



Standard Operating Procedure Total Discharge

WQDWQPBFM-03, Version 2.0 2026 Water Quality Planning Bureau

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The Montana Department of Environmental Quality (DEQ) Water Quality Planning Bureau (WQPB) Standard Operating Procedures (SOPs) are adapted from published methods or developed by in-house technical and administrative experts. Their primary purpose is for WQPB internal use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. DEQ may provide SOPs to other programs or partners. Distribution of these SOPs does not constitute a requirement to use a particular procedure or method unless stated in other binding communications. This document does not contain regulatory or statutory requirements unless specified.

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Although the WQPB follows this SOP in most cases, there may be situations where an alternative methodology, procedure, or process is used to meet specific project objectives. In such cases, the project manager is responsible for documenting deviations from these procedures in the Quality Assurance Project Plans (QAPPs), Sampling and Analysis Plans (SAPs), and end of project summary reports.

Document Revision and Version History

Revision Date	Version number	Summary of change(s)	Revised sections(s)	Revised by
January 2020	1.0	Initial document	All	Elizabeth McWilliams
April 2026	2.0	Clarified procedural steps for each flow method. Added “Interferences” section to Flow Meter Method and Float Method sections. Added Table 7-2, and Figures 7-1, 7-3, 7-4, and 7-5. Removed ADP information and referred reader to the ADP SOP (DEQ 2014). Removed Water Level Datalogger and Rating Curve Method sections and referred reader to the Digital Stage Recorder SOP (DEQ 2010). Added the “StAGE Network” section.	Re-arranged sections 2.0-6.0. Updated sections 7.0 – 7.6, 8.0-9.0, Appendix A, and Appendix B. Minor clarifying edits throughout.	Ella Bushnell

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ACRONYMS

ADCP	acoustic doppler current profiler
CFS	cubic feet per second
CMS	cubic meters per second
CSV	comma separated values
DEQ	Montana Department of Environmental Quality
DNRC	Montana Department of Natural Resources and Conservation
DSR	digital stage recorder
EWI	equal width interval
FPA	fixed period average
GPS	global positioning system
LWE	left wetted edge
MBMG	Montana Bureau of Mines and Geology
PT	pressure transducer
QAPP	quality assurance project plan
RWE	right wetted edge
SAP	sampling and analysis plan
SOP	standard operating procedure
StAGE	Stream and Gage Explorer
SVC	site visit code
SVF	site visit form
SWAMP	Surface Water Assessment and Monitoring Program
USGS	United States Geological Survey
WQPB	Water Quality Planning Bureau

1.0 PURPOSE

This document describes the Montana Department of Environmental Quality (DEQ) Water Quality Planning Bureau (WQPB) Standard Operating Procedure (SOP) for measuring stream width, depth, and velocity and calculating total discharge. Some methods apply only to wadeable streams and rivers, and other methods can be applied to nonwadeable conditions such as during runoff, flood events, or on large rivers (Flynn and Suplee 2010).

2.0 DEFINITIONS

Acoustic Doppler Current Profiler: An instrument used to estimate flow when a waterbody is either too swift or too deep to wade. ADCPs are typically mounted to a vessel and guided from one bank to another several times, using sound waves to measure stream bathymetry and velocity of particles suspended in the water column.

Capillary Action: The movement of water within the spaces of a porous material due to the forces of adhesion, cohesion, and surface tension.

Cross Section: A vertical plane, oriented perpendicular to the stream flow direction, that extends from bank to bank and from the channel substrate to the water surface.

Digital Stage Recorders: An instrument that uses capillary action and temperature data to determine a stream's stage.

Discharge: The volume of water that passes through a channel cross-section at a point in time. Units are either cubic feet per second (cfs) or cubic meters per second (cms).

Flow Meter: A mechanical or electronic instrument that measures water velocity.

Pressure Transducer: An instrument that uses barometric pressure and water density to determine a stream's stage.

Stage: The height of the water surface in a river or stream above an established water level.

Thalweg: The deepest location in a stream cross-section.

Top Setting Wading Rod: The tool used in conjunction with a flow meter to accurately collect velocity measurements at different water depths.

Velocity: The speed of the water in a channel. Units are either feet per second or meters per second.

Wetted Edge: The physical boundary between the water and the channel's solid surface (bed and banks). The left and right wetted edges are determined by facing downstream.

Wetted Width: The distance between the left and right wetted edges.

3.0 APPLICABILITY

Total discharge data are useful for many water quality investigations. Projects may use discharge data to help interpret water quality data as it pertains to seasonality, floods, droughts, total maximum daily load

development, and hydrologic models. Depending on the scope of the project, instantaneous and/or continuous data may be collected.

The following methods discussed in this document are used to collect instantaneous discharge data:

- Flow meter method (**Section 7.1**)
- Float method (**Section 7.2**)
- Visual estimation method (**Section 7.3**)

If a waterbody is too deep, wide, or swift to make wading measurements, it is recommended to use an acoustic doppler current profiler (ADCP). An ADCP uses sound frequency to determine the velocity of particles in the water and area of the cross-section to estimate the discharge of the waterbody. For information about ADCPs and instructions for use, see the Acoustic Doppler Profiler SOP (DEQ 2014).

If short term continuous discharge data are needed, water level dataloggers can be installed to regularly record water depth throughout the period of deployment to approximate the hydrograph. There are multiple types of water level dataloggers, each tailored to specific environmental conditions and project needs. Digital stage recorders (DSRs), such as AquaRod and TruTrack instruments, record water stage using capillary action and temperature data. Pressure transducers (PTs), such as HOBO U20L-01, use barometric pressure and water density (normally calculated from water temperature) to determine water stage. For information about water level dataloggers and developing rating curves, see the Digital Stage Recorders SOP (DEQ 2010). Instantaneous measurements are periodically collected during water level datalogger deployment using a flow meter or an ADCP, and a stage-discharge rating curve is developed to relate water depth to water discharge (DEQ 2010).

If long term continuous discharge data are needed, there are multiple agencies that operate and maintain stream gages that may provide both current conditions and historic discharge data (**Section 7.4**).

NOTE: Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by DEQ.

4.0 HEALTH AND SAFETY WARNINGS

Field personnel should be aware of job hazards associated with collecting total discharge data that could result in personal injury or loss of life. Driving, boating, wading, and tool use safety are especially pertinent to the procedures contained in this SOP. Personnel should be aware of unstable banks, loose substrate, and swift currents when wading and standing in moving water. DEQ field personnel must review and sign the Water Quality Division Job Hazard and Analysis form and review the Waterborne Operations Procedure (DEQ 2016) before collecting data.

5.0 CAUTIONS

Field personnel must be cautious when using equipment around water. Water may damage electronics if seals are damaged or left open. Follow appropriate equipment care and maintenance schedules (e.g., sensor cleanings, firmware updates, o-ring or other seal replacement). Batteries should be removed

from flow meters when they are not being used for an extended period of time (3+ months) to avoid damaging the housing or circuitry.

The same units (feet or meters) should be used throughout the data collection process for velocity readings, depth readings, and tape measurements during a sampling event.

6.0 PERSONNEL QUALIFICATIONS AND RESPONSIBILITIES

Field personnel must be trained by experienced personnel and must demonstrate proficiency in all applicable field protocols as described in this SOP before collecting data in the field. Field personnel must be able to troubleshoot common problems with equipment when in the field. Always keep a copy of appropriate field manuals and/or user guides for troubleshooting when in the field.

7.0 OVERVIEW OF METHODS

DEQ uses a variety of methods to collect discharge data. Total discharge is computed from variables that can be measured or estimated directly (stream depth, width, and velocity). A project SAP will specify which sites require discharge data collection, but field personnel may need to determine which discharge method is most suitable at the site (if not already specified in the SAP) and will need to choose a specific location to collect discharge data. Total discharge should be measured or calculated after chemical and biological information have been collected at a site to minimize disturbance (Makarowski 2020). The methods used by DEQ are described in **Table 7-1** and are listed in order of most accurate to least accurate.

Table 7-1. Discharge methods, descriptions, and applications

Method	Description	Application
Gage	Total discharge data are retrieved from a hydrologic gaging network online.	If there is a nearby gage, it should always be used for discharge data collection.
Water Level Dataloggers and Rating Curves (DEQ 2010)	A datalogger that continuously measures water depth levels is installed at a site and periodic discharge meter measurements are collected to correlate water depth to discharge through a rating curve.	Method is used when continuous discharge data are required and there is no nearby gage station.
Acoustic Doppler Current Profiler (DEQ 2014)	Total discharge is calculated using an instrument that derives the doppler shift from transmitted and recorded acoustic frequencies.	ADCPs are typically used for waterbodies that are too deep, swift, or wide for wading measurements.
Flow Meter	A meter with a top setting rod is used to record velocity and depth at intervals on a cross-section and total discharge is calculated by adding together the discharge from each section along the cross-section.	Method is used in wadeable streams.

Float	Discharge is calculated by averaging the travel time of buoyant objects floating downstream over a known distance.	Method is used when streams are unsafe to wade or too shallow for instrument measurements.
Visual Estimation	Discharge is visually estimated by field personnel while in the field.	Method is only used when all other methods are unavailable or inappropriate for stream conditions.

The steps below provide general guidelines for collecting total discharge measurements:

1. Choose a location

The ideal location for setting up a cross-section or reach is in a straight section of the stream with laminar flow (i.e., a glide). Avoid the following flow interferences when selecting a location:

- Flow modifications (e.g., swirls, eddies, vortices, backward flow, and dead zones)
- Pools
- Undercut banks and physical obstructions (e.g., boulders, tree snags, submerged vegetation, pipes, etc.)
- Braided channels
- Inflowing or outflowing side channels or tributaries
- Areas downstream of sharp bends, upstream or downstream of vertical drops, or where a stream empties into a stationary body of water (i.e., a lake or reservoir)

NOTE: When all of the above criteria do not exist, use best professional judgement to choose a location that avoids major flow interferences.

2. Determine a method

If the waterbody is wadeable, the following methods may be applicable:

- Flow Meter Method (e.g., Hach Marsh McBirney and OTT MF Pro meters) (**Section 7.1**)
- Float Method (**Section 7.2**)
- Visual Estimation Method (**Section 7.3**)
- Gage Method (if available) (**Section 7.4**)

If the waterbody is nonwadeable (e.g., during high flow conditions or for large rivers), the following methods may be applicable:

- Float Method (**Section 7.2**)
- Acoustic Doppler Current Profiler (ADCP) for open channels (DEQ 2014)
- Gage Method (if available) (**Section 7.4**)

NOTE: Determining the appropriate method will be unique to each site and may vary seasonally. If gage data are available and the gage station is close to a site, this method should always be used.

3. Collect measurements

Collect the applicable measurements for the determined method. Follow steps provided in **Sections 7.1 through 7.4** to collect accurate measurements and record detailed notes.

4. Record information

All measurements and notes made in the field must be recorded on the Site Visit Form (SVF) before leaving the site. Any discharge calculations, whether done in the field or in the office, must also be recorded on the field forms (i.e., SVF and Total Discharge Form) before they are scanned and filed. The location of the Total Discharge Calculation Spreadsheet, an example Site Visit Form, and the Total Discharge Form are available in **Appendix A**.

7.1 FLOW METER METHOD

The flow meter method is a common instantaneous method used to determine total discharge of a wadeable stream. A representative cross-section is determined and divided into sections. The total number of sections and the width of each section is dependent upon the channel's morphology. The ideal measurement is one in which each section contains less than 10% of the total discharge (Turnipseed et al. 2010). When discharge is well-distributed, the Equal Width Interval (EWI) method may be used to divide a cross-section. EWI divides a cross-section into equally wide sections and uniformly distributes velocity measurement stations across the entire width of the stream. However, for most rivers and streams, it is appropriate to divide the stream into equal section widths then insert additional stations where velocity significantly changes between stations. See **Table 7-2** for the number of stations recommended for different stream widths.

A top setting wading rod is used in conjunction with a flow meter to measure the total water depth and position the flow meter sensor at the correct depth from the water surface where velocity measurements are collected. A flow meter with a top setting rod can only be used in streams that have sufficient water depth to reliably use the instrument (≥ 0.2 in).

Depending on the type of flow meter used, distance, depth, and velocity measurements may be recorded automatically by the flow meter. Typically, if measurements are recorded by the meter, total discharge is also auto calculated by the meter at the end of the data collection. Regardless of the type of flow meter used, all distance, depth, and velocity measurements must be recorded on the Total Discharge Form and total discharge must always be recorded on both the Total Discharge Form the Site Visit Form (**Section 8.1**).

See **Appendix B** for the settings used to collect flow data for different types of flow meters.

NOTE: When recording measurements on a Total Discharge Form, it may be helpful to have a team of two: one person to measure the distance, depth, and velocity and the other to record the information on the form.

7.1.1 Equipment and Supplies

- Operating instructions/manual
- Flow meter (e.g., Marsh McBirney, OTT MF Pro)
- Sensor attachment
- Flow meter case
- Top setting wading rod
- Field tape measure (10th ft or m)
- Calculator
- Bank pins (or stakes/rebar)
- Clips or clamps (if applicable, for securing tape to bank pins)
- Hammer (if applicable, for stakes/rebar)

- ❑ Tagline stabilizer (if applicable, for wide streams or windy conditions)
- ❑ Screwdriver
- ❑ Applicable power source
 - Spare batteries (Marsh McBirney requires two D alkaline batteries)
 - Charger cable (OTT MF Pro)

7.1.2 Collecting Data

The following procedure is the same for all flow meters that require distance, depth, and velocity measurements:

1. After selecting a location at the site (**Section 7.0**), use a field tape measure to set up a cross-section:
 - Stretch the tape across the cross-section perpendicular to flow
 - Use bank pins or stakes to secure the ends of the tape in place
 - Make sure the tape is taught and not sagging

NOTE: It is acceptable to extend the tape beyond the wetted edges on either bank for ease of securing the tape.

2. Determine the wetted width of the cross-section from the field tape measure.
3. Determine the distance between the stations. **Table 7-2** provides guidance for determining the suggested minimum number of stations for a given stream wetted width (including the stations at each wetted edge) (British Standard 2007).

Table 7-2. Equal width interval stationing chart

Channel Wetted Width (in ft)	Number of Stations
< 1.5	As many as possible, 0.3 ft apart
$1.5 \leq W < 3$	5 to 9
$3 \leq W < 10$	10 to 14
$10 \leq W < 16$	15 to 19
$16 \leq W < 22$	20 to 24
≥ 22	25 to 30

Field personnel should do their best to approximate the number of stations, so no individual section contains more than 10% of the total discharge (OTT Hydromet 2015). If it appears that greater than 10% of the total discharge is or will be passing through any individual section of the cross-section, either:

- Divide the wetted width by a larger number to produce more stations across the cross-section (preferred if measurements have not begun yet), or
- Add additional stations within the section of the cross-section that has proportionally more flow (preferred if measurements are already in progress and recording on a form). **Try not to exceed 30 total stations.**

It may be challenging to visualize 10% of the total discharge of a stream. If there is a significant increase in velocity between stations, it is best practice to add an additional station(s) in that section. Field personnel may add stations at any point during the measurement, and stations can be added out of sequence.

NOTE: Stations should not be spaced less than 0.3 ft apart. If the channel width is less than 1.5 ft and deep enough to take flow meter measurements (≥ 0.2 ft), take as many measurements as possible at 0.3 ft intervals. Station spacing may need to be adjusted to accommodate added stations.

4. Ensure the instrument is set to the correct units and the averaging interval is set to 30 seconds. See **Appendix B** for instructions on setting the fixed-point averaging intervals.
5. Attach the flow meter sensor to the top setting wading rod and securely fasten the set screw. Do not overtighten the set screw. Check periodically that the screw is hand tightened and meter sensor is upright. If it is found that the meter was loose or unlevel, stations(s) should be remeasured where meter integrity was questionable. Adjust meter settings, as needed (**Appendix B**).

NOTE: Avoid handling the sensor bulb, as oils from your hand may disrupt the sensors.

6. Measure the total water depth and record the depth on the Total Discharge Form. A top setting wading rod is equipped with two different measuring rods, the depth gage rod and the sliding gage rod (**Figure 7-2**). Water depth is measured using the depth gage rod. The depth gage rod has etched calibrated graduation marks; single marks are 0.1 ft. increments, double marks are 0.5 ft. increments, and triple marks are 1.0 ft increments (**Figure 7-1**). When recording water depth, round to the nearest 0.05 ft.

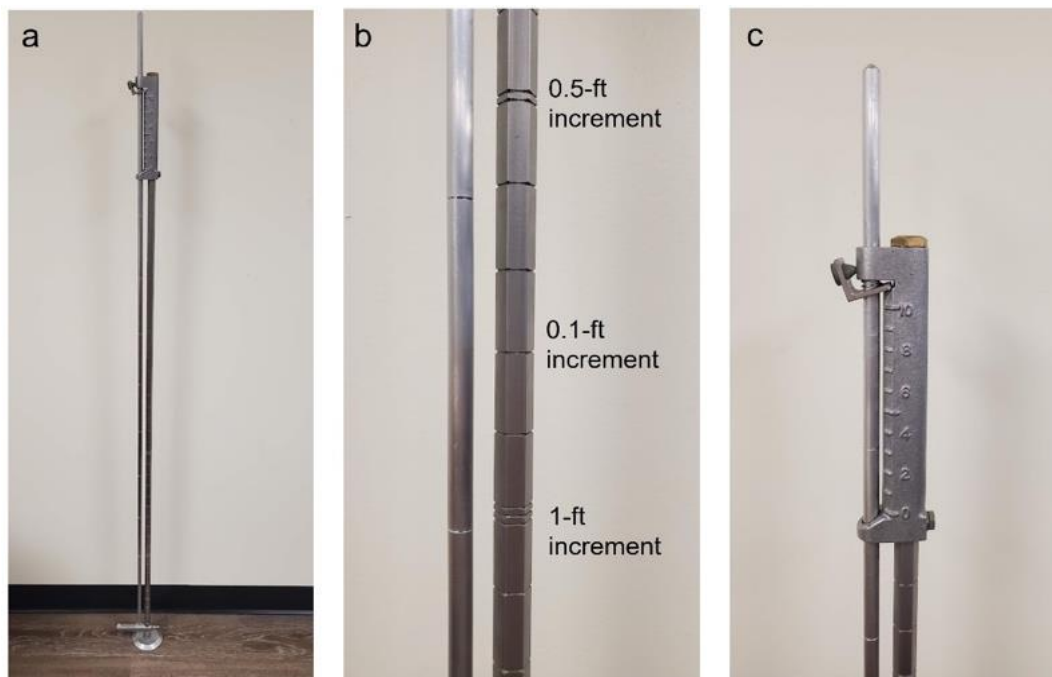


Figure 7-1. Top setting wading rod photo (<https://lgpress.clemson.edu/wp-content/uploads/sites/3/2023/03/three-images-of-a-top-setting-wading-rod-image-a.jpeg>)

7. Position the sensor at the appropriate depth from the water surface. To do this, adjust the sliding rod until the foot scale on the sliding rod is lined up with the tenth scale on the depth gage rod at the desired depth.

One Depth Method: If the total depth is **less than 2.5 ft.**, position the sensor at 60% depth from the water surface. To set the sensor at 60% depth, adjust the sliding rod to the total water depth. For example, if the total water depth is 1.7 ft., line up the "1" on the sliding rod with the "7" on the tenth scale on top of the depth gage rod.

Two Depth Method: If the total depth is **greater than 2.5 ft.**, measurements are collected at 20% and 80% depths from the water surface and averaged to determine the water's velocity at that station (Harrelson et al. 1994). To set the sensor at 20% depth, multiply the total depth by 2 and adjust the sliding rod to that value. To set the sensor at 80% depth, divide the total depth by 2 and adjust the sliding rod to that value (Marsh-McBirney 1990).

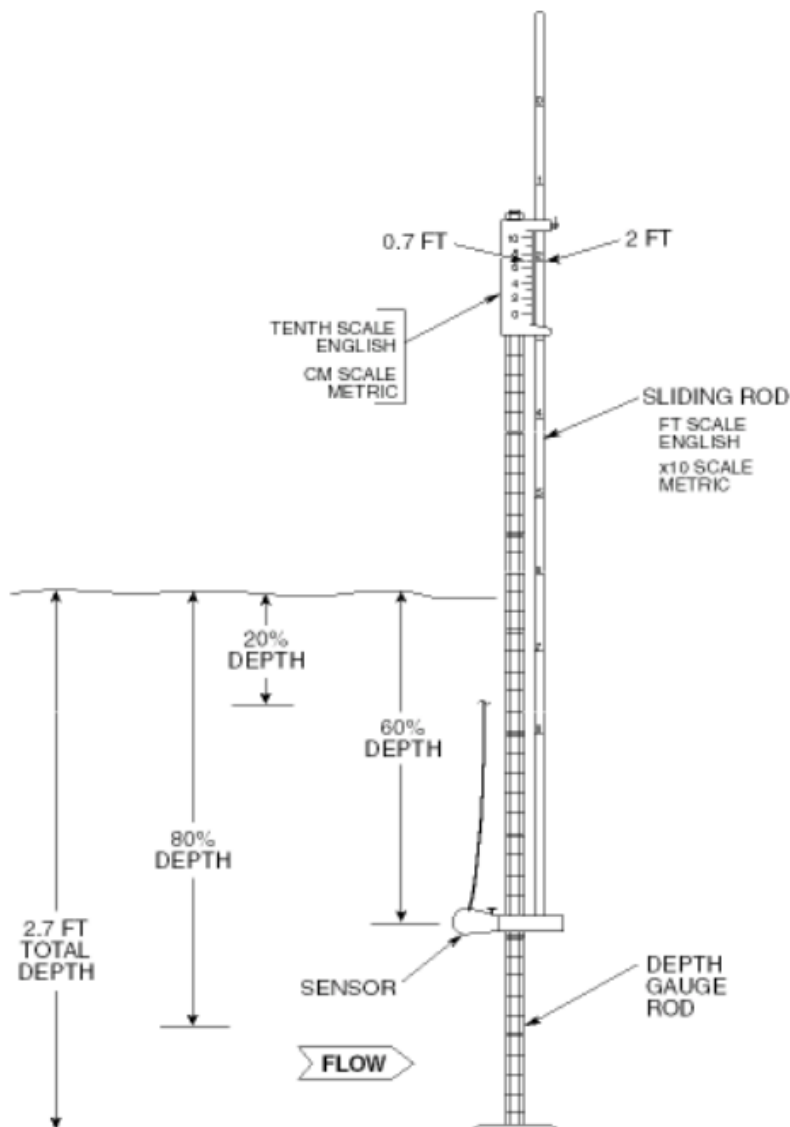


Figure 7-2. Top setting wading rod diagram (Marsh McBirney 1990)

8. Position the sensor so that it is facing upstream, perpendicular to the flow, with the base of the wading rod on the channel substrate.

NOTE: Avoid pushing the base of the top setting rod into the stream bed in streams with soft substrate.

9. Hold the wading rod upright and vertically level. Stand in a position that least affects the velocity of the water passing the flow meter: at least 3 inches downstream and approximately 1.5 feet to the side of the sensor (Figure 7-3, OTT Hydromet 2015).

If the stream is narrow, avoid standing in the water if possible, especially if a large percentage of the cross-section is occupied by feet/legs.

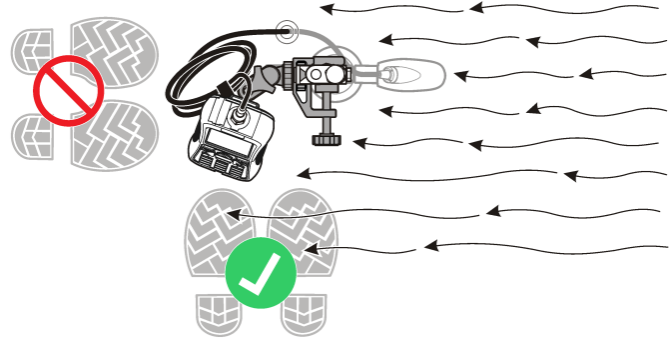


Figure 7-3. Correct standing position for using a flow meter (OTT Hydromet 2015)

10. Once in position, begin a new fixed-point averaging interval, wait for 30 seconds, and record the average velocity reading on the Total Discharge Form. All discharge measurements must be recorded on the Total Discharge Form at the time of measurement. Recording and storing measurements in the meter is optional unless otherwise specified in a project SAP.

NOTE: At the left wetted edge and right wetted edge (the initial and/or final points of measurement) the depth and velocity will each be recorded as “0” and noted as either “LWE” or “RWE” in the notes column on the Total Discharge Form (**Appendix A**).

11. Repeat steps 6 – 10 at each station along the cross-section.
12. Prior to disassembling the cross-section, field personal should review all recorded velocity measurements and evaluate if any additional measurements should be collected.

These steps may differ if a discharge auto-calculating flow meter is used. See **Appendix B** on how to enter data into the OTT MF Pro flow meter.

7.1.3 Interferences

When collecting discharge data using the flow meter method, there are a variety of interferences that may influence depth and velocity measurements. Use best professional judgement when determining how to handle interferences and make note of anything that may impact discharge on the Total Discharge Form and/or Site Visit Form (**Appendix A**). It is recommended to attempt minor stream channel engineering (e.g., removing minor flow obstructions such as rocks, woody debris, or vegetation) before taking any measurements. Listed below are potential interferences and suggested ways to address them in the field:

Large rocks/boulders – The best way to avoid large rocks/boulders is to not have them in your cross section. However, they are sometimes impossible to avoid. Do not take any measurements directly next to, behind, or in front of them. When water flows around an obstruction it moves in a swirling pattern, also known as an eddy, where velocity measurements may be erroneously low or negative. If a station is

positioned too close to an obstruction the velocity measurements will inaccurately represent the discharge in that section.

If a station lands on a large rock or boulder that is either sticking up out of the water or close to the water surface (about 0.5 ft), take depth and velocity measurements ~0.5 ft on either side of the rock/boulder. Make sure the distance(s) recorded on the Total Discharge Form reflects the new station(s) along the tape measure. If a large rock is submerged by at least 0.5 ft of water, take depth and velocity measurements on top of the rock.

Vegetation – If there is a small to moderate amount of vegetation near banks or along the cross-section, remove the vegetation before taking any measurements. If there is a significant amount of vegetation that will interfere with flow across the entire cross-section, try to find another location to set up the cross-section or attempt the float method if no alternative location is available. Always make a note on the Total Discharge Form where vegetation may influence a measurement.

Floating debris – Floating debris can get caught on the sensor or wading rod leading to inaccurate velocity measurements. Prior to taking a measurement, check for and remove any floating debris that may have been caught on the sensor or wading rod. If any floating debris is caught on the rod during the measurement, remove the debris and restart the measurement.

Wind – On wide streams in particular, wind may cause the tape measure to bounce or stretch, resulting in inaccurate distance measurements. If available, use a steel reinforced tape measure or Kevlar line to keep the tape measure taught. If tape reinforcement is unavailable, it may be helpful to tie pieces of flagging tape to the tape measure spaced out across the transect.

Negative readings – If the meter reading is a negative value, double check that there are no large obstructions upstream that may be interfering with the measurement. If there are, move the station to a location where flow is no longer obstructed and note the reason for moving the station in the “comments” column on the Total Discharge Form (**Appendix A**). Where large eddies may be present near banks, it is appropriate to record depth and velocity measurements at the approximate center of the eddy even if the velocity measurement is a negative value.

If any measurement seems incorrect, try taking another measurement and/or refer to the equipment help sheets in **Appendix B** or instrument user manuals for troubleshooting in the field.

Braided channels – If flow must be collected in a portion of a stream or river that has braided channels, treat each individual channel like it is its own stream. If possible, set up the cross-section across the entire width of all the braided channels and note the wetted edges for each channel. If the braided system is too wide for this method, attempt to set up the cross-sections for each channel along the same plane. Total discharge should be calculated for each flowing channel (or braid) then added together to get the total discharge for the entire system. If flow for all channels cannot be measured using a single method, it is appropriate to collect flow using a combination of measurement methods. On the Total Discharge Form and the Site Visit Form, record the number of channels, method used for each channel, total discharge for each channel, and total discharge after adding all channels together.

Vertical banks – If flow is collected in a cross section with vertical banks, indicate the location of the bank(s) on the tape measure as the wetted edge. Collect the first (and/or last) velocity measurement no

closer than 0.3 ft from the bank. Make a note of the vertical bank(s) in the “comments” column of the Total Discharge Form (**Appendix A**).

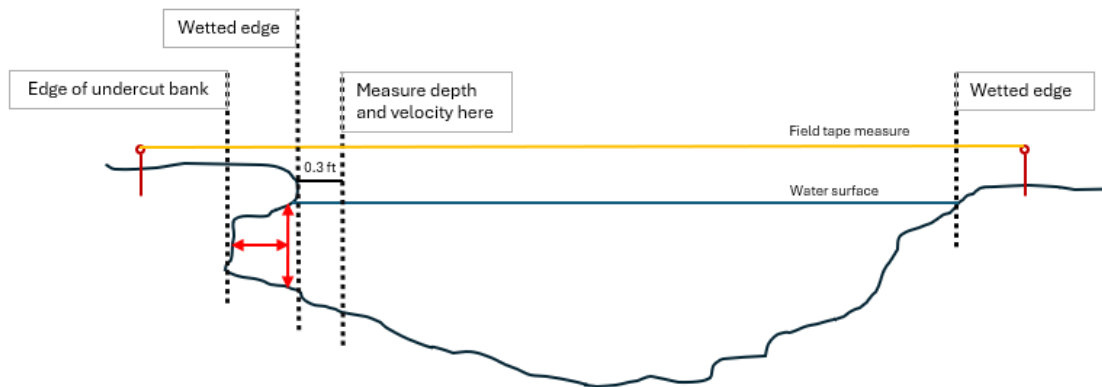


Figure 7-4. Channel cross section showing an undercut bank

Undercut banks – If there is noticeable flow in an undercut bank, take a depth and velocity measurement ~0.3 ft from the bank. Measure the horizontal and vertical depth of the undercut bank and note those measurements on the Total Discharge Form. Record the inner edge of the undercut bank as the “wetted edge”, record the outer edge of the undercut bank as “edge of undercut bank”.

7.1.4 Discharge Calculation

A flow meter discharge calculation is the summation of the products of the section areas and their respective average velocities (Rantz et al. 1982). DEQ uses the mid-section method where it is assumed that the velocity measurement at each vertical station represents the mean velocity in a rectangular section. Using this method, the area for each section extends laterally from half the distance from the preceding vertical to half the distance to the next vertical (Turnipseed et al. 2010).

The formula to calculate discharge using this method is: $Q = \Sigma (a v)$

Q = total discharge

a = an individual section area (width x depth)

v = the corresponding mean velocity of the flow

A total discharge calculation spreadsheet is available in **Appendix A**.

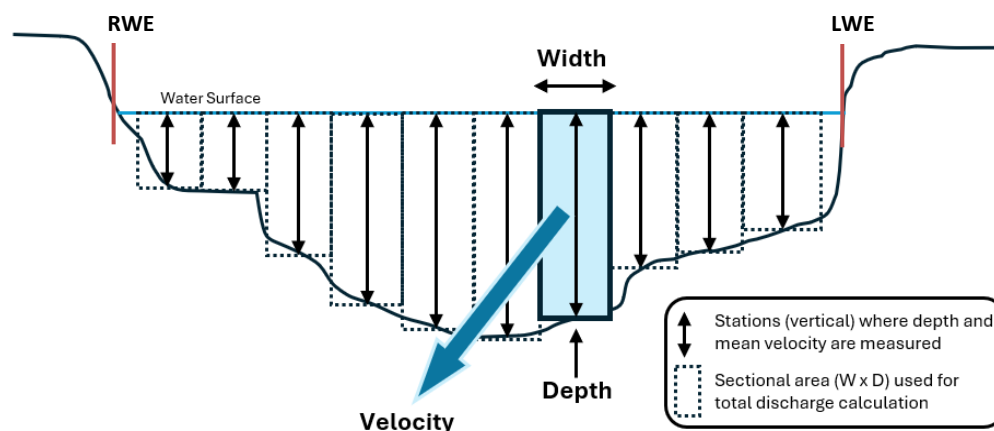


Figure 7-5. Channel cross section showing the mid-section discharge calculation method

7.2 FLOAT METHOD

The float method is often used when the flow meter or ADCP methods cannot be used (e.g., nonwadeable, high flow conditions, very low flows, very wide channels, etc.) and when there is no gage station nearby. A uniform reach of the stream is identified, and the average cross-sectional area of the reach is either measured or estimated. A stick or other biodegradable floating object is tossed into the stream and is timed to determine how long it takes the object to traverse the stream reach length to calculate the velocity. Cross-sectional area (width and depth) is then multiplied by velocity with a correction coefficient to determine total discharge.

NOTE: This semi-quantitative method tends to overestimate the flow due to higher velocity near the surface. A velocity adjustment coefficient of 0.85 is used to reduce the likelihood of overestimating discharge (Turnipseed et al. 2010).

7.2.1 Equipment and Supplies

- Calculator
- Flagging
- Field Tape Measure
- Bank pins
- Range finder
- Biodegradable floating objects (e.g., oranges, sticks, cheese balls, etc.)
- Stopwatch (seconds)

7.2.2 Collecting Data

1. Identify the stream reach to be measured (**Section 7.0**).
2. Measure the total reach length (ft or m). The length of the reach should be at least twice the mean wetted width and no less than 50 feet. A reach is measured following the curvature of the channel, rather than a straight line from start to end. Mark the start and end of the reach with flagging, bank pins, or by leaving the tape along the length of the reach. Record the reach length on the Total Discharge Form.
3. Measure the mean wetted width (ft or m) and record it on the Total Discharge Form:
 - If wadeable, measure and average at least three cross-sections throughout the reach with a field tape measure, or
 - If nonwadeable, measure and average at least three cross-sections throughout the reach with a range finder, or
 - Visually estimate and average three representative cross-sections throughout the reach.
4. Measure the mean water depth (ft or m) and record it on the Total Discharge Form:
 - If wadeable, measure and average multiple depths throughout the reach, or
 - If nonwadeable, make a visual estimation
5. Estimate the water surface velocity:

- Toss a small stick or other biodegradable floating object into the thalweg, upstream of the first marker at the top of the reach. If the thalweg is unknown, toss the object as close to center of the stream as possible.
- Begin timing with a watch or stopwatch (in seconds) when the object passes the upstream marker.
- Stop timing when the object reaches the downstream marker.
- Record the float time on the Total Discharge Form. A float time of at least 20 seconds is recommended, but a shorter time may be accepted where it is not possible to set up a reach of adequate length (Turnipseed et al. 2010).
- Complete three measurable floats.

NOTE: The three float times should be within a similar range of each other. If there are any float times that are considerably different, repeat the measurement.

7.2.3 Interferences

When using the float method, it is important to make sure that the object is heavy enough to stay in the main current and can travel through the reach without obstructions or snags. If the object gets stopped or snagged, repeat the measurement. In situations where obstructions or very low flows prevent the object from ever travelling through an entire reach, it is appropriate to reduce the length of the reach to complete three measurable floats. In situations where the water is too turbid to get an accurate depth estimate, still collect float data and record a depth estimate but make a note on the Total Discharge Form and the Site Visit Form that the depth is an estimated measurement.

7.2.4 Discharge Calculation

Complete the following calculations on the Total Discharge Form and record the adjusted discharge on the Site Visit Form:

- | | |
|---|--|
| • Cross-sectional area (ft ² or m ²) = | Mean width x Mean depth |
| • Average float time (sec) = | (Float time 1 + Float time 2 + Float time 3) / 3 |
| • Float velocity (ft/sec or m/s) = | Reach length / Average float time |
| • Discharge (ft ³ /sec or m ³ /sec) = | Cross-sectional area x Float velocity |
| • Adjusted Discharge (ft ³ /sec or m ³ /sec) = | Discharge x 0.85 |

7.3 ESTIMATION METHOD

The estimated flow method is the least accurate method and should only be used on very small streams that will not support the use of the flow meter method or the float method. Field personnel measure or estimate the width, depth, and average velocity of a channel cross-section and calculate the total discharge in the field.

7.3.1 Equipment and Supplies

A field tape or similar measurement tool should be used to measure average channel width and depth. Visually estimating width and depth is not recommended; however, it is acceptable if no measuring tools are available.

7.3.2 Collecting Data

1. Select a location at the site following the same guidelines as the flow meter and float methods (**Section 7.0**).
2. Determine a cross-section that is representative of the average width, depth, and velocity of the stream at the site.
3. Measure or estimate the following:
 - Wetted width (ft or m)
 - Mean depth (ft or m)
 - Velocity (ft/sec or m/sec)
4. Complete the discharge calculation in the field.
 - Calculated discharge (ft³/sec or m³/sec) = Width x Depth x Velocity
5. Record the calculated discharge on the Site Visit Form. The recorded value for discharge (ft³/sec or m³/sec) must be a single value and not a range.

Field personnel are encouraged to include comments about estimated flow measurements in the notes section of the Site Visit Form.

Field personnel can improve accuracy of estimates by:

- Practicing discharge estimation at a site where the flow meter method is used and comparing guesses to the calculated value
- Timing how long it takes to fill a container of a known volume
- Taking measurements whenever possible (e.g., measure actual width and mean depth in small streams rather than estimating)

7.4 ONLINE GAGE METHOD

Other organizations such as the US Geological Survey (USGS), the Montana Bureau of Mines and Geology (MBMG), and the Department of Natural Resources and Conservation (DNRC) collect real time discharge data on some waterbodies Montana.

If a project is relying on discharge data from a gage at or near a monitoring site, the project manager must:

- Verify that the gage is operating during the project's timeframe. Seasonal gages typically operate from April 1st – October 31st. It is important to plan alternative methods for flow if using a seasonal gage outside of this date range
- Note in the project SAP which gage is used (gage number and name) and which site(s) it applies to
- Note the distance between the gage and sampling site(s)
- Notify field personnel that the gage exists before the field personnel visit the monitoring site
- Have field personnel write the gage number on the applicable Site Visit Form (s)

NOTE: When using this method, it is easy to accidentally record the gage's water level elevation (stage) instead of discharge. Verify the data type as discharge and units of measure are in cubic feet per second (cfs) before recording the value on the Site Visit Form.

7.4.1 USGS gages

To locate a USGS gage:

- Visit <https://waterdata.usgs.gov/mt/nwis/rt>
- Either select a site on the "Daily Streamflow Conditions" map, or go to the "Current Streamflow Conditions Table" to select a site
- To view the USGS gage number, station name, and location, select the desired site on the map
- Alternatively, the gage page and gage data can be located quickly by typing the eight digit gage number into a browser search bar. All eight digits must be entered to reach the desired gage page.

To determine the discharge at a certain date and time:

- Select the desired USGS gage from the gage number recorded on Site Visit Form
- Select "View Monitoring Location Information"
- Under "Continuous Data", select "Discharge, cubic feet per second"
- Then, select "Change timespan" and enter the date range that will include the date and time of the site visit
- Record the discharge on the Site Visit Form

7.4.2 SWAMP Network

To locate a MBMG/DNRC Surface Water Assessment and Monitoring Program (SWAMP) Station:

- Visit <http://mbmg.mtech.edu/swamp/>
- Select Web Mapping Application or Stream Gauge Listing
- Once a site is selected, view the report
- The location of the station is listed on the web page

To determine the discharge at a certain date and time:

- Go to the desired SWAMP station
- Select a date range that will include the date of the site visit
- Download the data
- Locate the discharge measurement closest to the date and time listed on the Site Visit Form under the Field Measurements section
- Record the discharge

7.4.3 StAGE Network

To locate a DNRC Stream and Gage Explorer (StAGE) station:

- Visit <https://gis.dnrc.mt.gov/apps/stage/gage-report>
- Select the Station Code to view the station data
- The location of the station is listed on the web page

To determine the discharge at a certain date and time:

- Go to the desired StAGE station
- Select the date range that will include the date of the site visit
- Locate the discharge measurement closest to the date and time listed on the Site Visit Form under the Field Measurements section
- Record the discharge

To determine discharge from downloaded data:

- In the “Data Download” box, select the date range that will include the date of the site visit
- Select the intended “Site Sensors”
- Generate the CSV
- Locate the closest date and time listed on the Site Visit Form under the Field Measurements section
- Record the discharge

8.0 DATA AND RECORDS MANAGEMENT

All hardcopy documentation of the data, such as completed Site Visit Forms and Total Discharge Forms are kept and maintained by the Water Quality Planning Bureau (WQPB). Data collected will be reviewed, verified, and stored based on the WQPB Quality Control and Quality Assurance procedures (**Section 9.0**) and the Quality Assurance Project Plan (QAPP) for the project. All instrument calibrations, checks, and maintenance are to be recorded in a Maintenance/Calibration Log Book (**Section 8.3**).

8.1 SITE VISIT FORM

Indicate the method that is used to collect total discharge on the Site Visit Form under the Field Measurements section (**Figure 8-1**). An example of a Site Visit Form is available in **Appendix A**.

Flow:	ft ³ /sec	<input type="checkbox"/> Dry Bed	<input type="checkbox"/> Stranded Pools)
<input type="checkbox"/> Meter	<input type="checkbox"/> Float	<input type="checkbox"/> Gage #	_____
<input type="checkbox"/> ADCP	<input type="checkbox"/> Visual Est.		

Figure 8-1. The discharge portion of the Field Measurements section on a SVF

- If flow is calculated or estimated in the field, record the total discharge while at the site
 - If flow is 0 ft³/s then indicate if that is because the stream bed is dry or is made up of stranded pools. If the flow is 0 ft³/s for a different reason, record that information in the notes section of the Site Visit Form
- If the flow meter method is used, check the “Meter” box
- If the float method is used, check the “Float” box
- If there is a gage at or near the site, check the “Gage” box and record the gage number
- If an ADCP is used, check the “ADCP” box

- If the visual estimation method is used, check the “Visual Est.” box.

NOTE: Site Visit Forms may look different depending on the project. Always refer to a project SAP for instructions on how to fill out Site Visit Forms.

If a Total Discharge Form was used to record data for the flow meter method or float method, check the “Total Discharge” box under the Field Assessment section (**Figure 8-2**).

Field Assessments		
Photos <input type="checkbox"/>	Aquatic Plant Visual Assessment <input type="checkbox"/>	SAM <input type="checkbox"/>
Aquatic Plant Tracking <input type="checkbox"/>	Rosgen <input type="checkbox"/>	NRCS <input type="checkbox"/>
EMAP <input type="checkbox"/>	Total Discharge <input type="checkbox"/>	Channel X-Section <input type="checkbox"/>
Wetland <input type="checkbox"/>	Bacteria <input type="checkbox"/>	Other: _____

Figure 8-2. The Field Assessments section on a SVF

8.2 TOTAL DISCHARGE FORM

If discharge was calculated using the flow meter or float method, use the Total Discharge Form (**Appendix A**) to record measurements and field notes. Use the same Site Visit Code (SVC) on the Total Discharge Form as the Site Visit Form.

Follow the guidelines outlined below when filling out the Total Discharge Form:

Date: Record the date of the site visit.

Personnel: Include all personnel involved in collecting and recording flow measurements.

Waterbody: Include the name and location of the waterbody from the Site Visit Form.

Nearest Transect (A-K): It is assumed that water chemistry samples are collected at transect F at most sites. If flow is measured within 15 meters upstream or downstream of the water chemistry sampling location, write “F” under “Nearest Transect”. If flow is measured in a different location, assume the distance between each transect is 15 m and note the nearest transect accordingly (A is furthest downstream, K is furthest upstream).

TOTAL DISCHARGE – FLOW METER METHOD:

Averaging Interval: Record the number of seconds the meter uses to calculate the average velocity (typically 30 seconds).

Distance from initial point: Circle “ft” or “m”. Starting at either the left or right wetted edge, record the number on the tape measure that corresponds to each station to the nearest tenth of a foot. For example, if you secure your tape measure on a stable part of the bank and the wetted edge is at 1.4 ft., record 1.4 ft. as the first station and indicate “LWE” or “RWE”. From there, if your sections are 0.5 ft. wide, the next station should be at 1.9 ft., then 2.4 ft., then 2.9 ft., etc. until you reach other wetted edge (adjusting stationing and adding stations as needed).

Depth: Circle “ft” or “m”. Record the total depth of the water to the nearest 0.05 ft. in the “Total Depth” column. The first and last stations are the wetted edges and should have zero depth.

Velocity: Circle “ft” or “m”. If using the one-depth method, record the velocity for 60% depth. If using the two-depth method, record the velocities for both 20% and 80% depths and write “two depth method” in the comments. The first and last stations are the wetted edges and should have zero velocity.

Comments: Always record the left wetted edge (LWE) and right wetted edge (RWE). Note any interferences such as vegetation, rocks/boulders, undercut banks, eddies, gravel bars, braided channels, etc. in the comment box for each affected velocity measurement.

Total Discharge = ____ cfs: Regardless of where discharge is calculated (field or office), always write the total discharge at the bottom of the form.

TOTAL DISCHARGE – FLOAT METHOD:

Average Width: Circle “ft” or “m”. Measure or estimate at least three wetted widths from various points along the reach and calculate the average. Record the average width here.

Average Depth: Circle “ft” or “m”. If possible, use a wading rod or measuring stick to take multiple depths measurements along the reach. If nonwadeable, estimate average depths at multiple locations along the reach. Use these values to calculate the average depth. Record the average depth here.

Longitudinal Distance: Circle “ft” or “m”. Note the length of the reach here (2x the average width, minimum 50 ft.)

Travel Time 1/2/3: Record the three float times (in seconds) here.

Comments: Record any comments from the site visit here (e.g., the water is very turbid and you are unable to see the bottom, a value is visually estimated, there are multiple large boulders or other interferences, cutbanks, braided channels, etc.).

Total Discharge = ____ cfs: Regardless of where discharge is calculated (field or office), always write the total discharge at the bottom of the form.

8.3 MAINTENANCE/CALIBRATION LOG BOOK

Each field meter must have a water-resistant maintenance/calibration log book dedicated to that meter. Each log book must include the manufacturer, model, and serial number of the meter to distinguish it from other meters’ log books. All maintenance (e.g., battery replacement, charging, cleaning) and zero checks must be recorded in the equipment’s log book.

Each entry in the log book must include the following information:

- Calibrated by: [first initial, last name] (e.g., J. Doe)
- Date of calibration: [MM/DD/YYYY]
- Maintenance activity(ies) performed (e.g., zero check, battery replacement, repairs, cleanings, and any corrective actions)
- Relevant information (e.g., batteries leaked and damaged circuitry)

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

It is the responsibility of the field personnel to collect good and accurate data and ensure that forms are properly filled out and the information is recorded correctly. All equipment users must be familiar with the equipment and be able to troubleshoot common problems in the field. Additionally, field personnel are required to review all relevant documents, SOPs, and user manuals prior to using equipment and collecting data in the field.

Routine inspections, maintenance, and repairs are necessary to ensure quality of collected data. It is up to the user to document instrument malfunction in the maintenance/calibration log and notify the WQPB equipment technician as soon as possible. All equipment must be checked and verified before field use and flow meters (e.g., Marsh McBirney, Ott MF Pro) should be routinely calibrated or “zero checked” in a bucket of standing water. See the appropriate user manual for instructions on calibrating or zero checking instruments.

10.0 REFERENCES

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APPENDIX A – FIELD FORMS

The following forms are included in this appendix:

- Total Discharge Calculation Spreadsheet
- Site Visit Form Example (Front) (**NOTE:** DEQ modifies this form to meet project-specific needs)
- Total Discharge Form – Flow Meter Method
- Total Discharge Form – Float Method

TOTAL DISCHARGE CALCULATION SPREADSHEET

An Excel spreadsheet template is available for DEQ staff [here](#).

[G:\WQP\7 QAProgram\3 SOPs\Discharge\1 Total Discharge SOP\Discharge_Template.xls](G:\WQP\7_QAProgram\3_SOPs\Discharge\1_Total Discharge SOP\Discharge_Template.xls)

If a flow meter and Total Discharge Form were used in the field (**Section 9.2**), the total discharge for the channel will need to be calculated before the SVF is processed. Enter the information recorded on the Total Discharge Form into the spreadsheet. Record the final Total Discharge result on the Site Visit Form, and save the spreadsheet with the following name convention:

	A	B	C	D	E	F	G	H	I	J
1	CHANNEL DISCHARGE									
2	Date:			Site Visit Code:			Station ID:			
3	Waterbody:					Location:				
4	Personnel:									
		Distance from initial point (ft)	Total Depth	0.6 Velocity (ft/sec)	0.2 Velocity (ft/sec)	0.8 Velocity (ft/sec)	Width (ft)	Area (ft²)	Discharge (ft³/sec)	Notes
5										
6	1									
7	2									
8	3									
9	4									
10	5									
11	6									
12	7									
13	8									
14	9									
15	10									
16	11									
35	30									
36	31									
37	32									
38	33									
39	34									
40	35									
41	36									
42	37									
43	38									
44	39									
45		<i>Width Check</i>	<i>Mean Depth (ft)</i>	<i>Total Area (ft²)</i>			<i>Mean Velocity (ft/s)</i>	<i>Total Discharge (ft³/s)</i>		
46		PASS/ERROR	0.00	0.00			0.00	0.00		

Waterbody_StationID_YMMMDD_(SiteVisitCode)_FLOW

Figure A-1. Discharge_Template example

SITE VISIT FORM

Place Site Visit Label Here	Site Visit Form	Project ID: _____
Date: _____ Time: _____ Personnel: _____		
Waterbody: _____ Location: _____		
Station ID: _____ HUC: _____ County: _____ AUID: _____		
Latitude: _____ Longitude: _____ Elevation: _____ ft m		
<input type="checkbox"/> Field Duplicate to _____ <input type="checkbox"/> Field Blank <input type="checkbox"/> Trip Blank <input type="checkbox"/> Field Equipment Blank		
Samples Collected	Sample ID	Sample Collection Information/Preservation
Water	<input type="checkbox"/>	<input type="checkbox"/> GRAB <input type="checkbox"/> EWI <input type="checkbox"/> BACT
1. Analysis:		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL Ice Frozen
2. Analysis:		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL Ice Frozen
3. Analysis:		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL Ice Frozen
4. Analysis:		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL Ice Frozen
5. Analysis:		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL Ice Frozen
6. Analysis:		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL Ice Frozen
7. Analysis:		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL Ice Frozen
8. Analysis:		0.45µ Filtered HNO ₃ H ₂ SO ₄ H ₃ PO ₄ HCL Ice Frozen
Sediment	<input type="checkbox"/>	SED-1
Analysis:		Preserved: None Other:
Benthic Chl-a	<input type="checkbox"/>	Sample Method: C=Core H=Hoop T=Template N=None
<input type="checkbox"/> Composite at Lab <input type="checkbox"/> AFDW <input type="checkbox"/> Visual Est. <50		Sample Location: R=Right C=Center L=Left
Transect: A - B - C - D - E - F - G - H - I - J - K -		
Phytoplankton Chl-a	<input type="checkbox"/>	D1 Filtered: _____ mL D2 Filtered: _____ mL
Phytoplankton CNP	<input type="checkbox"/>	CN Filtered: _____ mL P Filtered: _____ mL
Algae	<input type="checkbox"/>	<input type="checkbox"/> PERI-1-MOD <input type="checkbox"/> PERI-1 <input type="checkbox"/> OTHER:
Macroinvertebrates	<input type="checkbox"/>	<input type="checkbox"/> MAC-R-500 <input type="checkbox"/> OTHER: # of Jars:
Field Measurements	Time: (24 hr)	Field Assessments (additional forms)
Water Temp: _____ °C	Air Temp: _____ °C °F	<input type="checkbox"/> Photos <input type="checkbox"/> Data Logger <input type="checkbox"/> Aquatic Plant Tracking
Bar. Pressure: _____	SC: _____ uS/cm	<input type="checkbox"/> AQPVA <input type="checkbox"/> Total Discharge <input type="checkbox"/> SAM (Sediment Assess)
pH: _____ DO: _____ mg/L	Turbidity: _____ NTU	<input type="checkbox"/> EMAP <input type="checkbox"/> Bacteria <input type="checkbox"/> NRCS (Riparian Assess)
Turbidity: <input type="checkbox"/> Clear <input type="checkbox"/> Slight <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque		<input type="checkbox"/> BEHI <input type="checkbox"/> Greenline <input type="checkbox"/> HAM (Habitat Assess)
Flow: _____ ft ³ /sec (<input type="checkbox"/> Dry Bed <input type="checkbox"/> Stranded Pools)		<input type="checkbox"/> SUM <input type="checkbox"/> Wetland <input type="checkbox"/> Other:
<input type="checkbox"/> Meter <input type="checkbox"/> Float <input type="checkbox"/> Gage # _____		<input type="checkbox"/> Only Transect F Total Site Length _____ m
<input type="checkbox"/> ADCP <input type="checkbox"/> Visual Est.		Transect Length _____ m Average Wetted Width _____ m
Calibration Dates	Meter type: _____	SC: _____
		pH: _____
Chemistry Lab Information		
Lab Samples Submitted to: _____	Account #: _____	Term Contract Number: _____
Invoice Contact: _____		
Contact Name & Phone: _____		EDD <input checked="" type="checkbox"/> Format: MT-eWQX Compatible
1) Relinquished By & Date/Time: _____	1) Shipped By: <input type="checkbox"/> USPS <input type="checkbox"/> Hand <input type="checkbox"/> FedEx/UPS	1) Received By & Date/Time: _____
2) Relinquished By & Date/Time: _____	2) Shipped By: <input type="checkbox"/> USPS <input type="checkbox"/> Hand <input type="checkbox"/> FedEx/UPS	2) Received By & Date/Time: _____
Lab Use Only - Delivery Temperature: Wet Ice _____ °C Dry Ice _____ °C		

TOTAL DISCHARGE – FLOW METER

Place Site Visit Label Here

Total Discharge – Flow Meter

Date: _____ Personnel: _____

Waterbody: _____

Reach: EMAP layout Nearest Transect (A-K): _____ Averaging Interval: _____

** circle units used **

	Distance from initial point (ft) or (m)	Depth (ft) or (m)	Velocity (ft/sec) or (m/sec)	Comments (Record LWE and RWE)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Total Discharge = _____ cfs

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TOTAL DISCHARGE – FLOAT METHOD

Place Site Visit
Label Here

Total Discharge – Float Method

Date: _____ Personnel: _____

Waterbody: _____

Nearest Transect (A-K): _____

Data Collected	
Average width: _____ (ft) or (m)	Travel time 1: _____ seconds
Average depth: _____ (ft) or (m)	Travel time 2: _____ seconds
Longitudinal Distance: _____ (ft) or (m)	Travel time 3: _____ seconds

* circle units used *

Comments: _____

Discharge calculations
Channel area = Average width x Average depth Channel area = _____ x _____ = _____ (ft ²) or (m ²)
Average travel time= (Sum of Travel times 1, 2, and 3) / 3 Average travel time= (_____ + _____ + _____) / 3 = _____ seconds
Velocity = Longitudinal distance ÷ average travel time Velocity = _____ ÷ _____ = _____ (ft/sec) or (m/sec)
Discharge = Channel area x Velocity Discharge = _____ x _____ = _____ (cfs) or (m ³ /sec)
Correction Factor = 0.85 Total Discharge = discharge x correction factor Total discharge = _____ x <u>0.85</u> = _____ cfs

Total Discharge = _____ cfs

conversions
1 m = 3.28084 ft
1 m ³ /sec = 35.31467 cfs

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APPENDIX B – EQUIPMENT HELP SHEETS

Users should always reference the appropriate equipment manuals. These sheets are designed to help personnel prepare and use equipment in the field.

All calibration and maintenance activities must be recorded in the meter's calibration log book (each meter has its own log book, log books should be kept with their meter). If a meter is calibrated or maintained, record the following information in equipment calibration/maintenance log book:

- Calibrated by: [first initial, last name] (e.g., J. Doe)
- Date of calibration: [MM/DD/YYYY]
- Maintenance activity(ies) performed (e.g., zero check, battery replacement, repairs, cleanings, and any corrective actions)
- Relevant information (e.g., batteries leaked and damaged circuitry)

NOTE: Users are required to reference the appropriate user manual when conducting all calibration and maintenance activities.

OTT MF PRO SET UP

An internal rechargeable battery powers the MF Pro. When fully charged, the battery has approximately 18 hours of use. Field crews are required to bring the power cord and must have a means of charging the meter while in the field. Do not store in direct sunlight or high temperature environments (closed vehicle in direct sunlight), the battery may overheat and cause a fire or explosion.

The sensor and cable connect to the handheld meter. Only hand tighten the sensor connector. Never use tools for tightening. Disconnect the sensor cable from the meter when not in field use.

If any error or FAIL is reported - Do not use the meter until the problem is resolved. See the manual's troubleshooting section to resolve the issue.

Before using the OTT MF Pro, users must:

- Charge the batteries fully
- Check the settings, and if necessary, change settings match the information listed in **Table B-1**
- Check for a firmware update
- Perform a Zero Check to verify that the sensor is reading correctly

After the field season or when the meter will not be used for 3 months or longer:

- Check the sensor and cable for any damage or fouling, clean as necessary
- Review calibration log books and determine if the meter needs maintenance or repairs
- Complete calibration and maintenance as necessary
- Wipe down and clean the case
- Make sure that the meter has all of its necessary equipment and materials: cables and charger, spare set screws, adjustable meter mount, user manual, and correct calibration log book.

The OTT MF Pro settings can be customized for several different discharge measurement methods. Field personnel must check the meter settings before collecting a measurement. DEQ's method require the

meter settings be set to those in **Table B-1** to ensure proper data collection for instream velocity and discharge (a project design may require different measurement methods, always refer to the project SAP).

Table B-1. OTT MF Pro setting options

Main Menu	Description/Reason
Velocity Calibration	Zero Check, follow user manual instructions
Filter Parameters	Fixed Period Avg. = 30s (default)
Wet/Dry Threshold	Default (20.00%)
Auto Zero Depth - Sub menu: On	If On, the meter will zero calibrate when the sensor is taken out of water; if "Off" the user will have to manually zero the sensor after 30 minutes of flow measurements.
EMI	Default (50 Hz.)
Clock	Sets Time and Date (Does not support Daylight Savings Time)
USB	Select Mass Storage for computer connection. CDC option is only used to update firmware.
Language	English
Units	Units for Velocity (ft/sec), Flow (ft ³ /sec), Depth (ft), and Area (ft ²)
Beeper	On/Off
Flow Calculation	Mid-Section Calculation
Station Entry	Fixed Station Entry, Top reference
Measurement Resolution	0.01

OTT MF PRO FIELD HELP SHEET

Field Check List

- | | |
|---|--|
| <input type="checkbox"/> Flow meter (MF Pro) | <input type="checkbox"/> Operating instructions/manual |
| <input type="checkbox"/> Sensor attachment and cable | <input type="checkbox"/> Top setting wading rod |
| <input type="checkbox"/> Extra screws for sensor attachment | <input type="checkbox"/> Field Tape Measure (10 th ft or m) |
| <input type="checkbox"/> Charger cord | <input type="checkbox"/> Bank Pins |
| <input type="checkbox"/> Adjustable meter mount | <input type="checkbox"/> Calculator |
| <input type="checkbox"/> Flow meter case | <input type="checkbox"/> Total Discharge Form |

Turn On Meter

Press and hold Power Button until beep is heard
Once the sensor is connected, Press "OK"

Turn Off Meter

Press Power Button and confirm power off

NOTE: Meter goes to sleep if it has not been used in a few minutes. The meter does not turn off unless the power button is pressed and power is confirmed to being turned off.

Collecting Stream Discharge in the Field

Refer to **Sections 7.0 and 7.1** when selecting a cross section and collecting discharge data.

Real-Time Velocity Measurements

Select **Real-Time** to collect real-time velocity:

1. Set filter mode to "FPA" and set the fixed period averaging time to 30 seconds
2. Wait 30 seconds then record the average velocity on the total discharge form

3. Repeat steps 1-3 at all stations along the cross section

Ott MF Pro Real-Time options include:

Capture: Stores the velocity information in the memory until the user exits the Real-Time mode.

Clear: Erase the last captured information or all of the captured information that has not been saved.

Save: Saves the captured information to a file. Name file as necessary.

Settings: Change Real-Time settings if needed (FPA vs. RC filter modes).

Files: Views the saved data.

Profiler Velocity Measurements

Select **Profiler Menu** to collect and record all stream discharge information:

1. Sampler: Enter in user initials
2. Choose "Stream"
 - a. Name: Use Site ID from Site Visit Form
 - b. Stage Reference: If none is available press "Enter"
3. Stream width
 - a. "Enter Stream width from tagline zero": enter the distance along the tape at the left wetted edge
 - b. "Enter tagline offset": enter the distance along the tape at the right wetted edge
 - c. "Enter desired number of stations": refer to **Table 7-2**
4. Station Page
 - a. Edge/Obstructions: Where are you at in the cross-section?
 - i. Left Edge of Water (wetted edge)
 - ii. Right Edge of Water (wetted edge)
 - iii. Open Water
 - b. Distance to Vertical: The location of the next reading.
 - c. Set Depth: How deep is the water?
 - i. Edge of water must always be "0"
 - d. Measure Velocity: Measures water velocity
 - i. Edge of water at "0" depth will always have a velocity of "0".
 - ii. Choose the number of points that will be collected on the vertical at that station (one depth method if total depth <2.5 ft, two depth method if total depth is .2.5 ft).
 - iii. Meter will collect velocity, wait 30 seconds
 - iv. Press "Main" to go back to the Station screen
 - e. Press "Next" to go to the next station
5. Repeat Station Page as necessary
6. Save Data and Exit: Name file with Site Visit Code number

To Insert or Delete a Station

"Prev", "Next", "Ins", and "Del" options are shown at the bottom of the display on the Station screen. Use "Prev" and "Next" to navigate to a previous or subsequent station. Use "Ins" and "Del" to insert or delete a station.

Example: to add a station between station 3 and 4, select "Prev" and push "OK" until the display shows information from station 3. Select "Ins" and push "OK" – the instrument will add a new station and name it station 4, all subsequent stations will be renamed automatically.

To View Data on Meter

Return to main menu and select Profiler → File → Files are named by: Time Started, Date (MM.DD), File Name. (No year is recorded.)

How to Record

Record the calculated discharge on the Site Visit Form and mark “meter”. Even when using the OTT in “Profiler”, record distance, depth, and velocity measurements on a Total Discharge Form and check “Total Discharge” on the Site Visit Form.

MARSH MCBIRNEY SET UP

Two D batteries power the Marsh McBirney. The battery compartment is located at the bottom of the meter. To change the batteries, unscrew the three screws on the bottom cover, replace the batteries, and reinstall the bottom cover. Brand new alkaline batteries have approximately 25-30 hours of continuous use. Do not store in direct sunlight or high temperature environments (closed vehicle in direct sunlight).

The sensor cable is attached to the bottom of the meter. It does not need to be disconnected unless it needs to be replaced. The sensor needs to be checked before each field season using a “zero check” and can be calibrated following the “zero adjust” procedure if it is not reading ± 0.05 ft/sec during the zero check.

Before using the Marsh McBirney, users must:

- Check battery power and replace as needed
- Set up Fixed Period Average (FPA)
 - Press the ↑ and ↓ keys at the same time to set FPA
 - Press the ↑ keys to read appropriate average (5 sec. for zero check, 30 sec. for field use)
- Set up Units
 - Press the On/C and OFF keys at the same time to set units and beeper
 - FT/S or M/S
 - No beeper or with beeper (indicated by beeper symbol in bottom right)
- Zero Check
 - Clean sensor with soap and water (Do not use hydrocarbon solvents)
 - Set FPA to 5 sec.
 - Fill 5-gallon bucket with water,
 - Place sensor in bucket of water (minimum 3” away from side and bottom)
 - Wait 10-15 min (Water must not have movement)
 - Flow meter zero stability is +/- 0.05 over a 5 sec.
- Zero Adjust (if flow meter zero stability is outside +/- 0.05 over a 5 sec.)
 - Set up as for Zero Check
 - Press STO and RCL buttons at the same time, number 3 will display
 - Press down key to count down from 3 – 2 – 1, number 32 will display
 - The unit will count down from 32 to 0 and turn off.

After the field season or when the meter will not be used for 3 months or longer:

- Check the sensor and cable for any damage or fouling, clean as necessary
- Review calibration log books and determine if meter needs maintenance or repairs
- Complete zero check/zero adjust and maintenance as necessary

- Remove batteries
- Wipe down and clean the case
- Make sure that the meter case has all of its necessary equipment and materials: manual, sensor, meter, key function summary sheet, extra batteries

MARSH MCBIRNEY FIELD HELP SHEET

Field Check List

- | | |
|--|--|
| <input type="checkbox"/> Flow meter (Marsh McBirney) | <input type="checkbox"/> Bank Pins |
| <input type="checkbox"/> Sensor attachment | <input type="checkbox"/> 2 D batteries |
| <input type="checkbox"/> Flow meter case | <input type="checkbox"/> Screwdriver |
| <input type="checkbox"/> Top setting rod | <input type="checkbox"/> Operating instructions/manual |
| <input type="checkbox"/> Field Tape Measure (10 th ft or m) | <input type="checkbox"/> Total Discharge Form |
| <input type="checkbox"/> Calculator | |

NOTE: Always bring extra batteries and a screwdriver to replace batteries in the field.

Fixed Point Average

Use the “↑” and “↓” buttons to select 30 sec. This setting will collect velocity readings for 30 seconds and display the average velocity over that period.

Turn On Meter

Press “On/C”

Turn Off Meter

Press “Off”

Collecting Stream Discharge in the Field

Refer to **Sections 7.0 and 7.1** when selecting a cross section and collecting discharge data







1. Position sensor facing upstream, parallel to flow, and vertically level
2. Press the ON/C button to start a new 30 second recording interval
3. Wait 30 seconds then record the average velocity on the total discharge form
4. Repeat steps 1-3 at all stations along the cross section

If any error or FAIL is reported, do not use the meter until the problem is resolved. See manual for information on reported error types. If there is any concern that the velocity is not being correctly reported during the field season: go through the zero check and zero adjust procedures.









MARSH MCBIRNEY KEY FUNCTION SUMMARY

KEY FUNCTION SUMMARY

One-Key Functions

-  - Turns Unit ON. Clears the display and restarts the meter.
-  - Turns Unit OFF.
-  - Increments FPA, TC, and Memory Location.
-  - Decrements FPA, TC, and Memory Location.
-  - Alternates Between Recall and Real-Time Operating Modes.
-  - Stores Values In Memory.

Two-Key Functions

-   - Change Units, Turns Beeper ON/OFF.
-   - Alternates Between FPA and rC Filtering.
-   - Clears Memory.
-   - Initiates zero adjust sequence. Zero stability is ± 0.05 ft/sec.

1 FPA = Fixed Point Average

2 TC = Time Constant Filtering

Error Codes

- Error #1 Problem with sensor drive circuit. Check sensor disconnect.
- Error #2 Memory full error. Memory must be cleared before another reading can be stored.
- Error #3 Incorrect zero-adjust-start sequence. Reinitiate zero-adjust-start sequence.
- Error #4 Zero offset is greater than the zero adjust range. Repeat the zero-adjust procedure. If the error is still displayed, the unit needs servicing.
- Error #5 Conductivity lost or noise detected during zero adjust. Usually caused by the sensor being out of the water.

