**Sampling & Analysis Plan**

2023 Regional Monitoring Network

Lakes

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Massachusetts Department of Environmental Protection

Division of Watershed Management

Watershed Planning Program

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Worcester, MA

***NOTE: This draft sampling plan provides detail re: sampling locations, frequencies, analytes, etc. and is intended to augment WPP’s multi-year programmatic QAPP approved by EPA for 2020 through 2024. The contents mirror selected elements of WPP’s programmatic QAPP (i.e.,QA-R5 EPA Guidance). See the QAPP for relevant information not provided in this SAP.***

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#### Project Organization

The Massachusetts Department of Environmental Protection (MassDEP), Division of Watershed Management (DWM), Watershed Planning Program (WPP) gathers background information, formulates sampling plans, and carries out monitoring and assessment activities on rivers, lakes, and coastal waters pursuant to the requirements of the Clean Water Act (CWA). Massachusetts’ water monitoring programs include both deterministic (targeted) and probabilistic (random) sampling networks and encompass both rotating watershed monitoring cycles as well as non-rotating, priority-driven schedules (see *A Strategy for Monitoring and Assessing the Quality of Massachusetts’ Waters to Support Multiple Water Resource Management Objectives 2016 – 2025* at <https://www.mass.gov/doc/water-quality-monitoring-strategy-2016-2025/download>) (MassDEP 2018). Targeted monitoring networks are a component of the Massachusetts’ water monitoring strategy and are used to achieve a wide range of objectives, including trend analysis.

The United States Environmental Protection Agency (EPA), Office of Research and Development is supporting EPA regional offices, states, tribes, river basin commissions, other federal agencies, universities, and other entities to establish Regional Monitoring Networks (RMNs) for freshwater resources (wadeable streams and lakes). RMNs are a collaborative effort to collect long-term monitoring data at targeted sites to detect changes over time due to climate change. The RMNs are intended to supplement existing monitoring efforts. The intent is to pool the RMN data at a regional scale, which will enable more robust analyses and allow for detection of widespread patterns that may otherwise be missed at the state and local level. Currently, there are two lake RMNs (Northeast and Midwest) active in the United States (USEPA 2020). The objectives of the RMNs align with and supplement Clean Water Act (CWA) goals (fills data gaps, protocol consistency, emerging technology utilization) and therefore have been integrated into the monitoring efforts of WPP since 2012 for wadeable streams. In 2023, WPP is planning to integrate the lake RMN efforts into the long-term monitoring efforts of WPP.

This Sampling and Analysis Plan (SAP) provides details pertaining to the targeted water resource monitoring planned by the WPP for Massachusetts lakes in the Northeast RMN. Specific descriptions of WPP staff roles and responsibilities for this monitoring project are detailed in Table 1. In addition, the WPP fulltime monitoring program staff will be augmented by the hiring of five (5) seasonal employees from May through September to ensure that enough personnel are available to carry out field surveys and selected laboratory analyses, as planned.

| **Table 1.** Project Roles and Responsibilities related to monitoring and data use | |
| --- | --- |
| **Project Personnel** | **Responsibility** |
| Project Coordinators  - James Meek (RMN)  - Dan Davis (RMN) | Responsible for lake reconnaissance, obtaining landowner access permission, defining logistics for efficient monitoring and generation of useable data at assigned sites using the procedures contained in WPP SOPs. |
| Water quality survey crews  -James Meek (lead)  -Dahlia Tympanick (lead)  -Pete Mitchell (lead)  -Dan Davis (lead)  -Steve Bittner (lead)  -WPP staff and seasonal employees | Responsible for the collection of samples and data at assigned lakes using the sample collection techniques and probe use procedures contained in WPP SOPs. |
| Macrophyte survey crews  -James Meek (lead)  -Dahlia Tympanick (lead)  -Pete Mitchell (lead)  -Dan Davis (lead)  -Steve Bittner (lead)  -WPP staff and seasonal employees | Responsible for documenting macrophyte surface cover, biovolume and species composition using techniques and procedures contained in WPP SOPs. |
| Littoral macroinvertebrate survey crews  -James Meek (lead)  -Dan Davis (lead)  -Pete Mitchell (lead)  -Dahlia Tympanick (lead)  -Steve Bittner (lead)  -WPP staff and seasonal employees | Responsible for littoral macroinvertebrate and aquatic habitat survey data collection using procedures contained in WPP SOPs. |
| WPP Laboratory (algal)  -Joan Beskenis (lead)  -Sue Flint (backup)  -Dahlia Tympanick (backup)  -WPP staff and seasonal employees | Responsible for the analysis of chlorophyll samples using techniques and procedures contained in WPP SOPs |
| WPP Laboratory (color and turbidity)  -Shervon DeLeon (lead)  -Sue Flint (backup)  -Dahlia Tympanick (backup)  -WPP staff and seasonal employees | Responsible for the analysis of color and turbidity samples using techniques and procedures contained in WPP SOPs |

For each field monitoring survey event, the staff member serving as the survey crew leader (at a minimum) will have met the following qualifications:

• Familiarity with this SAP and all applicable SOPs for that survey

• Completion of a multiprobe sampling/grab sampling/QC training segment

• Prior field experience with survey equipment and with similar monitoring surveys

• Be physically able to access the sites, carry equipment and samples, and perform the sampling.

Survey crew leaders will be accompanied by one or more additional crew members for each survey, depending on the kind of sampling to be undertaken (e.g., water, macroinvertebrates, fish, etc.). All field survey crew personnel and WES/WPP lab personnel will be trained in the proper application of standard operating procedures (SOPs). Field training may range from formal WPP training sessions to field instructions provided by a trained and experienced WPP survey crew leader. WPP lab training (e.g., chlorophyll *a*, color, turbidity) will be provided to selected WPP staff, who will run the analyses. All WPP training activities will be documented using signature sheets.

Dr. Oscar Pancorbo, Director of MassDEP’s Wall Experiment Station (WES), and/or his designees, will coordinate with the WPP regarding sample delivery, analyses, and reporting. WES has been selected to perform total phosphorus, total nitrogen, chloride, total alkalinity, total hardness, and dissolved organic carbon (DOC). If WES is unable to perform any analyses due to resource constraints, the samples will be sent to Alpha Analytical (WES backup laboratory) for analyses. If necessary, WES will coordinate with Alpha Analytical and/or their designee regarding sample delivery, analyses, reporting, and invoice payment.

The project manager at Phycotech, and Cole Ecological and/or their designees will coordinate with the WPP regarding sample delivery, analyses, and reporting. Phycotech has been selected to perform phytoplankton taxonomic identification on samples collected as part of this project. Cole Ecological has been selected to perform macroinvertebrate taxonomic identification on samples collected as part of this project.

#### Project Definition and Background

Lake RMNs have been established in the Northeast and Midwest and new networks are expanding into other regions. With the intention of pooling comparable data with other organizations in the Northeast network, MassDEP is working to provide data that can be used by programs for multiple purposes over short and long timeframes. While developing and designing the lake RMNs (e.g., indicators, waterbody type), EPA and lake RMN partners drafted the following mission statement and goals:

Missions Statement (USEPA 2020)

In an effort to maximize lake monitoring return on investment, this grassroots effort is based on the premise that while some states and tribes are attempting to develop lake biocriteria and sentinel lake networks on their own, states and tribes can make more progress more quickly by working collaboratively and can build capacity simultaneously. The lake RMNs will build on existing lake monitoring efforts with the goal of collecting comparable data at targeted sites that can be pooled and analyzed at a regional level. Pooling data enables more robust regional analyses, improves the ability to detect trends over shorter time periods and allows for detection of widespread patterns that may otherwise be missed at the local level. The lake RMNs will also increase our ability to understand how changing thermal and hydrologic conditions are affecting our lakes and will help inform strategies to enhance the resiliency of lakes to these changes.

Goals (USEPA 2020)

* Help support Clean Water Act (CWA) programs and initiatives
* Gain a better understanding of current (“baseline”) conditions and natural variability
* Identify and monitor trends over time
* Better understand mechanisms behind trends
* Gain insights into effects of regional phenomena such as changing climatic conditions and pollutant/nutrient deposition on lake ecosystems
* Build capacity to utilize emerging technologies like continuous temperature and dissolved oxygen (DO) sensors
* Help guide management that sustains lake resources for future generations
* Improve public understanding of lake habitats, environmental stressors, and ecological responses to stressors

The goal of the 2023 monitoring effort is to collect physical, chemical, and biological data at the target RMN effort level or better (e.g., indicators and frequency) that will permit the analysis of long-term trends due to climate change. The WPP proposes to gather the following kinds of environmental data and information at each site in fulfillment of this goal:

* Discrete vertical profile (dissolved oxygen, temperature, pH, conductivity)
* Continuous vertical profile (dissolved oxygen, temperature)
* Secchi disk transparency
* Nutrients (total phosphorus, total nitrogen)
* Water chemistry (true color, alkalinity, hardness, turbidity, chloride, dissolved organic carbon)
* Chlorophyll a
* Phytoplankton community
* Littoral macroinvertebrate community
* Macrophytes (percent cover, biovolume, exotics)
* Water level
* Ice cover duration
* Aesthetics observations
* Human disturbance observations
* Bathymetry

#### Project Description

**Overview of Regional Monitoring Network (RMN) Lakes in 2023**

##### Index Site - Water Quality (Chemical, Biological and Physical)

Water quality [discrete vertical profile (DO, temperature, pH, conductivity), nutrients, chlorophyll a, phytoplankton, true color, alkalinity, hardness, turbidity, chloride, dissolved organic carbon] samples will be collected approximately once during spring turnover (if resource available) and once a month between July and September (4 sampling events) at the index site of each lake using techniques described in WPP standard operating procedures (SOP). The index site is located at the maximum depth point in each lake. Samples will be field preserved, as appropriate, and delivered to the Senator William Wall Experiment Station in Lawrence (WES) for nutrient (total nitrogen, total phosphorus), chloride, alkalinity, and hardness analyses, the WPP lab in Worcester for chlorophyll a, turbidity, and color analyses, and PhycoTech for phytoplankton taxonomy, enumeration and biovolume. Alpha Analytical in Westborough will serve as a backup laboratory for WES and any analyses that cannot be performed by WES due to resource constraints will be sent to Alpha Analytical. A minimum of one duplicate and one blank sample per analyte will be tested for QC biweekly (@ approx.10% of the samples).

Onset multiprobe (dissolved oxygen and temperature) and Tidbits (temperature) will be deployed on a long-term continuous basis from April (or ice out) through October (or fall turnover) at each lake using RMN protocols (Stamp 2020). A WPP SOP for vertical profile deployments will be developed based on the RMN protocols. The probes will be deployed vertically on a stringer with a buoy at the top and anchor at the bottom to provide data on stratification and dissolved oxygen changes over time. Two Onset multiprobes will be deployed on the stringer near the surface and near the bottom with Tidbits every 0.5 or 1 meter (depending on overall depth and equipment availability) between the Onset multiprobes (Figure 1). In addition, a pressure transducer will be deployed on the stringer near the bottom to continuously measure water level and another pressure transducer will be deployed on land to allow barometric pressure corrections. At deployment and prior to retrieval of multiprobes, as well as at various times during the deployment, QC readings will be taken using a separate meter as specified in WPP’s unattended probe SOPs. After retrieval of deployed multiprobes, post-deployment calibration and QC checks on the data will be performed.

|  |  |
| --- | --- |
|  | C:\Users\rdamstra\Desktop\Arrays\Picture1.png |

**Figure 1.** Examples of vertical profile deployments.

##### Macrophyte Community and Bathymetry

The macrophyte community (percent cover, biovolume and species composition) and bathymetry will be surveyed once during the summer in each lake using protocols described in WPP SOP. Bathymetric mapping will be conducted in May using BioBase. The percent cover and biovolume of macrophytes will be estimated using BioBase. BioBase is cloud based software that automates processing of depth finder sonar log files to make aquatic vegetation and bathymetric maps (Navico 2015). Macrophyte species composition will be estimated by identifying macrophyte species from periodic spatially diverse rake drags within each lake until no new species are identified by the survey crew with the goal of producing a dominant species list. Any macrophyte species that cannot be identified by the survey crew will be delivered to the WPP biological lab in Worcester for identification.

##### Littoral Macroinvertebrate Community

The littoral macroinvertebrate community will be sampled at each lake on one occasion during late summer or early fall, using protocols developed for the 2012 National Lake Assessments (NLA) (USEPA 2011) and adopted into WPP SOPs. These organisms can integrate environmental conditions (chemical – including nutrients and toxics; and physical – including shoreline alteration and water level fluctuations) over a long period of time and are an excellent measure of the water body’s health. Specimens will be placed into 2L Nalgene jars, preserved with denatured 95% ethanol and transported to the WPP lab for storage. Cole Ecological will process (i.e., subsample) the macroinvertebrate samples and complete the necessary taxonomic identifications. In addition, habitat evaluations will be completed at all lakes sampled for littoral macroinvertebrates.

##### Ice Cover

Ice cover will be documented on a continuous basis throughout the year using RMN protocols (Stamp 2019). A time lapse trail camera will be mounted on shore in a location that captures as much of the lake as possible or as much of vertical profile deployment area. The time lapse camera will capture a minimum of two image per day during the time of day when the ice is most visible. The daily ice cover images will be downloaded at the end of the ice season and interpreted to estimate daily percent ice cover. The daily ice cover estimates will then be entered onto an Excel spreadsheet and batch uploaded (along with selected photos) to the Lake Observer website (<https://www.lakeobserver.org/>) for RMN analysis.

#### Sampling Process Design

The RMN lake selection process balances scientific and practical considerations. There are no firm criteria or requirements for inclusion, but the characteristics listed in below are preferred (the more of these characteristics a lake has, the stronger its candidacy) (USEPA 2020). WPP focused on the four bolded characteristics for selecting RMN lakes.

* Located in an established monitoring network with lengthy historical sampling records.
* Low levels of human disturbance
* Watersheds that are protected from development (e.g., state forest, Nature Conservancy)
* Access allows multiple site visits per year.
* Lakes with environmental characteristics of interest (e.g., oligotrophic, cold water)
* Opportunities to partner with outside agencies or organizations
* Highly valued site (e.g., has ecological or cultural significance)

Lakes with low levels of anthropogenic disturbance or ‘reference lake’ were selected using attribute data from the Lake-Catchment (LakeCat) Dataset (Hill et al. 2018), which is a standardized nationwide dataset of natural and anthropogenic geospatial metrics. The percent of developed land for the catchment, watershed, and shoreline (100-meter buffer) of each lake in Massachusetts (greater than 2 acres) was calculated using GIS. The average percentile rank of the three different spatial levels of percent developed land was calculated to indicate where each lake was ranked in terms of disturbance within the population of lakes. Generally, a lake had to fall in the bottom quartile for the average percent of developed land to be considered for the RMN. Priority was given to oligotrophic cold-water lakes with relatively easy access on public land. The Northeast Lake and Pond Classification by the Nature Conservancy was used to determine modeled trophic status and thermal class of each lake (Olivero-Sheldon and Anderson 2016).

Using desktop reconnaissance and other information resources (e.g., LakeCat), a final master list containing 14 candidate RMN lakes was created for field reconnaissance. Two lakes from the candidate list were selected for the RMN following field reconnaissance. The RMN lakes were assigned to individual WPP monitoring coordinators who are responsible for lake reconnaissance, obtaining landowner access permission, defining logistics for efficient monitoring, and generation of useable data at assigned lakes using the procedures contained in WPP and RMN SOPs. Based on the desktop and field reconnaissance information and logistical/resource considerations, a final list of 2 lakes (1 groups of 2 lakes) was developed for monitoring in the RMN lake network (Table 2). Lake locations and monitoring sites are detailed and illustrated in Table 2 and Figure 1. Lake locations are detailed and illustrated in Table 2 and Figure 2. The project and monitoring schedules are outlined in Table 3.

| **Table 2.** RMN lake location and general information. | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Site ID2** | **Waterbody** | **Town** | **Northeast Lake and Pond Class** | **Index Site1**  **Unique ID** | **General Location** | |
| **Latitude** | **Longitude** |
| [RMN-001](http://maps.google.com/maps?q=loc:42.18135,-73.11784) | Upper Spectacle Pond | Sandisfield | Warm to Cool, Eutrophic, Acidic | W1748 | 42.18135 | -73.11780 |
| [RMN-002](http://maps.google.com/maps?q=loc:42.15464,-72.86475) | Russell Pond | Russell | Very Cold, Oligo-Mesotrophic, Acidic | W3255 | 42.15464 | -72.86480 |
| 1 – Index site is located at the maximum depth point in the lake.  2 – Google Maps hyperlink is the general lake location and not a specific sampling location. | | | | | | |

Map

Description automatically generated

**Figure 2.** Location of RMN Lakes

| **Table 3.** Project Schedule for 2023 at RMN lakes | | | |
| --- | --- | --- | --- |
| **Activity** | **Approx. Date of Initiation** | **Approx. Date of Completion** | **Deliverable** |
| Coordination, staff meetings, reconnaissance, river/stream sampling plan development, site selection, etc. | Jan 2023 | Apr 2023 | Draft sampling plan; meeting notes, etc. |
| Draft sampling plan review and approval | Mar 2023 | Apr 2023 | Internal WPP concurrence on sampling plan |
| Vertical profile probes deploy/retrieval | April 2023 | Oct 2023 | Continuous DO/temperature data |
| Water quality sampling surveys  (4 visits) (*Index Site)* | July 2023 | Sep 2023 | Field data; lab samples to WES, WPP, EPA and/or contract lab(s) |
| Benthic/Habitat sampling surveys  (1 visit) | Jul 2023 | Sep 2023 | Field data; benthic samples to contractor |
| Ice Cover (fall - spring) | Oct 2023 | April 2023 | Images |
| Macrophyte surveys (1 visit) | Jul 2023 | Sep 2023 | Field data |
| Data QA/QC review and validation | Jan 2024 | Jun 2024 | 2023 Data Validation Report |
| Data review, analysis, and preliminary reporting | Jun 2024 | Mar 2025 | Final data analysis |

#### Non-Direct Measurements

Table 4 presents a brief list of relevant external data sources that may be used in coordinating monitoring efforts or the interpretation of monitoring data. For example, stage data from the USGS could be used to determine if water levels are appropriate for certain types of sampling or rain data from NCEI could be used to determine if a sampling event occurred during wet or dry weather.

**Table 4.** External data sources used for the 2023 RMN monitoring.

|  |  |
| --- | --- |
| **Organization** | **Data** |
| United States Geological Survey (USGS)  <https://www.usgs.gov/centers/new-england-water/> | Continuously stream stage and discharge measurements at gage stations within the project extent. |
| National Centers for Environmental Information (NCEI)  <https://www.ncdc.noaa.gov/> | Daily precipitation and temperature data weather stations within the project extent. |
| The Weather Underground  <http://www.wunderground.com/> | Daily precipitation and temperature data weather stations within the southwestern basin group. |

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