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APPENDIX A:

Rapid Assessment of Marsh Sites SOP

Added to QAPP: March 2025

Rapid Assessment of Marsh Sites SOP

Background

Rapid assessments of marsh sites are carried out for a variety of purposes, including gathering information to provide technical assistance to partners, or assessing sites as potential restoration targets. While the details of the rapid assessment may vary slightly based on the purpose, the general goal is to determine if a site merits additional data collection for planning restoration or long-term monitoring. Rapid assessments consist of a Desktop Assessment somtimes followed by a Rapid Field Assessment and are done without a formal SAP.

Desktop Assessment

A desktop assessment utilizes existing and readily available remote sensing data via GIS, Google Earth, and similar tools to inform assessment and monitoring activities, and inform where to invest staff and resources for further work. Desktop assessment may be carried out with or without rapid field assessments. Initial summary information is recorded on a data sheet (Appendix A) and electronic data (typically geospatial data) gathered during the desktop assessment, if any, are stored in a site-specific folder on CBEP computers or servers, along with related data documentation.

Information sources consulted as part of a desktop assessment may include

- General Geographic Data
- Vertical Control Points
- Supplementary Geospatial Data

General Geographic Data

The following data is available via review of readily available on-line sources of geographic data and aerial imagery, such as the Maine Office of GIS (MeGIS) and Google Earth.

- Location
- Wetland boundary and area
- Ownership and parcel information
- Narrative description of adjacent land use
- Characterization of anthropogenic impacts to the marsh, such as number of visible structures on the marsh (roads, berms, dams, etc.)
- Visual indicators of impact of tidal barriers, such as scour pools in tidal channels.
- Presence of utilities (power lines, sewer lines), especially at road crossing
- Houses, freshwater wells or other infrastructure located on or near the marsh that may face potential flood or other risks if site hydrology changes.

Note: location information in Google Earth is provided in unprojected geographic coordinates (latitude and Longitude), based on a WGS84 datum. Reprojection is necessary to incorporate this with data from MeGIS. Historically, MeGIS has provided data principally in UTM coordinates (Zone 19 North) / NAD83, but some data layers (especially raster and image data) use other coordinate systems. Automatic reprojection by ArcGIS provides sufficient accuracy for visual inspection and rapid assessment.

Vertical control points ("benchmarks")

The ability to tie local elevations to a consistent vertical datum (NAVD 88) is often important for site assessment, restoration design, hydrological modelling, assessment of potential impacts of sea level rise, and for other purposes.

In general, CBEP will not establish a vertical control point to support rapid site assessments. CBEP will always establish vertical controls to support (1) planning of habitat restoration projects that involve alteration of hydrology, and (2) long-term monitoring. For other purposes, CBEP staff will assess whether the need for accurate vertical controls justifies the cost.

Wherever possible, CBEP makes use of existing, nearby benchmarks and transfers vertical control to a semi-permanent benchmark near the monitoring location (e.g., on a structure or bedrock adjacent to the marsh.) CBEP reviews several sources of information in order to determine whether existing benchmarks are available near field sites. These include:

- National Geodetic Survey Web Map: https://noaa.maps.arcgis.com/apps/webappviewer/index.html?id=190385f9aadb4cf1b0dd8759893032db
- MEDOT Survey Control Points: https://mdotapps.maine.gov/dataviewer/?app=survey
- Correspondence with Maine Geological Survey

Determination of whether an existing benchmark can be used depends on its location, topography, and other factors. CBEP staff will only use an existing benchmark to establish a semi-permanent benchmark (1) if it is within 150 m / 500 ft of the marsh surface and (2) the benchmark can be used directly, or a working benchmark established adjacent to the marsh using no more than two turning points.

Where suitable vertical control points are not available, vertical controls will be established by (1) hiring a qualified surveyor to establish a benchmark, or (2) estimating elevations of a semi-permanent benchmark using RTK GPS technologies.

When existing benchmarks are not available, and project purpose does not justify the expense of establishing a new local benchmark, CBEP uses approximate methods to estimate vertical elevations. Elevations may be estimated by:

1. Using available LIDAR data.
2. Matching elevation of tidal waters at the peak of a spring tide to predicted tidal elevations for the same spring tide at the Portland Tide Station.

Nominal accuracy of existing LIDAR data (~ 16.5 cm RMSE) limits value of Method 1 for all but preliminary investigations. Methods 2 can achieve better accuracy, although quantitative estimates of accuracy are unavailable. Methods 2 is well suited to sites with unimpeded tidal flow from open water but can be misleading when applied far up a tidal creek or above tidal restrictions.

Supplementary Geospatial Data

Additional online geographic data provides supplementary insight into site characteristics. CBEP staff regularly reviews the following sources when developing narrative site descriptions:

- Maine Stream Habitat Viewer (Maine Coastal Program): presence of documented fish barriers and associated data; presence of priority fish habitats; tidal marsh area. https://www.maine.gov/ifw/fish-wildlife/wildlife/beginning-with-habitat/maps/maine-stream-habitat-viewer.html
- Historic USGS map research: http://docs.unh.edu/nhtopos/nhtopos.htm
- Maine Geological Survey Sea Level Rise/Storm Surge maps: http://www.maine.gov/dacf/mgs/hazards/slr_ss/index.shtml
- Maine Tidal Restriction Atlas: presence of current and predicted restrictions to tidal flow associated, as well as marsh migration corridors, associated with different sea level rise scenarios. http://www.maine.gov/dmr/programs/maine-coastal-program/habitat-restoration-tools/tidal-restriction-atlas
- An abbreviated literature review will be conducted, to obtain and review relevant knowledge about a site. Typical sources include:
- Geomorphology and the effects of sea level rise on tidal marshes in Casco Bay (Bohlen et al 2012)
- Land Use Planning for Sea Level Rise: A Report for Planners in Casco Bay Area Communities (Bohlen et al 2013)
- Maine Tidal Restriction Database (Bartow-Gillies et al 2020)
- Casco Bay Watershed Fish Barrier Priorities Atlas (CBEP 2012)
- Correspondence with Maine Natural Areas Program, Maine Department of Transportation, or other state agencies
- Local historic societies
- Web search based on local place names

Rapid Field Assessment

A rapid field assessment provides general information for planning purposes. Rapid assessments are designed to be flexible, and responsive to site-specific and project-specific needs. Typical rapid field assessments include documentation of site surroundings, presence of tidal restrictions or other structures on the marsh, interpretation of geomorphology, informal observation of site hydrology, and documentation of general vegetation characteristics.

The basis of a rapid assessment is one or more site visits during which CBEP staff walk a site, making qualitative observations, supplemented by digital photographs. A rough plan for the site visit (identifying important locations or features of the marsh to examine) is developed in advance based on available information, including results of a Desktop Assessment, if any. The plan may be modified in the field based on site conditions or observations.

Limited field equipment (e.g., soil augers, refractometers, tape measures, consumer-grade GPS receivers) may be brought along to facilitate site characterization.

Location of Observations

Approximate location of field observations is recorded, but the method varies. They may be recorded as a narrative description (e.g., "just south of the big pine on the east side of the marsh"), by marking approximate locations on a pre-printed paper map, recorded using consumer-grade GPS receivers, or by a combination of these methods.

General Observations

While walking a site, CBEP staff record general observations that place other observations into context, and relating field observations to a Desktop Assessment, if one was carried out. Typically, these observations address large-scale questions about the marsh, such as how the site is being used by fish, birds, and wildlife; potential human impacts to the marsh; geomorphological characteristics such as sediment characteristics or topography; or characteristics of the vegetation, such as presence of invasive *Phragmites*.

These observations often include measured or estimated numerical data, such as depth of a tidal channel, surface water salinity, width of a vegetation zone, height of a plant, or area of a tidal pool. Estimated values are labeled as estimates; methods used for measuring values are described in the notes where they are not clear from context.

Hand-drawn maps

General observations may be supplemented by sketch maps that clarify spatial relationships among features on the marsh. Maps are not drawn to scale, but observations may be roughly georeferenced using GIS after returning to the office.

Assessment of anthropogenic structures

Where structures like roads or dikes cross the marsh, notes are taken on characteristics of the structure, such as width, height, and construction material. Values may be measured with tape measures, stadia rods, meter stick, etc., or estimated. Estimated values are labeled as estimates.

Surface Water Salinity

Spot checks of surface water salinity are helpful in understanding site hydrodynamics. Spot checks are made using refractometers, in parts per thousand. Location of spot checks are recorded in the field notes.

Soil and Sediment Characteristics

Characteristics of the sediments are assessed informally. Soils and sediments are accessed by (1) Collecting samples with a soil auger, or (2) observing sediment along existing channel banks. Soils are evaluated with attention to vertical structure (“horizons”), but typically without measuring the thickness of each horizon. Soils and sediments are described qualitatively based on examination of samples. Descriptions of soil layers may include reference to texture (sandy / silty / clay); moisture content (saturated / wet / moist / dry); presence of organic matter (high organic matter / low organic matter / staining); presence of organic inclusions like roots, vegetation or wood; and color (matrix color and mottles).

If higher accuracy data on sediment condition is deemed useful, soils will be collected by digging a soil test pit or with a sediment probe, Russian corer or similar sampling equipment that minimizes sample compression. Thickness of sediment horizons can then be measured with a meter stick or tape measure. Colors will be recorded using a Munsell color chart.

Soil Probes

Soil probes are used to support rapid assessment of tidal marshes, particularly locating, mapping, and surveying historic agricultural features in tidal marshes that are no longer evident on the marsh surface. A typical soil probe has a ½" diameter solid fiberglass shaft that is 4' long with a T-grip handle and a corrosion-resistant metal tip. The probe is typically used in conjunction with a GPS unit and a fold rule, along with a field notebook.

There is an art to using soil probes and effectiveness builds with experience. The shaft is pushed down vertically into the marsh surface to provide qualitative information about subsurface features based on the resistance encountered. When possible, the survey should begin by pushing the probe into a section of marsh that is only comprised of peat, to establish a baseline against which to compare resistance of other features. In using the soil probe, the typical objective is to field verify one of the following agricultural features that modify surface hydrology and contribute to marsh subsidence and must be factored into restoration design:

- Presence of remnant ditches (subterranean ditch voids): Ditches that are not visible on the marsh surface or through analysis of aerial imagery. Subterranean ditch voids typically occur where marshes were over-drained by agricultural ditching. A ditch void is evidenced by the sudden lack of resistance while applying steady pressure to the T-bar in pushing the probe downward.
- Presence of hard structures below the marsh surface, typically installed to control the movement of water into a section of marsh. Hard structures typically were built from wood and/or rock. The presence of hard structures is evidenced by a sudden hard refusal while applying steady pressure to the T-bar in pushing the probe downward. Subtle vibrations can be detected by hand as the probe tip strikes a hard structure and used to ascertain whether the structure is rock or wood. Generally, a rock structure will provide a vibration that is stronger than when the tip strikes wood.
- Presence of clay embankments. Less frequently, soil probes can be used to detect the presence of clay within an embankment. This can be important because the presence of clay has a significant effect on subsurface water movement. Clay embankments are thought to be uncommon, but occasionally used, in this part of Maine. When surveying for clay embankments, it is important to calibrate resistance manually by working the probe into a known peat layer, if possible, as well as into a known clay layer, to feel the difference immediately prior to a survey. The presence of clay within an embankment is evidenced by a greater level of pressure needed on the T-bar to push the probe down into the marsh. A thick layer of clay will require increased pressure to continue moving downward. Sometimes, a vacuum is encountered, and it becomes difficult to withdraw the probe from a layer of clay.

Soil probes are used with fold rules to identify the depth of detected features below the surface, as well as to measure the peat thickness above the feature. Accompanying geospatial data is collected to document the locations. Observers will record descriptive data into a rapid assessment data sheet or field notebook along with accompanying and geospatial information.

Vegetation

On larger sites, documentation of characteristics of the vegetation, as well as longitudinal and lateral patterns of vegetation can provide insight into processes influencing marsh condition. Vegetation species of concerns (e.g., invasive species, monospecific cattail stands) will be noted and may be indicated on hand drawn maps if appropriate.

During rapid field assessments, CBEP uses a simplified "relevé" method to characterize vegetation in terms of dominant and conspicuous plant species. Sample locations are selected in the field (often informed by prior Desktop Analysis) and are not randomly located. They are selected to be representative of vegetation zones or transitions between them, as described in the field notes. Zones often include salt marsh, brackish marsh, and freshwater swamp, but other divisions may be appropriate based on-site characteristics.

The observer stands at one location (recorded in the notes, marked on the site map, or recorded via GPS), records all plant species readily observed in adjacent vegetation, and adds a measure of relative abundance for each (using percent cover estimates or Braun-Blanquet cover classes). The area observed is not formally defined (hence this is a "plotless" method), but left up to the judgement of the observer. In herbaceous wetlands, the area sampled will typically be under 3 meters in diameter, while in forested wetlands the implicitly sampled area may be 20 m or more in diameter. Vegetation data is always supplemented by one or more photographs.

Sampling and Analysis Plans

If a rapid assessment indicates that restoration is warranted or that collecting more in-depth information may be beneficial to understanding dynamics at a site, then a Sampling and Analysis Plan (SAP) will be developed prior to further data collection. Under an SAP, data collection will occur at pre-selected (not random) locations, but otherwise adhere to methods described in this QAPP for data collection during baseline site characterization or long-term monitoring. Site locations and further details will be provided in SAPs.

Sample Handling, Data Management and Analytic Methods

Formal samples are not collected during rapid site assessments. Any informal samples (e.g., soil samples, plant material used to identify plant species in the lab) are discarded.
A variety of recording methods may be used, including use of a field notebook, data sheets, voice recorder, or loose-leaf paper on a clipboard. All primary field records are dated, transcribed if necessary, and archived. Electronic records, including photographs, are stored in a site-specific electronic folder on CBEP computers or servers.
The primary products of a rapid field assessment are the raw field notes themselves and improved staff understanding of site conditions. For sites considered more important, or when results of the rapid assessment will be shared with Partners, CBEP staff prepares a narrative site description, summarizing observations and preliminary interpretations of those observations. Interpretation of observations is qualitative, with little or no analysis of numeric data. When data analysis occurs, it emphasizes graphical methods and mapping to facilitate understanding of site condition.

APPENDIX B:
Rapid Assessment of Eelgrass Sites SOP

Added to QAPP: March 2025

Rapid Assessment of Eelgrass Sites SOP

Background

Rapid assessments of eelgrass sites are carried out for a variety of reasons including evaluating condition of a newly discovered bed, assessing possible causes of decline, assessing a site as a potential restoration target, or gathering information to provide technical assistance to partners. The details of a rapid assessment may vary slightly based on bed condition and the purpose of the assessment, the general goal is to determine if a site merits additional data collection or long-term monitoring. Rapid assessments consist of the collection of site information followed by a field visit.

Site Information

The first step in a rapid assessment is to collect basic information on a site that will provide context for a field visit and information on how to safely access the bed. This information includes:

- Historic presence of eelgrass (based on GIS layers from state mapping efforts)
- Possible threats to water quality in the region
- Site access and waterfront ownership
- Potential safety concerns for a field visit (currents, known shark sightings, etc.)

This information can be readily collected through online sources and conversations with partners. Map layers of historical eelgrass extent are available through the Maine Office of GIS web app (ttps://maine.maps.arcgis.com). Water quality threats and safety concerns are evaluated through conversations with partners familiar with the site of interest, including Maine DEP, Friends of Casco Bay, and local shellfish farmers and harvesters. Waterfront ownership and access for walk-in sites is assessed from property records.

Rapid Field Assessment

If the collected site information indicates that a field visit is warranted, possible, and safe, then one will be scheduled. Field visits are ideally scheduled during daylight hours during astronomically low tides. Low tides are particularly important for walk-in sites in order to be able to observe the eelgrass bed. For sites that must be accessed by kayaking, boating, snorkeling, or SCUBA, low tides are still preferred but are less essential. In the case of sites requiring boat access, the timing and tidal height at the visit is constrained by the boat draft. A site access plan is developed in advance of the visit based on tidal predictions and site access restrictions. This plan will include an ideal time of site visit, including a cut-off time by which the assessment must be completed. This cut-off time may be based on the flood tide covering the bed and reducing visibility, the ebb tide falling below the boat draft, loss of daylight, predicted current or weather changes, or other factors restrict site access or lead to safety concerns.

Typical rapid field assessments include documentation of site surroundings, the extent and condition of eelgrass present at the site, potential disturbances to eelgrass, informal assessment of water and environmental conditions at the site. During a rapid assessment, CBEP staff will access a site and make qualitative observations, supported by digital photographs if water conditions allow. A rough plan for the site visit, identifying areas of the bed to visit (dense vs. patchy areas, shallow vs. deep edges) or stressors to look for, is developed in advance based on historical map layers, local knowledge, and the results of the site information search. The plan may be modified in the field based on site conditions or observations. Limited field equipment may be brought along to facilitate site characterization, including a water quality probe, bottles for grab samples, rulers, handheld GPS, underwater camera, waterproof paper, and snorkel or SCUBA gear.

Location of Observations

Approximate location of field observations is recorded, but the method varies depending on the means of site access. They may be recorded as a narrative description (e.g., "standing on the big flat rock to the left of the dock"), by marking approximate locations on a pre-printed paper map, recorded using a handheld or boat mounted GPS, or a combination of these methods.

General Observations

While visiting a site, CBEP staff record general observations that place other observations into context. Typically, these observations address large-scale questions about the eelgrass beds, such as the general condition of the bed, level of fouling, sediment characteristics, potential disturbances such as sediment plumes, algae blooms, or disturbed substrates, and exposure to wave and wind energy.

These observations often include measured or estimated numerical data, such as bed area. Estimated values are labeled as estimates; methods used for measuring values are described is notes associated with the recorded data.

Hand-drawn maps

General observations may be supplemented by sketch maps that clarify spatial relationships between areas of the eelgrass bed, potential sources of disturbance, and shore features. Maps are not drawn to scale, but observations may be roughly georeferenced using GIS after returning to the office.

Assessment of anthropogenic structures

Where structures like docks, piers, pipes, and mooring fields are present, notes are taken on the characteristics of the structures and the condition of eelgrass adjacent to the structure. Distance from structures to features of the eelgrass bed may be measured with tape measures, meter stick, etc., or estimated. Estimated values are labeled as estimates.

Eelgrass metrics

Eelgrass metrics are the values typically measured as part of a routine assessment of eelgrass density. During a rapid assessment these metrics are measured in randomly chosen areas in different regions of the bed (shallow vs deep, central vs fringe). These metrics include shoot density/m^2, % cover of eelgrass, % cover of macroalgae, and canopy height. These values may be measured directly using a quadrat and meter stick or may be estimated based on visual observation. Estimated values are labeled as estimates.

Eelgrass phenology

Eelgrass phenology is the observation of the reproductive status of eelgrass. It can be scored qualitatively as the presence/absence of reproduction, or quantitatively as the reproductive stage and density of reproductive shoots. Documentation of phenology during rapid assessments will be primarily qualitative, noting the presence/absence of reproductive shoots, but may involve scoring the observed shoots following standard methods (Carr and Colarusso, 2023). More quantitative assessments of eelgrass phenology at a site will only be done during a rapid assessment if a site is being assessed primarily as a donor bed for seed collections. In this case, the sampling protocol laid out in Carr and Colarusso (2023) will be followed, but will only be conducted once, instead of every other week as described in the protocol.

Water quality

Rapid assessment of water quality in an eelgrass bed consists of one-time collection of the standard suite of water quality parameters. The exact parameters collected will be dependent on the equipment that is available for the rapid assessment. Water quality rapid assessment may consist of sampling a single point in the water column or a depth profile throughout the water column (depending on tide and equipment) and will collect readings on some or all of the following parameters: temperature, depth, salinity, dissolved oxygen, pH, turbidity, and chlorophyll a.

Light conditions

Two methods can be used in rapid assessment of light conditions. The first is collection of light data throughout the water column through use of a LI-COR Underwater Quantum Sensor, which is lowered through the water to measure PAR (photosynthetically active radiation) at different depths. From this light profile we can calculate the light attenuation coefficient (Kd) using the formula below.

$$K_{d(z,\lambda)} = -\frac{1}{E_{d(\lambda)}}\frac{dE_d}{dz}$$

$K_d(z,\lambda)$ = attenuation coefficient
$E_d(\lambda)$ = downwelling irradiance
dE_d = differential in downwelling irradiance between two depths
dz = difference between two depths

Kd is a measure of light propagation through the water column. A higher Kd value means light is attenuated more quickly, therefore less light is reaching a given depth. For rapid assessments, 1 – 3 light profiles will be taken at a site on a clear day to enable calculation of Kd.

The other method that may be employed in a rapid assessment of light at an eelgrass site is a short-term (< 1 month) deployment of a light sensor in the eelgrass canopy. HOBO Pendant MX temperature/light data loggers are typically used for these deployments, although other sensors may be used instead depending on equipment availability. These sensors are manufacturer calibrated and then are initiated and deployed following manufacturer recommendations. They are attached to a semi-permanent structure (PVC pipe or screw anchor) so they are at the top of the eelgrass canopy. One sensor will be deployed in an eelgrass patch at the average depth of the bed. If the sensor is deployed for >2 weeks, it will be maintained on a biweekly basis until retrieval. Upon retrieval, data is downloaded from the sensor for analysis.

Sediment characteristics

Sediment characteristics can provide important information about wave energy at a site and allow us to make inferences about eelgrass rooting depth and presence of burrowing faunal species. Characterization of sediment during a rapid assessment will be done qualitatively, recording observations of grain size, presence of burrows, and sediment appearance and small to provide information on redox conditions and organic matter content. Sediment observations will be supported by photographs where possible.

Sampling and Analysis Plans

If a rapid assessment indicates that restoration is warranted or that collecting more in-depth information may be beneficial to understanding dynamics at a site, then a Sampling and Analysis Plan (SAP) will be developed prior to further data collection. Under an SAP, data collection will occur at pre-selected (not random) locations, but otherwise adhere to methods described in this QAPP for data collection during baseline site characterization or long-term monitoring. Site locations and further details will be provided in SAPs.

Sample Handling, Data Management and Analytic Methods

Formal samples are not collected during rapid site assessments. Any informal samples (e.g., reproductive shoots, soil samples) are discarded.

A variety of recording methods may be used, including use of a field notebook, data sheets, voice recorder, underwater video, or loose-leaf paper on a clipboard. All primary field records are dated, transcribed if necessary, and archived. Electronic records, including photographs and downloads from data loggers, are stored in a site-specific electronic folder on CBEP computers or servers.

The primary products of a rapid field assessment are the raw field notes themselves and improved staff understanding of site conditions. For sites considered more important, or when results of the rapid assessment will be shared with partners, CBEP staff prepares a narrative site description, summarizing observations and preliminary interpretations of those observations. Interpretation of observations is qualitative, with little or no analysis of numeric data. When data analysis occurs, it emphasizes graphical methods, summary statistics, and mapping to facilitate understanding of site condition.

APPENDIX C:
Rapid Assessment of Water Quality SOP

Added to QAPP: March 2025

Rapid Assessment of Water Quality SOP

Background

Rapid assessments of water quality in a water body are carried out for a variety of reasons including evaluating condition of a water body near a disturbance or location of new development, assessing possible causes of decline, assessing a site as a potential restoration target, or gathering information to provide technical assistance to partners. The details of a rapid assessment may vary slightly based on bed condition and the purpose of the assessment, the general goal is to determine if a site merits additional data collection or long-term monitoring. Rapid assessments consist of the collection of site information followed by a field visit.

Site Information

The first step in a rapid assessment is to collect basic information on a site that will provide context for a field visit and information on how to safely access the water body. This information includes:

- Location
- Possible threats to water quality in the region
- Site access
- Waterfront ownership and parcel information
- Potential safety concerns for a field visit
- Narrative description of adjacent land use
- Characterization of anthropogenic impacts to the water body, such as sewer outflows and shoreline development

This information can be readily collected through online sources and conversations with partners. Waterfront ownership and access for sites is assessed from property records. CBEP maintains a map of active combined sewer overflows in the Casco Bay watershed, and other anthropogenic impacts and structures can generally be assessed using Google Earth. Water quality threats and safety concerns are evaluated through conversations with partners familiar with the sites of interest, including Maine DEP, the Volunteer River Monitoring Program, Lake Stewards of Maine, Lakes Environmental Association, Friends of Casco Bay, local land trusts and conservation groups,

Rapid Field Assessment

If the collected site information indicates that a field visit is warranted, possible, and safe, then one will be scheduled. Timing of the visit is dependent on project goals and access restrictions. In the case of sites requiring boat access, the timing and tidal height at the visit is constrained by the boat draft. A site access plan is developed in advance of the visit based on tidal predictions and site access restrictions. This plan will include an ideal time of site visit, and may include a cut-off time by which the assessment must be completed.

Typical rapid field assessments include documentation of site surroundings, any observable water quality impairments (surface scum, sediment plumes, algae blooms), documentation of observed flora and fauna, and documentation of structures, construction, or other nearby disturbances. During a rapid assessment, CBEP staff will access a site and make qualitative observations, supported by digital photographs if conditions allow. A rough plan for the site visit, identifying areas of the water body or stressors to look for, is developed in advance based on historical map layers, local knowledge, and the results of the site information search. The plan may be modified in the field based on site conditions or observations. Limited field equipment may be brought along to facilitate site characterization, including a water quality probe, a Secchi disk, rulers, handheld GPS, underwater camera, waterproof paper, and snorkel gear.

Location of Observations

Approximate location of field observations is recorded, but the method varies depending on the means of site access. They may be recorded as a narrative description (e.g., "standing on the big flat rock to the left of the dock"), by marking approximate locations on a pre-printed paper map, recorded using a handheld or boat mounted GPS, or a combination of these methods.

General Observations

While visiting a site, CBEP staff record general observations that place other observations into context. Typically, these observations address large-scale questions about the quality of a water body, such as the presence of harmful algal blooms, sediment plumes, flow restrictions, or discharges.

These observations often include measured or estimated numerical data. Estimated values are labeled as estimates; methods used for measuring values are described is notes associated with the recorded data.

Hand-drawn maps

General observations may be supplemented by sketch maps that clarify spatial relationships between areas water body features, potential sources of disturbance, and shore features. Maps are not drawn to scale, but observations may be roughly georeferenced using GIS after returning to the office.

Assessment of anthropogenic structures

Where structures like docks, piers, seawalls, pipes, and mooring fields are present, notes are taken on the characteristics of the structures and any observations adjacent to the structure. A water quality probe may be used to measure water quality parameters in relation to the structures. Estimated values are labeled as estimates.

Measurement of field parameters

Rapid assessment of water quality consists of one-time collection of the standard suite of water quality parameters. The exact parameters collected will be dependent on the equipment that is available for the rapid assessment and site-specific questions. Water quality rapid assessment may consist of sampling a single point in the water column or a depth profile throughout the water column (depending on water body, tide, and equipment) and will collect readings on some or all of the following parameters: temperature, depth, conductivity/salinity, dissolved oxygen, pH, turbidity, and chlorophyll a. Parameters may be assessed using digital water quality probes and sensors, or manual methods such as a refractometer (salinity) or Secchi disk (turbidity). The method used to measure parameters will be noted on the rapid assessment data sheet.

Sediment characteristics

Sediment characteristics can provide important information about water or wave energy at a site. Characterization of sediment during a rapid assessment will be done qualitatively, recording observations of grain size, and sediment appearance and small to provide information on redox conditions and organic matter content. Sediment observations will be supported by photographs where possible.

Sampling and Analysis Plans

If a rapid assessment indicates that restoration is warranted or that collecting more in-depth information may be beneficial to understanding dynamics at a site, then a Sampling and Analysis Plan (SAP) will be developed prior to further data collection. Under an SAP, data collection will occur at pre-selected (not random) locations, but otherwise adhere to methods described in this QAPP for data collection during baseline site characterization or long-term monitoring. Site locations and further details will be provided in SAPs.

Sample Handling, Data Management and Analytic Methods

Formal samples are not collected during rapid site assessments. Any informal samples (e.g., water or soil samples) are discarded. A variety of recording methods may be used, including use of a field notebook, data sheets, voice recorder, underwater video, or loose-leaf paper on a clipboard. All primary field records are dated, transcribed if necessary, and archived. Electronic records, including photographs and downloads from data loggers, are stored in a site-specific electronic folder on CBEP computers or servers.

The primary products of a rapid field assessment are the raw field notes themselves and improved staff understanding of site conditions. For sites considered more important, or when results of the rapid assessment will be shared with partners, CBEP staff prepares a narrative site description, summarizing observations and preliminary interpretations of those observations. Interpretation of observations is qualitative, with little or no analysis of numeric data. When data analysis occurs, it emphasizes graphical methods, summary statistics, and mapping to facilitate understanding of site condition.

APPENDIX D:
Discrete Water Quality SOP

Added to QAPP: March 2025

Discrete Water Quality SOP

Goal

Water quality parameters can be informative for a wide array of questions, including understanding the abiotic stressors in a system, the suitability of a habitat for flora and fauna, and the responses of a site to restoration activities. Collection of discrete water quality measures can be useful for capturing "snapshots" of water quality and allow for analysis of baseline conditions and detection of long-term trends, if samples are regularly collected over an extended time period. The goals of measuring water quality are very project-dependent

Sampling Design

Water quality can be assessed through the measurement a suite of parameters, and the definition of "water quality" is dependent upon the question being asked. One common method is the use of probes to take discrete readings of important parameters. Other parameters are measured through the collection of grab samples for analysis in a lab. Common parameters assessed as part of water quality sampling include:

- Temperature
- Dissolved oxygen
- Dissolved oxygen % saturation
- Specific conductance/conductivity
- Total dissolved solids
- Salinity
- Water depth
- pH
- Total alkalinity
- Turbidity
- Secchi Depth
- Chlorophyll fluorescence
- Nutrient concentrations
- Bacteria (*E. coli, Enterococcus*, or Fecal Coliform)

The exact list of parameters sampled as part of a project is dependent upon the goals of the project, the type of site (freshwater, brackish, or marine) and the available equipment. All of these details will be provided within the SAP for a given project. Data sheets will also be project specific and included with the SAP given the variety of parameters and equipment that might be used. A list of commonly used equipment and equipment specifications are included at the end of this section. Discrete sampling with a probe can be done by deploying a probe to a set place in the water column (e.g., surface water, mid-water column, bottom), or by taking a profile, where the probe is slowly lowered through the water column and readings are taken at pre-determined depths. Secchi depth is measured by lowering a Secchi disk into the water in a sufficiently deep area until the white and black portions of the disk can no longer be differentiated. Grab samples can be collected from surface water or pre-selected points in the water column using a depth sampler such as a Van Dorn Bottle or Kemmerer sampler. Grab samples are typically used to obtain water samples for lab analysis. CBEP and partners work with a variety of labs for sample analysis, so if a project requires lab analysis, the lab will be identified and lab protocols will be provided in the project SAP.

Sampling locations within a site and sampling frequency are also heavily dependent on project goals. Sampling across multiple sites in the same time period facilitates characterization of spatial variability within a site, while sampling the same site multiple times facilitates characterization of temporal variability.

Discrete water quality sampling in freshwater sites will typically occur in the early daylight hours (prior to 10 AM) to capture potential low dissolved oxygen conditions. Discrete sampling in brackish or marine environments will occur between 9:30 AM and 2:30 PM, but will typically require multiple site visits to characterize site conditions over a range of tides.

Restoration projects will involve sampling within restoration areas and similar locations in nearby reference areas. Long-term monitoring of a waterbody will involve low-frequency multi-year sampling throughout the waterbody. Monitoring the effects of a disturbance will involve high-frequency short-term (<3 years) sampling in a defined area. Sites, sampling locations, sampling frequency, and the reasons for selection of the sampling locations will be detailed in SAPs. For projects where specific sampling sites are identified, sites will be marked by GPS and narrative descriptions will be provided to assist in site location.

Common Equipment

YSI Xylem Pro 2030 – handheld meter
Parameters: dissolved oxygen, salinity, conductivity, specific conductance, total dissolved solids, barometric pressure, temperature
Manual: https://www.ysi.com/File%20Library/Documents/Manuals/605056-YSI-Pro2030-User-Manual-RevC.pdf
Specifications: Dissolved Oxygen % air saturation- 0 to 500% air saturation, Dissolved Oxygen (mg/L)-0 to 50 mg/L, Conductivity-0 to 200 mS/cm, Salinity-0 to 70 ppt, Total Dissolved Solids (TDS)-0 to 100 g/L, TDS constant range .30 to 1.00 (.65 default), Temperature--5 to 55°C, Barometer-500 to 800 mmHg

YSI Exo2 – multiparameter sonde
Parameters: temperature, conductivity, dissolved oxygen, fDOM, chloride, nitrate, pH, ORP, depth, salinity, total dissolved solids, total suspended solids, chlorophyll a
Manual: https://www.ysi.com/File%20Library/Documents/Manuals/EXO-User-Manual-Web.pdf
Specifications: Dissolved Oxygen % air saturation- 0 to 500% air saturation, Dissolved Oxygen (mg/L)-0 to 50 mg/L, Conductivity-0 to 200 mS/cm, Salinity-0 to 70 ppt, Total Suspended Solids (TSS)-0 to 1500 mg/L, TDS constant range 0 to 100,000 mg/L, Temperature--5 to 50°C, Barometer-375 to 825 mmHg, fDOM – 0-300 ppb, Nitrate- 0 – 200 mg/L, pH- 0 -14 units, ORP- -999 to 999 mV, Chlorophyll a 0 to 400 µg/L Chl

SAPs

Sampling and Analysis Plans (SAPs) are site-specific documents that contain information on how protocols will be implemented as part of a set project or at a defined site. SAPs for projects involving water quality sampling must include information on:

- Site

- Sampling locations within site
- Parameters to be collected
- Sampling frequency and duration of monitoring effort
- Additional relevant sampling details (profiles vs discrete samples)
- Equipment to be used, calibration frequency, methods, and equipment specifications (if using equipment other than that described above)
- Lab information and protocols where lab analysis of any grab samples will be done
- Data sheet

Sampling Methods

Sampling typically consists of taking readings at one site over multiple months/years or at multiple sites during the same sampling event depending on if characterizing spatial or temporal variability is more important for project goals. For some projects characterizing both spatial and temporal variability may be important, in which case samples will be taken from multiple sites during multiple sampling events.

In the field, if a sampling site is specified as part of the project, locate the site using a handheld GPS with coordinates pre-loaded, using the narrative description for help if necessary. Given the mobile nature of water, it is not necessary to use benchmarks or site markers to locate the site as long as you are within the same stretch of habitat (e.g., near a sandy bank and not the nearby riffle in a stream).

Upon reaching the correct sampling location, prepare the probe or sonde for deployment and perform any necessary field checks. At each site, a data sheet will be completed, including the site code, date and time. Ancillary weather observations will also be recorded, noting the cloud cover (as a percentage of cover in 25% increments), and wind speed and direction (using the Beaufort Scale and compass degrees). A Secchi depth measurement will be collected and recorded where appropriate. Secchi depth is not typically employed in shallow flowing water, such as streams, but is a useful technique in the deeper waters of lakes and coastal regions.

Secchi depth is determined by using a Secchi Disk. The disk is lowered into the water by technician who is not wearing sunglasses and has the sun behind them. The technician notes the depth (to 0.1 meters) when the disk just disappears from view, continues to lower the disk, then starts to pull the disk back up, noting the depth that the disk just reappears. The Secchi Disk measurement is the average of those two depths if they are different.

Following the Secchi depth reading, prepare equipment. When the equipment is ready for deployment, carefully lower the probe or sonde into the water to the desired depth. Hold the probe/sonde in place until the readings stabilize, which may take up to a minute. Record the readings on the appropriate data sheet, then either remove the probe or lower it to the next desired depth if you are collecting a profile.

If a grab sample is being collected, this should be done following the probe/sonde deployment. Each parameter that requires collection of a grab sample should be collected in a pre-labeled container of the appropriate type and volume. The chart below, adapted from the Maine DEP Volunteer River Monitoring QAPP (2019), provides information on appropriate container types, sample collection volumes and preservation techniques.

Prior to sample collection, triple-rinse each sampling container with water from the site. If a surface water sample is being collected, place the sampling container in the top 0.5m of the water body and allow it to fill to the appropriate volume. If a sample depth sample is being collected, lower the Van Dorn bottle/Kemmerer sampler to the appropriate depth, trigger the closing mechanism, then retrieve the sample and transfer it to the sample container. For techniques that require preservation through acidification/fixation, the fixing agent should be added in the field directly following sample collection. For samples that are preserved via refrigeration or freezing, place them in a cooler with ice while in the field, then transfer to a refrigerator or freezer directly following return from the field. Sample handling and preservation should be noted on chain of custody forms.

Table 1: Sampling and preservation details for water quality parameters obtained from grab samples. Adapted from the Maine DEP VRMP QAPP (2019).

Parameter	Sampling Techniques	Typical Sample Volume*	Sample Container Type* / Preparation	Sample Preservation / Maximum Holding Time*	Analysis Location
Total Kjeldahl Nitrogen	Grab sample	250 ml	Plastic or Glass	Cool, 4°C; H_2SO_4 to pH<2; 28 days (speak with lab about the H_2SO_4 & safety; they may add the acid)	VRMP certified lab
Nitrate or Nitrite	Grab sample	250 ml	Plastic or Glass	Cool, 4°C; 48 hr	VRMP certified lab
Total Phosphorus	Grab sample	55 ml	Plastic or Glass	Cool, 4°C; H_2SO_4 to pH<2; 28 days (speak with lab about the H_2SO_4 & safety; they may add the acid)	VRMP certified lab
Ortho-Phosphate	Grab sample	250 ml	Plastic or Glass	Cool, 4°C; 48 hr	VRMP certified lab
Chloride	Grab sample	250 ml	Plastic or Glass	(Cooling not required); 28 days	VRMP certified lab
Total Suspended Solids	Grab sample	500 ml	Plastic or Glass	Cool, 4°C; 7 days	VRMP certified lab
Suspended Sediment Concentration	Grab sample	500 ml	Plastic or Glass	Cool, 4°C; 7 days	VRMP certified lab
Turbidity	Grab sample	500 ml	Plastic or Glass	Cool, 4°C; 48 hr	VRMP certified lab
Hardness	Grab sample	250 ml (x 2)	Plastic or Glass	Cool, 4°C; HNO_3 to pH<2; 6 months (speak with lab about the HNO_3 & safety)	VRMP certified lab
Alkalinity	Grab sample	250 ml (x 2)	Plastic or Glass	Cool, 4°C; 14 days	VRMP certified lab
Bacteria	Grab sample	100 ml	Sterile Plastic or Glass (e.g., Whirl-pak or new cubitainer)	Cool, < 10°C; 6 hr (Samples must processed within 2 hr of arriving at laboratory.)	VRMP certified lab

Field duplicates will be collected for 10% of all field samples on a given project to ensure accurate measurement of field parameters. Lab duplicates will be run on 10% of grab samples to ensure accurate measurement of lab parameters. The volume of the collected grab sample should be increased accordingly on 10% of grab samples.

Sample Handling and Custody

No field samples are collected for probe/sonde measurements, but all measurements, sampling times, and other site visit and anecdotal observations are recorded on monitoring data sheets. Grab samples are collected from the field, may be transferred to a lab for preservation and short-term storage (<14 days) and then transferred to an analysis lab. Each sample will be tracked using a chain of custody form to note collection date and time, preservation technique and time, transfer times, and required analyses. Data sheets are stored at CBEP. Field data are transferred to a site-specific Excel database.

Detailed sampling methods

Collection of grab samples for bacteria or nutrient sampling will follow the DEP grab sample protocol (Danielson 2014).

Sampling methods using a YSI Pro 2030 are adapted from the VRMP QAPP (Dennis and Feindel 2020). Sampling methods for using a YSI Exo Sonde 2 are adapted from the Friends of Casco Bay QAPP. Reference these documents for additional detail.

Grab Samples

Grab samples are collected for lab analysis of bacteria , pH, total alkalinity, or nutrient concentrations in a body of water.

Sampling methods can be found in (Danielson 2014)

Sampling period and site location information will be documented in SAPs. Some sampling details and preservation techniques will be dependent upon what nutrients/bacteria are being investigated in the water body. Sampling containers will be pre-labeled with the labels below to indicate the type and location of sampling being done. All sampling containers should be triple rinsed with water from the site prior to sampling.

Figure 1: Sampling container label

SITE:____________DATE:___________ TIME:_______SAMPLER INIT.:________ *CIRCLE*: SURFACE BOTTOM TN pH TA Bacteria

Supplies

(1) For water samples:
   (a) Water quality kits from a VRMP-approved laboratory, which include containers specific to parameter(s) measured [see section C (1) below] and preservatives, as required
   (b) Waterproof labels (BE SURE TO STICK ON CONTAINER PRIOR TO SAMPLING)
   (c) VRMP-approved water sampling device, if using OPTION 3 [i.e., sampling from bridges or boats; see section C below]
   (d) VRMP approved laboratory chain of custody sheets
   (e) Permanent marker
   (f) Pencil
(2) Miscellaneous supplies (as needed based on QC criteria and preservation methods)
   (a) Cooler with ice
   (b) Waders
   (c) Gloves
   (d) Personal floatation device (PFD)

(e) Anchor, if sampling from a boat

YSI Pro 2030

This standard operating procedure (SOP) was developed by the Volunteer River Monitoring Program (VRMP) of the Maine Department of Environmental Protection's Division of Environmental Assessment to apply to the collection of dissolved oxygen (DO), temperature, specific conductance, and salinity from rivers and streams in Maine using the YSI Pro2030 handheld meter. We have adapted it slightly to make it more relevant to CBEP's work.

This purpose of this protocol is to provide standardized methods for groups to determine temperature, dissolved oxygen, specific conductance, TDS (Total Dissolved Solids), and salinity of rivers and streams as an instantaneous reading using the YSI Pro 2030 handheld meter.

Manual for the YSI Pro 2030 handheld meter can be found here
https://www.ysi.com/file%20library/documents/manuals/605056-ysi-pro2030-user-manual-revc.pdf

Definitions

Specific Conductance. A measure of the ability of a water solution to conduct an electrical current. Specific conductance is electrical conductivity (EC) that is being expressed in microsiemens per centimeter (µs/cm) at a normalized temperature of 25o C. Specific conductance is related to the type and concentration of ions in solution and can be used for approximating the dissolved-solids content of the water. Commonly, the concentration of dissolved solids (in mg/L) is about 65% of the specific conductance (in microsiemens). (Note: This relation is not constant from stream to stream, and it may vary in the same stream with changes in the composition of the water.)

Salinity. Salinity is a measure of the total amount of dissolved salts in a sample. Sodium and chloride are the predominant ions in seawater, and other substantial ions include magnesium, calcium and sulfates. Salinity is an important factor in determining many aspects of the chemistry of natural waters and biological processes. In marine waters, salinity affects dissolved oxygen and will need to be measured separately in order to accurately calibrate the meter, if the particular dissolved oxygen meter does not directly measure salinity. Salinity may be expressed in a number of ways, parts per thousand and parts per million are the two most common measurements, and it is sometimes expressed as a percentage as well.

Probe. Sensing device located at the end of a cable that is attached to the meter.

Electrolyte solution. Solution used to fill the probe.

Calibration. Set of procedures established by the manufacturer to ensure that the meter is operating properly; a critical quality assurance step in meter preparation prior to use.

Membrane Cap. A polyethylene cap on the on the end of the probe. The membrane is permeable and allows gases such as oxygen to pass through into probe sensors while at the same time isolating most other undesirable substances.

Jigging. To move the probe under water using steady movements. Unless the probe is being held in swiftly flowing water, the probe shall be moved ("jigged") approximately 6 inches per second to overcome the inherent consumption of oxygen by the sensor.

Total Dissolved Solids. In stream water, dissolved solids consist of calcium, chlorides, nitrates, phosphorus, iron, sulfur, and other ion particles that will pass through a filter with pores of around 2 microns (0.002 cm) in size. TDS is calculated by converting the electrical conductivity by a factor of 0.5 to 1.0 times the EC

Guidelines and procedures

A. YSI Pro2030 Meter Preparation.

- **First time use:** Follow manufacturer's instructions for preparing meter for first time use. (Refer to the manual).
- **Beginning of field season:** Before each field season conduct a full inspection of the meter. If membrane has been stored dry, follow manufacturer's instructions for (refer to the manual: Sensor Maintenance-Dissolved Oxygen). A new membrane cap and batteries shall be installed prior to the start of field sampling and additionally, as needed. Staff will check meter against "benchmark" DO meter accuracy. In addition, each meter "setup" should be equipped with the following items so that field repairs can be undertaken as necessary:
    - Extra electrolyte solution and membrane caps for probe
    - Extra batteries
    - Field data sheet
    - Screwdriver for removing back of meter to replace batteries
    - Distilled Water (to clean the conductivity cell)
    - Pencil with eraser
- **Prior to field sampling:** Before each field sample collection, the volunteer should inspect the meter including an inspection of the condition of the probe membrane, membrane cap, and batteries.

(1) Check the membrane cap for air bubbles and look for significant deposits of dried electrolyte on the membrane. If bubbles are present, remove membrane, refill with electrolyte solution, and replace membrane cap.

(2) Check to make sure drops of water are not clinging to the membrane. If drops are present, blow on membrane to gently remove droplets. Don't tap; these probes are very fragile. The sponge in the grey calibration/storage sleeve should be moist. It should not have excess water on it that could cause water droplets to get on the membrane.

(3) Batteries should be checked for charge and/or expiration.

(4) Be familiar with the testing, inspection, maintenance, and calibration considerations described in sections 5.6 through 5.8 of the VRMP QAPP (MDEP, 2014).

(5) Power on the meter and allow sufficient warm-up time (5-15 min) prior to initial use for the day.

- **Specific Conductance Calibration**. Staff should conduct a system calibration check according to manufacturer's instructions and make adjustments. (Refer to manual: Conductivity Calibration)
- **Dissolved Oxygen Calibration.** If collecting dissolved oxygen measurements, the YSI Pro2030 meter shall be calibrated each time the unit is turned on. Meters shall be calibrated to a 100%

water-saturated air environment (for instructions, refer to manual: Calibrating in Percent (DO%)). NOTE: [DO Local% and Quick DO Cal are disabled in the System]

- **Dissolved Oxygen Check Against "Zero Dissolved Oxygen" Standard.** Staff shall check DO meters using zero oxygen standard at the beginning, middle, and end of the field season and record the dissolved oxygen value they measure with their meter in the appropriate blank on the field data sheet.

B. Dissolved Oxygen/Temperature/Specific Conductance/TDS/Salinity Measurements.

- **Sampling Period and Site Location**. Sampling period and site location information will be documented in SAPs
- **Sample Timing.** Dissolved oxygen data collected between dawn and 8 am are important for assessment of attainment of DO criteria within Maine's Water Quality Standards. But, except as naturally occurs, DO concentrations below the applicable DO criteria at any time of day signal non-attainment. If there are no DO concentrations below the criteria after 8 am, then data between dawn and 8 am must be collected to assess attainment of the criteria.
- **General Sampling Protocol.**
    - Record site location on data sheet.
    - Remove probe from calibration chamber.
    - Submerge probe in the water at the site where you are monitoring, as described in your group's approved SAP.
    - For any parameter (DO, specific conductance, temperature, salinity, TDS), allow the reading to stabilize (at least 8 seconds) before recording the value on the field sheet.
    - Follow the instructions below for measuring specific parameters.
    - The meter should remain turned on between stations, unless time between samplings exceeds 30-60 minutes. If meter is turned off, the field probe should be stored inside the calibration chamber during transport, sufficient time (5-15 min) should be allowed for warm-up, and the meter should be recalibrated.
- **Dissolved Oxygen Measurements.**

(1) Review and follow the instructions for making DO measurements (Manual: Taking Measurements). Make sure units are taken in mg/L (or ppm).

(2) Note of caution: Unless the probe is equipped with a stirrer, jigging of the probe is extremely important for obtaining accurate dissolved oxygen readings, unless you have placed the probe in a swiftly-moving section of stream or river. (The probe is dependent on the amount of oxygen that passes across the membrane, and the probe actually consumes oxygen as it is making measurements.) An up-and-down motion (jigging) creating movement of 6 inches per second is recommended. If placing the probe in a stream or fast moving waters, it is best to place it perpendicular to the flow and not facing into the flow.

- **Specific Conductance, TDS and Salinity Measurements.**

(1) There are seven options for displaying conductivity to include Cond-mS/cm, Cond-uS/cm, SPC-mS/cm, SPC-uS/cm, Salinity-ppt, TDS-g/l and TDS-mg/l. Only two units can be enabled at the same time. Specific conductivity-uS/cm and Salinity are enabled. If other units are required see (Manual: Conductivity Units) for how to change.

- **Quality Control.**

(1) At the beginning of each field season, all staff who collect dissolved oxygen, temperature, specific conductance, and salinity data will have a training/ refresher/ certification session to (re)familiarize themselves with the contents of this SOP.
(2) A field duplicate shall be obtained for all parameters for at least 10% of sampling efforts. A field duplicate will be collected for every 10 samples monitored.
(3) Refer to the QAPP and SAPs for more QA/QC details.

Equipment Care

A. Start of field season

1. Follow manufacturer's directions for preparation of a new probe or renewing probe in the spring (refer to Manual: Sensor Maintenance). Replace membrane cap at the start of each sampling season.
2. Use new batteries at start of each sampling season. An extra set of appropriate size batteries should be included in the meter carrying case.
3. If needed, clean the probe (anode and cathode) according to manual directions.
4. Each D.O. meter should have the following items for making repairs in the field. See section 5-A of this SOP for a list of items.

B. Field Season

1. Ideally the meter should be in a water-resistant case with padding to protect it from damage.
2. Keep the calibration/storage sleeve over the probe guard. Be sure to keep a small amount of moisture (clean tap water) on the sponge in the sleeve during storage. The sensors should not be submerged.
3. Allow the case and contents to air-dry at the end of each day. This may be accomplished be simply propping the lid open. When contents are very wet, remove the contents and spread out to facilitate drying.
4. Keep meter from freezing.
5. Refer to the Manual: Trouble Shooting for specific problems.

C. End of field season

1. Completely dry meter, case, and all items in the case before storing.
2. Remove batteries.
3. Remove membrane cap, rinse and dry.
4. Rinse entire probe and calibration chamber with distilled water. Allow to air dry completely.
5. Follow manufacturer’s instructions for cleaning the conductivity electrodes.
6. Put membrane cap back on to keep dust and dirt out for winter.
7. Keep meter dry and at room temperature to prevent corrosion of electronic parts.
8. Review Manual: Warranty and Service Information for more tips.
9. Record winterization date and equipment repairs in the Equipment Log.

YSI EXO2 Data Sonde Multi-Parameter protocols

The following protocols are adapted from Friends of Casco Bay's water quality monitoring QAPP. The group carries out both continuous and discrete water quality monitoring in coastal and marine areas of Casco Bay using a YSI EXO2 Data Sonde and hasbecome the model for data collection by many other groups in the region.

The water column parameter measurements are collected using the YSI EXO2 data sonde, 30 meters of cable, and a YSI EXO handheld logger. Starting with the sonde at the surface (sensors about 0.2 meters below the water surface), then moving to one meter deep, then two meters deep, and every two meters down to the bottom. The sensor readings should be allowed to stabilize at each depth before logging a discrete measurement. See Appendix A for the Seasonal monitoring field protocol.

The EXO2 Data Sonde is the primary instrument used for water column profiles in coastal and marine environments. Regular maintenance and preventive measures are necessary to keep these instruments operating at peak performance. In addition to the regular calibration and maintenance that occurs approximately every month, a detailed annual check and accounting of all sensors, sensor ports, firmware, structural integrity, and memory capacity is conducted.

All calibrations and maintenance follow the procedures outlined in the YSI EXO2 manual unless noted otherwise, and only when increased accuracy can be achieved.

The manual can be found here:

https://www.xylem.com/siteassets/brand/ysi/resources/manual/exo-user-manual-web.pdf

Maintenance and Calibration

pH: Replacing the YSI pH sensor cap every six months (rather than the suggested 18 months) has resulted in improved pH sensor performance groups using this equipment. Leaving the sonde in a seawater filled calibration cup while on the way to the sites has also helped to improve accuracy during the first few measurements of deployment. A two-point calibration with 7 and 10 buffer, and then a post deployment calibration check of both buffers is conducted after every use.

Dissolved Oxygen: The YSI Dissolved Oxygen sensor caps are replaced annually.

A sonde will never be used if the calibration of any of the sensors does not pass. If an unexpected event happens, such as sensor malfunction, diagnosis and corrective procedures will be taken under the direction of YSI guidelines.

References

Danielson, Thomas J. 2014. “Protocols for Collecting Water Grab Samples in Rivers, Streams, and Freshwater Wetlands.” Maine Department of Environmental Protection. https://www.maine.gov/dep/water/monitoring/biomonitoring/materials/sop_watergrab.pdf.

Dennis, Mary Ellen, and Kristin Feindel. 2020. “Maine Volunteer River Monitoring Program (VRMP) Quality Assurance Project Plan (2019-2024).” https://www.maine.gov/dep/water/monitoring/rivers_and_streams/vrmp/qapp/VRMP%20QAPP.pdf.

Manuals

YSI Pro 2030 handheld meter: https://www.ysi.com/file%20library/documents/manuals/605056-ysi-pro2030-user-manual-revc.pdf

YSI EXO2 Multiparameter Data Sonde:
https://www.xylem.com/siteassets/brand/ysi/resources/manual/exo-user-manual-web.pdf

APPENDIX E:
Continuous Water Quality SOP

Added to QAPP: March 2025

Continuous Water Quality SOP

Goal

Water quality parameters can be informative for a wide array of questions, including understanding the abiotic stressors in a system, the suitability of a habitat for flora and fauna, and the responses of a site to restoration activities. Collection of continuous water quality measures can be useful for collecting detailed, high-frequency observations and for capturing daily and seasonal variability within a water body. The goals of measuring water quality are very project-dependent

Sampling Design

Water quality can be assessed through the measurement a suite of parameters, and the definition of "water quality" is dependent upon the question being asked. Parameters that are typically assessed through lab analysis, such as total alkalinity and nutrients, currently cannot be measured continuously in-situ in a cost-effective way. Continuous water quality measurements therefore typically only encompass the physical and chemical parameters that can be measured through the deployment of probes. Common continuous parameters assessed as part of water quality sampling include:

- Temperature
- Dissolved oxygen
- Dissolved oxygen % saturation
- Specific conductance/conductivity
- Salinity
- Water depth
- pH
- Turbidity
- Chlorophyll fluorescence
- pCO2
- Light (lux)

The exact list of parameters sampled as part of a project is dependent upon the goals of the project, the type of site (freshwater, brackish, or marine) and the available equipment. A list of commonly used equipment and equipment specifications is included at the end of this section. Continuous water quality sampling is typically conducted through long-term deployment of a probe or sensor ("logger"). The logger will be anchored within the site, often through construction of a housing that can be weighted down or attachment to features within the water body such as tree roots, dock pilings, or even large rocks. Unless the logger is deployed in association with a telemetry set-up for real-time data access, the site must be visited to retrieve data from a logger.

Sampling locations within a site and duration of logger deployment are heavily dependent on project goals. Sampling across multiple sites in the same time period facilitates characterization of spatial variability within a site, while sampling the same for longer periods of time allows detection of additional seasonal patterns. Duration of logger deployment is often constrained by the capacity to check on and maintain the logger, as deployed loggers undergo biofouling (the growth of organisms on the logger), especially in marine environments. This biofouling can impact measurement of parameters once it builds up, so loggers must regularly be cleaned. In situations of extreme fouling, the logger may have to be removed from the water and brought to a lab for cleaning.

Restoration projects will involve deploying loggers within restoration areas and similar locations in nearby reference areas. Long-term monitoring of a waterbody will seasonal or continuous logger deployment over multiple years. Monitoring the effects of a disturbance will involve short-term (<3 years) seasonal or continuous logger deployments in a defined area. Sites, sampling locations, sampling frequency and duration, and the reasons for selection of the sampling locations will be detailed in SAPs. Loggers left in the field will be marked with the name and contact information of the project lead and deployment locations will be marked with GPS and narrative descriptions to assist with relocation.

Common Equipment

YSI Exo2 – multiparameter sonde
Parameters: temperature, conductivity, dissolved oxygen, fDOM, chloride, nitrate, pH, ORP, depth, salinity, total dissolved solids, total suspended solids, chlorophyll a
Manual: https://www.ysi.com/File%20Library/Documents/Manuals/EXO-User-Manual-Web.pdf
Specifications: Dissolved Oxygen % air saturation- 0 to 500% air saturation, Dissolved Oxygen (mg/L)-0 to 50 mg/L, Conductivity-0 to 200 mS/cm, Salinity-0 to 70 ppt, Total Suspended Solids (TSS)-0 to 1500 mg/L, TDS constant range 0 to 100,000 mg/L, Temperature- -5 to 50°C, Barometer-375 to 825 mmHg, fDOM – 0-300 ppb, Nitrate- 0 – 200 mg/L, pH- 0 -14 units, ORP- -999 to 999 mV, Chlorophyll a 0 to 400 µg/L Chl

Onset HOBO MX800 Series Water Data Logger
Parameters: temperature, conductivity, salinity, dissolved oxygen, depth
Manual: https://www.onsetcomp.com/sites/default/files/2024-10/25707-B%20HOBO%20MX800%20Series%20User%20Guide.pdf
Specifications: Dissolved Oxygen % air saturation- 0 to 600% air saturation, Dissolved Oxygen (mg/L)-0 to 60 mg/L, Conductivity-0 to 100 mS/cm, Salinity-2 to 42 ppt, TDS constant range 0 to 100,000 mg/L, Temperature- -20 to 50°C, Depth-0 to 9 m

Onset HOBO Pendant MX Water Temperature OR Temperature/Light Data Logger
Parameters: temperature OR temperature, light
Manual: https://www.onsetcomp.com/sites/default/files/2023-05/21536-P%20MX2201%20and%20MX2202%20Manual.pdf
Specifications: Temperature- -20 to 50°C, Light- 0 to 167,731 lux

SAPs

Sampling and Analysis Plans (SAPs) are site-specific documents that contain information on how protocols will be implemented as part of a set project or at a defined site. SAPs for projects involving continuous water quality sampling must include information on:

- Site
- Sampling locations within site

- Parameters to be collected
- Sampling frequency and duration of monitoring effort
- Logger maintenance plan
- Additional relevant sampling
- Equipment to be used, calibration frequency, methods, and equipment specifications (if using equipment other than that described above)

Sampling Methods

Prior to deployment, all logger sensors will be calibrated or checked following manufacturer recommendations. Note that some onset loggers typically come from the manufacturer pre-calibrated and must be returned to the manufacturer if calibration is required. YSI sondes and HOBO MX800 loggers allow user to recalibrate probes themselves.

Calibration checks will be done on equipment that does not allow user-recalibration before and after each deployment by checking logger readings against a standard or piece of reference equipment. This may include a reference thermometer, zero-DO standard, or conductivity standard to ensure accurate and precise readings for each sensor. Three measurements will be recorded during the calibration check. If one reading falls outside of the precision goal stated in the QAPP, a fourth measurement will be collected. If more than 2 measurements during pre- or post-calibration are out of precision, the logger will be sent back to the manufacturer for calibration and collected data will be flagged (if applicable).

For equipment that allows user-recalibration, loggers will be recalibrated prior to each deployment. Calibration procedures for most equipment will follow manufacturer guidelines. Calibration procedures for YSI EXO sondes may instead follow the calibration procedure developed by Friends of Casco Bay, included at the end of this SOP. Friends of Casco Bay has been using YSI EXO sondes for years and has developed a robust calibration procedure that is more rigorous than that recommended by the manufacturer. Other organizations in the region model their data collection efforts after those developed by FOCB. FOCB collects water quality data under an EPA approved QAPP, which includes their calibration procedures.

Following calibration/calibration checks, sensors will be configured for logging. The frequency at which sensors can log data is variable and can be adjusted by the user. More frequent logging fills up the logger memory and drains the battery faster, shortening the overall deployment length. Typically logging frequencies are 1 – 3 minutes for short term deployments and 10 – 15 minutes for long term deployments. We will follow manufacturer recommendations for configuring loggers.

Upon arrival at the deployment site, general site characteristics will be recorded on a field data sheet. Site characteristics include water depth, observed flora and fauna, and potential disturbances. In addition, activity (deployment or retrieval), logger ID, date, and time will be recorded. The logger will be affixed to a structure at the site with zipties, screws, or other security devices and data recording will be initiated. When the logger is in place, a GPS waypoint marking the exact location of the deployed sensor unit will be collected using a GPS and latitude, and longitude will be recorded on the datasheet. The deployment crew will ensure the sensor is logging properly prior to departure.

Following the pre-determined maintenance schedule, crews will visit logger locations. Loggers will be visibly inspected and severe biolofouling or concerns will be recorded on deployment datasheet. The battery will be checked, data will be downloaded (if applicable), and loggers will be cleaned. If the battery is below what is expected to last the next two maintenance intervals, data cannot be retrieved, or biofouling is severe, the logger will be retrieved from the field.

Following deployment, loggers will be post-calibration checked against standards to ensure accurate and precise readings for each sensor. If checks are outside of the precision goal, the collected data will be marked as questionable, and the difference from the standard values will be noted to facilitate data correction if needed.

<u>B3. Sample Handling and Custody</u>

Data downloaded from sensors will be made and transferred to a TBEP server within 48 hours of logger retrieval. Each data file will be labeled using a standardized format which includes strata and date of deployment. Sheila Scolaro will be in charge of ensuring data is transferred and stored properly.

All calibration records and field notes will be initialed, noted with time and date, and kept as part of the permanent project record.

Quality Assurance

Regardless of equipment used, all parameters measured as part of continuous water quality monitoring will strive to meet the standards for accuracy, precision, and completeness laid out in the QAPP.

Sampling equipment will be maintained and calibrated following manufacturer specifications. Post-calibration checks and noting of in-situ logger maintenance are vital, as they allow for drift correction. Biofouling and regular use of loggers can both lead to “drift” in some parameters, where measurements by the logger slowly move farther away from the true value. This typically happens in a predictable or trackable way (e.g., biofouling may insulate a logger and artificially increase temperature readings), so post-calibration checks or noting any change resulting from field maintenance can facilitate drift correction. Drift correction involves calculating the accuracy departure from the beginning to the end of the deployment, then fitting a model to the departure. The model can then be used to back-calculate accurate values.

All parameters will be assessed for drift and the need for drift correction following data retrieval.

Sample Handling and Custody

Data downloaded from loggers will be transferred to the CBEP server within 48 hours of retrieval. Each data file will be labeled using a standardized format that includes site name and date of deployment. All calibration records, data sheets, and field notes are recorded on data sheets. Data sheets are stored at CBEP and if digitized are transferred to a project-specific Excel database.

EXO2 Data Sonde Calibration SOP

I. Seasonal Monitoring Program Calibration

a. Make sure all calibration chambers are clean and dry (remove caps on either end and make sure threads are also dry).
b. Connect sonde to laptop and click connect on the Kor EXO prompt. Check battery power – if below 80 percent then make a note that the batteries need to be replaced. Click on calibration tab. You will see all the parameters to be calibrated on the left.
c. Conductivity (salinity is calculated from conductivity and temperature). Use YSI conductivity standard 50,000 microsiemens per centimeter for the rinse and calibration.
   i. Remove Central Wiper brush
   ii. Pour a couple of inches of 'rinse' (previously used) 50,000 conductivity standard into calibration chamber.
   iii. Place the sonde into the calibration chamber with the conductivity rinse and shake well. Remove sonde and discard rinse, pouring it over the sensors into the sink. Repeat this twice more with 'rinse' standard.
   iv. Add fresh 50,000 conductivity standard to the to the second line in the calibration chamber. Always use fresh (new and unopened) standard.
   v. Place the sonde in the calibration chamber with the fresh conductivity standard.
   vi. Click on wiped conductivity tab in software, choose specific conductance, select sensor '1', then click calibrate.
   vii. Wait for green line and stable indicator in text box at top of screen. Then click 'apply'. Then click complete calibration. Then click exit.
   viii. Give sonde a tap water rinse, and rinse and dry chambers and threads. Pour the previously fresh calibration standard back into original bottle and mark as rinse.
d. pH Calibration. This is a 2-point calibration using YSI pH buffer 7 and 10, values which bracket our expected *in-situ* values.
   i. Add a couple of inches of 'rinse' pH 7 buffer to a clean and dry calibration chamber. Place sonde in chamber and shake to rinse. Discard rinse buffer by pouring it over the sensors into the sink. Repeat this twice more for a total of three rinses.
   ii. Add fresh pH 7 buffer to the calibration chamber to the top line and insert the sonde. Give the sonde a quick swirl to remove any air bubbles that may be trapped on the sensor.
   iii. Click pH tab in software. The buffer 7 dialog box will automatically come up. Click on advanced. In auto pH compensation check that 'USA' is

clicked (only need to do this once). Wait for line to turn green. Once green, wait another 30 seconds, then click apply.

1. Once you hit apply, the software holds the calibration data in the first dialog box
2. Record the sonde serial number, the pre-cal value, the calibration value, and the millivolts value

iv. Then click 'apply'. Then click complete calibration. Then click exit.
v. Give sonde a tap water rinse, and rinse and dry chambers and threads. Pour the previously fresh calibration standard back into original bottle and mark as rinse.
vi. Remove sonde and rinse with tap water.
vii. Add a couple of inches of 'rinse' pH 10 buffer to a clean and dry calibration chamber. Place sonde in chamber and shake to rinse. Discard rinse buffer by pouring it over the sensors into the sink. Repeat this twice more for a total of three rinses.
viii. Add fresh pH 10 buffer to the calibration chamber to the top line and insert the sonde. Give the sonde a quick swirl to remove any air bubbles that may be trapped on the sensor.
ix. The KorEXO software will default to the 4 pH buffer; make sure to switch to 10 in the calibration dialog box. Click calibrate sensor '1'. Wait for line to turn green. Once green, wait another 30 seconds, then click apply.
    1. Once you hit apply, the software holds the calibration data in the first dialog box
    2. Record the sonde serial number, the pre-cal value, the calibration value, and the millivolts value
x. Then click 'apply'. Then click complete calibration. Then click exit.
xi. Give sonde a tap water rinse, and rinse and dry chambers and threads. Pour the previously fresh calibration standard back into original bottle and mark as 'rinse'.
xii. Note:
    1. Do not force a calibration. If the line doesn't turn green, then don't click apply. Figure out what is wrong.
    2. Open brand new buffers every time. Used buffers then become a rinse for future use. New buffers ensures greater accuracy.

e. Chlorophyll fluorescence
    i. Fill a calibration chamber with a couple of inches of distilled water. Place sonde in distilled water shake to rinse. Discard rinse over sensors into sink. Repeat twice more. Fill chamber with distilled water to the second line. Place sonde in distilled water.
    ii. Click on TAL-PE tab in software. Click calibrate for chlorophyll (micrograms per liter). You will notice the line bounces and it might take a bit to turn green. Wait for the line to turn green, click apply, then click exit.
    iii. Leave the sonde in the chamber.
f. Turbidity

i. Choose turbidity tab in software and click calibrate (FMU unit is the only option).
ii. The line will show up green – let it run for a bit to make sure it remains settled. Then click apply, then click exit.
iii. Dump out distilled water and do tap water rinse of sonde and chamber.

g. Depth
i. Fill bottom 1/2 inch of chamber with tap water. Attach chamber to sonde loosely – do not tighten. Do not submerge the sensors in water, we want the chamber to become 100% water saturated air.
ii. Choose depth tab in software (should be in meters), then click calibrate. It will default to 0 m, which is correct for calibrating at sea level. When the line turns green, click apply, then click complete calibration, then click exit.
iii. Leave sonde in chamber.

h. DO
i. Click DO tab in software, then click calibrate for 'percent saturation'. Wipe the sensor – in the advanced box at the bottom there is a bar that says wipe sensors – click that. Watch for the wiper to stop wiping.
ii. Obtain local barometric pressure: Turn on the EXO handheld logger. From handheld menu, select sensor info, then enter. Look at barometric pressure (abbreviated baro) – using that number, change pressure in text box in KorEXO software and hit enter. On handheld logger, click escape and turn off by holding down power button.
iii. Wait for line to turn green. Wait 30 seconds, then click apply, then click complete calibration, then click exit.

I. **Continuous Monitoring Program Calibratio**n
a. Open KorEXO software

II. Calibration
a. All three sondes for the three-station swap will be calibrated together. Make sure all calibration chambers are clean and dry (remove caps on either end and make sure threads are also dry).
b. Connect sonde to laptop and click connect on the Kor EXO prompt. Check battery power – if below 85 percent then make a note that the batteries need to be replaced. Click on calibration tab. You will see all the parameters to be calibrated on the left.
c. Conductivity (salinity is calculated from conductivity and temperature). Use YSI conductivity standard 50,000 microsiemens per centimeter for the rinse and calibration.

   i. Remove Central Wiper from one sonde and then remove all sensors except the Conductivity/Temperature sensor. Install the Conductivity/Temperature sensors from the other two sondes. Install plugs into any empty ports.
   ii. Pour a couple of inches of ‘rinse’ (previously used) 50,000 conductivity standard into calibration chamber.
   iii. Place the sonde into the calibration chamber with the conductivity rinse and shake well. Remove sonde and discard rinse, pouring it over the sensors into the sink. Repeat this twice more with ‘rinse’ standard.
   iv. Add fresh 50,000 conductivity standard to the to the second line in the calibration chamber. Always use fresh (new and unopened) standard.
   v. Place the sonde in the calibration chamber with the fresh conductivity standard.
   vi. Click on wiped conductivity tab in software, choose specific conductance, select sensor ‘1’, then click calibrate.
   vii. Wait for green line and stable indicator in text box at top of screen. Then click ‘apply’. Then click complete calibration. Then click exit. Repeat for sensors ‘2’ and ‘3’.
   viii. Give sonde a tap water rinse, and rinse and dry chambers and threads. Pour the previously fresh calibration standard back into original bottle and mark as rinse.

d. pH Calibration. This is a 2-point calibration using YSI pH buffer 7 and 10, values which bracket our expected *in-situ* values.
   i. Remove two of the Conductivity/Temperature sensors from the sonde being calibrated, leaving one in place.
   ii. Install all three pH sensors. Install plugs in any empty ports.
   iii. Add a couple of inches of ‘rinse’ pH 7 buffer to a clean and dry calibration chamber. Place sonde in chamber and shake to rinse. Discard rinse buffer by pouring it over the sensors into the sink. Repeat this twice more for a total of three rinses.
   iv. Add fresh pH 7 buffer to the calibration chamber to the top line and insert the sonde. Give the sonde a quick swirl to remove any air bubbles that may be trapped on the sensor.
   v. Click pH tab in software. Click calibrate sensor ‘1’. The buffer 7 dialog box will automatically come up. Click on advanced. In auto pH compensation check that ‘USA’ is clicked (only need to do this once). Wait for line to turn green. Once green, wait another 30 seconds, then click apply.
      1. Once you hit apply, the software holds the calibration data in the first dialog box
      2. Record the sonde serial number, the pre-cal value, the calibration value, and the millivolts value
   vi. Then click ‘apply’. Then click complete calibration. Then click exit. Repeat for sensors ‘2’ and ‘3’.

vii. Give sonde a tap water rinse, and rinse and dry chambers and threads. Pour the previously fresh calibration standard back into original bottle and mark as rinse.
viii. Remove sonde and rinse with tap water.
ix. Add a couple of inches of 'rinse' pH 10 buffer to a clean and dry calibration chamber. Place sonde in chamber and shake to rinse. Discard rinse buffer by pouring it over the sensors into the sink. Repeat this twice more for a total of three rinses.
x. Add fresh pH 10 buffer to the calibration chamber to the top line and insert the sonde. Give the sonde a quick swirl to remove any air bubbles that may be trapped on the sensor.
xi. The KorEXO software will default to the 4 pH buffer; make sure to switch to 10 in the calibration dialog box. Click calibrate sensor '1'. Wait for line to turn green. Once green, wait another 30 seconds, then click apply.
    1. Once you hit apply, the software holds the calibration data in the first dialog box
    2. Record the sonde serial number, the pre-cal value, the calibration value, and the millivolts value
xii. Then click 'apply'. Then click complete calibration. Then click exit. Repeat for sensors '2' and '3'.
xiii. Give sonde a tap water rinse, and rinse and dry chambers and threads. Pour the previously fresh calibration standard back into original bottle and mark as 'rinse'.
xiv. Note:
    1. Do not force a calibration. If the line doesn't turn green, then don't click apply. Figure out what is wrong.
    2. Open brand new buffers every time. Used buffers then become a rinse for future use. New buffers ensures greater accuracy.
xv. When finished, remove two of the pH sensors and return them to the other sondes. Install the other sensors so that there are now three complete sondes with calibrated Conductivity/Temperature and pH.

e. Chlorophyll fluorescence
    i. Fill a calibration chamber with a couple of inches of distilled water. Place sonde in distilled water shake to rinse. Discard rinse over sensors into sink. Repeat twice more. Fill chamber with distilled water to the second line. Place sonde in distilled water.
    ii. Click on TAL-PE tab in software. Click calibrate for chlorophyll (micrograms per liter). You will notice the line bounces and it might take a bit to turn green. Wait for the line to turn green, click apply, then click exit.
    iii. Leave the sonde in the chamber!
f. Turbidity
    i. Choose turbidity tab in software and click calibrate (FMU unit is the only option).

   ii. The line will show up green – let it run for a bit to make sure it remains settled. Then click apply, then click exit.
   iii. Dump out distilled water and do tap water rinse of sonde and chamber.

g. Repeat steps 5 and 6 with the other two sondes.
h. Depth
   i. Fill bottom 1/2 inch of chamber with tap water. Attach chamber to sonde loosely – do not tighten. Do not submerge the sensors in water, we want the chamber to become 100% water saturated air.
   ii. Choose depth tab in software (should be in meters), then click calibrate. It will default to 0 m, which is correct for calibrating at sea level. When the line turns green, click apply, then click complete calibration, then click exit.
   iii. Leave sonde in chamber.
i. DO
   i. Click DO tab in software, then click calibrate for 'percent saturation'. Wipe the sensor – in the advanced box at the bottom there is a bar that says wipe sensors – click that. Watch for the wiper to stop wiping.
   ii. Obtain local barometric pressure: Turn on the EXO handheld logger. From handheld menu, select sensor info, then enter. Look at barometric pressure (abbreviated baro) – using that number, change pressure in text box in KorEXO software and hit enter. On handheld logger, click escape and turn off by holding down power button.
   iii. Wait for line to turn green. Wait 30 seconds, then click apply, then click complete calibration, then click exit.
j. Once everything is calibrated, click on deployment tab. Then click 'open templat'e at top. Select 'EXO Default 15 minutes' template, and click view selected deployment. In next window, click save and apply template to sonde. It will ask if you want to start internal logging, say yes. It will then ask when to start internal logging, select next interval. Then click start
   i. Double check three parameters:
      1. The right hand dialog box will display when it will log next – make sure it is today's date and the next 15 minute interval
      2. Bottom should say deployed
      3. There should be a big red hand that says stop deployment
   ii. Click home button. Then choose disconnect. Can now disconnect sensor from laptop
   iii. Repeat with other two sondes.

Manuals

YSI EXO2 Multiparameter Data Sonde:
https://www.xylem.com/siteassets/brand/ysi/resources/manual/exo-user-manual-web.pdf

Onset HOBO MX800 Series Water Data Logger
https://www.onsetcomp.com/sites/default/files/2024-10/25707-B%20HOBO%20MX800%20Series%20User%20Guide.pdf

Onset HOBO Pendant MX Water Temperature OR Temperature/Light Data Logger
https://www.onsetcomp.com/sites/default/files/2023-05/21536-P%20MX2201%20and%20MX2202%20Manual.pdf

APPENDIX F:
Monumented Cross Sections SOP

Added to QAPP: March 2025

Monumented cross sections SOP

Goal

Changes in creek channel morphology frequently occur as a result of restoration activities or changes in site hydrology. By assessing channel morphology at a site we can

- Document existing conditions or monitor long-term changes
- Assess geomorphological impacts of tidal restrictions on channel shape, depth, and capacity
- Inform development of hydraulic capacity estimates for conceptual design alternatives
- Evaluate how hydrological modifications affect sediment transport
- Monitor post-project geomorphological response to restoration and enhancement projects.

Monumented channel cross sections are one method to monitor channel morphology. Cross sections are transects that run perpendicular to a channel, crossing the channel and extending from the high marsh on one side of a channel to the high marsh on the opposite side. They are used to characterize changes in the geometry of a tidal channel, including width, depth, cross-sectional area, and channel form.

Sampling Design

Monumented cross sections are established adjacent to selected Stations within the project area. To the extent practicable, cross section transects are located on relatively straight channel reaches rather than on meander bends. Semi-permanent monuments (physical location markers) are set into the high marsh surface and georeferenced. Sampling occurs once per season.

If monitoring is of a restoration project, at least one monumented cross section will be located within the Reference Area. Cross sections are surveyed at least once prior to a tidal restoration project, and either at odd years post-project (i.e., year 1, 3, 5), or annually. This detail is specified in an SAP. Monitoring frequency at other long-term monitoring sites will be identified in the site SAP.

CBEP maintains equipment used for surveying cross sections, including a **Topcon AT-B3 auto level**, tripod, **Crain SVR-25-Tenths stadia rod** (decimal feet), and **Keson English/ Metric Open Reel Fiberglass Tape reel** (decimal feet).

Semi-permanent monuments are set to mark the start and end of a transect. Monuments are typically hollow PVC pipes or wooden stakes set into the high marsh surface and extending approximately 20 cm above the marsh surface. Monuments are set on the high marsh surface an adequate distance away from the creek edge to accommodate for channel evolution over the monitoring period, as specified in SAPs. Monuments are sometimes lost over the winter due to ice scour, and cross sections are re-established in subsequent monitoring years by reference to photographs, GPS coordinates, and the memory of field staff.

Sampling Methods

Detailed information on this SOP is provided in the *Stream Barrier Removal Monitoring Guide* (Collins *et al* 2007, p. 27-30).

Survey equipment is set up on one side of the transect, and a measuring tape is run from one monument to the other. Measurements are collected by a team, with one person operating the level and recording measurements, and one person setting the stadia rod laterally along the transect and reporting transect distance to the recorder. The stadia rod is held vertical by use of a rod-level, and the rod is always held on the opposite side of the tape. Lateral distances are referenced to river left (i.e., the left monument, looking downstream, is zero on the tape).

The level operator reads the center crosshair of the level to obtain the stadia rod measurement. No other information from the level is recorded. The first reading will be at the left monument and the last reading at the right monument. Measurements emphasize documentation of visible breaks in slope and significant geomorphic features such as top of channel bank, toe of channel bank, water depth, and the thalweg. In the absence of clear breaks in slope, elevations are recorded at a pre-determined interval equal to 1/20th of the total transect length. Elevations are tied into a local vertical control point, through back-sighting if necessary.

Data Quality Assurance

Equipment is stored at CBEP and periodically inspected for wear and tear, and maintained or replaced as needed, to maintain accuracy and functionality.

Sample Handling and Custody

Field data are recorded on data sheets, which are stored at CBEP. Rough sketches are drawn onto the datasheet showing the location of the cross section in relation to anecdotal observations and contextual information such as submerged aquatic vegetation (e.g., *Ruppia maritima*), overhanging channel banks, woody debris, and channel bank slumping.

Analytic methods `

Field data are entered into a copyrighted Excel spreadsheet tool, The Reference Reach Spreadsheet, developed by the Ohio Department of Natural Resources (Mecklenburg 2006). This tool is widely used for storing and analyzing channel survey data. Cross section data are entered into the Dimension tab, and the spreadsheet automatically plots a channel profile. Cross sectional area, channel width, mean depth, maximum depth, and other metrics are calculated for use in comparison between pre- and post-project conditions, as well as comparison between the project area and reference site.

Detailed Protocol

Reference: Collins *et al.*, 2007 (following pages); Neckles & Dionne 2000 (App. B).

Equipment: Handheld GPS unit, map, digital camera, cross section data sheets, clipboard, pencil, transit instrument/auto level, tripod, stadia rod, rod level, large (6-8”) nail, 300 ft. (decimal) measuring tape reel, hip waders, tide chart or knowledge of the day’s tide schedule.

Notes:

- Measurements require that water levels are sufficiently low for safe channel crossing and preferably, an uninhibited view of channel features; e.g., the lower end of the tide.
- Two people are required for measurements: one on the stadia rod (observer), and one at the level taking readings and recording measurements (recorder).
- Hip waders are necessary to traverse the channel.
- Direction is with regard to flow toward the bay: river right (R), river left (L), upstream (U/S), downstream (D/S).

Field instructions:

1. Using the map and/or GPS, locate cross section monitoring station, including monuments
(typ. PVC) that denote the start and end of a transect running perpendicular to the channel.
2. Observer sets up the transect. ○ Insert the nail through the end of the tape reel and into the top of the monument at river L. On data sheet, note transect start location (e.g., Station 1, 0’ at river L).
    - ○ Affix the reel end of the tape to the opposite monument and note the transect length on the data sheet. Ensure the tape is taut before commencing with the survey. Note: Windy conditions may prevent surveys at large channels if the tape is not taut. Either wait for the wind to die down or come back at a later time.
    - ○ With the tape in the foreground, take four photos of the channel: toward river R, river L, U/S and D/S. Ensure camera is level and that the image is taken in landscape format. Note the photo #’s and labels (river R.) on the data sheet.
3. Recorder sets up the level. ○ Draw a sketch of the cross section looking upstream and a second sketch of the general form of the channel. Include vegetation changes, slumped or overhanging banks, pools, and other features. Limit sketches to ~3 minutes apiece.
    - ○ Set up the level equipment. Extend the tripod legs, locking them into place and gently using the foot pads to stabilize the unit. Set the tripod up a few feet from the first stake, looking across at the other stake. Remove the lens cap and attach the level to the tripod, screwing on tightly. Level the instrument by adjusting the 3 wheels so that the bubble is centered.
4. Survey the transect. ○ If a local benchmark / control point is available, measure that point at the start and end of the survey, and note the rod height on the data sheet.

- Observer starts at 0’ (river L) with the rod placed on the ground immediately next to the monument and facing the level. The rod is held vertical by use of a rod-level, and

  the rod is always held on the opposite side of the tape from the observer. The observer calls out the distance along the transect and description. The recorder reads the center crosshair of the level to obtain the stadia rod measurement also records the distance and description.
- Along the transect, observer sets the rod to document visible breaks in slope/elevation, and significant geomorphic features such as top of channel bank, base of channel bank, water depth, undercut banks, and the thalweg.
- In the absence of clear breaks in slope or other features, elevations are recorded at a pre-determined interval as follows: (total transect length/20), with observations recorded at this distance along the transect.
- Transect ends at river R.

5. Pack up the equipment and head to the next cross section.

SOURCE: Collins, M., K. Lucey, B. Lambert, J. Kachmar, J. Turek, E. Hutchins, T. Purinton, and D. Neils. 2007. Stream Barrier Removal Monitoring Guide. Gulf of Maine Council on the Marine Environment. pp. 27-30 www.gulfofmaine.org /streambarrierremoval.

B. MONITORING METHODS

1. Monumented Cross-sections

Purpose

This section describes how to establish and survey permanent (i.e., monumented) stream cross-sections for long-term monitoring. It identifies the equipment needed, describes the basic protocol, discusses the frequency with which the cross-sections should be re-surveyed, and presents some site-specific considerations. This section does not provide detailed instruction on basic surveying techniques, such as conducting a level survey. For a more complete treatment of stream surveying techniques, see Harrelson et al. (1994).

Monitoring Design

Sampling Protocol

1. Define the monitoring reach.

Defining the length of the stream monitoring reach is the first step in conducting cross-section surveys. Upstream of the barrier, the monitoring reach should, at a minimum, include the length of the impoundment and a representative portion of undisturbed reach upstream of the barrier (e.g., a reach length of approximately 10 channel widths). The downstream monitoring reach is less easily defined because the length of reach physically impacted by the barrier, and/or its removal, is not generally known precisely beforehand.

Minimum Equipment

- ❑ Automatic level (surveyor's level) or laser level
- ❑ Leveling rod in English (to tenths and hundredths) or metric units, preferably 25-foot length
- ❑ Measuring tape in same units (300 ft or 100 m)
- ❑ Field book with waterproof paper
- ❑ Data sheets (see Appendix E)
- ❑ Pencil
- ❑ Permanent marker
- ❑ Two-way radios
- ❑ Topographic maps and/or aerial photographs
- ❑ Chaining pins
- ❑ Flagging tape
- ❑ Machete
- ❑ Wood survey stakes
- ❑ 4 ft (1.2 m) steel rebar stakes
- ❑ Hacksaw
- ❑ Small sledge or mallet
- ❑ Spring clamps
- ❑ GPS
- ❑ Compass

Maria Garcia / NOAA Restoration Center

Installing a monument.

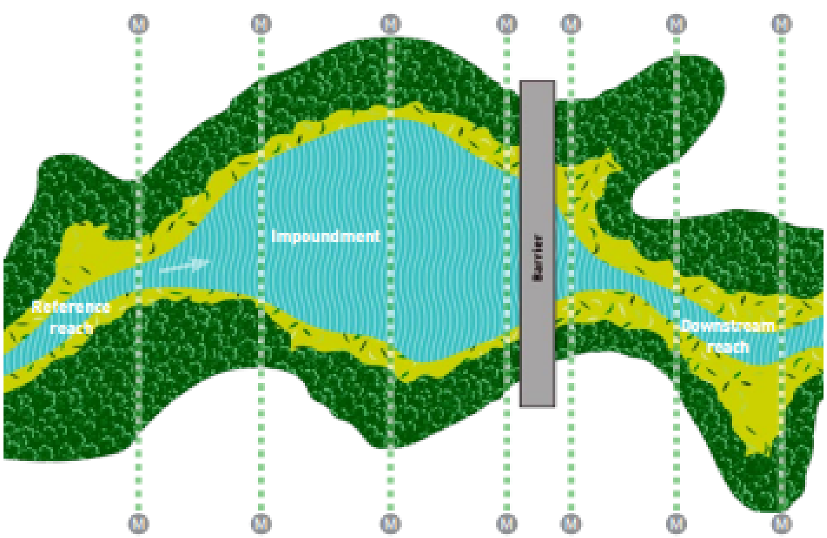

Figure 1.
At minimum, monumented cross-sections should be established immediately upstream and downstream of a stream barrier, at bridges, in the impoundment, and upstream and out of the influence of the impoundment. The number and location of cross sections will depend on site-specific conditions. Figure not to scale.

This length can be estimated, or the downstream limits can be identified based on other project considerations such as downstream habitats of concern, infrastructure, or locations of hydraulic or geomorphic controls such as bridges, outcrops, or knickpoints.

2. Determine number and location of cross-sections.
Once the length of the monitoring reach has been identified, the monitoring team must determine the number of cross-sections needed to adequately represent that reach. The most easily identifiable locations are those areas where infrastructure in the floodplain is likely to be impacted by the project. For example, cross-sections should be established immediately upstream and downstream of the barrier and at bridges within the identified project reach. There also should be cross-sections representing the impoundment (see Site Specific Considerations below), at least one in the undisturbed reach upstream of the impoundment, and at any locations judged to be sensitive to disturbance or of high habitat value. The engineering and geomorphic analyses used to plan the barrier removal should be consulted to identify critical locations. If present in the monitoring reach, cross-sections should be established at existing, monumented cross-sections and/or stream gage locations (Figure 1).

The choice of other cross-section locations should be based on the number of physically homogeneous stream reaches within the monitoring reach—those with similar slopes, bed and bank material, floodplain/terrace sequences, riparian vegetation, and channel-forming processes (Simon and Castro, 2003). For example, the number of cross-sections representing pools, riffles, meander bends, straight reaches, and flow divergence should closely approximate their proportion in the entire monitoring reach. Identification of these sub-reaches or cross-section types should begin with a pre-field inspection of available topographic maps, aerial photographs, surficial/bedrock geology maps, soil surveys, and other relevant information. In addition to subsequent field inspection, you may want to perform and plot a longitudinal profile to use in selecting cross-section locations (see section IV.B.2). Reviewing these data will be valuable for identifying reaches with similar physical characteristics and dominant processes.

3. Locate and establish the cross-section monuments.
At each cross section, establish the permanent markers for both endpoints by driving a ½-inch-diameter, 4-foot rebar stake either flush with the ground or ½ inch above the surface. You may want to cover the tops of the stakes with colored plastic caps available from survey suppliers and use different colors to distinguish different cross-sections (Harrelson et al., 1994). Be sure to note the color associations in the field book. The cross-sections should be straight and perpendicular to the bankfull flow direction, and they should extend across the floodplain/riparian zone to the first terrace or as far as practicable.

To facilitate locating each cross-section for future surveys, establish the horizontal position of the monuments via GPS and one other method. You can fix the position of monuments by taking a bearing and measured distance to the benchmark (see step 4 below), or by triangulating between the monument, benchmark, and another permanent feature on site (e.g., large, healthy tree or bedrock outcrop) (Harrelson et al., 1994; Miller and Leopold, 1961). If the benchmark is not visible from a given cross-section, triangulate with two permanent features. The GPS coordinates of each monument will facilitate mapping the cross-section locations in GIS. Once located, depict the cross-sections on a scaled map or aerial photograph of the project area.

4. Locate or establish the benchmark.
Once the cross-sections have been established, you must either locate, or establish, a local benchmark for the site. This is a permanent marker of known, or assumed, elevation that functions as survey control and the survey starting point. The U.S. Geological Survey (USGS) and other entities historically involved in developing geodetic control networks have benchmarks throughout the country. If one is available at your site, use it. They are typically found on stable site features such as bedrock outcrops; the tops of large, embedded boulders; and bridges.

In the event that a USGS or other geodetic control benchmark is not present in reasonable proximity to the project area, you will need to create a local, or project, benchmark. This offers the opportunity to establish it in a location that is advantageous for the survey; that is, locate it at a point relatively high on the site and visible from most, or at least many, of the permanent cross-sections. You can do so by driving a rebar stake 3 or 4 feet into the ground, chiseling a mark in an outcrop feature or stable boulder, or other means described by Harrelson et al. (1994). Be sure to describe its location in the field book and establish its coordinates with GPS. Always record the horizontal datum employed by the GPS (e.g., NAD 83). If you establish a benchmark, it is conventional to assign it an arbitrary elevation of 100 feet. Alternatively, the benchmark can be tied into an established vertical datum (e.g., NAVD

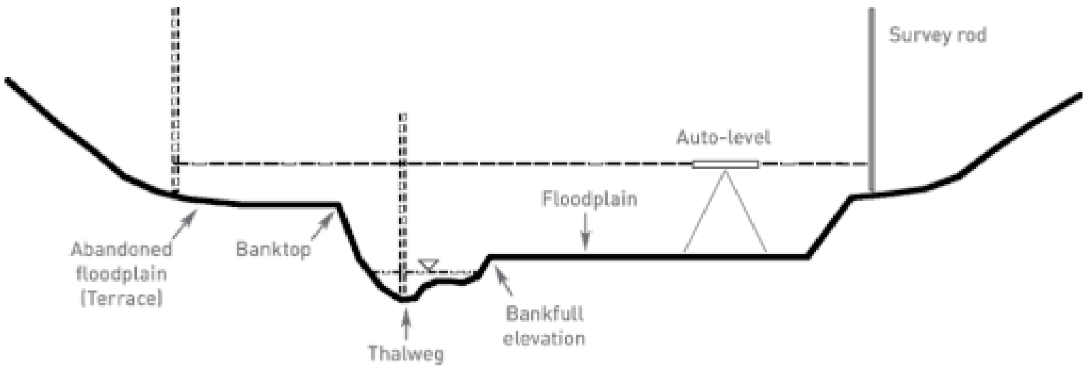

Figure 2. Basic channel and valley features of an unimpacted (reference) stream reach. Note that some features, such as the bankfull elevation, will not be identifiable in the impacted project reach or in all reference reaches.

88) or referenced to mean sea level for projects in areas subject to tidal influence. The horizontal and vertical datums used for the cross-sections should be used also for the longitudinal profile.

5. Set-up the survey instrument and tape.
If possible, set up the survey level in a location from which the local benchmark and all points of one or more cross-sections are visible. Though one or more cross-sections might be shot from one instrument station, to complete all cross-sections for your site you may need to set up two or more instrument stations. From each new instrument station you will need to take backsights on the benchmark (see below), if it is visible, or from turning points if it is not (Harrelson et al., 1994). A machete can be useful to trim low-hanging branches or other vegetation and decrease the number of times you need to move the instrument, but you should avoid cutting large amounts of vegetation for this purpose to minimize property and habitat impacts. At each cross-section, stretch a tape as taut as possible between the monuments. It can be attached to the monument itself with spring clamps, to a shorter rebar stake driven next to the monument with 6 inches exposed for easier attachment, or with chaining pins (Harrelson et al., 1994).

If you are using an optical surveyor's level (auto-level), the person operating the level will make and record the rod readings while the rod person will choose the survey points and call out the lateral distances to the level operator. Lateral distances are referenced to the left bank monument, which is the cross-section zero (left bank is referenced as the left bank looking in the downstream direction). A third person dedicated to recording all readings and descriptions in the field book is recommended and will be necessary for surveying the impoundment with a boat (see Site Specific Considerations below). One advantage of using a laser level is that one person can execute the cross-section survey (or two for impoundment surveys).

6. Survey the cross-section.
Begin with a rod reading on the benchmark. This "backsight" will be added to the elevation of the benchmark to establish the "height of instrument" (HI). All "foresights" on cross-section locations will be subtracted from the HI to obtain the elevation of those points (Harrelson et al., 1994). The first foresight will be taken at the left bank monument. From there, take readings at all breaks in slope and especially at significant geomorphic features as you make your way across the valley (e.g., bankfull, bank top, bank toe, bar tops, edge of water, thalweg), describing each feature in the notes for the respective reading (Figure 2). Capture features such as woody debris and bank-failure deposits, and record in the notes important changes in substrate type.

Also make notes about the nature of the vegetation, especially its structure (e.g., trees, shrub, herbaceous; see Section II.B.7 for the riparian plant community structure method), and be sure to record the locations where discrete changes occur. Adequately characterizing the complexity of the cross-section will typically require a minimum of 30 to 40 rod readings. Larger floodplains and more complex geometry can require many more. Record the horizontal distances to tenths of feet (0.1 ft) and elevations of benchmarks and turning points to hundredths of feet (0.01 ft). Cross-section elevations are also recorded to hundredths of feet.

Bear in mind that identifying a bankfull channel will be most applicable to the cross-section(s) upstream of the hydraulic influence of the impoundment that represent the un-impacted channel reach. The bankfull channel is adjusted to an approximately 1.5- to 2-year recurrence interval discharge and the prevailing sediment transport conditions (Leopold et al., 1964). Because water flow and sediment discharge conditions will, in most cases, be changing at a barrier removal site, a persistent bankfull channel likely will not be identifiable in the monitoring reach. This may also be true of the reference reach, especially in watersheds with changing land use. See Harrelson et al. (1994) for a good discussion about field identification of the bankfull channel. The USDA Forest Service Stream Systems Technology Center (2003) also produces a video specifically geared towards field identification of the bankfull channel in the eastern United States (www.stream.fs.fed.us/publications/videos.html).

Karla Garcia / NOAA Restoration Center

Monument at a cross-section.

Sampling Frequency

Pre-removal surveys are essential for comparison with post-removal data to assess channel and floodplain response. Pre-removal surveys may be most easily accomplished if the impoundment can be drawn down before removal (see Site Specific Considerations below), such as during project feasibility studies. In any case, for efficiency purposes, selection of the long-term monitoring cross-sections and pre-removal data collection should be integrated with any planned feasibility work. As a general guideline, post-removal re-surveys should occur annually, or every other year, for at least 5 years. However, sampling frequency and duration should reflect project objectives and site conditions. For example, sites with great amounts of loose sediment may require more frequent sampling over a longer period than sites with bedrock channels or beds dominated by coarse materials. At a minimum, the frequency should conform to any regulatory requirements. The monuments should be recoverable for much longer so that longer-term studies of channel evolution are possible.

Site-specific Considerations

Some of the pre-removal cross-sections will need to traverse the impoundment. The determination of whether cross-section data in an impoundment can be acquired by wading or using watercraft must consider the depth of the impoundment and suitability of sediment for wading. Impounded sediments may be unconsolidated, fine-grained material with saturated interstitial spaces, making them very soft and incapable of supporting a wader. In such conditions, it will be necessary to obtain the data from a boat. Depending on the nature and depth of the impoundment, surveying cross-sections within it can be accomplished either by employing the methods described in the previous section and taking rod readings at fixed intervals from a small boat, or by using a fathometer from a boat navigated along the transect and integrating the readings with the rod readings on shore via GPS positioning.

If you are taking rod readings from a small boat, you will need to take care in positioning the rod and try to make sure the rod rests on top of the sediments and does not sink into soft substrate. At least two people are needed for boat work—one to work the survey rod and the other to station the boat.

Analysis and Calculations

The data from a cross-section survey are elevations and distances. Horizontal distances are recorded to tenths of feet (0.1 ft) and elevations of benchmarks and turning points to hundredths of feet (0.01 ft). Cross-section elevations are recorded to hundredths of feet. These data should be recorded in standard level-survey notation (see Cross-Section Survey Data Sheet in Appendix E). Harrelson et al. (1994) also provide a nice graphic example of proper field book notation for level surveys. The horizontal and vertical datums of the survey must always be recorded (see Site Information Data Sheet in Appendix E). The distances and elevations can be plotted manually on graph paper as 'x' and 'y' coordinates, respectively, or brought into a spreadsheet program for plotting and analyses.

Additional Information

Harrelson et al. (1994) provide an excellent reference for basic survey techniques and for specific information on conducting cross-section and longitudinal profile re-surveys. We strongly recommend that readers with minimal experience consult this reference. It also is a useful review for those with more experience.

APPENDIX G:
Longitudinal Channel Profile SOP

Added to QAPP: March 2025

Longitudinal channel profile SOP

Goal

Changes in creek channel morphology frequently occur as a result of restoration activities or changes in site hydrology. By assessing channel morphology at a site, we can:

- Document existing conditions or monitor long-term changes
- Assess geomorphological impacts of tidal restrictions on channel shape, depth, and capacity
- Inform development of hydraulic capacity estimates for conceptual design alternatives
- Evaluate how hydrological modifications affect sediment transport
- Monitor post-project geomorphological response to restoration and enhancement projects.

Longitudinal profiles are one method to monitor channel morphology. Longitudinal profiles are established as a continuous transect of the channel thalweg. They are used to characterize changes in the depth of a tidal channel.

Sampling Design

At tidal restoration sites, the profile runs through a built structure from a downstream cross section station to at least one upstream cross section station, and preferably more. This monitoring reach is established to show representative channel depths downstream and upstream of a structure, and inclusive of the depth within the structure itself. At other monitoring sites, the longitudinal profile spans at least two cross section stations, and preferably more.

CBEP maintains equipment used for surveying longitudinal profiles, including a **Topcon AT-B3 auto level**, tripod, and**Crain SVR-25-Tenths stadia rod** (decimal feet),. Prior to set up, flags or other temporary markers are used to denote the start and end points of the transect. Typically, these markers will be located at intersections with monumented cross sections. These points are georeferenced with a GPS unit. Longitudinal profiles are surveyed at least once prior to a restoration project, and generally, at odd years post-project (i.e., year 1, 3, 5). Timing of samples will be specified in the SAP. Monitoring frequency at other long-term monitoring sites will be identified in the site SAP.

Set up involves positioning the auto level in such a way (i.e., atop a road shoulder) that to the extent practicable, an unobstructed view of the monitoring reach, as well as a benchmark/elevation control point, is provided. If only part of the reach is within a continuous sightline, it may be necessary to conduct a partial survey from this location, then using fore-sighting and back-sighting, relocate the level to another position that allows for completion of the survey. No tape measure is used.

Sampling Methods

Detailed information on SOPs is provided in Collins *et al* 2007, p. 31-32. Measurements are collected by a team, with one person operating the level and recording measurements, and one person setting the stadia rod along the transect. The stadia rod is held vertical by use of a rod-level. The benchmark is surveyed in as one of three reference locations outside of the transect, and at the benchmark, the angle of the level is set to 0°. The other reference locations should be fixed objects.

For all measurements, including the reference objects, the level operator notes the angle of a shot, as well as the height on the stadia rod of three cross hairs (mid, upper, and lower).

The transect survey begins at the downstream flag and is continuously surveyed until the upstream markers are reached. For sites containing road crossings or other structures, the survey includes measurement of key elevations associated with the structure, including the outlet invert, height to the top of the culvert, one or more measurement atop the structure (typically at the crown of a road) and the inlet invert. During the survey, all visible breaks in grade are surveyed. In the absence of clear breaks in slope, elevations are recorded periodically to show continuity in the plotted profile.

Data Quality Assurance

Equipment is stored at CBEP and periodically inspected for wear and tear, and maintained or replaced as needed, to maintain accuracy and functionality.

Sample Handling and Custody

Field data are recorded on data sheets, which are stored at CBEP. Descriptive information, such as changes in stream bed material, soft sediments, rip-rap, and other features are noted.

Analytic methods

Field data are entered into an Excel spreadsheet developed by MDOT that transforms field coordinates into survey points and calculates vertical elevation and distance along the transect, with 0' at the downstream marker. The transformed data are then transferred into an Excel spreadsheet tool, The Reference Reach Spreadsheet, developed by the Ohio Department of Natural Resources (Mecklenburg 2006). Longitudinal profile data are entered into the Profile tab, and the spreadsheet automatically plots a channel profile (example below). The location of cross sections, culvert inverts, and other features can be added to the plot and the slope of the monitoring reach is calculated. The plot allows for graphical comparison between pre- and post- project conditions, as well as comparison between the project area and reference site.

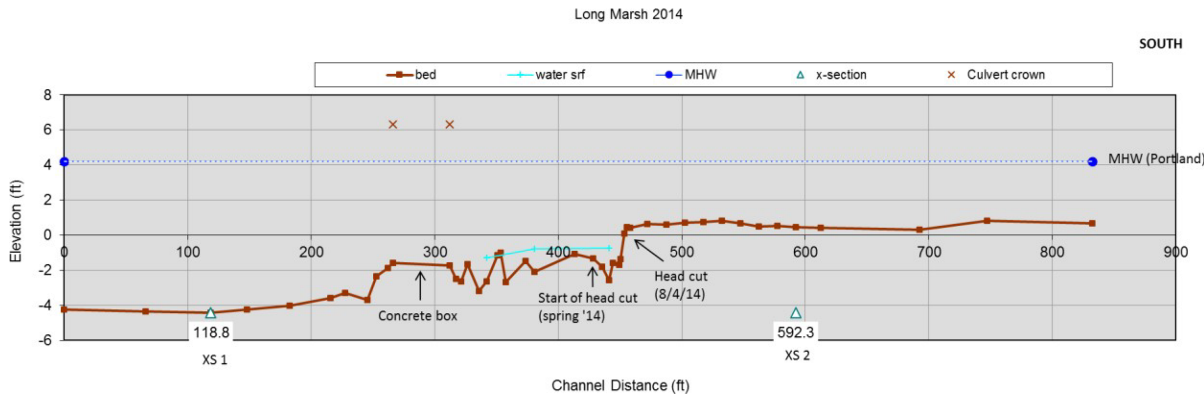

Figure 1. Example longitudinal profile.

Detailed Protocol

<u>Reference</u>: Collins *et al.*, 2007 (following pages)

<u>Equipment</u>: Hip waders (mud boots ok for the person at the transit), transit instrument, tripod, stadia rod, rod level, compass, data sheets, clipboard, and pencils.

<u>Notes</u>:

- Longitudinal profiles must be conducted at low tide.
- Two people are needed: observer handles the rod, recorder handles the transit.
- Prior knowledge of benchmarks (elevation control points) in the field is necessary.

<u>Field Instructions</u>:

1. Set up the transit instrument on its tripod in a spot with clear visibility to both sides of the structure, the channel reach to be surveyed, and a local benchmark / control point. Often, set up is along a road shoulder; be visible and wear a safety vest.
2. Position tripod legs and lock into place, pushing the feet firmly into the ground. Level the transit, adjusting the wheels until the bubble is in the center of the circle.
3. Turn the instrument toward a benchmark (e.g., nail on a telephone pole). Set the level angle at zero. Take a compass bearing on the benchmark and record magnetic angle from the level to the benchmark. Record height at the top cross hair, the mid cross hair, and the lower cross hair, as well as the angle (being 0 degrees at the first benchmark).

Repeat with additional benchmarks if available. Fill out other information on the data sheet.

4. The person with the stadia rod should walk toward the beginning of the transect starting with the location of the downstream cross section (typically, Station 1). The stadia rod should be positioned in the thalweg (deepest part of the channel) throughout the survey.
5. When in position, the recorder reads the rod height at all three cross hairs, and the angle.
6. The person with the stadia rod moves upstream by approximately 20 feet at a time, or at obvious elevation breaks, while the transit records all data. If there is a sharp change in the channel grade, position the stadia rod at closer increments so the change can be captured in the transit readings.
7. Continue upstream until the road/structure is reached noting visible changes in the channel such as a sandy bottom, muddy bottom, rocks etc.
8. Once at the structure, get a reading at the outlet invert. Note height of top of pipe/structure above the invert as well as water depth. On top of the road, survey the road crown height (typically in the road center). Go to other side of the structure and get the same measurements working upstream.
9. Continue up the channel using the same method as before making sure to stay in the thalweg and measure visible changes in elevation.
10. At a minimum, observer continues measurements until the first cross section upstream (typically, Station 2). Once recorder is unable to take a reading through the auto level, the profile is done.

2. Longitudinal Profile

Purpose

Thissection describes how to survey the longitudinal profile of the channel thalweg at your monitoring reach. It iden tifies the equip ment needed, outli.nes the basic protocol, discusses the frequencywith which the profileshou.ld be re<>urveycd, and presents any site-specific cons iderations. *As* with the monumented cross-section method (seeSection Iv.B.1), thissection does not provide detailed instruction on basicsurvey-ing techn iques. See Harrelson et al (1994) for a more complete treatment of thiss ubject.

Minimum Equipment

- D Automa tic level [s urveyor' s leve ll. l ase r l evel, or total s tation
- D Leveling rod in Englis h Ito te nths a nd hun d re dthsl or metr ic units, prefe ra bly 25 - foot leng th
- D Meas urin g tape in same units [300 ft or 100 ml
- D Field bookwith waterproof pa per
- D Oa ta s he ets [see Appendix El
- D Pe ncil
- ☐ **Permanent marker**
- D Tw-o way rad ios
- D Topographic maps and/or aerial photographs
- D Chaining pins
- D Flagging tape
- D Machete
- D Wood s urvey s takes
- D Sma ll s ledge or malle t
- D Spr ing clamps
- D Compass

Monitoring Design

Sampli ng Protocol

1. D efine the n10n itoring reach.

This must be al'ᐸOmplished before s urveying the lon1:r,itudinal profile and the cross,seL ions . SeeSec• tion TY.B.1 for genre aJ g ui de! ines. You.r longi tudin al profiles hould extend the len1:>,th of the monitoring reach, bei:,rinning at a st able ch annel featu.re (e.g, riffle) u pstream of the impoundment. Your profile should always bCbrin u pstream of the uppermost,cr·,ss-sa ion **and sho uld con tinue to the Jo, ..•,ermost cross-section and include s urvey shots at the tha)weg of a11 m onu • men ted ᐸT0SS-Sections.**

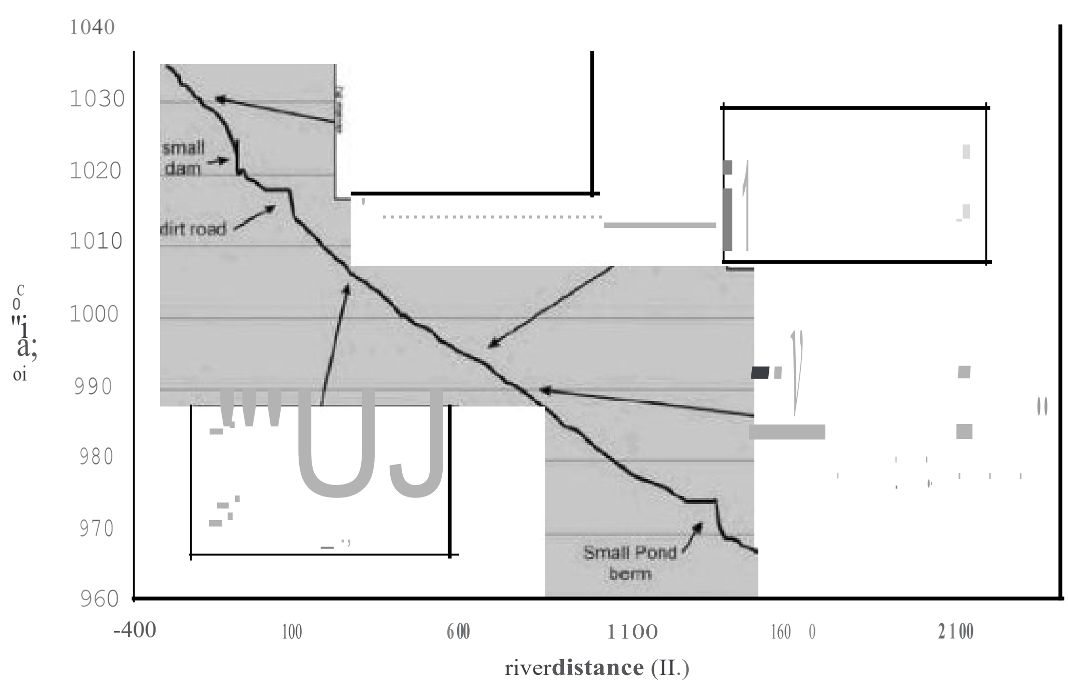

Figure 3. A longitudinal profile s urveyed pre•proj@ct a t Kamrath Creek, Wisco nsin. The s urvey points for a channel bed longitudinal profile are taken at the deepes t point in the channe l, i.e.. the thalweg [see Figure 21. **Profile pbt courtesy of Brian Grabᐸt.**

2. Set up the ,,;;un rey in,;;t111n1ent

If possible, se t up the level in a location from which **the benchmark, and as much of the monitoring reach** as possible, is visible (SeeSe<. ion IY.B.1, step *4,* forin- **formation on benchmarks). You may want to consider setting up the instrument in the channel, if the flow** and bed conditions permit (Harrelson et al., 1994). **Choose instrument locations carefully to minimii.e the number of timesyou need to reposition.**

3. £5tablish the .5tationing.

Downstream distance should be measured along the channel thalweg. A straightfonvard method is to sta· **tion the channel with a baseline alongone bank. The downstream distance of each survey shot is measured** as the rii,>ht-angle projec ion from that location to the baseline on the bank.

The baseline can be established by two people measu-r **ing along the stream thalweg with a tape, while some-one on shore drives, and clearly marks, wooden sur•** vey stakes at rei,,ular intervals (commonly a channel width). The purpose of the stationingstakes is to make **estimating distances easier. They do not necessarily** mark the locations ofac ual survey shots.See Harrel- son et al. (1994)for further information on stationing. Using a total station with a GPS interface, if available, **can make stationing unnecessary and considerably** simplify profile completion. These units can "fix" the **horizontal position of surveyshots in known datums** such as NAO 83 for subsequent plotting in GIS and **calculating distances. Total stations and laser levelsare** also advanta1,>eous for profile surveys because of the long distances over which they can obtain shots (Simon and Castro, 200'J).

4. Su,n ey the pivfi/e.

Begin with a rod reading on the benchmark to deter- mine the height of the instrument (HI) (see Se<. ion IY.B). Then take readini,rs along the thalweg (ie., deep- est part of the channel) at important bed features (e.g., pools, riffles, bedrock sills, woody debris), measu-r ing downstream distance U5ing the baseline. Include enough shots to well define each feature (Simon and Castro, 20<YJ). I t is particularly important to determine the highest elevation at poe l riffle (and/or run) transi- **tions.**

Along with distances and elevatiol\5, record in the field **book** details about the feature being measured and the locations of important changes in substrate type. Also, **take elevations of the water surface at each bed eleva •** tion measurement. This can bedone easily by taking **the elevation of the water's edge closest to the thalweg** along the proje<. ion to the baseline. Move the instr u- ment as needed to complete the profile.

Sampling Frequency

A<,; with the cross-section surveys, a pr-eremoval lon- gitudinal profile may be accomplished most easily **during an impoundment draw-down and should be** intei,..-ated with any planned feasibility work (see Site Spedfic Considerations below). As a 1,,eneral 1,,uideline, **po-stremoval re-surveys should <><."<.'Ur annually , or ev-** ery other year, for at least 5 years. However. sa mpling frequenc-y and duration should reflec projec objec- **tives and site conditions. At a minimum , the frequency should conform to regulatory requirements. Note that** follow up surveys should trace the post-barrier removal thalweg, which may not be in the same horizontal posi- **tion as the pre-removal thalweg.**

Site -specific Consi de rati ons

A portion of the pre-removal longitudinal profile will run through the impoundment. A5 with the cross-sec- tions, this may require a boat and should be done with great care.See SiteSpedfic Considerations under Sec- tion IY.B.1 **for general bruidelines and considerations.**

Analysis and Calculations

The data from a longitudinal profile survey are eleva- tions and distances. Horizontal distances are recorded to tenths of feet (0.1 ft) and elevations of benchmarks and turning points to hundredths offeet (0.01 ft). Profile elevatiol\5 are recorded to hundredths of feet as well These data should be recorded in standard, level survey notation (see Longitudinal Profile Survey Data Sheet in Appendix E). Harrelson et al (1994)also provide a nicegraphic example of proper field book notation for level surveys. The horizontal and vertical datums of the survey must always be recorded (see Site Lnformation Data Sheet in Appendix E). The distances and elevations can be plotted manually on graph paper as •x· and 'y' coordinates, respectively, or brought into a spreadsheet program for plotting and analyses (Figure 3).

Additional Information

Harrelson et al (1994)is an excellent reference for basicsurvey techniques and for specific information on conducting cross-section and longitudinal profile re-surveys. We strongly recommend that readers with minimal experience consult this reference It also pro- vides a useful review for those with more experience

APPENDIX H:
CBEP Total Station SOP

Added to QAPP: March 2025

Modified from: *Total Station Stream Surveys: Standard Operating Procedures* (Doose *et al* 2016)

Prepared by: Matt Craig, CBEP

Note: These instructions assume that the total station (TS) instrument is tying in to existing control points (benchmarks) established using RTK GPS through a <u>RESECTION</u> process, which differs from the USFWS methods, which establish locational data in the field.

Office Prep

- Charge TS batteries using plug in charging unit
- Charge Carlson controller by plugging in the unit & manually correct time on unit if needed
- Use total station (TS) checklist to assemble equipment and supplies (below)
- Preload benchmark information (below)

Uploading Benchmarks

- Turn on Carlson controller, power button lower right corner
- Use stylus to click on File Explorer
- Navigate in Explorer to LS site folder (e.g., “LS_WP” for Wharton Point)
- Once inside the site folder, click “Menu” then create “New folder”
- Click keyboard icon
- Rename folder with the date (e.g., “2020.07.20”)
- Close out of File Explorer
- Open SurvCE, icon lower right
- When prompted, click “Select new/existing job”
    - Use stylus to double-click Program files ➔ SurvCE ➔ Data
    - Double-click location (e.g., “LS_WP”)
    - Double-click folder with correct date (e.g., “2020.07.20”)
    - Bottom of screen, type in Job name
    - Confirm Job is set correctly (back out to File ➔ Job)
- Once Job is confirmed correct, go back out to File ➔ Points
    - Click “Add” (lower right corner)
        - Point ID is automatically sequenced (1, 2, 3, etc.)
        - Enter predetermined Northing, Easting, and Elevation in meters
        - In Description, use predetermined name (e.g., “WPBM01”)
            - Note which Point ID is assigned to which BM ID for use in field (typically, Point ID 1 is BM01, e.g., Point ID “1” = “WPBM01”)
        - Click green checkmark
    - Repeat for other benchmarks
    - When all benchmarks have been entered, click orange back arrow icon upper right
    - Points have been automatically saved, you can exit SurvCE and turn off controller

Equipment Checklist – Total Station Surveying

- Leica red protective hard case, with contents
  - Leica TS-07 total station
  - Two Leica batteries
  - Lecia battery charging station w/ two sets of cords (AC & auto)
  - Leica instrument height meter tape w/ black plastic mounting bracket
  - Carlson/Juniper Archer2 handheld controller/data collector
- Sokkia tripod (yellow)
- SitePro prism pole (red & white in yellow case; flat foot in pocket.)
- Prism (in orange protective case)
- Tape reel with 10” large nail
- Data on prior year’s station locations
- Compass
- GPS (yellow Garmin), spare AA batteries
- Digital camera
- Walkie-talkies or cell phones to communicate at long distance
- Blue painters tape to secure rubber foot to prism pole
- Fold-rule or retractable tape as backup for instrument height
- Data sheets
- Field notebook to record other survey notes, pencil
- Brush axe to clear branches and clear view b/t TS and prism
- Nail for use as temporary occupy station marker (may be in red TS case)
- Hammer, wooden stakes & magnails
- Flagging, spray paint
- 5 g. bucket

Set Up the Total Station and Prism Pole

1. Choose a location to set up centered between control points to optimize triangulation. (The set up location is referred to as "OCC1" [e.g., occupation point 1] in the controller). Set a temporary marker (nail) in ground so that marker is flush with ground surface.
2. Center tripod over nail, and roughly level the tripod, without forcibly driving the legs into the ground surface. Extend legs to height that, together with TS, will result in a comfortable height for the person operating the TS for sights in all directions.
3. Place battery in TS. Rotate black handle vertically to open battery door on left side of TS as you face the TS keyboard. Slide out. Secure battery in door w/ gold plates facing up and in. Reattach.
4. Attach TS to the tripod.
5. Turn on TS to activate the laser plummet. (If the level function does not appear initially, press "cont" (F4 softkey) to move past warning screens about calibration.)
6. Adjust tripod to center on the high point of the pin using vertical level on base of TS. Drive tripod legs in for stability.
    a. Adjust the tripod legs up and down to coarse level the TS using the circular bubble level on the base of the unit until the black dot appears in the levelling screen.
    b. Loosen the TS mounting screw and slide the TS so that the laser is exactly on the benchmark.
    c. Turn the TS so that the screen is parallel to two of the foot screws.
    d. Use arrows on the screen to finish the leveling process, using the foot screws for slight adjustments.
    e. Gently move the TS to finalize laser position on the pin, and make final adjustments to level, then accept level settings by pressing "cont" (F4) softkey.
7. Use fold rule or retractable tape to measure "Height of Instrument" from nail (OCC1) high point up to the level mark on the side of the TS (marks are the raised horizontal lines at the height of the lens, and next to "Leica" logo on both sides of TS). Record "HI" for that occupy point.
8. Set up prism pole.
    a. Choose foot for the pole (flat rubber protective foot, pointed metal foot, or heavy, large, round flat metal foot). Note foot on data sheet.
    b. Screw prism firmly onto top of pole.
    c. Measure the distance from the base of the pole to the center of circle on back of prism. Default pole height is 1.58 meters.
    d. **Make sure that the height reflected on the prism pole matches the actual height of the prism.** If distance is not 1.58 meters, adjust upper end of pole using gold knobs. Re-measure and continue to adjust as needed. Screw gold knobs tight when set.
    e. Once finished, check to be sure that the locking knobs are tight to the base of the prism and pole to reduce unintentional shifting.

Set up the Carlson Controller

1. Turn on Carlson controller by pressing power button on lower right
2. Ensure Bluetooth is on. Below Bluetooth icon should say, "on". Click icon to turn on. (Connecting to Wifi is not necessary).
3. Using the stylus, click on SurvCE icon
4. Click on "Select New/Existing Job"
5. TIP: If needed, ensure correct job (folder, file) is selected. (File tab, 1 Job). Toggle through Windows Extension folder system by using folder/green arrow icon to go up, and double clicking to go down.

Pull up the correct location (e.g., "LS_MBCL", "LS_LANES", or "LS_WP", then date) then the correct date (e.g., "2020.05.20"). Click on the file name for the survey (e.g., ("LANES PRE.crd").

6. Click the green check box to continue.
7. If prompted, press "Connect" to connect the Carlson unit to the TS.
8. In SurvCE window, click "Survey" tab, then "7 Resection"
9. Provide Point
10. Click on green check box to create the file and continue.
11. Accept defaults in "Job Settings" and click on the green check box to proceed.
12. Accept defaults in the "Point Coordinates," making sure the description reads "OCC 1"
13. Connect to last BT (BlueTooth) Device
14. Click on the "Survey" Tab
15. Click "Store Points" and wait for the controller to connect to the TS

Resection Process

Click resection
Ensure Instrument height is correct
Ensure prism height is correct
Put prism rod on existing control (ID set ahead of time)
Enter correct Point ID in controller – click on number icon (1, 2, 3).
Select correct point (e.g., "2"). Controller should pull up previously entered data for N, E, and Z.
Focus TS on the prism and hit "Read".

Repeat with other control points.

Then, once all controls have been surveyed, hit "CALC". This will provide the location and elevation of OCC1, where you are set up.

Survey can now begin.
Keep track of information on the data sheet.

Data Download

1) With thumb drive connected to computer, use Windows Explorer to create a folder (e.g., "TS Data")

2) Insert thumb drive into the Carlson Mini2 data collector

3) Open the Job that you are working on in SurvCE

4) Tap File / Import_Export / Export Ascii File and tap the Green Check twice to create a text file. Then tap OK to return to the main menu.

5) Once your back at the main menu = tap File / Data Transfer

6) Tap "Set Storage"

7) Navigate to the "Hard Disk" folder by tapping the "Up Folder" icon in the top middle three times (or until you see "Hard Disk" listed as a folder) then double-tap to open the \Hard Disk\ folder and tap on the "TS Data" folder you created

8) Tap the Green Check to set this as your destination folder

9) Now you can tap "Copy Current job to Folder" and it will transfer all the necessary CRD / RW5 and all other job files to the USB thumb drive

10) Plug in your USB flash drive to your laptop or desktop computer

11) Copy the files from the "USB Data" folder on the flash memory drive into a folder on your computer

These are the steps for transferring Points into the Data Collector:

1) Create a comma separated Ascii Text file and copy it to your USB Thumb Drive

2) Connect the USB Thumb Drive to your Mini2 data collector and Run SurvCE

3) Open the Job or start a new Job where you want the points loaded into

4) Then tap File / Import_Export / Import Ascii File

5) Tap "Select File" in the top right

6) Tap the "Up Folder" icon in the top middle a few times until you see "Hard Disk" listed as a folder

7) Double-tap "Hard Disk" then tap on the Text file you created in Step #1 and tap the Green Check twice to import the points into your Current CRD coordinate file

Parker Caswell
Casco Bay Estuary Partnership
June 11th, 2021

Converting (X,Y,Z) Data from Total Station to ArcMap Point Files

This is a basic overview of how to convert data output by the Total Station to point files in ArcMap 10.8. Once a point file is created with the appropriate elevation cataloged, it can then be used to create a DEM raster, topographic contour lines, or other 3D spatial data.

1.) Use the Carlson Controller or TS to determine the coordinate system the data is in. As of 6/11/2021, NAD 1983 UTM Zone 19N seems to be correct.
2.) Reorganize the data from the Total Station (TS) so that there are 3 columns with simple character (only letters and numbers, NO SPACES) headings. These should read "Northing", "Easting", and "Elevation" or something similar. Save this file to a local or network location with a title that distinguishes it from the raw TS data.
3.) Open ArcMap 10.8. Set the data frame coordinate system to NAD 1983 UTM Zone 19N
4.) Add a folder connection in ArcMap to the location that the reorganized TS data is stored.
5.) Use the search function to find the tool "Excel to Table". Run this tool on the reorganized TS data.
6.) Once the table is created successfully (will fail if there are spaces in the data), navigate to File>Add Data>(X,Y) Data. Set the X as "Easting" and the Y as "Northing". Optionally set the Z as "Elevation" depending on what method will be used to convert from (X,Y) data to (X,Y,Z) data in the future.
7.) Run the "Add Data" function and add a base map to confirm the location of your dataset.

Parker Caswell
Casco Bay Estuary Partnership
July 6, 2021

Creating a 2D Profile from Total Station UTM Data

Description:
This is a basic set of steps to convert a table of (X,Y,Z) UTM data from a total station to a two dimensional "flattened" cross section in Microsoft Excel. It is not recommended to use this method on data that is not purposefully collected in a straight line or cross section, because horizontal flattening of one axis occurs when converting the distance between points to a standardized "distance from zero". This conversion is necessary to display three dimensional data in two dimensions, and the margin of error is very low when data is collected along a physically marked transect such as a tape between two marked points.

The basic geometry used in this method was adapted from a thread on a public Mathematics forum on Stack Exchange, which explains how to calculate the distance between two points in UTM using the simple euclidean distance equation referenced in Step #4. The link to this forum and other information about simple euclidean distance calculations has been provided in the references.

Steps:

1. Import TS data in NAD1983 Zone 19N as an Excel file
2. Format and clean up data on a new sheet by copying "Northing, "Easting", and "Elevation" columns, taking care to remove the points noted as benchmarks and occupation points
3. Add a columns to the new sheet called "Distance" and "Distance from Zero"
4. Set the distance column to calculate the distance between consecutive UTM points by using the formula where the first point is (E 1 ,N 1), and the second point is (E 2 ,N 2), then populate this column by dragging.
5. Add each of these consecutive distances together to fill the "Distance from Zero" column, and populate it to show consecutively increasing distances
6. Plot "Distance from Zero" on the X-Axis and "Elevation" on the Y-Axis on a scatter plot.

References

https://math.stackexchange.com/questions/738529/distance-between-two-points-in-utm-coordinates

https://mathworld.wolfram.com/Distance.html

7. TOTAL STATION SET UP – FIELD FORM

LIVING SHORELINES SITE INFORMATION

Site Name:		**Date/Time:**		**Station #:**	
Purpose:					
Weather:					
Carlson Folder Location:			**File Name:**		
Location re. benchmarks:	***Strive to triangulate between 3 benchmarks. Center the TS within the triangle.***				

OBSERVERS

Total Station	**Prism Rod**	**Other**

Location	**Northing**	**Easting**	**Photo #**
Set up location (GPS)			
Secondary set up (if applicable)			
Benchmark: ___________			
Benchmark: ___________			
Benchmark: ___________			
Calculated location of OCC1			Elevation (m):

SET UP INFORMATION

Height of instrument (m) at OCC1:		**Measured rod height at start (m):**	
Foot used on prism pole (circle one):	Rubber foot / round metal foot / pointed metal foot		

Notes:

APPENDIX I:
USFWS Total Station SOP

Added to QAPP: March 2025

TOTAL STATION STREAM SURVEYS: STANDARD OPERATING PROCEDURES

Serena Doose
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4/28/16

Gulf of Maine Coastal Program
U.S. Fish and Wildlife Service

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PURPOSE

The purpose of this Standard Operation Procedure (SOP) is to establish a set of uniform procedures for using a Leica TS06 Total Station to conduct surveys at potential stream restoration sites. Total station surveys are conducted over many hours in a variety of field conditions. Having standardized procedures will enable field crews to minimize error and maximize efficiency, resulting in consistent, reliable data as a foundation for high quality restoration designs.

BASIC EQUIPMENT

- Leica TS06 Total Station
- Juniper Archer2 Data Collector
    - Carlson SurvCE v5.06 data collection software
- Juniper Geode GNSS (GPS) receiver
- Tripod
- Prism pole(s)
- Prism(s)
- Compass
- Digital Camera
- Radios
- Tape or ruler to record instrument height
- Small waterproof notebook to record survey notes
- Benchmark materials - rebar with caps, magnetic nails, spray paint
- Spray paint/flagging
- Wooden stakes for use as temporary benchmarks/occupy station markers
- Hammer and brush axe

See Attachment 2 for more a more comprehensive equipment checklist.

LEVEL THE TOTAL STATION

1. Choose a suitable location for the total station (TS) to begin the survey (referred to as "OCC1" or the first occupy point), and use a stake/nail/etc. as a temporary station pin.
2. Set tripod over the pin, roughly level.
   Note: *Make sure the setup height will be a comfortable height for the person operating the TS for sights in all directions.*
3. Attach the total station to the tripod.
4. Turn on the total station to activate the laser plummet. If the level function does not appear initially, press "cont" (F4 softkey) to move past warning screens about calibration.
5. Adjust tripod to place laser on the high point of the pin. Drive tripod legs in for stability.

a. Adjust the tripod legs up and down to coarse level the TS using the circular bubble level on the base of the unit until the black dot appears in the levelling screen.
b. Loosen the TS mounting screw and slide the TS so that the laser is exactly on the benchmark.
c. Turn the TS so that the screen is parallel to two of the footscrews.
d. Use arrows on the screen to finish the leveling process, using the footscrews for slight adjustments.
e. Gently move the TS to finalize laser position on the pin, and make final adjustments to level, then accept level settings by pressing "cont" (F4) softkey.

See <u>Attachment 1</u> for more detailed instructions and diagrams for leveling procedures from the Leica TS06 Plus manual.

ADDITIONAL SET-UP

1. Measure "Height of Instrument" from pin high point up to the level mark on the side of the TS. Record in field notebook as "HI" for that occupy point.
2. Mount the prism firmly on the pole.
    a. Measure the distance from the base of the pole to the center of the prism. Default height is 5.3 (feet).
    b. If distance is not 5.3, adjust by rotating the prism up or down, locking it in place with the black knob. Re-measure and continue to adjust as needed.
        Once finished, check to be sure that the locking knobs are tight to the base of the prism and pole to reduce unintentional shifting.

START A NEW JOB (SURVEY FILE)

1. Turn on Carlson data logger by pressing power button on lower right
2. Using the stylus, click on SurvCE icon
3. Select "new/existing job"
4. Create a new folder and/or rename the file at the bottom by clicking in the "Name" box. Then click the green check box to continue.
5. Click on green check box to create the file and continue.
6. Accept defaults in "Job Settings" and click on the green check box to proceed.
7. Accept defaults in the "Point Coordinates," making sure the description reads "OCC 1"
8. Connect to last BT (BlueTooth) Device
9. Click on the "Survey" Tab
10. Click "Store Points" and wait for the data logger to connect to the TS

SET UP GEODE FOR RECEIVING GNSS DATA

This procedure sets the real-world coordinates of the survey.

1. Turn on Geode; lower green light should turn on.

2. Place the Geode directly on top of the pin, supporting it with materials at hand (rocks, wood, hammer, etc.) so that it is approximately centered on the pin.
3. If possible, best Geode reception will be provided by a higher placement of the unit, such as perched on the top of the TS, so finding a way to configure such an attachment should be a priority at some point.
4. In SurvCE, go to settings for GPS Rover by either clicking the TS button in the upper right, and selecting GPS Rover, or go to the Equipment tab, then click the GPS Rover button. Either step will connect the data logger to the Geode via Bluetooth.
5. Click on the Survey tab, and then the Store Points button to begin storing the survey's first point based on the Geode, which will provide the starting point of XYZ coordinates of that pin location based on the current satellite configuration. Accuracy may be in the range of 3-5' horizontal and 5-8' vertical with 15-16 satellites available, which is within acceptable thresholds for the accuracy of our stream surveys. Note that the *relative* accuracy of points to each other is highly accurate based on the precision of the TS, but the real-world location of those positions will be less accurate, but generally sufficient for us to plot the points with existing GIS data layers for mapping purposes.
6. Click on the "A" button to average a set of GNSS points. The averaging dialog comes up to show a default of 300 points, which generally takes approximately five minutes at one point per second. Press the green check button to start averaging.
7. The position has been taken when you see a final averaged position, along with statistics on its accuracy. Click the green check button to proceed.

SET TRUE NORTH

*Now we need to set the orientation of our survey by determining **true** north as a "backsight".*

1. Determine magnetic north with a compass. In most of Maine, true north is approximately 16° east of magnetic north (negative/west variation/declination).
2. Direct the rod person to true north (16° on compass), using the cross-hairs in the scope, making sure the prism pole is plumb, and at least 20 feet away.
3. Sight the prism through the TS (using the vertical and horizontal side adjustment knobs and the middle focus ring).
4. On the data logger, you will see the "Remote Benchmark" screen
    a. Only three fields need to be completed:
        i. Instrument Height= Height of Instrument previously recorded
        ii. Backsight Point = 2 (this is the "Point ID")
        iii. Backsight HT= Height of Prism Pole (usually 5.3' to start)
5. Click on "Backsight" to continue
6. Click on "Set Angle and Read"
7. Once the sight has been completed, click the green check box to continue
8. Store Point as Point 2, Description = "NORTH"
9. Click on green check box to finish.
10. Verify on the map screen that the points make sense in terms of direction, distance and elevation.

BEGIN SURVEYING

For most efficient surveying, determine who will be on the TS and who will be the rod person. The rod person must be familiar and experienced with accurately determining landscape and channel features.

1. Before taking the first survey point (Point ID = 3), check to make sure you are using the proper feature code list: "FLIST"
    a. Go to the "File" tab on the data logger
    b. Click "Feature Code List"
    c. Verify the code list name as "FLIST"
        i. If not, click "load" to search for the proper file and click the green check box to continue.
2. Once you are ready to start your survey, have the rod person locate the first topographical/ in-channel feature for which you'll record elevation (e.g., top of riffle; note that we normally begin collecting thalweg ("TW") points)
3. **When the rod person changes the height of the rod, they MUST inform the TS operator immediately.**
    a. The TS operator will change the number in the HT box on the lower right corner of the screen.
    b. **Note:** *When the rod person changes the rod height, it is **critical** that they tell the TS operator in order to prevent elevation errors that will be compounded throughout the survey. The TS operator must orally confirm by repeating the new rod height back to the rod person. If the rod person doesn't hear the TS operator confirm, they must repeat their efforts. Conversely, if the TS operator initiates the change in prism height, the rod person must confirm the change orally.*
    c. <u>This is the most common opportunity for errors during TS surveys.</u>
4. The rod person will hold the prism as steady and plum (vertical) as possible.
5. The TS operator will use the crosshairs to sight the prism through the TS.
6. Press "S" to store the reading on the data logger.
   Note: "R" will take a reading, but will not store the data.
7. On the following screen, change the description code as needed (TW, RDE, etc).
    a. **Note:** *Use the dropdown list to choose your code. Do not type in the code.* This will ensure that the point you take remains tied to the pre-made code list, where certain codes are assigned as either points or polylines.
    b. See Attachment 3 for the official list of codes
8. Click the green check box to store the point.
9. You may now take your next point, following the same procedures. As you proceed, you will see your points appearing on the map. This is a good way to visually check your work, particularly when changing occupy stations. You should also notice that points which are meant to be connected with lines, such as Thalweg (TW) shots should be connected. The more you continue taking points with the same code and rod height, the faster, more efficient and accurate your survey will be.

COMMUNICATION

- Distance and noise from fast running streams or traffic make effective communication over the course of long survey days very important.
- Use the radios to relay information: more communication is better to prevent errors in the field, but efficient communication is best accomplished by using consistency and clarity.
- Use hand signals if verbal communication takes too much time or is not possible due to other factors. Discuss these beforehand with your survey crew.
- If a third person is stationed solely on the data logger, the TS operator (TSO) and the data logger operator (DLO) should pre-determine which words to use for communication to reduce confusion and potential for error.
    - TSO: *Once prism is sighted, tells DLO*: "OK" or "Ready"
    - DLO: A*fter point is read and stored, tells Rod Person:* "Good" or "Got It"
        - This allows the rod person to move on to the next feature as quickly as possible.
        - If TSO and DLO use the same word meaning different things, the rod person may misunderstand and move before the point is stored.
- The rod person must tell the TSO immediately after changing the rod height. The TSO (or DLO if applicable) must orally confirm by repeating the new rod height back to the rod person. If the rod person doesn't hear the TSO/DLO confirm, they must repeat their efforts until confirmed.

MOVING OCCUPY STATIONS

If you need to move the TS to acquire more features not visible from the current occupy point (e.g., moving downstream), you will need to identify and then shoot to the new occupy location before moving, and then shooting back to the previous station.

Note: Never move the tripod and TS without first shutting down the TS, removing it from the tripod, and storing all components in their carrying case. Always carry TS in carrying case.

1. Determine a new location for the TS where you will be able to see the next group of shots, but will also be able to see your previous location.
2. Stake the new location with a temporary station pin over which you will be able to set up the tripod and TS.
3. Set the prism on the new pin and shoot that location. (This is the foresight.) Description will be "OCC2" (etc.) for a new setup.
4. Record in the field notebook the point number (Point ID) for both your first occupy station and the new occupy station (e.g., OCC1 = 1 and OCC2 = 50).
5. Shut down the TS (hold down red power button on unit), remove from tripod and store in carrying case. It is not necessary to turn off the data logger.
6. Move to new occupy point, set up, turn on and level the TS. Measure and record the new instrument height (HI).
7. Click on the tripod icon in upper right of the screen.
8. Enter your new Occupy Point ID (e.g., point 50) and new Instrument Height.
9. Enter your backsight point (e.g., point 1) and Target Height (rod height).
10. Click on "backsight", and confirm that the TS icon on the map page has moved to your new occupy station, and is connected back to the previous occupy station by a

line. You are now ready to continue surveying from your new position. The temporary station pin at the previous occupy point can be removed if you are sure you will not need to return to that station.

OTHER DATA TO COLLECT

1. Before leaving, place three benchmarks and record type (capped rebar, magnetic nail or paint mark on immovable rock), location and other details in the field notebook, and take photos of each to help locate in the future. These benchmarks allow us to return to the site for additional survey, or as reference points for construction locations and elevations.
   - Make sure the benchmarks are located in a triangle (ideally equilateral) in relation to each other, as opposed to in a line, and best separated by 50-100'.
   - Don't place benchmarks where they may be disturbed by future snow plowing, road grading or construction.
   - Do place benchmarks where you can set up during construction and still see the construction area.
2. Record the benchmarks on the site map and take note of any utilities (include pole #s), driveways, houses, etc.
3. Take photos of the crossing (inlet, outlet, views upstream and downstream) and any cross-sections (upstream, downstream, and toward each overbank area).
4. Conduct substrate assessments as needed.

BACK IN THE OFFICE

- If any unit has gotten wet during your survey, be sure to open up the case(s) and remove to air dry after surveying.
- Charge the TS batteries, the data logger, Geode, and the radios
  - The charging station is located on the table to the immediate right as you enter the copy room.

DOWNLOADING DATA

1. Total Station Data Logger survey files:
   a. Export all feature 3D lines (and points if wanted) as ESRI Shapefiles:
      i. Open each file, and go to *Map View* (globe symbol in upper right)
      ii. Select *SHP File* from FILE menu, then *Export SHP File* (w/o projection)
      iii. Press *Select New SHP*, and accept default name
      iv. Press check mark (OK), and accept points and arcs without GIS data
      v. Back out with orange arrow keys to select each next file in turn, and follow above steps for each additional survey file
   b. Export each survey file (*.crd) as a TEXT file:
      i. Open each file, and go to *Import/Export*
      ii. Select *Export ASCII File*, using the default settings, and clicking the check button, then *OK*
      iii. Check to be sure all expected jobs/sites have associated *.txt files

2. Use one of two methods to download survey data from logger:
    a. Plug in logger to workstation, wait (possibly several minutes) until Windows Mobile Device Center opens and shows device is connected (but know that the Mini-B USB slot on the logger may have problems, so otherwise, follow next method),
        i. Navigate in Windows on the workstation to locate the files on the logger: Progam Files\SurvCE\Data\(town or other folder)
        ii. Copy all files to appropriate location on workstation
    b. Connect a flash drive to the USB slot, then navigate to Progam Files\SurvCE\Data\(town or other folder),
        i. Copy all files to appropriate location on the flash drive (which shows up as "Hard Disk", then transfer them to the workstation.
        ii. This usually requires copying all files using the *Menu* > *Select Files* > All, then *Menu* > *Edit* > *Copy* command, then creating a new folder (*Menu* > *New Folder*), in the *Hard Disk* (thumb drive) folder in File Explorer on the logger using the *Menu* > *Edit* > *Paste* command.

REFERENCES

1. *3.4.2 Total Station Data*, RIVERMorph, LLC. 2001-2012.
2. *Total Station Cheat Sheet*, California State University Monterey Bay. 23 January 2013. http://hydro.csumb.edu/essp%20495/html/totsta.html.

ATTACHMENTS

1. Leveling procedures from Leica TS06 Plus manual
2. Equipment Checklist
3. Feature Code List

ATTACHMENT 1: Leveling procedures from Leica TS06 Plus manual

3 Operation

3.1 Instrument Setup

Description

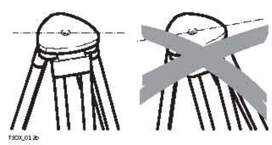
This topic describes an instrument setup over a marked ground point using the laser plummet. It is always possible to set up the instrument without the need for a marked ground point.

☞

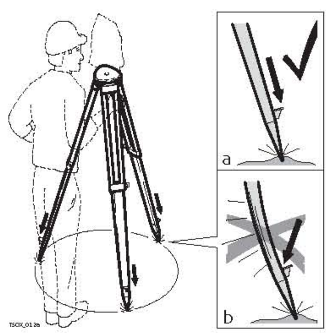
Important features

- It is always recommended to shield the instrument from direct sunlight and avoid uneven temperatures around the instrument.
- The laser plummet described in this topic is built into the vertical axis of the instrument. It projects a red spot onto the ground, making it appreciably easier to centre the instrument.
- The laser plummet cannot be used with a tribrach equipped with an optical plummet.

Tripod

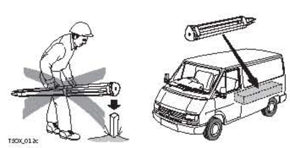


☞ When setting up the tripod pay attention to ensuring a horizontal position of the tripod plate. Slight corrections of inclination can be made with the foot screws of the tribrach. Larger corrections must be done with the tripod legs.



Loosen the clamping screws on the tripod legs, pull out to the required length and tighten the clamps.

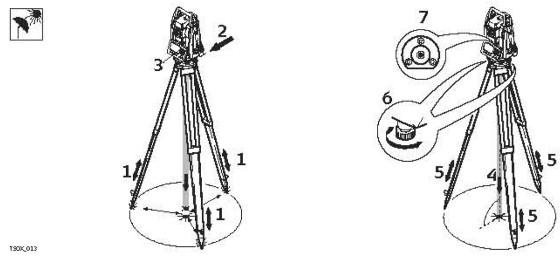
a) In order to guarantee a firm foothold sufficiently press the tripod legs into the ground.
b) When pressing the legs into the ground note that the force must be applied along the legs.



Careful handling of tripod.

- Check all screws and bolts for correct fit.
- During transport, always use the cover supplied.
- Use the tripod only for surveying tasks.

Setup step-by-step



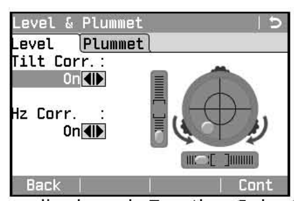
1. Extend the tripod legs to allow for a comfortable working posture. Position the tripod over the marked ground point, centring it as best as possible.
2. Fasten the tribrach and instrument onto the tripod.
3. Turn on the instrument, and, if tilt correction is set to **On**, the laser plummet will be activated automatically, and the **Level & Plummet** screen appears. Otherwise, press the FNC/Favourites key from within any program and select **Level & Plummet**.
4. Move the tripod legs (1) and use the tribrach footscrews (6) to centre the plummet (4) over the ground point.
5. Adjust the tripod legs (5) to level the circular level (7).
6. By using the electronic level, turn the tribrach footscrews (6) to precisely level the instrument. Refer to "Level up with the electronic level step-by-step".
7. Centre the instrument precisely over the ground point by shifting the tribrach on the tripod plate (2).
8. Repeat steps 6. and 7. until the required accuracy is achieved.

Level up with the electronic level step-by-step

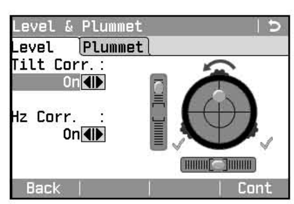
The electronic level can be used to precisely level up the instrument using the footscrews of the tribrach.

1. Turn the instrument until it is parallel to two footscrews.
2. Centre the circular level approximately by turning the footscrews of the tribrach.
3. Turn on the instrument, and, if tilt correction is set to On, the laser plummet will be activated automatically, and the **Level & Plummet** screen appears. Otherwise, press the FNC/Favourites key from within any program and select **Level & Plummet**.

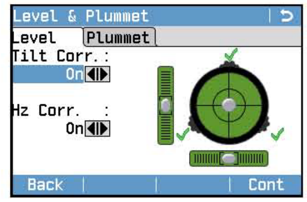
   ☞ The bubble of the electronic level and the arrows for the rotating direction of the footscrews only appear if the instrument tilt is inside a certain levelling range.
4. Centre the electronic level of the first axis by turning the two footscrews. Arrows show the direction of rotation required. The first axis is levelled, when the bubble is exactly between the squared brackets [] of the single axis bubble tube.



   ☞ When levelled correctly, checkmarks are displayed. For the Color&Touch display only: If the instrument is not levelled to one axis, then the icons for the single axis bubble tube and the circular bubble are framed red, else they are black.
5. Centre the electronic level for the second axis by turning the last footscrew. An arrow shows the direction of rotation required.



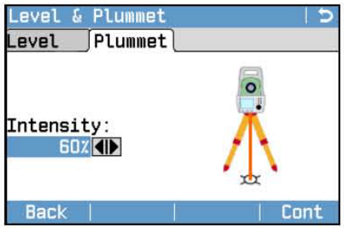
☞ When all three bubbles are centred, the instrument has been perfectly levelled up.



6. Accept with **Cont**.

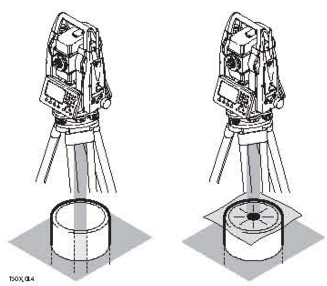
Change the intensity of the laser plummet

External influences and the surface conditions may require the adjustment of the intensity of the laser plummet.



In the **Level & Plummet** screen, adjust the intensity of the laser plummet using the navigation key.
The laser can be adjusted in 20% steps as required.

Position over pipes or holes



Under some circumstances the laser dot is not visible, for example over pipes. In this case, using a transparent plate enables the laser dot to be seen and then easily aligned to the centre of the pipe.

3.2 Working with the Battery

☞

Charging / first-time use

- The battery must be charged prior to using it for the first time because it is delivered with an energy content as low as possible.
- For new batteries or batteries that have been stored for a long time (> three months), it is effectual to make only one charge/discharge cycle.
- The permissible temperature range for charging is between 0°C to +40°C/+32°F to +104°F. For optimal charging we recommend charging the batteries at a low ambient temperature of +10°C to +20°C/+50°F to +68°F if possible.
- It is normal for the battery to become warm during charging. Using the chargers recommended by Leica Geosystems, it is not possible to charge the battery if the temperature is too high.

Operation / discharging

- The batteries can be operated from -20°C to +50°C/-4°F to +122°F.
- Low operating temperatures reduce the capacity that can be drawn; very high operating temperatures reduce the service life of the battery.
- For Li-Ion batteries, we recommend carrying out a single discharging and charging cycle when the battery capacity indicated on the charger or on a Leica Geosystems product deviates significantly form the actual battery capacity available.

ATTACHMENT 2: Field Equipment Checklist

W **Total Station & Data Logger**	W **Prism(s)________**
W **Tripod(s) ___**	W **Prism Pole(s) ___**
W **Rod(s) ___**	W **Radios ___**
W **Digital Camera**	W **GPS Unit & Batteries**
W **Laser Rangefinder**	W **Auto Level**
W **Compass**	W **Laser Level**

W **Tape Measures:**	W **Long**	W **Short**
W **Flagging**		W **Flags**
W **Stakes / Rebar & Caps**		W **Nails / Tape Anchor**
W **Paint for Marking**		W **Ruler(s)**
W **Hammer**		W **Brush Axe ___**

W **Forms**	W **Pencils**
W **Notebooks**	W **Spare Lead**
W **Permanent Markers**	W **Clipboard(s)**

W **Waders /Hipboots**	W **Wading Boots**
W **Wetsuit**	W **Neoprene Socks**
W **Life Jackets**	W **Neoprene Booties**

W **Backpack(s) ___**	W **Dry-Bag**
W **Hats**	W **Yellow Bag**
W **Sunglasses**	W **Croakies**
W **Insect Repellent**	W **Sun Block**

ATTACHMENT 3: Feature Code List

Code	Type	Description
BEM	3D Polyline	Bottom of Embankment
BKF	Point	Bankfull
BM	Point	Benchmark
GS	Point	Ground shot
HB	3D Polyline	High bank
LB	3D Polyline	Low Bank
LEW	Point	Left Edge Water
MB	3D Polyline	Mid Bank
OCC#	Point	Occupied Point
RDE	3D Polyline	Road Edge
REW	Point	Right Edge Water
TOE	3D Polyline	Toe of Bank
TW	3D Polyline	Thalweg
TW_Invert	Point	Primary Culvert: Invert
STR TOC	Point	Primary Culvert: Top of Culvert
STR	Point	General Structure (Wingwalls, etc.)
STR2	Point	Secondary Culvert
STR2 Invert	Point	Secondary Culvert: Invert
STR2 TOC	Point	Secondary Culvert: Top of Culvert
XS#	3D Polyline	Numbered Cross-Section

Note: *To include a description while surveying the thalweg, type in TW, add a space, and then type in the descriptor. Software such as RIVERMorph needs the space to identify the point as a thalweg shot (i.e. TW BC). Additionally, for Cross--Sections, it would be XS#, SPACE, descriptor (i.e. XS1 BKF)*

Additional Codes

Code	Type	Description
DW	Point	Driveway
UPOLE #	Point	Utility Pole and #
Backwater	Point	Backwater
BC	Point	Back Channel

APPENDIX J:
Surface Water Hydrology SOP

Added to QAPP: March 2025

Surface Water Hydrology SOP

Goal

Hydrology monitoring provides information on water levels at the site and the impact of tidal restrictions or barriers, such as culverts and road crossings, on water flow.

Sampling Design

Automated continuous monitoring of surface water level and salinity is conducted over a period of 4-6 weeks to create a contiguous dataset that includes at least one lunar cycle, and which documents water levels through at least one full neap and one full spring tide phase. Site specific monitoring objectives are outlined in SAPs and will inform deployment location. At tidal crossings, monitoring for assessment of tidal restriction requires deployment of monitoring equipment upstream and downstream of a structure. Multiple units can be deployed upstream of a structure to show change deeper into a system, but typically only one unit is deployed downstream.

Water level and surface water salinity in tidal marshes are monitored using continuous data loggers. CBEP utilizes Onset HOBO water level, temperature, and conductivity logging systems. Links to detailed equipment specifications, operating manual, and processing software are provided at the end of this SOP

For restoration monitoring, at least one surface water hydrology data set is collected prior to a project, and a second is collected after a project is completed. For non-restoration projects the number and timing of sampling events will be described in the SAP.

Equipment

a) HOBO U20 titanium water level and temperature logger

Parameter	Range
Temperature	-20 to 50^{o}C (-4 to 122^{O}F)
Pressure/level	0-4m (13 ft)

b) Barometric pressure sensor with micro station data logger

Parameter	Range
Barometric pressure	660 to 1070 mbar

c) HOBO saltwater conductivity/salinity data logger

Parameter	Range
Actual conductivity	5,000 to 55,000 µS/cm
Salinity	0 to 42 ppt
Temperature	-2 to 36ºC (28 to 97ºF)
Pressure/level	0-4m (13 ft)

Sampling Methods

The Onset water level logger and the conductivity logger units are deployed in PVC stilling wells set slightly above the channel bottom and secured to a post, consistent with methods described in the National Park Service report, *Continuous water level data collection and management using Onset HOBO data loggers: A Northeast Coastal and Barrier Network methods document* (Curdts 2017). The stilling wells are installed beyond the visible influence of roads or other hydrologic anomalies (e.g., scour pools), and at least 20m upstream or downstream of any road crossing or other structure. Loggers are suspended from well caps using stainless steel cable. The barometric pressure unit is installed along the upland edge of the marsh, off the ground attached to a wooden board and positioned in such a way that the instrument is shielded from frequent temperature and weather changes caused by exposure to direct sunlight and inclement weather. Additional information on deploying the Onset system is provided in field instructions.

A field data sheet is used to document conditions, locations, parameters, and other accompanying data for the deployment site by site basis (**Appendix A**). Instruments are programmed using proprietary software, HOBOWare Pro, to continuously log measurements at an interval of 6 minutes starting on the top of the hour, allowing for synchronization with Portland Tide Gauge monitoring (station 8418150). Temperature and conductivity data are simultaneously collected.

A scheduled start time is entered, but not a stop time, ensuring that the instrument will continue to log measurements until manually stopped. The instrument removal time is noted.

Data Quality Assurance

The Onset equipment is calibrated by the manufacturer, and no further calibration is required or recommended by Onset. Best practices for cleaning equipment follow Onset’s recommendations provided in the Product Cleaning Reference Guide in the references at the end of this SOP

At least two times during a deployment period, water levels are surveyed using the auto level and stadia rod in order to tie water level data into a known vertical datum. Also, at least two times during the deployment period, grab surface water samples are collected and salinity measurements taken using a refractometer. This ensures accurate readings are being collected and allows for any necessary drift correction.

Sample Handling and Custody

Instrument logs are stopped, and data sets are downloaded, in the office using HOBOWare Pro. Water level (raw absolute pressure) data are integrated with barometric pressure data using HOBOWare Pro, and water levels are post-processed using a tool provided with the software to compensate for changes in barometric pressure over the monitoring period. The processed water level data sets are exported to Excel. Data recorded when the instruments were out of the water is flagged and removed during an initial QA/QC review while data sets are exported to Excel. Both raw data and exported Excel data sets are archived with CBEP. Water levels are converted to a known vertical datum (e.g., NAVD 88) using the surveyed water level data tied to a vertical reference. Surface water salinity spot samples are used to detect any drift in conductivity data. Data from the Portland Tide Gauge are downloaded in NAVD 88 for comparison and integrated into the database. Twenty-four-hour precipitation totals are downloaded from the nearest available rain gauge over the duration of the monitoring period. Currently, the Portland Jetport is the only the only weather station in our region with precipitation data consistently and publicly available online. All data sets are plotted. Water level data points that outlie adjacent data are flagged and removed if needed. Data are examined for anomalies such as straight lines, gaps, or single outlying data points, and attempts to explain anomalies are made. If it is determined that data are erroneous, the associated data points are flagged and removed from further analysis.

Analytic Methods

Water level data are plotted in various timeframes to illustrate the degree of tidal restriction caused by a structure during different tide phases as indicated by muted tide range, lag in tides, impoundment and other indicators. If available, marsh surface elevation is included in analysis for evaluation of hydroperiod and the location of the marsh surface in comparison to known datums. Tidal metrics are developed for the data set according to definitions used by NOAA (https://tidesandcurrents.noaa.gov/datum_options.html) including highest observed water (HOW), mean higher high water (MHHW), mean high water (MHW), and mean tide level (MTL), allowing for quantitative comparison of upstream and downstream data sets, as well as comparison of pre- and post- project data sets. Beyond these summary statistics, additional analysis and plotting may be performed to further understand and quantify differences between data sets at a high resolution. At selected locations, water level data will be used in conjunction with LIDAR data to analyze hydroperiod and the area flooded associated with site specific tidal metrics and produce hypsometric curves.

Salinity data are plotted along with 24-hour rainfall data in various timeframes to illustrate differences upstream and downstream of a structure during different tide phases, and to associate changes in salinity with precipitation events. Summary statistics (mean/minima/maxima) are prepared allowing for quantitative comparison of upstream and downstream data sets, as well as comparison of pre- and post- project data sets.

Detailed Protocol

Equipment:

- Laptop w/ HOBOWare Pro
- Onset HOBO U20 Titanium Water Level Logger(s), range 0-4 m.
- Onset HOBO Conductivity Logger(s)
- Onset HOBO Barometric pressure station (micro station, sensor)
- Clipboard with datasheets & pencils
- Stadia rod (English, decimal feet)
- Auto level with tripod
- GPS
- Camera
- AA batteries
- Needle nose pliers
- Fence posts (short)
- PVC housing
- Zip ties
- Bucket
- Knife/scissors
- Refractometer
- De-ionized water

Data sheets:

- HOBO Water Level Logger Deployment Data Sheet
- HOBO Conductivity/Salinity Logger Deployment Data Sheet
- HOBO Baro-logger Deployment Data Sheet
- ONSET HOBO logger deployment check list

Notes:

- Equipment installation occurs at low tide, with equipment set at lowest point feasible given site constraints
- Equipment may be deployed by a lone individual, but tying elevations into a vertical datum requires surveying and therefore, two people.

Field Instructions:

Site specific monitoring objectives are outlined in SAPs and will inform deployment location.

Baro-Loggers

- Follow manuals for HOBO micro station and barometric pressure smart sensor to start up
- Use a bungie cord to attach housing and instrumentation to a tree or other structure in a shaded (24 hours) and discreet location. Instrument is sensitive to heat; shade is important.

U20 Water Level Loggers; Conductivity Loggers

- Program instruments (in the office or on site).
    - Set start time to the top of the hour with a sampling interval of 6 minutes to synchronize with Portland Tide Station.
- Deploy instrument(s) in PVC housing affixed to fence post or cinder block using zip/cable ties. Set configuration into the bottom with fence post or cinder block
- Deployment method will depend on local site conditions:

Option 1 – PVC housing affixed to a secure post.

Manufactured stilling wells are available for purchase or can be constructed. CBEP builds stilling wells by cutting 1 ½” (3.5 cm) PVC pipe to a 35cm length then drilling numerous .5 cm holes into the pipe to allow adequate flow and drainage. A comparably drilled cap is then affixed to the base of the well with adhesive. The top cap is drilled with an additional 1 cm wide slit cut to the cap end in order to accommodate the cable. The top cap is temporarily affixed to the well with a zip tie during deployment. Throughout deployment, care must be taken not to kink the instrument cable.

During deployment, the instrument is set into the well, which is first affixed to a secure post with zip/cable ties. The post (fence post or rebar) is then driven into the sediment to a sufficient depth so that the stilling well is above the sediment surface, but the post will also sit securely over the deployment period, and so that the instrument is vertical and the sensors sit at the bottom of the stilling well. The well does not need to be placed in the channel thalweg, and often is better set along the channel bank as this reduces the potential for wrack build-up and fouling over the deployment period.

The other end of the instrument cable, which ends with a large desiccant attachment, will sit in a protective cap affixed to a second fence post that stands above the marsh surface. The purpose of this cap is to protect the cable end from the elements. The cap is constructed of 1.5" PVC pipe cut to a length of approximately 6" / 15 cm with a cap on one end.

The instrument is affixed to the stilling well using zip ties looped through the holes. Once the instrument is immobilized within the stilling well, the cable-end cap is placed over top of the well and secured with a zip tie. The combined unit is then affixed to a green metal fence post approximately .5 - 1m long using plastic zip ties, high enough so that the post can be pushed deep enough to sit securely in the channel sediments. The cable should be affixed to the fence post with a zip tie to prevent catching, but not too tightly. To set the unit into the channel, the base of the fence post is pushed into the sediments of the creek bed during low tide. Site conditions dictate the specific location, but preferably the unit can be deployed at the thalweg where a steep bank rises vertically, ensuring that cable will not dangle loosely. Once the instrument is deployed, loose cable is gently secured to the channel bank and marsh surface using erosion control fabric staples until the foot of a fence post situated on the marsh surface. The loose end of the cable, attached to a large desiccant, is pushed up into the protective PVC cap affixed to the fence post, and attached to the post with a plastic zip tie. The fence post must be set so that the tip of the cable sits above the highest projected tide height for the deployment period. The 3m vertical green metal fence post is installed on the surface of the marsh. Any loose cable should be looped and secured to the fence post above the ground. A sign is often attached to this post to provide a point of contact for curious passersby.

Option 2 – PVC housing affixed to a cinder block

The deployment method is identical to option 1, except that rather than affixing the stilling well to a fence post, the well is affixed to a concrete block (typically, 4" by 8" by 16") using multiple screw clamps. This unit is then placed in the channel thalweg oriented in line with the channel, so that the instrument lies horizontally on the channel bottom. This low-profile deployment is sometimes optimal for wide, open channels or open mudflat where the instrument may be more exposed to wrack, waves, etc., and where the cable is more likely to get snagged. The block should be staked into the mud with a stabilizer such as rebar, fence posts, or stakes, to restrict lateral movement. Typically, the longer (40') cable is used for this option, since the length is needed to reach the fence post set in the adjacent marsh surface.

Deployment and Sampling

- Complete logger deployment data sheets
    - Record location with GPS, and photograph each instrument
    - Draw schematic of location
    - For U20 water level loggers, survey both the instrument and instantaneous water levels into a known benchmark. Water levels should be surveyed at least twice, and at least 15 minutes apart.
- Total deployment duration should be 4 – 6 weeks to document a full neap/spring tide cycle.
- At removal of U20 water level loggers, survey water levels (if there is water over the pressure transducer) and record time. Wait at least 6 minutes prior to actual physically removing the instrument.
- Remove instrument and note time/date of removal, as well as observations (fouling, etc.)

Data processing

- Use HOBOWare to stop recording and download data
- Enter water level observation in NAVD88 at specific data and time to tie the data set into NAVD 88.
- Analyze data using HOBOWare and Excel.
- Record associated metadata in Excel spreadsheet.
- Store raw data and post-processed data separately.

References:

Logger Manuals

- Onset HOBO U20 Water Level Logger: https://www.onsetcomp.com/sites/default/files/resources-documents/12315-J%20U20%20Manual.pdf
- Onset HOBO U24 Conductivity Logger Manual: https://www.onsetcomp.com/sites/default/files/resources-documents/15070-J%20U24-001%20Manual.pdf
- Onset HOBO USB Micro Station Data Logger: https://www.onsetcomp.com/sites/default/files/resources-documents/20875-E%20H21-USB%20Manual.pdf
- Onset Smart Barometric Pressure Sensor: https://www.onsetcomp.com/sites/default/files/resources-documents/12291-F%20MAN-S-BPB.pdf

Logger Software:

- HOBOWare User's Guide Available at: https://www.onsetcomp.com/sites/default/files/resources-documents/12730-AE%20HOBOware%20User%27s%20Guide.pdf
- HOBOWare Pro Barometric Compensation Assistant User's Guide: https://www.onsetcomp.com/sites/default/files/resources-documents/10572-J%20Barometric%20Compensation%20Assistant%20User%27s%20Guide.pdf

- HOBOWare Pro Conductivity Assistant User's Guide: https://www.onsetcomp.com/sites/default/files/resources-documents/15019-E%20Conductivity%20Assistant%20UG.pdf

Logger Cleaning:

Onset Product Cleaning Reference Guide: https://www.onsetcomp.com/sites/default/files/resources-documents/15667-D%20Product%20Cleaning%20Reference%20Guide.pdf

Logger Deployment:

National Park Service report: Continuous water level data collection and management using Onset HOBO data loggers: A Northeast Coastal and Barrier Network methods document. https://irma.nps.gov/DataStore/DownloadFile/563851

APPENDIX K:
Porewater Salinity SOP
Added to QAPP: March 2025

Porewater salinity SOP

Goal

Monitoring pore water salinity (salinity of water samples collected between 5-20 cm below the marsh surface) provides basic information about soil salinity, which is a driver of salt marsh plant community composition (Neckles et al 2002).

Sampling Design

Porewater salinity is sampled from specially designed semi-permanent salinity wells set into the marsh surface. Between five and fifteen wells (typically ten) are used to monitor a contiguous marsh system. Wells allow for rapid sampling of pore water from the soil root zone at depths of 5 to 20 cm below the marsh surface.

Porewater monitoring wells are established throughout the marsh area. CBEP uses porewater salinity wells based on design specifications provided in the GPAC protocols(Neckles and Dionne 2000, p. 10) and sampling is conducted consistent with GPAC SOPs. Wells are built from 19mm (¾ inch) diameter CPVC plastic pipe. Wells are cut to 35 cm with 7-10 pairs of 4 mm holes drilled at roughly even intervals 5-20 cm below the surface. The bottom of the well is sealed. The top of the well is constructed of two 90-degree PVC elbows connected by a short section of straight PVC pipe to form an inverted U-shape in order to limit water entering the well from above.

Wells are generally located at sampling Stations, but wells may not be located at every Station. Locations of porewater sampling wells for a given project are specified in the SAP. For monitoring associated with tidal marsh restoration projects, salinity wells will be located, at a minimum, at:

- One Reference Station (outside of the area affected by restoration, but as near to the restoration area as practicable)
- One Station at the downstream end of the Project Area (e.g., immediately upstream of a tidal restriction or at the furthest downstream extent of surface hydrologyrestoration)
- One Station situated at head of tide
- At least one station between downstream and head of tide

This minimum sample arrangement provides information on longitudinal pore water salinity gradients within the marsh and allows comparison of salinity changes in the Project and Reference Areas.

A subset of Stations will include a transect of three or more wells running perpendicular from the tidal channel (or open water) to the adjacent upland. This transect will run perpendicular to the long axis of the marsh for most of Casco Bay's long, narrow tidal wetlands, but would run from open water to the adjacent bluff for a fringing marsh. One station will be established within 3-4 meters of the water, one at the upland edge, and the third approximately midway between the other two. This lateral transect allows assessment of patterns in pore water salinity across the marsh surface.

For monitoring associated with restoration projects, one full season of monitoring occurs prior to a restoration project, and generally, at odd years' post-project (i.e., year 1, 3, 5). For long-term monitoring conducted for other reasons, the frequency of monitoring events will be specified in the SAP.

Sampling Methods

Well Installation:

Wells are installed so that the holes are set 5-20 cm below the marsh surface. Sampling does not commence until at least 24 hours following installation. Wells are inspected annually and removed and cleaned as needed to remove accumulated sediment.

Sample Collection:

Samples are collected by removing the well cap then inserting plastic tubing affixed to a plastic syringe into the well until it reaches the well bottom, and then lifted 5 cm. A sample is extracted using the syringe, then in the field, the sample is placed upon a handheld refractometer to take salinity readings. Salinity is measured in parts dissolved salts per thousand.

For comparison, surface water samples are collected at the adjacent tidal creek or open water when pore water samples are collected. Salinity is measured in surface water samples using the refractometer following the same methods used for pore water samples.

Samples are collected within 2 hours of low tide, at least once per month from April to October, and may be collected more frequently during the primary growing season (April – July). Sample collection will be scheduled so that half are collected during a spring tide phase, and the remainder during neap tide (Neckles & Dionne 2000).

Data Quality Assurance

The optical handheld refractometer is calibrated with DI water prior to use to ensure accurate readings. Three replicate measurements are recorded from a single sample to ensure readings are precise and representative.

Sample Handling and Custody

Following measurement, samples are discarded in the field. All salinity measurements, sampling times, and other site visit and anecdotal observations are recorded on a site-specific salinity monitoring data sheet (**Appendix A**). Data sheets are stored at CBEP. Field data are transferred to a site-specific Excel database.

Analytic methods

Summary statistics (mean, median, minima, and maxima) are computed for use in graphical or map displays. Standard statistical methods (t-tests, linear models or non-parametric equivalents) are used to evaluate long term or seasonal trends, comparisons between pre-restoration and post-restoration conditions, and comparisons between restoration and reference areas.

Detailed Protocol

<u>Reference</u>: Bottitta, G. and K.Whiting-Grant. 2004, based on Neckles and Dionne 2000 (App. B).

<u>Equipment</u>: Syringe with tubing; refractometer; salinity data sheets; clipboard; pencil; deionized (DI) water; handheld GPS unit; printed map of stations; watch; tide chart or knowledge of the day's tide schedule; hip waders or at least mud boots; Sharpie pen.

<u>Notes</u>:

- Pore water salinity must be measured within 2 hours +/- of local low tide.
- Sites are sampled at least once per month at each monitoring site during the sampling season (April – October).
- Monitoring can be performed by a lone individual; a second may assist with recording as resources permit.

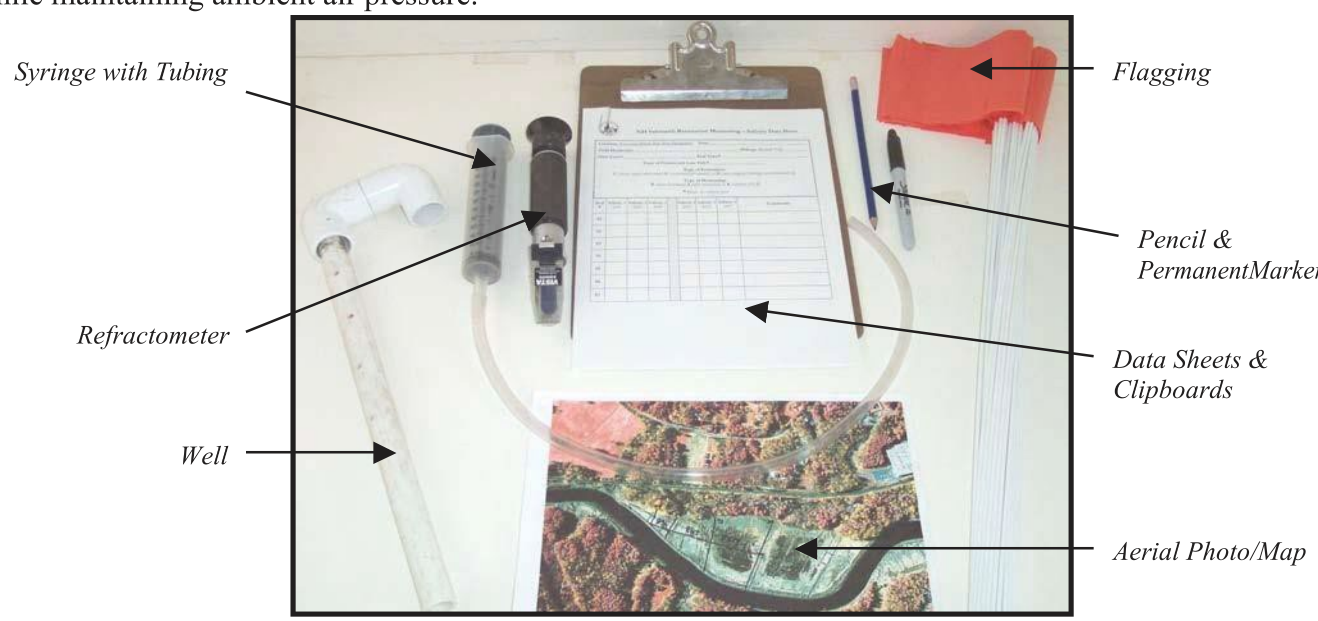
<u>Field instructions</u>:

1. Prepare site-specific pore water salinity data sheet to document a site visit.
2. Using the map and/or GPS, locate and arrive at a pore water sampling station.
3. Calibrate the refractometer using distilled or DI water. The reading should be zero PPT (0 ‰). Rinse tubing with DI water.
4. Remove U-shaped cap from the top of the pore water well. Insert tubing to the well, so that the tubing hits the base of the well, then lift ~ 5 cm off the bottom.
5. Withdraw sample by pulling on the syringe. Remove the tubing from the well and replace well cap. Note the sample time on the data sheet.
6. Shake the syringe and/or tubing to mix the sample.

7. Lift the refractometer's daylight sample plate and place several drops from the sample onto the face of the prism. Close the daylight sample plate cover.
8. Take a salinity reading while holding the refractometer facing toward the sun. Record measurement.
9. Repeat steps 7 and 8 twice more, so that there are three readings total.
10. Note any pertinent observations associated with the sample, such as presence of mud in the sample, or a dry well. If a well is muddy, remove the well, rinse it out, and reset the well. Wait 24 hours before sampling.
11. Discharge tubing and syringe.
12. Repeat steps 5-11 by taking a surface water sample from the adjacent channel.
13. Continue on to next station.
14. Salinity should be sampled at the frequency detailed in the SAP (typically once per month during the sampling season).
15. Make a note if the well or stakes are missing or broken. Replace if possible.

Equipment

Soil salinity is a relatively inexpensive parameter to incorporate into a monitoring program. Wells to obtain soil salinity are constructed from 19mm diameter CPVC plastic pipe with 7 pairs of 4mm holes at sediment depths between 5 to 20cm. The base of the 35cm pipe is sealed and the top is capped with two right angles in sequence. This prevents rain or floodwaters from entering the well while maintaining ambient air pressure.



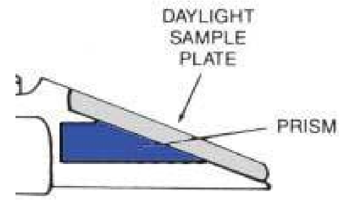
Sampling and Refractometer Use

1. Remove the elbow-shaped cap from the well and insert the syringe tubing to the base of the well.

2. Lift the tubing about an inch away from the base to minimize the presence of mud and silt in the sample.

3. Extract a sample from the well by pulling the circular knob at the top of the syringe and drawing as much water into the syringe as possible.

4. Shake the syringe to reduce stratification (layering) in the water.



5. Open the daylight sample plate. Place the end of the tubing onto the refractometer prism and gently push the plunger until a few drops of water fall onto the refractometer.

6. Close the daylight plate so the plate comes into contact with the prism surface. The sample should spread completely over the prism surface. Air bubbles or an insufficient sample will be hard to read. If this occurs, repeat the procedure, applying more of the liquid sample.

7. Hold the refractometer by the rubber grip and point the prism end of the refractometer to a light source and observe the field of view through the eyepiece. Focus the eyepiece by turning the crossstriped portion of the rubber eyepiece guard either clockwise or counter-clockwise until the scale becomes clearly visible.

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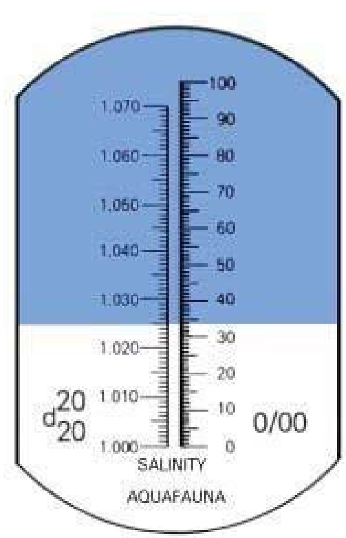
8. A horizontal boundary line separating the blue field of view (top) and white field of view (bottom) will appear in the field of vision. Adjust the angle of unit to the light source until line is sharp and distinct. The values on the scale are specific gravity and parts per thousand (ppt).

9. Measure the sample to the nearest parts per thousand (ppt). Record the information in the space provided on the data sheet for “sample 1”.

10. Wipe the refractometer prism surface dry and repeat steps 5 and 6 two more times for a total of <u>three</u> salinity readings.

11. Do not allow saltwater to remain anywhere on the unit. When through, wipe clean with damp cloth (fresh water) then wipe dry.



APPENDIX L:
Photo Stations SOP

Added to QAPP: March 2025

Photo Stations SOP

Goal

Standardized photographic monitoring of tidal restoration project allows for a visual record of changes associated with a tidal restoration project, beginning with baseline (pre-project) conditions. Detailed SOPs for photo stations are provided in Collins *et al* 2007, p. 36-37 (Appendix C).

Sampling Design

Photo stations are established using georeferenced points on the ground that are associated with the project site and monitoring stations. If necessary, semi-permanent monuments or markers may be left in the marsh to mark photo station locations. Photos are framed in the landscape format for year-to-year consistency. Photo station locations include:

- Project site, with views toward: 1) inlet, 2) outlet, 3) upstream channel, 4) downstream channel, 5) road approach right, 6) road approach left. Photos are taken at low tide.
- Channel morphology - cross sections, views toward: 1) river left, 2) river right, 3) upstream, 4) downstream. Photos are taken at low tide, during cross section surveys while the tape is across the channel, with the tape in the foreground. Photo numbers are recorded on cross section data sheets. Additional opportunistic photos are taken to document the longitudinal profile survey, including the start and end of the transect, as well as the location of head-cuts, collapsed peat, large woody debris, sediment deposition or other distinctive geomorphic features.
- Vegetation surveys: 1) view from the channel (start of transect) to the upland edge, 2) view from the upland edge (end of transect) toward the channel. Photos are taken during vegetation surveys, usually while the tape is laid out along the transect and thus visible in the foreground. Photo numbers are recorded on cross section data sheets.
- Surface water hydrology: 1) view of instrument(s), showing location within the channel during low tide, a) at time of deployment, and b) time of removal if possible.

For restoration projects, photos will be collected at minimum in the year preceding restoration and the five years following restoration. Photos will be taken in the late summer, unless other timing is needed for project goals, and researchers will aim for cross-year consistency in photo timing. Precise locations and timing of photos will be described in SAPs.

Sampling Methods

Choose a day with clear weather and good light to ensure good photo quality. At the site, take photos from each of the necessary views. Check to make sure all photos were successfully captured. Record the date on which photos were taken, the locations from which photos were taken, and any other relevant information such as georeferencing information from stations to nearby landmarks. If photos are being taken in association with another type of data collection (e.g., vegetation or channel morphology), note the photo numbers associated with different data collection points on those data sheets.

Sample Handling and Custody

All photos are transferred to site-specific folders that are saved on the CBEP drive, which is regularly backed up. Photos are tagged with the date on which they were taken and any other necessary metadata.

Analytic Methods

All analysis is observational based on year-to-year changes seen in photos. No numerical analysis is done.

APPENDIX M:
Marsh Vegetation SOP
Added to QAPP: March 2025

Marsh Vegetation SOP

Goal

On larger sites, documentation of characteristics of the vegetation, as well as longitudinal and lateral patterns of vegetation can provide insight into processes influencing marsh condition.

Sampling Design

Vegetation and other cover types (wrack, bare ground, water, litter) are monitored along a single transect set up at each station. Sampling occurs once annually during the middle of the growing season (July or August). A marker (stake) is established approximately 10 meters from the tidal creek. For consistency of sampling from year to year, transects are laid out along designated compass directions. Specific compass directions are determined in the field the first time samples occur, but each transect will be laid out approximately perpendicular to the axis of the marsh. At time of sampling, a transect is established by running a 100m fiberglass reel tape through that marker perpendicular from the tidal creek to a marked location at the upland edge of the marsh – typically, a tree. If it is more than 100m to the edge of the marsh, a second stake is placed at 100 meters, and the transect is continued along the same direction to the edge of the marsh. Compass directions and transect lengths are checked and recorded during each subsequent year of monitoring.

The number of plots per transect is typically ten, located equidistant along each transect, with spacing between quadrats determined by the distance between channel and edge of wetland (e.g., the transect length). Some variation in the number of plots sampled, and the distance between them, may occur based on unique characteristics of a specific transect, but plots are monitored at identical locations along a transect from year to year. Plots are placed no more closely together than 2 meters on center, so transects must be a minimum of 20m long. The upland end of the vegetation transects will be where there is a clear elevation break, so that the end of the transect lies approximately 1-2 meters vertically above the level surface of the marsh. Two photographs are taken at each transect, looking toward the upland, and toward the creek channel.

Transects are monumented or documented in the field using a variety of methods depending on constraints imposed by site conditions including semi-permanent PVC or wooden stake monuments at the edge of the tidal channel and low monuments (< 20 cm in height) located away from the channel. When possible, transects are designed to pass adjacent to groundwater monitoring wells or other long-term monitoring equipment. GPS coordinates are collected for each end of the transect (using consumer–grade GPS receivers, with WAAS enabled), and data is recorded on transect length and direction. These numerical data are combined with a brief narrative description (e.g., “From the center of a small point on the tidal channel to the large oak just east of a birch”). Each transect is documented with photographs. Where landowners permit it, trees at the upland end of a transect may be marked with paint or forestry flagging to facilitate relocating transects in subsequent years. Following these procedures, we estimate that, with few exceptions, transects are located within one to two meters of nominal position from year to year, with the largest errors introduced by channel migration, which alters the length and baseline of the transect.

Sampling Methods

Vegetation is sampled using $1m^2$ quadrats set on the marsh surface on the left side of the tape at set distances. Quadrats are constructed out of PVC pipes and additional design specifications for quadrats are provided in Carlisle et al. 2006, p. 6. Species composition and cover types are recorded at each plot location, and an estimate of percent cover is provided.

Observers are trained by senior staff to use standard methods to estimate percent cover. A percent cover reference sheet (Carlisle et al. 2002, Appendix A) is used to promote consistency. For each transect, a cover sheet is used to record information pertaining to the transect. Observations of percent cover by species and cover type at each plot is recorded on a vegetation plot data sheet (Appendix A).

Plant Identification

Plant identification follows Haines and Vining 1998. CBEP maintains a reference sheet of common tidal wetland species, with useful field characteristics to help facilitate identification and year-to-year consistency in plant identifications.

Samples of any plant species not readily identified in the field are collected for later identification in the office. Samples are placed in plastic bags, which are labeled by the site, station, and plot in which the species was observed. Each unknown species is given a temporary identification (e.g., “Unknown grass # 3”) so that data on its relative abundance can be collected even in the absence of definitive identification. Once in the laboratory, unknown plants are identified with the aid of a dissecting microscope. Once identifications are confirmed by senior project staff, the field data sheets are amended in pen (all field data are recorded in pencil) to add the correct identification. Plants that cannot be identified are recorded as unknown.

Very uncommon species are not always identified as their identification provides no meaningful ecological information and can confuse the analyses. For vegetation data to be of acceptable quality, all dominant species (cover > 50% in any plot) and all common species (present in more than 10% of plots) will be identified, and at least 80% of plant species and 80% of plant cover will be identified to species.

Data Quality Assurance

Identifications in the field are made by experienced observers, based on general plant characteristics, and sometimes with the use of a hand lens. Field staff must spend at least two days in the field with experienced observers and pass an informal assessment of their ability to identify common salt marsh plants before being allowed to collect vegetation data on their own.

Sample Handling and Custody

Field data are entered into site-specific Microsoft Access databases and data are independently reviewed by a second party for QA/QC. An independent plant species database interfaces with the site-specific vegetation databases. The plant database is reviewed and updated annually, so that any updates to nomenclature or classification are noted and integrated into the site data. Data sheets and databases are archived at CBEP.

Analytic Methods

Analysis of the vegetation data follows standard analytic methods. Analyses focuses on responses of individual species and the vegetation as a whole to restoration. Analyses will document any changes in species abundance and vegetation composition at each monitoring station and examine spatial patterns of vegetation along the axis of the marsh.

Vegetation in a given plot is characterized, with regards to flood tolerance and salinity tolerance, using weighted averages of species-specific indexes. Each plant species' Wetland Indicator Status (U.S. Army Corps of Engineers 2025; Lichvar et al. 2016) is used as an index of relative flood tolerance, while a salinity tolerance index indicates relative tolerance to salt, by grouping plant species into halophytic (salt tolerant), brackish, and glycophytic (not salt tolerant) categories (Verrill 2017).

Analysis of vegetation data employs multi-dimensional statistical methods, coupled with a variety of data visualizations to facilitate interpretation. Currently, vegetation data is analyzed using the 'vegan' package, in R (Oksanen et al. 2025), but may in future be analyzed with other suitable software. Ordination methods (principally nonmetric multidimensional scaling) are used to characterize vegetation pattern by reducing multi-dimensional vegetation data to two or three synthetic dimensions that offer the best[1] summary of pattern. Ordinations are based on simplified abundance classes derived from the percent cover data (e.g., Braun-Blanquet

[1] Different ordination methods use various definitions of what it means to offer the "best" summary of multivariate data.

vegetation cover classes), or presence-absence data. Ordination output is used principally for visualizations, but also for formal statistical tests of vegetation change. Groups of plots that share similar vegetation are identified using clustering algorithms. A primary purpose of clustering is to provide objectively-defined groups that can be used to aid interpretation of ordination output. Clusters can generally be interpreted in terms of widely recognized vegetation types or dominant species. These methods are known to provide robust results with vegetation data, readily illustrating shifts in species composition along major inundation and salinity gradients, and can provide quantitative indications of responses to restoration.

Detailed Protocol

Adapted from Neckles and Dionne 1999

Equipment: Graduated 300ft. (decimal) tape reel, 1 meter quadrat (PVC), camera, hip waders, handheld GPS, compass, site map, vegetation transect cover sheet, vegetation plot datasheet, vegetation transect summary, magnifying glass, field guide(s), Ziploc bags, clipboard, and pencils. Vegetation identification guide.

Notes:

- Vegetation monitoring is best conducted during low-mid tides.
- Feasible with one person, but optimal with two in the following roles:
    - Observer: identifies plant species, describes cover type and estimates percent cover
    - Recorder: assists observer with tape, photos, filling data sheets.
- Prior knowledge of transect length, location (start and end points), magnetic direction, and plot distances along the transect needed for replication (Vegetation Transect Summary).

Field Instructions:

- Prior to sampling:
    - At each station, fill out Vegetation Transect Cover Sheet.
    - Locate transect, using information in Transect Summary Form (Access form/report)
        - Locate start of station transect at channel edge using site map and GPS unit.
        - Locate end of transect at upland edge using compass bearing, GPS unit, and markers/descriptions
    - Run tape reel from transect start at the channel edge (0'), to channel end at the upland, or 300', (whichever is shorter).
    - Take photo (landscape orientation) of view from channel to upland.
- Proceed with sampling at pre-determined plot distances along the transect.
    - Place quadrat on opposite side of tape, with quadrat running parallel to tape beginning at the plot distance.

- Use percent cover estimates. For cover estimates less than 1 percent (“present”), use <1%
    - Record findings on Vegetation Plot Data Sheet.
    - For unknown species in the marsh, take a sample in a plastic bag and ID back at the office. Note on data sheet any samples taken, and ID the sample at the office
    - For unknown species at the upland edge, photograph, and note photo ID number, and ID back at the office
- Proceed to next plot by walking on the opposite side of the tape from what is being measured.
- At conclusion of sampling:
    - Take photo (landscape orientation) of view from upland back to channel.
    - Reel in tape.
- Proceed to next station.

References

Carlisle, Bruce K., Marc Carullo, Jan Smith, Cathleen Wigand, Richard McKinney, Mike Charpentier, Deborah Fillis, and Mark Stolt. 2006. “Vegetation Monitoring in Salt Marshes Using Rapid Assessment Method,” October. https://www.tidalmarshmonitoring.net/pdf/Carlisle2006_Rapid%20method%20for%20assessing%20estuarine%20marshes%20in%20New%20England.pdf.

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APPENDIX N:
Plant Species of Concern SOP
Added to QAPP: March 2025

Plant Species of Concern SOP

Goal

Additional vegetation surveys throughout the marsh ensure that the presence, location, distribution and quantity of plant species of concern (PSC) is documented for reporting and management purposes.

Sampling Design

A thorough meander survey of the marsh is undertaken to detect PSC. A meander survey is a semi-structured site visit, in which investigators walk the marsh examining vegetation in all areas of suitable habitat, looking for PSCs. The survey occurs in late July or early August during the typical flowering season for targeted species. The area surveyed includes the entire project area up to and including the upland edge, and if visible, the high-water mark from an astronomic high tide event. Indications of high water might include wrack accumulation, sediment deposition on plants and woody vegetation, displaced leaf litter, or stress indicators for terrestrial species (e.g., orange needles on *Pinus strobus*). The survey does not extend into the adjacent upland. For restoration sites, the survey includes both the Project Area and the Reference Area.

Plant species of concern fall into two categories: 1) non-native/invasive plants, typically including *Phragmites australis* (common reed) in salt marsh, and salt tolerant or intolerant species such as *Lythrum salicaria* (purple loosestrife) or *Berberis thunbergii* (Japanese barberry) in or adjacent to brackish and fresh marshes; and, 2) stands of native or cryptogenic species that often form large, monotypic stands on the marsh surface, such as *Typha latifolia* (broad-leaf cattail).

Prior to the survey, monitors are trained to identify targeted species through review of: 1) fact sheets developed by the Maine Invasive Species Network (University of Maine Cooperative Extension 2017); 2) species identification cards developed through the Vital Signs program (Gulf of Maine Research Institute 2017); and 3) techniques for differentiating invasive from native *Phragmites* (Swearingen and Saltonstall 2010).

Sampling Methods

The survey occurs by walking the entire project area, meandering through remote areas and densely vegetated areas. If a PSC is observed, the observation is photographed and georeferenced using a GPS. Data are recorded onto a field data sheet (Appendix A), and include species identification, contextual description of location, size of population, assessment of a monoculture vs. mixed stand, and the presence of seed heads or flowers.

Phragmites observations are distinguished as native, introduced, or mixed with detailed accompanying photographs. If a stand of *Phragmites* is present, the perimeter of the stand is documented using GPS. If a monoculture stand of *Typha latifolia* is present, the perimeter of the stand is documented using GPS.

Field staff document the general size and location of each stand by walking the stand's perimeter, and recording locations of several points on the edge of the stand. Typically, between four and ten points are used. The exact number depends on stand geometry and is left to the discretion of the field staff.

Positions are recorded using consumer-grade, hand-held GPS receivers, with WAAS enabled. Positions are recorded after allowing the GPS unit to average positions for at least 30 seconds, providing positional accuracy on the order of 2-5 meters under typical conditions.

Sample Handling and Custody

In some cases field samples may be collected for further identification. Field data are entered into site-specific Microsoft Excel databases and data entry is reviewed by a second party for QA/QC. Data sheets and databases are archived at CBEP.

Analytic methods

A map of PSC is prepared, and the area of any monoculture stands is calculated. Observations of *Phragmites australis* are immediately conveyed to project partners for management consideration.

References

Gulf of Maine Research Institute. Vital Signs – Species ID Cards.

Swearingen, J. and K. Saltonstall. 2010. *Phragmites* Field Guide: Distinguishing Native and Exotic Forms of Common Reed (*Phragmites australis*) in the United States. Plant Conservation Alliance, Weeds Gone Wild.

University of Maine Cooperative Extension. 2017. Maine Invasive Species Network – species bulletins. https://extension.umaine.edu/invasivespecies/

Detailed Methods

MONITORING PLANT SPECIES OF CONCERN (2022 CBEP)

Purpose:

- Document the distribution, spatial extent, and abundance of plant species of concern.
- Collect information indicating the health and ecological integrity of tidal wetland
- Monitor changes over time to provide insights into restoration status & outcomes
- Inform management responses, such as manual cutting, herbicide application, etc.

Plant species of concern:

- Generally, the focus of monitoring is for invasive-behaving, non-native plants that are likely to expand or form monocultures. The primary species concern is *Phragmites australis*, but several others may be found on the marsh plane, such as purple loosestrife (*Lythrum salicaria*).
- Other plants, particularly cattails (*Typha* spp.), may be of concern when they are present in monocultures on a tidal marsh, as they indicate hydrological modification, runoff / pollution, elevated nutrient levels, and other stressors.

Safety:

- Be sure to wear a hat and sunglasses or other eye protection at all times.
- Move slowly and deliberately around invasive plants, particularly if bending down or crouching. Stems can puncture eyes, go up a nostril, and are generally stiff.
- Wear long sleeves, long pants, and bug spray to protect against ticks.

Equipment:

- Handheld GPS
- Data sheets (invasive plants), clipboard, pencil
- Digital camera
- Flagging
- Small tape reel (100 m)
- Invasive plant identification binder, and invasive/native Phragmites binder
- Plastic bags for samples, seed heads
- Black sharpie
- Pruning shears

Protocols:

- Record date, time, site name, and other site information on data sheet

- This is a “meander survey” involving a slow, methodical walk around the perimeter of the marsh to observe invasive plants and plant species of concern. Care should be taken to walk through or around large vegetation, such as alders or cattails, to search for *Phragmites* hidden from view.
- If a plant species of concern is identified, the steps for each individual or patch (stand) are as follows:
  1. Tie flagging onto the plant, or if a stand, on a few plants, so that they are visible to others and future management
  2. Collect a GPS point for a single plant, or walk around the perimeter and collect multiple points, if a clonal stand or monoculture is present. Record GPS point numbers and sequence on the data sheet for each separate observation.
  3. Photo document the observation with one or more photos, and record photo numbers on data sheet.
  4. For each observation of a plant or a stand, estimate the number of stems on the data sheet.
  5. If multiple Phragmites plants are present in a stand, measure the height of the tallest 2 – 5 plants and record measurements on data sheet.
  6. Record whether there are any Phragmites seed heads in a stand on the data sheet.
  7. Record other anecdotes or observations, such as standing water on the marsh, standing dead stems, etc.

APPENDIX O:
Feldspar Marker Horizon SOP

Added to QAPP: March 2025

Feldspar Marker Horizon SOP

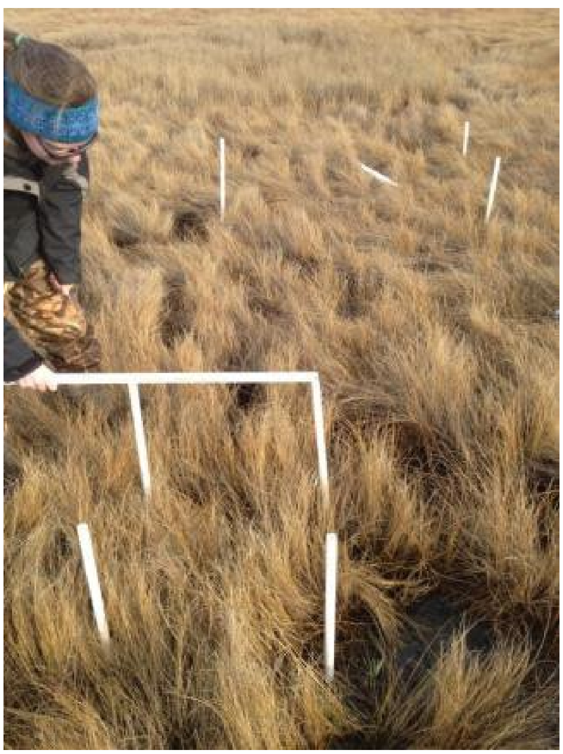
This protocol is adapted from the National Park Service Surface Elevation Table and Marker Horizon Technique SOPs (Lynch 2015). That document can be reference for additional information.

Goal

The goal of establishing feldspar marker horizons is to provide a way to directly measure marsh accretion over time. Understanding marsh accretion rates allows prediction of how marshes may respond to sea level rise and helps inform restoration decisions.

Sampling Design

Each feldspar plot is a square area of the marsh where powdered feldspar is spread. Plots are generally a minimum of 50 cm x 50 cm, but may be larger. Corners of plots are marked with PVC poles, wooden stakes, or other markers. At least 3 – 6” of corner markers should remain above the surface to allow for easy location in the future. The coordinates of each feldspar plot will be marked with GPS as well.



Cover each plot with a sufficiently thick layer of feldspar dust. Wear a dust mask while spreading feldspar to prevent inhalation. It should take ~ 8 lbs of feldspar to cover a 50 cm x 50 cm plot, or ~ 1/3rd of a lb per 100 cm^2 of plot area. The correct amount of feldspar to be used can be calculated using the following equation, where A is the area of the plot.

$$Feldspar\ lbs = \left(\frac{A}{100}\right) x\ 0.33$$

Ensure that feldspar contacts the marsh surface by gently brushing any dust that lies on top of vegetation. The feldspar dust forms a white layer on the surface of the marsh on top of which newly deposited sediments will accrete. Subsequent visits to the site will look at the depth of the sediment on top of the feldspar layer to estimate a rate of accretion at each site.

Note PVC frame used to establish marker horizon plot and location for pvc tubes at each corner.

Each site of interest should have a minimum of three feldspar plots. The location of felspar plots within the site is dependent upon project goals and will be detailed in project SAPs. Plots should be placed in areas that receive little to no traffic, as any activity that disturbs or compresses sediment will lead to inaccurate estimates of accretion rates. Plots spaced different distances from a shoreline or tidal creek can be used to estimate accretion rates over different elevations. Multiple plots at the same elevation will provide a more robust estimation of accretion rates, as they can be locally variable and it is difficult to get high-resolution estimates from feldspar plots.

Sampling Methods

The frequency at which feldspar plots are sampled is dependent on project goals and will be described in project SAPs. More frequent sampling of plots will enable detection of seasonal accretion trends. Sites undergoing long-term monitoring or where the impact of restoration is being examined may be sampled on an annual basis, or once every other year.

Feldspar plots are sampled by removing a small portion of the plot and examining soil layers. Any method that removes a small area of sediment without disturbing soil layers can be used, including cutting out a small area with a sharp-edged tool or using coring devices. Methods that do not require subsequent extrusion of a core are ideal, as extrusion compresses cores, leading to inaccurate accretion estimates. Two potential methods are outlined below.

One method is to cut out a small portion of the feldspar plot with a knife or other sharp edged tool by cutting at least 6 inches deep into the sediment. Be sure to sever any roots connecting the area to be removed to the larger plot. Then, use a trowel or similar tool to carefully remove the cut-out area of the marsh and lay it on a flat surface. This method does not require specialized equipment, but has the disadvantage of sometimes creating difficult to remove sections of sediment and disturbing wider areas of the plot if roots are not appropriately severed or the cut-out section is not carefully removed.

Another method is to use a clear coring device, such as one made out of a syringe tube or clear plexiglass tube. Drive the coring device straight into the marsh to a depth of at least 6 inches. Reach down along the coring tube with your hand or another tool to cover the end of the coring device, then lift the whole device up with the sediment core captured inside. Wipe off the outside of the tube as necessary to ensure that the sediment layers of the core are fully visible. This method can be easier to remove sections of sediment with, but requires additional coring equipment. Additionally, it runs the risk of smearing the sediment layers, making it difficult to see the white feldspar layer and requiring extrusion of the core anyways. If a core does need to be extruded, the total length of the core should be measured prior to extrusion (inside the coring tube) and following extrusion to calculate compression of the core. This compression can then be used to correct the measured accreted sediment layer.

Examine the exposed sediment layers and look for the white feldspar layer. If the layer cannot be seen, carefully cut the sediment in half vertically to expose new portions of sediment and continue looking for signs of the feldspar layer. If the feldspar layer still cannot be located, take a second core/block of sediment from a different area of the plot down to a depth of 12 inches to look for signs of feldspar in a different part of the plot and at a greater depth. When the feldspar layer is located, measure the distance from the top of the feldspar layer to the sediment surface, and record this on the data sheet. Then, measure the distance from the bottom of the feldspar layer to the sediment surface. Repeat this three times in each plot to obtain three distinct accretion measurement during each sampling event.

Data Quality Assurance

Feldspar marker horizons do not use any equipment that requires calibration to ensure data quality. The biggest potential risks to data quality are improper treatment of the plot or sediment cores/blocks. High quality data will be ensured by careful training of field staff surrounding marker horizon placement and coring to ensure that marker horizons are thick enough, plots are well marked and undisturbed by other field activities, and sediments are sampled in a way that does not disturb the soil layers.

Sample Handling and Custody

All observations are recorded on data sheets (**Appendix A**), the organization collecting the data is responsible for QA/QC and providing copies of data to CBEP in a commonly used electronic format. Copies of project photos and videos are also provided to CBEP. Electronic data are stored at CBEP in a project specific database. Field data sheets are stored at CBEP.

Soil samples are not typically kept for additional analysis of marker horizons but may be kept as needed for other sediment analyses (grain size, nutrient or organic content, etc.). If samples are being kept, they will be placed in individually labeled bags and transported to the lab in a cooler for use in appropriate analyses. The project field lead will be responsible for transport of samples and data sheets to the lab/office.

Analytic methods

Summary statistics (mean, median, standard deviation) are computed for cross-site or cross-plot comparisons and use in graphical or map displays. Standard statistical methods (t-tests, linear models or non-parametric equivalents) are used to evaluate long term or seasonal trends, comparisons between pre-restoration and post-restoration conditions, and comparisons between project areas.

References

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APPENDIX P:
Eelgrass Density Monitoring SOP
Added to QAPP: March 2025

Eelgrass Density Monitoring SOP

Adapted from Maine DEP Sampling and Analysis Plan, obtained through personal communication

Goal

In-situ monitoring of eelgrass beds provides detailed information on eelgrass health in a region and allows tracking of conditions over short and long time periods. This provides vital snapshots into the health of submerged aquatic vegetation in a region in between larger state mapping efforts (which occur every 5 years) and can provide information on the stressors leading to the decline of individual beds.

Sampling Design

Eelgrass density and associated parameters are monitored using underwater transect surveys. Transects for monitoring are set up following one of two designs: 1) two - three parallel transects following pre-determined depth contours, or 2) four radial transects from a central point of the bed. Transect start locations are marked with screw anchors with attached buoys during establishment, and locations are recorded with GPS. End locations of transects may also be marked if site conditions and gear placement restrictions permit, otherwise the compass bearing of each transect will be recorded during establishment and transects will be navigated with the use of transect reel tapes and underwater compasses during future visits.

Monitoring of transects is done with 0.25 m^2 quadrats placed at pre-determined, evenly spaced locations along the transect. The total transect length, number of quadrats, and spacing of quadrats is determined based on the size of the bed being monitoring and the project needs, and is detailed in project SAPs. Transects are generally 15 – 50 m long and are monitored with quadrats at 3-5 points along each transect.

Sites should be monitored a minimum of once per year between May and October. Ideally, monitoring within this period will be more frequent, but frequency and timing are dependent on project goals and resources and will be described in project SAPs. If possible, efforts will be made to follow the DEP sampling schedule of monitoring each site in June and September each year.

Visual belt transects may be documented with drop camera video prior to monitoring with quadrats or in between sampling events to assess quality and continuity of eelgrass or obtain observations at a higher temporal resolution. Timing of video transects will be purely opportunistic, based on upon availability of equipment and staff, and will typically be done when researchers are in the region on a boat as part of other projects.

One HOBO light and temperature sensor should be deployed at each site between June and September if possible. Each logger is suspended from a piece of PVC that is pushed into the substrate by hand, or some other semi-permanent structure, with the logger above the sediment surface at the top of the eelgrass canopy. Each logger contains batteries that should last for the duration of the deployment, though the sensor will need to be cleaned approximately every two weeks to prevent fouling impacts on temperature and light readings. Loggers should be placed at approximately the same depth as a transect, but outside of the transect survey area to minimize disturbances to the transects during routine logger cleaning and data downloads. The depth at which loggers are placed, particularly for light monitoring, should be informed by project goals and if monitoring is intended to capture typical light conditions (logger should be placed at the depth of the bed center) or low-light conditions that may cause bed stress (logger should be placed at the deep edge of the bed). Fouling can build up quickly on loggers in marine environments, so sites should be visited approximately every two weeks to clean loggers and download the data.

Sampling Methods

Monitoring of transects is typically done using SCUBA but may be done by snorkeling during low tides as conditions permit. Any SCUBA work will be carried out by fully certified divers following safety practices and restrictions of the divers' host organization. Upon arrival to the site, researchers will find the start point of the transect and will secure transect tapes between transect start and end points. Once transects are secure, monitoring will occur at the site locations (denoted as transect distances, e.g. 3m, 6m, 9m, etc.) described in the SAP. Upon arrival at each designated replicate location, a quadrat will be placed such that the lower left corner of the quadrat is aligned with the transect tape meter of interest.

Within each of the eelgrass beds identified in Figures 4-6, monitoring will occur along the intermediate and deep transects (T2 and T3, respectively) that are aligned parallel to bathymetric contours. T2 exists at Annual Sampling and Analysis Plan / Work Plan Page 9 of 14 roughly half the depth of the deepest transect (T3), and T3 is located approximately 25 m from the deep edge of each eelgrass bed. A fourth virtual transect, T4, bisects the alongshore transects and is used strictly for video monitoring via drop camera. The T2 and T3 transects have screw anchors, line and small buoys installed at the transect midpoint and 30 m to either side along the bathymetric contour. Although quadrat observations only occur along 50 m of transect (25 m to either side of the midpoint), an extra 5 m of transect length on each end allows for diver disturbance at the endpoints to be located away from the study area. Midpoint and endpoint markers as well as line and buoys will be cleaned or replaced prior to the start of monitoring. Upon arrival at the midpoint of the intermediate transect, T2, divers will extend and secure transect tapes in either direction from the midpoint. Monitoring along each of the transects will occur within 12, randomly located 0.25 m-2, PVC quadrats. For each quadrat, a still, vertical photo will be taken of the area just encompassed within the quadrat. Observations within the quadrat will then be recorded to include

- Percent cover of eelgrass
- Percent cover of macroalgae
- Density of all eelgrass shoots
- Number of flowering shoots
- Length of 80% of shoots in four handfuls (canopy height, including one handful in each of the four quadrat quadrants)
- Surface sediment observations

Other notes may also be recorded on the level of fouling, presence of seagrass wasting disease, presence of fauna, location of bed deep edge or deepest shoot, or other factors of potential interest.

All divers/snorkelers will be collecting observations, and each diver will utilize a datasheet on a modified clipboard ("writing cylinder") capable of being worn over the forearm. Researchers will work together on a single quadrat at a time such that members of a buddy pair are in close proximity to each other at all times. Upon completion of transect monitoring, tapes will be reeled back in.

One HOBO light and temperature sensor may be deployed at each site between June and September. Each logger is suspended from a piece of PVC that is pushed into the substrate by hand, with the logger approximately 1 m above the sediment surface at the top of the eelgrass canopy. Each logger contains batteries that should last for the duration of the deployment, though the sensor will need to be cleaned approximately every two weeks to prevent fouling impacts on temperature and light readings.

Data Quality Assurance

All temperature and light sensors used for data collection are factory calibrated, and calibrations are checked and maintained following manufacturer recommendations. Data downloaded from loggers will be drift corrected by using the comparison pre vs. post cleaning field measurements to correct for data drift as a result of the slow accumulation of fouling organisms.

Sample Handling and Custody

All observations are recorded on data sheets (**Appendix A**), the organization collecting the data is responsible for QA/QC and providing copies of data to CBEP in a commonly used electronic format. Copies of project photos and videos are also provided to CBEP. Electronic data are stored at CBEP in a project specific database.

Analytic Methods

Summary statistics (mean, median, standard deviation) for measured parameters are computed to match project goals. This may involve computation of statistics on the quadrat, transect, or site level, and at the scale of sampling events or an annual basis. Standard statistical methods are used to evaluate long term or seasonal trends.

Detailed Equipment List

General field

- boat with chart plotter/navigation system, marine radio with antenna
- PFDs for all staff and volunteers
- cell phone with data plan
- first aid kit
- waterproof, digital camera
- clipboard w/ grab sample bottle labels, pencils, Sharpies, site maps, hard copy data sheets
- portable charger for tablet & phones

Site set-up

- small weight attached to line and toggle buoy (5)
- stainless carabiners (3)
- screw anchors
- pieces of rebar
- line
- buoys (3)
- HOBO loggers

- PVC lengths w/ elbows
- Zip ties
- sledge

Eelgrass monitoring

- personal SCUBA gear with:
    - extra free weights
    - dive knife
- SCUBA tanks
- extra warm, dry clothes including hat and gloves
- hot water in thermos
- dive flag
- safety ladder
- mesh bags for equipment (3)
- writing cylinders with line and pencils (2)
- printed data sheets on waterproof paper
- electrical tape
- wide rubber bands
- 50m transect tapes (3)
- 0.25 m-2 PVC quadrats (2)
- extendable meter sticks (2)
- Handheld underwater camera
- towed video camera system (SplashCam or Seaviewer)

APPENDIX Q:
Crab Trapping SOP

Added to QAPP: March 2025

2024-2025 Maine Sea Grant Community Partner Trapping Protocol

PIs: Wells Reserve & Manomet

Why are we surveying Blue Crabs?
Blue Crabs have recently been increasing in occurrence in the Gulf of Maine, and their presence could have positive or negative impacts on local ecosystems and fisheries. However, formal trapping surveys are currently limited to just a handful of sites across the expansive Gulf of Maine coastline. By partnering with community organizations, we aim to extend trapping across a larger geographic area to detect the spread of this range expanding species more effectively in our system.

How are we surveying Blue Crabs?
Through community partnerships! Trapping surveys will *ideally* occur once per week Spring through Fall 2024-2025 using standard trapping protocols and data collection methods. However, the exact timing, frequency, and methods employed may vary slightly depending on the capacity of individual organizations. The number of traps/sites that are monitored will also depend on each organization's capacity and needs. Therefore, the following protocol is designed to provide some flexibility according to each organization's needs. However, the closer our methods align, the easier it will be to compare data across broad geographic scales.

General Trapping Supplies:

- 1-3 Ketchum Supply blue crab traps (*or similar*) with rope
- 1 HOBO temperature logger (attached inside trap w/ cable ties)
- Ziplock bags (gallon size)
- Permanent markers (for labeling bags)

Weekly Trapping Supplies:

- Bait (*ideally herring; alternatives: hot dogs, canned or raw chicken, etc.*)
- Bucket with lid
- Tongs
- Thick work gloves
- Ruler
- Clipboard
- Protocol
- Datasheets (1 per trap)
- Pencils
- *Optional: Spaghetti tags, dissection scissors, or hole puncher for tagging/notching crabs*

Weekly Trapping Protocol:
Gather supplies (see above).

1. On the top of the datasheet,record information about the trapping location (**Organization**, **Trap ID**, **Location**, **Latitude/Longitude**, **estimated Water Depth**, **Habitat type**). Feel free to add any additional site information you find relevant. You can re-use this datasheet each time you check the same trap in the same location.
2. Pull up the trap. Record the **date** the trap was **set** (baited/deployed) and the date it was **pulled** (checked). Count and record the **number of blue crabs** in the trap.
   *Optional: Record **number of green crabs** or **other bycatch** present in the trap. You may also measure and record water **temperature** (°C), **salinity** (ppt), and/or **dissolved oxygen** (mg/L).*
3. For each blue crab in the trap:
   a. Record the **date** it was found.
   b. Measure and record its **carapace width** in *millimeters,* measured from the tip of one lateral spine to the tip of the other (see diagram).
   c. Record its **sex** (male/female) based on the shape of its abdominal flap (see diagram).
   d. For females only, record its **maturity** (juvenile/adult/ovigerous) based on the shape of its abdominal flap (see diagram).
4. **If your organization is tagging crabs:*
   a. Record if the crab has a **tag/notch**. If it has a tag, record the **tag ID**.
   b. If the crab doesn't have one already, add a tag to its carapace and/or a notch to its swimmer paddle (*methods may vary between organizations*).
   c. Release the crab back into the water away from the trap.

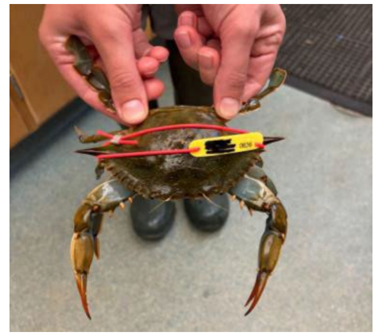
   **If your organization is NOT tagging crabs:*
   d. Place blue crabs in a bucket or cooler with some seawater. Try to keep crabs from different traps/sites separate from one another.
   e. Place blue crabs (without seawater) in the freezer as soon as possible.
   f. Once frozen, transfer blue crabs to a labeled Ziplock bag. Label with the date, location of capture, and your contact information.
5. Record any additional interesting **notes** about the site, trap, or crabs captured.
6. Any bycatch (non-blue crabs) can be dumped back into the water.
7. Close and re-bait the trap. Then drop the trap back into the water.

Questions? Feel free to contact:
Jason Goldstein (Wells Reserve) jgoldstein@wellsnerr.org
Laura Crane (Wells Reserve) lcrane@wellsnerr.org
Jessie Batchelder (Manomet) JBatchelder@manomet.org

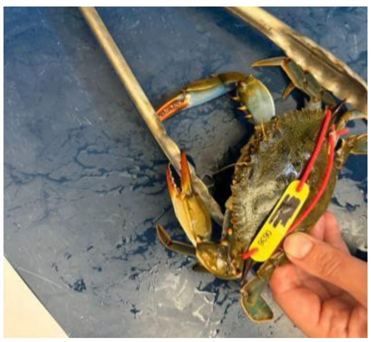
Methods for Safely Handling Blue Crabs

Dump crab on the ground and gently place your boot over its face and claws.

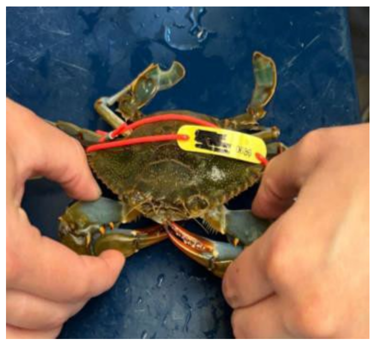
Remove crab from trap using tongs.



Grasp where the swimmer paddle meets the body. Keep *all* your fingers back here where it can't reach.



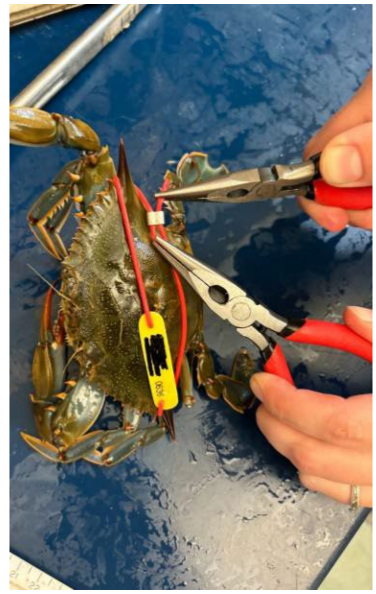
Let the crab clamp down onto a ruler, tongs, trap, or other object to distract its claws.

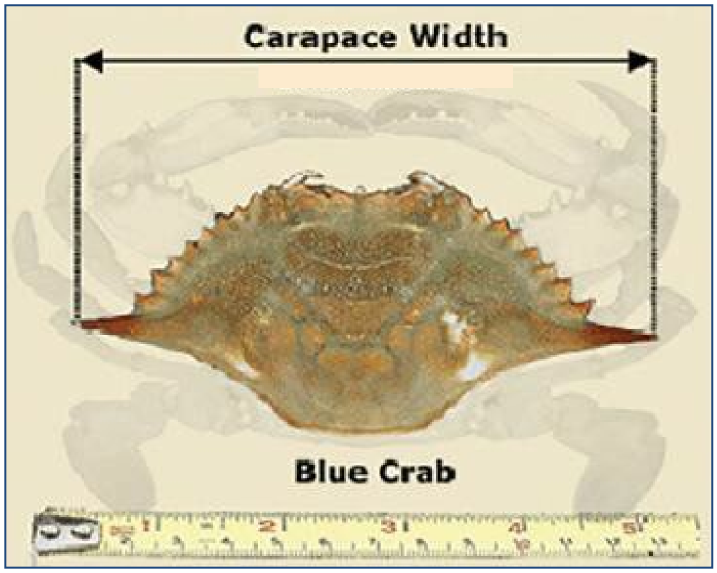


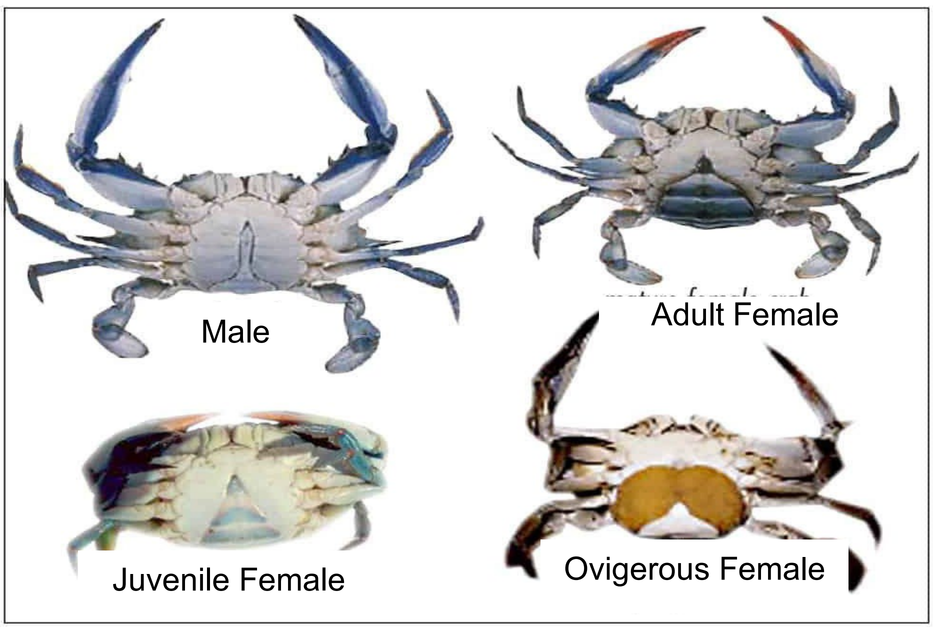
Fold both claws and hold them down with both hands.

To get a crab to let go of an object, dangle it above a bucket until it lets go.

Methods for Tagging Blue Crabs

V-Notch	O-Notch	Spaghetti Tag
		
Use dissection scissors to cut a V-shaped notch in the swimmer paddle.	Hold the hole puncher upside down so you can see through the bottom. Slide swimmer paddle about halfway through and squeeze to create a semi-circle notch on the edge of the paddle.	Loop spaghetti tubing around each lateral spine (like a backpack). Use pliers to pull the ends of the tubing until it's tight. Snip off extra tubing.
Pro: Notch will be retained if the crab molts. **Con:** Tells you if the crab has been caught before, but not who it is.	**Pro:** Notch will be retained if the crab molts. **Con:** Tells you if the crab has been caught before, but not who it is.	**Pro:** Tag provides a unique ID number for each crab so you can track individuals. **Con:** Tag will be lost if the crab molts.





Other Crab Species You Might Find

Jonah Crab (*Cancer borealis*)

Rock Crab (*Cancer irroratus*)

Green Crab (*Carcinus maenas*)

Asian Shore Crab (*Hemigrapsus sanguineus*)

APPENDIX R:
Presence/Absence Fish Monitoring SOP
Added to QAPP: March 2025

Presence/Absence Fish Monitoring SOP

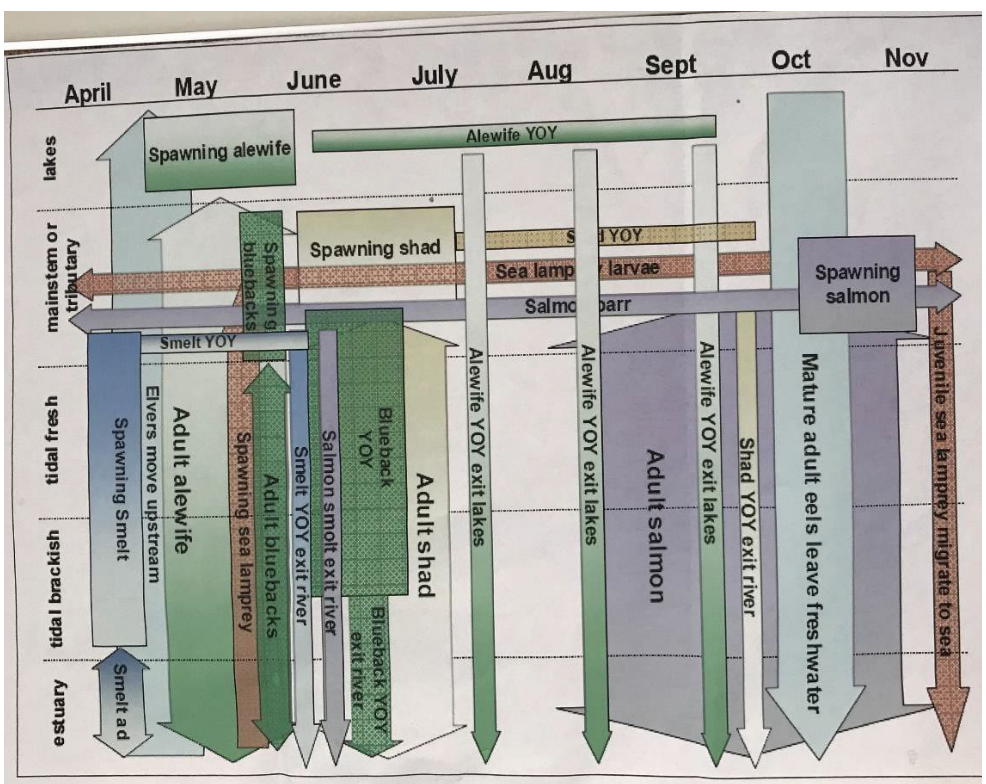
Goal

Migratory fish can be an important indication of stream health, and restoration of migratory fish populations is a primary goal of stream restoration projects, including dam removal, in Maine. Documenting fish population estimates or even fish presence/absence can provide important information on stream barriers, the efficacy of fish passages, and stream restoration success.

Sampling Design

Presence/absence monitoring is used to document observations of migratory fish during in-migration windows. These observations are most often conducted for river herring (alewife and blueback), so observations are typically scheduled during in-migration windows (May 1 – June 15). Observations for other species will take place during species specific in-migration windows, which are shown in **Figure 1.** Fish observations are led by a coordinator working with volunteers or natural resource professionals. Presence/absence monitoring through visual observation methods are used because of uncertainty of existing site conditions as well as following restorative actions, such as culvert replacement, dam removal, installation of fishways, or notching in ledge or steep falls to enhance fish passage.

Figure 1: Migration and spawning timing of anadromous fish



Sampling Methods

Visual observational monitoring occurs in 10-minute time counts at predetermined locations. Presence/absence observations are recorded on a standardized data sheet along with comments. Comments are used to document observations of predators, splashing, # of fish observed, species type, and other visual information. Still images or video footage can be useful for correlating observational data.

Observations are situated at predetermined locations, particularly when built or natural structures are likely to act as partial or complete barriers to fish movement. These include, but are not limited to, natural falls, bypass channels, dams, fishways, culverts at road and rail crossings, logjams, and other potential barriers such as beaver dams. Particularly noteworthy behavior is documented and described, such as schooling, staging, and resting; bursts and passage over falls and other obstacles; stranding; predation; mortality; and human uses including fishing.

Sample Handling and Custody

All fish presence and behavioral observations are recorded on data sheets and checked by the observation coordinator. Field data are entered into site-specific Microsoft Excel databases and data entry is reviewed by a second party for QA/QC. Data sheets and databases are archived at CBEP.

Analytic methods

Observations are primarily qualitative, so no statistical analysis will be performed. Data will be examined to note the migration window and peak migration for comparison with observations from other sites.

APPENDIX S:
External SOPs

The following is a list of SOPS used by CBEP that are produced and maintained by outside organizations. All protocols are either linked or included as appendices, with the exception of RTK SOPs, which CBEP keeps as separate documents due to the length of the files.

SOP	Source	Link/Reference	Section #s and notes
Added March 2025			
RTK use for Accurate Measurement of Elevation	USFWS SOP based on documents from USFWS and NOAA	CBEP N Drive	USFWS - full document NOAA - section 7.2
Total Station Stream Surveys: Standard Operating Procedures	USFWS	CBEP N Drive, Appendix I	Full Document
Eelgrass Phenology Monitoring	Massachusetts Bays National Estuary Program	CBEP N Drive, Appendix Q	Full document
Crab Trapping Surveys	Gulf of Maine Blue Crab Network	CBEP N Drive, Appendix R	Full document. Protocol is written for surveying blue crabs, but same methods can be used for green crabs
Eelgrass Biomass	SeagrassNet	https://repository.oceanbestpractices.org/handle/11329/2465	Section 4.5.7
Drone Monitoring of Coastal Wetlands	NERRS	https://nerrssciencecollaborative.org/sites/default/files/files/NERRS_drone_marsh_monitoring_SOP_w_authors.pdf	Full document
New Hampshire's Tidal Crossing Assessment Protocol	Collectively developed by TNC, NOAA, NHDES, and NHCP	https://www.nature.org/content/dam/tnc/nature/en/documents/nh-tidal-crossing-assessment-protocol.pdf	Full document

Grain Size Distribution	Stream Barrier Removal Guide	https://www.gulfofmaine.org/streambarrierremoval/Stream-Barrier-Removal-Monitoring-Guide-12-19-07.pdf	Section IV.B.3
Salt Marsh Sparrow SOPs (including Rapid Assessments, Capture Methods, Banding, and Body/Breeding Condition)	SHARP	https://www.tidalmarshbirds.org/index.php/publicly-availablr-products/products/vegatation-sampling-protocols/demographic-protocols/adult-bird-procedures-1	Individual SOPs as needed by project
Sediment Traps	UMass Amherst - Woodruff Lab	https://assets-eu.researchsquare.com/files/rs-5559787/v1_covered_2d09cb17-53c8-42c8-9253-612ce17dca12.pdf?c=1734451457	Full document.
Monitoring Nekton in Shallow Estuarine Habitats SOP	Cape Cod National Seashore	https://www.researchgate.net/profile/Kenneth-Raposa/publication/10871054_Monitoring_Nekton_as_a_Bioindicator_in_Shallow_Estuarine_Habitats/links/5644d3e308ae451880a88223/Monitoring-Nekton-as-a-Bioindicator-in-Shallow-Estuarine-Habitats.pdf	Full document
Groundwater hydrology		https://irma.nps.gov/DataStore/DownloadFile/563851	Full document