



Environmental Analysis Program

Pomona College
Biogeochemistry Laboratory

SOP-F301

Stream Discharge Measurement – Wadable Streams

Standard Operating Procedure

SOP Number	SOP-F301
Revision	0.2
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Date	2026-06-26
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1. Purpose

This SOP describes the procedure for measuring stream discharge (volumetric flow rate) in wadable streams using the USGS midsection velocity-area method with Price Pygmy or Price Type AA mechanical current meters. Discharge data are fundamental to characterizing watershed hydrology, calculating pollutant loads, and supporting water quality assessments (Rantz et al., 1982; Turnipseed & Sauer, 2010).

2. Scope

- **Applies to:** Wadable streams and channels where personnel can safely stand in the flow (generally depths < 3–4 ft and velocities < approximately 4 ft/s)
- **Does not apply to:** Non-wadable rivers requiring bridge, cableway, or boat measurements; acoustic Doppler instruments (see [SOP-F202](#)); or flume and weir installations
- **Location:** All EA Program stream monitoring sites

3. Responsibilities

Role	Responsibility
Lab PI	Approve measurement sites and protocols
Field Lead	Select cross-section locations, verify equipment
Trained Personnel	Perform measurements and record data per this SOP
New Students	Complete training before making independent measurements

4. Definitions

- **AquaCalc:** A digital flow computer that counts current meter revolutions and computes velocity automatically; eliminates manual timing with a headset and stopwatch and reduces transcription errors.
- **Cross-section:** The plane perpendicular to the direction of flow at which discharge is measured; ideally straight, uniform, and free of eddies or dead zones (Rantz et al., 1982).
- **Discharge (Q):** The volumetric flow rate of a stream, expressed in cubic feet per second (cfs) or liters per second (L/s); computed as the sum of the products of water velocity, depth, and width across all subsections of the cross-section (Rantz et al., 1982).
- **Midsection method:** The standard USGS computational approach in which the discharge of each subsection is calculated as the product of the measured velocity, the depth at that vertical, and the horizontal distance to the midpoints on either side of the station (Rantz et al., 1982; Turnipseed & Sauer, 2010).

- **Price Pygmy meter:** A small-cup mechanical current meter (5 cm diameter) used in shallow water (< 1.5 ft depth) or when velocities are low; 1 revolution = 1 click per second at approximately 0.1 ft/s (Rantz et al., 1982).
- **Price Type AA meter:** The standard USGS mechanical cup-type current meter (12.5 cm diameter) used in deeper flows; more accurate than the Pygmy for velocities above approximately 0.2 ft/s (Rantz et al., 1982).
- **Six-tenths-depth method:** Placement of the current meter at 0.6 of the total depth below the water surface; yields the mean vertical velocity in most natural channels; the standard method for shallow profiles (depth < 2.5 ft) (Rantz et al., 1982).
- **Spin test:** A quality control check in which the current meter bucket wheel is spun by hand and the time for it to stop is measured; the wheel should spin freely for a minimum number of seconds (see [SOP-F201](#)); indicates bearing condition and mechanical integrity.
- **Tag line:** A measuring tape stretched taut across the stream perpendicular to the flow; anchored at both banks; used to measure horizontal distances to each measurement station (Rantz et al., 1982).
- **Thalweg:** The line of deepest flow along the channel axis; usually the zone of highest velocity and the target for closely spaced measurement stations.
- **Two-point method:** Placement of the current meter at 0.2 and 0.8 of the total depth; the arithmetic mean of the two velocities gives the mean vertical velocity; preferred when depth > 2.5 ft (Rantz et al., 1982).
- **Wetted width:** The horizontal distance across the stream from water's edge to water's edge at the measurement cross-section.

5. Safety and Hazards

Hazards

- **Drowning and swift water:** Do not wade in flows deeper than approximately waist height or where you feel unstable. Use a wading rod as a support. Always face upstream while wading.
- **Slippery substrates:** Cobble, gravel, and algae-covered rocks are extremely slippery. Wear felt-soled or studded wading boots.
- **Hypothermia:** Prolonged immersion in cold water can cause hypothermia. Wear insulated waders in cold conditions.
- **Biological:** Waterborne pathogens may be present. Avoid swallowing water. Wash hands and equipment after each site visit.

5.1. Required PPE

- ☐ Chest or hip waders (neoprene or breathable)
- ☐ Wading boots with felt or studded soles
- ☐ PFD if flow conditions are marginal
- ☐ Sun protection (hat, sunscreen)
- ☐ Nitrile gloves (optional, for concurrent water quality sampling)

5.2. Emergency Procedures

If a team member loses footing, release the wading rod and equipment and focus on self-rescue by floating feet-first downstream. Never attempt a discharge measurement alone; a minimum of two people must be present. Refer to [SOP-F001 Field Safety](#).

6. Equipment and Materials

Item	Notes
Price Pygmy or Type AA current meter	See SOP-F201
Top-setting wading rod	Graduated in tenths of a foot
AquaCalc digital flow computer or headset and stopwatch	For counting revolutions
Measuring tape (50 m / 150 ft)	Fiberglass; for establishing the tag line
Tape stakes or rebar pins	Two; for anchoring the tag line
Mallet	For driving stakes
Field data sheet (Appendix A)	Printed on waterproof paper
Clipboard and pencils	
GPS unit or smartphone	For recording cross-section coordinates
Thermometer	For recording water temperature
Camera	For photo-documenting the cross-section

7. Estimated Time

Task	Time Required
Site selection and tag line setup	10–20 minutes
Spin test	5 minutes
Discharge measurement (20–30 verticals)	30–60 minutes
Data recording and site breakdown	10–15 minutes

8. Procedure

8.1. Site Selection

Select a measurement cross-section with as many of the following characteristics as possible (Rantz et al., 1982):

1. Straight channel reach for at least 3–5 channel widths upstream and downstream
2. Uniform flow – no eddies, backwater, or dead zones
3. Stable streambed (no excessive soft sediment or mobile cobbles)
4. Flow perpendicular to the tag line

5. Avoid locations immediately downstream of bridges, confluences, debris jams, or sharp bends
6. Depth sufficient to submerge the current meter cups; shallow enough to wade safely

 Tip

Ideal cross-sections are trapezoidal with gradually varying depth. Avoid abrupt depth changes, undercut banks, and boulders that create turbulence (Rantz et al., 1982).

8.2. Establishing the Tag Line

1. Stretch the measuring tape across the stream perpendicular to the flow direction.
2. Anchor each end with a tape stake driven into the bank.
3. Pull the tape taut so it does not sag into the water.
4. Record the distance at the left water's edge (LEW) and the right water's edge (REW), looking downstream. All station distances are measured from the same reference bank (typically the left bank, looking downstream).

8.3. Determining Station Spacing

Divide the wetted width into subsections. The goal is 20–30 subsections; no single subsection should carry more than 5–10% of total estimated discharge (Rantz et al., 1982).

Wetted Width	Recommended Station Spacing
< 5 ft (1.5 m)	0.5 ft (0.15 m)
5–15 ft (1.5–4.5 m)	1.0 ft (0.3 m)
> 15 ft (4.5 m)	Divide into 20–30 equal intervals

Space stations more closely near the thalweg where depth or velocity changes rapidly.

8.4. Assembling and Testing the Meter

1. Mount the current meter on the wading rod per [SOP-F201](#), Section 7.1.
2. Connect the cable to the AquaCalc or headset.
3. Perform a spin test and record the result on the data sheet.

8.5. Making the Measurement

Work from one bank to the other. At each station:

1. **Position yourself downstream** of the wading rod; your body must not disturb the flow at the measurement point.
2. Record the **station distance** from the tag line.
3. Measure and record the **water depth** to the nearest 0.01 ft.

8.5.1. Setting the Meter Depth

Method	Meter Position	When to Use
Six-tenths	$0.6 \times$ depth from the surface	Depth ≤ 2.5 ft or Pygmy
Two-point	0.2 and $0.8 \times$ depth (average the two)	Depth > 2.5 ft
Surface	$0.2 \times$ depth; apply coefficient 0.85–0.90	Very shallow or weedy

(Rantz et al., 1982; Turnipseed & Sauer, 2010)

4. **Count revolutions** for a minimum of 40 seconds (up to 70 s at low or unsteady velocities). Record revolutions and elapsed time (or velocity if using the AquaCalc).
5. Move to the next station and repeat.

! Important

When counting revolutions manually, look up velocity in the rating table for your meter model (see [SOP-F201](#), Section 9.3).

8.6. Edge Measurements

At the left and right water's edges, record depth = 0 and velocity = 0. These close the cross-section.

8.7. Post-Measurement Spin Test

Repeat the spin test after completing the measurement. A reduced spin time indicates potential bearing damage; the measurement quality is suspect (Rantz et al., 1982).

9. Discharge Calculation – Midsection Method

Total discharge is the sum of discharge through each subsection (Rantz et al., 1982; Turnipseed & Sauer, 2010):

$$Q = \sum_{i=1}^n V_i \cdot d_i \cdot w_i$$

where for station i :

- V_i = mean vertical velocity (ft/s or m/s)
- d_i = water depth (ft or m)
- w_i = width of the subsection = distance from the midpoint to the adjacent station on each side (ft or m)

Report discharge in cfs or L/s, rounded to three significant figures following USGS conventions (Turnipseed & Sauer, 2010):

Discharge Range	Rounding
< 1 cfs	Nearest 0.01 cfs
1–10 cfs	Nearest 0.1 cfs
10–100 cfs	Nearest 1 cfs

10. Data Processing

1. Enter field data into the lab's standard discharge spreadsheet template on the same day as the measurement.
2. Verify the total discharge calculation matches the field computation.
3. Flag any station carrying more than 10% of total discharge in a single subsection – this indicates station spacing was too wide.
4. Archive the original field data sheet (scan if paper).

11. Quality Control

- No single subsection should carry more than 5–10% of total discharge (Rantz et al., 1982).
- Pre- and post-measurement spin tests must meet minimum thresholds (see [SOP-F201](#)).
- If two measurements are made at the same cross-section, they should agree within 5%; if they differ by more than 5%, make a third measurement and use the mean of the two closest values (Turnipseed & Sauer, 2010).
- **Oblique flow:** If current is not perpendicular to the tag line, velocity readings underestimate true velocity. Reposition or apply a cosine correction.
- **Wading disturbance:** Stand downstream of the meter; avoid shuffling feet near the measurement point.
- **Unsteady flow:** In flashy streams, stage may change during measurement. Record the time at each station.

12. References

- Rantz et al. (1982)
- Turnipseed & Sauer (2010)

Rantz, S. E. et al. (1982). *Measurement and computation of streamflow: Volume 1. Measurement of stage and discharge* (Water-Supply Paper 2175). U.S. Geological Survey. <https://pubs.usgs.gov/wsp/wsp2175/>

Turnipseed, D. P., & Sauer, V. B. (2010). *Discharge measurements at gaging stations* (Techniques and Methods 3-A8). U.S. Geological Survey. <https://doi.org/10.3133/tm3A8>

13. Related SOPs

SOP	Title	Relationship
F001	Field Safety	Required prerequisite
F007	Field Decontamination	Equipment cleaning between sites
F201	Pygmy and Type AA Velocity Meters	Meter selection and operation
F202	SonTek Acoustic Velocity Meters	Acoustic alternative
F300	Surface Water Sampling	Water quality sampling at discharge stations

14. Training Record

Before making discharge measurements independently, personnel must:

1. Read this SOP and [SOP-F201](#) in full
2. Demonstrate safe wading technique and proper use of the wading rod
3. Successfully set up a tag line and conduct a pre-measurement spin test
4. Measure a discharge under supervision (minimum one complete cross-section)
5. Demonstrate correct midsection calculation
6. Be signed off by the PI or field lead

15. Appendix A: Field Data Sheet

Print on waterproof paper (Rite in the Rain). One sheet per measurement.

Site: _____ **Date:** _____ **Time:** _____

Operator(s): _____ **Meter type:** _____ **Meter #:** _____

Pre-measurement spin time: _____ s **Post-measurement spin time:** _____ s

Water temperature: _____ °C **Weather:** _____

Station (ft)	Depth (ft)	Meter depth setting (ft)	Revolu- tions	Time (s)	Velocity (ft/s)	Width (ft)	Q_sub (cfs)
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Station (ft)	Depth (ft)	Meter depth setting (ft)	Revolu- tions	Time (s)	Velocity (ft/s)	Width (ft)	Q_sub (cfs)
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Total Q: _____ cfs **Notes:** _____