AOS PROTOCOL AND PROCEDURE: STREAM DISCHARGE

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	02/06/2014	ECO-01092	Initial release
B	01/26/2015	ECO-02636	Migration to new protocol template
C	02/29/2016	ECO-03662	Baseline of protocol following FOPs review
D	02/03/2017	ECO-04480	Updated to new template; changes to sampling frequency, point of zero flow, removal of 3 depth sampling
E	01/29/2017	ECO-05292	Baseline update of protocol sent to FOPS for review. Made slight revisions to Sections 1.1, 4.1, 4.2, 4.4, 4.5. Added definitions to Section 2.4. Included language on continuous discharge calculation to Section 3. Section 7: re-organized content throughout; added instrument-specific steps to flowmeter setup and measurement procedures; refined calibration procedures (did not change); added list of common data entry errors to post-measurement review section based on NEON-9064; replaced Figure 7 with one that shows equations and natural control segments; revised PZF procedure based on NEON-8821; added additional language on natural control types and how they affect ratings; added additional steps to data entry and verification based on NEON-9064. Added Appendix A which introduces plan for measuring river discharge. Added additional citations into References section. Made slight revisions to Appendix B. Removed Appendix C.

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1 OVERVIEW

1.1 Background

The degree to which streamflow, or discharge, affects the structure of stream and river ecosystems cannot be overstated. Stream ecologists consider discharge a master variable, as varying rates of discharge directly affect the physical, chemical, and thermal attributes of the stream ecosystems. High flow events have the ability to entirely reshape the physical habitat of streams by repositioning large woody debris, sediment, and boulders within the active channel, or the active channel itself. Flow rates often directly affect water temperatures, particularly during flood and low-flow events (Poole and Berman 2001). Surface water discharge rates directly affect flow through the hyporheic zone (space between sediments in the benthic zones of streams) as well, where microbial activity is concentrated. Consequently, discharge can directly affect nutrient cycling in streams (Grimm and Fisher 1984). Because of these and other interactions between discharge and the physicochemical attributes of streams, flow regime characteristics have been found to be significantly correlated with life history attributes of stream-dwelling organisms such as fishes (Mims and Olden 2012).

Flow regimes in stream and rivers worldwide are rapidly changing due to environmental stressors, consequentially affecting the ecological services these systems support. Climate change impacts the timing, magnitude, and severity of flood and drought events with profound consequences for lotic ecosystems. For example, peak flows in western North American rivers are consistently occurring earlier in the spring (Clow 2010) and these changes may significantly alter the habitat suitability for species such as cutthroat trout (Zeiglar et al. 2012). Land use change from natural cover to human-dominated landscapes can also affect discharge. Impervious surfaces (such as roads and rooftops) in urban landscapes transfer water directly to stream channels, resulting in elevated flood frequencies and magnitudes (Schoonover et al. 2006). Agricultural lands may also impact flow regimes either by reducing flows directly through withdrawals or elevating flow when soils become compacted (Dodds et al. 2004). All flow regime changes associated with land use substantially impact the biological communities that reside in the receiving waters (Cuffney et al. 2010, Dodds et al. 2004).

Because discharge is fundamentally important to stream ecosystems, NEON will calculate discharge in all rivers and stream sites within the Observatory. The discharge data product will be a crucial input to a number of additional high-level NEON data products, such as stream metabolism and nutrient fluxes. Consequently, discharge represents a critical component in the NEON Aquatic Observation System.

1.2 Scope

This document provides a change-controlled version of Observatory protocols and procedures. Documentation of content changes (i.e. changes in particular tasks or safety practices) will occur via this change-controlled document, not through field manuals or training materials.

1.2.1 NEON Science Requirements and Data Products

This protocol fulfills Observatory science requirements that reside in NEON's Dynamic Object-Oriented Requirements System (DOORS). Copies of approved science requirements have been exported from DOORS and are available in NEON's document repository, or upon request.

Execution of this protocol procures samples and/or generates raw data satisfying NEON Observatory scientific requirements. These data and samples are used to create NEON data products, and are documented in the NEON Scientific Data Products Catalog (RD[03]).

1.3 Acknowledgments

NEON acknowledges the current definitive work on this topic, "Discharge Measurements at Gaging Stations", U.S. Geological Survey Techniques and Methods Book 3, Chapter A8, by D. Phil Turnipseed and Vernon B. Sauer (2010).

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

Applicable documents contain higher-level information that is implemented in the current document. Examples include designs, plans, or standards.

AD[01]	NEON.DOC.004300	EHS Safety Policy and Program Manual
AD[02]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD[03]	NEON.DOC.000724	Domain Chemical Hygiene Plan and Biosafety Manual
AD[04]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[05]	NEON.DOC.004104	NEON Science Performance QA/QC Plan

2.2 Reference Documents

Reference documents contain information that supports or complements the current document. Examples include related protocols, datasheets, or general-information references.

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]	NEON.DOC.005003	NEON Scientific Data Products Catalog
RD[04]	NEON.DOC.001271	NEON Protocol and Procedure: Manual Data Transcription
RD[05]	NEON.DOC.001646	General AQU Field Metadata Sheet

2.3 Acronyms

Acronym	Definition
LEW	Left edge of water (looking downstream)
P&P	Procedure and Protocol
REW	Right edge of water (looking downstream)
USGS	U.S. Geological Survey
SDRC	Stage Discharge Rating Curve
PZF	Point of Zero Flow

2.4 Definitions

Area (A): The cross-sectional area of a stream or a subsection of a stream. For a rectangular subsection, it is the width times the depth. For an irregular cross-section, it is the summation of a series of subsection areas, or the width times the average depth.

Control: A specific section of a stream channel, located downstream from the staff gauge that controls the relation between gauge height and discharge at the staff gauge.

Depth (D): The depth of the water column at a particular point, measured from the water surface to the stream bottom.

Discharge (Q): (streamflow) The volume of water flowing through a cross-section during a given period of time, measured in units of volume per unit time, such as cubic feet per second, cubic meters per second, liters per second, gallons per minute, or acre-feet per year. Discharge is computed as velocity x area.

Left edge of water (LEW): The edge of the stream that is on the observer's left when looking downstream.

Right edge of water (REW): The edge of the stream that is on the observer's right when looking downstream.

Stage: (i.e. stream height, water level) Height of a stream or river relative to a fixed point. Stage can be measured at a single point in time by reading the water level on a calibrated staff gauge mounted in the stream channel, or by using a weighted measuring tape to measure down from a fixed point to the water surface. Stage can also be measured continuously with a pressure, optic or acoustic sensor, or a staff gauge.

Stage Discharge Rating Curve (SDRC): An empirical relationship (formula) between a stream stage and the associated discharge at given stage, which allows automated measurements of stage to be converted to discharge.

Station: A location along the stream discharge measurement transect where velocity and depth are measured and area and streamflow are calculated. Station, or vertical, spacing is dependent on the wetted width of the channel and velocity distribution throughout the transect.

Thalweg: The line that connects the deepest part of the active channel.

Transect: The stream cross-section under the measuring tape stretched across the measuring section, along which velocity measurements are made to compute discharge.

Velocity (V): The speed of water flowing past a point along the transect, measured in liters per second.

Wetted Width: Width of a stream channel that contains water. As water levels fluctuate in streams, the wetted width may as well, depending on the cross-sectional shape of the channel.

3 METHOD – WADEABLE STREAMS

A continuous record of stream discharge is derived using discharge measurement and observed gauge height data collected by field technicians and raw depth data collected by *in-situ* pressure transducers at each NEON aquatic site that contains a wadeable stream. Stage-discharge rating curves are developed that regress observed gauge heights (or stage) against a measurement of streamflow, or discharge. To build a stage-discharge rating curve NEON field personnel measure discharge data across a wide range of stream stage levels. These sampling events are known as wading surveys. During a wading survey discharge is a calculated metric obtained from a series of stream velocity and area measurements collected along a fixed cross-section in the stream. Velocity and area measurements are then integrated into a single value of stream discharge that is associated with the gauge height (or stage) during the measurement.

Once the rating curve is established, and barring significant changes in channel morphology due to stochastic events, a single measurement of water column depth in the stream channel is sufficient to estimate streamflow. Hence, a pressure transducer located at a fixed location in the stream is able to yield a continuous estimate of stream discharge by measuring water depth.

Each NEON aquatic site contains an in-stream staff gauge that is located in a fixed positioned near a Level Troll which automatically measures and logs absolute pressure values *in-situ* at one-minute intervals throughout the year, or while water is present within the sub-reach. Absolute pressure data is converted to raw depth using CAL/VAL calibration coefficients. During each wading survey technicians record gauge height. The raw depth values derived from the pressure transducer are regressed against gauge height measurements collected throughout the water year to derive an equation that transforms raw depth to stage. A continuous record of stream discharge is derived by applying stage-discharge rating equations to continuous stage data. During the site characterization period, in-stream and barometric pressure is measured at 15-minute intervals by HOBO transducers which provide data that is converted to continuous stage and discharge in a similar manner.

The purpose of this protocol is to provide detailed instructions on how to successfully implement a discharge wading survey. This involves pre-deployment and post-measurement review, step-by-step field methods, data entry procedures, troubleshooting, instrument quality assurance plans, and safety guidelines specific to NEON sites and personnel. The methods detailed in this document follow the United States Geological Society (USGS) protocols (Rantz et al. 1982, Turnipseed and Sauer, 2010).

Wading surveys involve positioning a velocity meter sensor attached to a rod in the flowing stream. The velocity meter is designed to measure the speed of water around the sensor tip, yielding an instantaneous localized velocity measurement. To obtain an estimate of total stream discharge within the cross-section, the stream is divided laterally into sub-sections. Within each sub-section, an instantaneous velocity magnitude is obtained and transformed to a volumetric discharge magnitude by applying the velocity across the full sub-section area. Total stream discharge is then calculated by summing up the discrete volumetric discharges for each sub-section. Should site-specific conditions become unfavorable for wading surveys, such as insufficient water levels or velocities, alternative methods may need to be performed. Science staff will make this decision based on site conditions and site constraints.

While the rating curve is under initial development, it is particularly important to perform wading surveys frequently in order to form the basis of the stage-discharge relationship. NEON's target is to conduct 24 discharge surveys over a wide range of stage levels until Science has approved a valid SDRC.

Once the rating curve has undergone this initial development, it is important to check the rating periodically, as it may shift due to scour, aggradation, or other changes in channel geometry. Channel morphology in streams with unconsolidated bed materials is expected to fluctuate (to varying degrees) on an annual and storm-event basis. As a result, rating curves for these channel types will require more frequent measurements than those for bedrock channels, which are more stable. NEON's target is to use wading surveys to verify the rating curve twelve (12) times per year across a range of stages. Discharge surveys that occur during and following high-flow events (which may substantially alter channel geometry) are especially important for detecting shifts in the stage-discharge relationship.

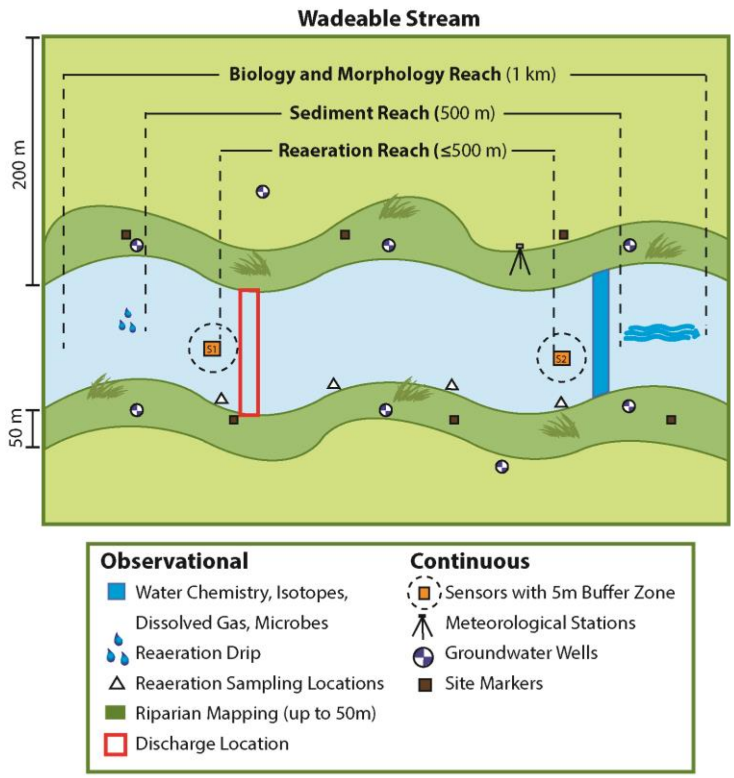

Figure 1. Discharge transects must be placed on a run or riffle associated with the pool that the staff gauge and pressure transducer is placed.

Standard Operating Procedures (SOPs), in Section 7 of this document, provide detailed step-by-step directions, contingency plans, sampling tips, and best practices for implementing this sampling procedure. To collect an accurate discharge measurement, field technicians must follow the protocol and associated SOPs. Use NEON's problem reporting system to resolve any field issues associated with implementing this protocol.

The value of NEON data hinges on consistent implementation of this protocol across all NEON domains, for the life of the project. It is therefore essential that field personnel carry out this protocol as outlined in this document. In the event that local conditions create uncertainty about carrying out these steps, it is critical that technicians document the problem and enter it in NEON's problem tracking system.

Quality assurance will be performed on data collected via these procedures according to the NEON Science Performance QA/QC Plan (AD[05]).

4 SAMPLING SCHEDULE – WADEABLE STREAMS

4.1 Sampling Frequency and Timing

Stream discharge must be measured at aquatic sites with wadeable streams a minimum of twenty-four (24) times in order to establish an SDRC followed by twelve (12) times per year to validate and refine the rating. After the first year of sampling, the SDRC will be reviewed and approved by NEON Science. If SDRC is not approved by Science, then Science will request that field operations staff schedule additional sampling bouts to fill in data gaps needed to improve the SDRC.

Following each sampling bout after the SDRC has been established, field technicians must compare the measured discharge value to the predicted value derived from the rating. Consecutive discharge sampling bouts that yield discharge values greater than ± 10% of the predicted value may be an indication that the stage-discharge relationship at a given site has changed, or shifted. Sampling frequency must then be increased in order to validate a potential shift, which, if validated, would result in a new rating equation. Shift validation typically involves targeting sampling bouts to occur during stage levels. If a rating shift is validated Science will direct field operations staff to increase annual sampling frequency to 24 measurements. More information regarding identifying and reporting potential rating shifts is available in SOP A.8.

Table 1. **Required sampling frequency for wading discharge measurements at NEON aquatic sites with wadeable streams.**

Domains	Sampling Dates	Sampling Bouts per Year
All Domains: pre-SDRC establishment	Year-round (as feasible)	24
All Domains: post-SDRC establishment	Year-round (as feasible)	12

4.2 Criteria for Determining Onset and Cessation of Sampling

- Data collection:
  a) Is there flowing water in the stream channel? If NO then STOP; If YES, proceed to (1b)
  b) Is the staff gauge absent from the site or has it been displaced in any way? If YES then STOP, if NO, proceed to (1c)
  c) Is >30% of the transect at a depth >0.06m? If NO then consider implementing PZF methodology ; if YES, proceed to (1d)

d) Is there sufficient time to collect a discharge survey? If NO then STOP; if YES, perform discharge survey

4.3 Timing for Laboratory Processing and Analysis

There is no domain lab processing for this protocol.

4.4 Sampling Specific Concerns

- If technicians determine that logs, boulders, thick ice and or other submerged objects immediately upstream or downstream of the transect influence the streamflow at the specific measurement station, do no collect a discharge measurement. Technicians shall submit a trouble ticket that includes pictures or videos of the obstruction, and consult with Science.

4.5 Factors That May Negatively Impact Measurement Results:

- Rapidly changing stage (> ~0.10m) during the discharge measurement;
- Velocities that are outside the range of the flowmeter to accurately measure;
- Dropping equipment into the stream;
- Heavy precipitation;
- Severe cold or wind;
- People or animals approaching the sampler while in the stream;
- Low or dead batteries in the current meter;
- Errors in reading or entering data in the handheld velocity meter;
- Using the meter in the wrong mode, such as getting readings in English rather than metric units;
- Failure to read or set the depth on the wading rod in the correct manner;
- Failure to stretch the tape line perpendicular to the direction of flow;
- Improper site selection (too slow, too shallow, effects of backwater, too turbulent, too many rocks and eddies, undercut banks, bends, large woody debris, other obstructions);
- Insufficient attention to the protocol

4.6 Criteria for Permanent Reallocation of Sampling Within a Site

Discharge sampling will occur on the schedule described above at one location per site. Ideally, sampling will occur at these sampling locations for the lifetime of the Observatory (core sites) or the duration of the site's affiliation with the NEON project (relocatable sites). However, circumstances may arise requiring that sampling within a site be re-located from one particular location to another. In general, sampling is considered to be compromised when sampling at a location becomes so limited that data quality is significantly reduced. If sampling at a given transect becomes compromised, a trouble ticket should be submitted by Field Operations to Science.

There are two main pathways by which sampling can be compromised. Sampling locations can become inappropriately suited to answer meaningful biological questions (i.e., a high flow event significantly alters the discharge cross-section), or sampling locations may become located in areas that are logistically impossible to sample on a schedule that that is biologically meaningful.

5 SAFETY

This document identifies procedure-specific safety hazards and associated safety requirements. It does not describe general safety practices or site-specific safety practices.

Personnel working at a NEON site must be compliant with safe fieldwork practices as outlined in the Operations Field Safety and Security Plan (AD[02]) and EHS Safety Policy and Program Manual (AD[01]). Additional safety issues associated with this field procedure are outlined below. The Field Operations Manager and the Lead Field Technician have primary authority to stop work activities based on unsafe field conditions; however, all employees have the responsibility and right to stop their work in unsafe conditions.

Personnel should wear clothing appropriate for weather conditions at the site. Both team members are required to wear hip waders and wading boots with no-slip soles. Technicians should consider wearing NEON approved personal flotation devices in high velocity streams or streams with pools and runs deeper than one meter. Activities in streams should only be performed when flow conditions are safe. Do not attempt to wade a stream where velocity x depth is ≥ 10 ft^2/s (0.93 m^2/s).

6 PERSONNEL AND EQUIPMENT

6.1 Equipment

The following equipment is needed to implement the procedures in this document. Equipment lists are organized by task. They do not include standard field and laboratory supplies such as charging stations, first aid kits, drying ovens, ultra-low refrigerators, etc.

Table 2. **Equipment list – Field equipment**

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
Durable items							
			R	Survey Tape (15-100m, site specific lengths)	Establishing the transect	1	N
MX106043 MX104361	Amazon Capital Services Inc. Ben Meadows Co., Inc.	B001JYXXH8 100952	R	Stakes	Anchoring survey tape	2	N
MX106199	McMaster-Carr Supply Co.	50065A21	S	Clamps	Attaching and securing tape to stakes	2	N
MX100526	Grainger, W.W.	34A216	R	5 Gallon Bucket	Zero Calibration of sensor	1	N
MX106032	Hach Company	1040500195S 10405005950N	R	Velocity Meter (Ex. Hach FH950.1)	Measuring velocity	1	N

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
MX103015	Fondriest Environmental, Inc.	105-009	R	Top setting wading rod	Measuring velocity	1	N
MX100491 MX100494 MX107505	Ben Meadows Co., Inc. Grainger, W.W. Forestry Suppliers, Inc. Cabela's		R	Waders (per person)	Safe wading	1	N
			R	Personal Flotation Device (at sites where required)	Safe wading	1	N
Consumable items							
				No Consumable Items			

R/S=Required/Suggested

6.2 Training Requirements

All technicians must complete required safety training and protocol-specific training for safety and implementation of this protocol as required in Field Operations Job Instruction Training Plan (AD[04]).

Personnel should be:

- Trained in Water Safety Awareness and Cold Water Safety Awareness
- Trained in making wading discharge measurements
- Adept at wading in streams.

6.3 Specialized Skills

N/A

6.4 Estimated Time

Once at the discharge site, one discharge transect should take from setup to completion between 0.5 and 1.75 hours. Time spent will increase if the technician needs to sample the transect more than once.

7 STANDARD OPERATING PROCEDURES

SOP A Field Sampling

A.1 Prior to Leaving the Office

- Ensure that the flow meter is fully charged.
- Gather and prepare all necessary equipment (See Table **2** for equipment list).
- If a site has an approved SDRC, current rating equations must be available in order to compare measured vs. predicted discharge values. Once established, rating equations will be provided to FOPs via the Fulcrum platform.

A.2 Navigate to the Discharge Transect

- If a discharge transect, or cross-section, has already been established, the bounds should be permanently marked using stakes or plot markers (one on each side of the stream). Navigate to this location and proceed to Step 3.

- If a discharge transect has not been established at the site proceed with the following steps:

  a) Determine an appropriate location to establish a discharge transect.

    - The transect location must be located in the riffle habitat unit in close proximity (just downstream) of the pool where the staff gauge and sensor set are installed (typically this is the S2 sensor set location). Request coordinates from Science if the S2 location is unknown or has not yet been established.

    - An ideal discharge transect will:
      (1) Be located in a reasonably straight channel with velocity lines that are more or less parallel to each other;
      (2) Contain velocities that are, for the most part, > 0.15 m/s, and depths that are, for the most part, 0.15m;
      (3) Contain a stable streambed free of obstructions that would create eddies, slack water, and turbulence;
      (4) Contain measurement sections that are roughly parabolic, trapezoidal, or rectangular;
      (5) Contain a stable downstream control feature.

    - Take a picture of the transect location that best meets this criteria as well as the downstream control feature and send to Science for consultation.

- Prior to collecting the discharge measurement identify any instrumentation or environmental issues that would negatively affect data quality. If conditions are unfavorable to discharge measurement collection, submit a trouble ticket and consult with Science.

  Unfavorable conditions include, but are not limited to:

  a) The staff gauge is either not present or has been displaced in some way.

     - A discharge measurement **should not be collected** if a staff gauge is not present at the site or the gauge has been displaced in any way. Submit a trouble ticket to Science that includes photos of the gauge.

  b) A pressure transducer or Level Troll is either not present or has been displaced in some way.

     - A discharge measurement **may be collected** in the event that the pressure transducer is missing or has been displaced. However the absence of this instrument prevents continuous discharge from being estimated. Submit a trouble ticket to Science immediately following the discharge measurement.

  c) Too much water is present in the channel to safely conduct the wading survey. Refer to NEON Operations Field Safety and Security Plan (AD[02]) for details. If the transect has too much water flowing to safely measure discharge **do not collect** a discharge measurement and submit a trouble ticket to Science for consultation.

  d) There is an insufficient amount of water in the channel to conduct velocity measurements.

     - A minimum water level of 0.06 meters is required to conduct the discharge measurement at each point within the transect. Depths less than 0.06 m may cause bias in the velocity reading. Edge stations are typically shallow and may contain depths < 0.06m.
     - If the transect contains a wetted width where >30% of depths are less than 0.06 m, a point of zero flow measurement may be in order (see SOP A9).
     - The minimum velocity range for the HACH FH950 flowmeter is 0.01 m/s. The instrument is not rated to accurately estimate velocity below this threshold. If

measured velocity is < 0.01 m/s in >30% of stations within the transect, a discharge measurement **should not be collected** and a trouble ticket should be submitted.

e) Environmental issues that can affect sampling such as thunderstorms (refer to NEON Operations Field Safety and Security Plan (AD[02] for details), or frozen stream surfaces (refer to NEON Operations Field Safety and Security Plan (AD[02] for details).

- If the water surface is "lightly iced" over (< 1" of ice) and you can safely break through the ice to clear/open up a 1m width along the entire discharge transect, **collect a discharge measurement.** On the General Field Metadata sheet RD[05] record ice conditions and indicate that surface ice was broken in order to collect the measurement.

- If the surface ice thickness is > 1", **do not collect** a stream discharge measurement.

A.3 Preparing to Measure Discharge: Setup Flowmeter and Check Flowmeter Settings

It is very important that the flowmeter settings are set correctly in the handheld units. Incorrect settings will negatively affect data quality and, in some instances, prevent the discharge file from being uploaded onto the SOM portal (see SOP A.8). Follow the steps below to setup the flowmeter and ensure that flowmeter settings are correct prior to measuring discharge. The most common flowmeter currently at use at NEON aquatic sites with wadeable streams is the HACH FH-950. The following steps detail calibration procedures for this model. If another flowmeter is used for discharge, consult with Science regarding unique calibration settings.

- Attach the flowmeter to the rod.
  a) Ensure the hexagonal flowmeter rod is attached properly to the rod base. The base and rod screw together, so tighten if loose.
  b) Attach the velocity flowmeter to the mounting shaft of the wading rod, using the thumbscrew (**Error! Reference source not found.**). Do not touch the tip of the sensor bulb, residue from oil on your fingers and hands can negatively affect the calibration procedures.

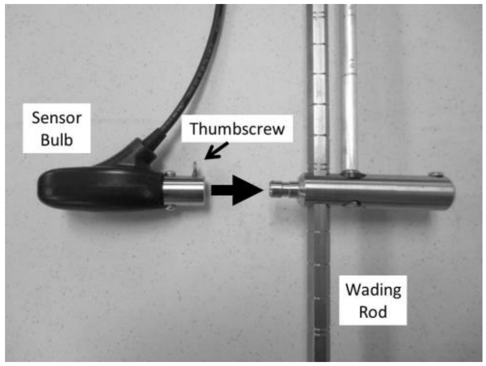

Figure 2. Velocity meter and the thumbscrew that attaches it to the wading rod.

- Turn the flowmeter on by pressing and holding the “ON/OFF” button on the outside of the handheld instrument. Note that the meter may first run a diagnostic check to ensure it is connected to the sensor. Once complete, the Start Menu will appear on the screen, as shown in **Error! Reference source not found.**.

Figure 3. **Hach FH950 velocity meter showing the “Start” menu.**

- Set Measurement Units**.**
  a) From the Start Menu, select “Setup” and press OK.
  b) Select “More” at the bottom of the screen.
  c) Select “Units” and press OK.
  d) Select “Metric” and press OK.
  e) Under the “Select function” screen, select “Velocity” and press OK.
  f) Select “m/s” and press OK.
  g) The “Parameters successfully saved” screen will appear. Press OK.
  h) Select “flow” and press OK.
  i) Select “liters/s” and press OK.
  j) The “Parameters successfully saved” screen will appear. Press OK.
  k) Select “depth” and press OK.

l) Select "m" and press OK.
m) The "Parameters successfully saved" screen will appear. Press OK.
n) Select "area" and press OK.
o) Select "m^2" and press OK.
p) The "Parameters successfully saved" screen will appear. Press OK.
q) Once all units have been set correct, press OK.

- Set Filter Parameters.
  a) From the Start Menu, select "Setup" and press OK.
  b) Select "Filter Parameters" and press OK.
  c) Select "Main filter" and press OK.
  d) Select "Fixed Period Averaging" and press OK.
  e) In averaging time box, enter a value of "40" and press OK. Note that values must not be < 10 seconds.
  f) The "Parameters successfully saved" screen will appear. Press OK.
  g) Check that "Pre-filer" is enabled and the data acquisition pre-filter rank is set to "5". These are default values and should not be changed.

- Set Flow Calculation Method.
  a) From the Start Menu, select "Setup" and press OK.
  b) Select "More" at the bottom of the screen.
  c) Select "Flow Calculation" and press OK.
  d) Select "Mid-section" and press OK.
  e) The "Parameters successfully saved" screen will appear. Press OK.

- Set Station Entry Method.
  a) From the Start Menu, select "Setup" and press OK.
  b) Select "More" at the bottom of the screen.
  c) Select "Station Entry" and press OK.
  d) Select "Non-Fixed" and press OK.
  e) The "Parameters successfully saved" screen will appear. Press OK.

- Set Measurement Resolution.
  a) From the Start Menu, select "Setup" and press OK.
  b) Select "More" at the bottom of the screen.
  c) Select "Measurement Resolution" and press OK.
  d) Select "0.001" and press OK.
  e) The "Parameters successfully saved" screen will appear. Press OK.

- Set Auto-Zero Mode.
  a) From the Start Menu, select “Setup” and press OK.
  b) Select “Auto Zero Depth” and press OK.
  c) Select “On” and press OK.
  d) The “Parameters successfully saved” screen will appear. Press OK.

- Set EMI.
  a) From the Start Menu, select “Setup” and press OK.
  b) Select “EMI” and press OK.
  c) Select “60Hz.” and press OK.
  d) The “Parameters successfully saved” screen will appear. Press OK.

- Set Wet/Dry Threshold.
  a) From the Start Menu, select “Setup” and press OK.
  b) Select “Wet/Dry Threshold” and press OK.
  c) Select “Default” and press OK. Note: if the specific conductivity of the water is very low
  d) The “Parameters successfully saved” screen will appear. Press OK.

- Set Clock.
  a) From the Start Menu, select “Setup” and press OK.
  b) Select “Clock” and press OK.
  c) Follow the instructions to set current time and date and press OK.
  d) The “Parameters successfully saved” screen will appear. Press OK.
  e) Update Clock settings to reflect periods of daylight savings time.

A.4 Preparing to Measure Discharge: Calibrating the Flowmeter

All flowmeters must be “zero-calibrated” prior to measuring discharge. The most common flowmeter currently at use at NEON aquatic sites is the HACH FH-950. The following steps detail calibration procedures for this model. If another flowmeter is used for discharge, consult with Science regarding calibration instructions.

To calibrate the HACH FH-950 flowmeter:

1. Fill a 5-gallon bucket with water from the stream you will be measuring discharge. Using the local water will ensure that the ionic strength of the “zeroing water” is the same as the water being measured.

2. Place the velocity meter in the water. Keep the sensor bulb positioned the center of the bucket (or as close to it as possible). The sensor bulb must be kept a minimum of 3-inches from the sides and bottom of the bucket as well as the surface of the water.

3. Allow water settle for 1-2 minutes to stabilize. Water in the bucket must remain still throughout the calibration process.

4. Turn on the handheld flowmeter and select "Setup".

5. Select "Velocity Calibration".

6. Select "Zero Calibration".

7. Allow the flowmeter to cycle through a calibration reading and, once complete, verify that the unit reads a velocity of 0.00 m/s. Note that -0.00 m/s is acceptable.
    a. If the calibration velocity is 0.00 m/s, return to the main menu on the handheld flowmeter.
    b. If the final calibration velocity does not equal 0.00 or -0.00 m/s at the end of the calibration cycle (100%), repeat Steps 1-7. Reasons for calibration errors may include:
        i. The sensor bulb tip was touched or is dirty and needs to be wiped off with a dry cloth.
        ii. Flowmeter batteries are low.
        iii. The water in the 5-gallon bucket was shifted during the calibration procedures.
        iv. The sensor bulb tip was too close to the bucket edges or the water surface during calibration procedures.
    c. If, after five attempts, the flowmeter cannot be zero-calibrated, the flowmeter should not be used and discharge should not be measured. Submit a trouble ticket and consult with Science. If possible use another flowmeter to measure discharge that can be zero-calibrated.

A.5 Preparing to Measure Discharge: Setting Up the Transect and Delineating Station Spacing for Depth and Velocity Measurement

Discharge measurements at NEON wadeable stream sites are to be measured from the right to left bank, looking downstream. Stations are to begin at the right edge of water (REW) and extend to the left edge of water (LEW).

To ensure high data quality is collected, velocity measurements must be spaced correctly across the stream discharge transect. To determine proper station spacing across a transect technicians must assess streamflow magnitude, water surface elevation, and wetted width prior to each discharge measurement. Use the following steps to properly space stations across the discharge transect.

1. Attach the measuring tape to the permanent stake on the right bank and extend it across the stream so that is perpendicular to the flow. Attach the opposite end to the permanent stake on the left bank. (Figure 2).

2. Measure the wetted width within the transect (the distance between the REW and the LEW) (Table 3).
   a. If the wetted width is >2.00m divide the transect into 20-25 sampling stations.
   b. If the wetted width is ≤ 2.00m, space stations at a maximum of 0.1m increments from REW to LEW. Divide the transect into 20-25 sampling stations. Note: this may not be possible in very narrow streams, in these cases less sampling stations are permitted.

3. Assess whether streamflow appears to be relatively uniform across the channel.

Table 3. Station spacing relative to wetted width.

Wetted Width (m)	Station Spacing
≤ 2.00	Set station widths at 0.1m unless any one sub-section contains >10% of the total measured discharge, then space sample points every 0.05m.
> 2.00	Establish 20 – 25 stations unless any one sub-section has >10% of the flow, then increase the number of sampling points.

4. Discharge measured at a single station should not exceed 10% of the total measured discharge across the transect. If non-uniform flow conditions are present (more concentrated areas of high flow within the transect), increase the number of sampling stations so that a higher number of stations are concentrated along the part of the transect with greatest flow (**Error! Reference source not found.**). This will aid in distributing discharge measurements across a greater number of stations.

5. A minimum width of 0.05m must always be maintained between stations. If stations widths are < 0.05m duplicate velocity profiles will be captured and measured at congruent stations.

6. Proceed with discharge measurement collection once stations widths have been determined,

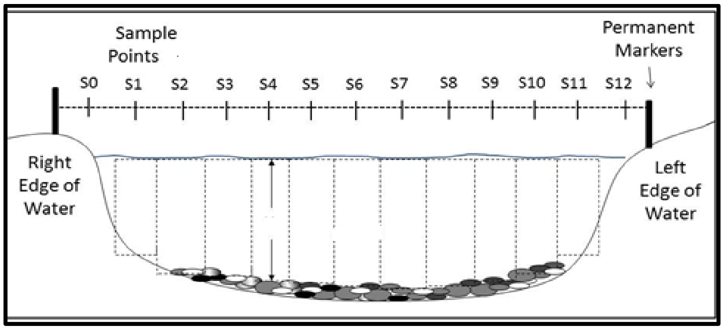

Figure 4. Example of well-distributed stations across a discharge transect that exhibits laminar flow. S0-S12 represent stations and dashed rectangles represent sub-sections.

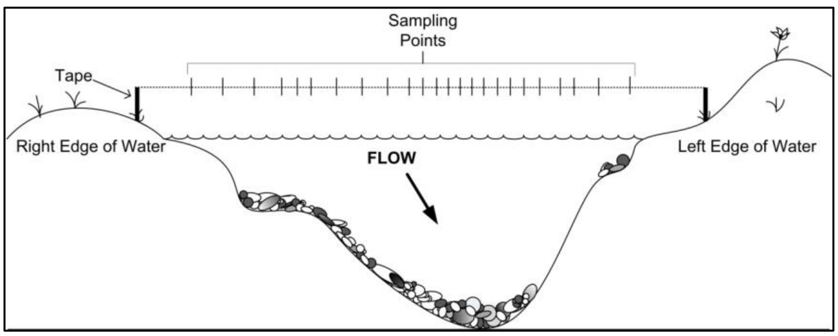

Figure 5. Example of un-even station spacing due to un-even flow distribution across the discharge transect.

A.6 Measuring Discharge: Proper Techniques and File Setup

When collecting a discharge measurement in the stream the wading rod is to be held directly in front of the operator (at arm's length) at each station along the transect. The sensor bulb on the flowmeter must be pointed directly upstream into the flow and perpendicular to meter tape.

Do not stand upstream or downstream of the velocity meter but rather to the side (i.e. towards the right bank). Standing directly in front of or behind the flowmeter would create conditions that would cause errors in the velocity readings.

To set up a discharge file on the handheld flowmeter:

1. Turn the unit on by holding on the ON/OFF button.
2. In the main menu, select "Profiler" and press OK.
3. Under "Enter Operator Name", enter the technician's name that is collecting the measurement and press OK.
4. Select "Stream" and press OK.
5. Select "Enter name for Stream" and press OK.

6. Enter the 4-letter site code for the stream name (i.e. "ARIK") and press OK.
    a. Note: Special characters, numbers, or any other deviations from the 4-letter site code will prevent the discharge file from being uploaded.
7. Select "Enter Stage Reference" and press OK.
    a. Note: Discharge should not be measured if a staff gauge is either not installed, or is displaced at the site. If a staff gauge is displaced for whatever reason do not collect the discharge measurement and write a trouble ticket to Science immediately.
8. Enter the water level on the staff gauge.
    a. Note: During periods of moderate to high flow, waves may be creating fluctuating water levels at the staff gauge. In these instances observe where the water level hits the gauge at the highest and lowest crest and record the value between those as the stage reference value. Submit a trouble ticket to Science that states that the staff gauge was difficult to read at this time.

A.7 Measuring Discharge: Collecting Velocity and Depth Measurements

- Once station spacing has been determined, navigate to the first station (1) along the meter tape at the right edge of water to begin the discharge measurement.

- Enter Edge/Obstruction = "Right", as this is at the first station on the REW.

- Enter Edge Factor = "0.75".
    - This is the standard edge factor value for all NEON aquatic sites.

- Select "Dist. To Vertical" value.

- Enter the value where the station location falls along the meter tape.

- Determine the station depth.
    a) Position the base of the flowmeter rod flat on the bottom of the streambed and note where the stream surface meets the graduated marks etched into the flowmeter rod.
        a) Graduated marks are etched into the flowmeter hexagonal rod to allow for water depth measurement. The marks are delineated into 2 cm (one band mark), 10 cm (two band marks – the bottom double band), and 50 cm (three band marks).
        b) Water depth measurements should be rounded to the nearest 1 cm.
        c) If needed, practice this step prior to collecting the discharge measurement in order to familiarize yourself with the increments.

- Select "Set Depth" to enter the depth value at the station.
    a) Note: this value could be "0.00m" if the angle of the streambank is low or it could be > 0.00m for streams with vertical banks.

- Select "Measure Velocity" and press OK.

- Determine Velocity Point Method: one-point (60%), or two-point (20% and 80%) (Error! Reference source not found.**).**
    - If station depth is <0.45m, collect a one-point measurement at 60% depth. See A.5.2 for instructions on setting the flowmeter rod to the appropriate depth.
    - If stream depth is >0.45m, collect a two-point measurement at 80% and 20% of the total depth. See A.5.2 for instructions on setting the flowmeter rod to the appropriate depth.
        a) 60% and 80% measurements are relative to the stream surface equaling 0m.
            (1) For example, if station depth = 0.50m, the first of the two-point velocity measurement (at 60% depth) would be collected 0.30m below the water surface, or 0.20m above the stream bottom. The second of the two-point velocity measurement (at 80% depth) would be collected 0.40m below the water surface, or 0.10m above the stream bottom.

Table 4. Velocity point methods are based on station depth.

Stream Depth at Measurement Location	Velocity Point Method
< 0.45 meters	1 point - 60% of Depth
≥ 0.45 meters	2 point - 20% and 80% of Depth

- Select "One Point" or "Two Point" Velocity Method depending on depth.

- Set the wading rod to appropriate depth.
    a) The wading rod must be adjusted in order to set the velocity meter at the correct depth in the streamflow (Figure 5). The round sliding rod (located behind the hexagonal rod) is used to set the measurement depth and is scaled with 0.10m graduations from top (0.00m) to bottom. A smaller scale on the handle of the hexagonal fixed rod is used to fine-tune the depth, and is scaled with 1 cm graduations (0 to 10cm).

    b) Listed below are three examples on how to collect velocity measurements at desired depths on the wading rod. Refer to Section A.5.2 to determine the amount and locations of velocity measurements required for various water depths in the field.

- **One-Point Velocity Method: 60% Depth, Station Depth = 0.36m**
  a) Line up the 3 on the sliding rod (represents 0.30m total station depth) with the 6 on the handle of the fixed hexagonal rod (represents 0.06m total station depth). Coupled, these two settings set the flowmeter at 60% of station depth 0.36m. The one-point velocity method requires no calculations by the user.

- **Two-Point Velocity Method: 80% Depth, Station Depth = 0.85m**
  a) Divide the station depth by 2 (0.85/2 = 0.425m), and round to the nearest 0.01m (0.43m). Line up the 4 on the sliding rod (represents 0.40m of the total station depth) with the 3 on the handle of the fixed hexagonal rod (represents 0.03m of total station depth). Coupled, these two settings set the flowmeter at 80% of station depth 0.85m.

- **Two-Point Velocity Method: 20% Depth, Station Depth = 0.85m**
  a) Multiply the station by 2 (0.85*2 = 1.70m) and round to the nearest 0.01m (1.70m). Line up the 17 on the sliding rod (represents 1.70m of the total station depth) with the 0 on the handle of the fixed hexagonal rod (represents 0.00m of total station depth). Coupled, these two settings set the flowmeter at 20% of station depth 0.85m.

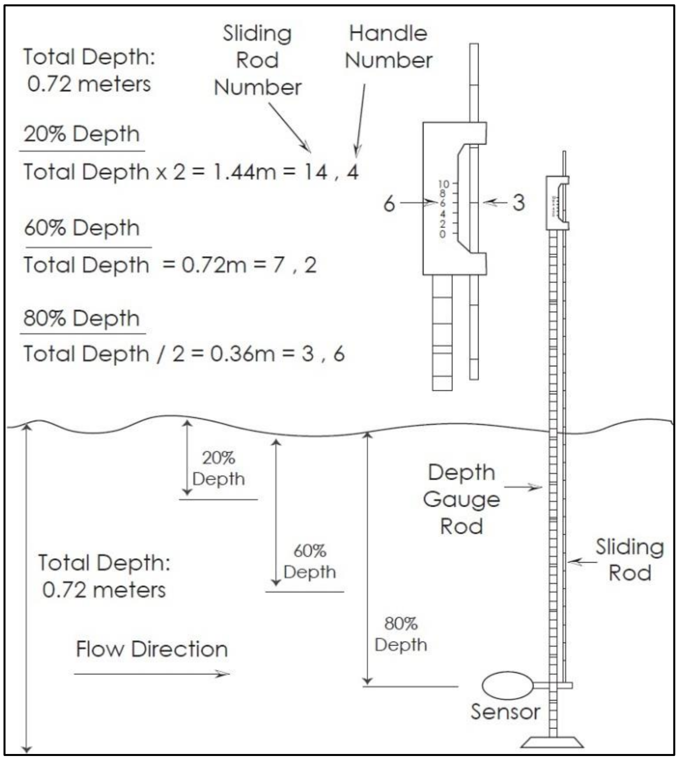

Figure 6. Wading rod adjustments at 60% (one-point), and 20% and 80% (two-point) depths. Station depth = 0.72m.

- Once the flowmeter has been set to the correct depth and the correct velocity method has been selected, select "Capture" on the handheld flowmeter to begin measuring velocity.
  a) The screen will display a graph showing the instantaneous values and the progress of the reading.
  b) If velocities appear to be inaccurate or are fluctuating > ±5%, repeat the reading.
  c) If repeated velocity values seem inaccurate or are fluctuating >5% during the measurement collection, consider the following causes:
     (1) Streamflow is turbulent. Increase the Fixed Period Averaging Time to 40 seconds in the Filter Parameters settings (See SOP A3 Step 4).
     (2) There is an obstruction immediately upstream or downstream of the station location. Move the station location so that is not directly above or below the obstruction and try another velocity measurement.
     (3) Flowmeter was not calibrated correctly. Re-calibrate flowmeter and start discharge measurement over.
     (4) Flowmeter is low on batteries. Replace batteries in flowmeter and repeat measurement.
  d) If you cannot diagnose the source of the problem, continue discharge measurement and submit a trouble ticket explaining the issue.

- Once the measurement has been completed (>10 seconds, 40 seconds is ideal) press OK to save data and move to the next station location.

- Move to the next station location and repeat Steps 4-13. Note that you will not need to enter an Edge value as these stations should be in open water environments (not along the edge of a bank or near an obstruction).

- The final station location will be at the LEW.
  a) Repeat Steps 1-3 entering "Left" as "Edge/Obstruction" value.

- Select "Summarize Collection and Save Data".
  a) Observed "Channel Summary" and verify that units are in liters/second.
  b) Select "Save Data and Exit". <u>This is a critical step as all data will be erased if this is not completed.</u>
  c) Enter "Name of File".
     a) Use a unique file name to delineate discharge measurement in the following format "XXXXMMDD" where:
        (1) XXXX = 4-digit site ID (i.e. "GUIL")

(2) MMDD = Year, Month, Date of measurement
(3) Example: "GUIL0927"
   (a) The flowmeter only allows 8 characters to be used for each filename which makes it not possible to enter the year of the measurement. As such, at the end of each calendar year delete all measurement files on the flowmeter, **only after ensuring that each file on the flowmeter has been properly saved on the AOS dropbox and uploaded onto the SOM portal.**

A.8 Evaluating the Discharge Measurement

The discharge measurement must be evaluated once the measurement has been completed. A thorough evaluation must include the following components:

- Check for data entry errors;
- Check the total percentage discharge collected at each station;
- Compare the total measured discharge to the predicted value from the rating curve (if available)

1. Check for data entry errors

Review the discharge measurement file for data entry errors. In addition to negatively affecting data quality, certain errors in the discharge file will prevent the file from being uploaded. Verify that:

- The station (or location) values are increasing from the right (first station) to left edge (last station).
- Depth values were entered correctly (i.e. check decimal points, "0.8" instead of "8")
- Depth value at a given station is less than 10 times greater than the preceding station.
   a. If this error occurs than stations were likely set too far apart in the transect. Additional velocity measurement should be collected between set stations.
   b. Zero depth values (0.00m) should not be present within the discharge transect. If this is the case the transect should be moved upstream or downstream to a cross-section where water is flowing uniformly (more or less) across the transect. Submit a trouble ticket if the discharge transect was temporary re-located to facilitate these conditions.
- The stream profile name was entered correctly (4-digit site code).
- The stage reference value was entered correctly.
- All units were set correctly.

- The filter parameter was set correctly in flowmeter settings (>10 seconds).

2. Check the total percentage of discharge collected at each station

NEON uses the mid-section method to compute stream discharge. In this method, the transect is divided into rectangular sub-sections. The sub-section area extends laterally from half the distance from the proceeding station to half the distance to the next station. The width of the sub-section (variable across the transect) is calculated by subtracting the distance to the previous station from the distance to next station, then dividing by 2. The area of the sub-section is the width of the sub-section times the depth of each station. Discharge per station equals the sub-section area times the measured velocity. The total discharge is the summation of the discharge all each stations.

Certain flowmeter models automatically calculates discharge per station and total discharge per measurement. Ideally, no more than 5% of the total measured discharge should be measured within a single station, but this can be difficult to achieve in small streams with narrow or irregular channels.

In general, no more than 10% of the total measured discharge should be measured within a single station. Following the discharge measurement, check the file to verify that this has not occurred (if possible given the make and model of the flowmeter). If it is observed that >10% of the total discharge was measured in one or more stations:

If >10% of the total discharge was measured in one or more station in streams with a wetted width ≤ 2m:

- Reduce the station spacing to 0.05m.

If >10% of the total discharge was measured in one or more station in streams with a wetted width > 2m:

- Reduce the distance between stations by increasing the number of stations within the discharge transect.
- Reduce the width of stations where flow is the most concentrated (Error! Reference source not found.).

If, despite these attempts, >10% of the total discharge is still collected in more than one station, save and upload the discharge measurement and submit a trouble ticket in order to consult with Science. Again, this metric may be very difficult to achieve in narrow or irregularly-shaped channels.

3. Compare the total measured discharge to that predicted by the stage-discharge rating curve (if available).

Once a stage-discharge rating curve has been developed for a site, a rating equation is derived that predicts discharge given stream stage (Figure 7). Once established, rating equations will be provided to FOPs by Science. Rating equations are commonly expressed as power relationships:

$$Q = C_r(G - \alpha)^{\beta}$$

Where:

Q = discharge;

G = the stage, or gauge height;

α = the gauge reading corresponding to zero discharge; and

C_r and β = rating curve constants

Following the discharge measurement, enter the stream stage (G) into the rating equation that is associated with the site and calculate predicted discharge. Evaluate whether the discharge (just measured) is ±10% of the discharge predicted by the equation. If the measured discharge is >±10% that predicted **and the stream stage has not changed**, collect another measurement immediately. If, after a second attempt, the measured discharge remains >±10% the predicted rating discharge, upload both measurements and submit a trouble ticket to Science. This may indicate a shift in the rating, which, if validated by additional measurements, would warrant an increase in the frequency of discharge measurements at the site.

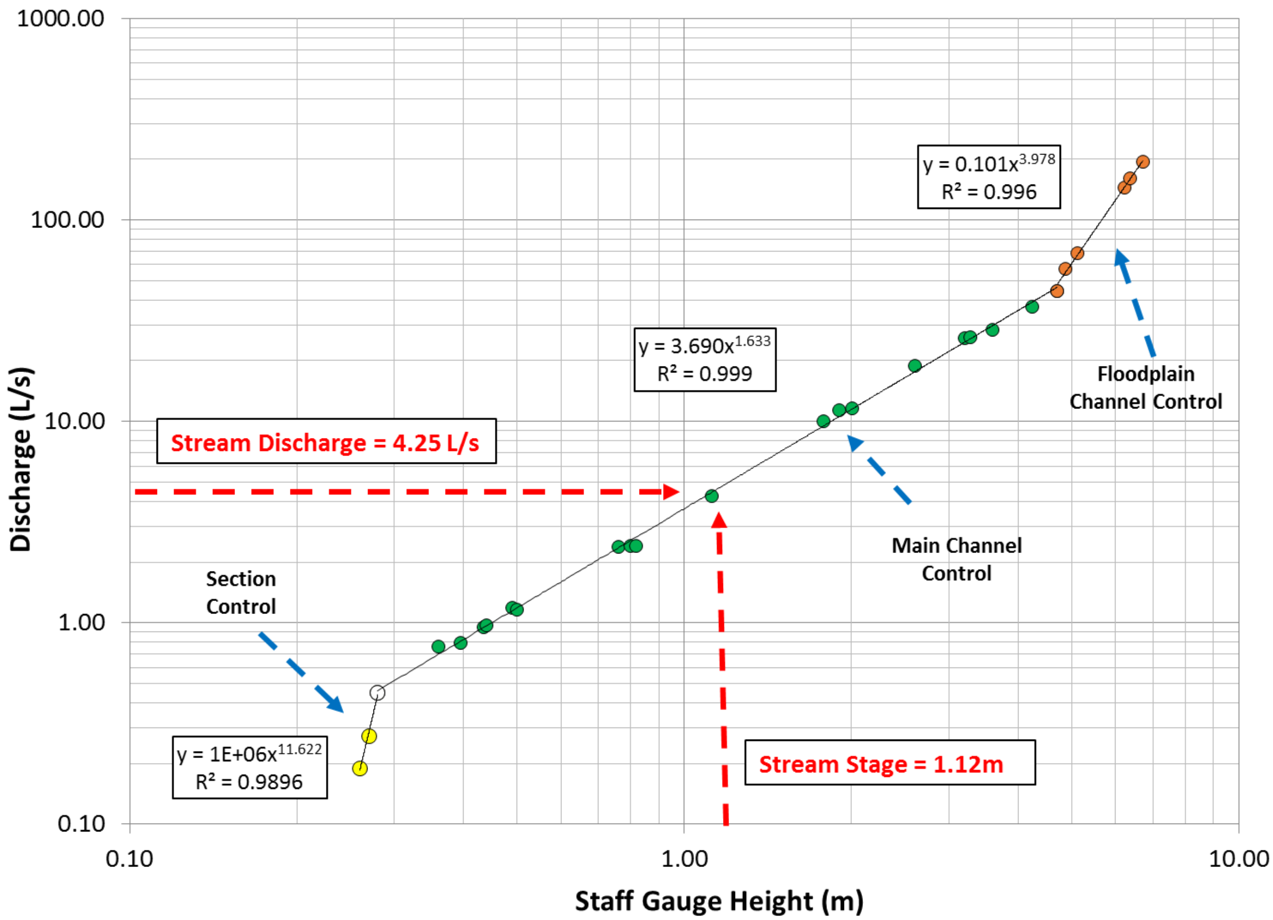

Figure 7. **Example of stage-discharge rating curve. Circles indicate discharge measurements collected across a wide range of gauge heights. Rating equations for each of the three distinct segments are shown representing low, medium, and high flow regimes. In this example, a section control governs the stage-discharge relationship during the low-flow regime and the main channel control becomes de-activated at higher stages when as the streamflow tops the banks. Once flow exceeds the channel capacity the stage-discharge relationship is governed by floodplain channel control.**

A.9 Calculating the Point of Zero Flow

The point of zero flow (PZF), or gauge height at zero flow, is the reading on the staff gauge that corresponds to zero, or infinitesimal discharge in the transect. The point of zero flow serves as a constant value that is subtracted from the gauge height in the rating curve equation so that a straight line is formed when stage-discharge data is plotted on logarithmic x and y scales.

In fluvial environments, the PZF is the physical location of the deepest point of the control. Three types of controls are common in natural streams, each of which depend on streamflow and channel conditions (Figure 8) (Braca 2008):

1. Section Controls: a natural downstream feature such as a riffle, rock ledge, sand bar, or severe channel restriction that tends to control the low-flow regime. As gauge height increases with higher streamflow the section control becomes submerged in such a way that it no longer controls the relation between gauge height and discharge.

2. Channel Controls: a combination of downstream features throughout the reach such as channel size, shape, curvature, slope and roughness. The length of channel controls can be extremely variable. Channel controls typically govern stage-discharge relations during periods of higher streamflow.

3. Combination of Section and Channel Controls: at some stages, the stage-discharge relation may be governed by a combination of section and channel controls. This usually occurs during a short range in stage between section-controlled and channel-controlled segments of the rating curve, or the transition zone. Channels with unstable controls tend to exhibit section/channel combinations.

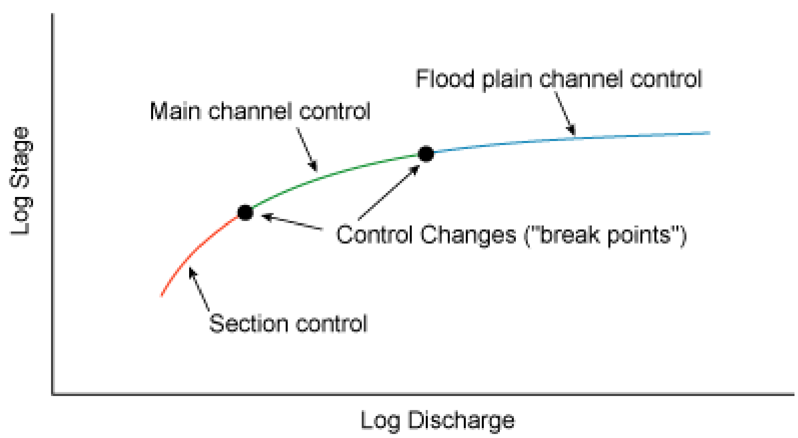

Figure 8. **Schematic representation of control range in a rating curve. (Illustration: Braca 2008)**

It is important to note that the point of zero flow will not be measured at every stream or in every year. Point of zero flow typically occurs in the summer, or during the lowest flow regime at a site. If the stream is hydrologically connected and discharge is measured to equal zero, or nearly so, proceed with the following steps:

1. Ensure the pool where the staff gauge is located contains water. If streamflow has narrowed to a degree that the staff gauge is dry (i.e. outside the channel) attempt to dig a small trench that connects the gauge to the

edge of water. In most situations water will fill the trench and allow for the staff gauge level to be read. This is not possible at streams with bedrock streambeds. In this instance write a trouble ticket and consult with Science and how best to proceed.

2. Collect the discharge measurement as outlined in SOP A.7. Enter the observed staff gauge height as the stage reference value.

3. Identify the section control feature downstream of the discharge transect. Using the graduated marking on the flowmeter rod, measure the depth of water at the deepest point the section control. Note that this may be dry (the depth would then equal 0.00m). Record this value in a field notebook. If you are unsure of the where the downstream control is located take a picture of where you took the measurement and include it in the trouble ticket described in Step 4.

4. Save and upload the discharge file. Write a trouble ticket informing Science that you have collected a point of zero flow measurement. Include the site, date, time, gauge height, control picture (if available), the measured discharge, and the depth of the downstream control.

A.10 Ending the Sampling Day

After each discharge survey the velocity meter, wading rod, and waders shall be cleaned following standard operating procedures for cleaning field equipment used in aquatic systems. Batteries for the velocity meter shall be charged or replaced as applicable.

SOP B Data Entry and Verification

There are no field data sheets for this protocol. Electronic data should be uploaded to the appropriate location within seven days of collection. However, given logistical constraints, the maximum timeline for entering data is within 14 days of collection or the end of a sampling bout (where applicable). See RD[04] for complete instructions regarding manual data transcription.

Extract stream discharge data from the digital meter to a local computer using the correct cable type (e.g., a USB to micro-USB cord).

- Refer to the velocity meter's manual to locate the USB connection port. Plug the correct ends of the connection cord into the display unit and the computer.
- Turn the velocity meter on.

a) A "PVM Drive" should appear on the computer screen.
b) Locate the utility via *My Computer*. Two folders should be present: *P* and *RT*. Select the "P" folder.
c) Note: if a dialog box appears asking to format the drive, close the window. DO NOT format the drive.

- Select the appropriate file to transfer (e.g., POSE0930.TSV).
- Copy the file to the computer.
- Rename the file if needed.
- Re-check the discharge files for potential errors as described in SOP A.8.
- Upload one copy of the discharge file onto the AOS Dropbox in the appropriate folder.
- Upload an additional copy of the discharge file onto the SOM/WebUI Portal.

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APPENDIX A RIVER DISCHARGE

A.1 Overview

Discharge will be measured at all NEON aquatic sites (core and re-locatable) that contain large rivers using acoustic Doppler current profile (ADCP) instruments. Vertically-facing ADCP's (River Pro by Teledyne RDI) will be mounted to motorized boats that will transport the instrumentation across the river. Velocity and depth profiles will be created and stored by the profilers which, in combination with distance and rate of speed data, will be used to estimate river discharge across a range of stages.

River discharge methodology will be based on USGS Techniques and Methods 3-A22 (Mueller and Wagner 2009) which provides standard procedures for measuring discharge with ADCPs from a moving boat. WinRiver II software will provide technicians with real-time feedback during ADCP data collection and, in concert with Q-View (Teledyne) and Q-Rev (USGS) software, will be used for data review and post-processing.

River discharge will occur twelve (12) times per year at each NEON aquatic site that contains a river. Stage-discharge rating curves will be developed and assessed in a similar manner as those developed for wadeable stream sites.

Once the instrumentation is fully prototyped a complete methodology will be produced and made available to all field operations staff. This documentation will include detailed pre-deployment and post-measurement review and data entry procedures, step-by-step field methods, instrument quality assurance plans and safety guidelines specific to NEON sites and personnel. Field training will be provided for all field operations staff that will be conducting river discharge.

APPENDIX B QUICK REFERENCES

Step 1 – Check and make sure that all supplies necessary gear is packed.

Step 2 – Ensure the Field Metadata and Gauge Height table is completed per field site visit in the Fulcrum app.

Step 3 – Navigate to the sampling location and divide the stream up into subsections according the width and uniformity of the streambed:

- Ideally, no more than 5% of the discharge should be in one subsection, but this can be difficult to achieve in small, irregular stream channels.
- No more than 10% of the discharge should be in one subsection. This can also be difficult to achieve in narrow channel types.

Step 4 – Delineate the correct station width and/or count based on the wetted width.

Width of Stream	Station Width/Number of Locations
≤ 2.00m	Sample every 0.1 m, or 0.05 m if there is >10% of the flow in any one subsection
> 2.00m	20 – 25 sampling locations, or increase the number of sampling stations if > 10% flow, flows through any one subsection.

Step 5 – Determine if a one point (60%) or a two point (80% and 20%) velocity method is required per station.

Station Depth	Velocity Point Method
< 0.45 meters	1 point - 60% of Depth
≥ 0.45 meters	2 point - 20% and 80% of Depth

Step 6 – Set up the measurement transect.

Step 7 – Zero-calibrate the velocity meter.

Step 8 – Measure velocity and depth at each station along the transect.

Step 9 –Calculate total discharge with the handheld flowmeter.

Step 10 – Review file for potential data entry errors and % total discharge per station.

Step 11 – Save data.

Step 12 – If necessary follow point of zero flow procedures.

Step 13 – If a stage-discharge rating curve is available, insert the stage value into the appropriate rating equation and evaluate observed vs. predicted discharge values. If predicted discharge is > ±10% of observed and the stage has not changed, collect another discharge measurement.

Step 14 – Decontaminate equipment.

Step 15 – Recharge or replace batteries in the velocity meter.

Step 16 – Upload discharge measurement file onto the AOS Dropbox and the SOM/WebUI portal.