New Mexico Environment Department
Surface Water Quality Bureau

Standard Operating Procedure

for

STREAM FLOW MEASUREMENT

Approval Signatures

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1.0 Purpose and Scope

The purpose of this procedure is to describe the process for measuring stream flow.

Besides measuring flow in the field, flow data can be obtained from USGS gaging stations. USGS flow measurements can be used if they correspond to the location and time that water quality data were collected.

In all cases, stream flow should be measured as close as possible, in relation to location and time, to water quality measurements.

The SWaB commonly determines flow by measuring water velocity with a current meter and cross-sectional area with a wading rod and a tagline. USGS Techniques of Water Resources Investigations Reports\(^1\) refers to this as the Current-Meter Method. Flow measurement using a wading rod, tagline and current meter is based on the continuity equation, \(Q = AV\), where \(Q\) = flow (cfs); \(A\) = cross-sectional area (ft\(^2\)); \(V\) = mean velocity (ft/s).

2.0 Responsibilities

All personnel who measure stream flow are responsible for implementing this procedure.

Before using equipment necessary for this procedure staff are required to sign out the equipment for the period of time it will be used on the Bureau’s online check-out.

One individual within the SWaB is designated as the Current Meter Manager. The manager is responsible for keeping the stream flow measurement equipment in working order and ready for use.

3.0 Precautions

Streambed Dangers and Obstacles

Some channels have quicksand-like areas, deep holes, sharp rocks, fallen logs, etc., that can cause foot entrapment, injury, or falls. The wading rod (without the current meter attached) can be gently used for stabilization and to probe the streambed when conditions are uncertain. Use professional judgment to assess risks involved with working in the streambed.

Rule of 10

Wading across a streambed can be dangerous depending on flow and substrate conditions. Do not attempt to wade into a stream if the depth (in ft) multiplied by the velocity (in ft/s) equals or exceeds 10. For example, a stream 2 ft deep and with a velocity of 5 ft/s or more should be considered too dangerous to wade. If you start to take measurements and discover part of the way across a stream that you are violating or will violate the rule of ten, return to the nearest bank and note “too fast/deep to measure” on the field form.

4.0 Definitions

LEW – Left edge of water. The left edge of the wetted stream channel, facing downstream.

REW – Right edge of water. The right edge of the wetted stream channel, facing downstream.

ft/s – Feet per second

cfs – cubic feet per second

5.0 Equipment and Tools

The velocity meters that the Bureau uses are manufactured by:

Marsh-McBirney
Flo-Mate 2000 Portable Flowmeter
Phone: 800.368.2723 or 800.635.1230 (24/7 Technical Support)
Email: hachflowservice@hach.com
Internet: http://www.marsh-mcbirney.com/

Price Pygmy and AA
Rickly Scientific
Email: sales@rickly.com
Internet: http://www.rickly.com/sgi/pygmy.htm or http://www.rickly.com/sgi/AA.htm

The meters are used in conjunction with a USGS top setting wading rod, available from:

Rickly Scientific
Phone: 1-800-561-9677
Email: sales@rickly.com
Internet: http://www.rickly.com/sgi/wading_rods.htm

Additional necessary equipment includes bank pins and a tape measure (in feet) to serve as the tag line.
6.0 Step-by-step Process Description


This procedure describes the process for determining stream flow by measuring stream cross-sectional area using a wading rod and tagline and measuring velocity using Marsh-McBirney or Price current meters. Data can be recorded on printed versions of either the Flow Sheet and Calculator or the Flow Field Sheet depending on staff preference.

1) Select Measurement Location

The measurement cross section should be located in a straight run or gentle riffle. Do not place a cross section through a pool. Where the length of straight run is limited, the length upstream from the cross section should be twice the downstream length.

- The channel should be as free of flow disturbances as possible. Try to avoid areas with sudden changes in stream width, contributing side streams, outgoing side streams or obstructions such as pipes, boulders, or logs. Divided channels can be used by calculating the flow in each channel and summing.
- Depths need to be at least 0.15 ft and should ideally be greater than 0.5 ft, and velocities mostly greater than 0.5 ft/s. If depths are less that 0.15 feet, use the timed-fill method described in Section 6.2.1., or just visually estimate. Enter flows judged to be less than 1 cfs simply as <1 cfs.
- The flow should be laminar (i.e., free of swirls, eddies, vortices, backward flow, or dead zones). Avoid areas immediately downstream from sharp bends or obstructions.
- The ideal streambed is "U" shaped, stable and free from large rocks, weeds and protruding obstructions that would create turbulence or interfere with the current meter. The investigator may modify the channel by removing cobbles that interrupt flow, or to temporarily make the channel deep enough to measure. Alternatively, consider using the timed-fill method, which is more accurate at very low flows.
- If necessary, build small dikes to keep water from flowing around the cross section. This is to keep all water flowing through the cross section and to prevent leaks into secondary channels (although choosing a better site is strongly recommended).

2) Set the Tagline

String a tagline (tape measure) or lay a survey rod across the stream at the chosen cross section and secure it using bank pins, a Silvey stake or vegetation. The tagline should be perpendicular to the flow (not necessarily at right angles to the whole channel) and about one foot above the water level. Make sure the tagline is tight, level and does not contact the water.

3) Establish Cross Sectional Windows

Measure the stream’s wetted width and divide this width into at least 20 partial sections (windows). If the channel is too narrow to establish 20 windows (less than 10 ft wide), then flow may be estimated using fewer windows. Flow measurements made with fewer than 20 windows should be entered into NMEDAS as estimated values.

The above width serves only as a guideline for setting cross sectional windows. As necessary adjust for changing depths and velocities, increase or decrease individual window widths. The goal is to have equal flow through each window, not equal window widths. In addition the first and last flow measurements should be made as close to the REW and LEW as possible.
If a cross section cannot be established that is free of boulders or other debris that, these should noted on the field form as they may influence measurements. If these obstructions create windows that have no flow they are not be included in the tally of windows measured.

4) Take Velocity and Depth Measurements

Observe the tagline measurement at LEW. Enter measurement on first row (marked LEW) of field flow sheet. Enter depth = zero, velocity = zero.

Move to the first point in the water – which as noted above should be the first point with sufficient depth to take a flow measurement. Enter the tagline measurement on the flow sheet. Measure water depth by reading the hexagonal portion of the top set wading rod. Enter water depth on the flow sheet. Place the current meter at the appropriate depth (see box below). Stand several inches downstream from the tagline and about 18 inches to one side of the meter to avoid disrupting the flow near the meter. For small streams, where your feet would occupy a significant portion of the wetted perimeter, stand on the bank, entirely out of the water. Ensure that the wading rod is vertical (if unsure, hold a rod level against the wading rod to check). Ensure that the current meter is facing upstream directly into the flow.

Marsh-McBirney Operation

Press "clear" (ON/C) and wait for the reading to stabilize. Check to make sure the meter is recording in ft/sec. If recording in m/sec change units by pressing “on” and “off” buttons at the same time.

Record the velocity after the reading has stabilized. If the reading does not stabilize, wait for the time bar to fill completely (40 seconds) and record the velocity.

Move to the next location, press clear to reset the averaging and repeat the procedure.

See Attachment 1 for more details

Price Meter Operation

Model 921 Revolution Counter: Allow a few moments (several seconds or longer in velocities less than one foot per second) for the meter to stabilize. Press “on” and start the stopwatch simultaneously. Count revolutions for 40 to 70 seconds. End the measurement at some convenient number of revolutions (generally a multiple of five, as listed across the top of the rating table included with the meter). Look up the velocity on the rating table supplied with the meter. Locate the column corresponding to the number of revolutions, and then locate the row corresponding to the number of seconds. Record the velocity. Move to the next location and repeat the procedure.

See Attachment 2 for more details
**Placing the Current Meter**

Place the current meter at the velocity measurement depth by matching the measured depth (or a multiple or fraction) with the vernier scale on the top-setting wading rod (see Attachment 3 for more details). If the stream depth is less than 2.5 ft, measure velocity at 60% depth from the surface by matching the measured depth with the vernier. If the stream depths is 2.5 ft or greater, measure velocity at 20 and 80% depth by matching twice and one-half of the measured depth with the vernier (see box below).

If the depth is from 2 inches (0.15 ft) to 2.5 ft, measure velocity at 60% depth.

1. Measure the depth at each location using the scale on hexagonal (fixed) shaft of the top setting wading rod.
2. Use the measured depth to locate the current meter at 60% depth. Move the sliding (round) shaft so that the correct one foot line on the sliding rod lines up with the correct tenth foot line on the vernier scale. For example, if the stream depth is measured at 1.4 feet, move the one foot line on the sliding rod until it is adjacent to the 4 on the vernier scale.

If the depth is equal to or greater than 2.5 ft, measure velocity at 20% and 80% depth.

1. Measure the depth at each location using the scale on hexagonal (fixed) shaft of the top setting wading rod.
2. To place the current meter at 20% depth, double the water depth measurement, then move the sliding shaft so that the line corresponding to twice the measured depth is adjacent to the correct tenth foot line on the vernier scale. If the stream depth is 2.8 ft, position the 5 ft line on the sliding rod at the 6 on the vernier scale.
3. To place the current meter at 80% depth, halve the water depth measurement, then move the sliding shaft so that the line corresponding to half the measured depth is adjacent to the correct tenth foot line on the vernier scale. If the stream depth is 2.8 ft, move the 1 foot mark on the sliding rod to the 4 on the vernier scale.
4. Average the two values to obtain the mean velocity.

Enter in the field flow sheet velocity column either the 60% depth velocity, or the average of the 20 and 80% depth velocities.

Take last velocity measurement as close to the REW as possible. At the REW row (the last row), enter tagline measurement. Enter depth = zero, velocity = zero.

5) **Calculate Total Flow**

The flow in each section equals the average water velocity multiplied by the cross-sectional area of each window. To determine the cross-sectional area of a window, use the depth as measured in the middle of the window and multiply it by the window width.

For each window, calculate the window width based on the meter locations preceding and following (except those adjoining the REW and LEW which use the tag line distance at this location. That is, if you placed the meter at 3.0, 5.0, and 8.0 ft (along the tag line), then the window width at the “5-foot” section window would be 2.5 ft, calculated as follows:

\[
\text{Window width} = \left( \frac{8 - 5}{2} + \frac{5 - 3}{2} \right) = \left( \frac{8 - 3}{2} \right) = 2.5 \text{ feet}
\]
Calculate the flow through each window by multiplying the velocity by the window width by the window depth (velocity by cross-sectional area). **Table 1** illustrates these data and results (NOTE: The non-bolded items are directly measured in the field; the bolded items are calculated).

**Table 1 Example of velocity by cross-sectional area calculations for determining flow. Note that revolutions and time only need to be recorded for the Price Model 921 Revolution Counter.**

<table>
<thead>
<tr>
<th>Tag line location (ft)</th>
<th>Window width (ft)</th>
<th>Depth (ft)</th>
<th>Revolutions</th>
<th>Time (seconds)</th>
<th>Velocity (f/s)</th>
<th>Flow (cfs)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>1.0</td>
<td>0.0</td>
<td>NA</td>
<td>NA</td>
<td>0.000</td>
<td>0.00</td>
<td>LEW</td>
</tr>
<tr>
<td>5.0</td>
<td><strong>2.50</strong></td>
<td>0.7</td>
<td>15</td>
<td>44</td>
<td>0.361</td>
<td><strong>0.63</strong></td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td><strong>2.10</strong></td>
<td>0.8</td>
<td>25</td>
<td>43</td>
<td>0.596</td>
<td><strong>1.00</strong></td>
<td>Rock</td>
</tr>
<tr>
<td>9.2</td>
<td><strong>1.35</strong></td>
<td>1.3</td>
<td>40</td>
<td>43</td>
<td>0.937</td>
<td><strong>1.64</strong></td>
<td></td>
</tr>
<tr>
<td>10.7</td>
<td><strong>1.05</strong></td>
<td>1.9</td>
<td>60</td>
<td>41</td>
<td>1.460</td>
<td><strong>2.91</strong></td>
<td></td>
</tr>
<tr>
<td>11.3</td>
<td><strong>0.85</strong></td>
<td>2.1</td>
<td>150</td>
<td>40</td>
<td>3.690</td>
<td><strong>6.59</strong></td>
<td>Thalweg</td>
</tr>
<tr>
<td>12.4</td>
<td><strong>1.35</strong></td>
<td>1.4</td>
<td>80</td>
<td>45</td>
<td>1.760</td>
<td><strong>3.33</strong></td>
<td></td>
</tr>
<tr>
<td>14.0</td>
<td><strong>1.80</strong></td>
<td>1.0</td>
<td>20</td>
<td>47</td>
<td>0.444</td>
<td><strong>0.80</strong></td>
<td></td>
</tr>
<tr>
<td>16.0</td>
<td><strong>1.00</strong></td>
<td>0.2</td>
<td>NA</td>
<td>NA</td>
<td>0.200</td>
<td><strong>0.40</strong></td>
<td>REW</td>
</tr>
<tr>
<td><strong>13.0 ft</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>17.3 cfs</strong></td>
<td>TOTALS</td>
</tr>
</tbody>
</table>

**Calculating Total Flow Using the Spreadsheet**

The Excel spreadsheet associated with this SOP and also located in SWQB Public can be used to calculate total flow. Transfer data from field sheets to the spreadsheet and calculate the total flow. Enter the result into NMEDAS and save a copy of the completed spreadsheet for each station where flow was measured in the survey/project binder.

### 6.2 Alternate Flow Measurement Methods

Velocity meters are the most common tool used by the SWQB to measure stream velocity in order to determine flow. At times, however, these meters may not be available or stream conditions may require additional or alternate methods. Also, in some instances there may be a staff gauge to measure depth and determine flow based on previously measured channel geometry.

The SWQB can also measure flow by making direct volumetric (timed-fill) measurements, by using surface floats, by indirect methods (such as based on the Manning equation), by developing rating curves and measuring gage height, by constructing artificial controls (weir plates and Parshall flumes), or by dye dilution methods. Details on these methods can be found in USGS Techniques of Water Resources Investigations Reports ([http://pubs.usgs.gov/twri/](http://pubs.usgs.gov/twri/)) (USGS 1968 and 1969). Some of these methods are discussed below. Any measurements of flow made with these methods should be entered into NMEDAS as estimates.

#### 6.2.1 Timed-Fill

At low flows, the timed-fill method may be used. Collect the entire flow of the stream in a bucket; possible locations may be below a waterfall or weir. For example, use a stopwatch to measure the time it takes to fill a 5 gallon bucket. 5 gallons = 0.6684 ft\(^3\), so 0.6684 / elapsed time in seconds = cfs.
6.2.2 Surface Floats

The method involves measuring the velocity with a surface float and multiplying by the cross-sectional area. Estimates by this method may be too inaccurate for use in interpretation of data or final reporting, but may be useful in preliminary planning of studies and in conducting subsequent, more precise, measurements. The velocity measurement consists of dropping a neutrally buoyant object such as an orange or a rubber ball in the current and noting the time required for it to travel a known distance.

A suggested procedure for measuring the velocity using a surface float is as follows:

Measure and mark two points, one upstream and one downstream, at least two channel widths apart. Two observers are best, one upstream and one downstream. The upstream observer places the float into the channel above the marker and calls out when it crosses the upstream point, at which point the downstream observer starts a stopwatch. The downstream observer sights across the stream at the lower point. When the float passes the downstream point, the downstream observer stops the stopwatch and records the elapsed time.

Repeat the procedure 5 to 10 times. Each float should be a different distance from the bank to get a rough average of velocities across the channel. Average the values to get the mean surface velocity and then multiply it by a velocity adjustment coefficient of 0.85 (to account for friction) to calculate the mean velocity of the entire cross section.

Measure the cross-sectional area and multiply velocity by the area to calculate flow.

6.2.3 Manning’s Equation

Velocity can be estimated based on the physical characteristics of the channel. The characteristics include streambed roughness, channel shape and slope of the water surface. Several empirical methods are available to use these characteristics to estimate stream velocity. One of these is the Manning equation:

\[ V = \frac{(1.49/n)R_h^{2/3}s^{1/2}}{ } \]

where \( R_h = \frac{A}{WP} \)

\( V \) = average velocity in the stream cross section (ft/sec);
\( R_h \) = hydraulic radius (ft);
\( A \) = cross-sectional area of flow (ft²);
\( WP \) = wetted perimeter (ft);
\( s \) = energy slope as approximated by the water surface slope (ft/ft);
\( n \) = roughness coefficient.

To estimate velocity using the Manning equation, estimate a roughness coefficient for the stream bed from tables available in the literature. Values range from 0.026 for coarse sand to 0.070 for boulders. A common default value is 0.035.

The channel shape is described by the hydraulic radius, \( R_h \), which is the ratio of the wetted perimeter to the area. The wetted perimeter is the perimeter of the cross sectional area that is "wet"; that is, the portion of the stream bed that is in contact with the water. In wide rectangular channels the hydraulic radius approaches the depth as the channel width increases. Generally, it is necessary to measure both the wetter perimeter and the cross-sectional area.

Measure the water surface slope or estimate the slope from the slope of the stream bed. After estimating the velocity using the Manning equation, calculate the flow by multiplying the velocity by the cross-sectional area.
Using this method, wetted perimeter and cross-sectional area may be correlated to a stage (gage height) and flow may be estimated in the field using a staff gauge. Stream bed roughness, channel shape and slope measurements can be made in both wet and dry channels.

6.2.4 Rating Curve

A rating curve is the relationship of flow to stage (or gage height). It is constructed by plotting successive measurements of flow and gage height on a graph. This relationship is then used to convert records of gage height into flow rates. Due to changing channel morphology, curves must be checked periodically to ensure that the relationship between flow and gage height has remained constant. Scouring of the stream bed or deposition of sediment can cause the rating curve to change so that the same recorded gage height produces a different flow. A constant relationship between water level and flow rate at a given site can be assured by constructing a flow control device of known dimensions in the stream, such as a sharp crested weir or flume.

7.0 Related Forms

Attachment 1 Marsh-McBirney Flo-Mate 2000 Portable Flow Meter
Attachment 2 Price Current Meter (Pygmy or AA)
Attachment 3 Top Setting Wading Rod

Flow Sheet and Calculator
Flow Field Sheet

8.0 Revision History

Original modified from SOP 2007
Marsh-McBirney Flo-Mate 2000 Portable Flow Meter

The following information is a summary of the Marsh-McBirney, Inc. Flo-Mate 2000 Portable Flowmeter instruction manual (Marsh-McBirney 1990). The Marsh-McBirney flow meter measures velocity with an electromagnetic sensor and displays results in either feet per second (f/s) or meters per second (m/s).

Assembly and Calibration

1. Remove sensor and a comfortable length of cable from the flow meter case. Attach the sensor to the top setting wading rod on the mounting shaft at the bottom and tighten the thumbscrew. Check to make sure the base of the wading rod is secure.

2. The unit should always power up in real time operating mode, as opposed to memory recall. The display should be set to Fixed Point Averaging (FPA), where the readings are stabilized by averaging velocities over a fixed period of time (the alternative is time constant filtering [rC]). Pressing the up and down arrows simultaneously will alternate between rC and FPA displays and the FPA display will show the letters FPA when you first switch over and afterwards will be indicated by the time period bar at the bottom of the display. The fixed period of time default is 40s and may be altered with the up or down arrows. SWQB uses 40s as its time period standard.

3. Calibrate the sensor at the beginning of each field season. To calibrate the sensor, first clean it with soap and water. If there are nonconductive coatings, such as oil or grease, errors may occur due to noise or conductivity loss. Do not use any hydrocarbon solvents for cleaning. Place the sensor in a 5-gallon bucket filled with water at least 3 inches away from the sides and bottom of the bucket (use the wading rod to hold it in the appropriate position). Wait 10 or 15 min to make sure that the water is not moving. Set the time period to 5s. The zero stability is ± 0.05 ft/s. In order to reset the zero, press STO and RCL at the same time while the sensor is still in the bucket (unmoved). The number 3 will display. Decrement the 3 to 0 with the down arrow. Then the number 32 will display and the unit will decrement itself to zero and turn off. It is now calibrated. Make sure you return the time period to 40s.

Note: There is a 5 second time limit between keys when zeroing. If you wait too long and ERR 3 is displayed, turn the power off and start over.

Error Messages

- **Noise** – Indicates that there is excessive electrical noise in the water, and the display will blank out. It is normal for this message to appear for a few seconds when the sensor is first submerged.
- **Con Lost** – Indicates that the electrodes are out of the water or have been coated with grease and conductivity is lost. If this continues after washing with soap and water, the electrodes can be cleaned with very fine (600 grit) sandpaper. After 5 min of this message, the unit will shut down.
- **Low Bat** – Replace the 2 D-cell batteries in the bottom of the unit. Usually when this flag appears the battery will have 15-30 min of life left.
Price Current Meter (Pygmy or AA)

The following information is a summary of, and intended for use in conjunction with, the Scientific Instruments, Inc. Model 1205 Price Type “Mini” Current Meter user’s manual. All “Price-type” current meters operate essentially the same way regardless of size, method of measurement, suspension means or data collection methods. A balanced bucket wheel is mounted on a vertical pivot and is turned by flowing water. Water velocity is determined by counting the number of revolutions of the bucket wheel over a given period of time. A “cat whisker switch” produces a signal that is either manually counted or recorded by a counting instrument. This value, or count, is then compared on a cross reference chart, or rating chart, to yield water flow velocity.

- For velocities less than 3 ft/s, use the Mini (Pygmy) current meter.
- For non-wadeable flows or velocities greater than 3 ft/s, use the Price AA current meter.
- According to the USGS, a current meter should not be used in velocities less than 0.2 ft/s, unless there is no other option.

Assembly and Calibration

1. Inspect and assemble the meter. Remove the meter from the travel case and inspect the buckets for damage. Any visual damage, such as a bent cup, will yield an erroneous measurement. Replace the brass travel plug with the stainless steel pivot. Inspect the pivot for fractures, roughness, or other evidence of wear (use a new one as necessary). Put a drop of oil on the pivot. Insert the pivot firmly against the pivot-adjusting nut (the pivot has a flat side that should be positioned beneath the set screw that secures the pivot).
2. Ensure that the pivot is not too loose. The rotor (bucket wheel) should have a very small amount of vertical play, such that it is not impaired by the pivot while rotating. Loosen the pivot nut set screw, adjust the pivot nut out one-eighth turn and re-tighten the set screw. Loosen the pivot set screw, insert the pivot against the new adjusting-nut position and re-tighten this set screw. Check rotor play again and repeat this step as necessary.
3. Do not turn the bucket wheel clockwise. This can damage the contact wires, causing inaccurate readings. Always rotate counterclockwise as viewed from above.
4. Ensure that the pivot is not too tight. The rotor should spin freely (be sure it’s right-side up, because it will not spin freely when upside down). If the rotor tends to stop abruptly, inspect the pivot and pivot bearing (on the rotor) for damage. If the pivot bearing is too tight, loosen it by turning the pivot-adjusting nut out (use one-eighth-turn increments, as described above).
5. Conduct the spin test. This procedure must be performed completely out of the wind, such as in the vehicle. After assembling the meter, attach it to the wading rod. Tighten the mounting screw and attach the sensor wire to the binding post, ensuring that the electrical connection does not short-circuit from the post to the meter housing. Attach the counter or flow computer to the plug at the top of the wading rod. While holding the wading rod so that the rotor is horizontal (as used in the water), give the rotor a brisk flip with your finger (always counterclockwise; spinning clockwise may damage the sensor) and ensure that the counter is registering the spinning rotor. Ensure that the rotor spins for at least one minute and comes slowly to a stop. If it does not, readjust the pivot or identify and fix the meter damage.

Troubleshooting

Some waters cause an intermittent failure of the meter. This seems to be a mechanical failure of the whisker sensor associated with high turbidity resulting from some forms of silt-clay. SWQB staff have not found a solution to this problem, except to use a different measurement method (such as the Marsh-McBirney meter). Following exposure of the Price current meters to such waters, it must be disassembled and rinsed well (it appears to begin functioning properly after about ten minutes use in clear water).
Top Setting Wading Rod

The top setting wading rod is used both to measure depth and to position the current meter. The hexagonal rod is graduated at intervals of 0.1 ft with shallow machined lines. A single groove is used at the 0.1-ft graduations, double grooves at the 0.5-ft intervals, and triple grooves at the foot marks. The sliding or suspension rod moves up or down on the hexagonal rod and is held by a spring-actuated lock that uses a lever for release. The sliding rod is marked with grooves that are labeled 0 through 8. The current meter attaches to the sliding rod.

To position the current meter at the appropriate water depth, proceed as follows:

Attach the current meter to the sliding rod, and place the reader so that it can be seen comfortably in front of you.

Place the base of the wading rod at the stream bottom and read the stream depth to the nearest 0.1 foot on the graduated hexagonal rod.

The current meter can be set at 20, 60 or 80 percent of depth (depth from the surface) by aligning the appropriate line on the sliding rod with the appropriate line on the vernier scale.

Considering a depth of \(X.x\), with \(X\) the units value and \(x\) the decimal fraction,

For 60% - At a depth of \(X.x\) feet align number \(X\) on the aluminum rod with the \(x\) number on the vernier,

For 20% - multiply the depth by 2 then use the resulting value with the rule as for 60% depth,

For 80% - divide the depth by 2 then use the resulting value with the rule as for 60% depth.

**Example 1.** Depth is measured to be 2.0 ft using the lines on the hexagonal rod. One reading at 60% depth (1.2 ft from the water surface).

Based on the depth measurement of 2.0, move the sliding rod so that the line numbered 2 on the sliding rod is aligned with 0 on the vernier. The meter will be 1.2 ft from the surface.

**Example 2.** Depth is measured to be 2.5 ft. The objective is to take two readings at 20 and 80% depth (0.5 and 2 ft from the water surface).

For the first reading at 20% depth, multiply the depth by 2 to get 5.0. Move the sliding rod so that the line numbered 5 is aligned with 0 on the vernier. The current meter will be 0.5 ft from the surface.

For the second reading at 80% depth, multiply the depth by 0.5 to get 1.25. Move the sliding rod so that the line numbered 1 is aligned with 2.5 on the vernier. The current meter will be 2.0 ft from the surface.