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## STANDARD OPERATING PROCEDURE

Title: Calibrating, Deploying, Retrieving Stream Temperature, Intermittency, and Conductivity (STIC) Data Loggers, and Downloading and Converting Data

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**Standard Operating Procedure**

For

Calibrating, Deploying, Retrieving Stream Temperature, Intermittency, and Conductivity (STIC) Data Loggers, and Downloading and Converting Data

## 1. GENERAL

This SOP provides instructions on how to properly calibrate, deploy, and retrieve Stream Temperature, Intermittency, and Conductivity (STIC) data loggers; and download and convert data to a useable form. STIC loggers are modified HOBO temperature and light pendant loggers (HOBO UA-002-64, Onset, Corporation). The light sensing capability of the pedant loggers have been modified to measure conductivity. With this modification, these commercial loggers have been repurposed to continuously measure water temperature, intermittency (drying), and conductivity in water bodies. Calibration is required for each pendant to convert raw signal (electrical conductivity) data into specific conductance (µS/cm at 25° C) data. The HOBO-UA-002-64 units have 64 kB of memory, sufficient to store ~28,000 temperature and conductivity measurements (HOBO-UA-002-08 unit has 8 kB of memory and can store ~3,500 measurements). The pendant requires a 3-volt lithium battery (CR-2032) that typically lasts ~1 year but the life will vary depending upon temperature and the logging frequency. Extreme cold or hot temperatures and fast logging rates (e.g. one second) will drain the battery within two weeks.

## 2. REFERENCES

HOBO Pendant Temperature/Light Data Logger (UA-002-xx) Manual. Version: 2009-2017. Onset Computer Corporation, Bourne, MA.

Chapin, T. P., A. S. Todd, and M. P. Zeigler. 2014. Robust, low-cost data loggers for stream temperature, flow intermittency, and relative conductivity monitoring, Water Resources Research 50:6542–6548, doi:10.1002/2013WR015158.

## 3. EQUIPMENT & SUPPLIES

YSI 556 MPS or equivalent handheld meter that measures specific conductance with associated software (Ecowatch for YSI) installed on a personal computer

HOBO UA-002-64 pendants

HOBO waterproof shuttle with pendant coupler and USB cable

HOBOware Pro software installed on a personal computer

PVC casing

Large container (e.g., cooler)

Conductivity standard - 10,000 µS/cm (LabChem #187772 or equivalent commercial standard)

Lab notebook
Rebar stakes (1 ft.)
Hose clamps (25 cm.)
2 measuring tapes (50 m.)

## 4. CALIBRATION LAUNCH & SET UP

*Launching HOBO pendants for calibration*
4.1. Connect the HOBO waterproof shuttle to a computer with a USB cable and open HOBOware Pro to check for device communication (check bottom of the window in HOBOware for "HOBO Waterproof Shuttle U-DTW-1").

4.2. Insert the pendant in the attached coupler on the shuttle and hold in side lever to trigger communication (Image 1). Once the device status on the HOBOware window displays to "HOBO UA-002-64 Pendant Temp/Light", the pendant can be launched by selecting "Launch Device" in the top right of the HOBOware task bar.



Image 1. HOBO pendant detached and attached to the waterproof launch shuttle

4.3. Check battery status at the top of the launch window. If lower than 50%, it is recommended replacing the CR-2032 coin battery inside the device. Refer to the HOBO pendant user manual for specific instructions on this step. After inserting a new battery, reseal the pendant head using silicon grease around the o-ring if necessary, rescrew it back in place and launch again to verify proper battery level.

4.4. Select the deployment parameters for the pendant launch. **Logging Interval** should be set to **1 second** and **Start Logging** should be **On Date/Time** for a target time within the elapsing 30 minutes from the first launch, allowing the pendants to launch in unison. This time may vary depending on the number of pendants the user would like to calibrate together.

NOTE: Check to verify that all pendants are actively logging before continuing. Blinking speed reflects the current logging status: every 1 to 4 seconds (depending on selected interval) indicates the device is currently logging at the launch-set interval, every 8 seconds indicates that the pendant is awaiting a launch-set time to start logging.

*Set-up*
4.5. Place all pendants within their PVC housing and secure the caps on each, taking precaution that the electrode pins on each pendant do not protrude past the lip of each cap (Image 2).
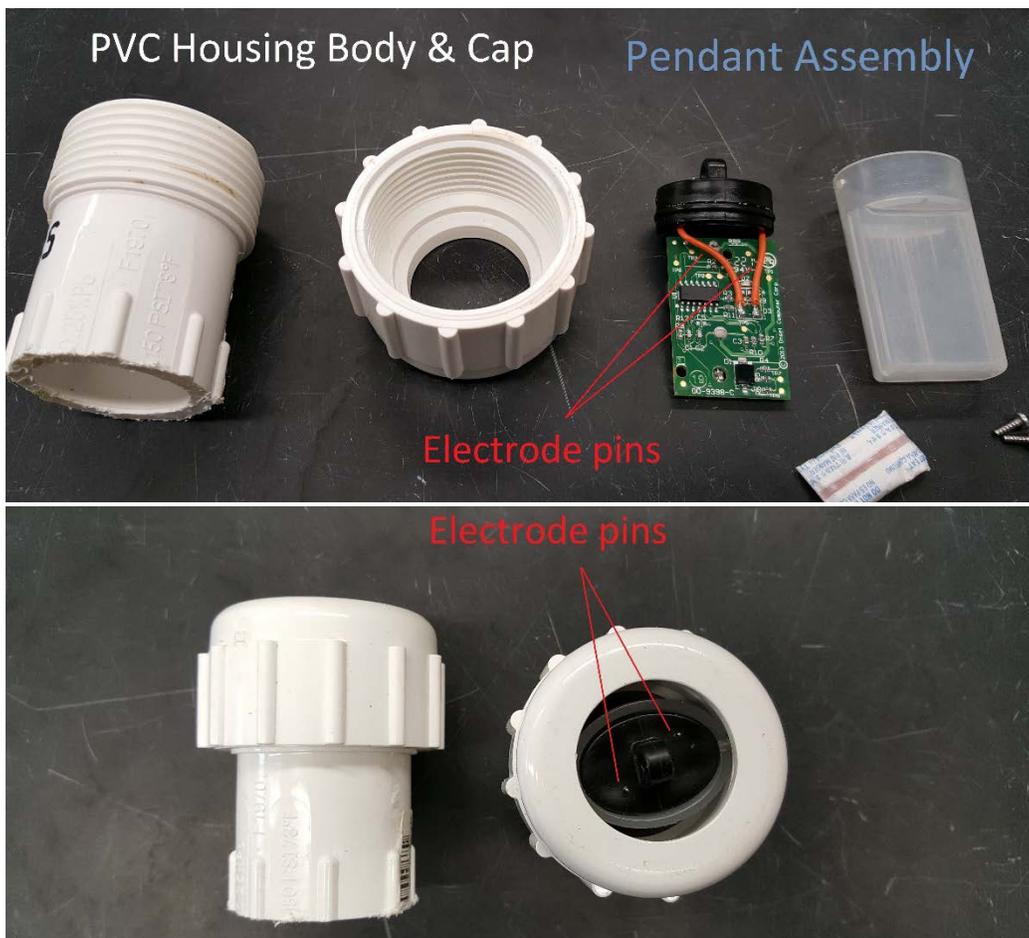


Image 2. All components disassembled (above) and assembled (below). Electrode pins are located by red lines.

4.6. Place each pendant with the electrode side-down in a clean, large container. PVC housings may contact each other in a horizontal plane, however, do not stack them vertically.

4.6. Carefully lower and adjust the YSI 556 probe so that the conductivity sensor will read on or close to the same plane as the pendants. It may have to lay flat in order to achieve this (Image 3). Start a continuous reading on YSI 556 device so that the measurement intervals are unison with the pendants.



Image 3. The calibration test with a YSI meter and HOBO pendants properly submerged in conductivity solution within a container.

## 5. CALIBRATION PROCEDURE

Calibrations must be performed when collecting any data from new pendants for the first time, or after any modifications or repairs to the pendant.

5.1. Measure out 8 liters of deionized (DI) water (~1.0 µS/cm at 25°C) in a large beaker and slowly but uniformly fill the container. Perform a rinse of all pendants/PVC housings/YSI 556 by lowering them in to the container. Record the time at which all pendants have entered the container in a lab notebook. It is important that there must be a sufficient volume (~7-8 liters) in order to ensure all pendants are submerged and will accurately measure the water temperature in addition to conductivity.

5.2. After rinsing, remove the initial water and add the same conductivity/volume to the container, recording the time of this addition in a lab notebook. Data used for calibration will be pulled from this step. Leave all pendants submerged for approximately 10 minutes.

5.3. After 10 minutes, remove pendants/YSI and carefully discard the water. Measure out the standards below using a graduated cylinder and add them to a large beaker. Fill the beaker to 8 liters as before and repeat steps 5.1-5.3:

| Prepared Standard to 8 Liters | Volume 10,000 µS/cm Standard | Volume of D.I. Water (~1.0 µS/cm) |
| --- | --- | --- |
| ~300 µS/cm (tap water) | - | - |
| 600 µS/cm | 480 mL | 7520 mL |
| 1200 µS/cm | 960 mL | 7040 mL |

5.4. When all tests are finished, thoroughly rinse all pendants and the YSI 556 with DI water and set aside to air dry.

*Reading and preparing pendant and YSI 556 probe data*

5.5. Repeat steps 4.1 & 4.2 for the pendants, this time selecting to "Readout Device". Select the appropriate units to display the data in and save it. Export the file under File > Export Table Data as a .csv for compatibility in the next few steps. Use an easy naming format such as [TESTNUMBER]_[PENDANTID] in a folder with the test date. Example: "Test1_P27" in folder "5-24-17"

5.6. Now upload the YSI 556 data by connecting the handheld meter to a computer with the 19-pin cable to a USB port. Open the installed Ecowatch software and select File > New Connection. On the YSI 556 handheld meter, go to the main menu and select File > Upload to PC > Desired Filename. The transfer should begin and can be opened through the File > Open option within Ecowatch. Once opened, export the file as a .csv through File > Export > CSV and save using a format similar to PENCAL_[TESTNUMBER]_[DATE] (i.e. Pencal_Test3_5-25-17.)

5.7. Create a spreadsheet, importing data for each pendant into columns for Date/Time, Temperature and Intensity. Align these by timestamp. Uploaded YSI 556 data through Ecowatch is now imported (only columns for Date/Time, Temperature and SpCond), aligning Temperature and SpCond by timestamp with the identical timestamps of the pendants. Any timestamps outside of the range of one another, whether pendant or YSI 556, can be deleted from this spreadsheet.

*Temperature correction and conductivity calibration*

5.8 Select a pendant and corresponding YSI 556 reading from a range of stable measurements for calibration and correct for temperature using the Microsoft Excel equation below

$$P_i \text{ (corrected)} = P_i/(1-((25-P_t)*0.025/100))$$

where $P_i$ is pendant intensity and $P_t$ is pendant temperature.

5.9. To convert $P_i$ (corrected) to relative conductivity (RC) as a percentage relative to the maximum intensity measured over a dataset, use the equation below

$$RC = P_i \text{ (corrected)}/MAX(XX:XX)*100$$

where XX:XX is the total range of cells for $P_i$ (corrected).

5.10. A standard curve is developed for each pendant to convert raw signal values to specific conductance (µS/cm at 25° C) by plotting the YSI conductivity values for standards against the corresponding pendant temperature-corrected values. Within the specific conductivity range used here (1 – 1200 µS/cm) the relationship between $P_i$ (corrected) and specific conductivity (YSI values) best fit a power relationship. Solve for estimated specific conductivity using

$$= (P_i \text{ (corrected)}/b)^{1/a}$$

where *b* is the slope and *a* is the y-intercept from the standard curve.

Acceptance criterion for pendant calibration is an $R^2$ fit of 0.95. Pendants not meeting the acceptance criterion could be repaired (i.e., pins replaced) and recalibrated. Pendants should be recalibrated when there is an average deviation >15% from field YSI measurements of conductivity. If conductivity based on field measurements are outside the standard curve (300 – 1000 µS), another standard curve is developed over the range of the field values.

## 6. FIELD DEPLOYMENT & RETRIEVAL

*Deployment*

6.1. Pendants selected for deployment in the field may be launch-set to start as in the calibration section above, launched immediately or also launched in the field with what is known as a triggered start. To perform a trigger start, the HOBO shuttle and associated coupler are used to launch the pendant only via magnetic contact. Again, verify that the pendant has launched by observing the flashing red LED on the device before inserting pendants into their PVC casing. It is important to set the preferred measurement interval prior to entering the field as this cannot be modified without a direct HOBO software launch.

6.2. The exact location for pendant deployment may vary depending upon the ultimate purpose of the study. If the purpose is to characterize the duration, frequency, and timing of drying within streams then the locations for pendant deployment should be positioned to capture low flow conditions but avoid false positives associated with standing water conditions (i.e., deep pools). Deploy the pendant along deepest flow path (channel thalweg) in an area that has water depth that is typical of the reach. Drive the stake or length of rebar firmly into the streambed with a small sledge hammer, avoiding loose substrate that would be susceptible to wash out from stormflows. The pendant within PVC casing must be oriented with the pins facing down so electrode pins will contact water under low flow near the streambed. Attach the pendant within PVC casing firmly to a metal (rebar) stake with a hose clamp and screwdriver such that it is positioned on the downstream side of the stake.

6.3. After deploying the pendant, drive a metal stake into the stream banks adjacent to the pendant (right and left banks facing in the direction of flow), then connecting measuring tape to the ends of each stake to pull out the tape and record the distances (to nearest centimeter) to the pendant in the field notebook or field sheet (Attachment 1). Facing in the direction of flow to designate right and left banks. Record the date, time (when pendant placed in channel), temperature and specific conductivity (handheld YSI) in a field notebook or field form.
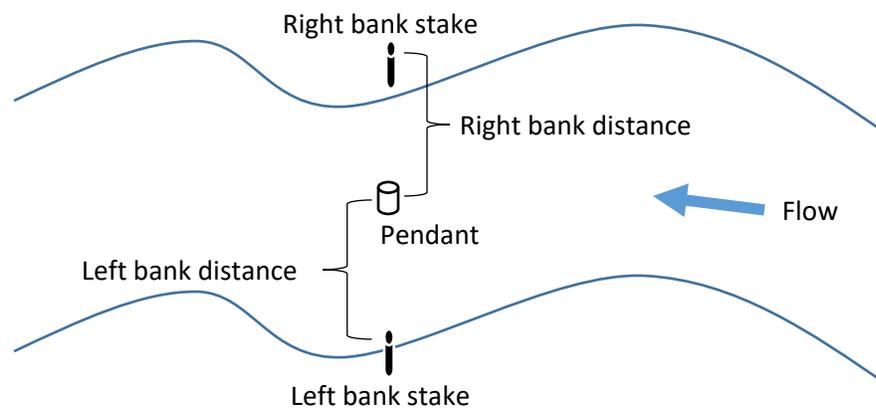


*Retrieval*

6.4. Locate pendants within the streambed by pulling measuring tape attached to stakes on the right and left banks to the previously recorded distances. Note in the field notebook the presence of debris that may be covering the pendant. If possible, remove the stake directly from the streambed. Otherwise, unclamp the pendant from the rebar stake. Record the date, time (when pendant removed from channel), temperature and specific conductivity (handheld YSI) in a field notebook.

6.5. Once returned from the field, remove all pendants from PVC housing and follow steps 5.5-5.9 to upload and convert data. This time, use the previously defined slope and y-intercept to calculate estimated specific conductivity for each respective pendant.

**Attachment 1: HOBO Pendant Data Field Sheet**

# HOBO Pendant Data Field Sheet

Date:_____          Initials:_____

DEPLOYMENT  /  RETRIEVAL    (circle one)

| Site ID | Pendant ID | Time | Temp. (°C) | Cond. (µS/cm) | Distance (m) from | | Comment |
| | | | | | Right | Left | |
|---------|-----------|------|-----------|--------------|-------|------|---------|
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