



Title: AOS Protocol and Procedure: GAG – Aquatic Staff Gauge Measurement Readings and Field Metadata		Date: 01/10/2023
NEON Doc. #: NEON.DOC.005277	Author: B. Nance	Revision: B

## AOS PROTOCOL AND PROCEDURE: GAG – AQUATIC STAFF GAUGE MEASUREMENT READINGS AND FIELD METADATA

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## **1 OVERVIEW**

### **1.1 Background**

Staff gauge measurements are vital for relating empirical discharge measurements to water level and ground-truthing elevation data. NEON publishes multiple data products that are associated with discharge, including Continuous discharge [DP4.00130], Stage-discharge rating curve [DP.00133], and Discharge field collection [DP1.20048]. In order to create high quality stage-discharge rating curves and validate sensor data at NEON stream, river and lake inflow/outflow sites, manual discharge and staff gauge measurements must be taken. More information regarding discharge measurements can be found in NEON.DOC.001085 AOS Protocol and Procedure: Stream Discharge.

Field Metadata observations are used to help external researchers learn about NEON sites. These measurements help to track long-term change at each site.

### **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**

This procedure is based off the previous work of many staff. Nick Harrison, Liz Knapp and all of the field staff that have reported issues and taken photos of staff gauge impacts.



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## 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 Data Quality Plan
AD[06]	NEON.DOC.001085	AOS Protocol and Procedure: Stream Discharge

### 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.002652	NEON Data Products Catalog
RD[04]	NEON.DOC.001271	AOS/TOS Protocol and Procedure: DPM – Data Management
RD[05]	NEON.DOC.001646	AOS Field Metadata and Gauge Height
RD[06]	NEON.DOC.003282	NEON Protocol and Procedure: SIM – Site Management and Disturbance Data Collection
RD[07]	NEON.DOC.005247	AOS/TOS Standard Operating Procedure: NEON Aquatic and Terrestrial Site Navigation

### 2.3 Acronyms

Acronym	Definition
LWD	Large Woody Debris

### 2.4 Definitions

**Depth (D):** The depth of the water column at a particular point, measured from the water surface to the stream bed. This is not what staff gauge measures.

**Discharge (Q):** (streamflow) The volume of water flowing through the channel cross-section during a given period of time, measured in units of volume per unit time, such as liters per second or cubic meters per second. Discharge is computed as velocity times area.

**Fulcrum:** Software tool used to create NEON electronic data entry applications.

**Metadata:** Observations made in the field during every site visit. These observations are meant to mimic the use of a field notebook used by field researchers to collect observational site data.



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**ServiceNow:** Software tool used for problem/incident tracking and resolution.

**Staff Gauge:** Water level measurement device installed at all NEON aquatic sites.

**Stage:** (i.e., stream height, water level) The height of the water level 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. Stage can also be estimated continuously by relating continuous surface water pressure data to staff gauge readings.

**Stage Discharge Rating Curve (SDRC):** An empirical relationship (formula) between stage and discharge that is developed by conducting frequent discharge measurements throughout the flow regime at a given aquatic monitoring site. Rating curve equations are applied to the continuous stage record to estimate continuous discharge.

**Temporary Hydrologic Condition:** Unique occurrences that impact or influence the physical reading of the staff gauge.



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### 3 METHOD

All aquatic field sites have a staff gauge installed where water level height is measured visually (**Figure 1**). Measurement quality is dependent on the integrity of the infrastructure. If for any reason the staff gauge has been impacted, bent, or otherwise disturbed, do not take a measurement and immediately submit an incident ticket to document the damage. These measurements are used in conjunction with higher tier AIS and AOS data products.

Field metadata collection helps to form external data users understanding of NEON aquatic sites. Providing an understanding of conditions in the field that are not measured by specific protocols help data users learn more about NEON sites.

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 properly collect and process samples, 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 is performed on data collected via these procedures according to the NEON Science Data Quality Plan (AD[05]).



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Figure 1. Example of a staff gauge installation.



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## 4 SAMPLING SCHEDULE

### 4.1 Sampling Frequency and Timing

Staff gauge measurements do not occur on a set schedule; however, staff gauge readings are required under three scenarios:

- Upon arrival to the site
- In conjunction with the AOS Discharge protocol [AD07]
- Before leaving site if conditions are indicative of a change in stage:
  - Changes in stage relative to the first observation
  - Naturally occurring events (i.e., rainfall and snowmelt)
  - Anthropomorphic events (i.e., upstream/downstream dam release)

Field Metadata measurements do not occur on a set schedule. These measurements should be recorded every day a field crew is on site.

### 4.2 Criteria for Determining Onset and Cessation of Sampling

#### ***Sampling Onset***

Sampling occurs year-round, in all site conditions.

#### ***Sampling Cessation – Disturbed gauge***

If for any reason the staff gauge has altered position (**Figure 2**) do not take a reading. Immediately report the status of staff gauge infrastructure in an incident ticket, including descriptions and photographs. Select a sampling impractical reason (**Table 2**) in the Field Metadata and Staff Gauge Fulcrum app.



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**Figure 2.** Examples of gauges needing repair.

### 4.3 Sampling Timing Contingencies

**Table 1.** Contingency decisions for Staff Gauge SOP.

Delay/Situation	Action	Outcome for Data Products
Hours to weeks/ Damaged or disrupted gauge	If staff gauge is altered in any way, do not record a measurement. Designate sampling impractical. Submit a trouble ticket immediately that documents any infrastructure damage.	Decreased data availability and quality

### 4.4 Missed or Incomplete Sampling

Any missed measurements have an impact on multiple discharge related data products. A reduced number of annual staff gauge readings increases the uncertainty in the conversion of continuous pressure to continuous stage. Always work quickly to repair and resurvey, as needed, to minimize the length of time that the staff gauge is not usable in order to maximize data availability, quality, and the scientific integrity of the associated data products.



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Incomplete or missing records for field metadata should not exist. If field crew can access site, information will be able to be collected. Any other occurrences that result in field work cancellation are documented based on the scheduled activities of that day.

**To Report Missed or Incomplete Sampling:**

Document occurrences that impede the collection of staff gauge readings in the Field Metadata and Staff Gauge Fulcrum app. If the staff gauge cannot be read because it is disrupted or displaced, select a Sampling Impractical reason (**Table 2**) and document as specified in **Section SOP C.2: Document Incomplete Sampling Within a Site**.

**Table 2.** Protocol-specific Sampling Impractical records entered in the Field Metadata and Staff Gauge Fulcrum application. In the event that more than one record is applicable, choose the dominant reason sampling was missed.

Sampling Impractical reason	Description
Location Dry	Select this option only if no water is present at the base of the staff gauge. If water is present in other locations within the sub-reach, notify Science that a staff gauge re-location may be required.
Location Frozen	Select this option only if ice is present throughout the water column down to benthic layer.
Location Snow Covered	It may be necessary to dig through many feet of snow to obtain a staff gauge reading in certain environments. Select this option only if all other options are exhausted or if a staff gauge reading cannot be safely obtained.
Staff Gauge Disturbed	Select this option if the staff gauge is damaged in any way. If this option selected, verify the timeline for corrective maintenance.
Onshore Protocols Only	Select this option at lake or river sites if boat not in use for scheduled protocols. If gauge can be read from shore, do not select this option.
Night Fishing	Select this option at lake sites when night fishing.
Staff Gauge Not Installed	Select this option if the staff gauge is missing. If this option is selected, verify the timeline for corrective maintenance.
Other	If situation does not fit other impractical criteria, select this option and add a comment detailing site conditions.

**4.5 Estimated Time**

The time required to implement a protocol will vary depending on a number of factors, such as skill level, system diversity, environmental conditions, and distance between sample plots. The timeframe provided below is an estimate based on completion of a task by a skilled two-person team (i.e., not the time it takes at the beginning of the field season). Use this estimate as framework for assessing progress. If a task is taking significantly longer than the estimated time, a problem ticket should be submitted. Please note that if sampling at particular locations requires significantly more time than expected, Science may propose to move these sampling locations.



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**Table 3.** Estimated staff and labor hours required for implementation of Staff Gauge Protocol.

<b>SOP</b>	<b>Estimated time</b>	<b>Suggested staff</b>	<b>Total person hours</b>
Stream Sites	0.25 h	1	0.25 h
Lake / River Sites	0.5 h	1	0.5 h



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## 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 field work 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. All employees are responsible for working safely, protecting the safety and health of others, promptly reporting at-risk behaviors or conditions, and stopping work when observing imminent danger. Employees are expected to notify management or an ES&H representative of any issues or concerns regarding health, safety practices, and environmental issues.

Activities in streams should only be performed when flow conditions are safe. Do not attempt to wade a stream where velocity x depth is  $\geq 10 \text{ ft}^2 / \text{s}$  ( $0.93 \text{ m}^2 / \text{s}$ ). For non-wadeable streams, field workers should consult site-specific safety plans for safety guidelines. When working around ice, refer to (AD[02]), Section 10.3 Winter Water Safety. Do not attempt to walk on frozen lake if depth of ice is less than 6" (15 cm) or operate UTV or snowmobile on frozen lake if depth of ice is less than 8" (20 cm). Use caution and good judgment to carefully evaluate site conditions including ice strength. Local guidelines from natural resource officials, property owners or hosts, and domain managers should be consulted.

In addition to standard safety training provided by NEON, the following safety requirements are sought:

1. Due to site-specific hazards that may be encountered, technicians may perform GPS positioning around the lake, and measurements for inflow and outflow, without dismounting from the vessel. In addition, technicians are required not to put hands and feet in waters where alligators are present and to make sure a safe distance from hazards is maintained.
2. All personnel must be wearing a personal flotation device prior to entering the boat.
3. All employees shall have access to a form of communication with other team members such as a two-way radio.
4. Technicians should be aware of any site-specific hazards and to the waters of that particular location (i.e., current status, tidal charts, etc.)
5. Technicians should be aware of air and water temperatures and bring appropriate equipment and supplies (i.e., insulated waterproof gloves)
6. If personnel or loads will be on ice while performing their task for greater than 2 hours, all loads should be multiplied by 2 to determine safe ice thickness. Refer to (AD[02]), Section 10.3 Winter Water Safety.



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## **6 PERSONNEL**

### **6.1 Training Requirements**

All technicians must complete protocol-specific training as required in the Field Operations Job Instruction Training Plan (AD[04]). Additional protocol-specific required skills and safety training are described here.

### **6.2 Specialized Skills**

Where applicable, personnel will be licensed to operate a boat and able to safely handle a motor and drive a boat.

Basic knowledge of aquatic ecology is required to identify algae and aquatic plants.



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## 7 STANDARD OPERATING PROCEDURES

### SOP A Field Sampling Preparing for Data Capture

#### A.1 Preparing for Data Capture

Mobile applications are the preferred mechanism for data entry. Mobile devices should be fully charged at the beginning of each field day, whenever possible.

However, given the potential for mobile devices to fail under field conditions, it is imperative that paper datasheets are always available to record data. Paper datasheets should be carried along with the mobile devices to sampling locations at all times.

#### A.2 Preparing for Field Sampling

1. Plan and save sampling routes for field teams using standard site navigation procedures (RD[07]). Route planning enhances sampling efficiency and helps avoid accidental foot traffic within NEON plots.
2. No other specific preparation needed as this protocol is purely observational.



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## SOP B Field Sampling Staff Gauge Measurements

A majority of NEON sites contain the same fiberglass plate design, any exceptions to this are listed in **Appendix C Site specific Occurrences**. The 0.00 meter mark should be buried beneath the substrate, if possible, to ensure that, following instances of bed scour, the base of the staff gauge does not become exposed above the water line during the low flow regime.

### B.1 Measurement Procedure

1. Approach the gauge area and orient yourself to best view the gauge (perpendicular to plate).
  - a. Read gauge from bank, if possible.
  - b. If you must get in stream, approach from downstream and remain 0.5 m away.
  - c. If approaching in a boat, remain greater than 1 m from the gauge. Wait for wake to settle before taking reading.
2. Take a staff gauge reading (**Figure 3**).
  - a. The bottom of each black dash indicates 1.0 cm (0.010 m).
  - b. The top of each black dash indicates 0.5 cm (0.005 m).
  - c. The angled black dash indicates an interval of 2.5 cm (0.025m).
  - d. If the water level lies in the exact center of a 0.5 cm (0.005 m) dash, always round up to the closest 0.5 cm (0.005 m).
3. Enter measurement in Field Metadata and Staff Gauge Fulcrum app.
  - a. Data must be recorded down to a 0.005 m accuracy.
  - b. Data must be recorded in meters.
4. Note if any temporary hydrologic conditions are impacting the reading.
  - a. If questionable or unusual, take a photograph and submit a problem ticket.

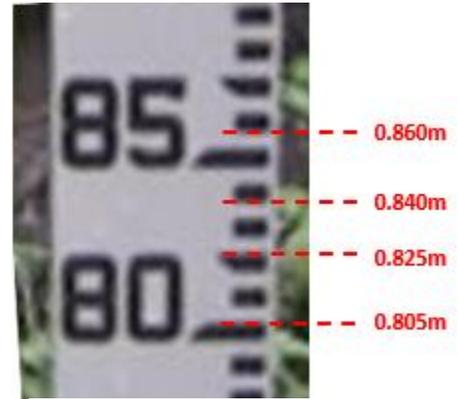


Figure 3. Reading the staff gauge



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Figure 4. Multi-meter designation.



*If newly trained technicians are in the field, have multiple people read the gauge and compare answers.*

At many NEON aquatic sites with large annual water fluctuations, multiple 1-meter staff gauges are installed on a single post in the channel (**Figure 4**). As stage rises to meet the second gauge, an additional meter must be added to the meter mark measurement at the water level to capture accurate stage conditions (**Figure 4**). Certain sites contain additional staff gauges that are installed on the floodplain. When reading these gauges, multiple meters may need to be added to the observed meter mark at water level depending on the number of staff gauges submerged. Contact Science with any questions regarding the number of staff gauges or how to interpret those installed at a given site.

In the event the gauge has a large amount of biofouling or organic buildup, clean the gauge and the adjacent area to obtain an accurate reading. Always maintain the staff gauge in a manner that does not disturb the co-located pressure transducer sensor.

There are multiple scenarios (**Figure 5**) in which the staff gauge reading can be adversely impacted by environmental conditions, but the measurement is still essential. In these cases, select a temporary hydrologic condition in the Field Metadata and Staff Gauge app (**Table 4**).

Table 4. Temporary Hydrologic Conditions

Temporary Hydrologic Condition	Description
LWD	Large woody debris is affecting water levels
Sediment	Sediment has formed at or around the staff gauge in a way that makes the base dry or is significantly changing the water level. Note that subtle changes in sediment depth under the surface of the water do not typically affect staff gauge measurements
Litter Jam	Organic debris has caused water to pool in an uncharacteristic way
Beaver Dam	A nearby beaver dam is affecting staff gauge measurements
Anchor Ice	Ice formation is occurring on the streambed and is affecting staff gauge measurements
Border Ice	Ice formation is occurring along the sides of the channel and is affecting staff gauge measurements



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Temporary Hydrologic Condition	Description
Sheet Ice	Thin ice formation is extending across the entire channel and is affecting staff gauge measurements. Note that thin ice should be broken through so that a staff gauge measurement can be collected
In-Channel Veg	Vegetation is impacting staff gauge measurements
Other	Submit a trouble ticket to Science that describes any other temporary hydrologic conditions that are affecting staff gauge measurements



Figure 5. Examples of temporary hydrologic conditions [Photos: sheet ice, beaver dam].

## B.2 Spatially Linked Protocols and data products

Staff gauge readings directly impact the following protocols and data products:

- Discharge field collection [AD07] [DP1.20048]
- Stage-discharge rating curve [DP4.00133]
- Continuous discharge [DP4.00130]
- Salt-based stream discharge [DP1.20193]



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## SOP C Field Sampling Metadata Observations

Field metadata measurements assist external researchers in developing a more thorough understanding of the NEON sites, and are meant to recreate a field ecologists' notebook. While these measurements must be as accurate as possible, a certain level of uncertainty and observer bias is expected such as location within reach and other qualitative measurements.

### C.1 Weather Information

The weather information portion of metadata must be filled out at the end of each site visit. Select the option that best reflects the predominant condition throughout the site visit.

#### 1. Ice Present on Water Surface

Presence or absence of surface ice. Document "Yes" if any ice is noted while sampling at a NEON site.

#### 2. Current Precipitation Description

Note the predominant weather pattern through the day. For example, if during 80% of the site visit, light rain is falling but there is a break in rainfall when filling out data, select "rain" or "light rain".

#### 3. Riparian Phenology Description

Document the dominant foliage characteristics. If different deciduous plant species are exhibiting multiple leaf-out qualities, choose the most dominant option.

### C.2 Biological Observations

When making note of biological observations, draw on visual assessments of all site locations that was visited for the day. If the entire reach was visited, answer based on the observations encountered throughout the full reach. If only the sensor reach or a single sensor set was visited, answer based on observations made at that specific location. When assessing conditions, "Absent" is defined as not visually observable. "Present" should reflect a visual presence without the use of aids such as magnifying glasses or NEON instruments. If a parameter covers greater than 75% of the wetted width, select "heavy" for the assessment.



### 1. Benthic Algae

Algal growth on the substrate of the stream or river is considered benthic algae (**Figure 6**). A common form of this seen at NEON sites is didymos.



**Figure 6.** Example of absent/present/heavy benthic algae.

### 2. Aquatic Plants

Assess the presence of aquatic plants along the portion of reach visited during field work. An aquatic plant is any plant that is rooted within the wetted width of the stream.



**Figure 7.** Example of absent/present/heavy aquatic plants.

### 3. Macroalgae/Filamentous algae

Assess the quantity of macro and filamentous algae at site within the wetted channel.



**Figure 8.** Examples of absent/present/heavy filamentous algae.



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#### 4. Leaf Litter

Assess the quantity of leaf litter within the channel. Leaf litter can include deciduous leaves as well as coniferous needles. Both can impact streambed roughness, reaeration, invert populations, and changes in stage.



**Figure 9.** Example of Absent/Present/Heavy leaf litter at D07 WALK.



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## SOP D Post-Field Sampling Tasks

### D.1 Data Entry and Verification

Mobile applications are the preferred mechanism for data entry. Mobile devices should be fully charged and synced at the beginning of each field day, whenever possible. For detailed instructions on protocol specific data entry into mobile devices, see the NEON Internal Sampling Support Library (SSL).

However, given the potential for mobile devices to fail under field conditions, it is imperative that paper datasheets are always available to record data. Paper datasheets should be carried along with the mobile devices to sampling locations at all times. Data collected on paper data sheets must be transcribed within 14 days of collection or the end of a sampling bout (where applicable). See RD[04] for complete instructions regarding manual data transcription.

### D.2 Document Incomplete Sampling Within a Site

Staff gauge sampling is scheduled to occur at all prescribed sampling locations according to the frequency and timing described in **Section 4.4: Missed or Incomplete Sampling**. Ideally, sampling will occur at these locations for the lifetime of the Observatory or the duration of the site’s affiliation with the NEON project. However, sampling may be shifted from one location to another when sampling is compromised. If this occurs, a new staff gauge will be installed and surveyed.

When a “samplingImpractical” record is created, select one of the pre-populated options in the field metadata app. Additional documentation is required for sampling impractical records occurring during discharge bout or if staff gauge is damaged:

1. Provide photographic evidence of impact.
2. Submit a Service Now ticket to Science with the following naming convention to document the missed sampling: ‘AOS Record Incomplete: [Give explanation]’.
  - a. Staff scientists will review the ticket and provide recommendations.



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**8 REFERENCES**

N/A



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## APPENDIX A QUICK REFERENCES

Record a staff gauge measurement:

- Upon arrival to site
- In conjunction with the AOS Discharge protocol [AD07]
- Before leaving site if conditions have changed

Temporary Hydrologic Conditions:

- **LWD:** Large woody debris is affecting water levels.
- **Sediment:** Sediment has formed at or around the staff gauge in a way that makes the base dry or is significantly changing the water level. Note that subtle changes in sediment depth under the surface of the water do not typically affect staff gauge measurements.
- **Litter Jam:** Organic debris has caused water to pool in an uncharacteristic way.
- **Beaver Dam:** A nearby beaver dam is affecting staff gauge measurements
- **Anchor Ice:** Ice formation is occurring on the streambed and is affecting staff gauge measurements.
- **Border Ice:** Ice formation is occurring along the sides of the channel and is affecting staff gauge measurements.
- **Sheet Ice:** Thin ice formation is extending across the entire channel and is affecting staff gauge measurements. Note that thin ice should be broken through so that a staff gauge measurement can be collected.
- **In-Channel Veg:** Vegetation is impacting staff gauge measurements.
- **Other:** Submit a trouble ticket to Science that describes any other temporary hydrologic conditions that are affecting staff gauge measurements.

**Reading the staff gauge:**

When looking at the gauge plate, the bottom of each black line correlates with a whole centimeter. The top of each black dash indicates half a centimeter. If the water level lies exactly between a 0.5 cm increment, always round up to the closest half centimeter.

**When in doubt, always collect a photo/measurement and contact the Aquatic Science team.**

**Metadata:** Make observations of weather and biological indicators throughout the day. Before leaving field, enter data based on those observations.

- Benthic Algae: Algal growth on the substrate
- Macroalgae: Submerged algal growth within the wetted width
- Leaf Litter: Deciduous and coniferous organic litter within the wetted width



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**APPENDIX B EQUIPMENT**

The following equipment and materials listed in **(Table 5)** are necessary 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 5.** Equipment list – General Equipment.

Supplier/ Item No.	Exact Brand	Description	Purpose	Quantity
	N	Mobile Device or Tablet	Fulcrum Data Collection	1
	N	Paper Datasheet	Backup data collection	1
	N	Hammer and Chisel	Breaking ice	1
	N	Scrub brush	Cleaning biofouling	1
	N	Digital Camera	Documenting staff gauge conditions	1



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**APPENDIX C SITE SPECIFIC OCCURRENCES**

<b>Site</b>	<b>Description</b>
<b>FLNT</b>	Site contains additional staff gauge on floodplain. Refer to section B.1
<b>BLWA</b>	Site contains additional staff gauge on floodplain. Refer to section B.1
<b>TOOK</b>	Inflow gauge belongs to LTER, readings must be converted to metric. This functionality has been built into Fulcrum