Protocol for Monitoring Springs at Ozark National Scenic Riverways, Missouri.
Heartland I&M Network

SOP 10: Measuring Spring Discharge

Version 1.10 (06/06/2018)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	06/06/2018	Bowles	Big Spring gage information added	The gage is now operational	1.1

This SOP is guidance for measuring discharge in springs at OZAR. The SOP describes sampling procedures, calibration, and general maintenance procedures. If other meters are used, field personnel should review the instruction manual for instrument-specific guidance on how to calibrate and operate those particular meters.

I. Background Information

Velocity and depth are measured using a current meter attached to a wading rod. The rod allows for quick and easy measurements of depth with incremental markings, and has an adjustable arm that places the current meter at the proper depth for measuring velocity (60% of the depth from the surface of the water; Carter and Davidian, 1969). Some current meters have rotating cups (Pygmy and Price models) while others have a pair of electronic contacts on a small head (FLO-MATE 2000 and Hach FH950) to measure velocity. The sensor in the Marsh-McBirney FLO-MATE 2000, for example, is equipped with an electromagnetic coil that produces a magnetic field. A pair of carbon electrodes measure the voltage produced by the velocity of the conductor, which in this case is the flowing water. Internal electronics process measured voltages and output them as linear measurements of velocity. Velocity is displayed as either feet per second or meters per second.

Spring discharge (Q) is the volume of water passing a cross-section per unit of time and is generally expressed in cubic feet per second (ft^3/s) or cubic meters per second (m^3/sec). Discharge is estimated by multiplying current velocity by the cross-sectional area (Carter and Davidian, 1969). Cross sectional area is determined by first measuring the width of the stream channel. The cross section is then divided into smaller increments (usually 15 to 20 intervals) and depth and velocity are measured at each increment. The depth and width of the interval are multiplied to get an area for each interval and then each interval area and velocity is multiplied to produce a discharge for each interval. These interval discharges are summed to produce a total discharge for that cross section of the stream. This process will be described in greater, step-by-step detail in the “Procedures” section.

II. Prior to the Field

A. Standard wading rods come in both metric and English standard units (feet). For this protocol, width, depth, and velocity will be recorded in metric units. If English units are used for measuring discharge due to instrument requirements, ensure there is consistency between the settings on the velocity meter, the wading rod, and the tape measure, and that the units are clearly recorded on the data sheet. This will allow conversion of English units to metric for data entry. Discharge measurements at USGS gauges are generally recorded in English units as cubic feet per second. English standard units are easily converted to metric units when required.

B. Ensure new batteries are placed in units that require them.

C. Calibrate velocity meters according to instructions in the manufacturer's operations manuals. Photocopies of the operations manuals should be taken to the field. If readings in the field should substantially fluctuate at a sample cell or appear to be very high, the meter may need recalibration.

D. Equipment maintenance and storage should follow guidance issued by the manufacturers.

III. In the Field

Discharge measurements require wading across the stream and may stir up sediments, disrupting accurate measurement of other parameters.

<u>Quantitative Discharge Procedure:</u>

A. Prior to taking any measurements, the location where discharge will be measured must be determined. An ideal cross-section in the sample reach will have the following qualities:

1. The stream channel directly above and below the cross-section is straight.

2. There is measurable stream flow, with a stream depth preferable greater than 10 cm and velocities generally greater than 0.15 meter/second.

3. The streambed is a uniform "U" shape, free of large boulders, woody debris, and dense aquatic vegetation (although this may be difficult in spring-runs where vegetation is dense).

4. The stream flow is laminar and relatively uniform with no eddies, backwaters, or excessive turbulence.

<u>Note</u>: The cross section will not likely meet all these qualifications

but the best location should be selected based on these standards. Record (or draw a diagram) on the data sheet a description of any discrepancies with the cross section.

B. Once the cross section is established, measure the width of the stream with a tape measure to the nearest 0.1 meter and secure the tape across the stream for the duration of the discharge measurement.

C. Divide the stream into equal intervals across the width of the cross section, usually 15 to 20. A minimum of 10 intervals is recommended. A velocity and depth measurement will be recorded for each interval across the stream at the center of each interval. For example, if the stream is 10 meters wide, 10 velocity and depth measurements will be taken at one meter intervals. The first measurement will be taken a half meter from the water's edge, the second will be taken at 1 ½ m from the water's edge, etc., as shown in Fig. 1.

D. Attach the sensor to the wading rod and ensure that the sensor is securely screwed onto the rod and facing upright.

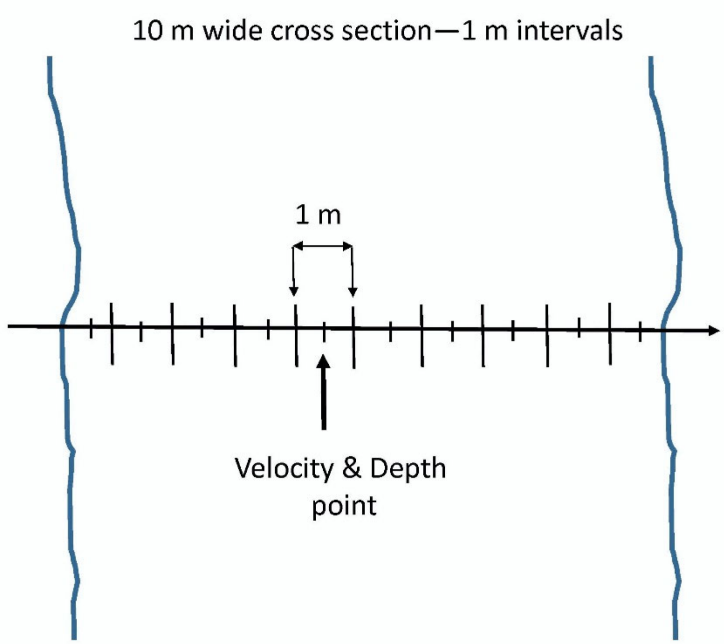

Figure 1. Cross section diagram.

E. One person should measure discharge and one person should remain on the bank, recording data. The person measuring discharge should direct the sensor upstream and stand behind the wading rod and sensor. The first readings are taken at water's edge and are recorded as depth=0 and velocity =0. Proceed to the next interval and record readings. Place the wading rod as level as possible and hold perpendicular to the water level. Read depth from the wading rod to the nearest centimeter. The rod will have graduated marks along its length, with single marks indicating two centimeters, double marks indicating 10 centimeters, and triple marks indicating one-half meter increments.

Stand behind the sensor and make sure there is no disturbance (including the senor cord) around the sensor that interferes with the velocity measurement. The meter may be adjusted slightly up or downstream to avoid boulders or other interferences.

Note: Make sure the sensor directly faces the flow of the water. This may not always be directly parallel with the water's edge; the rod and sensor may need to be turned slightly with each measurement.

F. Once depth has been read, adjust the arm of the sliding rod with the sensor attached to 60% of the water depth. The wading rod will place the sensor at 60% of the depth from the surface of the water when properly adjusted.

Note: For example, if the depth is 0.26 meters (26 cm), line up the 2 on the meter scale (sliding rod) with the 6 on the tenth scale (increments on handle of fixed rod). The sensor is now located at 60% of the water depth.

G. Allow the instrument enough time to get an accurate reading--generally around a minute. Watch the time bar complete two full cycles and then take the velocity reading. If something happens during the measurement, such as accidental movement of the wading rod, the reading should be repeated.

H. Call out the distance from the water's edge, the depth, and then the velocity to the person recording data. Continue moving across the stream until measurements have been taken at all intervals.

Note: If the water velocity increases greatly between intervals, additional measurements can be taken to shorten the width of the intervals within this area of high velocity. Be sure to change the interval width for these measurements on the field sheet and in the calculation of discharge.

I. When finished, detach the sensor from the wading rod and place it back in the case for transportation. If you do not expect to use the meter for several days, turn the meter off, clean the sensor, and store properly.

J. For Big Spring, discharge can be obtained from the USGS gage 07067500 (http://waterdata.usgs.gov/mo/nwis/uv?site_no=07067500), and should be recorded as the daily mean for that site from the day sampling was undertaken. Values on the USGS gage are shown in cubic feet per second and therefore should be converted to cubic meters per second.

SPRING DISCHARGE

SPRING NAME: ______________________________ DATE: ____________________

CREW MEMBERS: ______________________________________

Taken at upper end of sampling area

	Distance Units ft ☐ m ☐	Depth Units ft ☐ cm ☐	Velocity Units ☐ ft/s XX.X ☐ m/s X.XX	
	Start at River Right; Final measurement should be at river left bank			
	Distance from Bank	**Depth**	**Velocity (@0.6 depth)**	**FLAG**
1	0	0	0	
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Flags: