New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB)

Standard Operating Procedure (SOP) for

Stream Flow Measurements

Approval Signatures

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1.0 Purpose and Scope

This procedure describes the process and equipment for measuring stream flow. Flow is used by SWQB staff to validate and calibrate programs that model flow; for determining if flow-based standards criteria are in effect when chemical data was collected; for loading calculations in TMDLs; and in models such as Stream Segment Temperature Models ("SSTemp"), used for estimating temperature load reductions.

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

Besides measuring flow, flow data can be obtained from numerous sources, such as USGS, New Mexico Office State Engineer("OSE"), local irrigation districts, and Colorado State gaging stations. Most commonly flow data is obtained from the USGS or New Mexico Office of the State Engineer websites: http://waterdata.usgs.gov/nm/nwis/current/?type=flow or http://meas.ose.state.nm.us/meas/home.jsp. Measurements from gages are generally accurate, with two exceptions: a stagnant pool sometimes forms around a gage stilling well, causing a positive reading when there is no flow; and, after, channel altering flows, gages may need recalibration. Therefore, regularly visiting gages, both physically and on the above-mentioned websites, is necessary to make sure the data they generate is accurate and suitable for use by SWQB staff. The operating agency may alter discharge ratings based on changes at the site, so use approved data if possible.

2.0 Personnel Responsibilities

The Program Manager coordinates with the Project Manager(s), and applicable staff to ensure quality data is collected, verified, and validated to support program commitments. The Program Manager will provide input on the scope and intent of the SOP as it pertains to the program's goals and objectives. The Program Manager will review SOP every two (2) years after revisions are made by the Subject Matter Expert and/or Quality Assurance Officer.

The Quality Assurance Officer ("QAO") is involved in the development and revision of this SOP to ensure the SOP meets the requirements of the SWQB's Quality Assurance Project Plan for Water Quality Management Programs (NMED/SWQB 2021). The QAO, will coordinate will applicable staff to determine if any revisions to this SOP are needed at a minimum of every two (2) years in accordance with SOP 1.1 for the Creation and Maintenance of SOPs (NMED/SWQB 2020). Pending the review and approval of the document, the QAO will ensure the SOP is accessible through the SWQB's SOP webpage.

The Subject Matter Expert ("SME") reviews the SOP every two (2) years and updates the SOP as the procedure or equipment changes in coordination with the QAO and Program Manager.

Personnel who conduct flow measurements, perform flow data verification and validation, or supervise those who do must be familiar with this SOP and sign the acknowledgment statement associated with this SOP.

Staff should have experience taking flow measurements in New Mexico streams, if their job duties require the collection of stream flow by measuring velocity with a current meter. Staff who conduct flow measurements by measuring water velocity with a current meter will receive training and perform

procedures described in this SOP under the supervision of an experienced staff member at least once before being permitted to take flow measurements unsupervised.

3.0 Background and Precautions

3.1 Background

The SWQB utilizes flow measurements to achieve the objectives of assessing the condition of New Mexico's waters. This procedure describes the process for determining stream flow by measuring stream cross-sectional area using a wading rod and tagline and measuring velocity using current meters. Data can be recorded on printed versions of either the Flow Sheet and Calculator or the Flow Field Sheet depending on staff preference. Digital recording is also an option when using advanced flow meters.

Two types of current meters are used by the SWQB to measure stream flow velocity. The first one is an OTT MF Pro, which is a digital current meter. Flow measurements are stored on the device and can be uploaded to a computer after fieldwork is completed. The second velocity meter commonly used is the Marsh – McBirney Flo-Mate 2000. This meter is more easily used when there are two people present to take measurements. One person will take the measurements while a second team member will need to use a tablet/laptop with the Flow Sheet and Calculator (excel file) or physical hard copy of the Flow Sheet and Calculator or Flow Field Sheet to record measurements. If the measurements are written on a physical hard copy of the Flow Sheet and Calculator or Flow Field Sheet, they will have to be transcribed onto the digital copy upon return to the office.

3.2 Procedural Precautions

This SOP is designed to be used in wadeable perennial streams. Site conditions or project-specific data collection objectives may necessitate the use of alternative field procedures not included in this SOP. The use of field methods to collect stream flow other that those presented in this SOP must be approved by the applicable Program Manager or QAO, and the alternative methods must be accurately documented.

3.3 Safety Precautions

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

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

Field staff should exercise their best professional judgement regarding all sampling conditions and whether to begin or continue traveling to a field site or conduct sampling. Field staff should not risk traveling to remote sites during weather events such as severe monsoon rainstorms or snowstorms and should not sample during nearby thunderstorms. Sampling should be rescheduled or delayed

accommodating for unsafe conditions. Field staff should always alert their supervisor on their sampling plan for the day and carry a cellphone in case of an emergency. Field staff should carry driving directions, a Global Position System ("GPS"), and a map of the area surrounding the site for navigating.

Refer to SWQB's Job Hazard Analysis ("JHA") and Field Safety Manual for further safety precautions when conducting field work.

4.0 Definitions

Bankfull – is defined as the point of incipient flooding or the elevation where flows overtop the active channel and spread across an adjacent active floodplain as constructed by the present stream in the present climate, and frequently inundated (Dunne and Leopold, 1978) at intervals of 1 to 2 years and represent the channel forming or maintenance flow.

Bankfull height – measurements are taken by measuring the distance from the water's surface to the bankfull tagline, leveled surveyor's rod or tape.

Bankfull Width – the distance between the bankfull stage on the left and right bank

Cubic feet per second ("cfs") – a cubic foot per second is an imperial unit / U.S. customary unit volumetric flow rate, which is equivalent to a volume of 1 cubic foot flowing every second.

Field Sampling Plan ("FSP") – a quality assurance project planning document which serves as the comprehensive record for each individual project. The FSP describes and details the sampling plan for a project.

Left Bank – the bank on the left as the observer faces downstream (in the direction of flow)

Left Edge of Water ("LEW") - The left edge of the wetted stream channel, facing downstream.

Program Manager- An individual within the SWQB that manages a program such as the Monitoring, Assessment, and Standards Section ("MASS"), Watershed Protection Section ("WPS") or Point Source Regulation Section ("PSRS").

Project Manager – An individual responsible for a specific project. This individual, in most cases, holds a different title within the organization. The Program Manager and Project Manager are not necessarily synonymous. The Project Manager may be the same individual as the Subject Matter Expert.

Quality Assurance ("QA") – An integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the SWQB.

Quality Control ("QC") – The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the SWQB; operational techniques and activities that are used to fulfill requirements for quality.

Quality Assurance Officer ("QAO") – An individual that is responsible for overseeing the development and implementation of all quality assurance procedures and processes within the SWQB including those

projects that receive support or funding from the SWQB. The QAO is also responsible for validating and verifying external data sets for potential use by the SWQB.

Quality Assurance Project Plan ("QAPP") – A formal planning document for environmental data collection activities that describes the data collection procedures and the quality assurance and quality control activities that must be implemented to ensure that the results are sufficient and adequate to satisfy the stated performance criteria.

Quality Management Plan ("QMP") – Establishes the principles, requirements, and practices necessary to implement the quality system for the SWQB's environmental data operations.

Right Bank – the bank on the right as the observer faces downstream (in the direction of flow)

Right Edge of Water ("REW")- The right edge of the wetted stream channel, facing downstream.

Sampling Analysis Plan ("SAP") – a planning document which details the procedural and analytical requirements for a one-time or time-limited project. A SAP must meet the quality requirements for any project funded by the EPA under which environmental measurements are to be taken. The SAP basically combines a FSP and QAPP into one document.

Standard Operating Procedure ("SOP") – A document that lists the steps that should be completed when performing a task.

Subject Matter Expert ("SME") – A person who is familiar with the purpose and procedure for accomplishing a task. The SME may hold another title within the organization.

Surface Water Quality Information Database ("SQUID") – The SWQB database for storing, retrieving and reporting environmental results which include laboratory results, field observations, biologic assemblage data, long-term datasets ("LTD") summary data, stream habitat/geomorphic data and their associated monitoring locations.

5.0 Equipment and Tools

- Field Form
    - Flow Sheet and Calculator
    - Flow Field Sheet
- Flow meter
    - Marsh-McBirney Flo-Mate 2000
    - Ott MF Pro (Digital Reading)
- Bank pins
- Measuring Tape (decimal feet)
- Wading rod
- Pencils

The velocity meters used by the Bureau are manufactured by:

Marsh-McBirney
Flo-Mate 2000 Portable Flowmeter
Phone: 800.368.2723 or 800.635.1230 (24/7 Technical Support)

Email: hachflowservice@hach.com
Internet: http://www.marsh-mcbirney.com/

Hach Hydromet (aka OTT MF Pro)
5600 Lindbergh Drive
Loveland, CO 80538
Phone: 970.9669.3050
Email: sales@hachhydromet.com
Internet: www.hachhydromet.com

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

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

6.0 Step-by-step Process Description

For planning and logistical purposes, it is recommended to review the most up to date survey's FSP to confirm planned flow sampling stations. SWQB staff often use the SWQB Mapper (https://gis.web.env.nm.gov/oem/?map=swqb) for visual representation of SWQB flow sampling stations, surface flow gaging stations and ancillary data in support of sampling efforts. SWQB staff will use online sources such as, USGS, New Mexico OSE, local irrigation districts, and other state agency's real-time gaging station locations to obtain flow measurements. This aids to reduce the amount of flow measurements needed.

The SWQB Monitoring Team typically will select either the Marsh-McBirney or the OTT MF Pro flow meter when collecting flow measurements. It is recommended to bring extra batteries for the Marsh-McBirney and ensure that it will turn on before leaving for the field. Consult the manual for instructions on battery installation. For the OTT MF Pro, ensure that is has been charged and has sufficient power to conduct stream measurements before leaving for the field and if going out for an extended trip be sure to bring the charging cord. Consult the manual for instructions on battery installation and charging.

The procedure for the collection of stream flow measurements collected by measuring water velocity with a current meter are described in section 6.1 through 6.4. Section 6.5 describes how to calculate flow using measurements taken in the field by manual hand calculation and Section 6.6 describes how to calculate flow by entering field measurements into the SWQB Flow Sheet and Calculator excel spreadsheet. Section 6.7 describes alternative methods for the collection of flow measurements when current meters cannot be used or an alternative methods is needed.

6.1. Flow Measurement Location Selection for Flow Velocity Meter Measurements

A cross section location needs to be established when using current meters to measure stream velocity for flow measurements. The measurement cross section should be located in a straight run or gentle riffle. Do not place a cross section through a pool. Where the length of straight run is limited, the length upstream from the cross section should be twice the downstream length.

- The channel should be as free of flow disturbances as possible. Try to avoid areas with sudden changes in stream width, contributing side streams, outgoing side streams or obstructions such as pipes, boulders, or logs. Divided channels can be used by calculating the flow in each channel and summing.
- Measurement location should not be located where there is severe undercutting of banks and vertical banks.
- Depths need to be at least 0.15 ft and should ideally be greater than 0.5 ft, and velocities mostly greater than 0.5 ft/s. If depths are less than 0.15 feet, use the timed-fill method described in Section 6.7.1, or visually estimate based on channel dimensions and velocity.
- The flow should be laminar (i.e., free of swirls, eddies, vortices, backward flow, or dead zones). Avoid areas immediately downstream from sharp bends or obstructions.
- The ideal streambed is "U" shaped, stable and free from large rocks, weeds and protruding obstructions that would create turbulence or interfere with the current meter. The investigator may modify the channel by removing cobbles that interrupt flow, or to temporarily make the channel deep enough to measure. Alternatively, consider using the timed-fill method, which is more accurate at very low flows.
- If necessary, build small dikes to keep water from flowing around the cross section. This is to keep all water flowing through the cross section and to prevent leaks into secondary channels (although choosing a better site is strongly recommended).

6.2 Set the Tagline for Flow Velocity Meter Measurements

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

6.3 Establish Cross Sectional Windows for Flow Velocity Meter Measurements

Measure the stream's wetted width and divide this width into partial sections (windows). Divide the cross section into windows so that each represents no more than 5% of the total streamflow. A high-quality measurement will usually take at least 25 windows to adequately characterize the cross section. However, it is possible to decrease the number of windows if the wetted width is small or if the velocity profile is consistent. See Table 1 for the minimum number of windows per stream width based on EN-ISO 748 standards. Measuring more than the minimum number of windows is encouraged for more accurate measurements; however, the spacing between measurements should be no less than 0.25 ft.

Table 1. Minimum number of stations in relation to waterway width based on EN-ISO 748 standards.

Stream Width (ft)	Number of Windows
< 1.6	5 to 6
> 1.6 and < 3.3	6 to 7
> 3.3 an < 9.8	7 to 12
> 9.8 and < 16.4	13 to 16
> 16.4	22 or more

The table above serves only as a guideline for setting cross sectional windows. As necessary, adjust for changing depths and velocities, increase or decrease individual window widths. The goal is to have equal flow through each window, not equal window widths. Windows should also be spaced to account for

sudden changes in velocity, turbulence, or depth. Attempt, as best possible, to completely characterize the channel cross section. In addition, the first and last flow measurements should be made as close to the REW and LEW as possible.

If a cross section cannot be established that is free of boulders or other debris, these should be noted on the field form as they may influence measurements. If these obstructions are upstream of the cross section and create areas of no flow, vertical measurements must be made just outside and inside the boundaries of the zero flow area (this is to prevent an incorrect attribution of streamflow behind the obstruction). If the obstructions create dry areas in the cross section, treat them as edge measurements (it is possible the edge depth may not be zero in these cases). The OTT MF pro has the ability to document and account for obstructions during the measurement. Make every attempt to avoid obstructions in the cross section or remove them and let flow stabilize for at least one minute before proceeding with the measurement.

Occasionally, velocities measured in still waters, near the water's edge, or at obstructions will be negative (moving upstream). Record negative values as reported by the instrument and add a comment to the measurement notes.

6.4 Velocity and Depth Measurements Collected with Flow Velocity Meters

If the channel dimensions are needed for modeling purposes (SSTEMP, etc.) and are not otherwise captured by physical habitat measurement collection (NMED/SWQB 2019), record the left and right bankfull height and intermediate out of bank measurements on the "flow form" (Flow Sheet and Calculator or Flow Field Sheet).

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

Remove the top-setting wading rod from its carrying case and attach the sensor from the flow meter to the sensor mount and tighten the thumbscrew. Adjust the cable linking the sensor to the meter to avoid unnecessary slack and interference with the sensor and wading rod mechanism. Unlike the other flow meters described in this SOP, the MF Pro can remain attached to the top-setting wading rod.

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

6.4.1 Marsh-McBirney Operation (Attachment 1)

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

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

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

Positioning the Current Meter (March-McBirney)

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

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

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

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

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

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

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

6.4.2 Hach Hydromet / OTT MF Pro Operation (Attachment 2)

Before leaving the lab, confirm that the battery is charged. Consult the manual for instructions on battery installation and charging. Pages 27 and 28 of the Operating Instructions (Attachment 2 should also be consulted to become familiar with the user interface. Unlike the other flow meters described in this SOP, the MF Pro can remain attached to the top-setting wading rod. For transportation of the MF Pro, cover the meter with a bubble-wrap sleeve.

Also, the sensor on this instrument measures depth electronically so reading depth from the hexagonal portion of the wading rod is not required (although manual verification is not discouraged).
When taking flow measurements stand several inches downstream from the tagline to avoid disrupting the flow near the meter. For small streams, where your feet would occupy a significant portion of the wetted perimeter, stand on the bank, entirely out of the water. Ensure that the wading rod is vertical and that the current meter is facing upstream directly into the flow.

To operate the MF Pro, push the power button on the meter (see Attachment 2, page 7) while the sensor is out of the water, until an audible beep is heard. The meter will perform a self-test. When it is complete push OK and push the main menu button to go to the main menu. The meter goes into a sleep mode and automatically shuts off when not in use.

1. In the main menu, select “Profiler”.
2. Enter the Operator’s name and press OK.
3. Select “Profile” and press OK
4. Enter a stream name (or sampling station name (abbreviation recommended)) using a maximum of 11 characters or leave the field blank and press OK. Entering a stream or sampling station name before taking measurements is optional and saves progress if the complete flow measurement is interrupted, the field identifies the file name and is helpful for file management.
5. Enter zero for the stage reference and press OK.
6. Select Edge/Obstruction left and press OK. For vertical banks, record a depth and assign a roughness factor of 0.5. The velocity will be set to zero automatically for Edge measurements.
7. Select “Next” on the menu screen.
8. Select Open Water and press OK. (Open Water is the default option and is automatically selected if “Edge/Obstruction” is not assigned for an individual window). Select “Edge/Obstruction” if the vertical location marks an island, dry boulder, or other obstruction and continue the measurement (steps 9-13), then proceed to the opposite side of the obstruction, establish another “Edge/Obstruction” vertical and continue the measurement (steps 9-13).
9. Select “Distance to Vertical” from the menu and press OK. Double-check tag line reading before moving on to next step. A diagram will appear on the sensor screen showing the position on the tagline for the window.
10. Select “Set Depth” and move the sensor to the lowest position possible on the wading rod and look for the max depth reading on the screen. When it stabilizes, press OK (The offset from the bottom has been pre-programed into the sensor).
11. Select “Measure Velocity” from the menu and select 1 or 2 point, depending on the max depth (see Positioning the Current Meter) and press OK.
12. Set the sensor at the depth indicated on the sensor screen and press “Capture”. When the reading has stabilized or the 30 second integration period has elapsed, press OK.
13. Press “Next” on the menu screen.
14. Repeat steps 8 to 13 until the opposite edge of water is reached and then repeat step 6 (selecting “Edge/Obstruction”) for REW.
15. Select “Channel Summary” from the menu and record the flow for the station on the field sheet for the station and press OK.
16. Select “Save File and Exit” from the menu and press OK.
17. Name the file using a maximum of 11 characters. A date will be appended to the file so it is unnecessary to include one in the filename. Press OK.

The meter is able to store a maximum of 10 files with up to 32 windows each.

Upon return from the field, files can be downloaded to PCs via the USB port. Connect the MF Pro to the PC. Turn on the MF Pro and set the meter to mass storage mode. On the PC, drag files from the MF Pro folder to the project folder. The files are saved as notes. Ensure that the note file name for each sampling event can be attributed to flow measurement location. These files should also be copied into Excel and saved as an Excel file that are traceable to flow location and raw data file. The flow files can be handled as Microsoft Excel files for use by the SWQB.

Downloaded files should be saved to the appropriate survey folder in MASS Monitoring Team Survey folders (or applicable project) on the NMED network.

Be sure to examine the MF Pro files for any errors. Errors, such as, tag line values not in sequential order have been known to occur with the older OTT MF Pro units. If errors do occur, it may be necessary to enter values into the Flow Sheet and Calculator spreadsheet for correct flow measurement.

After files are offloaded from the MF Pro, the files should be deleted from the MF Pro in order to save memory and prevent the loss of new files.

6.5 Calculate Flow Manually

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

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

$$\text{Window width} = \left(\frac{8-5}{2}+\frac{5-3}{2}\right) = \left(\frac{8-3}{2}\right) = 2.5 \text{ feet}$$

Calculate the flow through each window by multiplying the window width by the water depth to get area, then multiply the area by the velocity (velocity by cross-sectional area) to get flow. Table 2 illustrates these data and results. Example of velocity by cross-sectional area calculations for determining flow using Marsh McBirney shown below.

Table 2. Manual Calculations for Stream Flow

	Notes	Tag Line Distance	Width (ft)	Depth (ft)	Area (ft^2)	Velocity (ft/s)	Discharge (CFS)
	LBF				←Enter Bankfull Height Here		
1	LEW	1.8	0.35	0	0.00	0	0.00
2		2.5	0.85	0.3	0.26	1.29	0.33
3		3.5	1.00	0.4	0.40	1.79	0.72
4		4.5	1.00	0.4	0.40	2.27	0.91
5		5.5	1.00	0.5	0.50	1.88	0.94
6		6.5	1.00	0.5	0.50	2.52	1.26
7		7.5	1.00	0.6	0.60	2.51	1.51
8		8.5	1.00	0.6	0.60	1.86	1.12
9		9.5	1.00	0.4	0.40	2.34	0.94
10		10.5	1.00	0.4	0.40	2.68	1.07
11		11.5	1.00	0.7	0.70	2.52	1.76
12		12.5	0.75	0.5	0.38	2.82	1.06
13		13	0.50	0.5	0.25	2.04	0.51
14		13.5	0.50	0.8	0.40	2.44	0.98
15		14	0.75	0.8	0.60	2.28	1.37
16		15	1.00	0.8	0.80	1.66	1.33
17		16	1.00	0.8	0.80	2.15	1.72
18		17	1.00	0.7	0.70	1.58	1.11
19		18	1.25	1	1.25	0.89	1.11
20		19.5	1.25	0.7	0.88	1.19	1.04
21		20.5	1.00	0.5	0.50	1.65	0.83
22	REW	21.5	0.50	0	0.00	0	0.00
23							
24							
25							
26							
27							
28							
29							
30							
	RBF				←Enter Bankfull Height Here		
	TOTALs/AVR		19.70	0.54	11.31	1.83	21.59
			ft (total)	ft (average)	ft^2 (total)	ft/s (average)	cfs (Total)

COMMON NOTES: LBF = Left Bankfull, LEW = Left Edge of Water, B = Rock, THAL = Thalweg, REW = Right Edge of Water, RBF = Right

6.6 Calculate Flow Using the SWQB Flow Sheet and Calculator Spreadsheet

The Flow Sheet and Calculator excel spreadsheet associated with this SOP is located on SWQB SOP webpage (https://www.env.nm.gov/surface-water-quality/sop/ and can be used to calculate total flow. Transfer data from hard copy Flow Sheet and Calculator or the Flow Field Sheet to the spreadsheet and calculate the total flow. Save a copy of the completed spreadsheet for each station where flow was measured in the survey/project binder or applicable project folder. Directions for data input are detailed in the Flow Sheet and Calculator spreadsheet.

6.7 Alternate Flow Measurement Methods

Velocity meters are the most common tool used by the SWQB to measure stream velocity in order to determine flow. At times, however, these meters may not be available, or stream conditions may require additional or alternate methods.

6.7.1 Timed-fill

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

6.7.2 Rating Curve

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

7.0 Data and Records Management

Save all electronic forms in the proper project file on the shared network location. Save any hard copy field forms in the project binder located in the SWQB office.

Flow event data can be imported into the SQUID database by entering flow data into the macro-enabled Stream and River Field Form (SOP 8.2) and utilizing the macro-enabled SLD Submittal Form or by manually entering the data. Flow data is most commonly collected with water chemistry and field data and uploaded via the macro-enabled upload method.

7.1. Upload Flow Measurements to SQUID using Stream and River Field Form

1. Using the Stream and River Field Form navigate to page 2 “Streamflow Measurement” and select the streamflow measurement method used from the drop down.
2. Enter any flow measurement comments.
3. Enter the flow in CFS.
4. Save and publish the field form if when data entry is complete.
5. Refer to SOP 8.2 Chemical Sampling and follow instructions in 7.0 Data and Records Management and 7.1.2 Upload Chemical Sampling Event Into SQUID Using Macro-Enabled SLD Submittal Form.

7.2 Manually Adding a New Flow Sampling Event to a Sampling Station

1. Navigate to the applicable project folder in SQUID by selecting the “project” tab on the navigation bar, then selecting the appropriate folder icon with a green arrow under the “View/Add Monitoring Locations” column.
2. All stations that have been added to the selected project folder will should appear. To upload a flow sampling event to a particular station, select the folder icon with a green arrow under the “sampling events” column for that particular sampling station.
3. In the Sampling Events page, select “add a new sampling event” in the top navigational bar. Select a sampling event type from the drop-down menu. For flow sampling event data select “FLOW.” Select the “add new sampling event.”
4. A sampling event details box will appear. Populate the fields in the general tab with the appropriate data. Flow measurements should be in cfs. Result value type should be “actual” if the flow was measured, “estimated” if flow was visually estimated, and “calculated” if flow was calculated by adding or subtracting values from tributaries for which a flow measurement exists. Result status should “preliminary” until the data has been through the validation and verification process. Flow sampling method should match the method used.
5. Once all data has been entered, select “save.” The flow sampling event should appear under the monitoring location sampling events.

8.0 Quality Control and Quality Assurance

The SWQB controls the quality of the flow measurements collected by using standardized methods that are documented in this SOP. All personnel who conduct flow measurements, perform flow data verification and validation, or supervise those who do must be familiar with these protocols, sign the acknowledgment form associated with this specific SOP and collect data in accordance with the procedures as they are defined in this SOP. In addition to standardized methods, proper training of field personnel represents a critical aspect of meeting the data quality objectives in order to fulfill the goals of the SWQB's QAPP (NMED/SWQB. 2021).

The SWQB implements QA/QC through the training of the procedures detailed in this SOP for collecting stream velocity measurements by current meter. Any SWQB staff who conduct flow measurement collections by measuring stream velocity with current meters with less than one field season of flow measurement collection, or who have not been approved for flow measurement collection, are required to receive training and be supervised by trained staff for all aspects of flow measurement collections. Any staff who provide training in the field must have completed at least one field season of flow measurement collections by current meter with the SWQB and have approval from the Monitoring Team Supervisor. Once field training has occurred and all aspects of flow measurement collections have been observed as correct, personnel may conduct unsupervised flow measurement collections. The training will be documented and filed by Monitoring Team Supervisor. The trainee may request documentation of training from the Monitoring Team Supervisor if desired. The documentation of training may be requested up to 3 months after training, after 3 months it is at the discretion of Monitoring Team Supervisor. The trainee will be approved for flow measurement collections until next SOP revision. This process will ensure comparability and accuracy of data used for water quality assessments, refinement of water quality standards and TMDL development.

8.1 OTT MF Pro and Marsh-McBirney Zero Velocity Check

SWQB annually checks the OOT MF Pro and March-McBirney velocity meters to determine if they are operating correctly. Annual velocity checks and any needed calibrations or offsets will be saved and tracked in the SWQB monitoring equipment folder on the shared drive.

1. Fill a bucket with water. The bucket must be non-metallic and at least 8 inches. The water depth must be at least 6 inches deep.
2. Put the sensor in the center of the bucket so that it does not touch the sidewall or the bottom of the bucket.
3. Let the bucket become still.
4. Let the velocity reading stabilize.
5. Confirm the meter is measuring a velocity of zero.
6. If the meter is not measuring zero, follow the manufactures manual to correct/offset.
7. If corrections or offsetting does not measure a zero value in the bucket, return to manufacture for repairs/calibration.

9.0 Related Forms

Attachment 1 Marsh-McBirney Flo-Mate 2000 Portable Flow Meter Operating Instructions
Attachment 2 Hach Hydromet/ OTT MF pro Operating Instructions
Attachment 3 Top Setting Wading Rod

Flow Sheet and Calculator
Flow Field Sheet

10.0 Revision History

Revision 0. March 21, 2011. Original modified from SOP 2007

Revision 1. April 7, 2015. Added information on Hach Hydromet Flow Meter; edits to language regarding number of windows required for various stream widths.

Revision 2. March 21, 2022. Format change to SOP; Updated format to be consistent with SOP 1.1. Major updates to Personnel Responsibilities, Data and Records Management, Create New Sampling Event in SQUID, Uploading Excel Data to a Sampling Event, Viewing Uploaded Data in Excel, and Quality Assurance and Quality Control. Minor updates to Background and Precautions, Definitions, Equipment and Tools, Sample Process Description, Sample Processing, Removed Price Current Meter, and References.
Miguel Montoya, QAO; Eliza Martinez, SME; Kris Barrios, Program Manager – MASS

11.0 References

Hach Hydromet. 2018. OTT MF pro Operating Instructions, Edition 7. Available at https://www.ott.com/download/ott-mf-pro-operating-instructions-1/

New Mexico Environment Department / Surface Water Quality Bureau (NMED/SWQB). 2019. Standard Operating Procedure 5.0 for Physical Habitat Measurements. Available at: https://www.env.nm.gov/surface-water-quality/sop/

New Mexico Environment Department / Surface Water Quality Bureau (NMED/SWQB). 2020. Standard Operating Procedure 1.1 Creation and Maintenance of SOPs. Available at: https://www.env.nm.gov/surface-water-quality/sop/

New Mexico Environment Department / Surface Water Quality Bureau (NMED/SWQB). 2021. Quality Assurance Project Plan for Water Quality Management Programs. Available at: https://www.env.nm.gov/surface-water-quality/protocols-and-planning

Attachment 1

Marsh-McBirney Flo-Mate 2000 Portable Flow Meter Operating Instructions

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

Assembly and Calibration

1. Remove sensor and a comfortable length of cable from the flow meter case. Attach the sensor to the top setting wading rod on the mounting shaft at the bottom and tighten the thumbscrew. Check to make sure the base of the wading rod is secure.
2. The unit should always power up in real time operating mode, as opposed to memory recall. The display should be set to Fixed Point Averaging (FPA), where the readings are stabilized by averaging velocities over a fixed period of time (the alternative is time constant filtering [rC]). Pressing the up and down arrows simultaneously will alternate between rC and FPA displays and the FPA display will show the letters FPA when you first switch over and afterwards will be indicated by the time period bar at the bottom of the display. The fixed period of time default is 40s and may be altered with the up or down arrows. SWQB uses 40s as its time period standard.
3. Calibrate the sensor at the beginning of each field season. To calibrate the sensor, first clean it with soap and water. If there are nonconductive coatings, such as oil or grease, errors may occur due to noise or conductivity loss. Do not use any hydrocarbon solvents for cleaning. Place the sensor in a 5-gallon bucket filled with water at least 3 inches away from the sides and bottom of the bucket (use the wading rod to hold it in the appropriate position). Wait 10 or 15 min to make sure that the water is not moving. Set the time period to 5s. The zero stability is ± 0.05 ft/s. In order to reset the zero, press STO and RCL at the same time while the sensor is still in the bucket (unmoved). The number 3 will display. Decrement the 3 to 0 with the down arrow. Then the number 32 will display and the unit will decrement itself to zero and turn off. It is now calibrated. Make sure you return the time period to 40s.

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

Error Messages

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

Attachment 2

DOC026.53.80211

OTT MF pro

07/2012, Edition 3

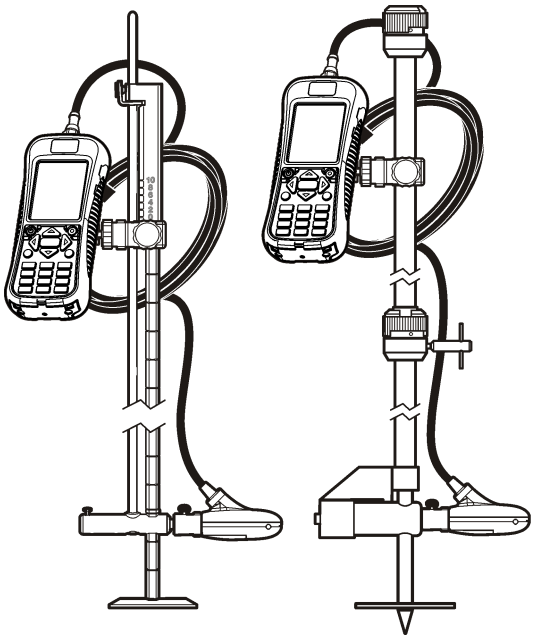
Operating Instructions

DOC026.53.80211

OTT MF pro

07/2012, Edition 3

Operating Instructions



Specifications

Specifications are subject to change without notice.

Sensor specifications

Specification	Details
Velocity measurement	
Method	Electromagnetic
Range	0 to 6.09 m/s (0 to 20 ft/s)
Minimum water depth	3.18 cm (1.25 in.)
Accuracy	±2% of reading ±0.015 m/s (±0.05 ft/s) 0 to 3.04 m/s (0 to 10 ft/s); ± 4% of reading from 3.04 to 4.87 m/s (10 to 16 ft/s)
Resolution	0.01 value < 100; 0.1 value < 1000; 1.0 value ≥ 1000
Zero stability	±0.015 m/s (±0.05 ft/s)
Material	ABS, glass filled
Enclosure rating	IP68
Dimensions (L x W x H)	11.9 x 4.3 x 6.3 cm (4.7 x 1.7 x 2.5 in.)
Cable material	Polyurethane jacketed
Cable lengths	1.5, 6.1, 12.2 and 30.5 m (5, 20, 40 and 100 ft)
Depth measurement	
Method	Diaphragm type: absolute pressure with single point calibration
Accuracy (static)	The larger of ± 2% of reading or ± 0.015 m (± 0.504 inches). Steady state temperature and static non-flowing water.
Range	3.05 m (0-10 ft)
Resolution	0.01 value < 100; 0.1 value < 1000; 1.0 value ≥ 1000

Portable meter specifications

Specification	Details
Pollution degree	2
Protection class	II
Charging temperature	0 to 40 ºC (32 to 104 ºF)
Operating temperature	–20 to 55 ºC (-4 to 131 ºF)
Storage temperature	–20 to 60 ºC (-4 to 140 ºF)
Enclosure rating	IP67
Battery life gauge	Five-segment bar graph
Battery type	Rechargeable lithium ion, 3.7 V, 4.2 Ah
Battery life	18 hours heavy typical day use[1]; 20 ºC (68 ºF)
Battery charger	External Class III power adapter 100–240 VAC, 50–60 Hz, 0.3 A input; 12 VDC, 1.0 A output
Dimensions (L x W x H)	21.8 x 9.3 x 5.3 cm (8.6 x 3.7 x 2.1 in.)

Specification	Details
USB connector	Type Mini-B, 5-pin, rated to IP67 when capped
Material	Polycarbonate with a thermoplastic elastomer (TPE) overmold

[1] Defined as 30 minutes of set up, six 1-hour periods of continuous use with an active sensor and the display at maximum brightness and 30 minutes of sleep mode between use periods, data download and power off.

User interface specifications

Specification	Details
Graphics display	Color, LCD 3.5" QVGA transflective (readable in direct sunlight)
Measurement resolution	0.01 value < 100; 0.1 value < 1000; 1.0 value ≥ 1000
Keypad	Alpha-numeric
Operating modes	Real time, profiling
Profile types	Stream, conduit
Conduit shapes	Circular, rectangular, trapezoidal, 2/3 egg, inverted 2/3 egg
Stream entries	Fixed, non-fixed stations
Noise rejection	User-selectable, 50 Hz or 60 Hz
Units of measure	Velocity: ft/s, m/s, cm/s, mm/s
	Flow: ft^3/sec, million gal/day, gal/day, gal/min, m^3/s, m^3/min, m^3/hour, m^3/day, liters/s, liters/min
	Depth: in., ft, m, cm, mm
Stream flow calculation	Mean-section or mid-section method
Diagnostics	Self test, keypad, display, event log
Conduit profiling methods	0.9 x Vmax, 0.2/0.4/0.8, velocity and level integrator, 2D
Stream profiling methods	1, 2, 3, 5 and 6 point (velocity method - USGS and ISO)
File types	Real-time, profiling, event log
Languages	English, French, Spanish, German, Italian, Dutch, Danish, Swedish, Chinese, Polish, Japanese, Korean, Portuguese, Slovak, Russian, Hungarian, Bulgarian, Romanian, Czech, Turkish, Finnish, Greek

General specifications

Specification	Details
Profiles	Data storage for up to 10 profiles with 32 stations per profile
Maximum number of real-time files	Three each with up to 75 readings captured by the user.
Firmware	The sensor and portable meter are field upgradeable via USB

General information

In no event will the manufacturer be liable for direct, indirect, special, incidental or consequential damages resulting from any defect or omission in this manual. The manufacturer reserves the right to make changes in this manual and the products it describes at any time, without notice or obligation. Revised editions are found on the manufacturer's website.

Safety information

NOTICE

The manufacturer is not responsible for any damages due to misapplication or misuse of this product including, without limitation, direct, incidental and consequential damages, and disclaims such damages to the full extent permitted under applicable law. The user is solely responsible to identify critical application risks and install appropriate mechanisms to protect processes during a possible equipment malfunction.

Please read this entire manual before unpacking, setting up or operating this equipment. Pay attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

Make sure that the protection provided by this equipment is not impaired. Do not use or install this equipment in any manner other than that specified in this manual.

Use of hazard information

⚠ DANGER

Indicates a potentially or imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

Indicates a potentially hazardous situation that may result in minor or moderate injury.

NOTICE

Indicates a situation which, if not avoided, may cause damage to the instrument. Information that requires special emphasis.

Precautionary labels

	This symbol, if noted on the instrument, references the instruction manual for operation and/or safety information.
	This symbol indicates the presence of devices sensitive to Electro-static Discharge (ESD) and indicated that care must be taken to prevent damage with the equipment.
	Electrical equipment marked with this symbol may not be disposed of in European public disposal systems after 12 August of 2005. In conformity with European local and national regulations (EU Directive 2002/96/EC), European electrical equipment users must now return old or end-of-life equipment to the Producer for disposal at no charge to the user. ***Note:*** *For return for recycling, please contact the equipment producer or supplier for instructions on how to return end-of-life equipment, producer-supplied electrical accessories, and all auxiliary items for proper disposal.*

Certification

Canadian Radio Interference-Causing Equipment Regulation, IECS-003, Class A:

Supporting test records reside with the manufacturer.

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numèrique de la classe A respecte toutes les exigences du Rëglement sur le matériel brouilleur du Canada.

FCC Part 15, Class "A" Limits

Supporting test records reside with the manufacturer. The device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions:

1. The equipment may not cause harmful interference.
2. The equipment must accept any interference received, including interference that may cause undesired operation.

Changes or modifications to this equipment not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at their expense. The following techniques can be used to reduce interference problems:

1. Disconnect the equipment from its power source to verify that it is or is not the source of the interference.
2. If the equipment is connected to the same outlet as the device experiencing interference, connect the equipment to a different outlet.
3. Move the equipment away from the device receiving the interference.
4. Reposition the receiving antenna for the device receiving the interference.
5. Try combinations of the above.

Product overview

The portable velocity system is used in the field, laboratory and municipalities. Turbulent, noisy and low flows can be measured with this system.

When the sensor is placed in flowing water, a magnetic field around the sensor creates a voltage proportional to the flow velocity. This voltage amplitude, which represents the rate of water flow around the sensor, is detected by electrodes in the sensor and processed by the sensor microprocessor. The processed signal is digitally transmitted through the sensor cable to the portable meter and the information is shown on the meter display. The system includes a portable meter, sensor with cable and accessories.

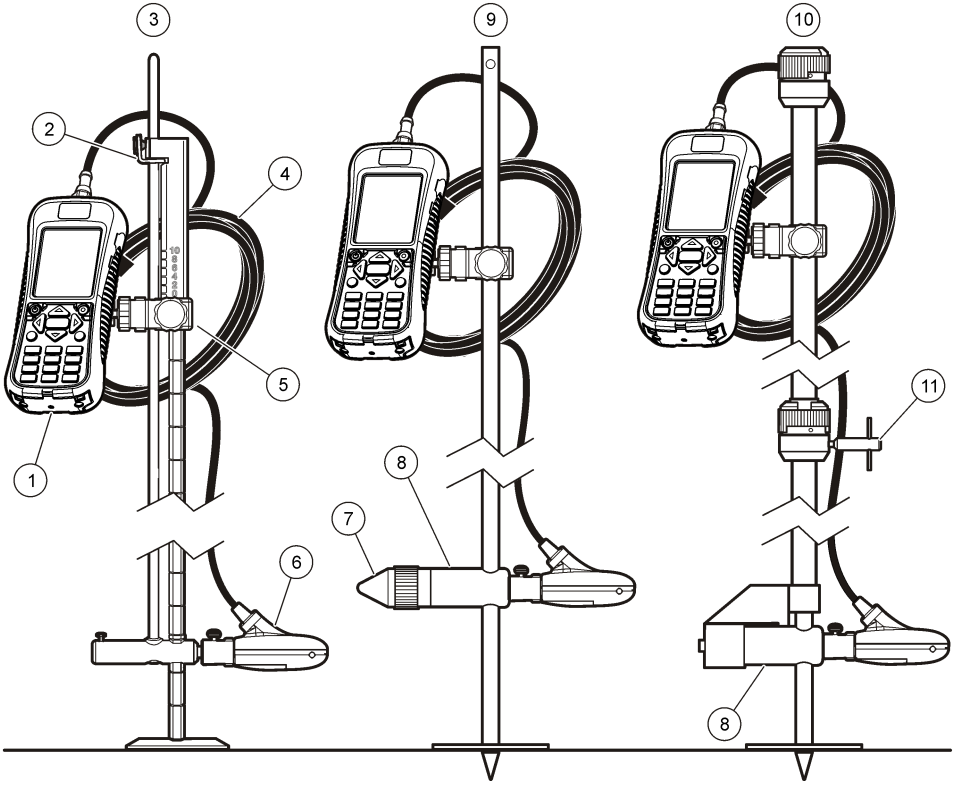
The meter and sensor get velocity information in conduits and streams. These measurements are important for calibration in municipal wastewater industries, as well as for developing and maintaining stage discharge relationship curves.

Two types of sensor are available: velocity-only and velocity plus depth. This manual covers both types of sensors. If information applies to a specified type of sensor, this fact is noted in the text.

System overview

An overview of the assembled system is shown in Figure 1 . Refer to the documentation supplied with the individual components or accessories for more information.

Figure 1 Assembled components

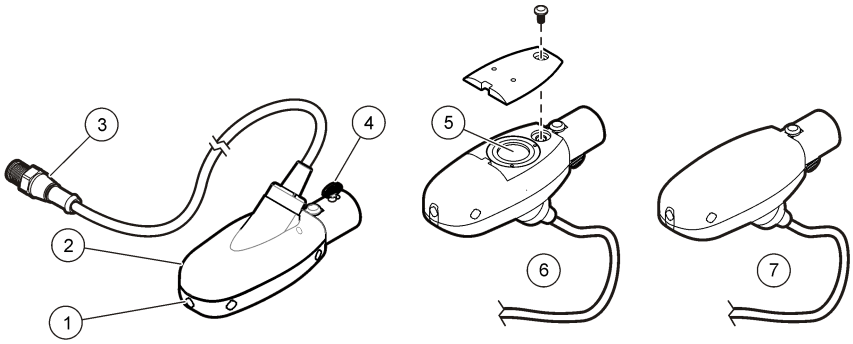


1 Portable meter	**7** Sensor height lock/release screw (optional accessory)
2 Sensor height lock/release device	**8** 20 mm/HERES wading rod adapter (optional accessory)
3 Top setting wading rod (optional accessory)	**9** 20 mm wading rod (optional accessory)
4 Sensor cable	**10** HERES wading rod (optional accessory)
5 Adjustable mount for portable meter	**11** Sensor height lock/release screw
6 Sensor assembly	

Sensor overview

Figure 2 shows the main sensor components. Instructions for how to attach the sensor on a standard or top-setting or HERES or 20 mm wading rod are supplied with the accessory.

Figure 2 Sensor components

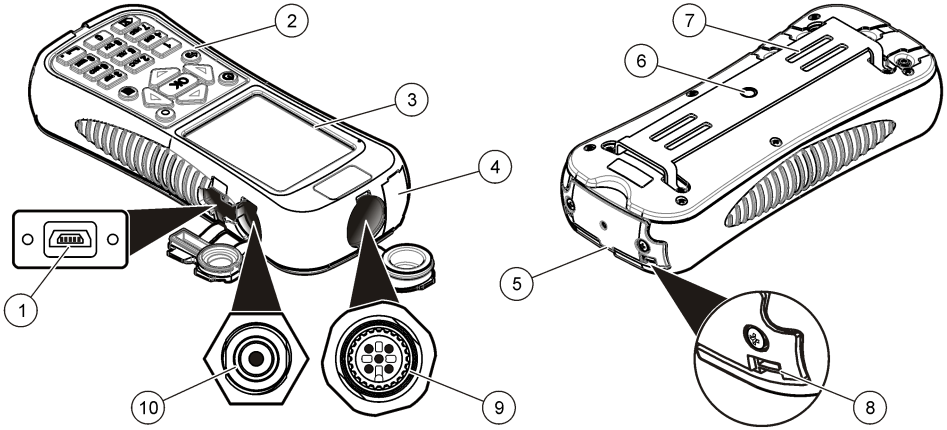


1 Sensor electrodes	**5** Pressure cell (sensors with depth option)
2 Sensor body	**6** Sensor with depth option
3 Sensor connection plug	**7** Sensor without depth option
4 Sensor attachment thumb screw	

Meter overview

Figure 3 shows the features of the meter.

Figure 3 Meter components

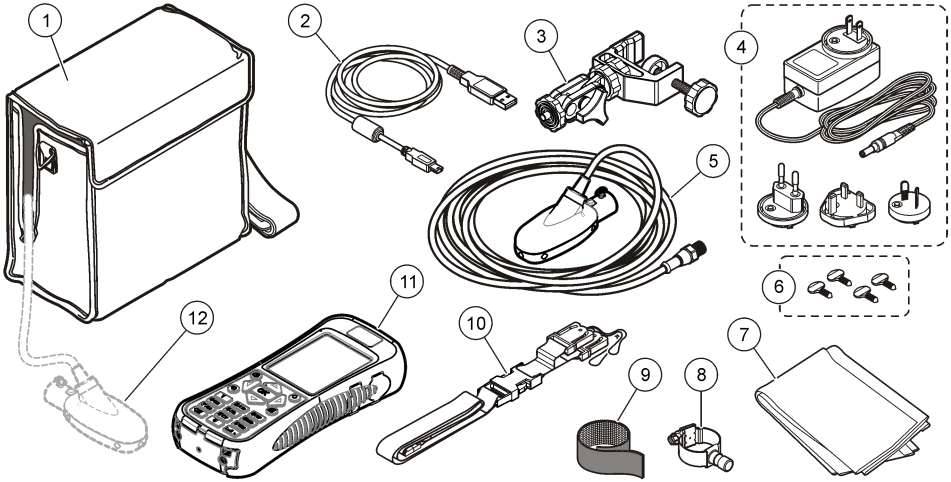


1 USB connection port	**6** Threaded hole for adjustable meter mount
2 Keypad	**7** Slots for velcro or strap attachment
3 Meter display	**8** Slot for neck strap attachment threads (2x)
4 Expansion port (not used)	**9** Sensor connection port
5 Battery compartment cover	**10** Wall-charger connection port

Product components

When purchasing a complete system, refer to Figure 4 to make sure that all components have been received. If any of these items are missing or damaged, contact the manufacturer or a sales representative immediately.

Figure 4 System components



1 Carrying case (with slot for sensor cable)	**7** Cloth to dry the sensor
2 USB communication cable	**8** Universal sensor mount
3 Adjustable portable meter mount	**9** Velcro strap
4 Wall charger and universal plug kit	**10** Lanyard
5 Sensor	**11** Portable meter
6 Extra thumb screws (4x)	**12** Sensor as connected to meter inside case

Installation

Installation with optional accessories

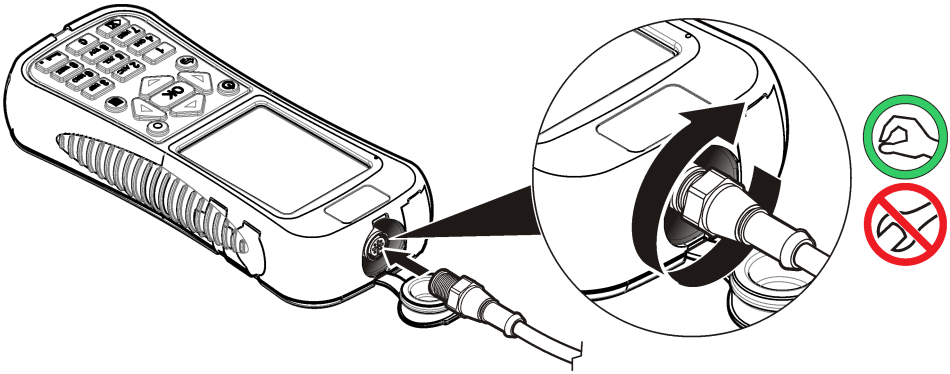
Mount the meter on an optional wading rod for use in low-stage stream environments where the stream can be waded. Optional accessories let the user take measurements from a bridge or cable over a stream. A torpedo shaped weight attached below the sensor keeps the sensor in place when under water. For more information, refer to the documentation supplied with the accessory.

Install the sensor on the universal sensor mount

Use the universal sensor mount to attach the sensor to poles 1 inch or less in diameter. For correct operation and accurate readings, the front of the sensor must be pointed upstream with the electrodes in full contact with the flow.
Note: *Keep the sensor electrodes free from nonconductive substances such as oil and grease. To remove sensor contamination, refer to* Clean the sensor *on page 26.*

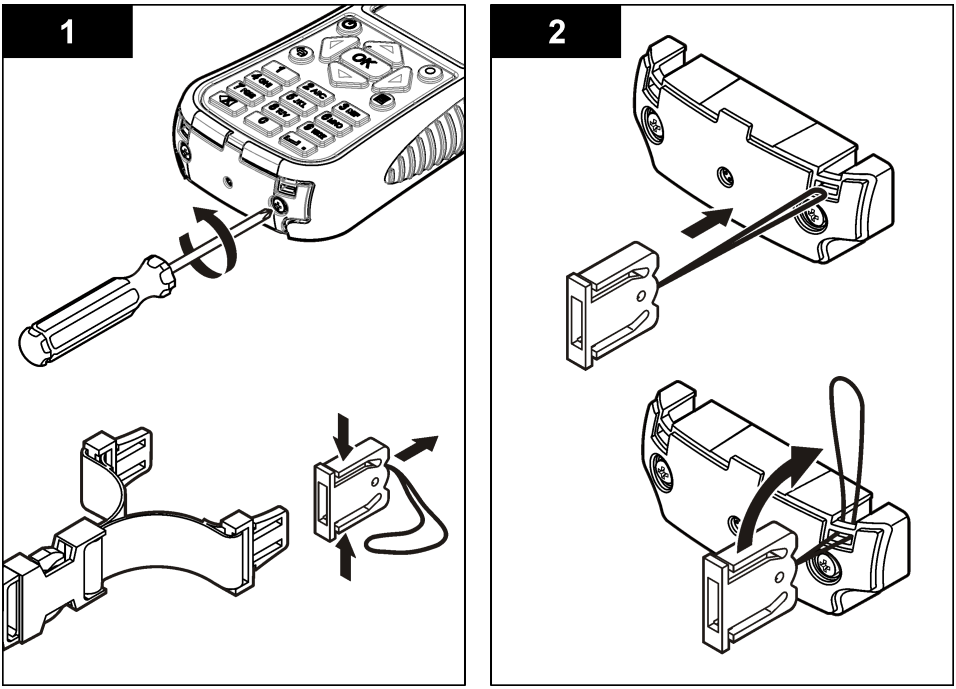
1. The front part of the sensor is round and contains three electrodes. The sensor has a mounting hole in back and a thumbscrew on top. Put the mounting shaft of the universal mount in the mounting hole at the back of the sensor. Make sure that the mounting shaft is completely engaged with the mounting hole and the thumbscrew is engaged with the groove.
2. Hand tighten the thumbscrew.
3. Move a pole 1 inch or less in diameter through the clamp of the universal sensor mount. Tighten the clamp.
   Note: *Instructions for how to mount the sensor on a standard, top-setting, HERES or 20 mm wading rod are supplied with the accessory.*

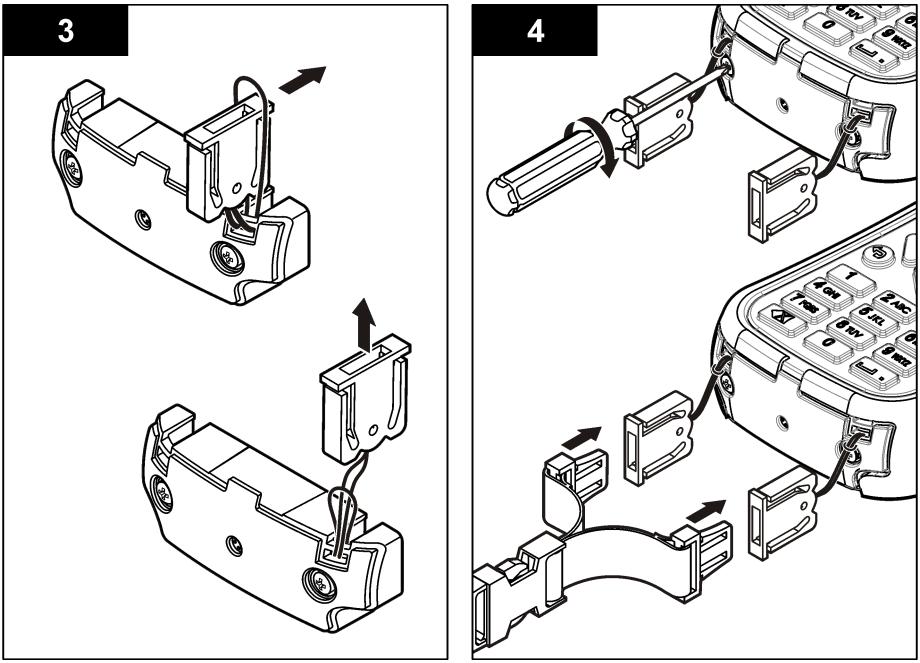
Connect the sensor to the meter



Attach the lanyard

Attach the lanyard to wear the meter safely around the neck.

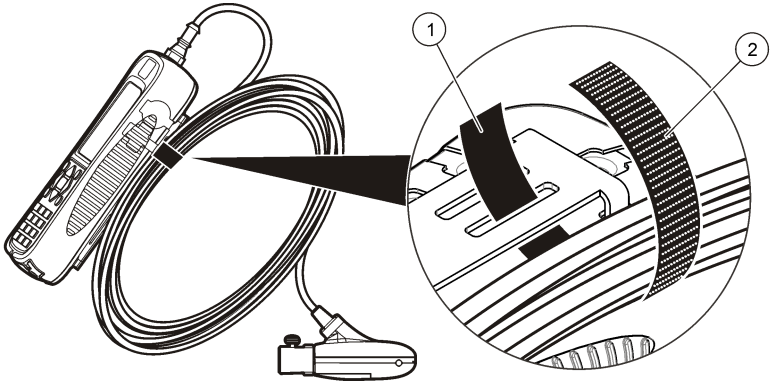




Attach the velcro strap

Use the velcro strap to hold the extra cable. Refer to Figure 5.

Figure 5 Attach the velcro strap



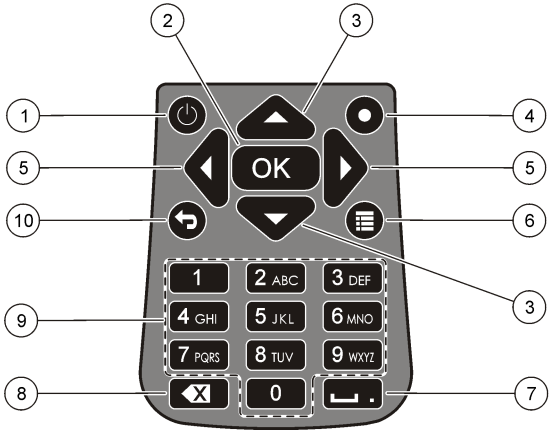
1 Loop side	**2** Hook side

User interface and navigation

Keypad and key functions

Figure 6 shows the meter keypad. Table 1 gives the functions of each key or key type.

Figure 6 Keypad



1 Power On/Off	**6** Main Menu
2 OK	**7** Underscore or decimal
3 Up and Down arrows	**8** Backspace
4 Quick Jump	**9** Alpha-numeric
5 Right and Left arrows	**10** Previous menu

Table 1 Key description

Key	Description
Power On/Off	Energizes and de-energizes the meter.
OK	Confirms an entry or highlighted menu option.
Up and Down arrows	Moves up or down in the display. If the cursor is at the top or bottom of the display, the cursor wraps to the bottom or top when the UP or DOWN arrow is pushed.
Quick Jump	In normal operation, this key jumps to the Select conduit shape screen. If the auto-zero feature is disabled, hold this key for five seconds to do a manual zero of the depth sensor. In Real-Time mode, the Quick Jump key toggles between the digital and graph views.
Right and Left arrows	Moves to the right or left in the display.
Main Menu	Moves to the Main Menu from any submenu or screen.
Underscore or decimal	Puts in an underscore or decimal character. In numeric-only fields, this key automatically puts a decimal point in the cursor position.
Backspace	Moves the cursor back one space.
Alpha-numeric	Puts in the key alpha or numeric value. Values are put in the order shown on the key. After 2 seconds, the value shown in the display is stored and the cursor advances.
Previous menu	Moves to the previous screen.

Status bar

A status bar is shown in the top of the display. Descriptions of the information in the status bar are given in Table 2.

Table 2 Status bar indicators

Indicator	Description
Time and Date	Shows the current time and date.
USB	Shows when a USB cable is connected. If a USB cable is connected and this indicator does not show in the status bar, the USB cable is not fully engaged. Make sure that the USB cable is pushed in completely and makes full contact with the connection port.
Conductivity	If the sensor is out of the water and non-conductive, a blue ring appears next to the battery icon. If the sensor is in the water and conductive, the indicator is a solid blue circle.
Battery	A five-bar graph shows the level of charge in the battery.
File access	Shows while the meter gets access to a file.
Auto zero depth indicator	If the depth sensor was zeroed in the last 30 minutes, a solid green circle shows next to the Conductivity indicator. If the depth sensor was not zeroed in the last 30 minutes, this indicator flashes red.

Navigation and Main Menu

Push **OK** to confirm a selected menu option or a value shown in the display. Select More and push **OK** to see additional screens and options if available. Push the Main Menu button to go to the Main Menu from a submenu.

Note: *Some operations cannot be completed unless a sensor is connected to the meter. If these operations are tried when there is no sensor connected, the display shows an error message. Connect a sensor and try the operation again.*

1. **Real time**—Select this option to get real-time velocity and depth information. (A sensor with depth capability is necessary to read depth). An example of a Real Time screen for sensors with velocity only is shown in Figure 7. Real time screens for sensors with both velocity and depth is shown in Figure 8. The format of the information and options shown depends on the type of sensor used. In Real Time mode, the Quick Jump key toggles between digital and graphic views of Real Time information. The velocity is updated in FPA filter mode according to fixed period averaging time. In RC filter mode, the velocity is updated continuously on the screen every 250 ms.

Option	Description
Capture	Stores the depth and velocity information shown in memory. The information is saved until power is cycled, the memory is saved to a non-volatile real-time file, or the user exits from real-time mode.
Save	Saves captured measurements in the volatile memory to a non-volatile real-time file. A message will show if the number of files is greater than the maximum possible. Files are stored in tab delimited (.tsv) format.
Done or OK	Exits the real-time mode and returns to the Main Menu. If there is unsaved data in volatile memory, a confirmation message asks the user to confirm the exit without saving the data.
Clear	Clears captured measurements from the volatile memory buffer. The user can choose from Clear Last, Clear All or Cancel options.

Option	Description
Setup	Allows the user to modify the main filter parameters and enable and program the Maximum Depth sensor positioning feature. The Maximum depth feature allows a user to enter system parameters for depth measurement in Real Time mode. The user can choose to enter a maximum depth value taken directly with a ruler measurement (manual), or taken indirectly with the depth measurement (automatic). Both methods enable the Maximum Depth sensor positioning feature. In automatic mode setup, the user directly enters the distance from the bottom of the channel to the bottom of the sensor mount (offset). The setup interface will continuously show the current depth value returned by the sensor plus the offset. The meter stores this value as the Maximum Depth when the OK button is pushed. In all other cases, the depth values shown do not include the offset. The Maximum depth feature requires a sensor with velocity plus depth.
Files or View	Shows a summary of each real-time file stored in non-volatile memory. Files can be individually viewed and deleted.

Figure 7 Real time screen

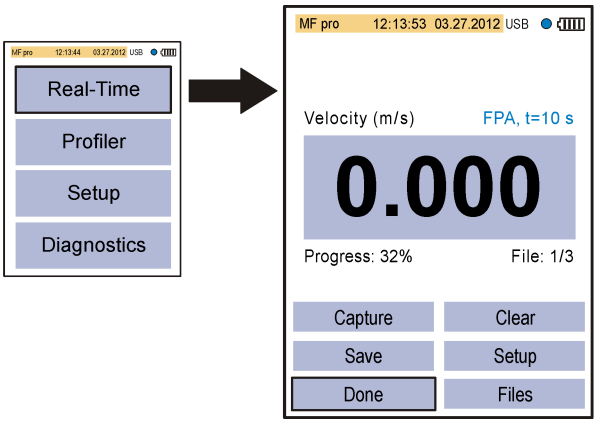
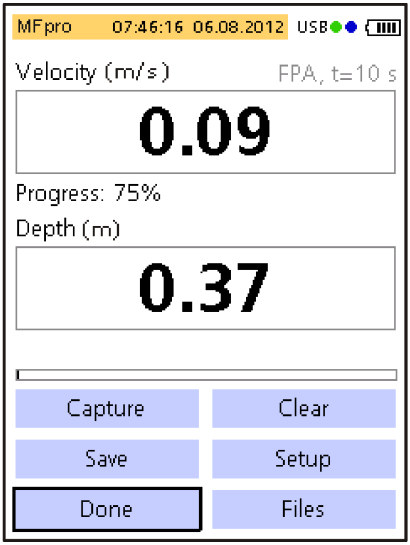


Figure 8 Real time screen for sensor with depth



2. **Profiler—** Select this option to do stream or conduit velocity measurements. The meter shows prompts when user input is necessary. The meter saves up to 10 profiles with up to 32 stations per profile. This number can be greater if data acquisition time is less than the maximum. A percentage of the remaining memory is given in 1% resolution. Refer to the Appendix on page 30 for more information about profiles.

Option	Description
Stream	This option is used to set up a profile for a stream or flowing channel. Do velocity measurements to calculate total discharge based on ISO 748 or USGS standards for Mid-section or Mean-section methods.
Conduit	This option is used to set up a profile for a conduit.
Files	This option is used to view or delete stored files. Files can be deleted all at once or individually.
Setup	This option is used to set up or change the settings for filter parameters and the Maximum Depth feature.

3. **Set up**—Select this option to change general system settings and preferences.

Option	Description
Velocity calibration	Calibrates the sensor. Adds a field offset to the factory calibration. Refer to the Appendix on page 30 for more information.

Option	Description
Filter parameters	Applies a data acquisition filter (Main filter or Pre-filter). The user can select the filter parameters. **Main filter** • Fixed Period Averaging (FPA)—Fixed Period Averaging averages data over a user selectable fixed period of time (1 to 480 seconds). The default is 30 seconds. If the FPA value is 5, the velocity value shown in the display is updated once every 5 seconds. • RCA time constant—The RC filter helps smooth out turbulence through the use of a selected time constant in the filter algorithm. This mode is useful when searching for a maximum velocity, for example in the common 0.9 x Vmax profile method. High RC filter time constants give higher degrees of smoothing. The time constant can be set from 2 to 20 seconds, with a default value of 6. At 1 time constant, the filter settles to approximately 60% of the final value. At 5 time constants, the filter settles to 99.9% of the final value. Thus, if the RC value is set to 2, the final value shows after 10 seconds. **Pre-filter** • Median filter—The filtering process is done in the sensor. The feature can be disabled. However, the recommended (default) value is 5. Enable the feature to enter or change this value.
Wet/dry threshold	Sets the sensor submersion threshold for wet and dry conditions. The default value is 20%. Refer to Wet/Dry threshold on page 33 for more information.
Auto zero depth	Sets the Auto Zero feature to On or Off. If set to On, the instrument does an air calibration when the sensor is removed from the water and is in the air. To do the air calibration, the instrument automatically zeroes the sensor. If set to Off, the user can manually zero the sensor. To do this, remove the sensor from the flow, then push and hold the Quick Jump key for five seconds. When the sensor has been in the flow for 30 minutes, the green circle in the upper right corner goes from green to red. This is a prompt to the user to remove and zero the sensor again.
EMI	Sets the local line frequency for ambient noise rejection to 50 Hz (default) or 60 Hz .
Clock	Sets the date and time of the portable meter in 24-hour format. Daylight savings time is not supported.
USB	Sets the USB mode. • Mass Storage (default)—This mode operates like a memory stick or hard drive. Files are read-only. • CDC—This mode is used to update firmware.
Language	Selects the language used in the menus.
Units	Sets the units for velocity, flow and depth measurements. Options are Metric (default) or English .
Beeper	On (default) or Off. If set to On, the meter makes an audible tone when the sensor is at the correct depth for applicable profile methods. The meter also makes an audible tone when an inactive button is pushed in any menu. This feature is available only with the optional depth sensor.
Flow calculation	Selects the method of flow calculation for open water segment (stream profiles only). Options are Mean-section or Mid-section. Refer to the Appendix on page 30 for more information.

Option	Description
Station entry	• Fixed—The operator puts in the width of the stream and the number of stations for measurements. The meter divides the cross-section into evenly spaced distances between the station verticals. • Non-fixed (default)—The operator selects the spacing between station verticals. This is the more commonly used option as it lets the operator include obstructions and other restrictions in the cross section.
Restore defaults	Sets all meter options to the factory default values.

4. **Diagnostics—** Select this option to troubleshoot problems with the meter or an attached sensor. For more information about the Diagnostics options, refer to Diagnostics on page 28.

Startup and self-test

⚠ DANGER

Chemical or biological hazards. If this instrument is used to monitor a treatment process and/or chemical feed system for which there are regulatory limits and monitoring requirements related to public health, public safety, food or beverage manufacture or processing, it is the responsibility of the user of this instrument to know and abide by any applicable regulation and to have sufficient and appropriate mechanisms in place for compliance with applicable regulations in the event of malfunction of the instrument.

⚠ WARNING

Fire and explosion hazards. Do not use or store the instrument in direct sunlight, near a heat source or in high temperature environments such as a closed vehicle in direct sunlight. Failure to take this precaution can make the battery overheat and cause a fire or explosion.

The battery must be installed in the meter and charged before use. For more information about battery installation and replacement, refer to Install or replace the battery on page 27. For information on how to charge the battery, refer to Charge the battery on page 28.
Note: *The meter is not operational while the battery charges.*

1. Push the meter power button until an audible beep is heard.
   The meter does a self test and the display shows the results. If the meter fails the self-test, the display shows FAIL next to the failed parameter. If the sensor fails, attach a different sensor if available.
2. When the self test is complete, push **OK** to go to the Main Menu.
3. To de-energize the meter, push the power button again. In the Confirmation screen, select Yes and push **OK**.
   If the portable meter becomes unresponsive, push and hold the power button for more than 3 seconds to force the power off. Do not force off the power in normal operation or when the file access icon is visible.

Sleep mode

The meter backlight goes dim after 30 seconds of no activity and goes into sleep mode after 60 seconds of no activity. These actions do not occur if the meter is in real-time mode or while the meter is measuring. After 30 minutes in sleep mode, the meter power goes off.

To cancel the sleep mode, push any key. The display brightness goes back to the normal level and all keys go back to their normal functions.

Operation

Stream profiles

Stations and station spacing

For a well-chosen cross-section, division into 25 to 30 partial sections is typically sufficient. If the cross-section is very smooth and the velocity distribution very consistent, it is possible to decrease the number of stations.

Make the distance between the partial stations so that no individual station contains more than 10% of the discharge. The ideal measurement is one in which each partial station contains 5% or less (≤ 5%) of the total discharge, but this is rarely possible when 25 stations are used. Partial stations should not have equal widths across the entire cross-section unless the discharge is well-distributed.

Distances between stations are generally smaller where water depth and flow velocities change significantly. Places where depth and velocities frequently change significantly include bank areas, vertical or steep slopes, ledges in divided cross-sections and transitions from the main stream bed to the foreland. Stations should also be located at points of significant changes in the stream bed profile.

The measurement cross-section must be set at right angles to the direction of flow. Cross-sections must not contain still areas, counter currents or eddies. Do not put the sensor in deep pools, below large inflows, or near ship moorings, ferries or sluices.

Use Table 3 as a guide for the number of stations necessary for an acceptable measurement. The information is based on EN - ISO 748 standards.

Table 3 Number of stations in relation to the waterway width

Feet	Meters	Number of stations
< 1.6	< 0.5	5 to 6
> 1.6 and < 3.3	> 0.5 and < 1	6 to 7
> 3.3 and < 9.8	> 1 and < 3	7 to 12
> 9.8 and < 16.4	> 3 and < 5	13 to 16
> 16.4	≥ 5	≥ 22

Measure velocity

Measurement quality is dependent on the correct selection of a measurement cross-section. Select a section of stream with the following characteristics:

- The flow directions at each measurement point across the stream are parallel to the bank and perpendicular to the cross-section.
- The streambed is stable and free of large rocks, weeds and protruding obstructions such as piers that cause turbulence.

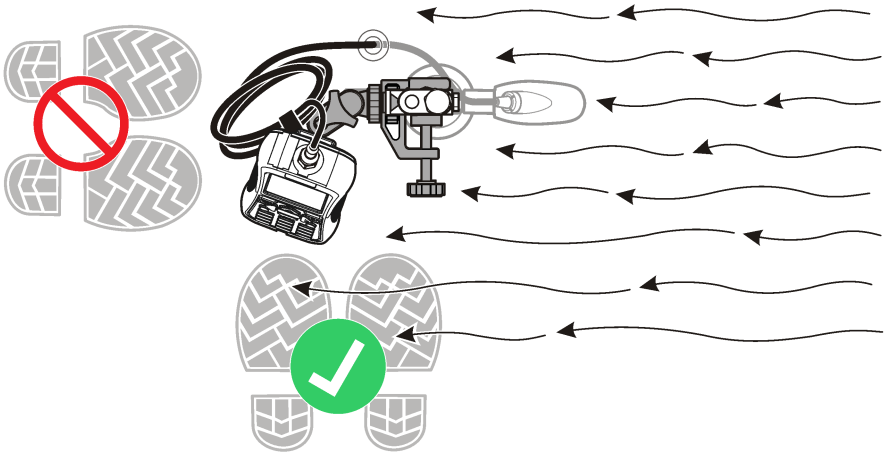
It is often not possible to completely satisfy all of these conditions. Use the criteria to select the best possible section and then select a cross-section.

The general procedure to take velocity measurements in river and stream profiles is described below. Make the first measurement in a stream profile at the top. Make each subsequent measurement below the last one.

- In fixed mode, divide the channel into stations of equal width.
- Conduct a velocity measurement at each station. The portable meter shows and stores the depth and measured velocity information.
- When the stream profile is completed, the meter automatically calculates the total flow.

For accurate measurement results, stand to the side of the instrument. Refer to Figure 9.

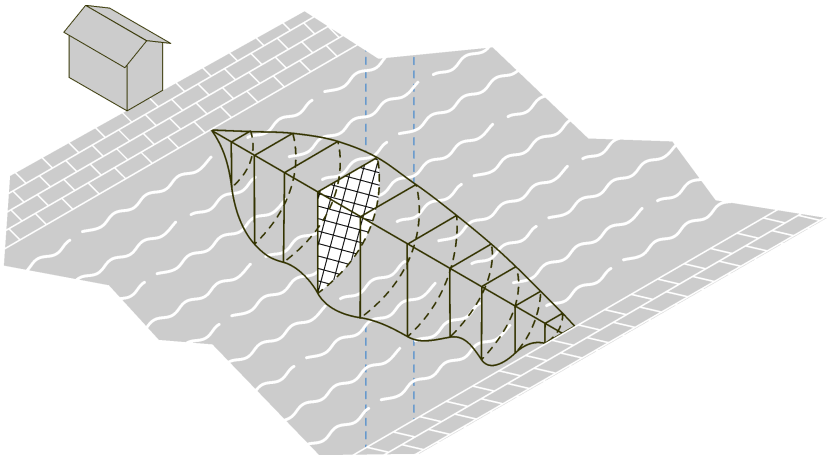
Figure 9 Position of user in the flow



Measure velocities in a cross-section

A typical stream cross-section is shown in Figure 10.

Figure 10 Example of a typical cross section



To measure velocities in a cross-section:

1. In the Main Menu, select Profiler.
2. Enter the Operator name. A list of options will show.

Option	Description
Stream	Used for measurements in a stream profile.
Conduit	Used for measurements in a conduit profile.

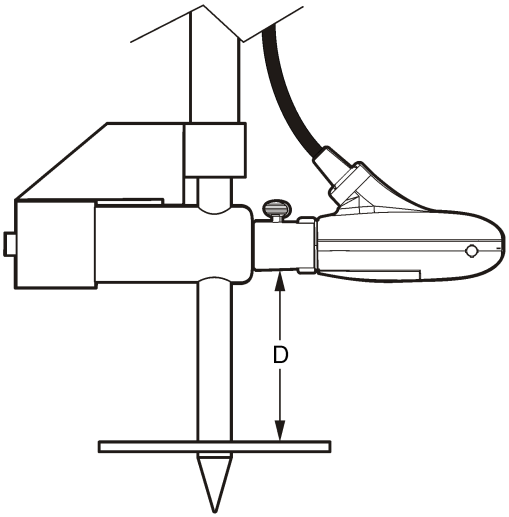
Option	Description
Files	Used to view or delete files.
Setup	Used to set up filter parameters and the Maximum depth feature.

3. Select Setup > Maximum depth. Select Manual or Automatic.

Option	Description
Manual	In this mode, the instrument prompts the user to manually enter the maximum depth of each vertical. This value is normally obtained from a wading rod.
Automatic	In this mode (available only on sensors with the depth option), the instrument uses the pressure transducer to measure the maximum depth at each vertical.

   a. If Automatic is selected, enter the distance from the bottom of the channel to the bottom of the sensor mount.
   b. Put the sensor at the lowest position on the wading rod.
   c. Enter the minimum depth (measured from the bottom) that the sensor can read. Refer to Figure 11. When rods with a base plate and/or tip are used, this extra distance can be larger. This depends on whether the subsurface is firm or yields. The extra distance is important as a parameter for the correct determination of the water depth.

Figure 11 Minimum depth



4. Select Top or Bottom for the measurement reference then push **OK**.
5. If necessary, change or update the filter parameters in Profiler Setup.
6. In the Profiler menu, select Stream.
7. Enter a name for the stream profile. Make profile names alpha-numeric with a maximum of 11 characters. Push **OK** to save the profile name or select Clear to delete all current stream profile data.
8. Enter the stage reference. This is typically an elevation value from an immovable object such as a survey marker or bridge, etc.

9. In the Station menu, select Edge/Obstruction. Select one of the options.

Option	Description
Left	Select this option if the station is at the left edge of the water or an obstruction (i.e, sandbar, pylon or large boulder).
Right	Use this option if the station is at the right edge of water or an obstruction (i.e., sandbar, pylon or large boulder).
Open water	Use this option to configure the edge as an open water environment (default).

10. Select Distance to Vertical and enter the information.
11. Select Set Depth and enter the information. If at an edge, the meter automatically sets this value to 0.00.
    a. If Manual mode was selected in the Profiler setup, enter the total depth of water at this vertical position.
    b. If Automatic mode was selected in the Profiler setup, push **OK** to set the maximum flow depth at the value shown.
12. If Left or Right was selected in Step 9, enter an edge factor for the vertical. Select a factor from the list or User-defined. For User-defined values, enter a roughness factor between 0.50 (very rough) and 1.00 (smooth). The roughness factor is relevant only for right angled cross sections. It is used as a factor in the calculation of the discharge proportion of edge areas. For example:
    - Smooth edge with no vegetation (e.g., concrete, steel, cement)— 0.8 to 0.9
    - Brick sides with vegetation— 0.7
    - Rough walls with heavy vegetation—0.6 to 0.5
13. Select Measure Velocity. Select the number of points on the vertical to collect.
14. Select a measurement point from the list. Obey the instrument prompts and adjust the sensor to the correct depth. If the sensor has a depth option, adjust the sensor depth until the depth box is green. This means the sensor is in at the correct position.
    Note: *Red indicates more adjustment is necessary. Yellow indicates the depth is close to the correct depth.*
15. Select Capture to start the measurement process.
16. If necessary, the setup can be changed and the measurement can be repeated. When the measurement is complete, push **OK** to store the data.
17. Repeat steps 13–16 for the other measurement points on the vertical.
18. When all measurements for the station are complete, select Main or Verify. results. Push **OK** to return to the list of measurement points.

Option	Description
Main	Returns to the station menu.
Verify	Shows the average velocity reading for the station based on the measurement method.

19. Select Next to go to the next station.
20. Repeat steps 10–19 for the remaining stations.
21. When all measurements for all stations in the profile are complete, select Channel Summary to view the results.
    Note: *A warning flag will show if the discharge in one or more segments is > 5% of the total discharge.*

Insert or delete a station

Prev, **Next**, **Ins** and **Del** options show at the bottom of the display in the Station screen. **Prev** and **Next** are used to navigate to a previous or subsequent station. **Ins** and **Del** are used to insert or delete a station.

For example, after measurements have been done at 10 stations, a user may wish to insert a new station between stations 3 and 4. The steps below describe how to do this. These steps can be applied in similar situations.

1. Select **Prev** and push **OK** until the display shows the information for Station 3.
2. Select **Ins** and push **OK**.
   The instrument adds a new station named Station 4. Subsequent stations are automatically given new sequential numbers.
3. To delete the current station (when in non-fixed mode), select **Del** and push **OK**.

Conduit profiles

It is possible to use all of the methods for conduit profiles in this section in sites with a typical profile shape and sufficient depth to measure 3-point velocities. The 0.9 x Vmax method can also be used when the depth is not sufficient for multi-point profiles.

Note: *In typical conduit profiles, the first measurement is made at the bottom. Subsequent measurements are made above the one made before. A different procedure may be necessary for some profiles.*

1. In the Main Menu, select Profiler.
2. Enter the operator name.
3. In the list of options, select Conduit.
4. Enter a name for the new Conduit profile.
5. Select the conduit shape.
   Note: *The input screens that show next depend on the shape selected.*
6. Enter values at the screen prompts.
   When the necessary values have been entered, the display shows the Select Method menu.
7. Select a profile method and do the steps for the method.

Option	Description
0.9 x Vmax	The meter calculates flow based on 90% of the fastest velocity. This is the recommended method when the depth is less than 12.7 cm (5 in.) or when the velocity is not stable.
0.2/0.4/0.8	The meter calculates the flow value based on velocity measurements taken at 0.2, 0.4 and 0.8 x the depth. One and two-point versions of this method are also possible.
Vel./Lev. Integ.	The meter integrates 10 separate velocity and level measurements to calculate the flow level.
2D	The sensor collects information while constantly moved through the flow in a specified pattern. The meter calculates the flow value when the user selects Save. This method is recommended for flows where a difference of 30% or more exists between the right and left side velocities.

0.9 x Vmax measurement method

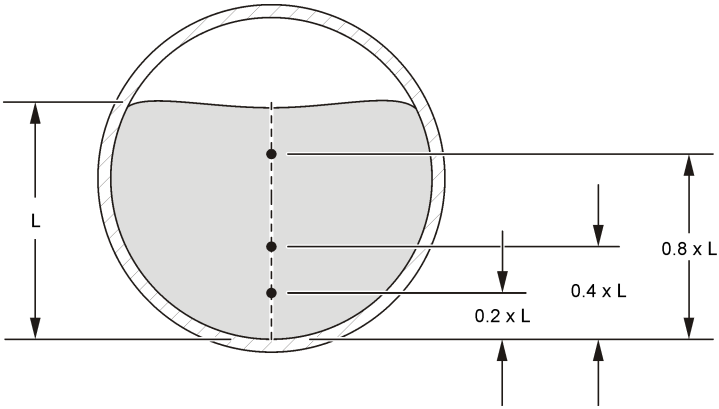
The meter uses the maximum velocity measurement in the conduit and multiplies this value by 0.9 to calculate the total flow.
Note: *The RC filter mode with a value of 2 to 4 seconds is recommended for this method.*

1. In the Select Method menu, select 0.9 x Vmax.
2. With the sensor in the flow, select Measure Velocity to get a velocity measurement.
   The measured values are shown on the graph.
3. Move the sensor until a point of maximum velocity is found, then push **OK**.
   The meter calculates and shows the flow, maximum and average velocity values.
4. Select Save.
   The information is saved to a data file.

0.2/0.4/0.8 method

Do measurements at one, two or three points to calculate an average velocity. Each point represents a percentage of the maximum depth as measured on the center line as shown in Figure 12.

Figure 12 2-4-8 profile



1. In the Select Method menu, select **0.2/0.4/0.8**.
2. Select one of the options.

Option	Description
One point	One-point measurement at 0.4 x maximum depth
Two point	Two-point measurement at 0.2 and 0.8 x maximum depth
Three point	Three-point measurement at 0.2, 0.4 and 0.8 x maximum depth

3. For the selected option, select a measurement point. The meter shows the sensor adjustment information.
4. If necessary, adjust the sensor as necessary.
5. Select Capture.
   The meter gets information from the sensor and shows the velocity value in numerical and graphical form.
6. If necessary, select Setup to change the Y-axis range or the data filter parameters.
7. Push **OK**.
8. Do steps 3–7 for all of the other measurement points then push **OK** to return to the list of measurement points.
9. Select Flow.
10. Select Save to save the information to a data file.

Velocity/Level Integration measurement method

Measurements are done at 10 different depths. The results from all segments are integrated to calculate the flow value.

- Select Prev or Next to go to another measurement.
- Select Main to return to the Select Method menu.

1. In the Select method menu, select Vel./Lev. Integ.
   The display shows the first measurement screen.
2. Select Measure Velocity.
   The sensor depth information is shown.

3. If necessary, adjust the sensor depth as shown.
4. Select Capture.
   The handheld unit gets information from the sensor and shows the average velocity value in numeric and graphical form.
5. If necessary, select Setup to change the Y-axis range in FPA filtering mode, the X and Y-axis range when in RC filtering mode or the data filter parameters.
6. Push **OK** to confirm the information.
7. Select Next. The next measurement screen in the series appears.
8. Do steps 2–7 for the other measurement depths.
9. Select one of the options at the bottom of the screen.

Option	Description
Save	Calculates the current flow value and saves this information to a data file.
Units	Changes the unit type (English or Metric).

2D measurement method

Velocity is measured while the sensor is moved through the flow as shown in Figure 13.

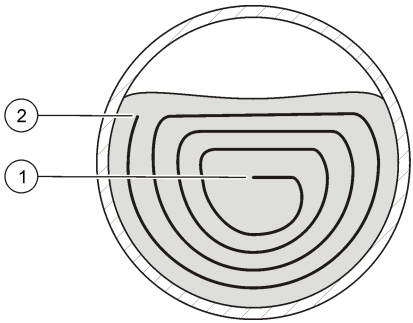
Select Cancel at any time to cancel the measurement and return to the Select Method menu.

Note: *The RC filter mode with a value of 2 to 4 seconds is recommended for this method.*

1. In the Select method menu, select 2D.
   The sensor depth information is shown.
2. If necessary, adjust the sensor depth.
3. Select Capture. While the sensor collects data, move the sensor through the entire cross-section in the pattern shown in Figure 13.
4. If necessary, select Setup to change the Y-axis range in FPA filtering mode, the X and Y-axis range when in RC filtering mode or the data filter parameters.
5. Push **OK**.
6. Select one of the options shown at the bottom of the screen.

Option	Description
Save	Calculates the current flow value and saves this information to a data file.
Units	Changes the unit type (English or Metric).

Figure 13 Path of the sensor in the flow



1 Start	**2** Finish

Download data

The meter directory is Read Only. In Windows, the meter operates as a mass storage device or removable hard drive.

1. Set the meter to USB Mass Storage mode.
2. To edit the data in a file, drag and drop the file to a laptop or PC. File names are limited to eight characters.
3. Data files are kept in the tab separated variable (.TSV) format. To see files in Microsoft® Excel, double or right-click a file and open the file with Excel.
   Real time files are stored in a directory called RT. Stream and conduit profile files are stored in a directory called P.

Delete data files

1. To delete all files from USB memory:
   a. Go to Main Menu > Diagnostics > Delete Files.
   b. In the confirmation window, select Yes.
   c. Push **OK** once to delete the files, then one more time to return to the previous screen.
2. To delete Real Time files:
   a. Go to Main Menu > Real-Time > Files.
   b. Select Delete All or use the UP or DOWN arrow to select a file in the list.
   c. Push **OK** once to delete the files, then one more time to return to the previous screen.
3. To delete Profiler files:
   a. Go to Main Menu > Profiler > Files.
   b. Select Delete All or use the UP or DOWN arrow to select a file in the list.
   c. Push **OK** once to delete the files, then one more time to return to the previous screen.

Maintenance

Download the PVM utility

The PVM utility is used to update the firmware in the portable meter. The PVM Utility is available at http://www.ott.com or http://www.hachhydromet.com. Do the steps listed for the selected URL.

1. Go to http://www.ott.com.
2. Login to MyOtt.
3. Click Software Updates.
4. Select MF pro.
5. Click More.
6. Click PVMSetup.msi.
7. Choose Save or Run.

1. Go to http://www.hachhydromet.com.
2. Click the Service and Support tab.
3. Click More (below Software Downloads).
4. Select MF pro.
5. Click the download link.
6. Select Save or Run.

Update the firmware

Note: *All data files in mass storage are lost when the firmware is updated. To download data, refer to* Download data *on page 25.*

The PVM Utility is necessary for this procedure. To download the PVM Utility, refer to Download the PVM utility on page 25.

This is the general procedure to update firmware for the meter and sensor. To update the sensor firmware, the sensor must be connected to the meter.

1. Double-click the PVM Utility desktop icon.
2. Push the power button on the meter. When the meter self-test is complete, push **OK**.
3. In the Main Menu, select Setup, then push **OK**.
4. Select USB>CDC, then push **OK**.
5. Connect the USB cable to the portable meter and the PC.
6. In the PVM Utility window, select Connect.
7. In the drop-down menu, select the PVM (COM X) port, where COM X is the virtual port number assigned to the PVM by Windows. Push **OK**.
8. In the left-side panel, select Firmware Update, then select the Meter or Sensor tab.
9. Select the correct firmware version, then click Start.
   The firmware download starts. A "Firmware update successful" message shows when the download is complete. For meter updates, the instrument display turns off until the instrument completes the update. Then, the instrument automatically resets and powers up again after a few minutes. Do not try to make the instrument power on or off before the update process is complete.
10. In the Main Menu, select Diagnostics > About. Make sure that the firmware versions for both the Handheld Boot and the Handheld Application are correct.

Clean the sensor

⚠ WARNING

Chemical exposure hazard. Obey laboratory safety procedures and wear all of the personal protective equipment appropriate to the chemicals that are handled. Refer to the current material safety data sheets (MSDS) for safety protocols.

Clean the sensor when unexpected increases or decreases in flow or level trends occur and after use in sandy or muddy waterways.

For heavy contamination, soak the sensor in clear water for a few minutes to help make the contamination easy to remove.

Disconnect the sensor from the meter before it is cleaned. Use only solutions listed as acceptable in Table 4 to clean the sensor. For sensors with a pressure cell (i.e., velocity plus depth sensors), make sure the holes for the pressure cell chambers are washed out and clear of contamination. Rinse the sensor with clean water before re-attaching the sensor to the assembly.

Table 4 Acceptable and unacceptable cleaning solutions

Acceptable	Do not use
Dish detergent and water	Concentrated bleach
Window cleaner	Kerosene
Isopropyl alcohol	Gasoline
	Aromatic hydrocarbons

Clean the meter

1. Push the power button to de-energize the meter.
2. Use a clean, moist cloth to clean the meter exterior. Mix the water with a mild detergent if necessary.
3. Dry the meter exterior with a clean cloth. Let the meter dry in air completely before it is energized again.
   Note: *Do not use paper-based cloths to clean the display. This type of cloth can cause damage to the display screen.*

Install or replace the battery

⚠ WARNING

Personal injury hazard. This instrument contains one or more batteries. To prevent battery degradation, leakage or explosion, do not use or keep the instrument in places where the temperature is higher than the specified temperature limits of the instrument.

⚠ WARNING

Fire and explosion hazards. Battery substitution is not permitted. Use only batteries that are supplied by the instrument manufacturer.

⚠ WARNING

Multiple hazards. Do not disassemble the instrument for maintenance. If the internal components must be cleaned or repaired, contact the manufacturer.

NOTICE

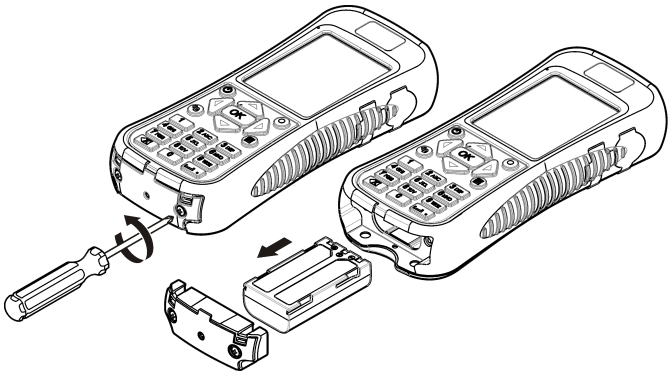
Discard used batteries promptly. Keep used batteries away from children. Do not disassemble the battery or discard the battery in fire.

The instrument is shipped without the battery installed. Order new batteries from the instrument manufacturer. Refer to Replacement parts and accessories on page 29. Recycle or discard used batteries in accordance with local regulations.

Note: *If the instrument must be returned to the factory for repair or maintenance, remove the battery and put the battery in a protective cover before shipment.*

1. If necessary, remove the used battery as shown in Figure 14.
2. Install a new battery in the same location and with the same orientation.
3. Install the battery cover. Make sure that the cover is secure to keep the enclosure rating.
4. Charge the battery if necessary. Refer to Charge the battery on page 28.

Figure 14 Remove the battery



Charge the battery

Make sure that the correct plug-type for the geographic location is installed on the wall charger.

Note: *Battery charger substitution is not permitted. Use only the charger specified in the list of parts and accessories for the instrument. Refer to* Replacement parts and accessories *on page 29*.

A lithium ion battery in the meter supplies power to both the meter and the sensor. Install and charge the battery before the instrument is used.

A full battery charge will supply power to the system for approximately 10–11 hours with constant use. When the level of battery charge drops to 3.4 V or less, the display shows a warning and the meter automatically powers off. The battery must be charged before the unit becomes functional again.

1. Connect the round end of the charger cable to the power jack of the portable meter. Refer to Figure 3 on page 8.
2. Connect the wall charger plug to a power outlet.
   A blue light shows around the charge port while the battery charges. When the charge process is complete, the blue light goes off. A discharged battery gets a full charge in about 8 hours.
   Note: *The meter is not operational while the battery charges. The battery does not charge through the USB cable connection.*

Troubleshooting

Diagnostics

In the Main Menu, select Diagnostics to see information about the meter and do the diagnostic tests in Table 5.

Table 5 Meter diagnostics

Option	Description
About	Shows information about the meter and the sensor. Includes the serial number and the firmware version.
Delete files	Deletes all files from memory to make space for new measurements. Make sure that the data is downloaded to a PC before this option is selected. The system automatically reformats the memory after file deletion.
Sensor	Shows diagnostic information about the sensor.
Self test	Makes the meter do a diagnostic self test.
Key pad test	Does a test of any button to make sure that the button is functional.

Table 5 Meter diagnostics (continued)

Option	Description
Display test	Does a test on the display to make sure that the display is functional.
Event log	Lets the user see, delete or export the event log. Export the event log to make the contents available as an accessible file through USB mass storage. This option is used primarily by factory service.

Troubleshoot errors

The meter and sensor contain no user-serviceable parts. For the errors and messages listed, try the corrective action.

If the problem does not go away or a problem occurs that is not in the list, contact the manufacturer.

Message or problem	Solution
Sensor is not connected	Connect a sensor and try the action again.
Value is out of range	Change the measurement parameters or put in a different value, then try the action again.
Sensor data is known to be not correct or not accurate	Clean the sensor and test.
Sensor is not recognized	Check the sensor connection. Make sure that the lock nut on the connection port is tight (finger-tighten only).
Display is dim or is not visible	Push a key on the keypad.
Data is not available or access to the data is not possible	Make sure that the USB option (Main Menu) is set to Mass Storage.
Meter is unresponsive	Push and hold the power button for at least 3 seconds. This de-energizes the meter. Energize the meter again. ***Note:*** *Do not use this method to power off while in normal operation or if the file access icon is visible in the display.*

Replacement parts and accessories

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Replacement parts

Table 6 Velocity only sensor

Description	Item no.
Sensor with 1.5 m (5 ft) cable	1040500595-0N
Sensor with 6.1 m (20 ft) cable	1040500595-1N
Sensor with 12.2 m (40 ft) cable	1040500595-2N
Sensor with 30.5 m (100 ft) cable	1040500595-3N

Table 7 Velocity with depth sensor

Description	Item no.
Sensor with 1.5 m (5 ft) cable	1040500595-0D
Sensor with 6.1 m (20 ft) cable	1040500595-1D

Table 7 Velocity with depth sensor (continued)

Description	Item no.
Sensor with 12.2 m (40 ft) cable	1040500595-2D
Sensor with 30.5 m (100 ft) cable	1040500595-3D

Table 8 Handheld meter

Description	Item no.
English/Metric	1040500195-S

Accessories

Table 9 General accessories

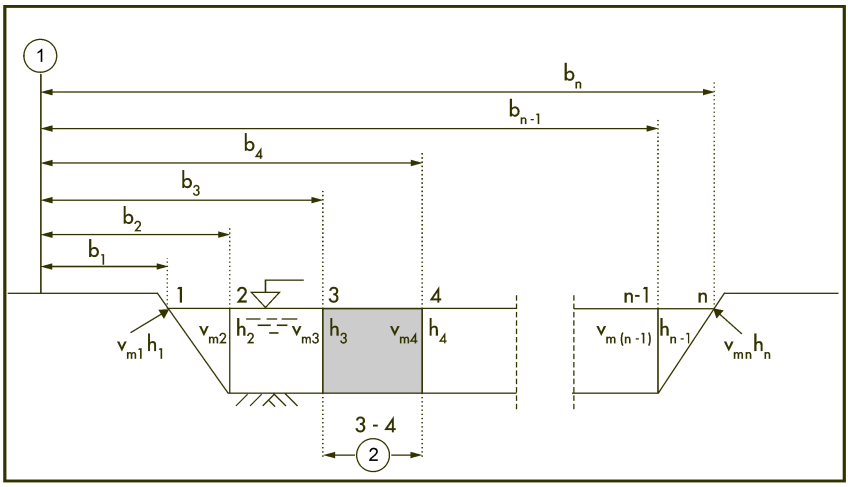
Description	Item no.
Adjustable meter mount	10.405.405.9.5
Battery charger	97.850.039.9.5
Carrying case	10.405.401.9.5
Lanyard, double ended loop	10.405.403.9.5
Lithium ion battery	97.820.021.9.5
Thumb screw kit (includes four thumb screws)	10.405.418.9.5
Universal sensor mount	10.405.419.9.5
USB cable	97.120.412.9.5

Appendix

Mean-section and Mid-section methods

The user can select the Mean-section or the Mid-section method for flow calculations. The Mean-section method divides the cross-section into individual flow segments. Pairs of adjacent verticals are the limits of the segments. The two edges of the cross-section are given values of 0 for the velocity and depth. The total flow is the sum of the partial flows of all segments. Figure 15 shows the definitions and the equation for the Mean-section method.

Figure 15 Mean-section method



$$q_{3-4} = \left(\frac{V_{m3} + V_{m4}}{2}\right) \times \left(\frac{h_3 + h_4}{2}\right) \times (b_4 - b_3)$$

Where:

V = velocity at vertical

b = distance to vertical from bank

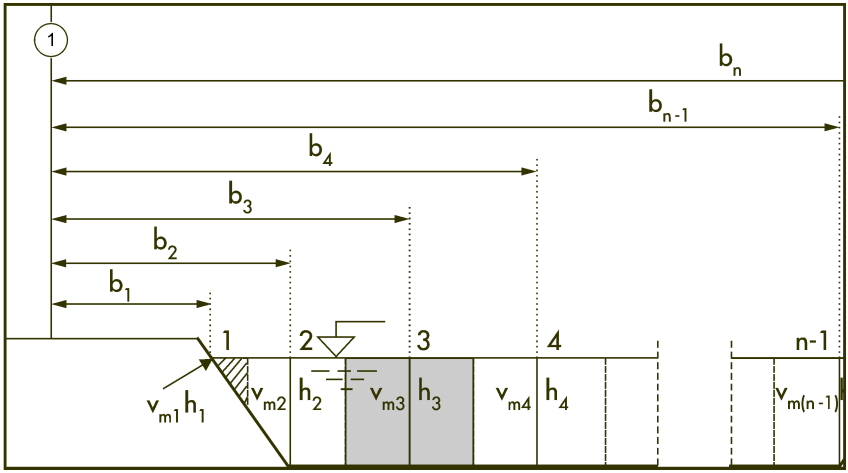
h = depth at vertical

q = flow at vertical

The Mid-section method also divides the cross-section into individual flow segments. With the Mid-section method, the segments are not between verticals but are defined by half of the distance to neighbor verticals in each case. For this reason, the first and last verticals should be as near to the edges as possible (i.e., left edge of water (LEW) and right edge of water (REW)). Boundary conditions dictate the proximity of the first and last vertical to the edge of water.

Experience shows that the Mid-section method gives more exact results compared to the Mean-section method so it is the default setting. Figure 16 shows the definitions and equation for the Mid-section method.

Figure 16 Mid-section method



$$q_3 = V_{m3} \times \left(\frac{(b_3 - b_2) + (b_4 - b_3)}{2} \right) \times h_3$$

Where:

m = station number

n = total number of stations

V = velocity at vertical

b = distance to vertical from bank

h = depth at vertical

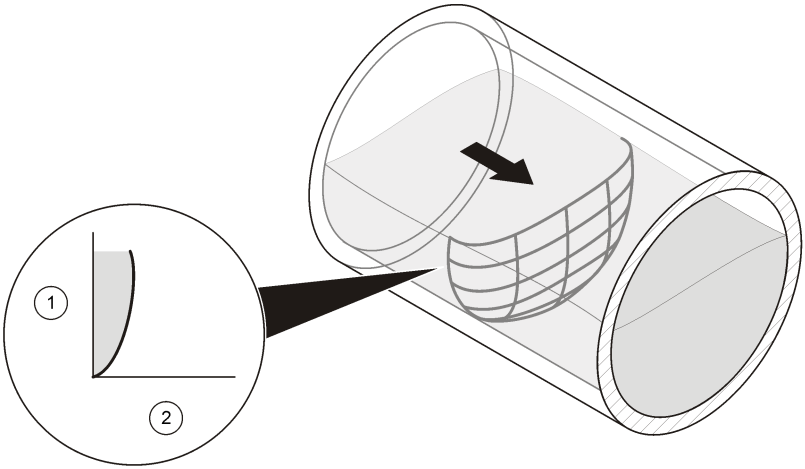
q = flow at vertical

Profiles and measurements

Profiles can be set up for streams or conduits. Figure 17 shows an example of a typical profile shape in a conduit. In a typical profile, velocity is less near a wall or edge than at the center and decreases near the surface. Multiple velocity measurements in the profile are averaged to calculate the total flow. Measurements for conduit profiles are made from the bottom up. Measurements for stream profiles are made from the top down.

In the Main Menu, select Profiler. The meter prompts for the operator name, the type of profile (stream or conduit) and the profile name. Do the instructions for the selected profile type.

Figure 17 Typical profile



1 Depth	**2** Velocity

Site selection

A site with the typical profile shape gives the most accurate results. Visual inspection is typically sufficient to identify problem sites. Use the information in these guidelines to help select the best site.

These guidelines apply to conduit and stream profiles.

- The channel should have as much straight run as possible. If the length of the straight run is limited, the length upstream from the profile should be two times the downstream length.
- The channel should be free of flow disturbances. The site must not have protruding pipe joints, sudden changes in diameter, contributing side-streams, outgoing side-streams or obstructions. Remove all rocks, sediment or other debris from the bottom of the pipe.
- The flow should not have visible swirls, eddies, vortices, back-flow or dead zones.
- Do not select areas immediately downstream from sharp bends or obstructions.
- Do not select areas with converging or diverging flow (approaches to a flume) or vertical drops.
- Do not select areas immediately downstream from sluice gates or places where the channel spills into a body of stationary water.

Do a velocity calibration

Use this feature to remove a velocity offset if necessary. The velocity offset stays active until the meter power is switched off.

1. Collect a bucket of water from the water in the profile area. The bucket must be non-metallic and at least 20.32 cm (8 in.). The water depth must be at least 15.24 cm (6 in.).
2. Put the sensor in the center of the bucket so that it does not touch the sidewall or the bottom of the bucket.
3. Let the water become still.
4. Let the velocity reading stabilize.
5. Select Zero Velocity.

Wet/Dry threshold

The wet/dry threshold is the trigger point for the meter to know when the sensor is in or out of the water. This information is important because if the meter does not know that the sensor is under the

surface of the water, the meter sets the velocity value to zero. For a profile or real-time reading, the meter prompts the user to submerge the sensor in the water.

If the specific conductivity of the water being measured is very low, adjust the threshold value for the best performance. Go to Setup Menu>Wet/Dry Threshold.

For troubleshooting, the present reading is used as a guide to set a custom threshold. Get a reading in the water (wet) and then out of the water (dry). The threshold value must be between the wet and dry value. For example, if the actual wet value is 17 and the actual dry value is 2, put in a threshold value half way between 2 and 17. The default value is 20.

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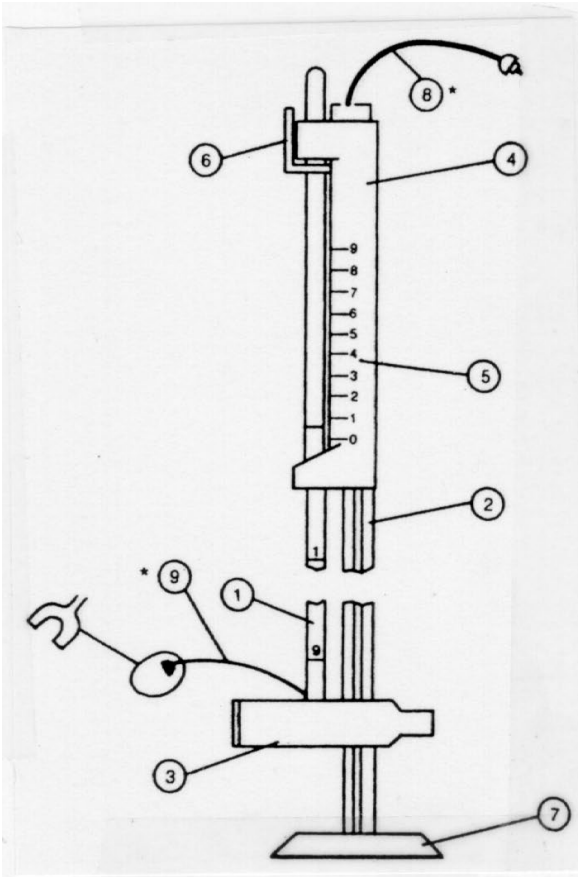
Attachment 3

Top Setting Wading Rod Operating Instructions

The top setting wading rod is used both to measure depth and to position the current meter. The hexagonal rod is graduated at intervals of 0.1 ft with shallow machined lines. A single groove is used at the 0.1-ft graduations, double grooves at the 0.5-ft intervals, and triple grooves at the foot marks. The sliding or suspension rod moves up or down on the hexagonal rod and is held by a spring-actuated lock that uses a lever for release. The sliding rod is marked with grooves that are labeled 0 through 9. The current meter attaches to the sliding rod.



(1) The 3/8" diameter Aluminum rod.
(2) The 1/2" Hexagon Stainless Steel rod.
(3) The Sliding Support.
(4) The Handle.
(5) The Vernier.
(6) The Trigger.
(7) The Base.
(8) The Wire Assy. - Handle.*
(9) The Wire Assy. - Meter.*

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

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

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

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

Considering a depth of **X.x**, with **X** the units value and **x** the decimal fraction,

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

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

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

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

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

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

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

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