MISSOURI STREAM TEAM
VOLUNTEER WATER QUALITY MONITORING PROGRAM
Standard Operating Procedure

ORIGINAL EFFECTIVE DATE: May 1, 2019
RECERTIFICATION DATE:
SOP TITLE: MoST-VWQM-SOP: Discharge Measurement of Streams
WRITTEN BY: Randy Sarver; VWQM QA/QC Officer

APPLICABILITY:	Applies to all Introductory, Level 1, Level 2, Level 3 and CSI trained Missouri Stream Team, Volunteer Water Quality Monitoring Program Participants

1.0 SCOPE AND APPLICABILITY

Discharge, also called flow, is the amount of water that flows past a given point in a stream in a given amount of time. It is the product of the cross-sectional area of the stream multiplied by the velocity of the water moving downstream. The VWQM Program expresses the rate of discharge as cubic feet per second (cfs).

The main reason the VWQM Program measures discharge is because it can affect the concentration of pollutants and natural substances in the water. In larger volumes of faster-moving water, a pollutant will often be more diluted and flushed out more quickly than an equal amount of pollutant in a smaller volume of slower-moving water.

Other important effects of discharge are dissolved oxygen content of water, influence to the channel shape and bottom substrate, erosion, transport of sediment, biological cues, habitat for aquatic organisms, and water quantity for human use.

2.0 DEFINITIONS AND ABBREVIATIONS

cfs – cubic feet per second
CSI – Cooperative Stream Investigation
MDC – Missouri Department of Conservation
MoDNR – Missouri Department of Natural Resources
MoST – Missouri Stream Team
SOP – Standard Operating Procedure
VWQM – Volunteer Water Quality Monitoring
QAPP – Quality Assurance Project Plan
QA/QC – Quality Assurance/Quality Control

3.0 SUMMARY OF METHOD

The discharge method described in this SOP is used by the MoST, VWQM Program participants that have received Introductory, Level 1, Level 2, Level 3 or CSI Program training.

4.0 HEALTH AND SAFETY REQUIREMENTS

Appropriate protective gear, such as gloves and water proof boots, should be worn to protect against encountering potential water-borne illnesses during measurement. It is also advisable to wash your hands with soap and water after measuring discharge, especially before eating or drinking.

Those participants that monitor near wastewater should be vaccinated for Hepatitis A. Please contact your county health department or your personal physician for this vaccination.

Do not attempt to measure discharge if you cannot safely wade across the stream (e.g., a large river like the Missouri River or a small stream during high flow). If chest waders are worn while wading, a safety belt should be worn on the outside to prevent filling the waders if submerged.

5.0 PERSONNEL QUALIFICATIONS

Participants will be knowledgeable of this SOP and will have, at a minimum, attended an Introductory VWQM workshop.

6.0 SUPPLIES AND EQUIPMENT

The following equipment is needed to measure stream discharge:

- Program provided tape measure (graduated in tenths of a foot)
- Program provided wiffle golf ball
- Program provided Stream Discharge Data Sheet (see attached)
- Ten foot rope
- Two metal pins or steel rod
- Stop watch or other timing device
- Depth measurement device (graduated in tenths of a foot)

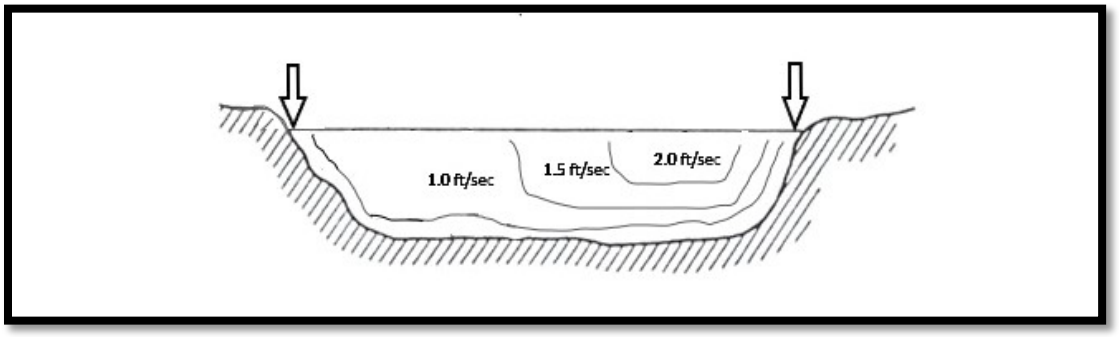
7.0 PROCEDURE

The accuracy of measuring stream discharge is affected by following this method and by selecting a suitable stream section. **Select a stream section that is relatively straight, free of large objects such as logs or boulders, with a noticeable current, and with a depth as uniform as possible.**

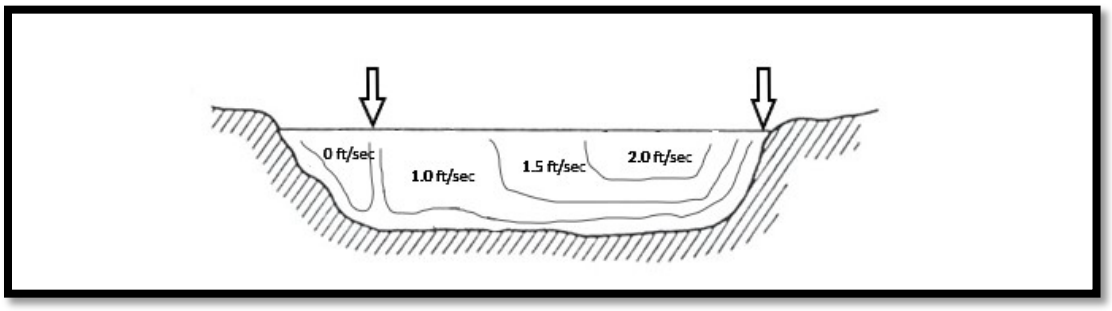
7.1 CROSS SECTIONAL AREA

1. Stretch the tape measure across the stream. The “0” point should be anchored at one wetted edge of the stream. The opposite end of the tape measure should be anchored on the opposite wetted edge of the stream so that the tape is taut and perpendicular to the flow.

2. If the entire stream width has flowing water, measure the width of the stream from wetted edge to wetted edge (see figure below) and record the width (tenths of a foot) on the Stream Discharge Data Sheet (Appendix A - Step 1a) A wiffle golf ball can be used to determine if the water is flowing across the entire width of the stream..



2’. If the entire stream width does not have flowing water, only the stream width that has water moving in a downstream direction will be used to collect depth and velocity measurements for discharge calculation. In the figure below, the wetted stream width is adjusted to the flowing water width that is shown between the arrows.



3. With the tape measure still in place, measure the stream depth for flowing water at predetermined intervals across the stream. For streams less than 20 feet wide, measure the depth every foot. For streams greater than 20 feet wide, measure the depth every two feet. For streams greater than 60 feet wide, measure the depth every three feet; and for streams greater than 90 feet wide, measure the depth every four feet. Remember that the depth must be measured to the nearest tenths of a foot (e.g., 0.8 ft.) and NOT in inches (e.g., 8 inches). Stand downstream of the tape measure when taking depth measurements so that you don’t influence the water’s depth. **Depths of “0” are not valid depth measurements**, and may not be recorded. Record all valid depth measurements on the Stream Discharge Data Sheet (Appendix A – Step 1b).

4. On the Stream Discharge Data Sheet sum all depths to calculate the sum of depths. Record this value (feet) on the Stream Discharge Data Sheet (Appendix A – Step 1b).

5. On the Stream Discharge Data Sheet calculate the average depth by dividing the sum of depths by the number of intervals. Record this value (feet) on the Stream Discharge Data Sheet (Appendix A – Step 1b).

6. On the Stream Discharge Data Sheet multiply the average depth times the stream width to calculate the cross sectional area. Record this value (square feet) on the Stream Discharge Data Sheet (Appendix A – Step 1b).

7.2 AVERAGE STREAM VELOCITIES

1. Determine equal distance width intervals for velocity measurements. Conduct no fewer than four velocity measurements. More velocity measurements are recommended for larger streams; with a maximum of ten.

2. Select two points approximately equal distance upstream and downstream from the tape measure you have stretched across the stream. Five feet above and five feet below the tape measure works well for most Missouri streams. However, this will be dependent on the swiftness

of the stream. In faster water, you may want this distance to be greater, or shorter in slower water.

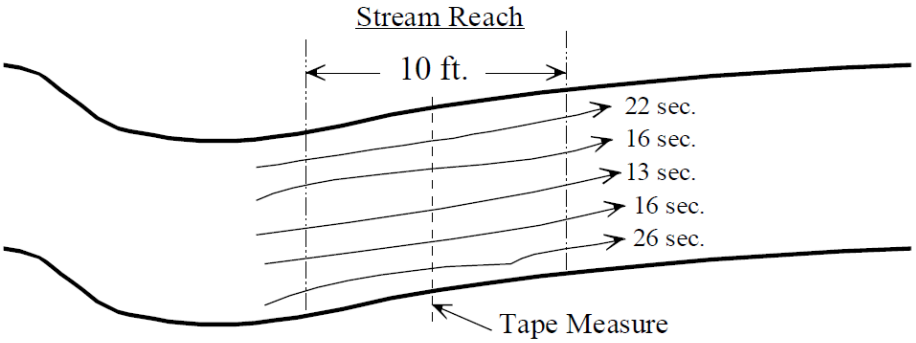
3. Record the distance between the upstream and downstream points (tenths of a foot) in the Distance Box on the Stream Discharge Worksheet (Appendix A – Step 2).

4. Drop the wiffle golf ball above the upstream point. Do not stand where the current could be affected, and remove the tape measure if it will interfere with floating the wiffle golf ball.

5. Begin the timer when the wiffle golf ball passes the upstream point, and stop the timer when it reaches the downstream point.

6. Record the time it takes to float the wiffle golf ball from the upstream point to the downstream point (seconds) in the Velocity Float Trials Table on the Stream Discharge Data Sheet (Appendix A – Step 2). **No zero velocities are allowed.**

7. Repeat Steps 4 – 6 for each width interval. See the example below.



Average Float Time = 18.6 sec.

8. Sum all float times and enter on the Stream Discharge Data Sheet (Appendix A – Step 2).

9. Calculate the average float times by dividing the sum of float times (seconds) by the number of trial floats (see example above). Record this value on the Stream Discharge Data Sheet (Appendix A – Step 2).

10. Divide the distance floated by the average float time. Record this value (feet/second) on the Stream Discharge Data Sheet as the Average Surface Velocity (Appendix A – Step 2).

7.3 CALCULATION OF STREAM DISCHARGE

1. Select the appropriate stream bottom correction value. The correction value for rough, loose rocks or coarse gravel is 0.8. The correction value for smooth, mud, sand, or bedrock is 0.9. Record this value on the Stream Discharge Data Sheet in the Correction Value Box (Appendix A – Step 2).

2. Multiply the correction value by the average surface velocity. Record this value (feet/second) on the Stream Discharge Data Sheet as Corrected Average Stream Velocity (Appendix A – Step 2).

3. Multiply the cross sectional area (square feet) by the corrected average stream velocity (feet/second). Record this value on the Stream Discharge Data Sheet as Stream Discharge (cfs) (Appendix A – Step 2).

8.0 SPECIAL CONSIDERATIONS

Measure stream discharge each time you monitor for chemical or biological monitoring.

If using discharge from a United States Geological Survey (USGS) stream gauge, the gauge must be within a half mile of the monitoring location; with no water inflow or outflow to the stream between the gauge and the monitoring location. If a USGS gauge is used, record the gauge number and discharge value (cfs) for the sampling time on the Stream Discharge Data Sheet.

Do not attempt to measure flow during periods of extremely low flow in which the wiffle golf ball becomes stalled, blows upstream, or touches bottom. If the flow is too low, check the appropriate box at the top of the Stream Discharge Data Sheet.

Do not attempt to measure flow during periods of extremely high flow. If the water is flowing and it is up to your thighs, it is very likely too dangerous to measure flow. If the flow is too high, check the appropriate box at the top of the Stream Discharge Data Sheet.

If the wiffle golf ball hits any type of obstacle in the stream, the float trial does not count and must be measured again.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

As part of attending a Level 3 QA/QC audit, discharge measurements will be checked against velocities measured with a flow meter. Level 3 audits are covered under a MoDNR QAPP.

10.0 REFERENCES

Missouri Department of Natural Resources, Quality Assurance Project Plan for Level 2 and Level 3 Volunteer Water Quality Monitoring.

Missouri Stream Team – Volunteer Water Quality Monitoring Program; Introductory Volunteer Water Quality Monitoring Training Notebook, Chapter 3, Stream Discharge
http://www.mostreamteam.org/assets/chapter-3-stream-discharge.pdf

Missouri Stream Team – Volunteer Water Quality Monitoring Program; Introductory Volunteer Water Quality Monitoring Workshop PowerPoint Presentation, Stream Discharge
http://www.mostreamteam.org/assets/03discharge.pdf

STREAM DISCHARGE DATA SHEET

Please check the box next to the "Site #" ***if this is a new site and please be sure to attach a map.*** (PLEASE PRINT)

☐ Site # _____ Stream _____ County _____

Site Location _____

Date ____/____/____ Time (military time) _____ Rainfall (inches in last 7 days) _____ Water Temp. (°C) _____

Trained Data Submitter (responsible volunteer) _____ Stream Team Number _____

Participants _____

If discharge is unmeasurable due to conditions, please indicate: ☐ Flow too low to measure ☐ Flow too high to measure

For reporting USGS gage value (special cases only): USGS gage # _____ at _____ cfs

Instructions for Calculation of Stream Discharge (Flow)

Step 1a: Determine stream width. Select a section of stream that is relatively straight, free from large objects such as logs or large boulders, with a noticeable current, and with a depth as uniform as possible. Stretch the tape measure provided by the program across the stream. The "0" point should be anchored at the flowing edge of the stream. The end of the tape measure should be anchored at the opposite end so that it is taut and even with the other flowing edge. Do not measure nonflowing water.

[ ] Stream Width (Feet)

Step 1b: Determine stream cross-sectional area. The first step in determining cross-sectional area is to measure and calculate the average stream depth. In the table below, for streams less than 20 feet wide, record depth measurements at every foot. For streams greater than 20 feet wide, record depth measurements every two feet. The depth must be measured in **tenths of a foot** (e.g. 1.7 feet equals one foot and seven tenths). **DO NOT MEASURE DEPTH IN INCHES.**

Record Depth at 1-Foot Intervals

Interval Number	Depth in Feet	Interval Number	Depth in Feet	Interval Number	Depth in Feet
1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	
Sum		Sum		Sum	

The average depth is calculated by dividing the sum of the depth measurements by the number of intervals at which measurments were taken.

[ ] Sum of Depths (feet) ÷ [ ] Number of Intervals = [ ] Average Depth (feet)

The final step in calculating the cross-sectional area is multiply the average depth (in feet) by the stream width (in feet) at the point where the tape measure is stretched across the stream.

[ ] Average Depths (feet) x [ ] Stream Width (feet) = [ ] Cross Sectional Area (feet)²

Step 2: Determine the average velocity for the stream. A minimum of four velocity measurements should be taken from equal intervals across the stream's width. For example, if the stream is eight feet wide, then velocity measurements should be taken at approximately every foot and a half across the stream in order to derive four measurements. For a stream width of 16 feet, velocity measurements should be taken at approximately three feet increments across the stream to derive four measurements. This method of measuring the stream velocity will ensure that velocity measurements are recorded for the slow and fast portions of the stream. For greater accuracy, more than four measurements are recommended for wider streams.

To measure the water's surface velocity, the first step is to select two points located equal distance upstream and downstream from the tape measure you have stretched across the stream. Determine the distance between these two points and record this value (in feet) in the **Distance Box** on the back of this page. A 10-foot total float distance is a recommended starting point. This distance can be lenghtened or shortened depending on stream swiftness. Count the number of seconds it takes a neutrally buoyant object (such as a wiffle practice golf ball) to float this distance. Record this time (in seconds) in the table on the back of this page for each float trial you complete.

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Velocity Float Trials	
Trial Number	**Time (seconds)**
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Sum	

Distance Box

Distance Floated (in feet)

The next step in calculating the surface velocity is to determine the average float time. Average float time is equal to the sum of the float times (in seconds) divided by the number of float trials.

	÷		=	
Sum of Float Times (seconds)		Number of Trials		Average Float Time (seconds)

The final step is to divide the distance floated (from the **Distance Box** at top) by the average float time.

	÷		=	
Distance Floated (feet)		Average Float Time (seconds)		Average Surface Velocity (feet per second)

Water in the stream does not all travel at the same speed. Water near the bottom travels slower than water at the surface because of friction (or drag) on the stream bottom. When calculating stream discharge, the water's velocity for the entire depth (surface to bottom) needs to be determined. Therefore, you must multiply the average **surface** velocity (from above) by a correction factor to make it represent the water velocity of the **entire stream depth.**

Choose the correction factor that best describes the bottom of your stream and multiply it by the average surface velocity to calculate the corrected average stream velocity.

Stream Bottom Type: Rough, loose rocks or coarse gravel: **correction value = 0.8**
Smooth, mud, sand, or bedrock: **correction value = 0.9**

	x		=	
Correction Value		Average Surface Velocity (feet per second)		Corrected Average Stream Velocity (feet per second)

<u>Step 3: Calculate the stream discharge.</u> Multiply the cross-sectional area (Feet)^2 from **Step 1** by the corrected average stream velocity (Feet/Second) from **Step 2.**

	x		=	
Cross-Sectional Area (feet)^2		Corrected Average Stream Velocity (feet per second)		Stream Discharge (feet)^3 per second or cubic feet per second (cfs)

Fish Present (Please Mark) **Yes** ☐ or **No** ☐

PLEASE KEEP A COPY AND SEND ORIGINAL DATA TO: VWQM Coordinator
Water Protection Program
Department of Natural Resources
PO Box 176
Jefferson City, MO 65102-0176

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