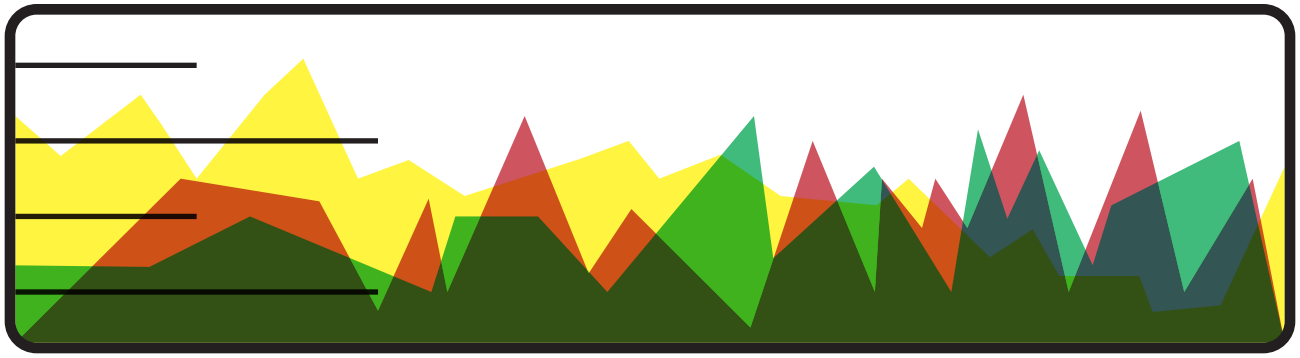
Quality Assurance Document for Temperature Monitoring



(Draft Version 1.5)

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Maryland's Temperature Measurement Protocols for Wadeable Streams

A. Introduction

This section describes the temperature measurement protocols used by Maryland to collect water temperature data from non-tidal wadeable streams. The protocols detailed here will be used by the State for the purposes of determining impairment in the Integrated Report (303(d) List/305(b) Report). All entities wishing to submit data for the Integrated Report (IR) should utilize these protocols (except where noted in the text below). Doing so will help ensure that water temperature data collected will be of the highest quality and therefore useful for regulatory decision-making. In some cases, uncommon circumstances may occur that require slightly different protocols. All such instances should be thoroughly documented and a rationale provided for why different protocols were used. The following protocols are presented in chronological order as a water monitor would approach water temperature measurement.

B. Equipment

The State of Maryland does not endorse or recommend any particular brand or model of temperature measurement equipment. The following equipment is identified only to describe what equipment the State currently uses. Other temperature measurement devices may be used as long as they have similar accuracy over the temperature ranges found in Maryland's streams and air. Maryland primarily uses Onset's HOBO Pro v2 temperature loggers to record continuous water and air temperatures at monitoring locations. Designed with a durable streamline case for extended deployment, the temperature loggers have an accuracy of ±0.2°C over a wide temperature range. Onset contact information is listed below.

Onset Computer Corporation
PO Box 3450
Pocasset, MA 02559-3450
1-800-564-4377
www.onsetcomp.com

HOBOware® software is used to program and download data recorded by temperature loggers. Please see the User's Guide at www.onsetcomp.com/files/manual_pdfs/12284-D-BHW-GS-web.pdf for more details on HOBO Pro v2 temperature loggers (Onset 2006).

C. Pre-Deployment Temperature Logger Calibration

The accuracy of temperature loggers are tested before and after field use with a single point (0°C) calibration check. These pre and post calibration checks verify that loggers precisely measure and record temperatures during deployment.

1. Setup

An ice water bath is prepared in a large insulated cooler (e.g., 48 quart). Fill the cooler half full with ice and add enough water to cover the top of the ice. Place an air stone in the bottom of the ice bath to ensure mixing of the water during the entire calibration check. Allow ice bath to sit for 30 minutes to allow water temperature to stabilize, before adding temperature loggers. Measure and record ice bath water temperatures using a NIST (National Institute of Standards and Technology) certified thermometer at 15 minute intervals throughout the calibration check process.

2. Accuracy Check

Set temperature loggers to record temperatures at 3 minute intervals. Set all loggers to launch at the exact same time (e.g., 10:00:00 a.m.). Launched loggers should be fully submerged sensor side down in the ice bath for a minimum of one hour. After the one hour period, record the end time and end temperature of the ice bath. Each logger is downloaded and the temperature is plotted. Export temperature logger data measurements in table form. Battery level should also be checked when the logger is being downloaded. A data logger fails the check if the logger temperature at the end time is greater than ±0.25°C of the NIST certified thermometer measurement of the ice bath end temperature. Review additional ice bath temperatures and corresponding temperature logger measurements during the submerged check period to ensure that values were within ±0.25°C. A Temperature Calibration Check Sheet should be completed during the accuracy check (Section G). Loggers that fail the temperature calibration check are separated and stored for further testing or returned to the manufacturer. Temperature loggers whose battery levels are low are also removed from circulation and returned to the manufacturer.

D. Temperature Logger Deployment

An air and water temperature logger must be placed at each monitoring location to enable a quality control check after deployment. The following sections describe logger placement details and the rationale for requiring these conditions.

1. Time Period of Measurement

In Maryland, the critical time period for most aquatic species survival is during the summer as stream temperatures reach annual highs. Elevated stream temperatures are positively correlated with aquatic life degradation and may result in loss of some desirable species. For this reason, the critical time period of measurement will be from

June 1 through August 31. However, temperature measurements outside this window (September 1 through May 31) can also be used for Integrated Report (IR) assessments.

Note: Temperature loggers deployed by DNR's MBSS program are generally placed at the monitoring site between March and April. Loggers deployed at this time are set with a delayed launch date of June 1.

2. Frequency of Measurement

Temperature loggers (both air and water) must be set to record at 20 minute intervals to provide adequate characterization of the diurnal flux during the critical period.

3. Physical Placement of Temperature Loggers

a. Water Loggers

Water temperature loggers should be deployed in the stream in the deepest section that can safely be reached by a wading crew member. Placing temperature loggers in the deepest section of a wadeable stream reduces the chance that the logger will become dewatered (and thereby fail the quality control check). Using sturdy zip ties, loggers should be attached to stable structures in the stream (e.g., rootwads or permanent large woody debris) or a 3' section of rebar that has been driven into the stream bed. In general, streams that are 'wadeable' have a maximum depth of 4 ft or less. Streams this shallow are well mixed (not stratified), therefore, placing a temperature logger in the deepest section will not bias the temperature readings significantly.

Water loggers must also be placed in portions of a stream segment that are NOT immediately downstream of a tributary confluence, impoundment, or effluent discharge, in isolated pools, wetlands, or beaver ponds. Loggers should also not be placed in areas near the bank that may have minimal depth and flow. Avoiding locations like these will ensure that loggers are placed in areas of the stream that are representative of that stream segment. Besides the factors previously mentioned, it is not important where temperature loggers are placed along the length or width of wadeable 1st-4th order streams. Due to the size and flow of these streams, they are well mixed from top to bottom and bank to bank. All efforts are made to avoid exposing the temperature logger to direct sunlight (e.g., attachment to the underside of roots, use of a PVC housing, covering logger attached to rebar with large substrate, etc.).

b. Air Loggers

Air loggers should be deployed in any structure (tree, shrub, fence, etc) adjacent to the stream that provides shade and protection to the logger. Do not place the logger in an area where it will have direct exposure to sunlight. The north side of a tree or shrub provides the most protection from direct exposure.

Mark the location of the water and air loggers independently with paint or flagging. On a data sheet, accurately record the logger serial number, time of deployment, and detailed descriptions of logger placement.

4. Number of Loggers to Adequately Characterize/Assess a Stream Segment

For the purposes of Integrated Report assessments, data from a single water temperature logger will be used to characterize a single stream segment. This stream segment will be defined longitudinally from the location of the logger upstream to the next upstream confluence, or if no upstream confluence exists, the headwaters of that stream. For determining what constitutes a confluence, MDE will use the 1:100,000 scale National Hydrography Dataset (NHD).[1] In rare cases, a stream segment may have an exceptionally deep section or pool. If, in the department's discretion, the pool is sufficiently deep relative to the rest of the stream that stratification could potentially occur, the department may require the deployment of additional loggers in other shallower portions of the stream.

In using the logger placement guidelines listed above in Section D.3. (e.g. Do not place logger immediately downstream of a tributary confluence), stream temperatures should vary little within a stream segment. For that reason and provided that the temperature logger passes all of the quality control checks, only one temperature logger should be necessary to characterize a stream segment (in wadeable 1st – 4th order streams). Only in rare cases where there is a potential for temperature stratification will two or more temperature loggers be required in a single stream segment.

5. Mid-Deployment Logger Check

A regular part of the MBSS temperature monitoring protocols involves checking both the water and air loggers to ensure that loggers are not missing and are properly positioned to accurately record temperatures. If the water logger is dewatered, it must be repositioned in a deeper section of the stream. The new logger location (with date and time) should be recorded on the data sheet used for initial deployment. Missing or dewatered loggers should also be noted on this sheet. *Note: This step is not necessary but provides an extra level of insurance that useful data will be collected from the logger devices.*

E. Logger Retrieval

The State typically retrieves loggers after September 1st. A standard Temperature Logger Data Retrieval Sheet is used to record logger serial number, date, time, logger dewatered, and comments for each site (Section G). Dewatered or missing air/water loggers are noted on this sheet. Each logger is marked with a temporary tag identifying site, date, and time of retrieval.

[1] The average 1:100,000 scale NHD stream reach (confluence to confluence) in Maryland measures 1.28 miles.

F. Temperature Data Quality Control

1. Data Download and Quality Control Check

Both air and water temperature logger data should be downloaded (the State uses HOBOware® software) and saved as an Excel file. There should be a separate Excel worksheet, containing both air and water temperatures for each sampling location. Temperature data for each site must be visually checked for problems associated with loggers becoming dewatered, buried in sediment, or general logger malfunction. For each site that has both air and water temperature loggers present, both sets of data are plotted together on one graph. When examining the combined plot, water temperatures should be lower and have less daily variability than air temperatures during summer (Figure 1). If the water temperature data matches the pattern described above, it is considered acceptable for use. For water temperature data to fully pass the quality control check it must 1) pass the visual inspection for data problems, 2) have a logger that passes the post-deployment calibration check (Section F.2.).

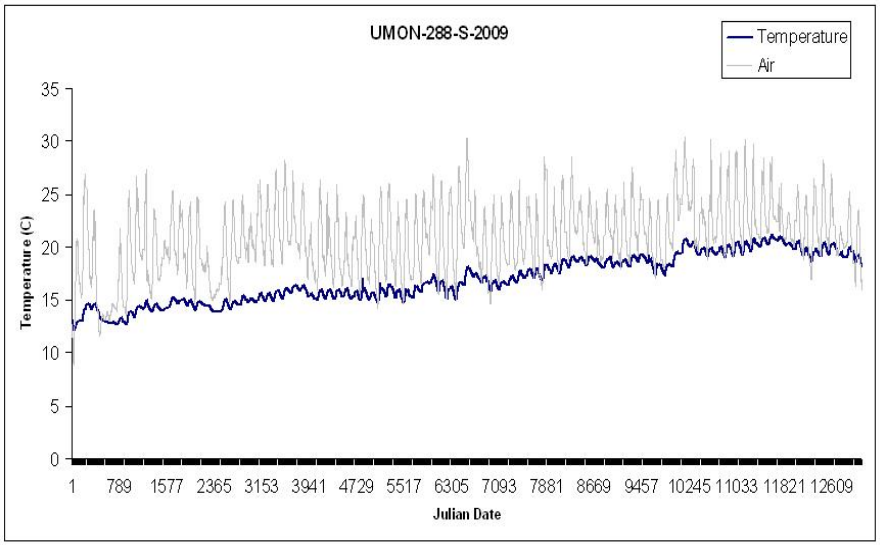


Figure 1: Example of MBSS site (UMON-288-S-2009) with water temperature data that passes quality control check.

Periods when water and air temperatures exactly match are strong indicators that the water logger became dewatered (Figure 2). Examination of the water temperature plots for unusually high water temperature spikes over multiple days are also flags for data problems. Field notes from the mid-deployment logger check and the Temperature Logger Retrieval Sheet can also be used to identify sites that had buried or dewatered loggers that would result in inaccurate temperature data. Any questionable data records must be noted on a quality control tracking sheet. Sites with questionable data records are removed from further analysis.

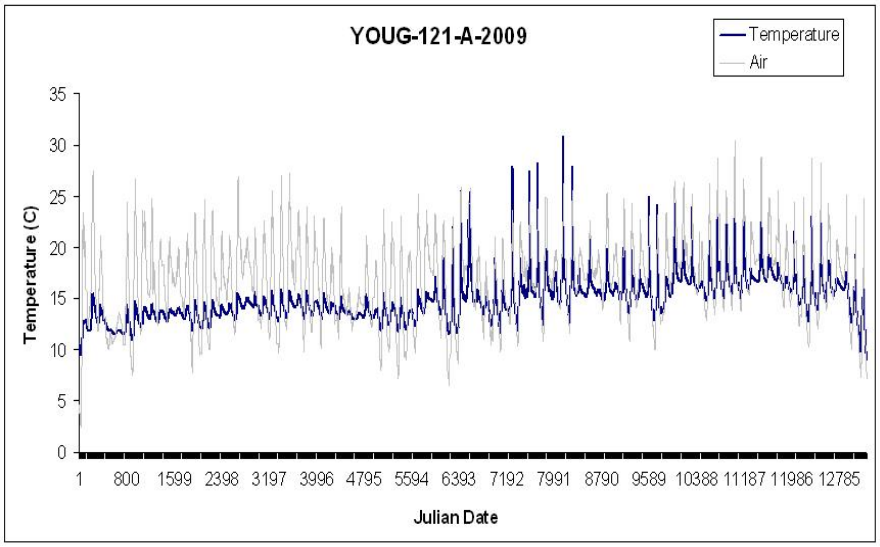


Figure 2: Example of MBSS site (YOUG-121-A-2009) with water temperature data that fails quality control check.

2. Post Calibration Check

Repeat the steps described in Section C. Pre-Deployment Calibration. If a logger should fail the post-deployment calibration check, that temperature data is considered questionable and fails the quality control check.

References

Allan, J.D. 1995. Stream Ecology: Structure and Function of Running Waters. Chapman and Hall, London, UK.

Bogan, T., Mohseni, O., and H.G. Stefan. 2003. Stream temperature-equilibrium temperature relationship. Water Resources Research 39(9): 1245.

Caissie, D. (2006), The thermal regime of rivers: a review, Freshwater Biolog, 51, 1389-1406.

Caissie, D., El-Jabi, N. and M. Satish. 2001. Modeling of maximum daily water temperatures in a small stream using air temperatures. Journal of Hydrology 251:14-28.

Coutant, C.C. 1999. Perspectives on temperature in the Pacific Northwest's freshwaters. ORNL/TM-1999/44. Oak Ridge, TN: Oak Ridge National Laboratory.

G. Example Temperature Logger Data Sheets

Temperature Logger Calibration Check Sheet

Date: _____ Start Time: _____

Logger calibration check by: _____

Ice Bath Temperature Log

Time	Temperature (°C)
End Time	End Temperature

Logger Calibration Check Log

Serial Number	Logger Temperature (°C) at End Time	Difference from Ice Bath End Temperature (°C)	Battery Level (Pass/Fail)	Pass Calibration Check (Pass/Fail)

Temperature Logger Retrieval Sheet

SITEYR	Water Logger Serial #	Air Logger Serial #	Date	Time	Logger Dewatered (Y/N)	Comments

Temperature Logger Quality Control Tracking Sheet

Date: _____ Logger quality control check by: _____

Logger Quality Control Tracking Log

Site	Logger (Y/N)	Start Date	End Date	Comments	Passed QC Check (Y/N)	Passed Calibration Check (Y/N)