Training Manual

for the

Marsh McBirney 2000

Flow Meter

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Introduction: Importance of Baseflow Monitoring

Stream flow, or discharge, is the volume of water moving down a stream or river per unit of time and is commonly expressed in cubic feet per second (cfs). Stream flow and velocity affect food sources, spawning areas and migration paths of fish and other wildlife (DNR, 2010). In streams with adequate groundwater flow (baseflow), significant flow is maintained during prolonged dry periods allowing fish and tiny aquatic organisms to survive.

Stream flow can be affected by humans. In watersheds with high human impacts, baseflow may be depleted by withdrawals for irrigation, domestic, or industrial purposes. **Figure 1** illustrates the affect groundwater pumping can have on water resources. Groundwater is drawn away from the stream creating a decline in the amount of water that would otherwise flow to the stream. The depletion of baseflow to the stream reduces flows overall, but reduced flows are more noticeable during dry periods and may leave little water for fish and other aquatic life at crucial times.

Streamflows in the Wisconsin Central Sands have been depressed in recent years, more so in areas with large densities of high capacity wells. For example, the Little Plover River, a former high-quality trout stream and a Wisconsin Exceptional Resource Water, was near dry in 2003 and has dried in stretches since (Kraft et al., 2010). Still the question of how big the human impacts are on central Wisconsin rivers and streams remains in question. By meeting the goals of this project, baseflow monitoring can help professionals throughout the state answer this question.

The goals of this project are as follows:

1. Produce high quality stream flow data using advanced methods and equipment.
2. Establish baseline information about a stream's natural flow rate.
3. Provide real stream flow data.
4. Help to clarify the impacts of groundwater pumping on Central Sands rivers and streams.

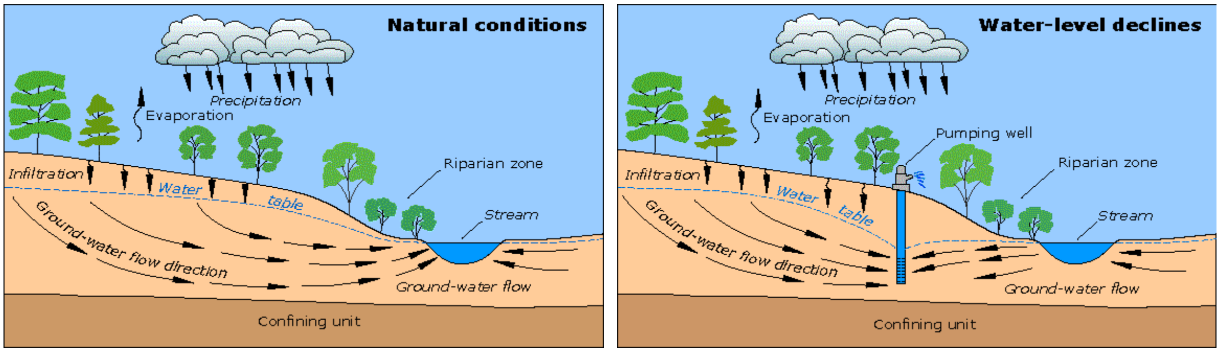


Figure 1. Pumping impacts on groundwater flow (baseflow) to a river.

Background on Baseflow (Where and When to take Measurements)

Where to take baseflow measurements

All rivers have a similar structure. A natural river is neither straight nor uniform yet a river's form remains relatively unchanged no matter its size. There are 3 basic parts to a river; a riffle, run, and a pool. Each is defined as follows:

A riffle has moderate to shallow depth and moderate to fast flow over a rough stream bed. Riffles are the food factories of a stream. Light is able to penetrate the stream bed because of the shallow depth which allows for the growth of aquatic plants. The rough stream bed provides more area for vegetation and aquatic insects to live. This combination results in the riffle being a prime area for fish.

Runs are deeper than riffles and have a smoother stream bed so the water is less turbulent. Flow velocities tend to be lower than in a riffle as a result of greater depth and a smoother stream bed. Runs connect a riffle and pool and are the ideal place to take a baseflow measurement.

Pools are the deep water areas of a river. Because of their depth, pools tend to hold larger fish and the velocity of the water is slow. **Figure 2** shows the different parts of a stream.

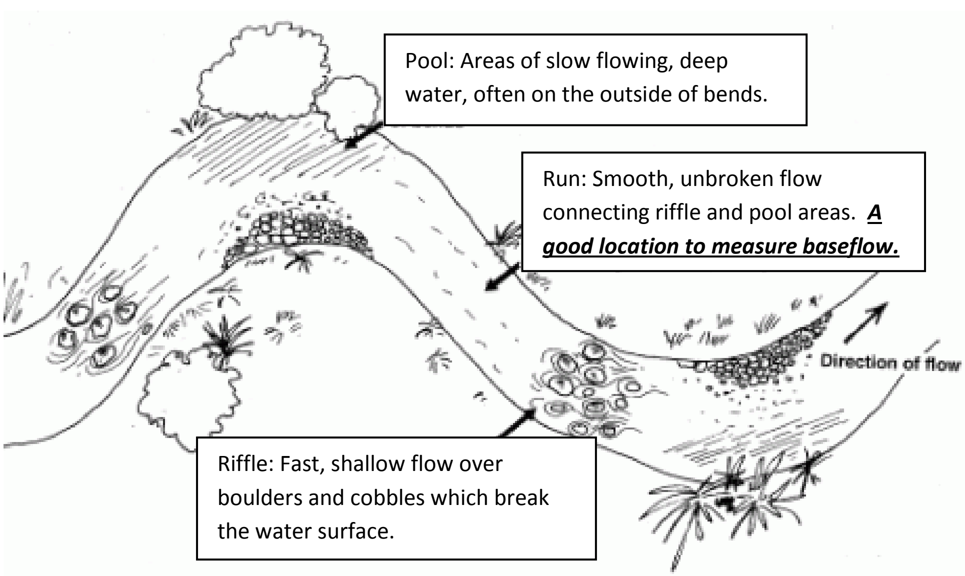


Figure 2. An example of the basic shape of a natural river and the best place to take a baseflow measurement.

The location of your stream site has already been determined, but when you get to your stream you will need to decide what part of the stream to measure. Try to pick an area of stream that most closely resembles a run. Many stream sites will be located at bridges or culverts. Try to choose a straight smooth area above or below the culvert or bridge.

When to take Baseflow Measurements

Water in a stream comes from 3 different sources. A small amount comes from rainfall directly. Larger amounts come from runoff from rain events or from groundwater flowing into the stream called baseflow. Baseflow is defined as the sustained low flow of a stream due to groundwater inflow to the stream channel. Groundwater flows into streams when the water table (top of groundwater saturation) rises above the streambed. Perennial streams flow because groundwater remains above the streambed throughout the year.

An example of when a river or stream is at baseflow conditions: It's late summer and it hasn't rained in a month. The lawn has turned brown and farm fields are dry and cracking. Yet a trip down to the nearby stream channel finds flowing water. What you are witnessing is the interplay between groundwater and surface water. Groundwater seepage into a stream channel is called *baseflow*. When groundwater provides the entire flow of a stream, *baseflow conditions* are said to exist.

For this project, it is important that stream flow data be collected during what are called baseflow conditions. Baseflow does not include runoff from a storm event. Because our main interest in this project is to monitor groundwater levels, it's critical that stream flow measurements occur during periods of baseflow. **Figure 3** shows stream discharge during and after a storm event. The bar graph represents rainfall. Below the bar graph is the flow of the river over time during and after the rain event. In **Figure 3** the best time to take a stream flow measurement is day 5 after the storm runoff is not part of the total discharge.

For most streams, baseflow may be measured during a period when there has been no significant thawing or precipitation for at least three to five days. This may vary according to stream size. Smaller streams need less time to return to baseflow conditions. Be extra cautious during periods of thaw as more runoff can occur at that time.

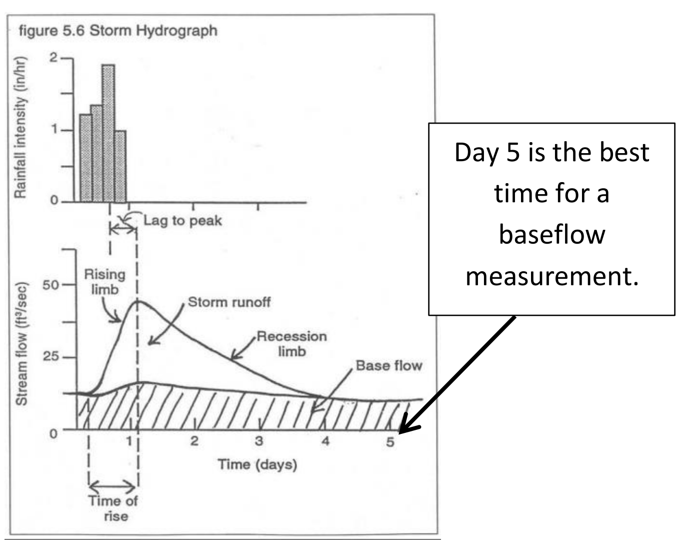


Figure 3. An example of flow in a river before and after a rain event and the best time to take a baseflow measurement.

Methods and Procedure

I. Equipment Needed For Measurement (Before you go to the stream)

-Tape Measure and Spikes

-Flow Meter and Case
(Make sure there are extra batteries)

-Wading Rod

-Clip board with Stream flow data sheets, pen, and calculator

-Waders

-Training Manual

II. Procedure for Measuring Baseflow with the Marsh McBirney 2000

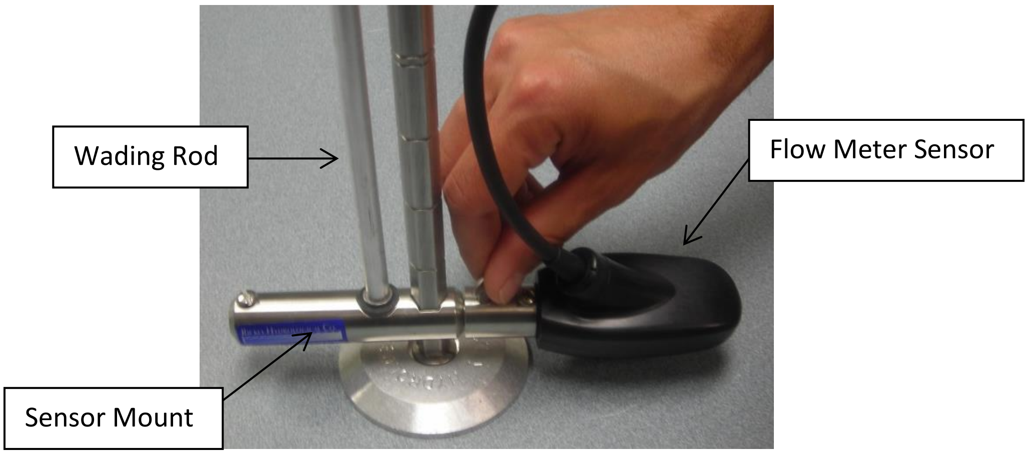
Give yourself at least 2 hours per stream the 1st time you measure baseflow

Safety considerations

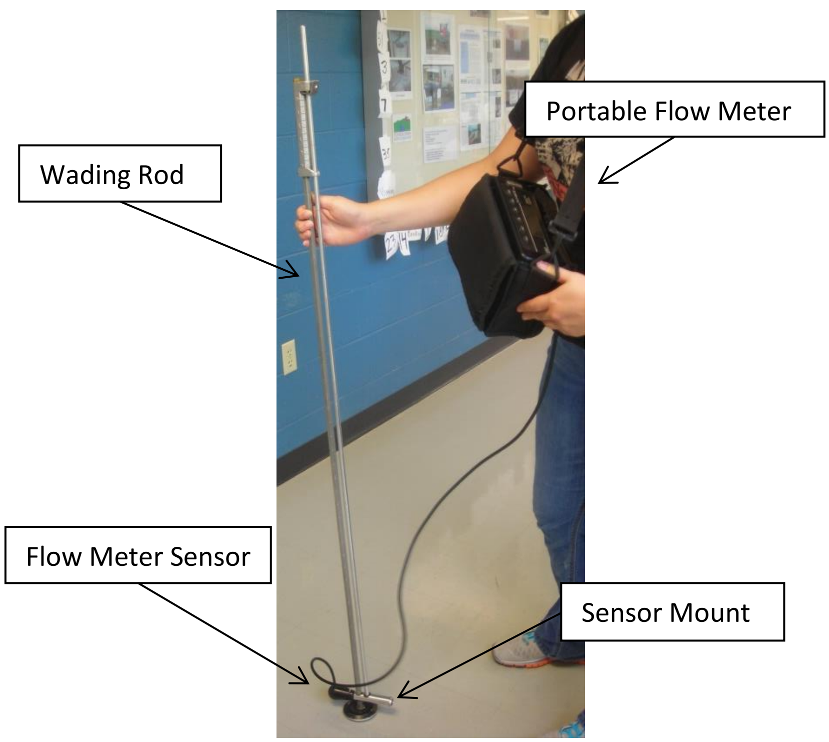
You will need to enter the stream channel to make width and depth measurements and to calculate velocity. Be aware of stream velocity, water depth, and bottom conditions at your stream-monitoring site. Do not attempt to measure stream flow if water velocity appears to be fast enough to knock you down when you are working in the stream. If you are unsure of water depth across the width of the stream, be sure to proceed with caution as you move across the stream, or choose an alternate point from which to measure stream flow (DNR, 2010 WAV).

1. Assemble the Marsh McBirney

a. Attach the flow meter sensor to the bottom of the wading rod by fitting the flow meter sensor onto the sensor mount and tightening the screw.



Finished Assembly



2. *Select a Stream Cross Section*

a. The quality of the baseflow measurement is dependent on the correct selection of a stream cross section. Figure 4 is an example of what a typical cross section looks like. The following site characteristics are important for cross section selection.

- The cross section lies within a straight reach of stream. Avoid cross sections directly below sharp bends.
- The flow directions at each measurement point across the stream are parallel to the bank and perpendicular to the cross section.
- Flow is relatively uniform and free from eddies, slack water and excessive turbulence.
- The streambed is stable and free of large rocks, weeds and protruding obstructions, manmade or natural, that cause turbulence.
- A minimum depth of >0.2 ft. is required to keep water above the flow meter sensor.

b. It is often not possible to completely satisfy all of the recommended conditions. Use the criteria to select the best possible section of stream and then to select a cross section. It may be necessary to "engineer" the stream by moving rocks, logs, branches, algae mats, rooted aquatic vegetation, debris, or other obstructions in order to construct a desirable cross section free of turbulence (Rantz et al., 1982). If this is necessary, make all adjustments and wait a few minutes for the system to stabilize prior to beginning the baseflow measurements.

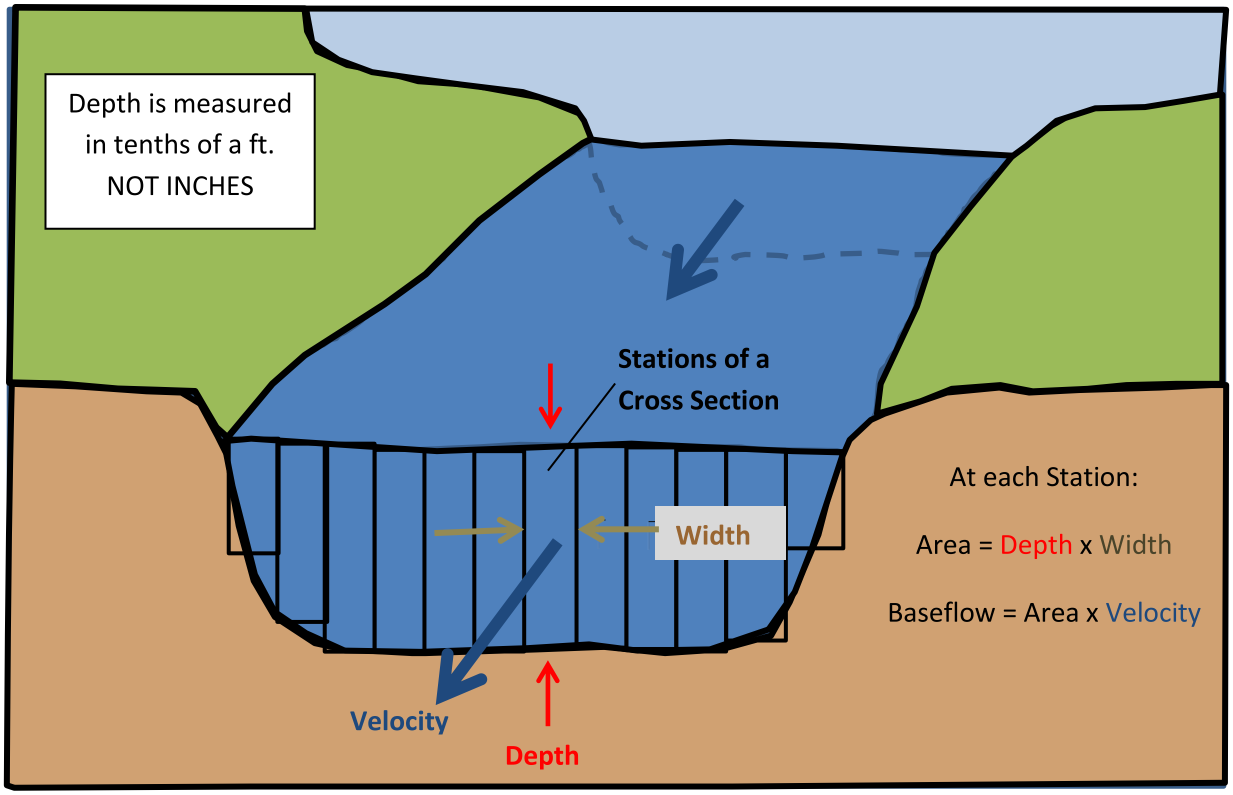


Figure 4. A typical cross section in a stream. Baseflow is calculated by multiplying the depth, width, and velocity of each station to get a volume/time, and then by adding the volume/time for each station to get a total volume/time for the whole cross section.

3. Set the Tagline

a. **After you select the best location for a cross section in your stream set up the tagline directly above the cross section by stretching the tape measure across the stream (Figure 5). The tagline should be:**

- Taut

- Perpendicular to stream flow lines

- Must not touch the water surface

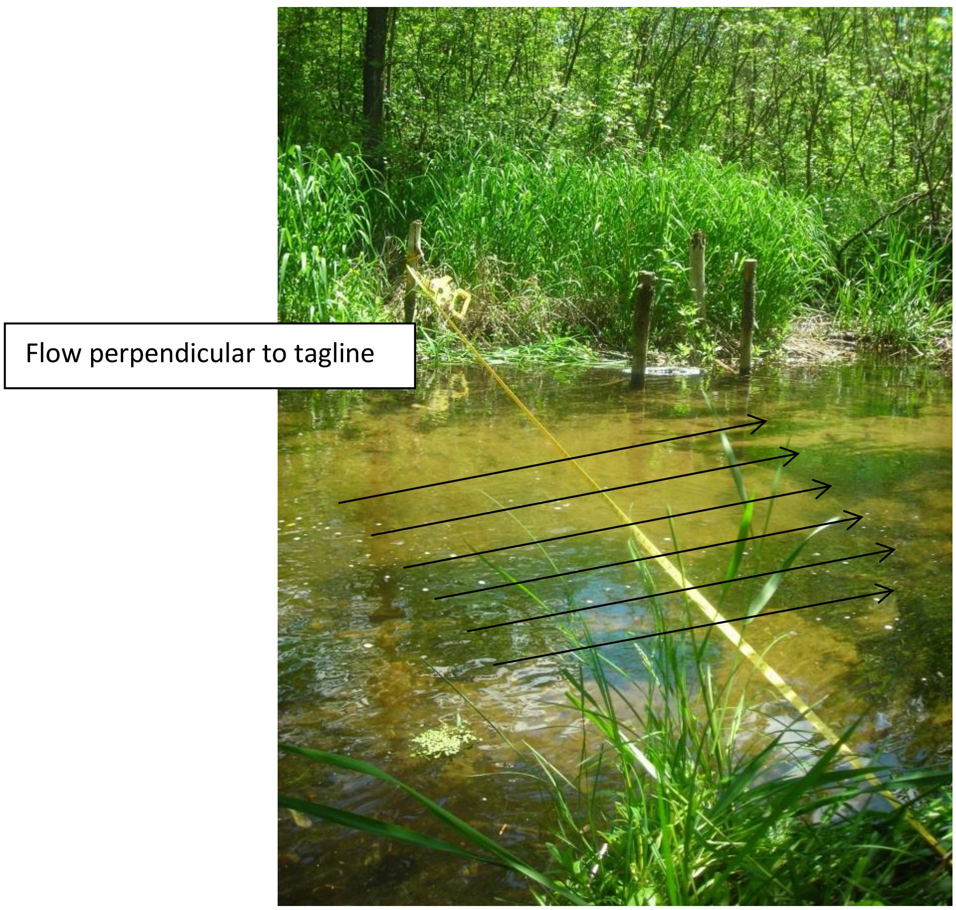


Figure 5. An example of a tagline above a stream cross section.

4. *Determine Station Width*

a. Stations are the subsections of a cross section (see figure 4).

b. To determine station width, start by calculating the approximate total width of the stream from the edge of the water on one bank to the edge of the water on the other bank using your tagline (tape measure). USE TENTHS OF A FT. NOT INCHES.

c. Divide the total stream width by 10 or 20 total stations depending on the size of the stream (see below). This will give you the width of each station in your cross section and will help you to determine where to locate the flow meter along the tagline.

- A guide is to use 10 to 20 stations as a target number for smaller streams <20 ft. wide and 20 to 25 stations for larger streams >20 ft.
- Total stream width___________ / 10 = station width _______ ft. (for small rivers)
- Total stream width___________ / 20 = station width_______ ft. (for large rivers)
- Example: I'm measuring a larger stream. My total stream width is 21 ft. Because that's >20 ft. I want 20 stations. I divide 21/20 and get a width of 1.05 ft. per station. I'll then round 1.05 ft. to 1 ft. so the calculations are easier. I have determined my station width will be 1ft.
- Stations within the cross section shouldn't be spaced less than 0.2 ft. apart. Therefore if the total width of the stream is less than 1 ft. the total number of stations in your cross section should be less than 5.

d. Station width can be the same across the cross section (example: 1 ft. width for all stations) or unevenly spaced as shown in figure 6 (example: 1 ft. station width at the edges of the cross section and 0.5 ft. station width in the center).

- You can widen or shorten station width if necessary during the measurement process. For now, note possible places in the cross section that are deeper and where velocities seem higher.
- It may be necessary to make the station width smaller in areas that are deeper or that have a greater velocity than the majority of the stream.
- Station width could be made greater in areas that are shallower or have lower velocity compared to the majority of the stream.

- A uniform station width should only be used if the stream is of relative uniform depth and velocity.

Figure 6. Examples of uniform (left picture) and uneven (right picture) station widths across a cross section. Stations in the middle of the uneven spacing have a smaller station width, while stations closer to the edges have a greater station width.

e. **If you need additional help keeping track of station widths, fill out the "Station Worksheet" located in the data sheets section of your training manual and at the end of this document. An example of a completed worksheet is also included in the data sheets section of you training manual.**

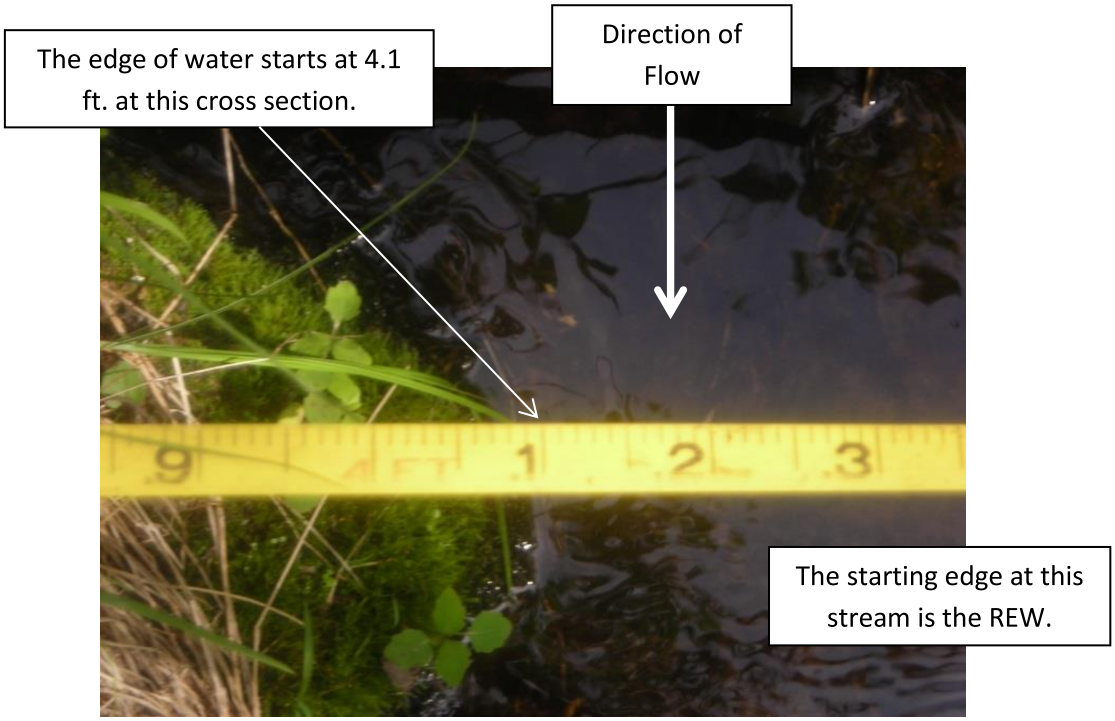
5. *Measure Velocity and Write down Station Information*

a. **Two people should be working together to record the information needed to calculate baseflow. One person should be in the water reading the station locations on the tagline, reading the water depth, and taking the velocity measurements. The other person should be recording these measurements on the stream flow worksheet provided.**

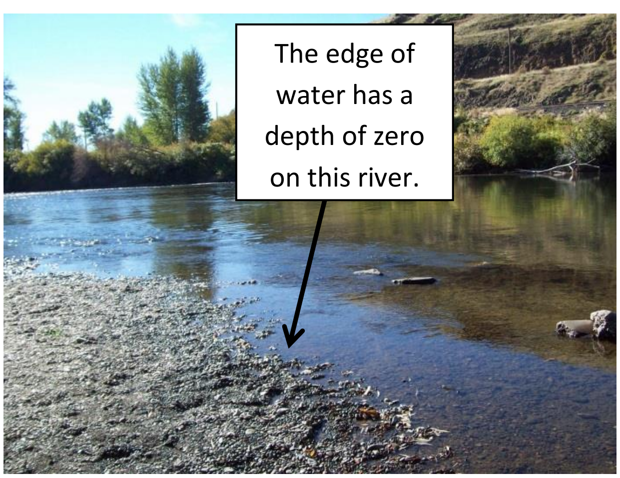
b. **If you're measuring more than 1 river, leave completed stream flow worksheets in your car or in a dry place so they aren't accidently dropped in the water.**

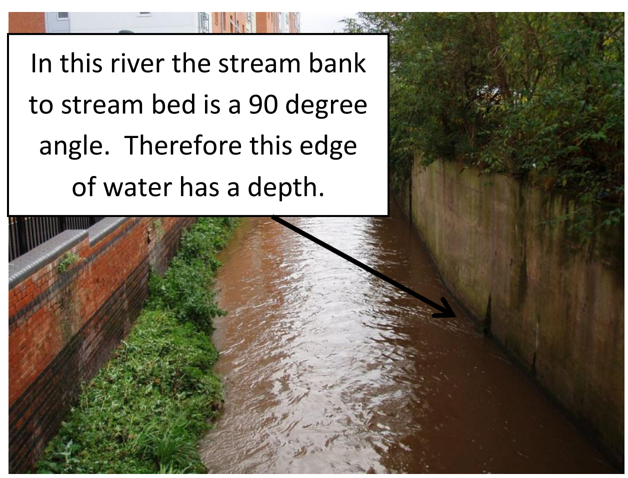
c. **Begin filling out the "Stream Flow Measurement Data Sheet" (an example of the stream flow data sheet is given at the end of this section). Record the stream name, the stream location or road crossing, date, time, measurer's name (put both people's names). All data should be recorded in PEN.**

d. **Identify the starting edge as either left edge of water (LEW) or right edge of water (REW) when facing downstream. The edge of the water doesn't need to start at zero on the tagline. Record LEW or REW with station 1 and where the edge of water starts on the tagline (highlighted in green on the stream flow data sheet). Edges of water will <u>NOT</u> have a velocity measurement.**



e. **Record the depth of the water at station 1 (highlighted in green on the stream flow data sheet at the end of this section). There are two options for water depth at the edge of the water. Either the depth of the water at the edge is 0 or there is a depth that needs to be measured with the wading rod. To have a depth at the edge of water the stream bank has to be approximately a 90 degree angle to the stream bed. Otherwise the depth at the edge of the water is zero. Examples are shown below.**



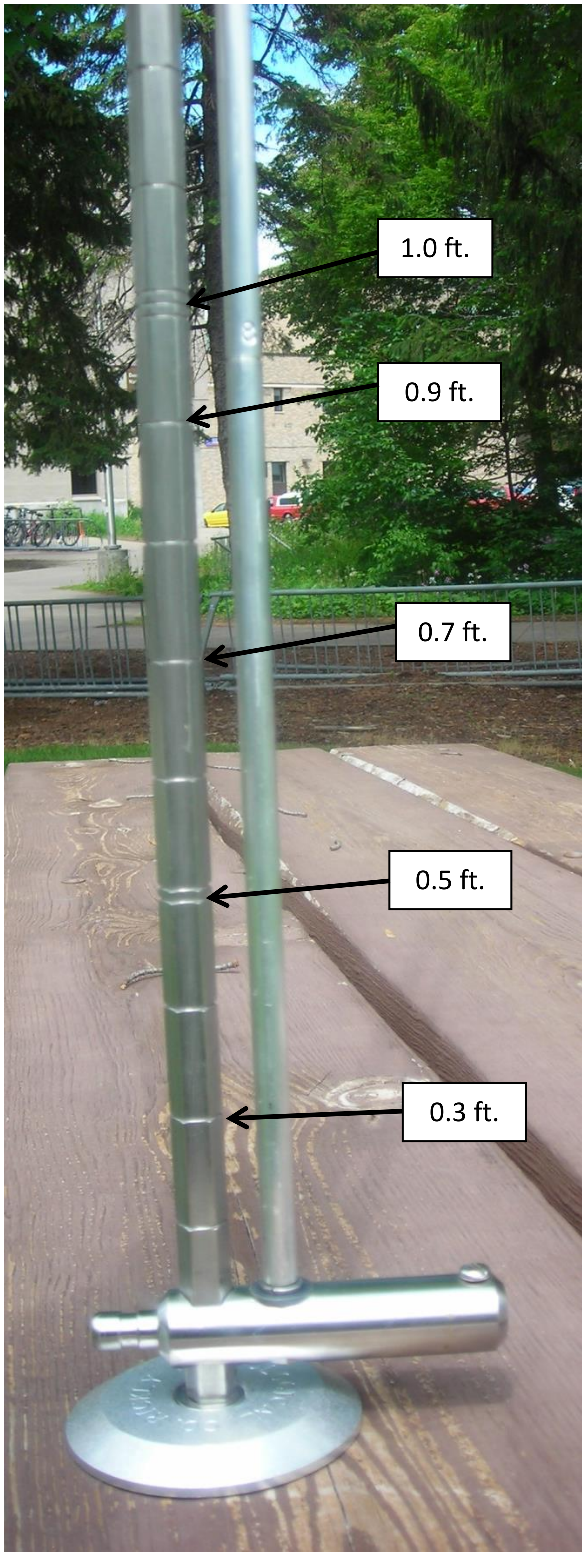


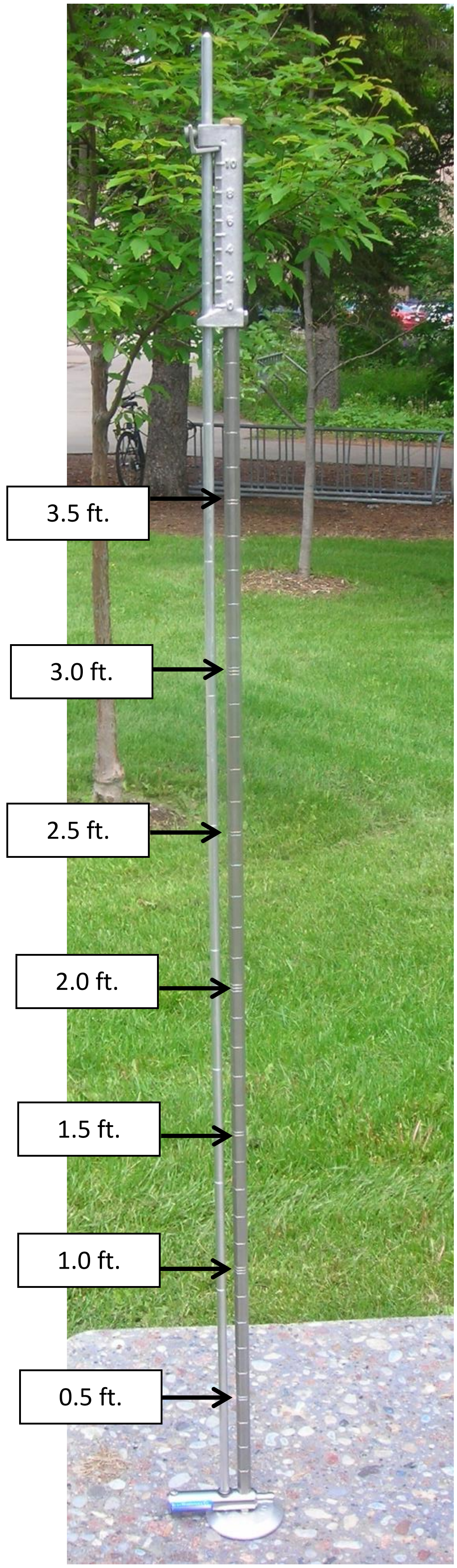
f. **If the depth at the edge of the water is NOT zero, measure a depth using the wading rod by placing the wading rod against the side of the bank and reading the mark at the water surface as described below and shown on the next page.**

   - The wading rod comes with 2 parts; a thicker and thinner rod. The thicker rod is used to measure the depth of water and is marked in 0.10 foot increments along the rod. It is appropriate to further estimate depth to the 0.02 ft. or 0.05 ft. increment level, despite the wading rod not being marked to this level. Examples of increments on a wading rod are shown on the next page.

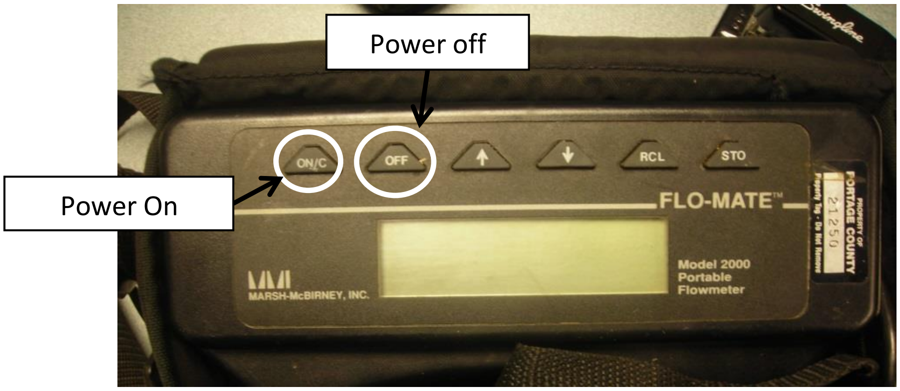
g. **Write down the water depth at the edge of the water.**

1 line represents 0.10 foot increments,
2 lines represent 0.50 foot increments, and
3 lines represent 1.0 foot increments.

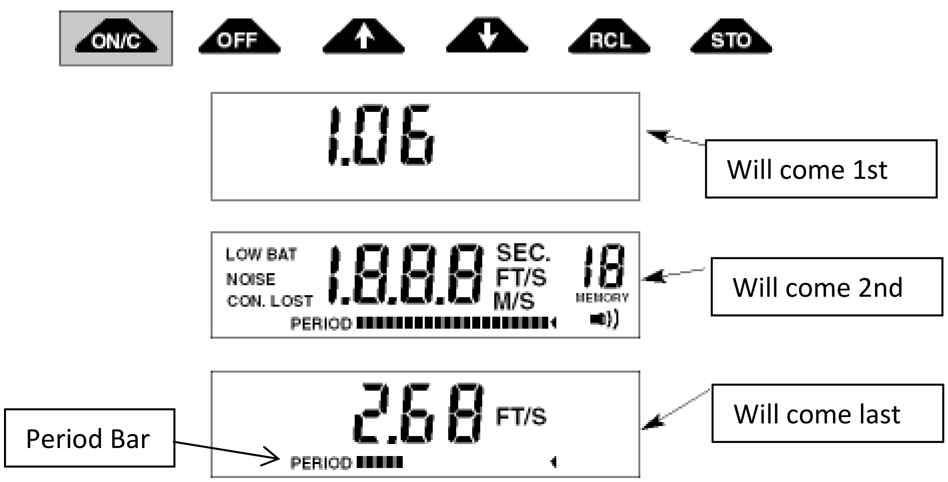




h. **Turn on the portable flow meter and move across the cross section and position yourself at station 2. Station 2 will be located at a point on the tagline you established earlier. Refer to your "Station Worksheet" if necessary. You should be in the stream at this time facing upstream with the tagline in front of you. Station 2 will be the 1st location where you will write down a velocity measurement.**



i. **A series of screens will appear when you turn the flow meter on (shown below). The "Velocity Output Display", the bottom screen shown below, will appear last and will display the water velocity. The flow meter will average a velocity over a 30 second time period and the units should be FT/S.**



j. **Allow the flow meter to run through two 30 second cycles.**

- Period bars on the bottom display keep track of the cycles and the bars start over every 30 seconds unless you press ON/C which will discontinue the current cycle and start a new cycle.

- The 1st 30 second period allows the turbulence and eddies around the flow meter sensor to reach equilibrium.

- Press the ON/C button to start the 2nd 30 second cycle after the period bars have finished their 1st 30 second cycle. After the 2nd cycle has run, you are ready to begin taking velocity measurements.

k. Write down Station 2, its location on the tagline, and its water depth (highlighted in blue on the stream flow data sheet at the end of this section). Station 2 will be the first station with a velocity measurement.

l. Place the wading rod at the designated station 2 location on the tagline.

m. Use the wading rod to set the flow meter senor (the probe) to the proper height in the water column as shown in the pictures on the following page. The proper height depends on the water depth.

Depths of ≤ 2.5 feet (*One point*)

When water depth is ≤ 2.5 feet, velocity is measured at 0.6 of the depth below the water's surface at each station, referred to as the 0.6-depth method (Rantz et al., 1982). A standard wading rod will automatically adjust the flow meter sensor to the proper depth when it is set as shown below.

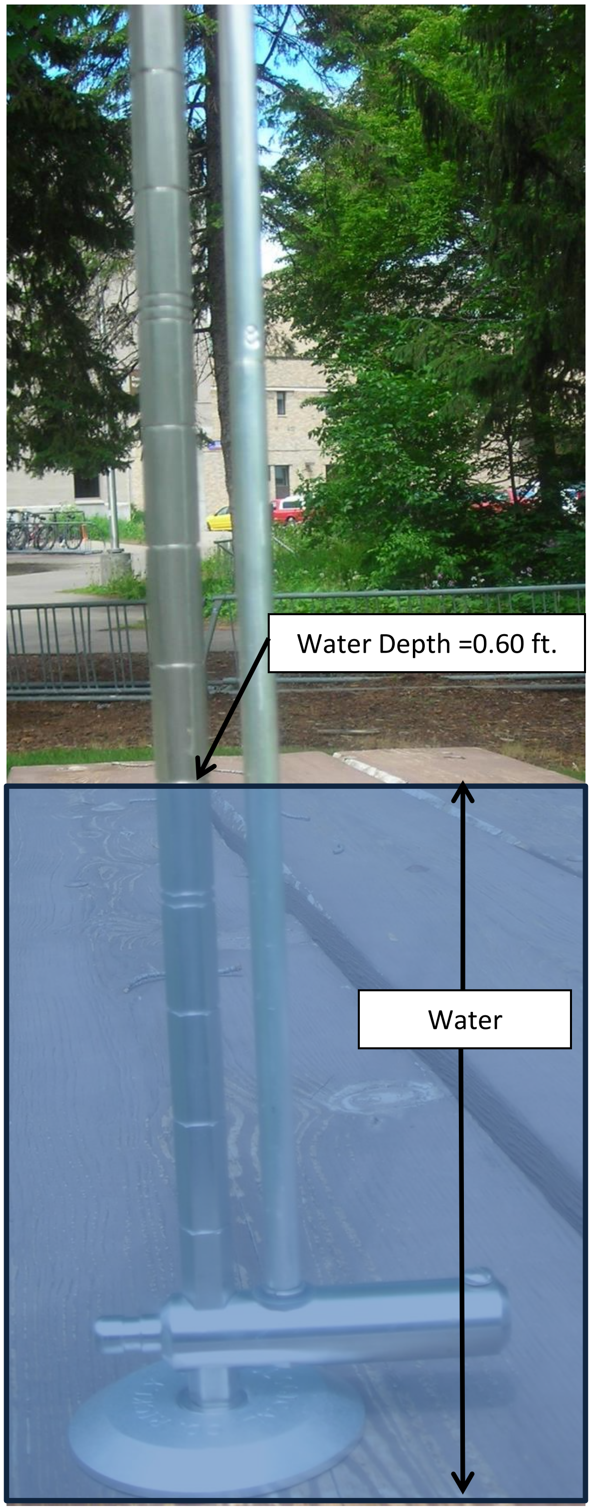
Depths of ≥ 2.5 feet (*Two point*)

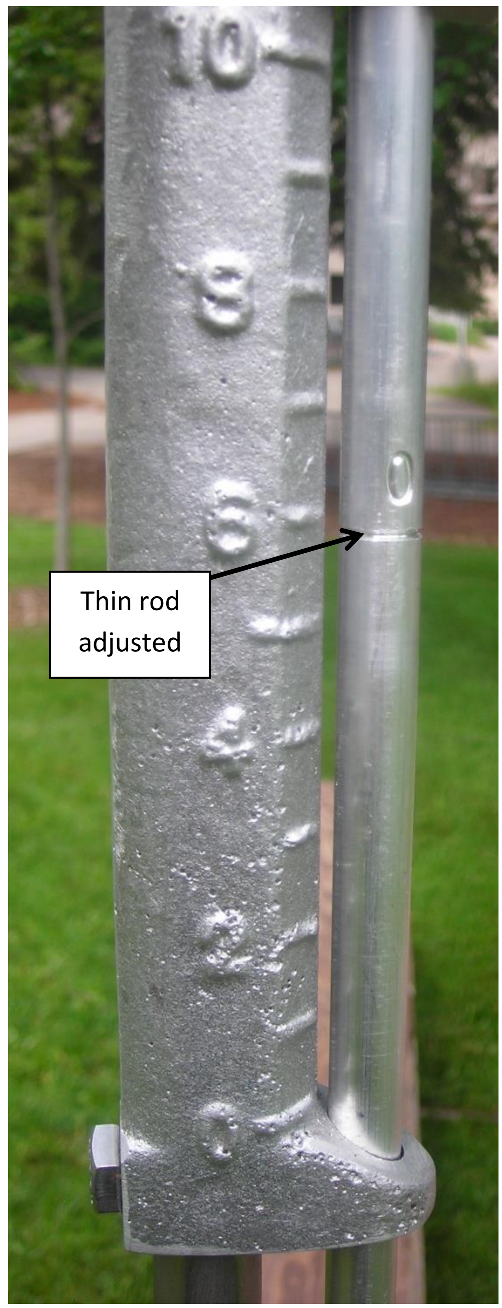
When water depth is ≥ 2.5 feet two velocity measurements are made at the station. Velocity is measured at 0.2 and 0.8 of the total depth below the water's surface at each station, referred to as the two-point method (Rantz et al., 1982).

For example, if the stream depth is 3 feet at a particular station, to set the rod at the 0.2-depth, position the top setting rod at ***half*** the water depth. Line up the 1 on the thin rod to the 5 on the thick rod (to represent 1.5 ft.). To set the rod at the 0.8-depth, position the setting rod at ***twice*** the water depth, so line up the 6 on the thin rod to the 0 on the thick rod (to represent 6.0 ft.).

- To correctly set the flow meter sensor height on the wading rod, determine the water depth on the thicker part of the rod and adjust the thinner rod to the proper height. Example below.

In this example the water depth is 0.60 ft. To adjust the thinner rod, line up the 0 with the 6. This represents 0.60 ft. If the water depth was 1.6 ft., line up the 1 on the thinner rod to the 6 on the thicker rod.





n. **After the location and water depth are written down and the flow meter sensor is properly set, you are ready to take a velocity measurement.**

o. **Before you begin the measurement, make sure you're facing upstream, the wading rod is in the proper location on the tagline, the flow meter sensor is parallel to flow, and you're holding the wading rod at arm's length.**

p. **Press the ON/C button to start a new cycle and allow the flow meter to run through the 30 second cycle. Write down the velocity at the end of the cycle on the stream flow data sheet (highlighted in blue under the station velocity column). Reminder: The flow meter will continue taking readings even after 30 seconds.**

- While the flow meter sensor is taking the velocity measurement, the wading rod should be held perpendicular to the water's surface and the sensor should be parallel to the stream flow. The individual making the measurements should be at least 1.5 feet away from the sensor and should be as still as possible so no turbulence is created.

q. **Repeat the procedure for entering station 2 information for the rest of the stations across the stream until you get to the other edge of water. Then repeat the procedure described earlier (d, e, f, and g) for the other edge of the water.**

r. **After you've finished measuring and writing down all the information for each station, you should have 4 columns filled out on the stream flow data sheet; "Station Number", "Location on Tagline", "Stream Depth", and "Station Velocity" columns. Now you can begin the calculations.**

Stream Flow Measurement Data Sheet
Example

River/Stream:	Little Plover River	Time:	9:50 AM
Location:	Hoover Ave.	Measurer:	J. Haucke
Date:	7/16/2013		

Station Number	Location on tagline (ft)	Station Width (ft)	Stream Depth (ft)	Station Velocity (ft/sec)	Discharge (ft^3/s)
REW 1	4.1		0	0	0
2	4.5	0.45	0.4	0.52	0.09
3	5	0.5	0.5	0.63	0.16
4	5.5	0.5	0.6	0.65	0.20
5	6	0.45	0.7	1.12	0.35
6	6.4	0.4	0.8	1.23	0.39
7	6.8	0.4	0.9	1.59	0.57
8	7.2	0.4	0.8	1.54	0.49
9	7.6	0.4	0.7	1.29	0.36
10	8	0.45	0.7	1.22	0.38
11	8.5	0.5	0.6	1.21	0.36
12	9	0.5	0.6	1.02	0.31
13	9.5	0.5	0.5	0.95	0.24
14	10	0.5	0.5	0.45	0.11
15	10.5	0.4	0.3	0.22	0.03
LEW 16	10.8		0	0	0
			Average Depth	**Average Velocity**	**Total Discharge**
			0.54	0.85	4.05
		Indicates calculated values			

If Stream Depth is over 2.5 ft., 2 velocity measures at 0.2 and 0.8 depths need to be taken
All Writing should be in PEN

Formula for Station Width = (Location after- Location before)/2
Example: Station Width = (5 (location 3) – 4.1 (location 1))/2 = (5-4.1)/2 = 0.9/2 = 0.45

6. Calculate Baseflow (Discharge in cubic feet per second (cfs))

a. After you've finished measuring and writing down all the information for each station, you will need to make some calculations (shown as the tan shaded columns and cells in the example stream flow measurement data sheet).

- First calculate the "Station Width" column,
- then the "Discharge" column,
- then "Average Width",
- then "Average Velocity",
- and finally "Total Discharge" needs to be calculated**.**

b. **The "Station Width" column is calculated by subtracting the "Location on the Tagline" for the station *after* from the "Location on the Tagline" for the station *before* and then dividing that number by 2. Calculate and write in all station widths.**

- For example, to find the "Station Width" for Station 4, subtract 6 (highlighted in pink in the "Location on Tagline" column on the example stream flow data sheet) from 5 (highlighted in yellow). 6-5=1. 1 divided by 2 = 0.5 (highlighted in red under "Station Width"). 0.50 is the station width for Station 4.

- REW and LEW will have no width, but their location on the tagline will be used to calculate the width of the second and second to last stations.

c. **Next calculate the "Discharge" column by multiplying the "Station Width", "Stream Depth", and "Station Velocity" at every station. For example station 6's discharge is calculated by multiplying 0.4 x 0.8 x 1.23 = 0.39 (highlighted in grey on the stream flow data sheet). Do this for each station and write down all Discharges.**

d. **Calculate "Average Depth" by adding all the numbers in the Stream Depth column and dividing the sum by the total number of stations.**

e. **Calculate the "Average Velocity" by adding all the numbers in the Station Velocity column and dividing the sum by the total number of stations. Do NOT include the REW and LEW of water where no velocity measurements are taken.**

f. **Calculate the "Total Discharge" by adding all the numbers in the "Discharge" column.**

g. **You can find out if any of your stations had more than 10% of the total flow by dividing the Discharge for each station by the Total Discharge (not shown on the stream flow data sheet example). This will give you an idea of where you need to make your stations smaller the next time you take a measurement.**

h. **Turn in the completed stream flow measurement data sheet to your county representative.**

<u>IMPORTANT NOTE:</u> If the stream you're supposed to measure has a 0 discharge or if discharge is undetermined, fill in the top and bottom of your stream flow measurement data sheet only. Include the name of the river/stream, location, date, time, and measurer at the top of the sheet. At the bottom of the sheet, if discharge is 0, circle whether it is due to the stream being dry, frozen, or because of stagnant water. Or if discharge is undetermined circle whether it is due to ice cover, high water, or the water in the stream being too shallow. Take a picture of the stream if discharge is 0 and include the name of the stream and the date as shown in the example below.

References

Information, procedures, and references gathered from sources below.

DNR, 2010. University of Wisconsin. DNR PUB WT-755. This publication is part of a seven-series set, “Water Action Volunteers- Volunteer Monitoring Factsheet Series” and is available from the Water Action Volunteers Coordinator at 608/264-8948.

Kentucky Energy and Environment Cabinet. 2010. Standard Operating Procedure. Measuring Discharge. Department for Environmental Protection Division of Water. http://water.ky.gov/permitting/documents/streamdischarge_rev1.pdf

Kraft, G.J. and D.J. Mechenich, 2010. Groundwater Pumping Effects on Groundwater Levels, Lake Levels, and Streamflow in the Wisconsin Central Sands. A Report to the Wisconsin Department of Natural Resources. Center for Watershed Science and Education, University of Wisconsin – Stevens Point/Extension, Project: NMI00000247.

Missouri Stream Teams. ***Volunteer Water Quality Monitoring.*** Missouri Department of Natural Resources, P.O. Box 176, Jefferson City, MO 65102.

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Rantz, S. E., and others. 1982. Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge. U.S. Geological Survey Water-Supply Paper 2175.

Glossary

Banks: See Stream bank

Baseflow: Sustained low flow of a stream due to groundwater inflow to the stream channel. Often written as a single word.

Bed: See Stream bed

Channel: See Stream channel

Cross-Section: a section of the river when the width and depth are measured to create an image of the river channel. Is used in calculating discharge.

Cubic Feet per Second: A unit of measurement used to express how many cubic feet of water a passing a given point in a second.

Current: The flow of water influenced by gravity as the water moves downhill.

Discharge: Rate of water movement

Downstream: A position of an observer in the water facing the same direction as the water is flowing towards the mouth of the stream or river.

Eddie: The swirling of water in a stream. Often creates a reverse current when the water flows past an obstacle.

Flow: See Stream flow

Flow Meter: An electronic meter that is used to measure the amount of water moving past a given point.

Flow Meter Sensor: The black ball that is attached to the wading rod. The sensor actually measures the flow.

Groundwater: Water occurring in the zone of saturation in an aquifer or soil

LEW: Abbreviation for the Left Edge of the Water in the stream when facing downstream

Perennial Stream: A stream that flows throughout the year

Pool: A quiet slow-moving portion of a stream

REW: Abbreviation for the Right Edge of the Water in the stream when facing downstream

Riffle: The shallow area of a stream where water accelerates and the water surface becomes rippled

Roughness: The roughness of land and stream features. Varies from smooth to rough.

Run: A relatively straight free-flowing stretch of stream.

Runoff: The portion of precipitation, snowmelt, or irrigation that flows over and through the soil, eventually making its way to surface waters.

Station: A given location on the tagline where a flow reading is taken. The number of stations in a stream cross-section is determined by the width of the stream and the amount of flow.

Stream bank: The terrain alongside the bed of a river or stream

Stream bed: The bottom of the stream or river channel. The physical confine of the normal water flow.

Stream channel: The bed and banks of a stream or river that contains a flow of running water.

Stream flow: The rate of water movement in a stream. Often written as two words.

Tagline: The measuring tape stretched across the river that measures stream width and helps to determine where stations are chosen.

Turbulence: Departure in a fluid from a smooth flow. Can often cause eddies.

Upstream: A position of an observer in the water facing into the flow of the water towards the headwaters of the stream or river. The flow will be coming at you.

Velocity: Rate of change of the position of an object, equivalent to a specification of its speed and direction of motion.

Wading Rod: A metal rod with a baseplate that rests on the bottom of the stream channel. The flow meter attaches to the wading rod and the wading rod has demarcations to measure stream depth.

Watershed: Land area that contributes runoff (drains) to a given point in a stream or river. Synonymous with catchment and drainage or river basin.

Station Worksheet (optional)

Stream Name: ____

Monitor: ________________ Total Stream Width: ______________________________

	Distance to Vertical (ft.)
Station 1	
Station 2	
Station 3	
Station 4	
Station 5	
Station 6	
Station7	
Station 8	
Station 9	
Station10	
Station 11	
Station 12	
Station 13	
Station 14	

	Distance to Vertical (ft.)
Station 15	
Station 16	
Station 17	
Station 18	
Station 19	
Station 20	
Station 21	
Station 22	
Station 23	
Station 24	
Station 25	
Station 26	
Station 27	
Station 28	

*** Distance to Vertical will **ALWAYS** be in tenths of feet. **NO** Inches.***

Total Stream Width: __________

1. Start by making the stream stations an even width.   1ft 2ft etc.

   Divide total width by 10 or 20

   Total stream width___________ / 10 = station width _______ ft. (for small rivers)

   Total stream width___________ / 20 = station width _______ ft. (for large rivers)

2. Examine the information above to determine how many stations you need

   # of stations needed______________

3. Start filling in station locations. (this is the location on the tagline (tape measure).

4. Fill in edge of water

5. Evenly space your stations unless you notice deeper water or higher velocities, and then make the spacing of the stations smaller.

6. Fill in rest of station locations

7. Fill in the other edge of water.

8. More information in station spacing in the manual.