- ***Supervisory oversight***

  Integrated water quality monitoring standard operating procedures have been peer reviewed and accepted for implementation. In addition, the UCBN program manager and park supervisory staff review all proposed field itineraries for activities to be completed in fulfillment of this protocol.

- ***Communications***

  Check in and out procedures are defined on the field itinerary form and are provided to park staff prior to field work. During UCBN integrated water quality monitoring the aquatic biologist will carry the UCBN issued cellular phone. The park will provide a radio and radio training to UCBN staff if deemed necessary by supervisory park staff. Use of a radio will be clearly identified on the itinerary form.

UCBN FIELD ITINERARY FORM

To be submitted to Program Manager and Park Contact at least one week prior to planned trip.

This form may contain confidential information and must be kept secure	
Field Crew Supervisor	Eric Starkey-UCBN Aquatic Biologist
Field Crew Leader	Eric Starkey
Monitoring Project etc	Water Quality Monitoring- BIHO
Field work description	The water chemistry monitoring instrument will be serviced (data download and calibration) at BIHO in the North Fork Big Hole River. In addition, a cross section survey will be conducted to address representativeness of monitoring site.
Dates of field work	7/24/2012 to 7/26/2012
Transportation arrangements	Eric Starkey will drive from Moscow ID to BIHO in the UCBN's GSA rig (Black Jeep Grand Cherokee). Access to sample sites will be via foot from the lower parking lot.
What will be the contact arrangement with the Park contact?	Contact person: Steve Black Phone number: 406-689-3155 x 1024, after hours: -- Frequency of contacts: Pre-trip, on arrival in the park, when field work has been completed Instructions: Check in should occur during operating hours of the visitor center (9:00 AM- 5:00 PM MST)
What shall UCBN staff do if no contact is made?	Contact person: Jimmer Stevenson Phone number: 406-689-3155, after hours: -- Instructions: Check in should occur during operating hours of the visitor center (9:00 AM- 5:00 PM MST) If Steve and Jimmer cannot be reached or after hours contact is necessary, check in/out should occur with park ranger Madi Wick in the visitor center or at 406-689-3416

DETAILS OF PARTICIPANTS

NAME	STATUS UCBN staff, UIdaho employee, student, volunteer	JOB HAZARD ANALYSIS ATTACHED? (Mandatory)
Eric Starkey	UCBN staff	Yes
		Yes No
		Yes No

ITINERARY DETAILS

DATE/TIMES	LOCATION	ACCOMMODATION	CONTACT DETAILS
Tuesday July 24th Departure: 9:00 AM (PST) Arrival: ~4:30 PM (MST)	Travel from Moscow ID to BIHO via ID State Highway 12	BIHO housing	Eric can be contacted at UCBN cell phone: (208) 596-3766 Eric will check in with the BIHO park contact (Steve Black or Jimmer Stevenson).
Wednesday July 25th 8:00 AM (MST) 11:00 AM (MST). 12:30 PM (MST) 1:00 PM (MST) 4:00 PM (MST)	Safety meeting, calibration of water quality monitor ~150 m to the west of the lower parking lot. Measure for placement of cross section transects, last transect will end approximately 700 meters to the east of the lower parking lot and ~50m from the encampment trail. Lunch at picnic table in parking lot Water chemistry measurements along cross section transects (see above) Deployment of water quality monitor ~150 m to the west of the lower parking lot.	BIHO housing	Eric can be contacted at UCBN cell phone: (208) 596-3766 Eric will check in with the BIHO park contact (Steve Black or Jimmer Stevenson).
Thursday July 26th ~8:00 AM	Drive back to Moscow via ID State Highway 12		Eric can be contacted at UCBN cell phone: (208) 596-3766 Checkout will occur with BIHO park staff (Steve Black or Jimmer Stevenson) The UCBN acting program manager will be contacted upon return to Moscow.

RISK ASSESSMENT

FIELD WORK ACTIVITY	POTENTIAL HAZARD What might harm you?	RISK RATING (Extreme, High, Medium, Low)	CONTROLS What are you going to do to make this activity as safe as possible?	PERSON WHO WILL ENSURE THIS HAPPENS
See attached JHA for activities and hazards				Eric Starkey

ITEMS THAT WILL BE COMPLETED PRIOR TO THE FIELD WORK

	Tick as appropriate
Participants briefed on details of proposed field work; relevant safety policies, procedures and expected conduct while in the field	X
Job Hazard Analysis signed by all participants	X
All equipment, vehicles and tools will be checked for safety compliance prior to field work commencing	X
I have made the necessary provisions for emergency situations such as the appropriate level of first aid, emergency contact telephone numbers; e.g., helicopter rescue, police, fire, etc	X
I have checked with participants whether they have any medical conditions that should be disclosed	X
I have checked that appropriate licenses, permits and agreements with have been obtained and are up to date for the use of specialized equipment such as boats.	X

PEOPLE RESPONSIBLE FOR SUBMISSION AND APPROVAL

NAME	SIGNATURE	DATE
Field Work Supervisor	/s/ Eric Starkey	7/13/2012
Field Crew Leader	Same as above	
Program Manager Based upon the information in the above Field Itinerary Plan: □ Approve XX □ Do not approve □ Grant conditional approval		
Park Superintendent or Natural Resource Manager Based upon the information in the above Field Itinerary Plan: □Approve		

□ Do not approve □ Grant conditional approval		
Conditions if relevant		
NOTE:- • A copy of this Field Itinerary Plan and associated Job Hazard Analysis forms are filed in the UCBN Moscow office. • Copies of all volunteer forms are filed in the UCBN Moscow office.		

Official Vehicle Travel Checklist

	CHECKLIST ITEM	YES	NO	N/A
1.	Has the traveler planned the trip to include rest stops and overnight stays?			
2.	Has the traveler checked the weather forecast for the intended route and planned accordingly?			
3.	Has the traveler been briefed to not drive more than 10 hours in a 24-hour period? (note 1 & 2)			
4.	Have you briefed the traveler on the need to get at least 8 hours of rest prior to departure?			
5.	Have you discouraged the traveler from driving during late hours unless mission dictates?			
6	Have you stressed the importance of obeying speed limits and wearing seatbelts?			
7.	Have you briefed the traveler to inspect the vehicle prior to departure? (note 3)			
8.	Have you discussed the results of the risk assessment required prior to multi-day trips? (note 4)			
9.	Does the traveler have a cell phone and in-car charger, and is s/he aware that texting is prohibited while driving while on official Government business? (note 5)			
10.	Does the traveler have the appropriate phone numbers in case of an emergency?			
11.	Does the traveler have maps that cover the planned route?			
12.	Is the vehicle equipped with an emergency kit? (note 6)			

Notes

1. *If traveler has worked any portion of their shift prior to departure, time worked must be added to driving time to equal a maximum of 10 hours.*
2. *Traveler can exceed 10 hour driving time if an emergency situation necessitates and only after s/he receives written approval from a supervisor.*
3. *The following items shall be inspected prior to departure:*
    a. *All fluids (fuel, coolant, windshield washer fluid, oil, brake fluid, power steering fluid, and transmission fluid)*
    b. *All lights*
    c. *Tires to include spare (tread depth, air pressure, and overall condition)*
    d. *Jack and necessary equipment to change tire*
    e. *Windshield wipers*
    f. *Horn*
4. *Risk assessment (e.g. Operational Leadership Green/Amber/Red or Severity/Probability/Exposure analysis).*
5. *Texting is prohibited by Presidential Proclamation 8610. It is recommended that the traveler use a cell phone only when stopped; however, if this is not possible, a hands-free device will be used.*
6. *Emergency kit should contain:*
    a. *Water*
    b. *Food (energy bars, etc.)*

c. *Blanket(s)*
d. *Road flares*
e. *Flashlight*
f. *First aid kit*
g. *Candle (matches or lighter)*
h. *Jumper cables*
i. *Any other item the traveler or supervisor deems necessary*

_____ _____

Supervisor's Signature Traveler's Signature

Appendix 4. USGS Gage Information

Gages listed in this table represent active and historical USGS stream gages for approximating discharge conditions in UCBN streams scheduled for water quality monitoring. Note that many UCBN streams do not have USGS gages; therefore, gages on the closest available streams may provide the best estimate of current and historical discharge conditions.

Park	Stream	Site Name	Site Number	Data Available	Period of Record	Location	Distance from Park
BIHO	Trail Creek[1]	Trail Creek near Wisdom MT	06024500	Historical	June 1948 to July 1972	Lat 45°39'24", Long 113°42'56" (NAD27)	< 10 rkm upstream
	Big Hole River[2]	Big Hole River below Big Lake Cr at Wisdom MT	06024450	Historical Real-time (seasonal)	May 1988 to current year	Lat 45°37'07", Long 113°27'25" (NAD27)	~ 40 rkm downstream
CIRO	Raft River[2]	Raft River above Onemile Creek Nr Malta ID	13078000	Historical, Real-time	Sept. 1946 to Dec. 1953, May 1955 to June 1971, Oct. 1975 to May 1984, Dec. 1984 to current year	Lat 42° 03'49", Long 113° 27'05" (NAD83)	~25 rkm downstream
CRMO	None available to approximate discharge in Little Cottonwood Creek						
JODA	John Day River	John Day River at Service Creek, OR	14046500	Historical, Real-time	Oct 1929 to current year	Lat44°47'38", Long 120°00'20" (NAD27)	~50 rkm downstream of Sheep Rock Unit
	Mountain Creek – Near Bridge Creek[3]	Mountain Creek near Mitchell, OR	14040600	Historical	Oct 1985 to Sept 1991	Lat 44°32'06", Long 120°01'45" (NAD27)	~ 20 km from Painted Hills Unit
NEPE	Lapwai Creek	Lapwai Creek near Lapwai ID	13342450	Historical, Real-time	Oct 1974 to current year	Lat 46°25'36", Long 116°48'15" (NAD27)	< 2 rkm upstream
WHMI	Mill Creek	Mill Creek at Walla Walla, WA	14015000	Historical, Real-time	April 1941 to current year	Lat 46°04'35", Long 118°16'21" (NAD27)	~ 20 rkm upstream

1. *Tributary of UCBN stream* 2.*UCBN stream is a tributary to this stream*
3. *Different drainage (i.e. no gage exists within the same drainage as the UCBN stream)*

Appendix 5. Datasheets

*Note that it is best to print datasheets from the files located on the DVD in the back of this document.

UCBN Multiprobe Calibration and Maintenance Log

UCBN Multiprobe Calibration/Maintenance Log

Park abbreviation_____ **Stream**_____ **Site ID**_____ **Multiprobe Number** _____

Monitor Inspected By_____ **Date (mm/dd/yyyy)**_____ **Time**_____**(MST / PST)**

Gage Ht_____ **(Rising, Falling, Steady, Peak)** **Channel Conditions**_____

Monitor Make/Model_____ **Monitor Serial No.**_____

Field Meter Make/Model_____ **Field Meter Serial No.**_____

Weather Cold Cool Warm Hot Rain Mist Sleet Snow Humid Dry Cloudy Pt Cloudy Overcast Clear Windy Gusty Breeze Calm

Comments:

Data Download

Did you download data from the past deployment? Y N

Log file name:_____ including site name, begin and end date (YYYYMMDD)
i.e. WHMI_Mill_20080422_20080520

Ending Battery _____volts _____% Remaining

Multiprobe Fouling Checks

	Before Cleaning Time_____				After Cleaning Time_____			
Parameter	Recorded/Live Monitor Reading		Field Meter Reading		Recorded/Live Monitor Reading		Field Meter Reading	
Temp (°C)								
SC (µS/cm)								
DO (mg/L, % Sat)	%Sat / mg/L	D.O. Table mg/l	%Sat / mg/L	D.O. Table mg/l	%Sat / mg/L	D.O. Table mg/l	%Sat / mg/L	D.O. Table mg/l
	Water Temperature °C		Barometric Pressure mmHg		Water Temperature °C		Barometric Pressure mmHg	
pH (units)								
Turbidity (NTU FNU)								

Calibration Drift Checks

Temperature Calibration Criteria > ± 0.2 °C when checked with another meter. > ± 0.5 °C when checked with NIST thermometer.	Recorded/Live Monitor Reading Time _____	Field Meter or NIST Reading Time _____	Difference Monitor – Field Meter or Thermometer	Field Meter 2-pt check Date_____

Comments:

Specific Conductance Calibration Criteria ± 5 µS/cm or ± 3%				Calibration Check Time _____			Recalibration Time _____		
Standard Value	Standard Lot No.	Standard Type KCl; NaCl	Expiration Date	Standard Temp.°C	SC Reading µS/cm	%Error	Standard Temp.°C	SC Reading µS/cm	%Error

Reading in air =
(should be zero)

Comments:

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Last updated on: 10/14/2010

Dissolved Oxygen Calibration Criteria > ± 0.3 mg/L			Calibration Check Time _____				Recalibration Time _____						
Temp °C	Barometric Pressure mm Hg	DO Table Reading mg/L	Salinity Corr. Factor	DO Reading	Error %	Reading in zero DO solution	Temp °C	Barometric Pressure mm Hg	DO Table Reading mg/L	Salinity Corr. Factor	DO Reading	Error %	Reading in zero DO solution
				%Sat mg/L							%Sat mg/L		

Altitude:	Salinity:	Salinity correction applied? Y N	DO Charge: (Clark cell sensor)	DO Gain: (Clark cell sensor)	Date Barometer Calibrated:

Comments:	Did you use a handheld barometer or a weather station to determine barometric pressure? (circle one) **Handheld** **Weather Station**_____ (location)

pH Calibration Criteria >0.2 pH units				Calibration Check Time _____			Recalibration Time _____				
pH Buffer	Theoretical pH from Table on Cal. Stand.	Buffer Lot No.	Buffer Expiration Date	Temp °C	pH Reading	Error %	Temp °C	pH Reading	Error %	Slope	Millivolts
pH 7											
pH___											
pH___											

Comments:

Turbidity Calibration Criteria: The greater of 0.5 TU or ± 5%				Calibration Check Time _____			Recalibration Time _____		
Stock Turbidity Standard	Lot no.	Exp. Date	Concentration	Temp °C	Reading (NTU/FNU)	Error %	Temp °C	Reading (NTU/FNU)	Error %
Zero Standard or <0.1 NTU									
Standard 1									
Standard 2									
Standard 3									

Turbidity Sensor Limits:	Comments:

Final Readings In Stream / Standard Solution		**Time**_____
Parameter	Recorded/Live Monitor Reading	Field Meter Reading/Standard Value
Temp (°C)		
SC (µS/cm)		
DO (% Sat. and mg/L)	% Sat. mg/L	D.O. Table mg/l
Barometric Pressure (mmHg)		
pH (units)		
Turbidity (NTU FNU)		

Last updated on: 10/14/2010

Maintenance Record For Multiprobe					
Sensors cleaned?	Yes	No	**Fouling Presence: Record type of fouling AND amount (e.g. A, E, / H)** Type: A = algae, E = eggs, F = fish, S=sediment, O = other, N = none / Amount: H = heavy, M = moderate, L = light, N = none Sonde / Guard _____DO Probe_____ External Screen_____ pH Probe_____ Temp / Cond_____ Turbidity_____		
Sensors changed?	Temp		Yes	No	Sensor ID_____
	SC		Yes	No	Sensor ID_____
	DO		Yes	No	Sensor ID_____
	pH		Yes	No	Sensor ID_____
	Turbidity		Yes	No	Sensor ID_____
	Sonde changed?		Yes	No	New Sonde No._____ Old Sonde No._____
pH Teflon junction changed?			Yes	No	Type of fouling_____
pH reference electrolyte changed?			Yes	No	
LDO cap changed?			Yes	No	Type of fouling_____
Lubricate O-rings?			Yes	No	
Changed O-rings?			Yes	No	
Wiper Parks 180 deg from Optics?			Yes	No	
Wiper replaced?			Yes	No	Type of fouling_____
Clock Set			Yes	No	
Battery changed prior to deployment?			Yes	No	_____volts _____% Remaining

Deployment		
Name of the new log file:_____(i.e. WHMI_Mill_20080521)		
Time of deployment: _____		
Housing Locked?	Yes	No
Security Cable Locked?	Yes	No

Field Meter			
	Make/Model	Serial No.	Correction Factor Applied?
Multiprobe/Sonde/Meter			None Yes No
Temp			None Yes No
Conductivity			None Yes No
pH			None Yes No
DO			None Yes No
Turbidity			None Yes No
Other			None Yes No

Comments/Observations:

UCBN Office: 208-885-3010 or 208-885-3684
HACH Technical Assistance 1-800-949-3766

Last updated on: 10/14/2010

Useful Equations

$$\%\ \boldsymbol{Error} = \left(\frac{\boldsymbol{Reading} - \boldsymbol{Standard\ Value}}{\boldsymbol{Standard\ Value}}\right) \times \mathbf{100}$$

To determine the current barometric pressure in mmHg record the current absolute (ABS) barometric pressure from the handheld barometer (inHg). Then divide by the constant 0.0393701.

$$\frac{\boldsymbol{ABS}\ \text{inHg}}{\mathbf{0.0393701}} = \boldsymbol{ABS}\ \text{mmHg}$$

If no barometer is available check the nearest weather station (Weather Bureau station is preferred http://www.wrh.noaa.gov/otx/) for barometric pressure in mbar. You will first need to convert from mbar to mmHg.

$$0.75 \times BPmbar = BPmmHg$$

Weather stations report a corrected barometric pressure, barometric pressure at sea level (BP). To convert the barometric pressure at sea level to barometric pressure at altitude BP' Use the following equation:

$$BP' = BP - 2.5\left(\frac{A_{ft}}{100}\right)$$

Where:
BP' = Barometric pressure at altitude mmHg
BP = Barometric pressure at sea level mmHg
A_{ft} = Altitude in feet

UCBN Cross Section Survey Form

UCBN Cross-Section Survey Form

Park abbreviation:	Survey Date (mm/dd/yyyy):	UCBN Staff (Initials):
Stream:	Proposed Multiprobe Site: Lat._____ Long._____	
Method: Modified Equal-width increments (EWI) Other_____ No. of Verticals_____		
Mean wetted width _____m	Survey Site Length (mean wetted width X 40) _____m	
Distance between transects _____m (Site length /3)		
Stream Mixing: Excellent Good Fair Poor		
Comments:		

Proposed Multiprobe Site

Allow the sonde to run for 10 min at the proposed site. Record the parameters values each minute.

Record #	Time	m from left bank	Total depth m	Depth of Measurement m (50% total depth)	Temp °C	pH Units	Cond. µS/cm	D.O. mg/L	Turbidity NTU
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

Transect 1 *0 m* upstream from proposed site

Allow the sonde to run for 1 min at each station. Record the parameter values at 1min., move to the next station (equal increment)

Wetted Width = m									
Station	Time	m from left bank	Total depth m	Depth of Measurement m (50% total depth)	Temp °C	pH Units	Cond. µS/cm	D.O. mg/L	Turbidity NTU
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

Page **1** of **4**

UCBN Cross-Section Survey Form

Transect 2_____ m upstream from proposed site

Allow the sonde to run for 1 min at each station. Record the parameter values at 1min., move to the next station (equal increment)

Wetted Width =		**m**							
Station	**Time**	**m from left bank**	**Total depth m**	**Depth of Measurement m (50% total depth)**	**Temp °C**	**pH Units**	**Cond. µS/cm**	**D.O. mg/L**	**Turbidity NTU**
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

Transect 3_____ m upstream from proposed site

Allow the sonde to run for 1 min at each station. Record the parameter values at 1min., move to the next station (equal increment)

Wetted Width =		**m**							
Station	**Time**	**m from left bank**	**Total depth m**	**Depth of Measurement m (50% total depth)**	**Temp °C**	**pH Units**	**Cond. µS/cm**	**D.O. mg/L**	**Turbidity NTU**
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

UCBN Cross-Section Survey Form

Transect 4_____ m upstream from proposed site

Allow the sonde to run for 1 min at each station. Record the parameter values at 1min., move to the next station (equal increment)

Wetted Width =		**m**							
Station	**Time**	**m from left bank**	**Total depth m**	**Depth of Measurement m (50% total depth)**	**Temp °C**	**pH Units**	**Cond. µS/cm**	**D.O. mg/L**	**Turbidity NTU**
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Median									

Cross-Section Comparison At _____**cfs**

(Use if a USGS gauge is available or if discharge is measured. If no gauge or discharge measure is available use the WRD Flow Severity definitions listed below)

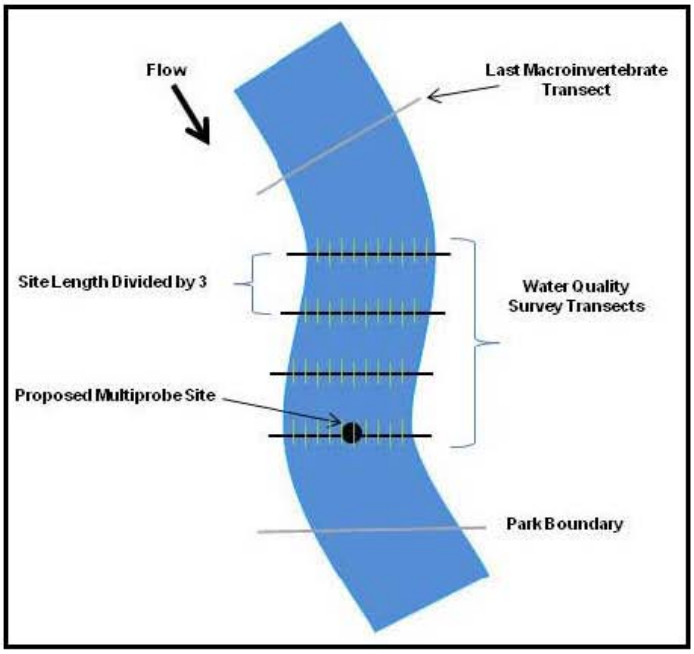
Flow Severity: **Dry** **No Flow** **Low** **Normal** **Above Normal** **Flood**

Based on statistical comparison is the sonde location representative of conditions throughout the cross section?*

Yes / No

UCBN Cross-Section Survey Form

General Survey Design



Notes: _____

UCBN Macroinvertebrate Site Verification and Establishment Form

UCBN Macroinvertebrate Site Verification / Establishment Form
Page 1 of 3
Updated 02/13/2013

Park abbreviation:	Date (mm/dd/yyyy):	UCBN Staff (Initials):
Stream:		
Site ID:		(denote sites sampled by PIBO vs UCBN only)

Stream / River Verification Information

Stream /River Verified by (X all that apply)	GPS ☐	Local Contact	Topo Map ☐
	Other ☐(Describe here):		
	Not Verified (Explain in comments)☐		

GPS Coordinates of X-Site or Bottom of Reach: (Left bank facing downstream, centered over permanent marker) *WGS84 datum*	**Relative Location Error (ft /m)**

Mean Wetted Width (m): **Measurements:**		**Total Length of PIBO Reach (m):** (minimum reach length of 160 m and a maximum reach length of 480 m – see established site descriptions for PIBO reaches)
		Distance Between Transects (m):
		(based on width category- see established site descriptions for PIBO reaches)

Has the X-site or bottom of reach been permanently marked? Yes / No

Have all other transects been permanently marked on the left bank? Yes / No

Photo point location(s): (circle applicable location)

X-Site (m from left bank):
(stretch tape measure between X-site markers, the center between the markers is the photo point)

Bottom of Stream Channel Characteristics Monitoring Reach:
Note that stream reaches sampled as part of the stream channel characteristics monitoring protocol will document photos on "Form 4 Photo Log"

Photo of upstream, downstream, left and right bank? Yes / No

Site Description:

General Directions to X-Site or Bottom of Reach Marker:

UCBN Site Verification / Establishment Form
Page 2 of 3

Did you sample this site?

Yes ☐

if yes check one below

- ☐ Wadeable – Continuous water, greater than 50% wadeable
- ☐ Partial – Sampled by wading (Explain in comments)
- ☐ Wadeable Interrupted – Not continuous water along each reach
- ☐ Altered – Stream/River present but not as on map

No ☐

if no check one below

- ☐ Dry –Visited
- ☐ Dry – Not visited
- ☐ High water
- ☐ Unable to reach site (Explain in comments)
- ☐ Unsafe to reach site (Explain in comments)

Flow Severity (circle one)	Description as defined by WRD
Dry	No visible water in stream (typical of dry period for an ephemeral/intermittent stream
No Flow	Discrete pools of water with no apparent connecting flow (at surface)
Low	Base flow for a stream of flow within roughly 10% to 20% of base flow condition
Normal	When stream flow is considered normal (greatest time that stream is characterized by this in terms of flow quantity, level, or general range of flow during a falling or rising hydroperiod, but above base flow).
Above Normal	Bank full flow or approaching bank full (generally within upper 20% of bank full conditions)
Flood	Flow extends outside normal bank full conditions or spreads across floodplain

Personnel

Name	Duties

General Comments:

Sketch Map – Arrow Indicates North

UCBN Macroinvertebrate Site Revisit Form

UCBN Macroinvertebrate Site Revisit Form

Park abbreviation:	Date (mm/dd/yyyy):	UCBN Staff (Initials):
Stream:		
Site ID:		

Stream / River Revisit Information

Site Description:
(To be filled in before traveling to site)

General Directions to X-Site/Bottom of Reach Marker:
(To be filled in before traveling to site)

GPS Coordinates of X-Site or Bottom of Reach:
(To be filled in before traveling to site)
WGS84 datum

Stream /River Verified by (X all that apply) GPS ☐ Site Marker ☐ Topo Map ☐

Are all bottom and top of reach markers remaining? Yes / No

If transect markers are missing which ones were replaced: (describe)

Photo point location (m from left bank):
NOTE: photos are now taken as part of the stream channel characteristics and riparian condition monitoring protocols at BIHO, CIRO, JODA, NEPE, WHMI). Site photos should be taken as described below for sites at CRMO.

(stretch tape measure between X-site (bottom of reach) markers, the center between the markers is the photo point)

Photo of upstream, downstream, left and right bank? Yes / No

Did you sample this site?

Yes ☐
if yes check one below
- ☐ Wadeable – Continuous water, greater than 50% wadeable
- ☐ Partial – Sampled by wading (Explain in comments)
- ☐ Wadeable Interrupted – Not continuous water along each reach
- ☐ Altered – Stream/River present but not as on map

No ☐
if no check one below
- ☐ Dry –Visited
- ☐ Dry – Not visited
- ☐ High water
- ☐ Unable to reach site (Explain in comments)
- ☐ Unsafe to reach site (Explain in comments)

Updated on 02/11/2013

UCBN Macroinvertebrate Site Revisit Form

Flow Severity (circle one)	Description as defined by WRD
Dry	No visible water in stream (typical of dry period for an ephemeral/intermittent stream
No Flow	Discrete pools of water with no apparent connecting flow (at surface)
Low	Base flow for a stream of flow within roughly 10% to 20% of base flow condition
Normal	When stream flow is considered normal (greatest time that stream is characterized by this in terms of flow quantity, level, or general range of flow during a falling or rising hydroperiod, but above base flow).
Above Normal	Bank full flow or approaching bank full (generally within upper 20% of bank full conditions)
Flood	Flow extends outside normal bank full conditions or spreads across floodplain

General Comments:

Sketch Map – Arrow Indicates North

Personnel	
Name	**Duties**

Updated on 02/11/2013

UCBN Field Sample Shipment Packing/Tracking Form

UCBN FIELD SAMPLE SHIPMENT PACKING/TRACKING FORM

* Use separate tracking form for each park*

This form is to be returned to UCBN when samples have been received and checked for condition.

*Park abbreviation:	Sample Date (mm/dd/yyyy):	UCBN Staff (Initials):
Stream:		
Shipping Method: Tracking Number:	UCBN Contact Name: Phone: Fax: Email:	Date Sent:

Site ID	Sample ID	Sample Type	# of Jars	Comments (Sample condition and other comments here)
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		
		Benthos - reach wide		

Lab Contact	Date Received	Condition Codes
Name:		C = Cracked Jar L = Leaking ML = Missing Label NP = Not Preserved OK = Seems fine
Phone:		
Fax:		
Email:		

Return tracking form to UCBN when Lab has received and checked samples for condition

Macroinvertebrate Sample Labels

Site ID: _____ Initials:_____ Date of Collection:_____ Jar____of_____ Type of Sampler / Mesh Size: D-Frame, 500µm
Site ID: _____ Initials:_____ Date of Collection:_____ Jar____of_____ Type of Sampler / Mesh Size: D-Frame, 500µm
Site ID: _____ Initials:_____ Date of Collection:_____ Jar____of_____ Type of Sampler / Mesh Size: D-Frame, 500µm
Site ID: _____ Initials:_____ Date of Collection:_____ Jar____of_____ Type of Sampler / Mesh Size: D-Frame, 500µm
Site ID: _____ Initials:_____ Date of Collection:_____ Jar____of_____ Type of Sampler / Mesh Size: D-Frame, 500µm
Site ID: _____ Initials:_____ Date of Collection:_____ Jar____of_____ Type of Sampler / Mesh Size: D-Frame, 500µm
Site ID: _____ Initials:_____ Date of Collection:_____ Jar____of_____ Type of Sampler / Mesh Size: D-Frame, 500µm
Site ID: _____ Initials:_____ Date of Collection:_____ Jar____of_____ Type of Sampler / Mesh Size: D-Frame, 500µm

Project Data Certification Form. Page 1 of 2
Version1.0, December 2007

Introduction
Data certification is a benchmark in the project information management process that indicates the data:

- are complete for the period of record;
- have undergone and passed the quality assurance checks;
- are appropriately documented, including identification of sensitive information; and
- are in a condition for archiving, posting and distribution as appropriate.

Certification is not intended to imply that the data are completely free of errors or inconsistencies which may or may not have been detected during quality assurance reviews.

All UCBN products (databases, maps, reports, etc.) are required to be accompanied by an up-to-date product certification form so that the UCBN data manager can ensure that the data has been certified.

Project Data Certification Form Page 2 of 2

Certification date:	Certified by:
Range of dates for certified data:	Title:
Project code:	Affiliation:

Project title:

Description and scope of data being certified:

List the applicable parks and provide any park-specific details about this certification.

Park:	Details:

This certification refers to data in accompanying files. Check all that apply and indicate the file name(s).

- ❑ Database file(s) _____
- ❑ Spatial data theme(s) _____
- ❑ Geodatabase file(s) _____
- ❑ Excel file(s) _____
- ❑ Other (specify) _____

- ❑ Certified data are already in the master version of a park, UCBN or NPS database. Indicate the database system(s): _____

Is there any **sensitive** information in the certified data which may put resources at greater risk if released to the public (e.g., rare plant or animal locations, cave locations, etc)?

- ❑ Yes Details: _____
- ❑ No _____

Description of data processing and quality assurance measures.
(Note: These can be cut and pasted from appropriate sections of the protocol.)

Results and summary of quality assurance reviews, including details on steps taken to rectify problems encountered during data processing and quality reviews.

UCBN Integrated Water Quality Season Closeout Checklist

Project Lead: _____ Monitoring Year: _____

Parks Involved: _____

Checklist Submitted to Network Coordinator and Data Manager on: _____ (mm/dd/yyyy)

Deliverable Product	Notes:	Completion Date
Tabular Data		
Data entry completed?		
Data quality verified?	Describe verification procedures (attach pages as needed)	
Certified data submitted?	This includes: ☐ Macroinvertebrate Lab Results ☐ Raw multiprobe log files (archived on NAS/Server) ☐ Aquarius corrected data (Aquarius output-Excel file) ☐ Site inspection summary worksheets (electronic format) ☐ Final Aquarius workstation file (Aquarius workflow file used in Aquarius only) ☐ All QA/QC Information for each parameter o MDL o AMS o AMS+ o RPD/Precision+	
Copies of field data forms submitted?	This includes: ☐ Multiprobe Calibration/Maintenance Log forms ☐ Cross Section Survey form ☐ Macroinvertebrate Site Verification/Establishment forms ☐ Macroinvertebrate Sample Collection Form ☐ Macroinvertebrate Sample Shipment/Tracking form	
Spatial Data		
Waypoints submitted?	This includes: ☐ Multiprobe station ☐ All X-site locations	
New GIS maps submitted?	Describe GIS layers (attach pages as needed)	
GIS metadata submitted?	Notes on metadata (attach pages as needed)	
Photos		
All monitoring photos posted on NAS or server and properly named?	This includes: ☐ Photo of Left and Right Bank for each X-Site ☐ Photo of Up and Down Stream for each X-Site ☐ Photo of each multiprobe station ☐ Other photos of each stream	

UCBN Integrated Water Quality Season Closeout Checklist

Reporting		
Revised Protocol/SOPs submitted?	Describe revisions (attach pages as needed)	
Annual report submitted?	Entered review process on: _____(date)	
Resource briefs submitted?	Sent to parks for peer review? Y / N	
Has the above information been posted on the website?		
Data Storage		
Creation of annual folder on NAS or Server?	This folder should include all of the electronic files mentioned above. Location (describe folder name/path on NAS or Server: (should be in the "Close" folder)	
Next-year project preparation files		
GIS files submitted	This includes sample point locations, sampling frames etc. (if applicable)	
Field data forms	Hardcopy or digital field forms for next field season	

Notes on documenting that submitted products have been certified by Project leader:
A Project Data Certification Form (available from appendix F of the UCBN Data Management Plan, or from the UCBN data manager) should be completed and included with any submission of a database file, a spreadsheet file (if project does not have a dedicated database application), a GIS file, and a project report if the report contains sensitive information (i.e., information that may put NPS resources at greater risk if released to the public).

NOTES on data certification; on changes to data collection/entry procedures; on database needs; etc.
Describe issues important to the collection, processing, and certification of project data. This may include descriptions of specific data certification procedures, or needed changes to data collection and/or data entry processes, or needed changes to the project database. (Attach pages as needed)

Appendix 6. Data Dictionary

The following data dictionary provides a table description for every table contained in the UCBN Integrated Water Quality database back-end file, and, for each table, provides each field name, the field type, the field size, and the field description.

Table: tbl_Sites

Description: Table stores descriptive data for Sites. Sites are waterways within Park units. Linked 1:Many to tbl_Locations.

Field Name	Field Type	Size	Field Description
Site_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Sites record
GIS_Location_ID	ReplicationID	16	Link to GIS feature, if applicable
Site_Name	Text	50	Unique name for a Site (constructed from UnitCode and Waterway)
Site_Waterway	Text	50	Waterway (stream or river) in which sampling occurs
Site_Desc	Text	255	Description for a site, if applicable
Unit_Code	Text	12	Park unit code (Park or Park sub-unit code)
Site_Notes	Text	255	General notes on the site, if applicable

Table: tbl_Locations

Description: Table stores sampling Location data. Locations are either a Multi-Probe site or the mid-point of an Invertebrate sampling reach. Linked 1:Many to tbl_Sites, and linked to tbl_Events.

Field Name	Field Type	Size	Field Description
Location_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Locations record
Site_ID	ReplicationID	16	Link to tbl_Sites (foreign key)
GIS_Location_ID	ReplicationID	16	Link to GIS feature, if applicable
Meta_MID	ReplicationID	16	Link to Metadata record
X_Coord	Double	8	X coordinate (either of Probe location or Invert Reach mid-point)
Y_Coord	Double	8	Y coordinate (either of Probe location or Invert Reach mid-point)
Coord_Units	Text	10	Coordinate distance units (e.g., meters)
Coord_System	Text	50	Coordinate system
UTM_Zone	Text	50	UTM Zone
Datum	Text	50	Datum of mapping ellipsoid
Est_H_Error_m	Single	8	Estimated horizontal accuracy in meters
Accuracy_Notes	Text	255	Positional accuracy notes, if applicable
GPS_Unit	Text	80	GPS unit used to collect Location coordinates, if applic

Table: tbl_Locations (continued)

Loc_Name	Text	100	Name of the location (constructed from Site_Name [tbl_Sites], Loc_Type, and Loc_Number)
Loc_Type	Text	50	Type of location (either Probe, for multi-probe data logger location, or InvReach, for macro-invert reach mid-point)
Loc_Number	Long Integer	4	Location number (either a Probe Loc number or a waterway Reach number for macro-invert benthos sample)
Updated_Date	Date/Time	10	Date of entry or last change
Loc_Notes	Text	255	General notes on the location

Table: tbl_Events

Description: Table stores sampling Event data. Linked 1:Many to tbl_Locations, and linked to all field data tables (Cross Section Surveys, Multi-Probe data records, and Invertebrate samples).

Field Name	Field Type	Size	Field Description
Event_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Events record
Location_ID	ReplicationID	16	Link to tbl_Locations (foreign key)
Protocol_Version_ID	Text	10	Link to tlu_Protocol_Ver (indicates the Protocol version in use at time of Event)
Event_Date	Date/Time	10	Date of sampling Event
EventData_Contact	Text	50	Identification of person entering the Event data

Table: xref_Event_Contacts

Description: Cross-reference table between tbl_Events and tlu_Contacts (stored in UCBN_Data_Dictionary backend file), allowing one or more contact persons to be associated with a given sampling Event.

Field Name	Field Type	Size	Field Description
Event_ID	ReplicationID	16	Link to tbl_Events
Contact_ID	ReplicationID	16	Link to tlu_Contacts (in UCBN Data Dictionary file)
Contact_Role	Text	50	The contact's role in collection of field data

Table: tbl_CrossSection_SurveyData

Description: Table stores descriptive data collected when Cross Section Survey is conducted at Multi-Probe deployment site to evaluate the representativeness of Prove site. Linked 1:1 to tbl_Events, and linked to tbl_CrossSec_ProbeSite and tbl_CrossSect_RepTrans.

Field Name	Field Type	Size	Field Description
ProbeSite_CrossSect_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_CrossSection_SurveyData record
Event_ID	ReplicationID	16	Link to tbl_Events (foreign key)
Fld_Method	Text	50	Field method used (e.g., Modified equla-width increments)
Num_Verticals	Long Integer	4	Number of vertical (depth) locations used in collecting field data (UCBN uses only 1)
WetWidth_Mean_Val	Double	8	Mean wetted width (m) of waterway
CrossSect_Site_Len	Double	8	Cross Section survey site length (calculated as 40 times the WetWidth_Mean)
InterTransect_Dist_Val	Double	8	Distance between Cross Section transects (calculated as 1/3 of CrossSect_Site_Len)
Probe_Dist_Lbnk	Double	8	Distance from left bank of Probe site
Probe_Depth_Water	Double	8	Total water depth at Probe site
Probe_Depth_Measure	Double	8	Depth of Probe during data collection
Stream_Mixing	Text	50	Level of stream mixing (lookup list = Excellent, Good, Fair, Poor)
Flow_CFS	Double	8	Flow rate (cfs) in waterway at time of cross section survey
Flow_Severity	Text	50	Flow severity at time of cross section survey (lookup list = Dry, No Flow, Low, Normal, Above Normal, Flood)
Comments	Text	255	Comments about the cross section survey

Table: tbl_CrossSect_ProbeSite

Description: Table stores Cross Section Survey data collected at Multi-Probe deployment site to evaluate the representativeness of Prove site. Linked 1:1 to tbl_CrossSection_SurveyData.

Field Name	Field Type	Size	Field Description
CrossSect_ProbeSite_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_CrossSect_ProbeSite record
ProbeSite_CrossSect_RecID	ReplicationID	16	Link to tbl_CrossSection_SurveyData (foreign key)
Rec_Number	Long Integer	4	Record number (goal is 10 records from Probe)
Rec_Time	Date/Time	6	Time (24 hour format) of Probe record
Rec_Temp	Double	8	Temperature from Probe
Rec_pH	Double	8	pH from Probe

Table: tbl_CrossSect_ProbeSite (continued)

Rec_SpCond	Double	8	Specific conductance from Probe
Rec_DissOx	Double	8	Dissolved oxygen from Probe
Rec_Turbid	Double	8	Turbidity from Probe

Table: tbl_CrossSect_RepTransects

Description: Table stores Cross Section Survey data collected at Transects upstream of Multi-Probe deployment site to evaluate the representativeness of Prove site. Linked 1:Many to tbl_CrossSection_SurveyData.

Field Name	Field Type	Size	Field Description
CrossSect_RepTran_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_CrossSect_RepTransects record
ProbeSite_CrossSect_RecID	ReplicationID	16	Link to tbl_CrossSection_SurveyData (foreign key)
Rec_Number	Long Integer	4	Record number (goal is 10 records from Probe, evenly spaced across waterway)
Rec_Time	Date/Time	6	Time (24 hour format) of Probe record
Dist_L_Bank	Double	8	Distance from left bank
Depth_Water	Double	8	Total water depth
Depth_Measure	Double	8	Depth of instrument during data collection
Rec_Temp	Double	8	Temperature from Probe
Rec_pH	Double	8	pH from Probe
Rec_SpCond	Double	8	Specific conductance from Probe
Rec_DissOx	Double	8	Dissolved oxygen from Probe
Rec_Turbid	Double	8	Turbidity from Probe

Table: tbl_Probe_FoulingCorrect

Description: Table stores Multi-Probe fouling correction data from field calibrations of Probe. Linked 1:1 to tbl_Events.

Field Name	Field Type	Size	Field Description
Calibrate_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Probe_CalibrationData record
Event_ID	ReplicationID	16	Link to tbl_Events (foreign key)
Deploy_StartDate	Date/Time	10	Date on which Probe deployment began
Deploy_StartJulian	Long Integer	4	Julian date on which Probe deployment began
Deploy_EndDate	Date/Time	10	Date on which Probe deployment ended
Deploy_EndJulian	Long Integer	4	Julian date on which Probe deployment ended
PreClean_Time	Date/Time	6	Time (24 hour format) when Probe cleaning began

Table: tbl_Probe_FoulingCorrect (continued)

PostClean_Time	Date/Time	6	Time (24 hour format) when Probe cleaning ended
Temp_Pre_Probe	Double	8	Probe-recorded water temperature when cleaning began
Temp_Pre_Meter	Double	8	Field meter reading of water temperature when cleaning began
Temp_Post_Probe	Double	8	Probe-recorded water temperature when cleaning done
Temp_Post_Meter	Double	8	Field meter reading of water temperature when cleaning done
Temp_FoulCorrect_Val	Double	8	Fouling correction to be applied to water temperatures, based on Probe recordings
Temp_FoulCorrect_Meter	Double	8	Fouling correction to be applied to water temperatures, based on field meter readings
SpCond_Pre_Probe	Double	8	Probe-recorded specific conductance when cleaning began
SpCond_Pre_Meter	Double	8	Field meter reading of specific conductance when cleaning began
SpCond_Post_Probe	Double	8	Probe-recorded specific conductance when cleaning done
SpCond_Post_Meter	Double	8	Field meter reading of specific conductance when cleaning done
SpCond_FoulCorrect_Val	Double	8	Fouling correction to be applied to specific conductance values, based on Probe recordings
SpCond_FoulCorrect_Perc	Double	8	Fouling correction percentage to be applied to specific conductance values, based on Probe recordings
SpCond_FoulCorrect_Meter	Double	8	Fouling correction to be applied to specific conductance values, based on field meter readings
DissOx_Pre_Probe	Double	8	Probe-recorded dissolved oxygen when cleaning began
DissOx_Pre_Meter	Double	8	Field meter reading of dissolved oxygen when cleaning began
DissOx_Post_Probe	Double	8	Probe-recorded dissolved oxygen when cleaning done
DissOx_Post_Meter	Double	8	Field meter reading of dissolved oxygen when cleaning done
DissOx_FoulCorrect_Val	Double	8	Fouling correction to be applied to dissolved oxygen values, based on Probe recordings

Table: tbl_Probe_FoulingCorrect (continued)

DissOx_FoulCorrect_Perc	Double	8	Fouling correction percentage to be applied to dissolved oxygen values, based on Probe recordings
DissOx_FoulCorrect_Meter	Double	8	Fouling correction to be applied to dissolved oxygen values, based on field meter readings
pH_Pre_Probe	Double	8	Probe-recorded pH when cleaning began
pH_Pre_Meter	Double	8	Field meter reading of pH when cleaning began
pH_Post_Probe	Double	8	Probe-recorded pH when cleaning done
pH_Post_Meter	Double	8	Field meter reading of pH when cleaning done
pH_FoulCorrect_Val	Double	8	Fouling correction to be applied to pH values, based on Probe recordings
pH_FoulCorrect_Meter	Double	8	Fouling correction to be applied to pH values, based on field meter readings
Turbid_Pre_Probe	Double	8	Probe-recorded turbidity when cleaning began
Turbid_Pre_Meter	Double	8	Field meter reading of turbidity when cleaning began
Turbid_Post_Probe	Double	8	Probe-recorded turbidity when cleaning done
Turbid_Post_Meter	Double	8	Field meter reading of turbidity when cleaning done
Turbid_FoulCorrect_Val	Double	8	Fouling correction to be applied to turbidity values, based on Probe recordings
Turbid_FoulCorrect_Perc	Double	8	Fouling correction percentage to be applied to turbidity values, based on Probe recordings
Turbid_FoulCorrect_Meter	Double	8	Fouling correction to be applied to turbidity values, based on field meter readings
DissOxSat_Pre_Probe	Double	8	Probe-recorded dissolved oxygen saturation when cleaning began
DissOxSat_Pre_Meter	Double	8	Field meter reading of dissolved oxygen saturation when cleaning began
DissOxSat_Post_Probe	Double	8	Probe-recorded dissolved oxygen saturation when cleaning done
DissOxSat_Post_Meter	Double	8	Field meter reading of dissolved oxygen saturation when cleaning done

Table: tbl_Probe_DriftCorrect

Description: Table stores Multi-Probe drift correction data from field calibrations of Probe. Linked 1:1 to tbl_Probe_FoulingCorrect.

Field Name	Field Type	Size	Field Description
CalibDrift_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Probe_DriftCorrect record

Table: tbl_Probe_DriftCorrect (continued)

Calibrate_RecID	ReplicationID	16	Link to tbl_Probe_CalibrationData (foreign key)
Temp_Probe_Val	Double	8	Temperature value recorded by Probe
Temp_Probe_Time	Date/Time	6	Time (24 hour format) of Probe-recorded temperature value
Temp_Meter_or_NIST	Text	10	Indicates whether Temperature was recorded with Field Meter or with NIST (lookup values = Meter, NIST)
Temp_MtrNist_Val	Double	8	Temperature value recorded by field meter/NIST
Temp_MtrNist_Time	Date/Time	6	Time (24 hour format) of field meter/NIST temperature value
Temp_DriftCorrect_Val	Double	8	Drift correction value for temperature
Temp_AbsoluteCorr_Val	Double	8	Absolute correction value for temperature
Temp_Correction_Status	Yes/No	4	Correction needed (Yes/No) for temperature data
Temp_CorrectPerDay_Val	Double	8	Correction factor to be applied per day to temperature data
Temp_Correct_Rating	Text	50	Data rating for temperature data
SpCond_Standard1_Val	Double	8	Standardized specific conductance value (for standard solution 1)
SpCond_Std1_Time	Date/Time	6	Time (24 hour format) of Probe-recorded specific conductance (stand sol 1)
SpCond_Std1_Probe_Val	Double	8	Specific conductance value (stand sol 1) recorded by Probe
SpCond_Std1_DriftCorr_Val	Double	8	Drift correction value for specific conductance (stand sol 1)
SpCond_Std1_DriftCorr_Perc	Double	8	Percent drift correction for specific conductance (stand sol 1)
SpCond_Standard2_Val	Double	8	Standardized specific conductance value (for standard solution 2)
SpCond_Std2_Time	Date/Time	6	Time (24 hour format) of Probe-recorded specific conductance (stand sol 2)
SpCond_Std2_Probe_Val	Double	8	Specific conductance value (stand sol 2) recorded by Probe
SpCond_Std2_DriftCorr_Val	Double	8	Drift correction value for specific conductance (stand sol 2)
SpCond_Std2_DriftCorr_Perc	Double	8	Percent drift correction for specific conductance (stand sol 2)
SpCond_Standard3_Val	Double	8	Standardized specific conductance value (for standard solution 3)

Table: tbl_Probe_DriftCorrect (continued)

SpCond_Std3_Time	Date/Time	6	Time (24 hour format) of Probe-recorded specific conductance (stand sol 3)
SpCond_Std3_Probe_Val	Double	8	Specific conductance value (stand sol 3) recorded by Probe
SpCond_Std3_DriftCorr_Val	Double	8	Drift correction value for specific conductance (stand sol 3)
SpCond_Std3_DriftCorr_Perc	Double	8	Percent drift correction for specific conductance (stand sol 3)
SpCond_Ave_DriftCorr_Val	Double	8	Average drift correction value for specific conductance
SpCond_Ave_DriftCorr_Perc	Double	8	Average percent drift correction for speicific conductance
SpCond_AbsoluteCorr_Val	Double	8	Absolute correction value for specific conductance
SpCond_AbsoluteCorr_Perc	Double	8	Absolute percent correction for specific conductance
SpCond_Correction_Status	Yes/No	4	Correction needed (Yes/No) for specific conductance data
SpCond_CorrectPerDay_Val	Double	8	Correction factor to be applied per day to specific conductance data
SpCond_Correct_Rating	Text	50	Data rating for specific conductance data
DissOx_Time	Date/Time	6	Time (24 hour format) of Probe-recorded dissolved oxygen
DissOx_BaroPress_Val	Double	8	Barometric pressure value (mmHg) at time of dissolved oxygen calibration
DissOx_Temp_Val	Double	8	Temperature at time of dissolved oxygen calibration
DissOx_StandSatur_Val	Double	8	Standard diss oxygen saturation value, from saturation table
DissOx_Probe_Val	Double	8	Dissolved oxygen value recorded by Probe
DissOx_Saturation_Perc	Double	8	Percent dissolved oxygen saturation, from Probe
DissOx_DriftCorrect_Val	Double	8	Drift correction value for dissolved oxygen
DissOx_DriftCorrSatur_Perc	Double	8	Percent drift correction for dissolved oxygen
DissOx_AbsoluteCorr_Val	Double	8	Absolute drift correction value for dissolved oxygen
DissOx_AbsoluteCorr_Perc	Double	8	Absolute percent drift correction for dissolved oxygen
DissOx_Correction_Status	Yes/No	4	Correction needed (Yes/No) for dissolved oxygen
DissOx_CorrectPerDay_Val	Double	8	Correction factor to be applied per day to dissolved oxygen data

Table: tbl_Probe_DriftCorrect (continued)

DissOx_CorrPerDaySatur_Perc	Double	8	Correction percent factor to be applied per day to dissolved oxygen saturation data
DissOx_Correct_Rating	Text	50	Data rating for dissolved oxygen data
pH_Standard1_Val	Double	8	Standardized pH value (for standard solution 1)
pH_Std1_Time	Date/Time	6	Time (24 hour format) of Probe-recorded pH (stand sol 1)
pH_Std1_Probe_Val	Double	8	pH value (stand sol 1) recorded by Probe
pH_Std1_DriftCorr_Val	Double	8	Drift correction value for pH (stand sol 1)
pH_Standard2_Val	Double	8	Standardized pH value (for standard solution 2)
pH_Std2_Time	Date/Time	6	Time (24 hour format) of Probe-recorded pH (stand sol 2)
pH_Std2_Probe_Val	Double	8	pH value (stand sol 2) recorded by Probe
pH_Std2_DriftCorr_Val	Double	8	Drift correction value for pH (stand sol 2)
pH_Standard3_Val	Double	8	Standardized pH value (for standard solution 3)
pH_Std3_Time	Date/Time	6	Time (24 hour format) of Probe-recorded pH (stand sol 3)
pH_Std3_Probe_Val	Double	8	pH value (stand sol 3) recorded by Probe
pH_Std3_DriftCorr_Val	Double	8	Drift correction value for pH (stand sol 3)
pH_Ave_DriftCorr_Val	Double	8	Average drift correction value for pH
pH_AbsoluteCorr_Val	Double	8	Absolute correctoin value for pH
pH_Correction_Status	Yes/No	4	Correction needed (Yes/No) for pH data
pH_CorrectPerDay_Val	Double	8	Correction factor to be applied per day to pH data
pH_Correct_Rating	Text	50	Data rating for pH data
Turbid_Standard1_Val	Double	8	Standardized turbidity value (for standard solution 1)
Turbid_Std1_Time	Date/Time	6	Time (24 hour format) of Probe-recorded turbidity (stand sol 1)
Turbid_Std1_Probe_Val	Double	8	Turbidity value (stand sol 1) recorded by Probe
Turbid_Std1_DriftCorr_Val	Double	8	Drift correction value for turbidity (stand sol 1)
Turbid_Std1_DriftCorr_Perc	Double	8	Percent drift correction for turbidity (stand sol 1)
Turbid_Standard2_Val	Double	8	Standardized turbidity value (for standard solution 2)
Turbid_Std2_Time	Date/Time	6	Time (24 hour format) of Probe-recorded turbidity (stand sol 2)

Table: tbl_Probe_DriftCorrect (continued)

Turbid_Std2_Probe_Val	Double	8	Turbidity value (stand sol 2) recorded by Probe
Turbid_Std2_DriftCorr_Val	Double	8	Drift correction value for turbidity (stand sol 2)
Turbid_Std2_DriftCorr_Perc	Double	8	Percent drift correction for turbidity (stand sol 2)
Turbid_Ave_DriftCorr_Val	Double	8	Average drift correction value for turbidity
Turbid_Ave_DriftCorr_Perc	Double	8	Average percent drift correction for turbidity
Turbid_AbsoluteCorr_Val	Double	8	Absolute correctoin value for turbidity
Turbid_AbsoluteCorr_Perc	Double	8	Absolute percent correction for turbidity
Turbid_Correction_Status	Yes/No	4	Correction needed (Yes/No) for turbidity data
Turbid_CorrectPerDay_Val	Double	8	Correction factor to be applied per day to turbidity data
Turbid_Correct_Rating	Text	50	Data rating for turbidity data

Table: tbl_Probe_HourlyData

Description: Table stores Multi-Probe hourly data, including raw and corrected values for each water chemistry parameter. Linked 1:Many to tbl_Probe_FoulingCorrect.

Field Name	Field Type	Size	Field Description
ProbeData_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Probe_HourlyData record
Calibrate_RecID	ReplicationID	16	Link to tbl_Probe_FoulingCorrect (foreign key)
Probe_DateTime	Date/Time	12	Date and Time associated with the Probe hourly data record
Probe_Temp_Raw	Double	8	Raw temperature value from Probe
Probe_Temp_Corr	Double	8	Corrected temperature value
Probe_SpCond_Raw	Double	8	Raw specific conductance value from Probe
Probe_SpCond_Corr	Double	8	Corrected specific conductance value
Probe_DissOx_Raw	Double	8	Raw dissolved oxygen value from Probe
Probe_DissOx_Corr	Double	8	Corrected dissolved oxygen value
Probe_pH_Raw	Double	8	Raw pH value from Probe
Probe_pH_Corr	Double	8	Corrected pH value
Probe_Turbid_Raw	Double	8	Raw turbidity value from Probe
Probe_Turbid_Corr	Double	8	Corrected turbidity value

Table: tlu_Probe_DriftCorrectCriteria

Description: Lookup table storing water chemistry parameter values used to apply drift corrections. Primary key includes the Protocol Version, so that drift correction criteria can change with future protocol versions.

Field Name	Field Type	Size	Field Description
DriftCriteria_RecID	ReplicationID	16	Primary key (in combo with Protocol_Version_ID). Uniquely identifies each tlu_Probe_DriftCorrectCriteria record.
Protocol_Version_ID	Text	10	Protocol version ID (from tlu_Protocol_Ver)
TempCriteria_Meter_Val	Double	50	Temperature criteria value for field meter. Values above criteria require drift correction.
TempCrit_Meter_Descript	Text	255	Temperature criteria description for field meter.
TempCriteria_NIST_Val	Double	50	Temperature criteria value for NIST. Values above criteria require drift correction.
TempCrit_NIST_Descript	Text	255	Temperature criteria description for NIST.
SpCondCriteria_Val	Double	50	Specific conductance criteria value. Values above criteria require drift correction.
SpCondCriteria_Perc	Double	50	Specific conductance percentage criteria value. Values above criteria require drift correction.
SpCondCrit_Desript	Text	255	Specific conductance criteria description.
DissOxCriteria_Val	Double	50	Dissolved oxygen criteria value. Values above criteria require drift correction.
DissOxCrit_Desript	Text	255	Dissolved oxygen criteria description.
pHCriteria_Val	Double	50	pH criteria value. Values above criteria require drift correction.
pHCrit_Desript	Text	255	pH criteria description.
TurbidCriteria_Val	Double	50	Turbidity criteria value. Values above criteria require drift correction.
TurbidCriteria_Perc	Double	50	Turbidity percentage criteria value. Values above criteria require drift correction.
TurbidCrit_Desript	Text	255	Turbidity oxygen criteria description.

Table: tlu_Probe_CorrectRatingCriteria

Description: Lookup table storing water chemistry parameter values used to apply data correction ratings. Primary key includes the Protocol Version, so that correction rating criteria can change with future protocol versions.

Field Name	Field Type	Size	Field Description
CorrectionRating_RecID	ReplicationID	16	Primary key (in combo with Protocol_Version_ID). Uniquely identifies each tlu_Probe_CorrectRatingCriteria record.
Protocol_Version_ID	Text	10	Protocol version ID (from tlu_Protocol_Ver)

Table: tlu_Probe_CorrectRatingCriteria (continued)

Temp_Excellent_MaxVal	Double	8	Maximum temperature correction value for a rating of Excellent.
Temp_Good_MaxVal	Double	8	Maximum temperature correction value for a rating of Good.
Temp_Fair_MaxVal	Double	8	Maximum temperature correction value for a rating of Fair. Correction values above are rated Poor.
Temp_Rating_Desripit	Text	255	Description of temperature correction values applied.
SpCond_Excellent_MaxPerc	Double	8	Maximum specific conductance percent correction value for a rating of Excellent.
SpCond_Good_MaxPerc	Double	8	Maximum specific conductance percent correction value for a rating of Good.
SpCond_Fair_MaxPerc	Double	8	Maximum specific conductance percent correction value for a rating of Fair. Correction values above are rated Poor.
SpCond_Rating_Desripit	Text	255	Description of specific conductance correction values applied.
DissOx_Excellent_MaxVal	Double	8	Maximum dissolved oxygen correction value for a rating of Excellent.
DissOx_Excellent_MaxPerc	Double	8	Maximum dissolved oxygen percent correction value for a rating of Excellent.
DissOx_Good_MaxVal	Double	8	Maximum dissolved oxygen correction value for a rating of Good.
DissOx_Good_MaxPerc	Double	8	Maximum dissolved oxygen percent correction value for a rating of Good.
DissOx_Fair_MaxVal	Double	8	Maximum dissolved oxygen correction value for a rating of Fair. Correction values above are rated Poor.
DissOx_Fair_MaxPerc	Double	8	Maximum dissolved oxygen percent correction value for a rating of Fair. Correction values above are rated Poor.
DissOx_Rating_Desripit	Text	255	Description of dissolved oxygen correction values applied.
pH_Excellent_MaxVal	Double	8	Maximum pH correction value for a rating of Excellent.
pH_Good_MaxVal	Double	8	Maximum pH correction value for a rating of Good.
pH_Fair_MaxVal	Double	8	Maximum pH correction value for a rating of Fair. Correction values above are rated Poor.
pH_Rating_Desripit	Text	255	Description of pH correction values applied.

Table: tlu_Probe_CorrectRatingCriteria (continued)

Turbid_Excellent_MaxVal	Double		Maximum turbidity correction value for a rating of Excellent.
Turbid_Excellent_MaxPerc	Double	8	Maximum turbidity percent correction value for a rating of Excellent.
Turbid_Good_MaxVal	Double	8	Maximum turbidity correction value for a rating of Good.
Turbid_Good_MaxPerc	Double	8	Maximum turbidity percent correction value for a rating of Good.
Turbid_Fair_MaxVal	Double	8	Maximum turbidity correction value for a rating of Fair. Correction values above are rated Poor.
Turbid_Fair_MaxPerc	Double	8	Maximum turbidity percent correction value for a rating of Fair. Correction values above are rated Poor.
Turbid_Rating_Desripit	Text	255	Description of turbidity correction values applied.

Table: tbl_Invert_ReachData

Description: Table stores descriptive data from invertebrate sample lab analysis results. Linked 1:1 to tbl_Events, and linked to all Invert_Lab data tables.

Field Name	Field Type	Size	Field Description
Invert_Reach_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_ReachData record
Event_ID	ReplicationID	16	Link to tbl_Events (foreign key)
Sample_Extent	Text	50	Sample extent as indicated on Lab Analysis form (e.g., Reach Wide)
Sample_CollectDevice	Text	50	Sample collection device as indicated on Lab Analysis form (e.g., D Frame)
Lab_SubSampled_Perc	Double	8	Percent Subsampled as indicated on Lab Analysis form
Lab_Sample_ID	Text	50	Sample ID as indicated on Lab Analysis form
Sample_Jars	Long Integer	4	Number of jars used to collect the macro-invert reach sample
Comments	Text	255	Comments relating to field collection of macro-inverts and/or lab analysis results

Table: tbl_Invert_TransectFeatures

Description: Table stores descriptibe data (substrate and channel types) from invertebrate sample collections. Linked 1:Many to tbl_invert_ReachData.

Field Name	Field Type	Size	Field Description
InvTran_Substrate_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_TransectSubtrate record
Invert_Reach_RecID	ReplicationID	16	Link to tbl_Invert_ReachData (foreign key)
Transect_ID	Text	10	ID of Transect within the Reach where macro-invert samples collected (e.g., A, B, C, D, etc.)
Tran_Substrate	Text	10	Substrate type, from tlu_Tran_Substrates
Tran_Channel	Text	10	Channel type, from tlu_Tran_Channels
Comments	Text	255	Comments (if Tran_Substrate is "Other", used to describe substrate)

Table: tbl_Invert_Lab_Abundance

Description: Table stores invertebrate abundance data from lab analysis results. Linked 1:Many to tbl_Invert_ReachData.

Field Name	Field Type	Size	Field Description
LabResult_Abund_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_Lab_Abundance record
Invert_Reach_RecID	ReplicationID	16	Link to tbl_Invert_ReachData (foreign key)
AbundMeasure_Descript	Text	100	Abundance Measure description, from lab analysis form
AbundMeasure_Val	Double	8	Abundance Measure value, from lab analysis form

Table: tbl_Invert_Lab_CommComp

Description: Table stores invertebrate community composition data from lab analysis results. Linked 1:Many to tbl_Invert_ReachData.

Field Name	Field Type	Size	Field Description
LabResult_Comm_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_Lab_CommComp record
Invert_Reach_RecID	ReplicationID	16	Link to tbl_Invert_ReachData (foreign key)
CommCompMeasure_Descript	Text	100	Community Composition Measure description, from lab analysis form
CommComp_Val	Double	8	Community Composition Measure value, from lab analysis form

Table: tbl_Invert_Lab_Diversity

Description: Table stores invertebrate diversity data from lab analysis results. Linked 1:Many to tbl_Invert_ReachData.

Field Name	Field Type	Size	Field Description
LabResult_Divers_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_Lab_Diversity record
Invert_Reach_RecID	ReplicationID	16	Link to tbl_Invert_ReachData (foreign key)
DiversMeasure_Descript	Text	100	Diversity Measure description, from lab analysis form
DiversMeasure_Val	Double	8	Diversity Measure value, from lab analysis form

Table: tbl_Invert_Lab_Dominance

Description: Table stores invertebrate dominance data from lab analysis results. Linked 1:Many to tbl_Invert_ReachData.

Field Name	Field Type	Size	Field Description
LabResult_Domin_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_Lab_Dominance record
Invert_Reach_RecID	ReplicationID	16	Link to tbl_Invert_ReachData (foreign key)
Domin_Sequential_Rank	Long Integer	4	Sequential rank (e.g., 1, 2, 3) of Dominant Taxon, from lab analysis form
Domin_Taxon	Text	150	Dominant Taxon scientific name, from lab analysis form
Domin_Abund	Double	8	Abundance value for Dominant Taxon, from lab analysis form
Domin_Perc	Double	8	Percent of Dominant Taxon present in the reach sample, from lab analysis form

Table: tbl_Invert_Lab_FuncGroup

Description: Table stores invertebrate functional group composition data from lab analysis results. Linked 1:Many to tbl_Invert_ReachData.

Field Name	Field Type	Size	Field Description
LabResult_FncGrp_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_Lab_FuncGroup record
Invert_Reach_RecID	ReplicationID	16	Link to tbl_Invert_ReachData (foreign key)
FuncGrpMeasure_Descript	Text	150	Functional Group Composition Measure description, from lab analysis form
FuncGrp_Perc	Double	8	Percent of Functional Group present in reach sample, from lab analysis form
FuncGrp_Rich_Val	Double	8	Richness value for Functional Group, from lab analysis form

Table: tbl_Invert_Lab_Indices

Description: Table stores invertebrate biotic index data from lab analysis results. Linked 1:Many to tbl_Invert_ReachData.

Field Name	Field Type	Size	Field Description
LabResult_Index_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_Lab_Indices record
Invert_Reach_RecID	ReplicationID	16	Link to tbl_Invert_ReachData (foreign key)
IndexMeasure_Descript	Text	150	Index Measure description, from lab analysis form
IndexMeasure_Val	Double	8	Index Measure value, from lab analysis form

Table: tbl_Invert_Lab_Richness

Description: Table stores invertebrate richness data from lab analysis results. Linked 1:Many to tbl_Invert_ReachData.

Field Name	Field Type	Size	Field Description
LabResult_Rich_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_Lab_Richness record
Invert_Reach_RecID	ReplicationID	16	Link to tbl_Invert_ReachData (foreign key)
RichnessMeasure_Descript	Text	150	Richness Measure description, from lab analysis form
RichnessMeasure_Val	Double	8	Richness Measure value, from lab analysis form

Table: tbl_Invert_Lab_TaxonCounts

Description: Table stores invertebrate taxon count data from lab analysis results. Linked 1:Many to tbl_Invert_ReachData.

Field Name	Field Type	Size	Field Description
LabResult_TaxonCnt_RecID	ReplicationID	16	Primary key, uniquely identifying each tbl_Invert_Lab_TaxonCounts record
Invert_Reach_RecID	ReplicationID	16	Link to tbl_Invert_ReachData (foreign key)
TaxonGroup	Text	150	Taxon Group, from lab analysis form
Taxon	Text	150	Taxon scientific name, from lab analysis form
Taxon_Count	Integer	2	Taxon Count, from lab analysis form

Table: tlu_Tran_Channels

Description: Lookup table storing waterway channel types for use in tbl_Invert_TransectFeatures.

Field Name	Field Type	Size	Field Description
ChannelType_RecID	ReplicationID	16	Primary key, uniquely identifying each tlu_Tran_Channels record
Channel_Code	Text	10	Channel Type code (e.g., Pol = Pool, Gld = Glide, Rif = Riffle, Rpd = Rapid)
Channel_Descript	Text	150	Description of Channel Type

Table: tlu_Tran_Substrates

Description: Lookup table storing waterway substrate types for use in tbl_Invert_TransectFeatures.

Field Name	Field Type	Size	Field Description
SubstrateType_RecID	ReplicationID	16	Primary key, uniquely identifying each tlu_Tran_Substrates record
Substrate_Code	Text	10	Substrate Type code (e.g., FSd = Fine/Sand, Grl = Gravel, Crs = Coarse, OTH = Other)
Substrate_Descript	Text	150	Description of Substrate Type

Table: tlu_Proto_VSign

Description: Lookup table of Vital Sign and Protocol. Linked 1:Many to tlu_Protocol_Ver.

Field Name	Field Type	Size	Field Description
Prototcol_Parent	Text	10	Primary key. Four letter code to identify each vital sign protocol (i.e., CAMA for Camas Lily Vital Sign).
Vital_Signl_Name	Text	150	Full Name of associated Vital Sign

Table: tlu_Protocol_Ver

Description: Lookup table of Protocol versions, linked to tbl_Events in order to associate a Protocol version with each individual sampling Event.

Field Name	Field Type	Size	Field Description
Protocol_Ver_ID	Text	10	Primary key. Four letter Protocol Parent code plus version (e.g., CAMA_1_0, SAGE_2_3, etc.).
Prototcol_Parent	Text	10	Link to tlu_Proto_VSign (foreign key). Protocol four letter abbreviation (e.g., CAMA for Camas Lily).
Description	Memo	NA	Description of this Protocol Version

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS XXX, March 2013

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

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