Measuring Flow with

FLOWATCH®

Centre County PaSEC

rl/kj October 2020

Why we measure the flow:

The flow rate (cubic meters per second) of a stream may vary greatly over the months. Investigator's using our data will want to know as the rate of flow will have effect on the concentration levels of the of all our field measurements. Comparison of our measurements over time is crucial to our mission. Our chemical and biological results are prime indicators of change and those are dependent on flow.

Discharges containing contaminants will have less effect on swiftly flowing streams than on small slow streams and are influenced tributaries and drains. Runoff, is a major element of the water cycle. It is one component of from surface runoff from adjacent hillslopes, from groundwater, flow out of the ground, and from water discharged from sewers and pipes.

Our method of determining Flow:

Determining flow is limited by the equipment available to us and in some degree depend on our procedure and the site selection. It is important that we be consistent in the application of the method we use at the stream site so that we can monitor seasonal changes. The flow meter improved accuracy and volunteer safety over our previous float method because it reduced the number of measurements needed and provide automatic averaging of the velocity. With it, only one person needs to enter the water and shortened the time the volunteer is in the stream.

The number of measurements is related to the level of accuracy of the estimate of stream flow. A larger sample containing more measurements will provide a more accurate estimate compared to a sample based on fewer measurements. This is a foundational statement based on statistics. A larger sample always produces a more accurate estimate.

Our method is similar to one used by the United States Geological Survey.
We thank Dr. Md. Khalequzzaman (*Loch Haven University Geophysics*) for introducing us to the Flowatch instrument. It was first used by our Marcellus teams. The instrument does not measure flow directly. It measures water velocity. Flow is express as cubic meters per second (M^3/Sec). To determine the flow rate, we measure velocity and stream depth at 3 to 10 and up to as many as 20 equal subsections across the width of the stream. Our website calculator does the math to compute the flow rate for us. How the calculator does that is described on pages 9 and 10.

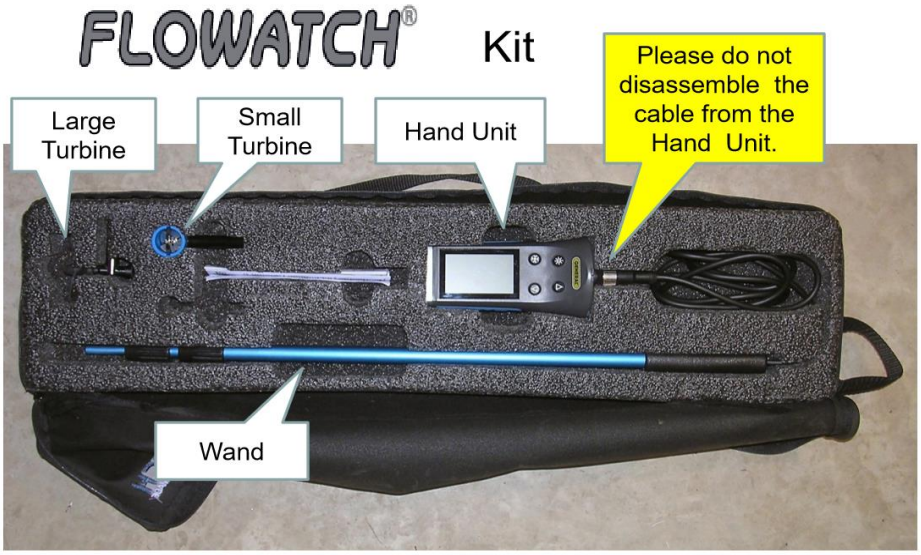
Go to the USGS website to learn more about measuring flow. https://www.usgs.gov/special-topic/water-science-school/science/how-streamflow-measured?qt-science_center_objects=0#qt-science_center_objects

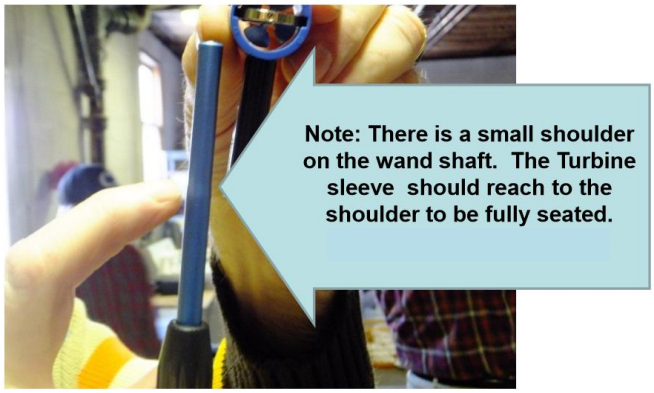
Safety Considerations

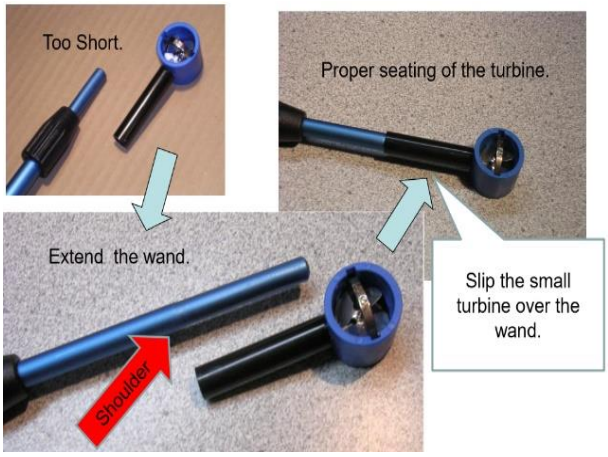
Listen to weather reports DO NOT go sampling if severe weather is predicted.

- STOP the process if a storm occurs while at the sampling location.
- No stream sampling will be conducted if there are small creek flood warnings or advisories.
- Winter adds extra safety concerns with ice and snow that reduce footing and with cold air and water temperatures that reduce physical capabilities.
- Never wade in swift or high water. Do not wade if depth is greater than knee-deep.
- Do not monitor if the stream is at flood stage. It is suggested that people who enter the water leave their important items like wallet, keys, etc. in a safe place on shore.
- Do not enter the water or collect a sample if the stream site is posted as unsafe for personal contact.
- Entering the stream: Use a walking stick to steady yourself. Use long handle measuring sticks and sampling devices when possible.
- To minimize time in the stream we recommend that teams rinse and scoop a water sample using a bottle or beaker with a long handled “dipper” and to perform the pH, conductivity, TDS, Salinity and colorimeter tests on shore.

Setting up and calibrating the meter







Assemble the SMALL turbine onto the wand. **Do not push it on by the blue housing**. Hold it by the black tube and pull it onto the wand. **It must be fully seated as shown in the illustration** or the meter will not record the velocity. **Please do not remove it. Keep it installed on wand**. The larger propeller may be used for very low velocities and is assembled in the same way.

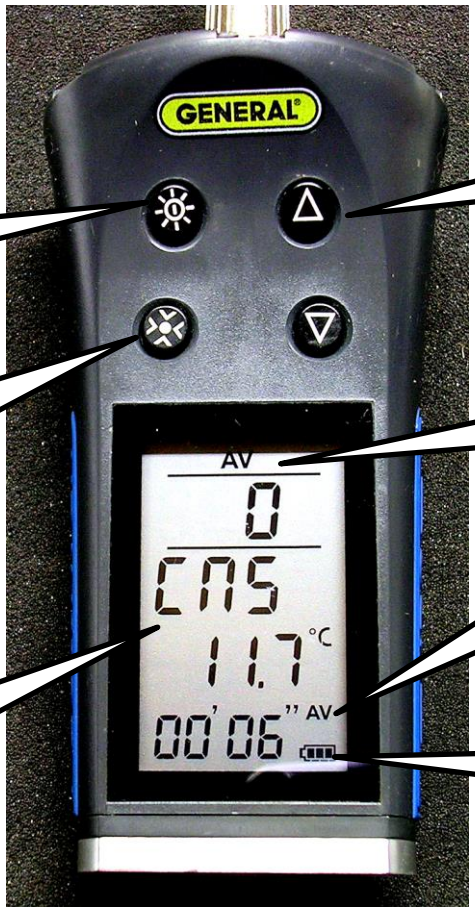
Test the operation of the meter by gently blowing on the turbine or gently swing it in the air. The turbine should spin freely. If not, try sliding the metal guard ring back and forth inside the blue housing.

Press and hold this button to turn the meter on. Press it again momentarily if you want to turn on the axillary light. Press and hold it to turn the meter off.

Press the setup button momentarily. To scroll through the available functions, press the setup button again to select the function you want to change. A bar will flash to indicate which function you may select. Use the up/down arrows to select the units for the function then press the setup button to save that selection.

NOTE: If you did not change the setting, the setup button will shift to the next function. After you have stepped through all the functions the meter will return to the normal operations

The meter will return to normal mod several seconds after no buttons have been pushed.



Press button to turn the meter ON.

Press the up/down arrows to select the units for the function.

Press button momentarily to begin the setup.

Set the meter to AVERAGE (AV).

Set the average period to 6 seconds as shown.

Set the flow to cm/Sec. as indicated on the display.

Note: the battery charge.

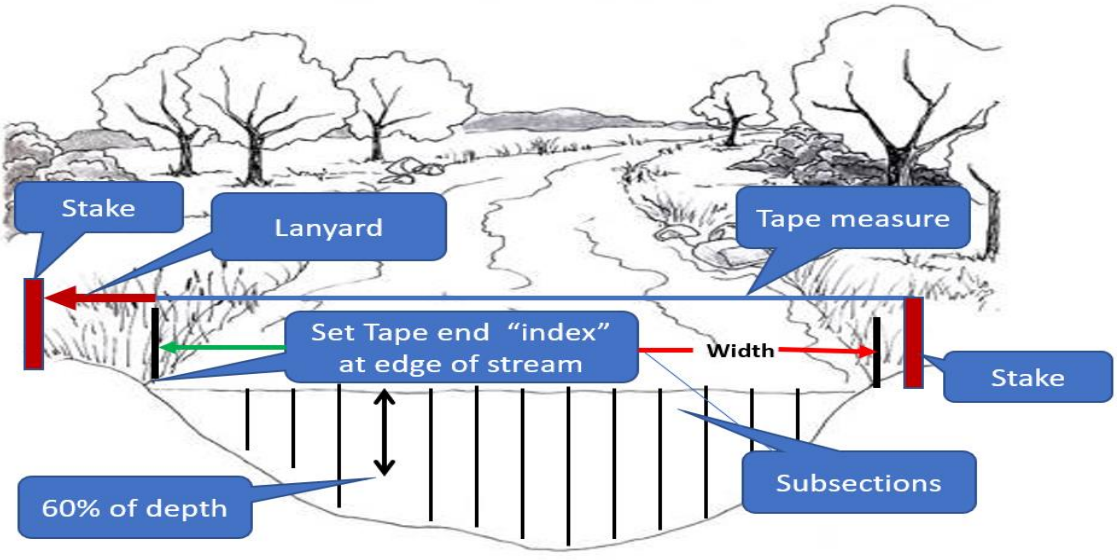
Select location

Choose a location perpendicular across the stream reasonably free of large rocks or obstructions, with a relatively flat streambed, away from the influence of abrupt changes such as eddies or in channel width or depth.

Example location to measure Flow: Lick Run

Procedure: Flow in a Small Stream

Establish a cross-section – Determine the width of the stream using a measuring tape at a right-angle to the flow. Divide the width into approximately equal subsections. Three is minimum, ten or more subsections are recommended, up to 20 can be accommodated by our website flow calculator.



Adjust the lanyard so that the tape measure index end is over the edge of the stream.

Units of measure for our calculator:

Width: Meters (m).

Depth: measured in Centimeters (cm).

Velocity: The average velocity in Centimeters per Second (cm/Sec) as measured at approximately 60% of the stream depth.

Flow that we perceive at the surface can be deceiving. The total flow is a function of velocity and cross section area. The velocity of moving water varies both with the width of a stream channel and from the surface to the bottom of the stream. Irregularities slows the water near the bottom and sides of a channel so that the fastest water is usually near the center of the channel and near the surface.

Our method follows the common practice to divide the stream width into subsections and measure the depth and average velocity in each subsection at about 60% of the depth from the surface.

Choosing how many subsections

The number of measurements is related to the level of accuracy of the estimate of stream flow. A larger sample containing more measurements will provide a more accurate estimate compared to a sample based on fewer measurements. This is a foundational statement based on statistics. A larger sample always produces a more accurate estimate.

The stream widths may vary greatly during the year and the topology of the stream bed may force a major portion of the flow into a narrow zone. In those situations, it may be useful to change the number of subsections to either simplify the process in the case of a very narrow stream or to capture an unusual narrow flow zone. If you find it necessary or to improve accuracy to choose a different number of subsections (say 4 or 15… up to 20) **but *you need to locate your subsections evenly across the stream width for our website calculator to determine the average rate of flow***.

Sampling is used often in a large number of research studies of people or of natural processes. In each of these disciplines a sample is an estimate of what is happening.

1. The location should remain the same each time we do the measurements.
2. Since our measurements constitute a sample, we can modify the intervals we use in making the measurements.
3. If we use more measurements one time and fewer the next time, we can still compare the flow on those because every set of measurements is a sample of the whole stream at a common location.
4. If we use fewer samples when the stream level and flow is high, we can still compare that flow estimate to one made on a stream when it is not as high or wide because that is how sampling works.

Figuring your subsection spacing:

The reason to use the lanyard to set the tape index "zero" at one edge of the stream become obvious as we use the tables or a calculator to equally space the subsections.

You should record your depth and velocity at the locations on the CCPaSEC data sheet

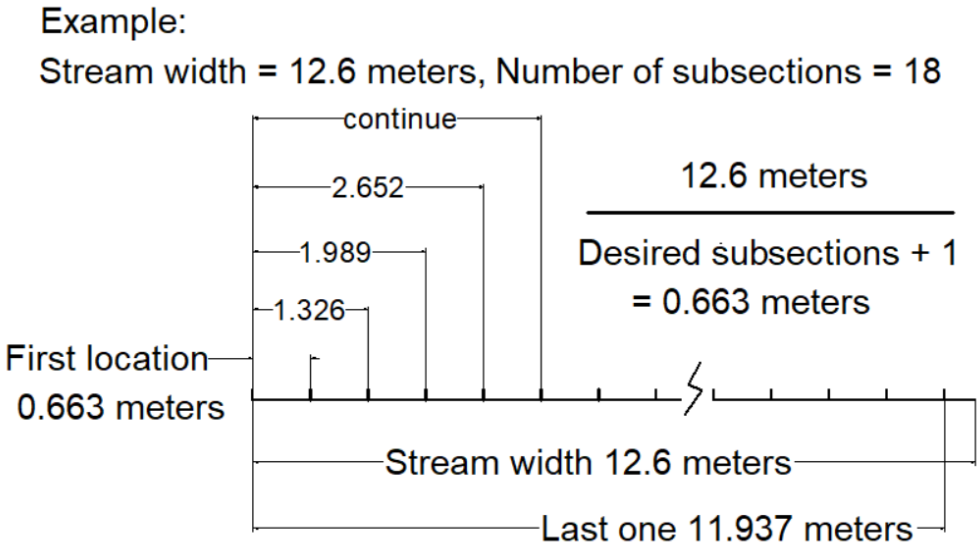
Example using a calculator:

For 10 subsections, divide the width by 11. (the width by the desired number of subsections + 1).

Another example, for 18 subsections and the stream width of 12.6 meters. You would divide the stream width by 19 (the number of subsections you chose plus one**)**.

For our example the result is 0.663 which becomes the desired spacing. Most smart phone would have a calculator App but an inexpensive solar-powered calculator will do.

Use your calculator result to find the locations. **Your first location is at 0.663 meters. Add 0.663 again for your second location, again for your third location and so on….>. Once you've completed the depth measurements, simply start backwards for the flow velocity or by repeatably "taking away" the same result.**



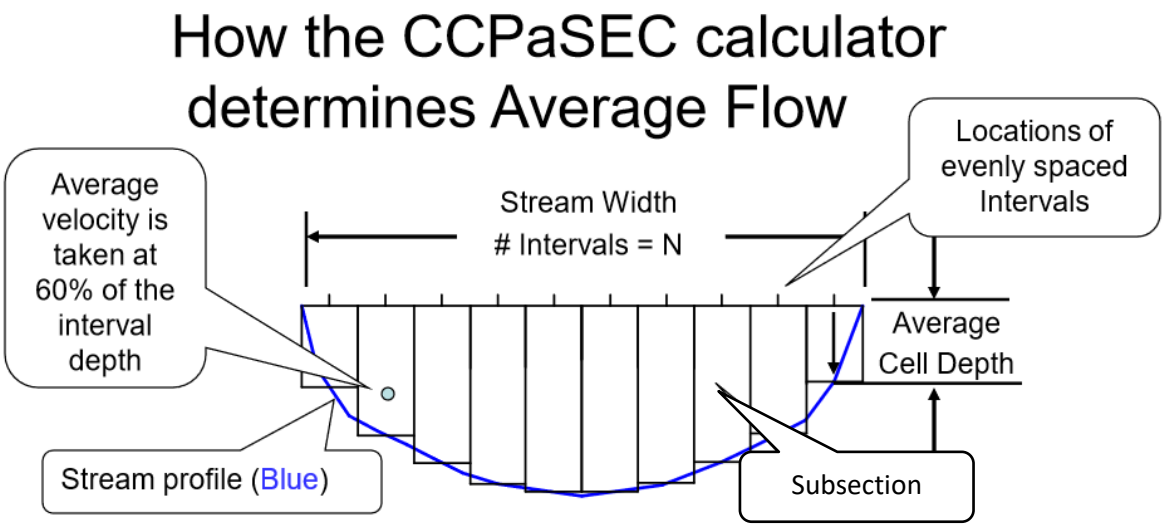
We've provided tables on pages 12 and 13 to help you approximate the spacing. You can also use a calculator method for greater precision and a more accurate determination of flow.

Online Flow Calculator

Our website flow calculator includes an option for the number of subsections you sample for up to 20 locations as needed to improve accuracy. **We recommend using 10 or more** and not less than 3 but you may use any number up to 20.

Record the measurements using latest CCPaSEC field data sheet available on our website: "Water Monitoring Site Physical and Chemicals".

Our calculator determines the AREA of each subsections by dividing the stream width by the number of subsections and multiplies that by the stream depth at each interval (the distance between subsections).



Go to the CCPaSEC website for the online flow calculator. Note: the velocity must be in units of *cm/sec*. and ENTER DATA in the yellow subsections. As you enter the depth readings you will see the profile chart develop. You may enter data for up to 20 Subsections. The calculator will calculate the flow as you enter the data.

The area of each subsection is approximated by dividing the stream width (meters) by the number of (subsections) you recorded and multiplied by the depth (converted to meters) at that interval. The calculator logic lets you use any number of subsections up to 20.

The flow for each subsection is determined by multiplying the area of that subsection times the average velocity cm/sec (converted to meters per Second) you entered for that subsection location. The calculator sums the results of the averaged subsections flows to provide the final result in cubic meters per second (m^3/sec).

Make sure to clear any previous entries. Enter the stream name, the depth (cm) and average velocity (cm/second) in the yellow boxes.

FLOWATCH

Flow meter Method **Enter data in the yellow cells**

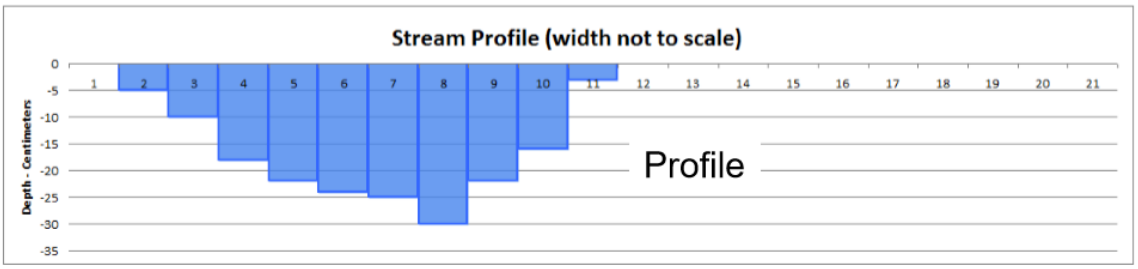
NOTE: THIS CALCULATOR MUST USE VELOCITY MEASURED IN CENTIMETERS PER SECOND (cm/Sec)

Site Name	Stream Name	Date mm/dd/yyyy	date

Enter Stream Width (meters) 3.30

Interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Depth (cm)	5.0	10.0	18.0	22.0	24.0	25.0	30.0	22.0	16.0	3.0										
Velocity (centimeters/sec)	0.00	3.00	6.00	15.00	22.00	20.00	12.00	10.00	8.00	3.00										
Cell M3/sec (NOTE 1)	0.000	0.001	0.004	0.011	0.017	0.017	0.012	0.007	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Flow = 0.073 M^3/sec



Please print, record or download your results, then: Press the Refresh/Reload icon on your browser tool bar to clear all entries for the next calculation.

Common Calculator Issues:

We've protected calculation formulars to prevent accidental change.

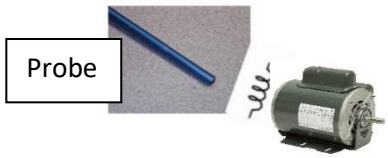
Be sure you used the correct units. you should have velocity (cm/Sec), width (Meters) and depth (centimeters). If not, you will need to convert them.

- The calculator must have an entry for the stream width. It uses that number to determine the area of each subsection.
- Clear all previous entries before starting another calculation.
- Check that you've entered the data correctly and with the proper decimal places.
- Check the profile visual aid – does it look like what was measured?

Calibrating the FLOWATCH® meter

You need to provide an alternating magnetic field to calibrate the FloWatch®. This can be done by holding probe close to a small motor running at 60 Hz single phase.

Turn the FloWatch® on. Hold the probe near the motor to pickup a reading. It should read 205 cm/Sec. If not, it will need recalibration.



1. Turn meter on.
2. Press both bottom buttons simultaneously. A count down will start on the screen.

3. Before the countdown ends release the bottom left button (do not release the bottom right) and press the top right button. ▲

4. Release both buttons and use the arrows to set the value on the screen to 123. ▲▼

5. The meter will return to normal mod several seconds after no buttons have been pushed.

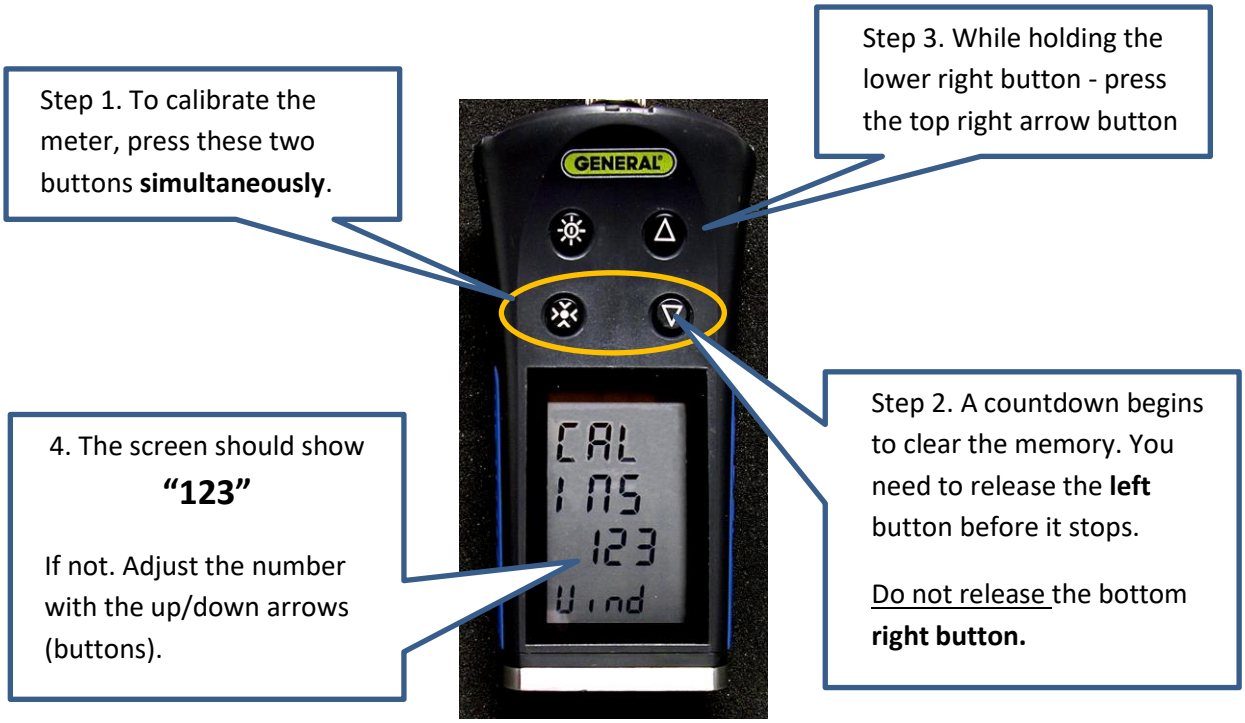


Table 1 Suggested 5 Interval Spacing

Approximate Stream Width (Meters)	Intervals					
	1	2	3	4	5	
	Meters					
1.00	0.17	0.33	0.50	0.67	0.83	1.00
1.25	0.21	0.42	0.63	0.83	1.04	1.25
1.50	0.25	0.50	0.75	1.00	1.25	1.50
1.75	0.29	0.58	0.88	1.17	1.46	1.75
2.00	0.33	0.67	1.00	1.33	1.67	2.00
2.25	0.38	0.75	1.13	1.50	1.88	2.25
2.50	0.42	0.83	1.25	1.67	2.08	2.50
2.75	0.46	0.92	1.38	1.83	2.29	2.75
3.00	0.50	1.00	1.50	2.00	2.50	3.00
3.25	0.54	1.08	1.63	2.17	2.71	3.25
3.50	0.58	1.17	1.75	2.33	2.92	3.50
3.75	0.63	1.25	1.88	2.50	3.13	3.75
4.00	0.67	1.33	2.00	2.67	3.33	4.00
4.25	0.71	1.42	2.13	2.83	3.54	4.25
4.50	0.75	1.50	2.25	3.00	3.75	4.50
4.75	0.79	1.58	2.38	3.17	3.96	4.75
5.00	0.83	1.67	2.50	3.33	4.17	5.00
5.25	0.88	1.75	2.63	3.50	4.38	5.25
5.50	0.92	1.83	2.75	3.67	4.58	5.50
5.75	0.96	1.92	2.88	3.83	4.79	5.75
6.0	1.00	2.00	3.00	4.00	5.00	6.00
	Distance from the far side (meters)					

Table 2 suggested 10 Interval Spacing

Approximate Stream Width (Meters)	Intervals										
	1	2	3	4	5	6	7	8	9	10	
	Meters										
1.00	0.09	0.18	0.27	0.36	0.45	0.55	0.64	0.73	0.82	0.91	1.00
1.25	0.11	0.23	0.34	0.45	0.57	0.68	0.80	0.91	1.02	1.14	1.25
1.50	0.14	0.27	0.41	0.55	0.68	0.82	0.95	1.09	1.23	1.36	1.50
1.75	0.16	0.32	0.48	0.64	0.80	0.95	1.11	1.27	1.43	1.59	1.75
2.00	0.18	0.36	0.55	0.73	0.91	1.09	1.27	1.45	1.64	1.82	2.00
2.25	0.20	0.41	0.61	0.82	1.02	1.23	1.43	1.64	1.84	2.05	2.25
2.50	0.23	0.45	0.68	0.91	1.14	1.36	1.59	1.82	2.05	2.27	2.50
2.75	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75
3.00	0.27	0.55	0.82	1.09	1.36	1.64	1.91	2.18	2.45	2.73	3.00
3.25	0.30	0.59	0.89	1.18	1.48	1.77	2.07	2.36	2.66	2.95	3.25
3.50	0.32	0.64	0.95	1.27	1.59	1.91	2.23	2.55	2.86	3.18	3.50
3.75	0.34	0.68	1.02	1.36	1.70	2.05	2.39	2.73	3.07	3.41	3.75
4.00	0.36	0.73	1.09	1.45	1.82	2.18	2.55	2.91	3.27	3.64	4.00
4.25	0.39	0.77	1.16	1.55	1.93	2.32	2.70	3.09	3.48	3.86	4.25
4.50	0.41	0.82	1.23	1.64	2.05	2.45	2.86	3.27	3.68	4.09	4.50
4.75	0.43	0.86	1.30	1.73	2.16	2.59	3.02	3.45	3.89	4.32	4.75
5.00	0.45	0.91	1.36	1.82	2.27	2.73	3.18	3.64	4.09	4.55	5.00
5.25	0.48	0.95	1.43	1.91	2.39	2.86	3.34	3.82	4.30	4.77	5.25
5.50	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50
5.75	0.52	1.05	1.57	2.09	2.61	3.14	3.66	4.18	4.70	5.23	5.75
6.0	0.55	1.09	1.64	2.18	2.73	3.27	3.82	4.36	4.91	5.45	6.00
	Distance from the far side (meters)										

Centre County Senior Environmental Corps

Water Monitoring Site Physical &

Chemical Data Recording Sheet table for Flow 3/26//2016 p. 2

Stream Flow using Flowmeter:			
Segment #	**Depth (cm)**	**Velocity (cm/sec)**	→ Enter values for width, depth and velocity in CCPaSEC's online stream flow calculator to calculate flow. Record results in cubic meters/sec.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Fill in 11-20 below only if needed.			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Width (meters):			