AOS PROTOCOL AND PROCEDURE: ASI – STABLE ISOTOPE SAMPLING IN SURFACE AND GROUND WATERS

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	11/21/2014	ECO-02430	• Initial release
B	01/22/2015	ECO-02632	• Migration to new protocol template
C	09/03/2015	ECO-03164	• Aligning lake sampling with water chemistry protocol
D	01/21/2016	ECO-03423	• Updates following FOPS review
E	02/07/2017	ECO-04367	• 2016 updates following FOPS training and reviews • Updated template • Updated field replicate strategy • River stationID changed to 'c0', no longer 'rs' • Updated shipping info and data entry
F	01/10/2018	ECO-05285	• Clarified replicate wording to match updated SWC • Updated wording on lake inlet and outlet sampling to indicate only lakes with permanently flowing inflows and outflows will be sampled as inlet and outlet locations. Lakes without permanent inflows and outflows will only be sampled at buoy location • Updated shipping of H_2O samples to every 2 months per CLA schedule • Added barcode language
G	12/17/2018	ECO-05959	• Fill H_2O vial 80%, reduced from 90% to account for freezing • Removed sample type from labels • Added clarity on drying filters • Updated barcode language • Updated shipping manifest language to include STORK app.
H	12/15/2021	ECO-06702	• Updated to new template (NEON.DOC.050006 Rev K) • Updated filter folding SOP • Update labelling SOP for POM samples • Removed shipping
J	03/03/2025	ECO-07131	• Updated to new template (NEON.DOC.050006 Rev M) • Updated timing and frequency of replicate sampling • Standardized sampling schedule section (Section 4) with AOS Protocol and Procedure: Water Chemistry Sampling in Surface Waters and Groundwater

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1 OVERVIEW

1.1 Background

The following protocol outlines field sampling of stable isotope chemistry in aquatic environments (e.g., stream, rivers, lakes, and groundwater). Naturally occurring stable isotopes are useful ecological research tools. Isotopes are forms of the same element, differing in the number of neutrons in the nucleus. These different forms have similar chemical reactivity, but the different number of neutrons affects the weight of the element. While these elements have similar chemical reactions, the extra weight of the neutron can result in slower reactions than observed in the lighter isotope, resulting in a changing ratio of heavy to light isotope. This is known as fractionation.

Isotopes are measured as the fractional amount of heavy isotope (^{H}F) over the light (^{L}F) isotope, relative to a standard.

$$\delta = [(R_{sample}/R_{standard} -1)] *1000,$$

where $R = {}^{H}F/{}^{L}F$.

Common stable isotopes of ecological interest include nitrogen, carbon, oxygen, hydrogen and sulfur, which are useful in studying elemental cycling, food web dynamics, nutrient transfer and hydrological modeling (Fry 2008).

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]).

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

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: DMP – Data Management
RD[05]	NEON.DOC. 002211	Datasheets for AOS Protocol and Procedure: Stable Isotope Sampling in Surface and Ground Waters
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
RD[08]	NEON.DOC.001646	General AQU Field Metadata Sheet
RD[09]	NEON.DOC.001152	NEON Aquatic Sample Strategy Document
RD[10]	NEON.DOC.002905	AOS Protocol and Procedure: SWC – Water Chemistry Sampling in Surface Waters and Groundwater
RD[11]	NEON.DOC.001199	AOS Protocol and Procedure: SDG – Surface Water Dissolved Gas Sampling
RD[12]	NEON.DOC.003044	AOS Protocol and Procedure: AMC – Aquatic Microbial Sampling
RD[13]	NEON.DOC.002494	Datasheets for AOS Shipping Manifest
RD[14]	NEON.DOC.005224	NEON Protocol and Procedure: SCS – Shipping Ecological Samples and Equipment

2.3 Acronyms

Acronym	Definition
Ah	Amp Hours
^{o}C	Degrees Celsius
$^{13}C/^{12}C$	Carbon stable isotope ratio
cm	centimeter

CLA	Collections and Laboratory Analysis
DI	De-ionized
ft^2	Square foot
GF/F	Glass fiber filter
GPS	Global positioning system
h	Hour
$^2H/^1H$	Hydrogen stable isotope ratio
H_2O	Water
Hg	Mercury
L	Liter
m	meter
m^2	Square meter
m^3	Cubic meter
mph	Miles per hour
mL	milliliter
mm	millimeter
µm	micrometer
NEON	National Ecological Observatory Network
$^{15}N/^{14}N$	Nitrogen stable isotope ratio
$^{18}O/^{16}O$	Oxygen stable isotope ratio
POM	Particulate organic matter
s	Second
SOP	Standard operating procedure

2.4 Definitions

Epilimnion: Top layer of water of a stratified lake, denoted by highest temperatures and least dense water in the summer.

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

Headspace: A gaseous space above a closed liquid sample.

Hydrograph: A diagram depicting the change in discharge (m^3/s) over a given time(s).

Hypolimnion: The dense bottom layer of a stratified lake that sits below the thermocline. This layer is denoted by cooler summer temperatures and slightly warmer winter temperatures relative to the epilimnion.

Isotope: An atom with the same number of electrons and protons, but different numbers of neutrons.

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

Stable isotope: Isotopes (i.e., atomic species) that do not undergo spontaneous radioactive decay.

Thalweg: The deepest part of a stream channel.

Thermocline: The vertical section of the lake where the rate of decrease in temperature with increasing depth is greatest. The denser and cooler layer below the thermocline is defined by the hypolimnion. The warmer upper layer is termed the epilimnion.

3 METHOD

The following protocol describes the collection, processing, storage, and shipping of the stable isotopes $^{15}N/^{14}N$, $^{13}C/^{12}C$ of Particulate Organic Matter (POM) and $^{2}H/^{1}H$, $^{18}O/^{16}O$ of water samples from aquatic environments, including streams, rivers, and lakes. $^{2}H/^{1}H$, $^{18}O/^{16}O$ of water will also be sampled from groundwater.

In streams, disruption of the sediment by walking or by sampling too close to the stream bottom can contaminate samples. Thus, always sample upstream from wading activity and minimize the suspension of sediments when sampling. If sediments are disrupted, wait until the area has cleared before sampling.

In lakes and rivers, care must be taken to avoid contaminating the sample with re-suspended bed sediment. Such contamination may be minimized by anchoring the boat upwind (or upstream) of the sampling site and using an anchor line 2-3 times as long as the depth of the lake or stream. Ensure that when anchoring in rivers, the anchor and boat are within the permitted reach. If sediments are disrupted, wait until the area has cleared before sampling (normally this only takes a few minutes).

In **wadeable and non-wadeable streams**, samples are collected in the deepest part of the channel (A.K.A. thalweg, the line of least resistance to water flow), where it is assumed that the stream channel is well mixed. The stream sampling location is located away from, or upstream of, any major local disturbances and other areas where NEON sampling activities commonly occur. Stable Isotope samples should be collected with water chemistry samples immediately downstream of sensor set 2 in **wadeable streams** (**Figure 1**– Wadeable Stream, orange square) and just downstream of the only sensor set in **rivers** (**Figure 1**– River, yellow circle). In streams with a shallow water column, technicians must be cautious not to disturb the benthic sediment when sampling.

In **lakes** (**Figure 1**), sample collection depends on lake depth and stratification, as detailed in RD[10]. For all lakes, one sample is taken at 0.5 m (Kemmerer sampler should be placed with top at 0.25 m and bottom at 0.75 m) below the surface of the water from the buoy location. If the lake is stratified at the time of sampling, an additional sample will be collected from the hypolimnion at the buoy location (4 total samples). In lakes with **very** shallow hypolimnions (hypolimnion thickness <2 m) do not collect a hypolimnion sample. In lakes with shallow hypolimnions (hypolimnion thickness 2-4 m), the sample is collected from the mid-point of the hypolimnion. In lakes with deep (i.e., thick) hypolimnions (hypolimnion thickness >4 m) an integrated sample is collected as described in the water chemistry protocol (RD[10]). Note that if inflow and outflow streams are present, samples are collected just downstream of the inflow and outflow infrastructure, following the wadeable stream sampling design.

Groundwater well samples should be collected to align in space and time with the groundwater water chemistry samples (RD[08]). Groundwater samples are only sampled for $^{2}H/^{1}H$ and $^{18}O/^{16}O$ isotopes, no $^{15}N/^{14}N$ or $^{13}C/^{12}C$ isotopes are collected from groundwater wells.

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]).

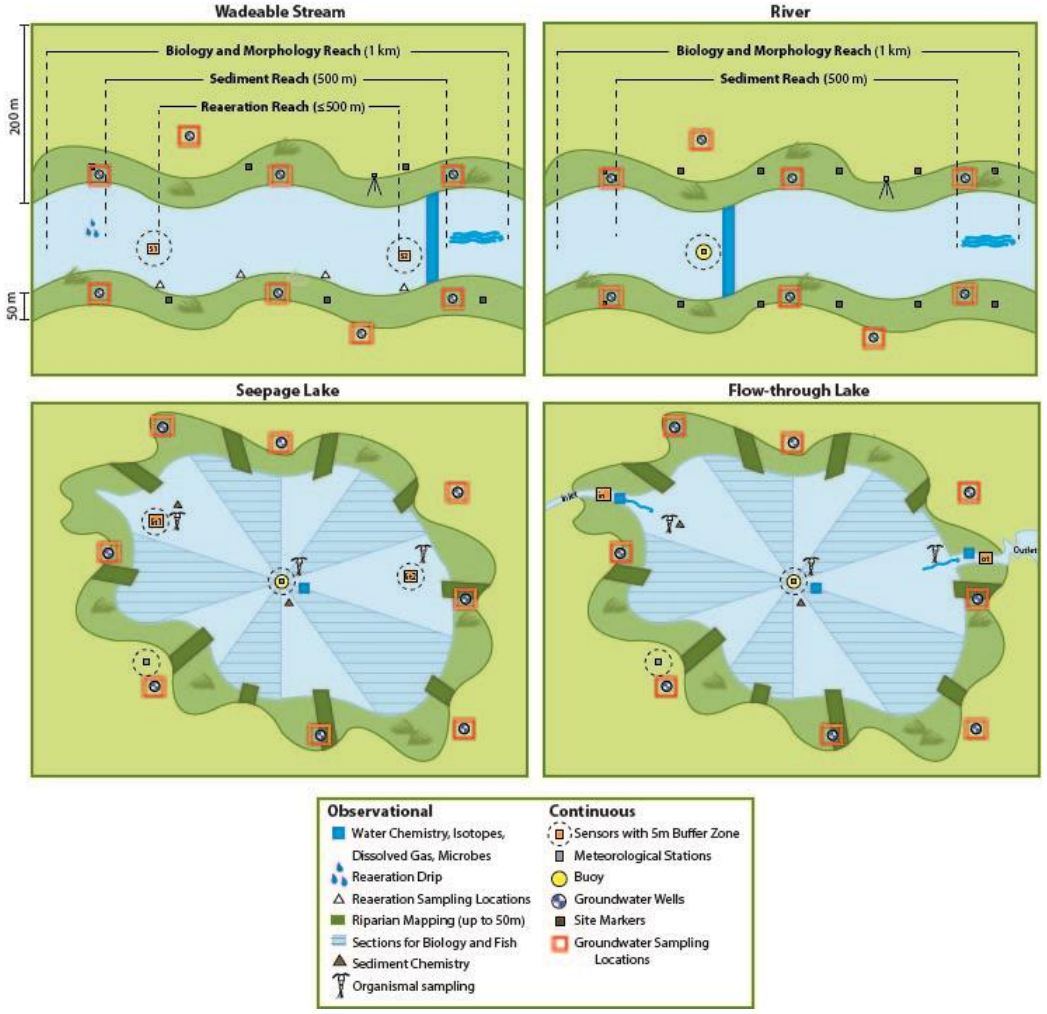

Figure 1. Generic site layouts for wadeable streams, rivers (AKA non-wadeable streams) and lakes surface water and groundwater sampling locations. Seepage lakes are lakes with no observed inflow and outflow, while flow-through lakes have an observed inflow and outflow.

4 SAMPLING SCHEDULE

The sampling schedule for routine stable isotope sampling is generally identical to the sampling schedule defined in AOS Protocol and Procedure: Water Chemistry Sampling in Surface Waters and Groundwater (RD[10]). Information in each subsection of Section 4 of this protocol details only the points at which the sampling schedule for stable isotope sampling deviates from that of RD[10].

4.1 Sampling Frequency and Timing

Refer to Section 4.1 of RD[10] for routine stable isotope sampling frequency and timing.

In addition to the routine sampling mentioned above, replicate samples are collected once per year. Replicates are collected to help quantify measurement uncertainty and environmental variability by collecting two additional surface water samples for external analysis H and O stable isotopes. Considerations for replicate sampling are:

1. It is not required to collect water stable isotope replicates on the same day as water chemistry replicate collection if there are timing/logistical constraints.
2. In stratified lakes, water stable isotope replicate sampling events should occur during periods when the lake is not stratified.
3. No water stable isotope replicates are collected from groundwater wells.
4. Two (2) POM filters are collected at each sampling event. No additional POM replicates are collected.

4.2 Criteria for Determining Onset and Cessation of Sampling

Refer to Section 4.2 of RD[10] for the criteria for determining onset and cessation of stable isotope sampling.

4.3 Timing for Laboratory Processing and Analysis

Stable isotope samples should be stored on ice (4 °C) immediately after collection. Process (filter and store appropriately) surface and subsurface isotope samples as soon as possible, and within 4 h of sample collection. For storage and shipping timelines see the NEON Protocol and Procedure: Shipping Ecological Samples and Equipment Protocol (RD[14]).

Table 1. Timing for laboratory processing and handling of Stable Isotope samples.

Sample type	Activity	Holding Time
Oven-dried (65 °C) POM Samples	Filter, dry, store in desiccator, and ship to external lab	Shipped with Algal Chemistry or every 2 months
Room temperature H_2O samples	Filter, cap, parafilm cap, store, and ship to external lab	Shipped every 2 months on CLA-defined schedule

4.4 Sampling Timing Contingencies

Refer to Section 4.4 of RD[10] for stable isotope sampling timing contingencies.

4.5 Missed or Incomplete Sampling

Refer to Section 4.5 of RD[10] for direction on handling missed or incomplete stable isotope sampling events.

4.6 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.

Table 2. Estimated staff and labor hours required for implementation of the Stable Isotope Sampling protocol.

SOP	Estimated time	Suggested staff	Total person hours
B.2: Field Sampling in Surface Water	1-2 h	1-2	1-4 h
B.2: Field Sampling in Groundwater	4-16 h	1-2	4-32 h
B.3: Sample Collection and Processing	1-2 h	1	1-2 h

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 EHS Safety Policy and Program Manual (AD[01]) and Operations Field Safety and Security Plan (AD[02]). Additional safety issues associated with this field procedure are outlined below. If an employee witnesses any unsafe conditions or uncontrolled hazards that present an imminent danger, they should immediately take action to stop work and report such conditions to their manager. Employees must also report all workplace injuries, illnesses, incidents, or releases to the environment as soon as possible, regardless of the severity.

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) (AD[02]). When working around ice, refer to (AD[02], Section 9.3 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 regarding work on ice, prior to deploying employees and equipment. Do not continue if the risk is too great.

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

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, minimum of 20 m, from hazards is maintained.
2. All personnel must be wearing a personal flotation device prior to entering the boat, and in wadeable streams when conditions are approaching the allowed wading limit (AD[02]).
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 water hazards of that particular location (i.e., current status, tidal charts, etc.).

If personnel or loads will be on ice while performing their task for greater than 2 h, all loads should be multiplied by 2 to determine safe ice thickness.

5. Access to Safety Data Sheet shall be available for work with chemicals (including Dry Ice) associated with this protocol.

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.

All personnel required to operate a boat shall be trained through a NEON Safety approved program (AD[02]). All others shall be aware of boating safety procedures.

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 safely.

7 STANDARD OPERATING PROCEDURES

SOP Overview

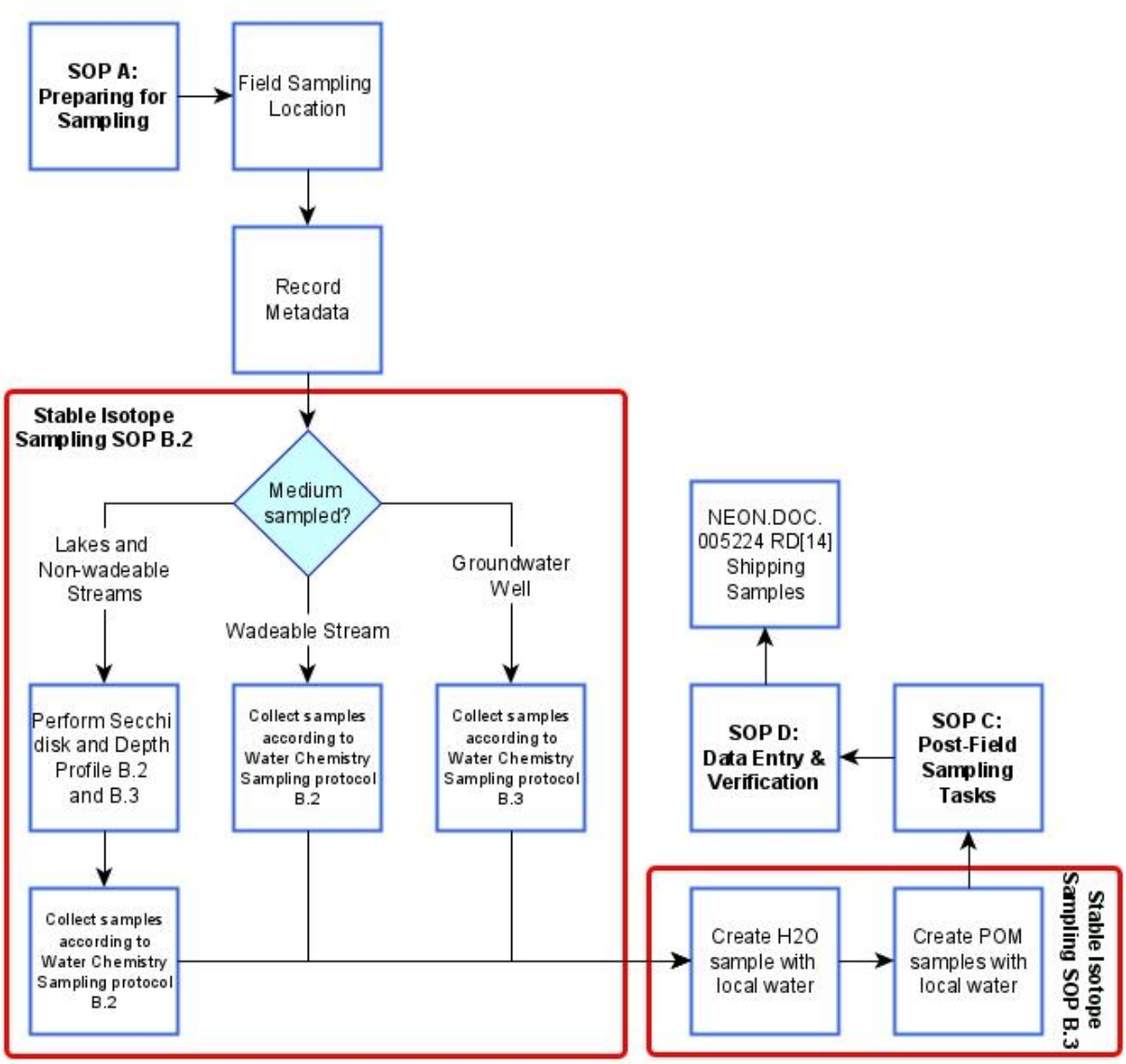

Figure 2. A high level workflow diagram that visually shows how the separate SOPs are sequentially connected.

SOP A Preparing for Sampling

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. For detailed instructions on protocol specific data entry into mobile devices, see the NEON Internal Sampling Support Library (SSL). Always sync your tablet before leaving for the field to capture any updates that may have been incorporated since the last sampling.

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. Pre-ash GF/F filters:
    a. Place layers of 25 mm GF/F filters on aluminum foil. Use multiple layers of foil if needed, filters can be touching and placed on top of one another but should not be stacked more than 3 filters deep.
2. Place in muffle furnace (500 °C) for at least 6 h.
    a. After the furnace has cooled, remove from the furnace and stack filters using filter forceps, and place in original box.
    b. Label box with permanent marker to read “ASHED, Your Name, Date”.
    c. Place box in in sealed zip-top bag.
    d. Ashed filter may be stored indefinitely, as long as they remain in the box and stay dry.
3. Check the aquatic isotope field sampling kit to make sure all supplies are packed.

A.3 Labels and Identifiers

Many protocols use a mix of human intelligible labels and barcodes in their workflow. Barcodes are useful for minimizing transcription errors and tracking samples from the domain support facility to external locations. **All field samples must use a barcode and all samples being shipped from the DSF must have a barcode.** In addition, barcodes should be used for lab procedures where it makes sense. Rules of thumb for using barcodes in the lab:

- In general, apply a barcode if a sample is generated and returned to for processing over a period of > 5 business days.
- Barcodes are optional for temporary samples that are created and consumed in < 1 day. For example, pooled samples that are then immediately sorted, split, or ground may not need a barcode.

All barcodes need to be applied to dry containers for 30 minutes before use. Type I (prefix A, plus 11 numbers) are for all field samples and any non-cryo applications; they have a tolerance of 4-105 °C and still scan (**Figure 3**).

1. Prepare final sample containers by affixing one Type I adhesive barcode label to each container used to contain each sample. Adhesive barcode labels should be applied at the DSF to dry, room temperature containers in advance of their use in the field (at least 30 minutes prior, but may be applied at the start of the season).
    a. For H_2O isotope sample vials, barcode labels should be oriented such that it is possible to scan them; the scanner will not work on a curved surface. This means aligning the barcode lengthwise along a vial, not horizontally wrapping around a vial.
    b. For POM isotope foil packs, put on a pair of nitrile gloves and apply the label to a new piece of foil layed flat on an ethanol-cleaned surface (e.g., lab bench, tray). The side of the foil laid against the ethanol-cleaned surface will become the inside of the foil pack. Apply the labels to the upward-facing side of the foil.
        i. DO NOT touch the area that will become the inside of the foil pack with ungloved hands
    c. Barcode labels must be associated with a unique sample and each barcode must be mapped to one sample in the database. Barcodes are unique, but are not initially associated with a particular sample, so you are encouraged to adhere barcode labels to needed containers in advance.
2. Attach pre-printed labels (**Figure 4**).
    a. SampleID: **site.stationID.YYYYMMDD.sampleType.Rep**. *siteID* is the 4-digit side code. *StationID* is the 2-digit station code where sample was taken (i.e., Station ID for streams ="ss", non-wadeable streams/rivers = 'c0'; in Lakes, inlet="in", outlet="ot", center="c0", if center is stratified: "c1", "c2", "c3" with “c1” being the top layer; "w1"-"w8" for groundwater wells). *sampleType* is the 3-letter sample code (H_2O or POM), do NOT include isotope numbers (i.e. 2H,18O or 15N13C) to sampleID. *Rep* is replicate #.
        i. For regular H_2O collections without replicates, rep is always “.1” See example:
            1) Ex.) **PRIN.ss.20151013.H2O.1**
        ii. Use a printer and/or sharpie to fill out labels before going into the field

Figure 3. An example of a Type I barcode. These large-size, field-tolerant barcodes have a prefix of 'A' followed by 11 numbers.

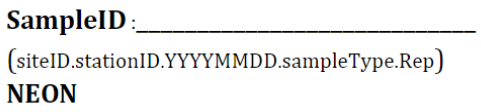

Figure 4. NEON aquatics stable isotope chemistry labels example.

About Barcode Uses and Placement

Although it is always acceptable to use barcodes, in some cases barcodes are absolutely required. **Table 3** provides a quick reference to the types of samples this protocol generates that require barcodes. The final disposition of all vialed/filtered samples must have a barcode affixed to assist in the shipping and receipt of samples destined for the Biorepository or an external laboratory.

Table 3. Barcode requirements for sample types generated by the Stable Isotope Sampling protocol.

Sample Type	Description	Example Identifier	Fulcrum App	Container Type	Barcode Used	Barcode Required	Barcode Qty
POM.1 POM.2	N and C Isotopes of Particulate Organic Matter	CARI.ss.20200429.POM.1 CARI.ss.20200429.POM.2	(AOS) Water Chemistry	Foil Packet	Type I	**Always Required**	1 per filter
H2O	H and O Isotopes of Water	CARI.ss.20200429.H2O.1	(AOS) Water Chemistry	15 mL vial	Type I	**Always Required**	1 per vial

SOP B Field Sampling

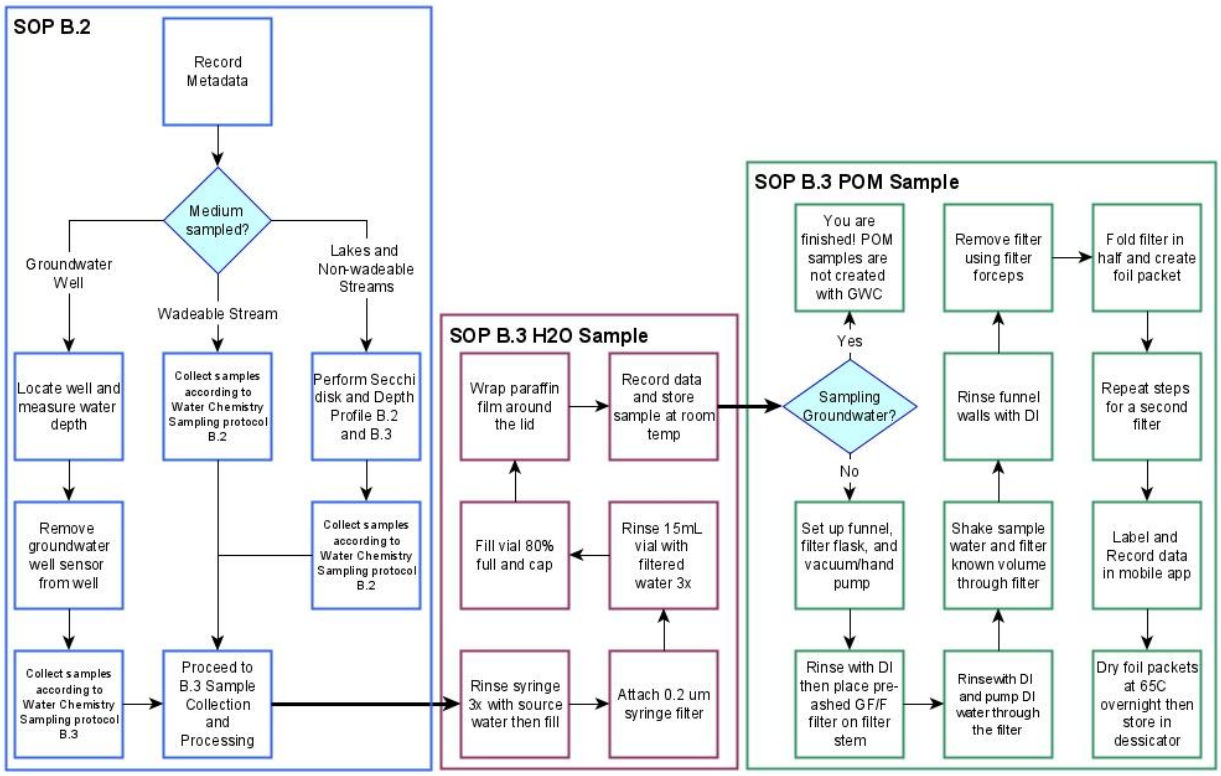

Figure 5. An expanded diagram of the workflow for Field Sampling.

B.1 Spatially and Temporally Linked Protocols

Water Chemistry Sampling in Surface Waters and Groundwater

- Isotope sampling in wadeable streams will be completed in the same location as surface water chemistry, immediately downstream of Sensor Set 2 (**Figure 1**) and upstream of any stream disruption and in a flowing area of the stream, if possible.
- Isotope sampling in lakes and rivers will follow the Water Chemistry Sampling in Surface Waters and Groundwater Protocol (RD[10]).
- Groundwater wells are only sampled for H_2O, no POM samples are collected. Groundwater H_2O sampling will be completed in the same location/assigned wells as water chemistry sampling occurs.

Dissolved Gas Sampling

- Isotope sampling in surface water will be completed in the same location as surface water dissolved gas sampling (RD[11]) in wadeable streams, lakes, and rivers.

Aquatic Microbial Sampling

- Isotope sampling in surface water will be completed in the same location as surface water aquatic microbe sampling (RD[12]) in wadeable streams, lakes, and rivers.

B.2 Field Sampling

1. In the field, complete the General AQU Field Metadata and the Water Chemistry Application on the mobile data recorder. You only need to fill out one General Field Metadata Application per site per day.
    a. Always make note of any weather or stream conditions that could influence chemistry, including but not limited to wind, activities in the surrounding watershed, prior flood or rain events, ice, and changes in sampling locations (RD[06]). For lakes, also record new Global Positioning System (GPS) coordinates (accuracy is <4 m) and total depth of the water column sampled with the water chemistry protocol (RD[10]).
2. Collect samples according to water chemistry sampling protocol (RD[10]) in streams, rivers and lakes, or groundwater wells, as appropriate. Samples should be collected at the same depth as the water chemistry samples are collected. Samples for isotopes should be collected out of the same sampler and collection jug as water chemistry, if possible.
3. Station ID is the 2-digit station code where sample was taken (i.e., Station ID for streams ="ss", non-wadeable streams/rivers = 'c0'; in Lakes, inflow="in", outflow="ot", center="c0", if center is stratified: "c1", "c2", "c3" with “c1” being the top layer; "w1"-"w8" for groundwater wells).
4. Wadeable Streams
    a. Collect stream isotope samples and metadata following the Water Chemistry Sampling in Surface Waters and Groundwater Protocol (RD[10]).
    b. ALWAYS sample in the thalweg (the deepest location in the stream cross-section) and 5-10 cm below the surface (to avoid sampling floating material or surface film). If the usual location is too shallow select another location within the stream reach that is deep enough, preferably in the thalweg. Personnel can step into the stream, but be sure to take samples upstream from the standing location.
    c. Proceed to SOP B.3, Sample Collection and Processing.
5. Lakes and Rivers (Non-wadeable streams)
    a. Collect river and lake water samples and metadata following the Water Chemistry Sampling in Surface Waters and Groundwater Protocol (RD[10]).
        i. Move to the sampling station and note the station ID in the mobile recorder (on the field sheet, if necessary) (RD[10]; **SOP B.2)**.
        ii. Determine the depths for sampling according to Secchi Application.

iii. Sample using the Kemmerer bottle, as described in the water chemistry protocol (**Figure 6**, RD[10]; **SOP B.2**).

b. Proceed to **SOP B.3**, Sample Collection and Processing.

Figure 6. Image of a Kemmerer Sampler.

6. Groundwater Wells

a. Collect groundwater sample water and associated metadata from selected wells following the Groundwater Chemistry Sampling Protocol (RD[10]).

i. Locate well and measure water depth.

ii. Remove groundwater well sensor from the well.

iii. Extract groundwater from well, using appropriate pump method.

iv. Collect water samples for H_2O. No POM samples are collected for GW.

b. Proceed to **SOP B.3**, Sample Collection and Processing.

B.3 Sample Collection and Processing

$^{18}O/^{16}O$ and $^{2}H/^{1}H$ of H_2O samples from Surface and Ground Water

1. Rinse a 5 mL or 60 mL syringe 3 times with source water. Discard rinse water downstream or on the bank.

a. Some may prefer to use a 5 mL syringe because it is easier to press the water through the filter. However, you will need to fill the 5 mL syringe several times to collect the appropriate sample volume.

2. Fill the syringe with sample water.

3. Attach a 0.2 µm syringe filter.
4. Rinse collection bottle (15 mL glass vial with rubber closure) with filtered sample water 3 times. To rinse: filter at least 1-3 mL of sample water into vial, recap (you may just hold cap on with your hand instead of rescrewing cap each rinse), and shake to ensure water touches all parts of the bottle and cap.
5. Filter the remaining water in the syringe into a 15 mL glass bottle (**Figure 6**). Fill the vial with **12 mL** of filtered water. This volume will minimize evaporation and will leave enough headspace to ensure bottle will not break if freezing occurs.
6. Securely attach lid and **wrap plastic paraffin film** around the lid and vial to secure the lid and to reduce air movement.
7. Record data in the mobile app.
    a. If available, scan the barcode label with the tablet (**Figure 7**).
    b. Ensure that the human-readable sample ID matches the sample ID generated by the mobile app.

Figure 7. Barcode label scanning.

8. No additional preservation or special shipping is required. Store samples at room temperature until shipment

$^{13}C/^{12}C$ and $^{15}N/^{14}N$ of POM from Surface Waters

1. Put on a pair of nitrile gloves.

2. Collect water using a 4 L jug to be filtered within 4 h. In shallow streams, you may need to use the peristaltic pump to get the water out of the stream and into the 4 L jug.
    a. When transporting water back to the DSF, to reduce biological activity, keep jug on ice and in the dark until you are able to process the sample.
    b. When processing samples in the field, keep the 4 L jug in a shaded and cool place until you are able to process the sample.
3. Set up filter funnel, filter flask, and vacuum pump (**Figure 8**).
    a. Connect flexible tubing from vacuum pump to hose connection on filter flask.
    b. Make sure filter stem is inserted into the hole in the rubber stopper.
    c. Insert rubber stopper into the top of the filter flask. Push in tightly.
    d. Attach top of filter funnel to filter stem. This may be a magnetic connection or a screw-in connection.

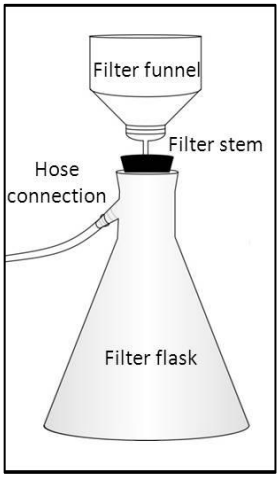

Figure 8. Filter apparatus setup.

4. Rinse the filter funnel and stem with de-ionized (DI) water, using a squirt bottle and wipe with Kimwipes if needed.
5. Remove the top of funnel.
6. Place pre-ashed GF/F filter on top of the filter stem (**Figure 8**).
7. Re-attach the top of funnel.
8. Rinse the filter with DI water. Use the vacuum pump to create suction in the flask and draw the DI water through the filter.
9. Shake sample bottle vigorously for ~15 s to mix sample.
    a. Filter known volume of sample.

i. Measure using a graduated cylinder.

ii. Triple rinse the graduated cylinder with sample water before measuring out the sample

iii. Pour sample slowly in ≤200 mL increments into filter funnel.

b. Do not pour more sample into funnel than will pass through the filter. All water in the filter funnel must pass through the filter, if filter becomes clogged while there is still sample water in the funnel, discard sample and filter and start again.

10. **Keep track of the volume of sample filtered on the Mobile Data Recorder**

11. Draw suction on filter apparatus using the hand vacuum pump (or vacuum manifold, if available). Do not exceed 15 inches of mercury (in Hg) vacuum on the pump dial. High pressure ruptures cells and causes chlorophyll and other compounds to dissolve and pass through the filter.

    a. If you have added too much sample and the filter appears to be clogged, you may discard the contents of the filter funnel and the filter and start over. **If you decant water from the filter funnel, you must discard the filter and start over.**

12. Check the filter, if it still appears white, filter more sample. If the filter appears green or yellow tinged, proceed to next step.

    a. **Record the volume of sample filtered for each Replicate on the mobile recorder.**

    b. Filter as much as possible (should be >500 mL, if possible). If unable to filter the minimum amount, filter as much sample as possible and record volume.

13. Rinse inside walls of funnel using wash bottle of DI.

    a. Do not include DI rinse water in the volume of sample filtered.

14. Continue to draw suction on the filter until there is no water left in the funnel and there is no excess water on top of the filter.

15. Remove top of filter funnel, release suction by turning the valve on the manifold. If using the hand pump, you may need to remove stopper.

    a. You may wish to remove the stopper entirely from the flask or manifold to reduce pressure on filter. This will make removing the filter easier.

16. Carefully remove the filter from the stem using filter forceps (forceps with flat ends). Take care not to touch the filter with your fingers.

17. Place the wet filter in the middle of the pre-labelled foil pack (**Figure 9**).

18. Create a crease in the filter by partially folding within the pre-labelled foil pack (**Figure 10**). Do not fold filter completely or let the two sides of the filter touch/smear sample.

a. The wet filter will stick to the aluminum foil, creasing with relative ease as the foil is folded in on itself (**Figure 10**). If the filter is not folding easily within the foil pack, use a pair of blunt-ended filter forceps to hold the filter in place, then fold the foil.

19. Leave the filter unfolded, but creased, in the foil square. It will partially unfold on its own if it was not folded completely.

20. Enclose the sample in the pre-labelled foil pack by folding one edge of the foil pack in then folding the top down (**Figure 9**). One end should be left open to allow drying in the drying oven (**Figure 10**).

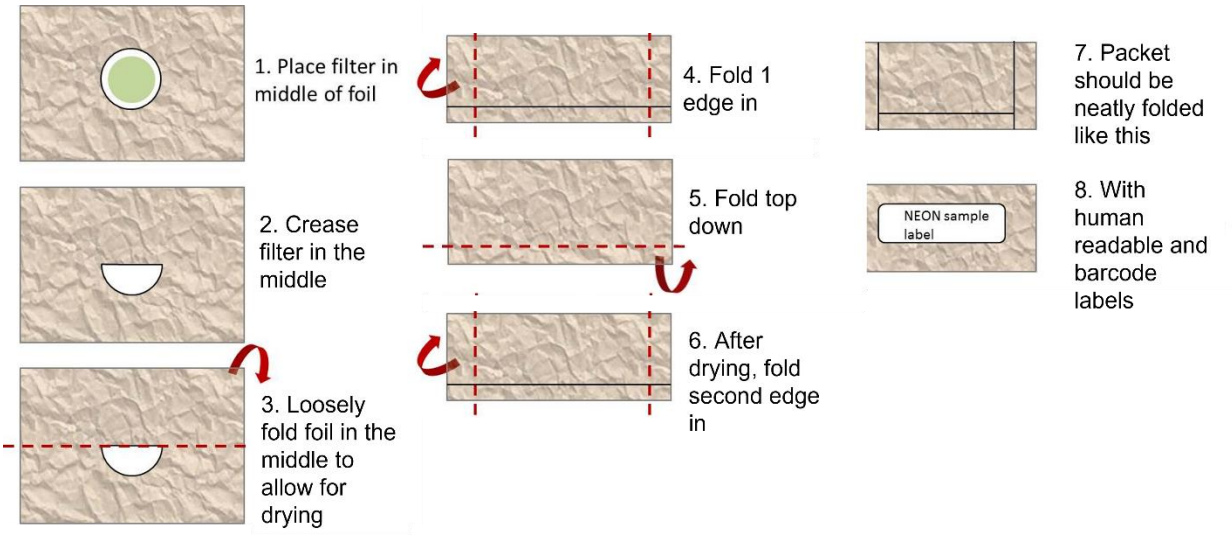

Figure 9. Correct filter packet folding procedure. Make sure packet can be easily opened at the external lab without destroying the NEON sample label or barcode label. Do not use excess foil.

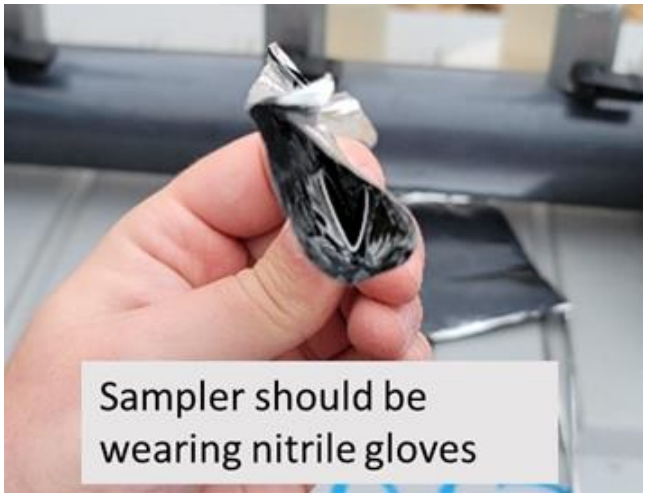

Figure 10. Correctly folded foil pack ready to be placed in the drying oven.

21. If transporting from the field, pack in a rigid container with light packing materials so that the foil pockets/samples are not crushed during transport. Keep foil containers right-side-up. Place filters in the cooler with the water sample(s).
22. At the DSF, place the pre-creased, but partially unfolded, sample in drying oven with foil pack opened on one end to allow air flow. Dry overnight at 65 °C.
23. After filter is dried, remove the foil pack from the drying over and fold the remaining end closed. Ensure the label and barcode are clearly visible/scannable for shipping to the external lab (**Figure 9**).
    a. Rinse funnel with DI and wipe with Kimwipes if needed, and wipe filter forceps with Kimwipes.
24. Repeat above steps until you have 2 POM replicate filters from the same sample.
25. Record data in the mobile app.
26. If available, scan the barcode label with the tablet (**Figure 7**).
27. Ensure that the human-readable sample ID matches the sample ID generated by the mobile app.
28. Place all foil packs from one site inside a resealable bag. Using a permanent marker, label the outside of the resealable bag with Domain, Site, Date, and the “lab type” ($^{13}C/^{15}N$).
29. Place all dried filters in a desiccator until shipping.

SOP C Post-Field Sampling Tasks

C.1 Ending the Processing Day

Refreshing the sampling kit

1. Restock the sampling kit (shipping cooler) with new isotope chemistry sampling bottles with new labels attached, filters, resealable plastic bags, etc. Refer to **Table 6** for tables detailing equipment and materials.

Equipment maintenance, cleaning and storage

1. Generally, decontaminate and store all sampling equipment in accordance with RD[10].
2. Peristaltic Pump:
    a. Run clean water through the peristaltic pump to rinse tubing. Make sure to pump all water out of tubing before storage.
    b. Charge batteries.
3. Rinse Filter Funnel apparatus with DI and wipe using Kimwipes.

C.2 Document Incomplete Sampling Within a Site

Aquatic stable isotope sampling is scheduled to occur at all prescribed sampling locations according to the frequency and timing described in Section 4 and Appendix C. 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, sampling may be shifted from one location to another when sampling is compromised. In general, a sampling location is compromised when sampling becomes so limited that data quality is significantly reduced.

There are two main pathways by which sampling can be compromised. First, sampling locations can become inappropriately suited to answer meaningful biological questions – e.g., a terrestrial sampling plot is compromised after road-building activities, or a stream moves after a flood and the location is no longer within the stream channel). Second, sampling locations may be located in areas that are logistically impossible to sample on a schedule that that is biologically meaningful.

If sampling at a given location is not possible during a given bout a problem ticket should be submitted by Field Science staff.

<u>To document locations not sampled during the current bout:</u>

1. Review the completed sampling effort and create **Sampling Impractical** records as described in Section 4.5 for plots at which sampling was scheduled but was not completed.
2. To document whether a location is compromised according to the criteria above:

a. Review **Sampling Impractical** records from the *(AOS) Water Chemistry [PROD]* application and Portal data to identify locations where sampling was scheduled but was not completed due to environmental or site management factors.

3. Create an incident with the following naming convention to document the missed sampling and compromised location: 'AOS Sampling Incomplete: ASI – [Root Cause Description]'

   a. Example: 'AOS Sampling Incomplete: ASI – Entire stream is dry'

Staff scientists review incident tickets periodically to determine whether a sampling location is compromised.

SOP D Data Entry and Verification

Mobile applications are the preferred mechanism for data entry. Data should be entered into the protocol-specific application as they are being collected, whenever possible, to minimize data transcription and improve data quality. Mobile devices should be synced at the end of each field day, where possible. Alternatively, devices should be synced immediately upon return to the Domain Support Facility.

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.

Quality Assurance

Data Quality Assurance (QA) is an important part of data collection and ensures that all data are accurate and complete. Certain QA checks can be conducted in the field (i.e., before a field team leaves a plot or site), while others can be conducted at a later date in the office (typically within a week of collection). Field QA procedures are designed to prevent the occurrence of invalid data values that cannot be corrected at a later time, and to ensure that data and/or sample sets are complete before the sampling window closes. Invalid metadata (e.g. collection dates, plotIDs) are difficult to correct when field crews are no longer at a sampling location.

Office QA procedures are meant to ensure that sampling activities are ***consistent*** across bouts, that sampling has been carried out to ***completion***, and that activities are occurring in a ***timely*** manner. The Office QA will also assess inadvertently duplicated data and transcription errors to maintain data ***validity*** and ***integrity***. See the Data Management Protocol (RD[04]) for more discussion of QA measures.

Before samples ship to external facilities and/or their digital records load to the NEON database, the data must undergo thorough quality checks. The steps needed to accomplish this are outlined in the Water Chemistry QC Checklist, which is available on the NEON SSL

Sample Identifiers & Barcodes

By default, each (sub)sample produced by this protocol receives a sample identifier, which contains information about the location, date, and sample type. Each (sub)sample will also be associated with a scannable barcode, which will not contain information about sample provenance, but will improve sample tracking and reduce transcription errors introduced by writing sample identifiers by hand.

Adhesive barcode labels should be applied to dry, room temperature containers in advance of their use in the field (at least 30 minutes prior but may be applied at the start of the season). Barcodes are unique, but are not initially associated with a particular sample, thus it is encouraged to apply these in advance. Use the appropriate barcode label type with each container (i.e., cryogenic Type II barcode

labels only used for samples that are stored at -80°C, etc). Note that a barcode label is applied *in addition to* a sample identifier (hand-written or printed).

Barcodes are scanned into the data entry application when a sample is placed into a container; only one barcode may be associated with a particular sample. Do not reuse barcodes. If a barcode is associated with multiple samples, the data ingest system will throw an error and refuse to pull in entered data.

SOP E Sample Shipment

1. Follow sample shipping timelines in Section 4 to maintain appropriate sample hold times and storage conditions.
    a. Discrepancies between this protocol document and the Shipping Protocol should be communicated to Science.

Follow instructions in the NEON Protocol and Procedure: Shipping Ecological Samples, Sensors, and Equipment in order to ship samples to external laboratories or the biorepository (RD[14]).

8 REFERENCES

Didan, K. 2015. MOD13Q1 MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V006. NASA EOSDIS Land Processes DAAC. https://doi.org/10.5067/MODIS/MOD13Q1.006.

Fry, B. (2008). Stable Isotope Ecology. Springer, New York, New York.

APPENDIX A QUICK REFERENCES

A.1 Flowchart of Sample Collection and Filtration

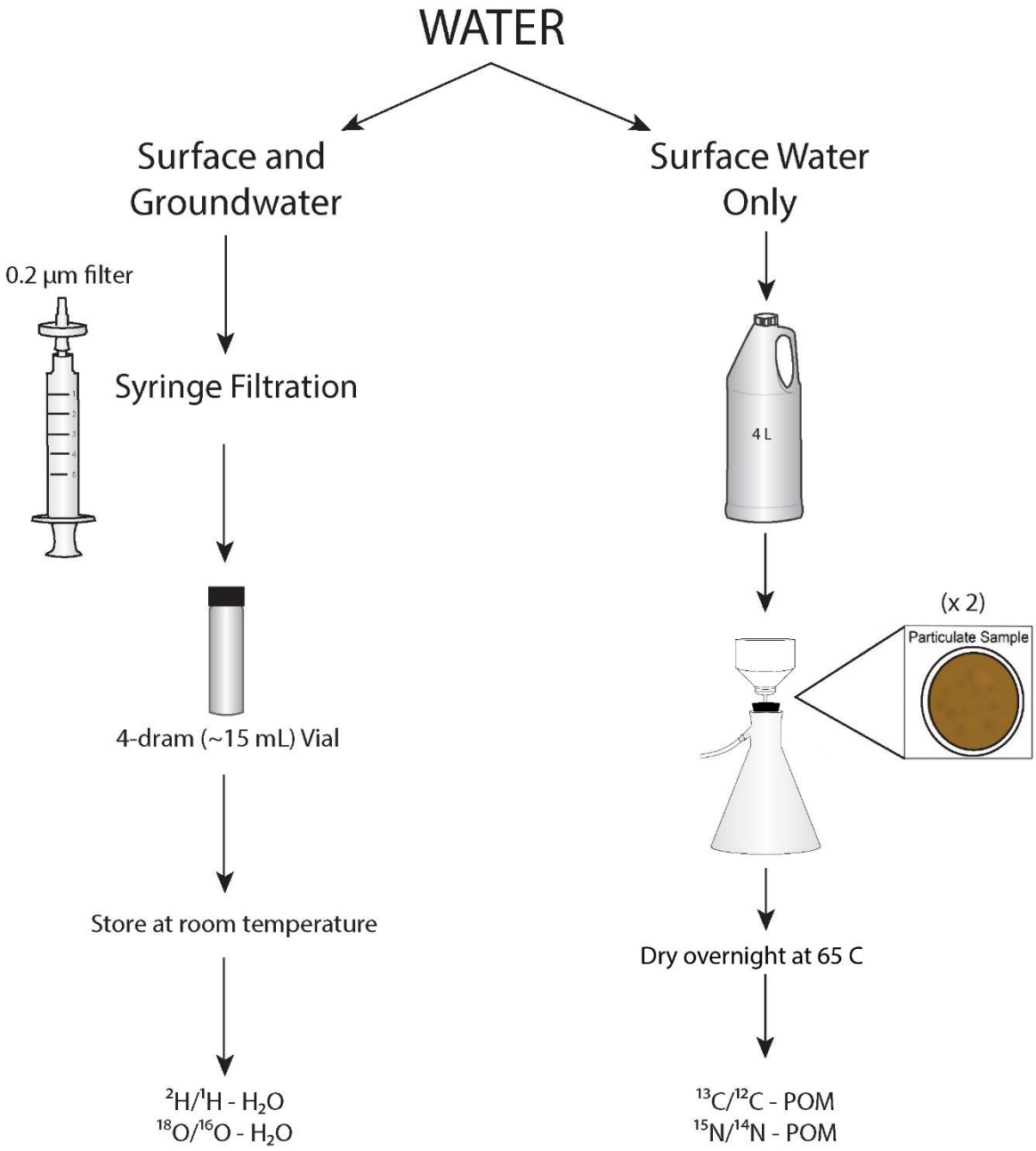

Figure 11. Flowchart of Sample Collection and Filtration

A.2 Steps for Sample Collection and Filtration

Step 1 – Pre-ash filters.

Step 2 – Check the isotope field sampling kit to make sure all supplies are packed.

Step 3 – Prepare labels (1 x 2 $^{5}/_{8''}$)

SampleID:_____
(siteID.stationID.YYYYMMDD.sampleType.Rep)
NEON

Step 4 – Ensure the General AQU Field Metadata Sheet (RD[06]) is completed per field site visit.

Step 5 – Wadeable streams: Collect isotope samples in the thalweg following the Water Chemistry Sampling in Surface Waters and Groundwater protocol (RD[08]).

Step 6 – Lakes and non-wadeable streams: Collect isotope samples following the Water Chemistry Sampling in Surface Waters and Groundwater protocol (RD[08]). Select sampling depth and collect samples using the Kemmerer.

Step 7 – Groundwater wells: Collect isotope samples from selected wells following the Water Chemistry Sampling in Surface Waters and Groundwater protocol (RD[08]).

1. Locate well and measure water depth.
2. Remove groundwater well sensor from the well.
3. Extract groundwater from well, using appropriate pump method.
4. Collect water samples.

Step 8 – Process (filter and store appropriately) surface and subsurface isotope samples within 4 h of sample collection:

1. $^{18}O/^{16}O$ and $^{2}H/^{1}H$ of H_2O samples from Surface and Ground Water:
    a. Filter using a 0.2 µm filter with syringe into sample vials
2. $^{13}C/^{12}C$ and $^{15}N/^{14}N$ of POM from Surface Waters (2 filters):
    a. Filter with a vacuum pump and ashed GF/F filters

Step 9 – Ship samples:

1. $^{18}O/^{16}O$ and $^{2}H/^{1}H$ of H_2O samples: Ship samples Ground every 2 months per CLA schedule.
2. Filters ($^{13}C/^{12}C$ and $^{15}N/^{14}N$ of POM): Ship filters every 2 months or at the same time as the biology bout shipment. Filters shall be dried at 65 °C. Allow to dry at least overnight and store in a desiccator until shipped.

APPENDIX B REMINDERS

Before heading into the field: Make sure you…

- ☑ Collect and prepare all equipment including labels.
- ☑ Pre-print labels on waterproof adhesive labels.
- ☑ Fill out the labels before they get wet.

Sample collection: Be sure to…

- ☑ Not sample anywhere you or other field technicians have walked, or locations that appear recently disturbed. Wait for disturbance to pass.
- ☑ Avoid contaminating the sample with re-suspended bed sediment.
- ☑ Use caution when sampling as items can easily fall into water while sampling.
- ☑ ALWAYS sample in the THALWEG in wadeable and non-wadeable streams.

Sample filtering: Be sure to…

- ☑ Keep track of the volume of sample filtered on the mobile data recorder or paper Data Sheet (RD[05]).
- ☑ If you decant water from the filter funnel, you must discard the filter and start over.

- ☑ DO NOT add more water into the filter tower than you can filter.

APPENDIX C ESTIMATED DATES FOR ONSET AND CESSATION OF SAMPLING

The seasonal timing of groundwater sample collection is driven by the seasonal and cumulative hydrograph of the stream, river, or lake at the specific NEON aquatic site as surface water hydrology is often linked to groundwater hydrology and water quality (Soulsby et al. 2009). At river and stream sites, groundwater sample collection is temporally timed to capture seasonal variability around 25% and 75% (± 5%) of cumulative annual discharge. Groundwater chemistry sample timing will be reassessed once a minimum of three years of water table data are available to ensure that we are capturing seasonal variability in chemical and hydrologic conditions.

Table 4. Site-specific groundwater sampling windows and wells to samples.

Domain Number	Site ID	Bout 1 Window Start Date	Bout 1 Window End date	Bout 2 Window Start Date	Bout 2 Window End date	Wells to Sample
01	HOPB	3/5	3/24	6/16	10/7	1, 2, 3, 4
02	POSE	2/27	3/19	6/30	10/5	1, 3, 6, 8
02	LEWI	3/2	3/24	7/19	9/12	1, 2, 6, 8
03	SUGG	2/20	3/20	9/20	10/20	1, 5, 6, 8
03	BARC	2/20	3/20	9/20	10/20	4, 5, 6, 8
03	FLNT	2/14	3/6	7/14	9/27	1, 3, 6, 7
04	GUIL	5/4	6/1	10/2	10/25	1, 3, 5, 6
05	LIRO	4/15	5/15	10/10	11/10	1, 3, 5, 6
05	CRAM	4/15	5/15	10/10	11/10	1, 2, 4, 7
06	MCDI	4/8	4/24	6/26	7/17	2, 4, 5, 6
06	KING	4/8	4/24	6/26	7/17	1, 2, 4, 8
07	WALK	2/11	2/27	6/15	9/2	1, 2, 3
08	MAYF	2/18	3/11	8/6	10/9	1, 2, 7, 9
08	TOMB	2/11	3/2	5/29	8/15	1, 2, 3
08	BLWA	2/14	3/5	6/16	9/9	1, 2, 3
09	PRPO	4/15	5/15	10/15	11/15	1, 3, 5, 7
09	PRLA	4/15	5/15	10/15	11/15	1, 3, 7, 8
10	ARIK	4/2	4/26	7/25	8/19	1, 2, 4, 5
11	PRIN	3/24	4/28	7/25	9/17	1, 2, 4, 6
11	BLUE	4/2	5/8	7/24	10/13	2, 4, 7, 8
12	BLDE	5/18	6/12	7/13	8/10	1, 2, 7, 8
13	COMO	5/24	6/13	7/18	8/4	1, 2, 3, 4
13	WLOU	4/24	5/18	8/10	9/12	1, 2, 5, 8
14	SYCA	1/20	2/12	3/30	6/17	1, 2, 3, 4
15	REDB	4/7	4/23	8/17	9/26	2, 3, 4, 5
16	MART	2/15	3/11	10/14	11/19	1, 2, 5, 6
17	BIGC	3/31	4/16	5/31	6/13	1, 2, 5, 6
18	OKSR	7/1	7/28	8/1	9/1	3, 5, 7, 8
18	TOOK	7/1	7/28	8/1	9/1	1, 2, 7, 8
19	CARI	6/1	6/21	8/25	9/22	1, 5, 7, 8

APPENDIX D SITE-SPECIFIC INFORMATION

Each domain has site specific guidelines for timing of sample collection and can be found in Domain Specific Sampling Designs (**Table 5**). The dates in the Sampling Design documents are estimated from historical hydrologic data. Dates presented are only a guide and are derived according to the logic presented in Section 4.2. Because individual years may vary widely from the average dates provided below, it is essential that domain staff monitor real-time conditions to determine when to start (and stop) sampling per environmental conditions, as described in Section 4 of this protocol.

Table 5. Aquatic Site Sampling Design documents.

Domain Number	Document Number	Document Name
01	NEON.DOC.003600	Aquatic Site Sampling Design – NEON Domain 01
02	NEON.DOC.003601	Aquatic Site Sampling Design – NEON Domain 02
03	NEON.DOC.003602	Aquatic Site Sampling Design – NEON Domain 03
04	NEON.DOC.003603	Aquatic Site Sampling Design – NEON Domain 04
05	NEON.DOC.003604	Aquatic Site Sampling Design – NEON Domain 05
06	NEON.DOC.003605	Aquatic Site Sampling Design – NEON Domain 06
07	NEON.DOC.003606	Aquatic Site Sampling Design – NEON Domain 07
08	NEON.DOC.003607	Aquatic Site Sampling Design – NEON Domain 08
09	NEON.DOC.003608	Aquatic Site Sampling Design – NEON Domain 09
10	NEON.DOC.003609	Aquatic Site Sampling Design – NEON Domain 10
11	NEON.DOC.003610	Aquatic Site Sampling Design – NEON Domain 11
12	NEON.DOC.003611	Aquatic Site Sampling Design – NEON Domain 12
13	NEON.DOC.003612	Aquatic Site Sampling Design – NEON Domain 13
14	NEON.DOC.003613	Aquatic Site Sampling Design – NEON Domain 14
15	NEON.DOC.003614	Aquatic Site Sampling Design – NEON Domain 15
16	NEON.DOC.003615	Aquatic Site Sampling Design – NEON Domain 16
17	NEON.DOC.003616	Aquatic Site Sampling Design – NEON Domain 17
18	NEON.DOC.003617	Aquatic Site Sampling Design – NEON Domain 18
19	NEON.DOC.003618	Aquatic Site Sampling Design – NEON Domain 19

APPENDIX E 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 6. Equipment list – Surface and subsurface (groundwater) water isotope sampling.

Supplier/Item No.	Exact Brand	Description	Purpose	Quan-tity
CDW-G/4452963	Y	Mobile data entry tablet, fully charged and synced before field work	Field data entry	1
Thomas Scientific, Inc./8939D81	Y	60 mL syringe (numbers covered with clear packing tape)	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	1
Thomas Scientific, Inc./1227H00 Fisher Scientific Company, LLC/14823220	Y	5 mL syringe (numbers covered with clear packing tape)	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	6
GB08760000	Y	Vacuum-pump filter manifold assembly, pre-made	Filtering samples	1
Part of GB08760000	Y	Filter Unit and 25 mm, 200 mL funnel (Part #: 0341440000)	Filtering samples – part of filter manifold assembly	1
Part of GB08760000	Y	1 L Polypropylene vacuum flask (Part #: 0341520000)	Filtering samples – part of filter manifold assembly	1
Part of GB08760000	Y	2 L Polypropylene vacuum flask (Part #: 0342980000)	Filtering samples – part of filter manifold assembly	
Amazon Capital Services, Inc. /MV8510	Y	Vacuum hand pump – back up to filtering manifold, metal handle	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	1
Amazon Capital Services, Inc./MVM8900	Y	Vacuum Hand Pump replacement parts	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	1
Fisher Scientific Company, LLC/975350	N	Filter forceps (flat ends)	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	1

Supplier/Item No.	Exact Brand	Description	Purpose	Quan-tity
Fisher Scientific Company, LLC/300742	N	Graduated cylinder, 250mL	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	1
Cole-Parmer/EW0608953 Fisher Scientific Company, LLC/0343814B Thomas Scientific, Inc./1212W94	N	Collection jug, 4L	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	1 per station
Consumable items				
Fisher Scientific Company, LLC/033433G Thomas Scientific, Inc./1231B94	Y	Vial, 16 mL, 21 Dia. x 73 mm H., Black Phenolic Cap, 14B Rubber Liner Material, Clear, Glass; VWR or Equivalent	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	1
Fisher Scientific Company, LLC/9719006	Y	Syringe Filter, non-sterile, nylon, 0.2 µm pore size, 33 mm diameter	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	1* per station
Fisher Scientific Company, LLC/1337412	N	Plastic Paraffin film (e.g., Parafilm)	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	As needed
Fisher Scientific Company, LLC/987464	Y	GF/F filters (25 mm diameter, pre-ashed)	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	2 per station
Grainger, W.W./6CHG5	N	Aluminum foil squares (~4” X 4”)	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	2
Grainger, W.W./5NHH1 Amazon Capital Services Inc./B00006IBUV Arrow SameDay/5520	Y	Isotope waterproof labels (1” x 2 $^{5}/_{8}$”), pre-printed adhesive labels	Labeling samples, human readable	As needed
	Y	Adhesive barcode labels (Type I)	Labeling sample bottles with barcode-readable	1 sheet

Supplier/Item No.	Exact Brand	Description	Purpose	Quantity
Amazon Capital Services Inc./ B00006IFI3	Y	Permanent markers	Labeling samples	1

* May require more than 1 per sample in turbid waters

Table 7. Equipment list – Additional equipment and consumables for surface water isotope sampling in lakes and rivers.

Supplier/Item No.	Exact Brand	Description	Purpose	Quantity
Fisher Scientific Company, LLC/EW0548610	Y	Kemmerer sampler	Collecting samples	1
Thomas Scientific, Inc./1207W05 Cole-Parmer/EW0640776 Fisher Scientific Company, LLC/14171212	Y	Tubing (1/8” ID)	Sample transfer from Kemmerer to syringe for H_2O sample	1
	N	Ice auger	Drilling a hole in the ice	1
	N	Boat		1
Amazon Capital Services Inc./B003ZZG5EM	N	Anchor with rope		2
	N	Oars		2
West Marine Products, Inc./13487178	N	Trolling Electric Motor		1
Grainger, W.W./2UKJ5	N	Battery (12 volt)		1
Amazon Capital Services Inc./B003QKQ4V0	N	Safety kit for boat (e.g., flares, bailer, float with rope)		1

Supplier/Item No.	Exact Brand	Description	Purpose	Quan-tity
	N	Personal Flotation Devices (PFDs)		1 per person
	N	Waders or boots		1 pair per person

Table 8. Equipment list – Additional equipment and consumables for sampling isotopes in groundwater.

Supplier/Item No.	Exact Brand	Description	Purpose	Quantity
In-Situ, Inc./73310	Y	Water level tape	Measuring water level	1
Uline/S-7914	N	Clean 5 gallon bucket	Pumping sample water	1
Cole-Parmer/EW0608953 Fisher Scientific Company, LLC/0343814B Thomas Scientific, Inc./1212W94	N	4-L jug	Collecting sample water	1 per well sampled
QED Environmental Systems/MPSP4P	Y	QED Sample Pro Pump	Pumping sample water	1
QED Environmental Systems/MP50	Y	QED MP-50 Compressor / Controller	Pumping sample water	1
	N	Key	Unlocking well	1
Grainger, W.W./2UKJ5	N	Battery (12V, minimum of 3.6 Ah)	Pumping sample water	2*
QED Environmental Systems/DTTP4B	Y	Bucket of ¼" x ¼" dual bonded tubing (250 feet of tubing in each bucket). Tubing will be dedicated per each well for the duration of the sampling events.	Pumping sample water	1 per site, required for 1st sampling event.
QED Environmental Systems/DTTP4B	Y	Dedicated tubing for wells (in 1-gallon bags). Make sure to get	Pumping sample water	1 dedicated piece of

Supplier/Item No.	Exact Brand	Description	Purpose	Quantity
		the tubing identified for the well that will be sampled. The sealable bags shall be labeled with the Well ID.		tubing per well sampled (after 1st sampling event)

*Always take Extra batteries into field

Table 9. Equipment list – Sample field storage, lab processing, and shipping.

Supplier/ Item No.	Exact Brand	Description	Purpose	Quan-tity
	N	Cooler	Transporting sampling back to the lab for processing	1
	N	Squirt bottle	Rinsing filtration unit with DI	1
Thomas Scientific, Inc./1229N43	Y	Drying oven	Drying samples	1
Consumable items				
	N	Cardboard box	Shipping H_2O Glass Vials and POM samples	As needed
	N	Packing material	Filling up extra space and adding absorbent material	As needed
Grainger, W.W./5LH30	N	Resealable plastic bags (gallon and quart size)	Separately enclosing the shipping labels, ice packs and samples	1
Fisher Scientific Company, LLC./3532100	N	Ice or ice packs	Keeping the samples cool in field	As needed
Grainger, W.W./15F814	N	Clear Packing tape, roll	Labeling shipment	1
	N	Shipping labels	Labeling shipment and cooler return	2
	N	DI water	rinsing during filtration of POM samples	1 lb.