

FT 1800. Field Measurement of Water Flow and Velocity

Use in conjunction with:

- FT 1000 General Field Testing and Measurement
- FQ 1000 Field Quality Control Requirements
- FS 1000 General Sampling Procedures
- FD 1000 Documentation Procedures

1. INTRODUCTION

This SOP describes the procedures used during intensive surveys of water bodies (rivers and streams) where the discharge measurement (Q) is an important parameter in the calculation of wasteload allocations by DEP. These procedures are applicable to shallow rivers and streams (depth less than 4 feet) where the measurements are conducted by wading with assistance from other personnel.

1.1. Site Selection: Survey the study area before taking flow measurements, and carefully select flow sites that will allow the most accurate flow measurements.

1.1.1. Constricted areas are usually the most convenient and allow greater accuracy because the constriction reduces the width of each subsection and increases the current velocity.

1.1.2. Flow sites should have a uniform flow and should be free of eddies, slack water, and excessive turbulence.

1.1.3. In addition, the streambed should be free of boulders or aquatic vegetation. Obstructions in the stream may need to be removed both at the measurement site and upstream of the flow site. Obstruction removal allows for more accurate flow measurements and should not affect the actual stream flow.

1.1.4. These site selection criteria introduce a bias that tends to overestimate the stream velocity. In general, velocities taken for flow measurements are not representative of the average stream velocity. Time-of-travel dye studies should be used to determine average stream velocities.

1.2. Current Meter Selection: After the flow sites have been determined, select the appropriate current meter for each site.

1.2.1. DEP recommends electronic current meters such as the Marsh-McBirney or SonTek ADV because these meters are more sensitive than mechanical meters and are easier (quicker) to use. In order to have the most flexibility when using a meter, consider using meters that measure flow at a variety of depths and can be attached to a wading rod, a long staff, or even to the sounding unit of the bridgeboard.

1.2.2. Do not change or substitute current meters during a transect. If a meter malfunctions mid-way through a cross-section, then repeat the entire transect with a new meter.

1.2.3. DEP recommends that the same type of current meter be used during subsequent intensive surveys at the same site.

2. EQUIPMENT AND SUPPLIES

2.1. Field instruments: DEP personnel use the Marsh-McBirney Model 201D or Flo-Mate Model 2000 Flow Meter. Both measure water velocity by creating a magnetic field and measuring the voltage produced when water (a conductor) flows through the field. Other flow meters with the sensitivity and accuracy required for the study are acceptable.

2.2. Recordkeeping and Documentation Supplies:

- Field notebook (w/ waterproof paper is recommended) or forms Indelible pens

3. CALIBRATION AND USE: The following are instructions for the Marsh-McBirney Flow Meters, however, other flow meter types are acceptable. Follow the manufacturer's instructions for calibration and use.

3.1. Marsh-McBirney 201D

3.1.1. Assembly: Assemble the 201D per manufacturer's instructions.

3.1.2. Calibration

3.1.2.1. After the unit has been assembled, perform a calibration to determine if the internal circuitry is functioning properly:

- Turn the selector switch to the CAL position and the time constant switch to 2.
- The reading must be in the range of 9.8 and 10.2 after a 10-second warm-up.
- If the reading is not within the above-mentioned range, turn the meter off and check the batteries, then repeat the above two steps.
- If the unit fails the CAL test after the battery charge, send the unit to the manufacturer for maintenance.

3.1.3. Measurements with the Marsh-McBirney 201D- once this meter has been properly mounted onto the wading rod and calibrated, current measurements can be obtained:

3.1.3.1. Position the submersible sensor perpendicular to the current at the depth determined for the appropriate velocity method, and allow several seconds for the meter to adjust to the current.

3.1.3.2. Follow the manufacturer's instructions for operation.

3.1.3.3. Record the measurement on the Discharge Measurement Notes (form FD 9000-11).

3.1.3.4. Turn the SCALE switch to the off position and move to the next sampling location.

3.2. Marsh-McBirney Flo-Mate 2000

3.2.1. Calibration: Following assembly per manufacturer's instructions, perform a zero calibration check to determine if the internal circuitry is functioning properly:

3.2.1.1. Clean the sensor to remove oil that can cause noisy readings.

3.2.1.2. Place the sensor in a five-gallon bucket of water keeping it at least three inches away from the sides and bottom of the bucket.

3.2.1.3. To make sure the water is not moving, wait 10 or 15 minutes after you have positioned the sensor before taking any zero readings.

3.2.1.4. For the Flo-Mate 2000, use a filter value of 5 seconds. Zero stability is +/- 0.05 ft/sec.

- To initiate the 'zero start sequence' press the STO and RCL keys at the same time. You will see the number 3 on the display.
- Decrement to zero with the down arrow key.
- The number 32 will be displayed.
- The unit will decrement itself to zero and turn off. The unit is now zeroed.

3.2.2. Measurements with the Marsh-McBirney Flo-Mate 2000: Current measurements can be made after the meter has been properly mounted onto the wading rod and calibrated:

3.2.2.1. Position the submersible sensor perpendicular to the current at the depth determined for the appropriate velocity method, and allow several seconds for the meter to adjust to the current.

3.2.2.2. Depress the ON/C button on the display unit.

3.2.2.3. Set the FPA (fixed point average) to five seconds by depressing either the up or down arrows.

3.2.2.4. Select the FT/SEC position by toggling between the ON/C and OFF buttons.

3.2.2.5. Record the measurement on the Discharge Measurement Notes (form FD 9000-11).

3.2.2.6. Depress the OFF button and move to the next sampling location.

4. FLOW MEASUREMENTS

4.1. Estimating Discharge

4.1.1. The instruments identified in section 3 above are designed to take individual velocity measurements. These measurements are sometimes used as point velocities to calibrate model velocities, but are more frequently used to determine the volume rate of flow (discharge) of a water body.

4.1.2. To determine discharge, divide the cross-section of the water body into subsections.

4.1.2.1. Measure and record the velocity, width, and depth of each subsection.

4.1.2.2. The sum of the products of the individual subsection observations provides an estimate of discharge using the following basic formula:

$$Q = \sum_{i=1}^n (A_i \times V_i)$$

Where:

Q = discharge in cfs

A_i = cross-sectional area of subsection i (ft²)

V_i = velocity of subsection i (ft/s)

4.2. The Mid Section Method: This method determines the discharge using the subsection velocity measurements.

4.2.1. Secure the end of a tag line (tape measure) to the right bank of the stream (facing downstream).

4.2.2. Extend the line across the stream and secure the other end of the line to the left bank.

4.2.3. Make sure that the tape is tight and the numbers are visible.

4.2.4. Read and record the tape measurements corresponding to both the left and right edges of the water and calculate the total width of the stream.

4.2.5. Then divide the stream into approximately 15-20 subsections. While it is generally easier if subsections are of equal width, it may be necessary to vary the subsection widths if the flow varies significantly along the cross section.

4.2.5.1. Subsections must be narrower where the depth and velocity is highest.

4.2.6. Starting at the right edge of the water and standing on the downstream side of the tape, move along the tape to the first subsection.

4.2.6.1. Measure and record the depth (from the water surface) and the tape measure length.

4.2.6.2. If the depth is greater than 2.5 feet, measure the velocity at two points in each vertical at depths corresponding to two-tenths and eight-tenths the total depth.

4.2.6.3. If the depth is less than 2.5 feet, then measure velocity at a depth of six-tenths the total depth.

4.2.6.4. Do not stand in a position that interferes with the current. The USGS recommends placing the current meter at least three inches downstream from the tape measure and that the hydrologist stand at least 1.5 feet from the meter.

4.2.7. Repeat steps 4.2.6.1 through 4.2.6.4 above at each position corresponding to the distance of successive subsections. Continue the procedure until reaching the left edge of the water.

4.3. Sample Depths for Velocity Measurements:

4.3.1. An accurate estimate of the mean velocity in the vertical is made by averaging the velocity at two depths (see 4.2.6.2 above).

4.3.2. In shallow water (depth less than 2.5 feet), use top-setting wading rods that are designed to easily adjust to the six-tenths depth. To set the rod, first measure the depth of the water (to the nearest tenth of a foot) on the fixed support rod. Then adjust the sliding support rod so that the top scale reads the depth of the water. This automatically adjusts the meter to the six-tenths depth. Note that the sample depth terminology can be confusing when using the wading rod because the sample depths are referenced to the water surface and the natural tendency is to adjust the wading rod from the bottom up. For example, if the total depth is four feet, then the six-tenths depth is 2.4 feet ($4 \times .6 = 2.4$) from the surface. This means that the current meter should be positioned 1.6 feet off the bottom (the remaining four-tenths of the depth).

5. PREVENTIVE MAINTENANCE: Refer to FT 1000, section 3.

6. DOCUMENTATION

6.1. Field Instrument Calibration Documentation: Document acceptable calibration and calibration verification for each instrument unit and field test or analysis, linking this record with affected sample measurements.

6.1.1. Retain vendor certifications of all factory-calibrated instrumentation.

6.2. Designate the identity of specific instrumentation in the documentation with a unique description or code for each instrument unit used.

6.2.1.1. Record manufacturer name, model number and identifying number such as a serial number for each instrument unit.

6.2.2. Record the time and date of all initial calibrations and all calibration verifications.

6.2.3. Record the instrument reading (value in appropriate measurement units) of all calibration verifications.

6.2.4. Record the name of the analyst(s) performing the calibration.

6.2.5. If applicable, document the specific standards used to calibrate or verify the instrument or field test with the following information:

- Type of standard or standard name
- Value of standard, including correct units

6.2.6. Retain manufacturers' instrument specifications.

6.2.7. Document whether successful initial calibration occurred.

6.2.8. Document whether each calibration verification passed or failed.

6.2.9. Document any corrective actions taken to correct instrument performance according to records requirements of FD 3000.

6.2.9.1. Document date and time of any corrective action.

6.2.9.2. Note any incidence of discontinuation of use of the instrument due to calibration failure.

6.2.10. Describe or cite the specific calibration or verification procedure performed (DEP SOP or internal SOP).

6.3. Field-Testing Measurement Data:

6.3.1. Record all flow readings and supporting information. See United States Geological Survey Guidance (USGS) on flow measurement for examples of standard documentation (<http://pubs.usgs.gov/tm/>).

6.3.2. Also record each of the following, if not addressed in 6.3.1 above

- Project name
- Date and time of measurement or test (including time zone, if applicable)
- Source and location of the measurement or test sample (e.g., monitoring well identification number, outfall number, station number or other description)
- Latitude and longitude of sampling source location (if required)

- Analyte or parameter measured
- Measurement or test sample value
- Reporting units
- Initials or name of analyst performing the measurement
- Unique identification of the specific instrument unit(s) used for the test(s)