Standard Operating Procedure 13: Measuring Discharge, version 1.0

Overview

Stream discharge can dramatically influence the nature and composition of macroinvertebrate habitats at each monitoring site and can also affect sampling error. Discharge is collected during every sampling event at Shenandoah National Park. One set (cross section) of discharge measurements are collected at every site any time macroinvertebrates are sampled. Discharge is calculated by measuring the width, depth, and water velocity within subsections across a transect of the stream channel (see Figure 1). This SOP provides a summary of equipment and techniques to quantify stream flow at monitoring sites. Required equipment includes: Marsh-McBirney (MMB), model 2000 "Flo-Mate™" flow meter, top setting metric wading rod, 30 meter tape, and discharge data sheet.

A discharge field sheet is located in SOP 16.

Flowmeters

The park has two Marsh-McBirney (MMB), model 2000 "Flo-Mate" flow meters for collecting discharge information. Each unit consists of three components including the display box, cable with electromagnetic sensor (probe), and a USGS top setting (metric) wading rod. The display box and cable/probe are permanently connected. The probe should be attached to the wading rod for operational use only. The units are shock resistant, waterproof, and generally durable. The zero should be checked according to the directions and the Flo-Mate can be re-calibrated to zero following instructions in the operator's manual (located in the Wet Lab of Lower NCR and a photocopy in the unit's case).

Selecting a transect location to measure discharge

One of the most critical factors in measuring water flow is selecting the appropriate location for the discharge cross section. The specific cross section location may be variable from year to year and is based on field conditions during the time of sampling. The ideal cross section is a single channel where flow is restricted, and water depth and substrate are uniform. Bedrock is an ideal substrate for the cross section because flow occurring below the substrate will be zero. Avoid cross sections with split channels, obvious subterranean flows, exposed boulders or other large substrates, areas with large subsurface obstructions, large areas of slack flow along banks, eddies, or sections where the center of the stream is flowing at a much faster rate than the edges. At some sites, optimal locations do not exist, especially during low flow conditions. In these cases, it may be necessary to temporarily modify the streambed or channel by removing rocks to ensure a more uniform and measurable flow. If the channel bed is modified, restore the channel to its prior condition following the discharge measurement.

Establishing intervals across the discharge transect

Measurements must be taken from at least ten evenly spaced intervals at the selected cross section, perpendicular to stream flow. In selecting the interval spacing, start by dividing the entire cross section into tenths. Select an interval that is easy to compound across the channel to the nearest 0.1m. Consider the example of a cross section with a total width of 3.7m. Dividing by ten would result in intervals of 0.37. Rounding down to 0.30 would ensure at least 10 measurements across the transect. Every effort will be made to select a portion of channel where at least 10 measurements of stream depth and velocity can be collected. During instances of very low flow, or in very small stream channels, this may be impossible. In those cases, collect as many measurements at 0.1 intervals as allowed by the stream channel (e.g. a 0.4 m transect would allow for 3 measurements of depth and velocity). In even rarer

instances, the best location for flow measurements may be in a split channel. In this case, get at least eight measurements from each channel and note it on the datasheet. This will have to be dealt with separately in the database.

Using the flow staff.

The wading rod or flow staff is calibrated to utilize the 6/10ths flow measuring technique recommended by the USGS (Buchanan and Somers 1969) and the U.S. Forest Service (Platts et al. 1983). This method results in measurements of water velocity 6/10^{ths} down from the water surface, which is the average water velocity in the column under ideal conditions. An examination of the top setting rod, while reading the instructions below, will provide an understanding of the mechanics of the top setting rod. By aligning the sliding decimeter scale (on the round rod) with the fixed centimeter scale (marked on the fixed portion at the top of the rod), the probe can be rapidly set to 6/10ths of the recorded depth at all of the sampling intervals. The fixed portion (octagonal shaped) of the rod is graduated in 0.02 m increments. Each 0.02 m increment is designated by a single line, the first of which is located above the base plate or stand. From the base plate, each 0.10 m increment is designated by a double line and each 0.50 m increment is designated by a triple line. To set the probe at 6/10ths depth, read the water depth as determined from the single, double or triple lines on the octagonal shaped rod and slide the round rod up until the graduations on the round rod match the estimated depth. For example, at a depth of 0.15 m (2 ½ single lines above the first set of double lines), align the "1" on the sliding round rod between the "4" and "6" on the fixed scale and the probe will be set at 6/10ths or approximately 0.06m above the streambed. The two scales are aligned by depressing the button at the top of the rod and sliding the small (round) rod up or down to the appropriate setting.

Collecting data.

Once the location and interval for measuring flow has been established, do the following:

1.) Stretch the 30 m tape from left to right across the stream channel, perpendicular to the direction of flow. Pull any slack out of the tape and secure it at both ends.

2.) Mark the discharge device used on the datasheet.

3.) Measure the channel width (i.e. waterline to waterline wetted width). Record width to the nearest 0.1 m in the space provided on the "Discharge Measurements" data sheet (SOP 20). From the measured channel width, determine an appropriate sample interval (Interval Selected for Measurement) following the criteria outlined above and fill in the distances on the data sheet.

4.) Once the sampling intervals have been determined, attach the probe to the wading rod with the thumbscrew.

5.) You will see on the data sheet, that at point 0, depth and flow have already been recorded as 0. This is because point 0 corresponds with the starting stream bank. Start actual measurements by placing the wading rod at the first interval beyond the "0" distance, and make sure the flow meter bulb is in the water facing upstream (the bulb should be perpendicular to the measuring tape and parallel to the flow).

6.) Turn the flow meter on and read/record the depth on the flow staff. Ensure that the velocity readings are in M/S and the Period is set to 6. **Note: It is not necessary to switch the unit on and off for each measurement, just keep the probe submerged throughout the entire sequence.**

7.) Set the wading rod for the depth at that location according to the instructions above. **Always stand at least 0.3 m on the downstream side of the probe to avoid interfering with the velocity measurements.**

8.) Once the probe is in position facing upstream, allow the reading in the display box to stabilize (at least six seconds or two periods) before calling out the value to the data recorder. You should see the period counter at the bottom of the screen cycle through once. The resulting number represents flow in meters per second at that point. Repeat steps 4 through 8 until flow measurements at all of the subsequent intervals have been completed.

9.) The final interval should be recorded as depth 0 and velocity 0 as this will correspond with the "ending" stream bank width.

For a more thorough discussion of this procedure, see Buchanan and Summers (1969).

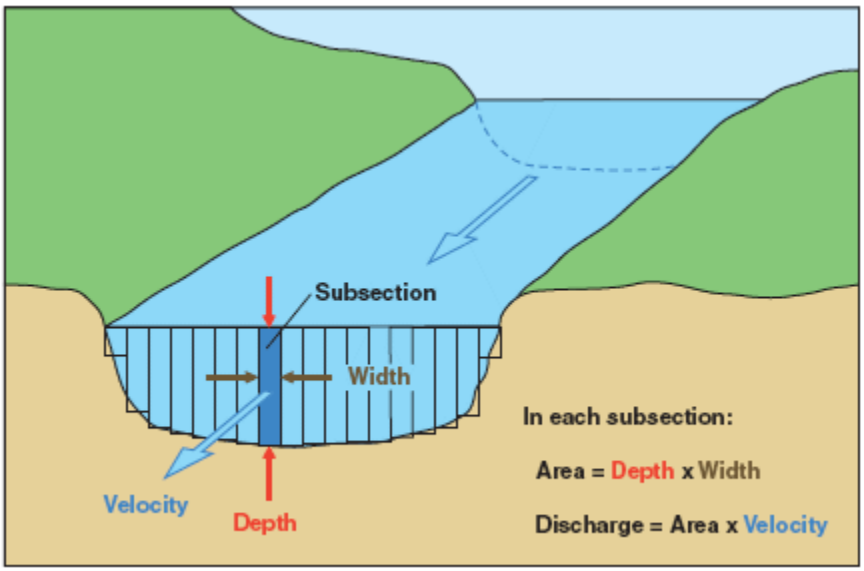

Figure 1. Schematic of discharge measurements. Discharge is calculated by measuring the width, depth, and water velocity at a number of subsections across a transect. Discharge for each subsection is then summed for a total measurement of discharge.

References

Buchanan, T.J., and Somers, W.P., 1969, Discharge measurements at gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap A8, 65 p. (Also available at http://pubs.usgs.gov/twri/twri3a8/.)

SOP Revision History

All protocols, regardless of how sound they are originally, require modification as new and different information becomes available. SOP version numbers increase incrementally by tenths (e.g. version 1.1, version 1.2…etc.) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …). Small changes or additions to existing methods will be reviewed in-house by Shenandoah or Mid-Atlantic Network staff. However, if a complete change in methods is sought, an outside review is required.

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #