Standard Operating Procedures for the Collection of Stream Water Temperatures Utilizing the Deployment of Temperature Data Loggers

Water Quality Control Division • Environmental Data Unit

1.0 Introduction

This Standard Operation Procedure (SOP) describes the methods used for calibrating, deploying and retrieving the temperature data loggers. The temperature data loggers will be utilized to collect baseline water temperature data from rivers and streams of the State of Colorado.

The goal and purpose of this SOP and the associated water quality monitoring is the collection of data: 1) Used to assess ambient stream water temperature; 2) To assess physical/biological health of the stream; 3) To develop water quality standards; 4) To assess trends and to determine if water quality standards are being met, once stream standards have been determined. The objective is to collect representative water temperatures from the stream. It is, therefore, important that collection methods are consistent to minimize data bias and to ensure that data collected at different locations are collected in a comparable manner.

2.0 Equipment

- Tidbit v2 Temperature Logger manufactured by Onset Computer Corporation
- PVC protective housing for TidbiT v2 Temp logger (white PVC tube with 3/8 inch holes drilled in both sides for zip ties – see pictures)
- Anchor to secure protective housing in streambed (1/2 cinder block or 2-3 ft rebar)
- Monitoring sign, sign post, and post pounder
- Zip ties to attach logger to housing and to rebar
- Sledge hammer for rebar, shovel, wrench and pliers
- HOBO software (HOBOware Pro)
- HOBO Waterproof Shuttle and adaptor
- Wire Cable and cable cutters
- Laptop with HOBO software installed and USB cable to connect to shuttle
- Meter (In-Situ, YSI, etc.) and extra batteries
- GPS, camera, and extra batteries
- Temperature Monitoring Field Log book and pen for recording data
- Waders, shoulder length waterproof gloves
- Safety equipment – cell phone, SPOT, life vest, first aid kit
- Personal equipment – extra clothes, hat, gloves, sunglasses, sunscreen, lunch, water

3.0 Accuracy Check of Data Loggers

The TidbiT v2 temperature data logger does not allow calibration adjustments, but the range of accuracy specified by the manufacturer can be verified using simple procedures at freezing and measured temperatures. The best procedure for checking the accuracy of a data logger is the "ice bucket" method (see also the StowAway TidbiT Users Manual or www.onsetcomp.com). The procedure involves the following steps:

1. Deploy the temperature logger at a short sampling interval of five (5) minutes, with a delayed launch time of at least a half hour.
2. Put crushed ice and water in an insulated container (for example, a large cooler with ice water), and let the ice water bath equilibrate for at least two hours with the TidbiT's completely submerged in the ice water to ensure the loggers reach equilibrium. Be sure to use fresh water (dissolved minerals may alter the thermal properties of water).
3. Record water temperatures using a NIST (National Institute of Standards and Technology) thermometer every five (5) minutes, after the loggers have been in the ice bath for at least two hours.
4. Leave the loggers in the ice bath for at least an hour while recording the NIST temperatures every five minutes. Remove the loggers and download the data.
5. Accuracy checks should be conducted before they are deployed in the field and after they are retrieved from the field. It is also recommended to use a NIST thermometer to test the accuracy of data loggers at other temperatures. Data loggers that fail an accuracy check should be returned to the manufacturer for service or replacement. The TidbiT v2 logger has an accuracy of ± 0.2˚C in the range of 0˚C to 50˚C.

4.0 Launching Temperature Data Loggers

Connect the HOBO Waterproof Shuttle to the host computer using the appropriate interface cable and attach the coupler to the shuttle, then insert the logger into the coupler (see instructions that came with the shuttle and logger for proper alignment). Briefly press the coupler lever to put the shuttle into base station mode. Use the HOBOware software to launch the logger, check the logger's status, read it out, or to stop it manually.

Note: *The shuttle's clock is used to set the logger's clock at re-launch. Make sure the host computer's clock is correct before launching the shuttle. If you need to adjust the computer's clock, quit HOBOware, set the computer's clock, then reopen HOBOware and launch the shuttle.*

Click the Launch icon on the toolbar and configure the launch.

- Description: Enter the serial number of the logger, located on the side of the logger.
- Channels to Log: Use the default settings of temperature and battery voltage.
- Logging Interval: Choose a logging interval. The default interval is 15 minutes in order to collect adequate data to assess the daily maximum temperature standard. Other intervals may be chosen for reasons such as wanting to leave the logger out for a longer time period when the interval would be set for 30 or 60 minutes. Launch Options: Choose a delayed launch to the day and time you expect to have it deployed or if you are at the stream location you can launch it now.

Click the Launch button and the progress of the launch will be displayed. Do not unplug the logger while it is being configured. When it is finished launching, you can check the status of

the logger by clicking on the status icon or remove the logger from the coupler and look for the red (LED) flashing light on the front of the logger to confirm that it is logging.

Note: *The battery power of the logger is drained more rapidly while checking status and when it is connected to a base station or shuttle.*

5.0 Deploying the Temperature Data Loggers

Before leaving the office, the HOBO Waterproof Shuttle needs to be launched in order to synchronize the shuttle's clock to the host computer. Check the shuttle's memory and make sure there are enough banks available to accommodate the number of loggers you plan to read out. The Shuttle's memory holds 63 banks and one logger read out can be stored in one bank. The battery level should also be checked at this time and the batteries changed if they are weak (2.2 V or less). The shuttle uses 2 AA batteries and lasts approximately one year or at least 50 complete memory fills. To replace the shuttle's batteries please refer to the HOBO Waterproof Shuttle manual.

Note: *If you change the batteries in the field, the shuttle's clock will stop, and the shuttle will not read out loggers again until you re-launch it in HOBOware. Any logger data that is already in the shuttle will remain safe, but the shuttle will not read out another logger until the batteries are replaced and the shuttle is re-launched. You can offload data stored in the shuttle even when the batteries are depleted.*

When going into the field, be sure to take a laptop computer that has HOBOware 2.2 or greater installed. This is the best way to launch the loggers at deployment and this will also ensure that if you run into any problems with the shuttle or logger, you can check the status, synchronize clocks, launch, or offload data.

During the deployment process, all field data including site number, stream name and location, logger serial number, water temperature measured with a field meter and the start/end times need to be recorded on the field logger data form (Appendix B). In addition, a sketch and description of the logger location that notes a unique landmark, such as a bridge, rock, tree, or log should also be recorded. A picture of the logger location, including the landmark and GPS coordinates should be taken. A complete description of the logger location must be documented thoroughly to ensure that the logger can be relocated and to describe any factors that may influence surface water temperature, such as water depth, habitat type, channel width, distance from stream bank, overhead cover, and if any warm or cool water sources exist.

After the initial deployment process, visits to recover and relaunch the loggers shall be documented on additional field logger data forms. Accordingly, throughout the deployment period of a logger, more than one field logger data form will necessary to thoroughly document all visits to that site.

The underwater data loggers will be housed in a white 1¼" PVC pipe that is approximately 2-3 inches long and secured with plastic cable ties. A cable tie will go through a pre-drilled ⅜ inch hole in one side of the PVC pipe, then through the mounting bail of the TidbiT logger, and then through the other ⅜ inch hole of the PVC pipe on the opposite side (figure 1). The cable tie then will need to be cinched tight over the PVC pipe, so that the logger is snug and secure.

Note: *A clear or translucent case may act as heat collectors and give artificially high temperature values due to solar radiation warming inside the case. White, non-translucent cases are recommended to avoid solar radiation warming.*

Figure 1 - PVC pipe and TidbiT logger housing to be used with rebar or cinder block

Two methods may be used to deploy loggers and are discussed below. Appropriate materials should always be brought into the field for both methods in the event that one method does not work.

Rebar Method: If the stream is suitable for wading and rebar can be hammered into the streambed, then attach the logger housing to rebar.

Two additional cable ties will be cinched around the logger's cable tie with a 1 inch diameter loop remaining (figure 1), which will be used to secure the logger housing to a rebar stake. The logger housing will be attached to a one foot rebar that is hammered into the streambed, with approximately 8 inches of the rebar exposed above the streambed, but beneath the water surface. The logger housing assembly will be attached to the rebar about 6 inches off the bottom, using the two additional cable ties cinched tight (figure 2). The exact height of the rebar and logger housing assembly will vary depending on the depth and size of the stream. If using a rebar without the predrilled holes then add an additional cable tie or hose clamp to the rebar above the logger housing assembly attachment point to prevent the housing from moving up the rebar. A metal sign will be posted along the stream bank, identifying this as a monitoring area to prevent the public from removing or tampering with the temperature structure.

Figure 2 - Logger housing assembly attached to rebar

Cinder Block Method: If the substrate is too rocky to hammer rebar into the streambed or not suitable for the rebar method, then attach the logger housing to a cinder block.

The logger housing will be attached to a half cinder block. The logger should be secured so that it is on top of the cinder block in the stream flow (figure 3). Attach one end of the stainless steel cable to the cinder block with clamps and the other end should be attached to a foot long rebar with a 1/8 inch hole near the top (figure 4). Clamp the cable to the rebar and place the cinder block into the thalweg while holding onto the rebar. Once the cinder block is in the appropriate location, hammer your rebar into the bank.

The rebar should be hammered all the way into the ground, with some rocks placed around it to prevent it from being detected or becoming a tripping hazard to the public. The cable should be at a sufficient length so that the logger is in deep enough water and does not dry up during low flows. Cover the cable with rocks and sediment to prevent it from being a tripping hazard. Metal signs will be posted on the left and right banks near the loggers that identify this as a monitoring area (figure 5).

Figure 3 - Logger housing attached to the top of a cinder block

Figure 4 - Stainless steel cable attached to a half cinder block and a foot long rebar

Figure 5 – Metal signs identifying the temperature monitoring area

6.0 Site Selection and Placement of Logger at Site

As a general rule, temperature loggers should be located in the thalweg or deepest point in the channel cross-section (figure 6). Always place loggers in a well mixed area, but not in riffles prone to low water flow or in deep pools prone to ground water flows. In small streams loggers should be installed as close to the thalweg as possible and at least six (6) inches off the bottom to help avoid being covered with sediment and/or debris. In large streams, areas of potential temperature stratification (from eddies, groundwater, tributaries, and effluents) need to be avoided. This can be checked by using the meter (In-Situ or YSI) to take temperature measurements upstream and downstream of the desired location.

Make sure that the water depth is enough so that the loggers do not dry out in the summer months and freeze in the winter. If possible, the stream depth should be no less than 12 inches to ensure that the logger is sufficiently covered with water. Check the loggers in low flow conditions in the summer and winter months. In general, large pools and/or deep glides/runs, braided channels, wide shallow reaches and reaches with a poorly defined thalweg, areas of significant groundwater influence, and sites in close proximity to upstream tributaries or discharges should be avoided, if possible.

If loggers are to be relocated or moved from one location to another within the home site it must be placed within a comparable hydrological setting so logged data between the two

points are analogous. Placement of the logger location to outside the comparable hydrological setting requires the establishment of a new site and description.

Figure 6 - Example of good locations for loggers

7.0 Documentation of Site

Complete documentation of the survey used to determine temperature logger locations and the results of these surveys is critical to enable others to locate the data loggers when needed. The documentation should include a description of the site, photographs, and possibly a sketch of the area. Photos should clearly show the sensor location and landmarks both upstream and downstream from the logger location (Appendix A). A GPS location also needs to be recorded. An aerial photo, if available, should also be printed off to show possible landmarks for relocating the logger.

During the deployment all field data, including site number, stream name, location, latitude, longitude, logger serial number, and field measurements need to be recorded on the field log sheet included at the end of this SOP (Appendix A). A sketch and description of the logger location with a landmark reference point such as a rock or tree should also be noted on the bench sheet. In addition a picture should be taken to help locate the logger in the future.

When returning to retrieve/re-launch the logger, inspect the site looking for signs of disruption of channel conditions (i.e. possible times of low water). Also inspect the logger and housing for possibilities of damage and/or vandalism. This information should also be noted on the field log sheet.

8.0 Logger Retrieval

Watershed Staff are encouraged to make non-routine visits to the site whenever possible, to make any needed adjustments to the logger or the housing. When a non-routine visit is made, document the condition of the site and logger, date, time, and measure the water

temperature with a field meter. This documentation and temperature measurement should also be done whenever retrieving the logger for offloading data.

To retrieve the data logger, cut the securing materials (cable ties or wire) with wire cutters, remove the PVC pipe assembly from the anchor, and remove the anchor materials from the stream. Remove the logger from the PVC pipe and make sure the logger is clean by gently rinsing and wiping any dirt or film that could block the optic communication LEDs. To clean the logger, use a little water and a soft cloth. Do not use any harsh chemicals, solvents, or abrasives that could damage the sensors.

9.0 Data Retrieval/Relaunch

The data will be offloaded from the logger to a shuttle, laptop or PC, every three months or depending on monitoring objectives. The memory capacity of data loggers are capable of recording 15 minute intervals for at least 6 months, but for easier data handling the data will be downloaded quarterly.

If the HOBO Waterproof Shuttle will be used to offload data from the logger, the Shuttle needs to be launched in order to synchronize the shuttle's clock to the host computer. Check the shuttle's memory and make sure there are enough banks available to accommodate the number of loggers you plan to read out. The Shuttle's memory holds 63 banks and one logger read out can be stored in one bank. The battery level should also be checked at this time and the batteries changed if they are weak (2.2 V or less). The shuttle uses 2 AA batteries and lasts approximately one year or at least 50 complete memory fills. To replace the shuttle's batteries please refer to the HOBO Waterproof Shuttle manual.

Reading out and re-launching loggers in the field using the shuttle:

- Make sure the shuttle's batteries are good (greater than 2.2 V), there is plenty of memory available, and the shuttle's clock is synchronized.
- Make sure the shuttle's large cap and center cap are securely closed so that the center cap is flush with the large cap and the O-ring is not visible. Clean the communication end of the shuttle and attach the coupler to the shuttle.
- Insert the logger into the coupler and refer to TidbiT v2 instructions if needed for proper alignment.
- Momentarily press the coupler lever until the amber LED lights up. The amber LED will blink continuously while the readout and re-launch are in progress. Do not remove the logger when the amber LED is blinking.
- After reading out the logger, the shuttle synchronizes the logger's clock to the shuttle's clock and re-launches the logger to the settings already in the logger.
- The re-launch is complete when the green LED blinks. Momentarily press the coupler lever to stop the blinking.
- Remove the logger from the coupler.

Note: *The data files downloaded to the shuttle need to be offloaded to a computer every evening to reduce the risk of losing data.*

Offloading data from the shuttle to the computer:

- Connect the shuttle to a computer running HOBOware.
- Click on the readout icon. The dialog box shows you how many banks are occupied and

whether they have already been offloaded and saved. Check the banks that need to be offloaded from the shuttle.
- Click the readout button "Offload Checked" and save in the appropriate files.
- When finished, disconnect the shuttle from the computer and close the center cap.

Reading out data from the logger to the computer:

- Connect the shuttle to the host computer running HOBOware.
- Attach a coupler and logger.
- Momentarily press the coupler's lever.
- The amber LED blinks, then the green LED should illuminate, indicating that the logger is ready to communicate.
- Save the data file in the appropriate folder.
- Choose the settings on the Plot Setup window and click Plot.
    - Temperature should be in degrees Celsius. Temperature and Battery should be checked.
    - All Event Types should be checked.
- Remove the logger from the coupler. The green LED stops glowing when you disconnect the logger or USB cable.
- Export the points into an Excel spreadsheet.

When going into the field, be sure to take a laptop computer that has HOBOware 2.2 or greater installed. This will ensure that if you run into any problems with the shuttle or logger, you can check the status, synchronize clocks, launch, or offload data in the field with the laptop.

Note: *Please reference the TidbiT v2 and HOBO Waterproof Shuttle manuals and the HOBOware User Guide for more detailed instructions on downloading, saving, viewing, plotting, and exporting data points.*

10.0 Safety

Before leaving for the field, obtain all the information needed to complete a safety checklist, including emergency contact information, and other information as described below, and carry this with you in the field. Become familiar with the emergency information and the information in the checklist before you are in the field and confronted with an emergency.

Passenger cars, vans, and 4-wheel-drive vehicles can differ in operation and in safety features, depending on the vehicle's age, make, and model. Become familiar with all operating systems of the vehicle before you leave for the field. Examine the section of a stream or river you plan to wade. Do not attempt to wade a stream for which values of depth multiplied by velocity equal or exceed 10 ft^2/s. For example, a stream only 2 ft deep but with velocities of 5 ft/s or more can be dangerous to wade. It is highly recommended that you work in pairs, one person in the stream deploying the logger and one person on shore documenting the location. While the multi-person field team also might be important to carrying out technical procedures, the field team or buddy system can be a life-saving practice.

While wading:

- Wear a personal flotation device (PFD) during wading activities.

- Approved PFDs for wading include the standard jacket type and the suspender type. The PFD must fit properly, be rated for your weight, and be in good condition.
- Wear hip boots or chest waders that fit properly. Boots and waders provide protection from cold and pollutants, as well as from underwater objects. Be aware of the possibility of slipping and going underwater (feet up, head down) while wearing them. Wear a wading belt to create a seal between your body and the wader.
- If you fall, don't panic. Don't fight the current, work with it. Allow the current to drift you downstream as you work your body towards the bank.

Be aware of surrounding conditions:

- Watch for debris floating downstream, such as logs and aquatic vegetation.
- Watch for sand channels that can shift under foot and become quicksand (not an uncommon condition in Colorado, e.g. South Platte River).
- Watch the stream stage, especially when it could rise rapidly.
- When wading below a dam or control structure, contact the gate operator before entering the stream.

***Note**: If stream side hazards such as high flows, hazardous weather conditions, and floating debris make temperature logger installation dangerous, then a different deployment time or location should be considered.*

11.0 QA/QC

To verify data quality, temperature measurements will be taken with a field meter (In-Situ or YSI) at the sensor location that corresponds with the data logger recording times. These measurements will be taken during deployment, downloads, retrieval, and other times when opportunity exists.

The field meter (In-situ or YSI) should be checked for temperature accuracy at least monthly. This accuracy check can be done with a modified water bath method similar to that used for the accuracy check of data loggers.

Appendix A

Photo examples of the logger location in relation to the bank, landmarks, upstream and downstream

Appendix B

Field Logger Data Form

Sample date: _____
Start Time: _____**hrs** End Time: _____**hrs**
Site No. _____
Stream / Site Name _____
Location Description _____
_____
GPS: Type_____ No._____
Latitude _____**N** Longitude _____**W** Elevation _____
Map Datum _____ Sat Status _____

SAMPLE COLLECTION INFORMATION: SAMPLER: _____

TYPE OF COLLECTION: Deployment Recovery Relaunch

DEPLOYMENT OF LOGGER: Serial Number: _____
Date Placed in Stream: _____ Time Placed in Stream: _____
Sampling Interval: _____ (mins) Habitat type: Pool Riffle Run
Depth of Logger: _____
Is the red "OK" light (LED) blinking? Yes / No
Site Description/Location in Stream: _____
_____
_____
_____
_____
Tethering Method: _____
_____

Detailed Map of Site: Photos Yes / No

FIELD MEASUREMENTS:
Instruments Used: Quanta In-Situ Other_____
Instruments Calibrated at this site? Yes / No Meter Index No. _____
Measurement Method: From bridge w/bucket In-stream w/bucket In-stream direct
Measurements:
Stream Temp _____º C Spc _____ µS/cm DO _____ mg/L
pH _____su @ _____º C Other _____ Air Temp _____º C

Other Field Activity (Check all that apply):

Habitat RBP Macroinvertebrate Flow Other _____

Field/Weather Observations and Comments: _____

_____

_____

Water Samples Collected? Yes / No If Yes, Barcode_____

RECOVERY OF LOGGER: Serial Number: _____

Date Recovered: _____ Time Recovered: _____

Depth of Logger: _____ Habitat type: Pool Riffle Run

Signs of Tampering Yes / No _____

Signs of Logger Drying Out Yes / No

Is the red "OK" light (LED) blinking? Yes / No

RELAUNCH OF LOGGER: Serial Number: _____

Logger Relaunched? Yes / No

Date of Relaunch: _____ Time Relaunched: _____

Depth of Logger: _____ Habitat type: Pool Riffle Run

Relaunched via Shuttle / Computer

Is the red "OK" light (LED) blinking? Yes / No

DATA DOWNLOAD

Date of Data Download to Computer from Shuttle: _____

Time of Data Download to Computer from Shuttle: _____

Filename: _____

12.0 Document Version

2.0_121714

13.0 Approval Signatures

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