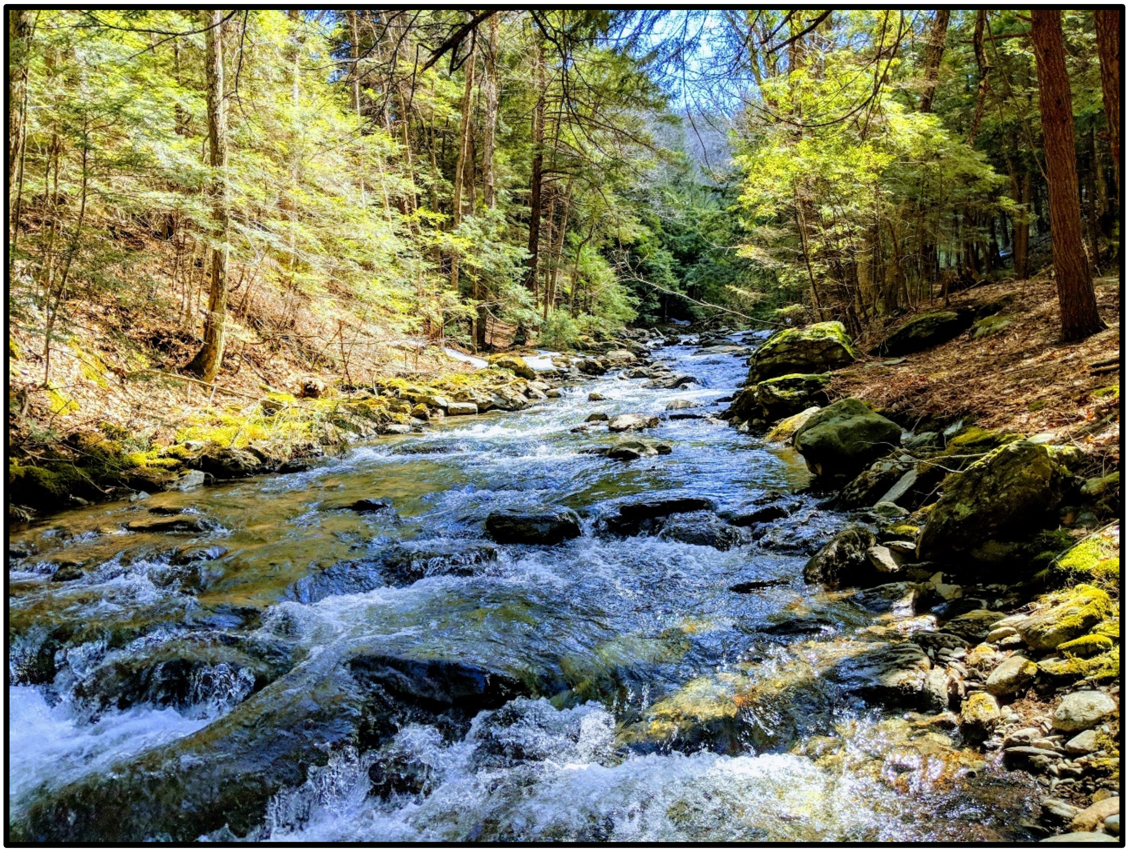
# MASSACHUSETTS PROBABILISTIC MONITORING AND ASSESSMENT PROGRAM ASSESSMENT OF WADEABLE RIVERS AND STREAMS 2011-2015



**COMMONWEALTH OF MASSACHUSETTS**

**EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS**

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Cover Photo: Ashley Hill Brook in Mt. Washington, MA (MassDEP)

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## Abbreviations

| | |
|---|---|
| CALM | Consolidated Assessment and Listing Methodology |
| CI | Confidence Interval |
| CWA | Clean Water Act |
| DWM | Division of Watershed Management |
| EPA | Environmental Protection Agency |
| GHCN | Global Historical Climatology Network |
| GRTS | Generalized Random Tessellation Stratified |
| MAP2 | Massachusetts Probabilistic Monitoring & Assessment Program |
| MassDEP | Massachusetts Department of Environmental Protection |
| NHD | National Hydrography Dataset |
| NHEERL | National Health and Environmental Effects Research Laboratory |
| NOAA | National Oceanic and Atmospheric Administration |
| QA | Quality Assurance |
| QC | Quality Control |
| RBP | Rapid Bioassessment Protocols |
| SOP | Standard Operating Procedures |
| Std | Standard |
| SWQS | Surface Water Quality Standards |
| UMASS | University of Massachusetts - Amherst |
| WED | Western Ecology Division |
| WPP | Watershed Planning Program |

# Executive Summary

The Massachusetts Probabilistic Monitoring and Assessment Program's (MAP2) *Assessment of Wadeable Rivers and Streams 2011-2015* report presents the results of an overall assessment of the Commonwealth's wadeable rivers and streams. It encompasses a wide range of waters – from small high gradient cold water streams, to larger low gradient meandering rivers, and everything in between. It provides information on the condition of designated uses (*Aquatic Life Use* and *Recreation Use*), biological communities (macroinvertebrates and fish), and the key stressors that affect them.

The overall goal of MAP2 is to provide an unbiased and statistically valid assessment on the condition of selected designated uses in all waters of the state and the key stressors that affect them. Wadeable rivers and streams was the first water resource type assessed within MAP2 and future efforts will focus on lakes and coastal water resources. The goals of the wadeable rivers and stream assessment were to determine the extent of wadeable rivers and streams supporting *Aquatic Life Use, Recreational Use*, healthy macroinvertebrate and fish communities and the extent affected by key important stressors.

The key findings of the report are:

- *Aquatic Life Use* was assessed as impaired in an estimated 59.0% of the wadeable river and stream miles.
- *Recreational Use* was assessed as impaired in an estimated 35.1% of the wadeable river and stream miles.
- The biotic integrity of the macroinvertebrate community was assessed as impaired in an estimated 39.6% of the wadeable river and stream miles.
- The biotic integrity of the fish community was assessed as impaired in an estimated 23.5% of the wadeable river and stream miles.
- Habitat quality was assessed as impaired in an estimated 36.4 % of the wadeable river and stream miles.
- Temperature assessment criteria were violated in an estimated 30.4% of the wadeable river and stream miles.
- Temperature assessment criteria were violated in an estimated 49.5% of the wadeable river and stream miles classified as cold water.
- Dissolved oxygen assessment criteria were violated in an estimated 24.0% of the wadeable river and stream miles.
- Dissolved oxygen assessment criteria were violated in an estimated 34.2% of the wadeable river and stream miles classified as warm water.
- Nutrient enrichment, pH, metals, chloride, and ammonia assessment criteria were violated in an estimated 16.8%, 22.1%, 9.5%, 1.8%, and 0.0% of the wadeable river and stream miles, respectively.

# Introduction

The goal of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. To meet this objective, the CWA requires states to assess the quality of the Nation's water resources and report this information to the U.S. Environmental Protection Agency (EPA), the U.S. Congress, and the public. Section 305(b) of the Clean Water Act (CWA) requires states to report biennially on the condition of all waters in their state. In the past, Massachusetts Department of Environmental Protection (MassDEP), Division of Watershed Management (DWM), Watershed Planning Program (WPP) conducted monitoring primarily at targeted sites to fulfill this requirement. Targeted monitoring approaches are by design limited to sites at targeted locations, which limits the reporting on the condition of the waters to only those waterbodies or assessment units. Typically, this covers just a small percentage of the total waters in the state. There are two monitoring strategies that enable reporting on the condition of all waters in the state, a census strategy and a probabilistic strategy. A census strategy requires the monitoring of all waters or assessment units in the state and consumes significantly more resources than a probabilistic strategy to meet the same requirement. Use of probabilistic monitoring is based on the principle that the quality of waters in a target population can be statistically estimated with a stated level of certainty by monitoring a random subset of the waters in the target population (EPA 2002). Unlike census monitoring, probabilistic strategies can be realistically implemented using MassDEP-WPP's current resources.

In 2011, the Massachusetts Probabilistic Monitoring & Assessment Program (MAP2) was initiated as a component of the overall monitoring strategy to help fulfil the requirements of CWA Section 305(b) using a probabilistic network design. The overall goal of MAP2 is to provide an unbiased and statistically valid assessment on the condition of selected designated uses (*Aquatic Life Use* and *Recreation Use*) in all waters of the state and the potential stressors impacting those uses. Wadeable rivers and streams were the first water resource type monitored by MassDEP using a probabilistic design and are the focus of this report. Future MAP2 reports will cover probabilistic monitoring results for lakes and coastal water resources.

# Survey Design

The MAP2 utilizes the Generalized Random Tessellation Stratified (GRTS) design strategy developed principally by EPA's National Health and Environmental Effects Research Laboratory, Western Ecology Division (EPA-NHEERL-WED) (EPA 2010a) (Stevens and Olsen 2004). The basic survey design specifics for MAP2 wadeable river and streams are:

- Stratified by five basin groups with a target of 32 sites per basin group and rotated through a five-year cycle until approximately 160 sites are monitored statewide. Each basin group or stratum is comprised of 2-7 watersheds with roughly an equivalent number of river miles (Figure 1).
- The target population is defined as all wadeable $1^{st}$ – $4^{th}$ Strahler Order non-tidal perennial rivers and streams.
- Within the target population, unequal selection probabilities are used to create multi-density categories and allocate sites equally into Strahler Orders $1^{st}$, $2^{nd}$, $3^{rd}$, and $4^{th}$.

- The sampling frame is the National Hydrography Dataset (NHD) at a resolution of 1:24,000. MassDEP contracted with the University of Massachusetts – Amherst (UMASS) to enhance the high resolution NHD (1:24,000) by adding Strahler Order and refining the classification scheme so it could be used as the sampling frame (Rees et al. 2010).

Based on this design, 800 sites were selected (32 primary sites and 128 oversample sites per basin group or stratum) for the 2011 – 2015 MAP2 wadeable streams monitoring effort. GRTS software package (spsurvey) developed by EPA for the R statistical package was used to select the sites and to calculate the population estimates based on the survey data (EPA 2010b) (Kincaid 2019). Additional survey design details are available in the survey design document (Appendix A).

## Site Evaluation

Site evaluations using desktop and field reconnaissance were conducted on the primary sites according to WPP standard operating procedures for site evaluation (MassDEP 2009a). If it was determined that a site was not part of the target population (e.g., intermittent, tidal) or inaccessible (physically or access permission denied), the site was rejected from the survey and replaced with the next oversample site on the list. Extra sites above the target of 32 sites per stratum were included in the survey to account for any site evaluation errors or new information that would require removing a site during the survey.

Site evaluations were conducted on a total of 414 primary and oversample sites during the wadeable river and stream survey (2011 -2015) and 237 sites were rejected as not part of the target population or inaccessible (Appendix B). All the 177 sites determined to be part of the target population and accessible were sampled during the wadeable river and streams survey (Figure 1). Detailed site identification and location information for the target sampled sites are in Appendix C.

Based on the site evaluations, an estimated 49.1% of the sample frame or 4,446 stream miles were part of the defined target population for the wadeable rivers and streams survey. This estimate assumes that inaccessible sites (access permission denied or physically inaccessible) were part of the target population since confirmation was not possible. The most common non-target categories were intermittent and wetland (i.e., lacked a defined channel) at 23.8% and 13.8% of the sample frame, respectively. Intermittent sites were assumed to be non-target and not impaired target sites in the absence of any direct anthropogenic sources (e.g., water withdrawal).

The extent of the sample frame estimated to be both part of the target population and sampled (referred to as the target population going forward) was 33.3% or 3,019 stream miles. The population estimates of designated use support, biotic integrity, or water quality condition presented in the following sections of this report apply only to this portion of the sample frame. The extent of the sample frame in each site evaluation category is summarized in Figure 2 and Table 1.

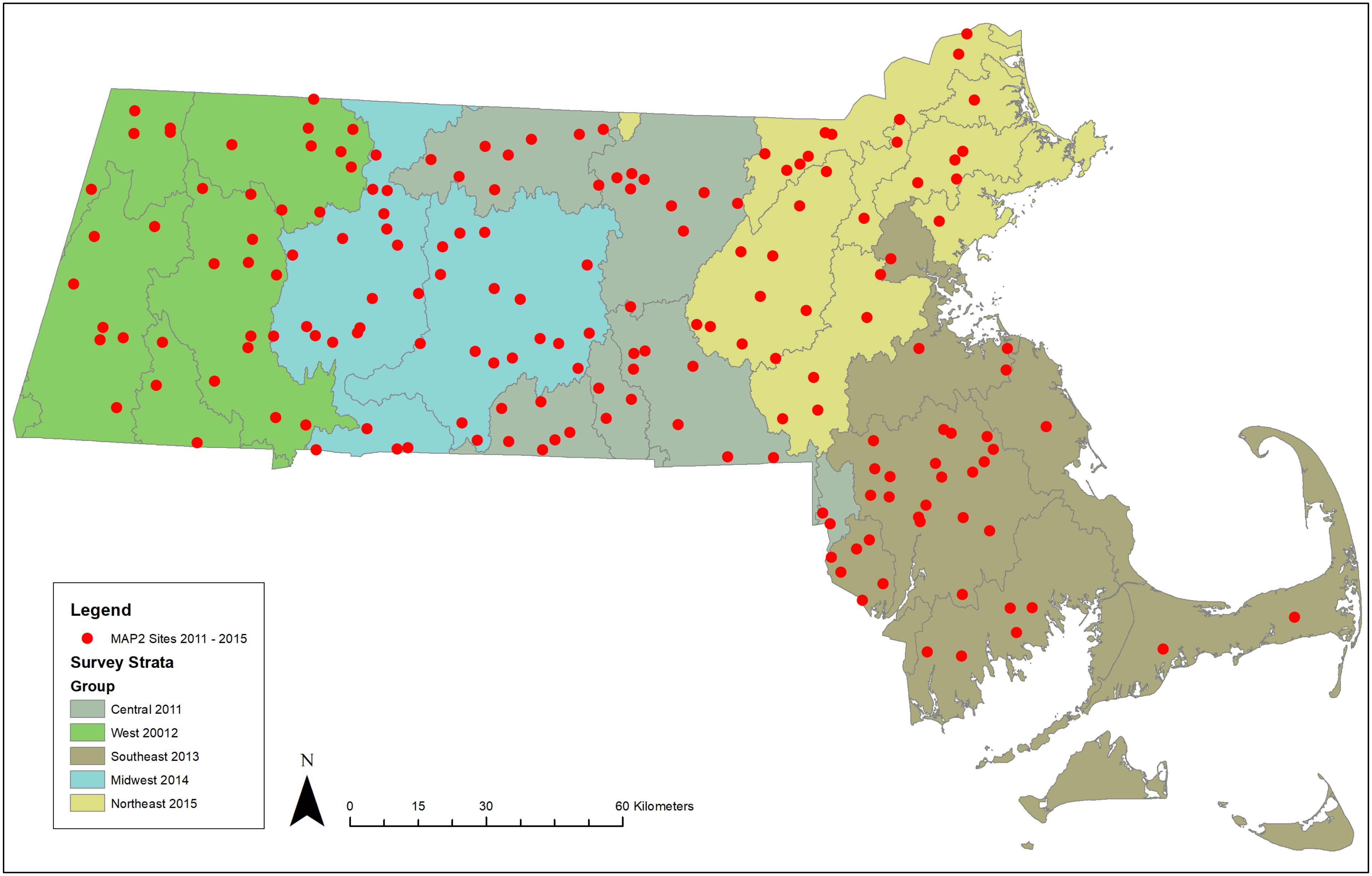


**Figure 1.** MAP2 target sampled sites 2011 – 2015.

*error bars represent the 95% confidence intervals

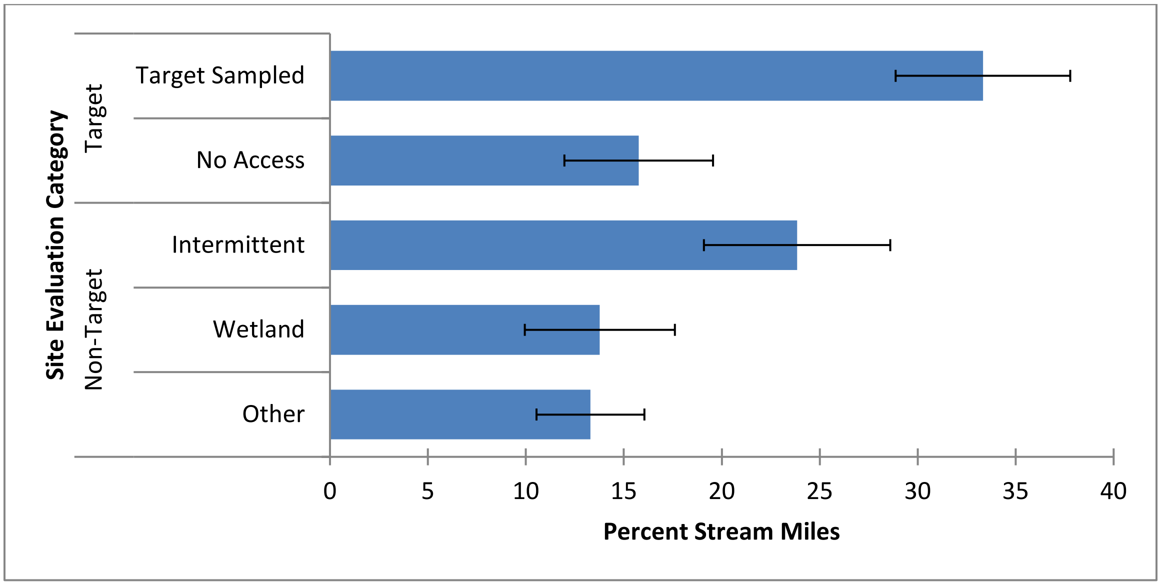


**Figure 2.** Extent of the sample frame in each site evaluation category.

**Table 1.** Extent of the sample frame in each site evaluation category.

| Category | | Sites | Percent Sample Frame Estimate | Percent Sample Frame Std. Error | Percent Sample Frame Lower 95% CI | Percent Sample Frame Upper 95% CI | Sample Frame Miles Estimate | Sample Frame Miles Std. Error | Sample Frame Miles Lower 95% CI | Sample Frame Miles Upper 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|
| Target | Sampled | 177 | 33.3 | 2.3 | 28.9 | 37.8 | 3019 | 199 | 2628 | 3409 |
| | No Access[1] | 64 | 15.8 | 1.9 | 12.0 | 19.6 | 1427 | 183 | 1068 | 1786 |
| Non-target | Intermittent[2] | 58 | 23.8 | 2.4 | 19.1 | 28.6 | 2159 | 249 | 1671 | 2648 |
| | Wetland | 48 | 13.8 | 2.0 | 9.9 | 17.6 | 1248 | 185 | 885 | 1610 |
| | Other[3] | 67 | 13.3 | 1.4 | 10.5 | 16.0 | 1204 | 133 | 943 | 1465 |

1 – Category includes access permission denied, no response to access request, and physically inaccessible, all assumed to be target.
2 – Intermittent was assumed to be non-target and not impaired target in the absence of direct anthropogenic sources (e.g., water withdrawals).
3 – Category includes nine minor site rejection categories (no stream channel, artificial, tidal, impounded (man-made), not wadeable, not wadeable (man-made impoundment), not wadeable (natural impoundment) cranberry bog ditch, other), ranging from 0 %– 4% of the sample frame (MassDEP 2009a).

# Monitoring Design

## Sampling Plan

The monitoring goal of the MAP2 wadeable rivers and streams survey (2011-2015) was to collect water quality and biological data at each of the 177 probabilistically selected target sites located throughout the Commonwealth to assess the status of selected designated uses (*Aquatic Life Use and Recreational Use*) and potential stressors at those sites, thus estimating the status of those designated uses and stressors in the target population as a whole. The types of data that were collected at each of the sites to reach this goal were:

- Nutrients (total phosphorus, total nitrogen, nitrate-nitrite and ammonia)
- Turbidity
- True color
- *E. coli* bacteria
- Chloride
- Dissolved heavy metals
- pH
- Specific conductance
- Continuous temperature
- Continuous dissolved oxygen
- Aesthetics observations
- Benthic macroinvertebrate community
- Fish community
- Habitat assessments

***Water Quality (Chemical, Microbiological and Physical)***

Water quality grab samples were collected once a month from May to September (5 sampling events) at each MAP2 site using wade-in techniques described in WPP standard operating procedures (SOP). Samples were field-preserved, as appropriate, and delivered to the appropriate laboratory for nutrient (total nitrogen, total phosphorus, nitrate-nitrite and ammonia), chloride, *E. coli*, turbidity, and color analyses. A minimum of one duplicate and one blank sample per analyte were tested for quality control (QC) for each sampling crew trip (approximately 10% of the samples).

Dissolved metals samples were collected at each site on three occasions from May to September using wade-in clean-hands techniques described in WPP SOPs. Filtered samples were placed on ice and delivered to the appropriate laboratory. The samples were preserved at the laboratory with nitric acid within 24 hours of collection and analyzed for aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. A minimum of one duplicate and one blank sample per analyte were tested for QC for each sampling crew trip (approximately 10% of the samples) (MassDEP 2011a; MassDEP 2012a; MassDEP 2013a; MassDEP 2014a, MassDEP 2015a).

***Continuous Dissolved Oxygen and Temperature***

Multiprobes or dissolved oxygen and temperature probes were deployed on either multiple short-term (4 - 5 days) deployments or a long-term continuous basis (May through September) at all MAP2 sites to measure either dissolved oxygen, temperature or both. After deployment and prior to retrieval of the probes, as well as during various points throughout the deployment, QC readings were taken using a separate meter as specified in WPP's continuous probe SOPs. Quality control checks on the data were performed following the retrieval of the deployed probes and after all post-deployment calibration checks were completed (MassDEP 2011a; MassDEP 2012a; MassDEP 2013a; MassDEP 2014a, MassDEP 2015a).

***Benthic Macroinvertebrate Community***

The benthic macroinvertebrate community was sampled once at all MAP2 sites in late summer (July/August) except on a few occasions when conditions (e.g., flow, depth) or resources did not allow it. These organisms can integrate environmental conditions (chemical – including nutrients and toxics; and physical – including flow and water temperature) over a long period of time and are an excellent measure of a water body's health. The sampling methodologies varied per WPP SOPs depending on available habitat (i.e., high gradient versus low gradient). Specimens were placed into 2L jars, preserved with denatured 95% ethanol, and transported to the WPP laboratory for storage. A contractor processed (i.e., subsampled) the macroinvertebrate samples and completed the necessary taxonomic identifications. In addition, Rapid Bioassessment Protocols (RBP) habitat assessments were completed at all sites sampled for benthic macroinvertebrates (MassDEP 2011a; MassDEP 2012a; MassDEP 2013a; MassDEP 2014a, MassDEP 2015a).

***Fish Community***

Fish community analyses were conducted once during the summer at all MAP2 sites except on occasions when environmental conditions (e.g., flow, depth) or resource limitations prevented it. Fish were collected within a 100-meter reach using a backpack or tote barge electroshocker using non-lethal techniques described in WPP SOPs. Collected fishes were held in plastic buckets containing stream water until they were identified to species and a maximum of 25 individuals of each species were measured and weighed. The collected fish were then redistributed throughout the reach. In addition, RBP habitat assessments were completed at all sites sampled for fish (MassDEP 2011a; MassDEP 2012a; MassDEP 2013a; MassDEP 2014a; MassDEP 2015a).

Appendix C and Figure 1 provide the locations and other pertinent details pertaining to the MAP2 sites, including the years when monitoring occurred at those sites. Additional information regarding the monitoring plans may be found in *Sampling & Analysis Plan 2011 Monitoring Central Basin Group* (MassDEP 2011b), *Sampling & Analysis Plan 2012 Monitoring Western Basin Group* (MassDEP 2012b), *Sampling & Analysis Plan 2013 Monitoring Southeastern Basin Group* (MassDEP 2013b), *Sampling & Analysis Plan 2014 Monitoring Massachusetts Probabilistic Monitoring and Assessment Program Reference Site Network* (MassDEP 2014b) and *Sampling & Analysis Plan 2015 Monitoring Massachusetts Probabilistic Monitoring and Assessment Program Reference Site Network* (MassDEP 2015b).

## Field and Analytical Methods

Procedures used for water quality sampling and sample handling are generally described in CN 1.21 - *Sample Collection Techniques for Surface Water Quality Monitoring* (MassDEP 2009b) and CN 101.1 - *Ambient Trace Metal Sampling* (MassDEP 2007a). Procedures used for multiprobe calibration and deployment are described in CN 4.24 - *Water Quality Multiprobe* (MassDEP 2010a) and CN 4.41 - *Multiprobe Sonde Deployments for Continuous Unattended Water Quality Data Collection* (MassDEP 2007b). Procedures used to collect biological community (aquatic macroinvertebrates and fish) data are described in the CN 39.2 - *Water Quality Monitoring in Streams using Aquatic Macroinvertebrates* (MassDEP 2003) and CN 75.1 - *Fish Collection Procedures for Evaluation of Resident Fish Populations* (MassDEP 2011c).

Concurrent with the collection of water quality samples and biological community data, site characteristics, habitat quality, and sampling conditions were recorded on WPP field sheets. Riparian vegetation, observed uses (e.g., swimming, boating, fishing), potential pollution sources, the presence/absence of objectionable deposits (trash, debris and, scum), the extent of periphyton/algae/aquatic plant growth within the sampling reach, and sampling conditions were all noted at each site.

## Quality Assurance and Quality Control

Quality assurance (QA) and quality control (QC) procedures used in collecting samples and measurements were consistent with the prevailing WPP SOPs and EPA-approved quality assurance plans (MassDEP 2009b; MassDEP 2007a; MassDEP 2010a; MassDEP 2007b; MassDEP 2003; MassDEP 2011c; MassDEP 2010b). The WPP quality assurance and database management staff reviewed laboratory data reports and all multiprobe data. The data were validated and finalized per data validation procedures outlined in CN 56.15 - *DWM Water Quality Data Validation Process (Summary)* (MassDEP 2012c), CN 56.3 - *Data Validation Decision Table* (MassDEP 2005), CN 56.4 - *DWM Water Quality Probe File Processing and Validation for Attended Probe Data* (MassDEP 2012d), CN 56.5 - *File Processing and Data Validation for Unattended Water Quality Probe Data* (MassDEP 2012e), CN 56.61 - *DWM Water Quality Data Processing and Validation - Laboratory Data* (MassDEP 2012f), CN 56.7 – *DWM Data Reporting Rules* (MassDEP 2010c), and CN 56.9 - *DWM Data Validation Processes – Overview* (MassDEP 2013c). All laboratory and discrete/continuous probe data were validated by reviewing QC sample results, analytical holding time compliance, QC sample frequency, QC measurements, and related ancillary data/documentation, as applicable.

# Survey Conditions

Precipitation data from five Global Historical Climatology Network (GHCN) weather stations in each stratum were analyzed to estimate the general hydrological conditions during the MAP2 monitoring in 2011 – 2015 (Table 2) (Figure 3) (NOAA 2016). Daily precipitation totals measured at the selected stations during the corresponding monitoring year for each stratum were downloaded from the National Oceanic and Atmospheric Administration (NOAA), National Centers for Environmental Information.

**Table 2.** GHCN weather stations in each MAP2 stratum used in survey condition analysis.

| Year Stratum | GHCN Station ID | GHCN Station Name |
|---|---|---|
| 2011 Central | USC00192107 | East Brimfield Lake MA US |
| | USW00004780 | Fitchburg Municipal Airport MA US |
| | USC00195524 | Northbridge 2 MA US |
| | USW00054756 | Orange Municipal Airport MA US |
| | USW00094746 | Worcester MA US |
| 2012 West | USC00193229 | Greenfield Number 3 MA US |
| | USW00054768 | North Adams Harriman Airport MA US |
| | USW00014763 | Pittsfield Municipal Airport MA US |
| | USC00199371 | West Otis MA US |
| | USW00014775 | Westfield Barnes Municipal Airport MA US |
| 2013 Southeast | USW00094720 | Hyannis Barnstable Municipal Airport MA US |
| | USC00195984 | Norton MA US |
| | USW00054704 | Norwood Memorial Airport MA US |
| | USW00054769 | Plymouth Municipal Airport MA US |
| | USW00054777 | Taunton Municipal Airport MA US |
| 2014 Midwest | USC00190120 | Amherst MA US |
| | USC00190408 | Barre Falls Dam MA US |
| | USC00190562 | Belchertown MA US |
| | USC00198278 | Sunderland MA US |
| | USC00198793 | Ware MA US |
| 2015 Northeast | USC00192997 | Franklin MA US |
| | USC00193890 | Jamaica Plain MA US |
| | USC00194313 | Lowell MA US |
| | USC00194744 | Middleton MA US |
| | USC00195285 | Newburyport 4 NNW MA US |

The daily precipitation totals were summarized into monthly totals for all selected stations. The monthly precipitation totals for the five stations in each stratum were averaged by month to estimate the general hydrological condition in each stratum during the corresponding monitoring year. In addition, the 20-year monthly normal precipitation for the selected stations were downloaded and averaged by month for the five stations in each stratum to compare average observed monthly precipitation totals and average normal precipitation totals (Table 3). The years that deviated most from the normal precipitation totals were 2011 (abnormally wet) and 2015 (abnormally dry). Hurricane Irene (August 28$^{th}$ and 29$^{th}$) contributed significantly to higher than normal observed precipitation totals in 2011.

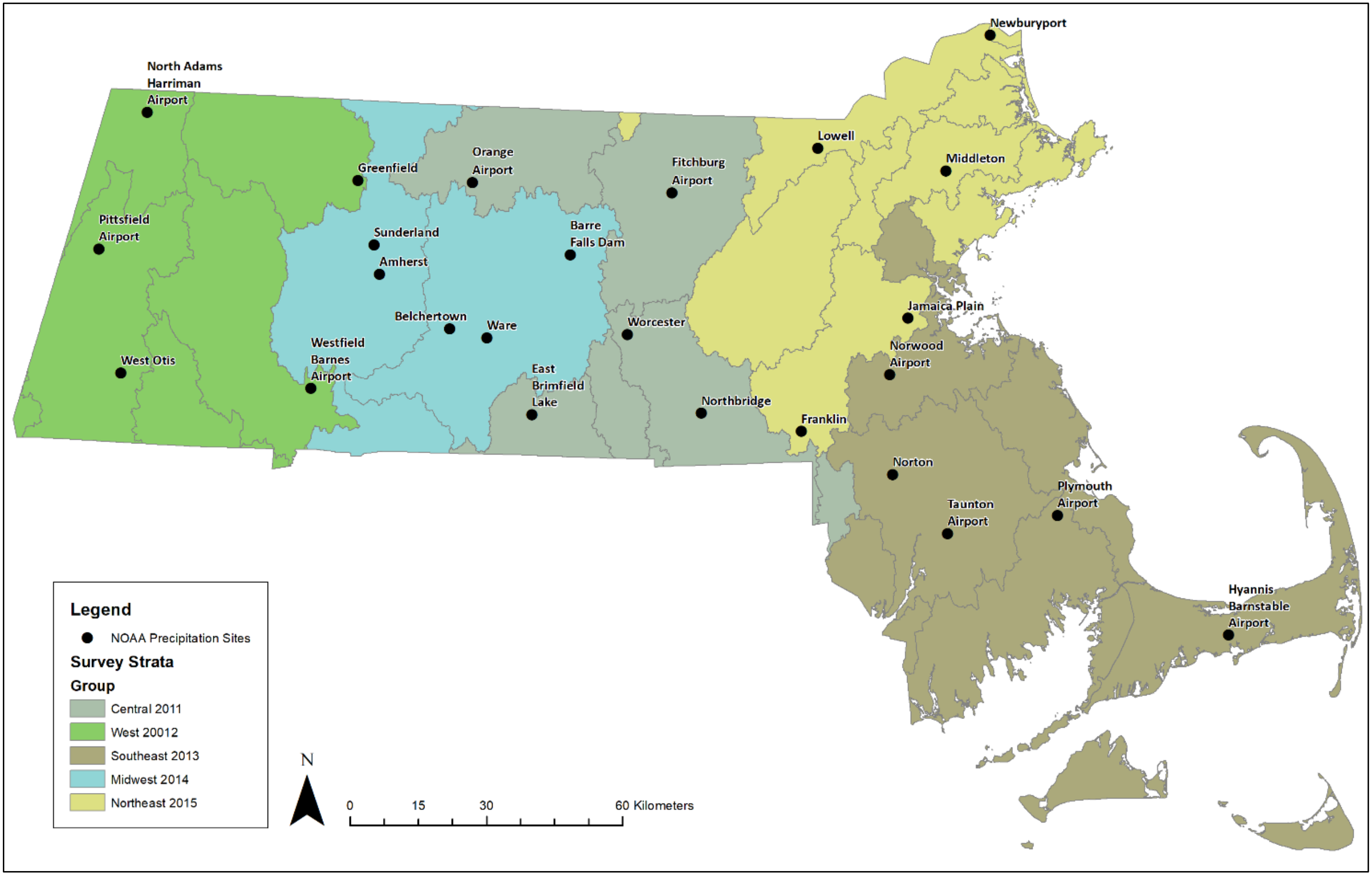


**Figure 3.** NOAA precipitation stations.

**Table 3.** Average monthly observed and normal precipitation totals (inches) for five select weather stations in each stratum. Area shaded in gray indicates the May - September sampling period.

| | 2011 Central | | 2012 West | | 2013 Southeast | | 2014 Midwest | | 2015 Northeast | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | Average Monthly | Average Normal | Average Monthly | Average Normal | Average Monthly | Average Normal | Average Monthly | Average Normal | Average Monthly | Average Normal |
| 1 | 3.30 | 3.41 | 3.08 | 3.17 | 1.80 | 3.87 | 3.23 | 3.38 | 3.60 | 3.61 |
| 2 | 4.38 | 3.12 | 0.88 | 2.88 | 4.43 | 3.54 | 3.61 | 3.13 | 3.60 | 3.41 |
| 3 | 4.38 | 4.21 | 1.52 | 3.81 | 4.16 | 5.00 | 4.64 | 3.71 | 2.81 | 4.62 |
| 4 | 5.33 | 4.03 | 2.30 | 4.11 | 2.20 | 4.49 | 4.01 | 3.95 | 2.75 | 4.44 |
| 5 | 3.62 | 3.90 | 5.20 | 4.18 | 3.98 | 3.66 | 5.17 | 4.10 | 0.58 | 3.93 |
| 6 | 6.29 | 4.20 | 3.14 | 4.49 | 10.72 | 3.81 | 2.29 | 4.29 | 6.99 | 4.16 |
| 7 | 1.96 | 4.07 | 2.09 | 4.24 | 3.15 | 3.61 | 6.40 | 4.23 | 2.26 | 3.91 |
| 8 | 11.59 | 3.71 | 4.72 | 4.10 | 2.61 | 3.88 | 3.90 | 4.24 | 2.89 | 3.77 |
| 9 | 7.42 | 3.76 | 6.72 | 4.18 | 2.53 | 3.97 | 2.02 | 4.07 | 2.01 | 3.87 |
| 10 | 6.31 | 4.35 | 4.43 | 4.71 | 0.99 | 4.21 | 6.31 | 4.65 | 4.61 | 4.53 |
| 11 | 3.93 | 4.19 | 0.61 | 4.05 | 4.22 | 4.58 | 3.51 | 3.92 | 2.50 | 4.50 |
| 12 | 4.65 | 3.80 | 4.50 | 3.59 | 4.12 | 4.36 | 4.72 | 3.61 | 4.74 | 4.25 |
| **Annual Total** | 63.2 | 46.8 | 39.2 | 47.5 | 44.9 | 49.0 | 49.8 | 47.3 | 39.3 | 49.0 |
| **Summer Total** | 30.9 | 19.6 | 21.9 | 21.2 | 23.0 | 18.9 | 19.8 | 20.9 | 14.7 | 19.6 |

Precipitation that occurs prior to a sampling event can potentially impact the water quality conditions. However, the exact timing and nature of any impact can be difficult to determine and is influenced by several factors, including stream size, watershed development, gradient, rainfall intensity and amount, and soil saturation. Each MAP2 site was associated with a nearby GHCN station and the precipitation totals from two days and one day prior to water quality and biological sampling events at each site (site visits) were calculated from the GHCN precipitation data. The percentage of site visits each year where precipitation totals exceeded 0.5 inches for two days and one day prior to the site visit was calculated to evaluate inter-year differences. As illustrated in Table 4, 2012 had the highest percentage of site visits where precipitation totals (2-day or 1-day) prior to the site visit exceeded 0.5 inches even though it did not have the highest summer precipitation total (Table 3)

**Table 4.** Percent of site visits associated with water quality and biological sampling where precipitation totals for the 2 days and 1 day prior to the survey day exceeded 0.5 inches.

| | | Percent Site Visits Precipitation Totals > 0.5 in. | |
|---|---|---|---|
| Year | Total Site Visits | 2 Days Prior | 1 Day Prior |
| 2011 | 388 | 24.2 | 12.6 |
| 2012 | 382 | 30.1 | 19.1 |
| 2013 | 366 | 21.0 | 10.4 |
| 2014 | 261 | 14.6 | 8.8 |
| 2015 | 219 | 12.8 | 8.2 |

## Human Disturbance

Human disturbance within Massachusetts occurs on a distinct east-west gradient with the eastern portion of the state exhibiting higher levels of disturbance than the western portion.  The MAP2 sites were assigned a human disturbance class using the method outlined in *Development of Indices of Biotic Integrity for Assessing Macroinvertebrate Assemblages in Massachusetts Freshwater Wadeable Streams* (Jessup and Stamp 2019) to estimate the level of human disturbance (e.g., urbanization, agriculture, impoundments) present in the target population.  An estimated 44.8% of the stream miles in the target population are in the Stress or High Stress categories for human disturbance while 25.5% are in the Best Reference, Reference, or Sub-Reference categories (Table 5).  The extent of the target population in each human disturbance category is summarized in Figure 4 and Table 5.

*error bars represent the 95% confidence intervals

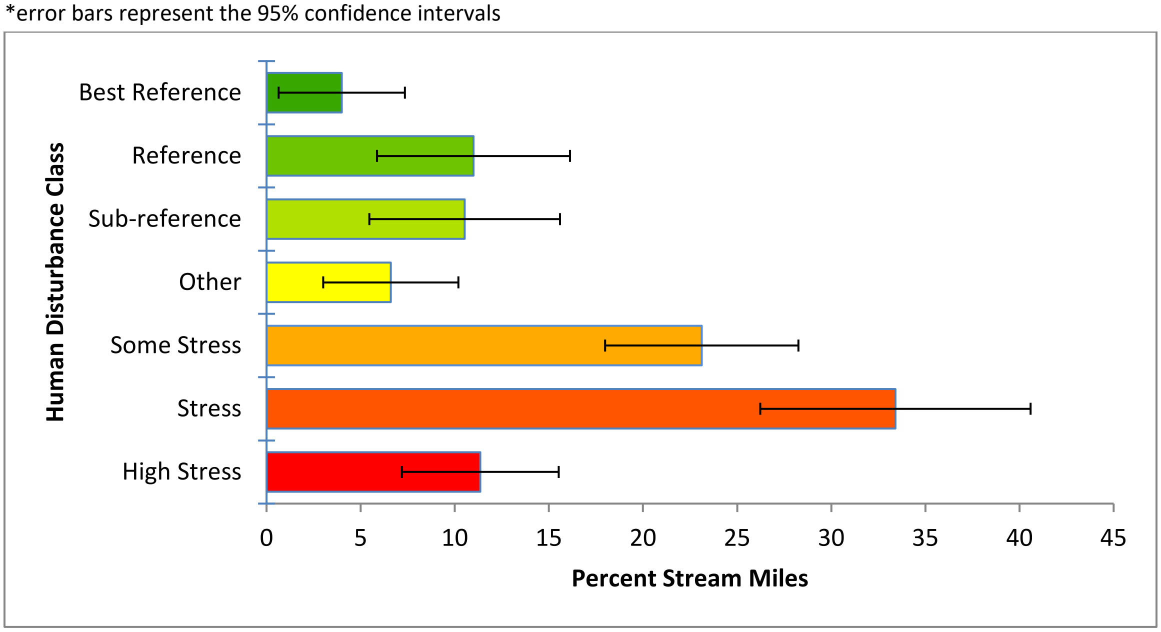


**Figure 4.** Extent of the target population in each Human Disturbance Class.

**Table 5.** Extent of the target population in each Human Disturbance Class.

| Human Disturbance Class | Percent Stream Miles Estimate | Percent Stream Miles Std. Error | Percent Stream Miles Lower 95% CI | Percent Stream Miles Upper 95% CI | Stream Miles Estimate | Stream Miles Std. Error | Stream Miles Lower 95% CI | Stream Miles Upper 95% CI |
|---|---|---|---|---|---|---|---|---|
| Best Reference | 4.0 | 1.7 | 0.6 | 7.4 | 121 | 52 | 18 | 223 |
| Reference | 11.0 | 2.6 | 5.9 | 16.1 | 332 | 79 | 177 | 487 |
| Sub-reference | 10.5 | 2.6 | 5.5 | 15.6 | 318 | 79 | 163 | 473 |
| Other | 6.6 | 1.8 | 3.0 | 10.2 | 199 | 58 | 86 | 313 |
| Some Stress | 23.1 | 2.6 | 18.0 | 28.3 | 698 | 85 | 531 | 865 |
| Stress | 33.4 | 3.7 | 26.2 | 40.6 | 1008 | 145 | 724 | 1293 |
| High Stress | 11.4 | 2.1 | 7.2 | 15.5 | 343 | 66 | 214 | 471 |

# Assessment Methodology

This section outlines the general assessment methodology for *Aquatic Life* Use and *Recreational Use*. More detailed information regarding *Aquatic Life Use* and *Recreational Use* assessment and the assessment of most individual indicators may be found in the *Massachusetts Consolidated Assessment and Listing Methodology (CALM) Guidance Manual 2018* (MassDEP 2018). The CALM describes the data evaluation procedures and criteria used to assess water quality conditions of surface waters in the state. A summary of the CALM assessment methodologies, data evaluation procedures, and criteria used to evaluate MAP2 data are provided in Appendix D. Alternative or modified CALM assessment methodologies were used for the biological (macroinvertebrates and fish) and habitat indicators to utilize recent advancements (i.e., biocriteria) and meet the objectives of the report. The alternative or modified methodologies are detailed in Appendix E.

## Aquatic Life Use

Waters supporting the *Aquatic Life Use* should be suitable for sustaining a native, naturally diverse, community of aquatic flora and fauna. This use includes reproduction, migration, growth and other critical functions. Two subclasses of aquatic life are designated in the Massachusetts Surface Water Quality Standards (SWQS) for freshwater bodies – Cold Water Fishery (designated or existing) - capable of sustaining a year-round population of cold water stenothermic aquatic life, such as trout, and Warm Water Fishery - waters that are not capable of sustaining a year-round population of cold water stenothermic aquatic life (MassDEP 2013d).

All available biological and physicochemical data from the MAP2 surveys were considered in assessing the *Aquatic Life Use*. The type, quality, and amount of data generated for each indicator are first evaluated to determine if they are appropriate for use in the assessment decision-making process. In cases like the MAP2 dataset where data are available from multiple indicators and the data are equally usable, the biological community data usually outweigh all other data types in the decision-making process because they are considered an integration of the effects of pollutants and other conditions over time. The biological community data, particularly those evaluated using a calibrated and verified multimetric index or, in the case of cold water fisheries, the fish population data are usually considered by the MassDEP to be the best and most direct measure of the *Aquatic Life Use*. Thus, assuming all data are equally usable, the weight-of-evidence gradient for data used for the MAP2 dataset followed this order - biological data first followed by physicochemical data. The exception to this order occurs with cold water fisheries where continuous temperature data are given equal weight with biological data (MassDEP 2018).

## Recreational Uses

*Recreational Use* is divided into two types of uses based on the level of contact with the water. Waters supporting the *Primary Contact Recreational Use* are suitable for any recreation or other water use in which there is prolonged and intimate contact with the water with a significant risk of ingestion of water during the primary contact recreation season. These include, but are not limited to wading, swimming, diving, surfing and water skiing. The primary contact recreation period each year is defined as 1 April to 15 October. Waters supporting the *Secondary Contact Recreational Use* are suitable for any recreation or other water use in which contact with the water is either incidental or accidental. These include, but are not limited to fishing, including human consumption of fish, boating, and limited contact incident to shoreline activities. The secondary contact recreation period is year-round (MassDEP 2018).

The assessment of the *Primary and Secondary Contact Recreational Uses* are based on sanitary (i.e., bacterial indicators of pathogens) and/or aesthetic conditions (i.e., pleasing to the senses for both active and passive activities) of the waters. These uses are assessed as support when sanitary and aesthetic conditions are suitable for the associated contact. While the current bacteria criteria for Massachusetts surface waters include a geometric mean and a single sample maximum, the bacteria assessment decisions are based only on whether or not the geometric mean of bacteria samples collected within the recreation period meet the criteria for *Primary and Secondary Contact Recreation Uses* (MassDEP 2018).

# Aquatic Life Use

## Overall

*Aquatic Life Use* was assessed as impaired in an estimated 59.0% of the stream miles in the target population. The two subpopulations (cold water and warm water) within the target population showed similar levels of impairment at 57.4% and 61.6%, respectively (Table 6). Additional information (e.g., confidence intervals) regarding the population estimates is detailed in Figure 5 and Table 6.

*error bars represent the 95% confidence intervals

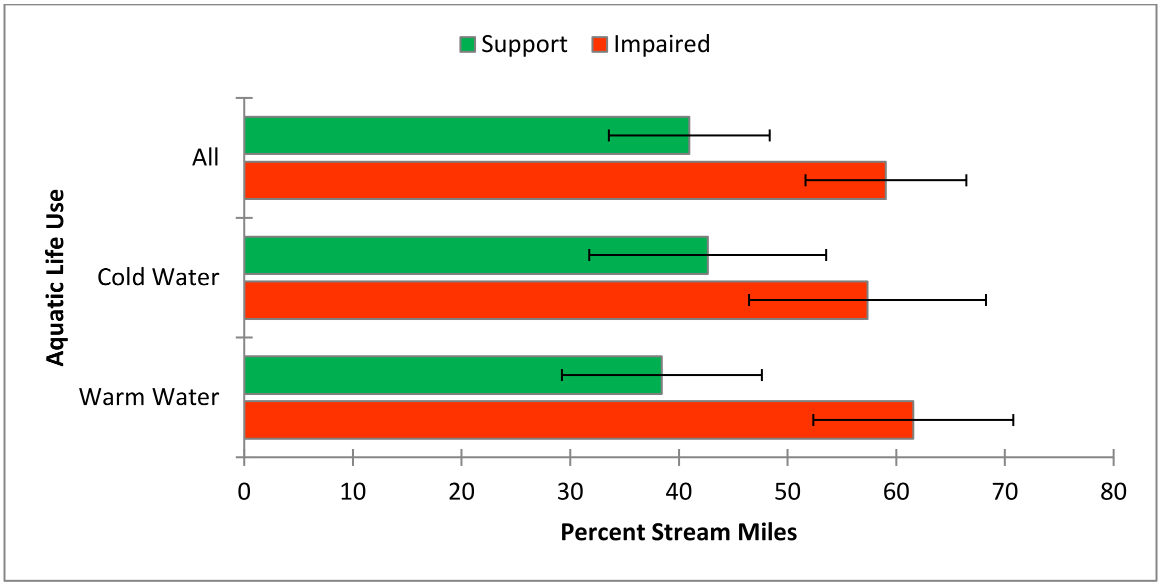


**Figure 5.** *Aquatic Life Use* condition (support, impaired) in the target population and temperature regime subpopulations.

**Table 6.** *Aquatic Life Use* condition (support, impaired) in the target population and temperature regime subpopulations.

| | | Percent Stream Miles | | | | Stream Miles | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Population** | **Indicator Status** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** |
| All | Support | 41.0 | 3.8 | 33.5 | 48.4 | 1236 | 142 | 957 | 1515 |
| | Impaired | 59.0 | 3.8 | 51.6 | 66.5 | 1782 | 137 | 1514 | 2051 |
| Cold Water | Support | 42.6 | 5.6 | 31.7 | 53.6 | 770 | 132 | 511 | 1028 |
| | Impaired | 57.4 | 5.6 | 46.4 | 68.3 | 1035 | 110 | 819 | 1251 |
| Warm Water | Support | 38.4 | 4.7 | 29.3 | 47.6 | 466 | 56 | 357 | 575 |
| | Impaired | 61.6 | 4.7 | 52.4 | 70.7 | 747 | 80 | 590 | 904 |

## Macroinvertebrate Community

The biotic integrity of the macroinvertebrate community was assessed as impaired in an estimated 39.6% of the stream miles in the target population while 29.9% were in excellent condition. The percentage of stream miles with an impaired macroinvertebrate community was significantly higher in the warm water subpopulation at 58.7% than the cold water population at 26.8% (Table 7). Warm water streams are more commonly found in the eastern portion of the state where human disturbance is higher, so this result was not unexpected. A portion of the target population was not assessed due to environmental conditions (e.g., high flow events) or resource limitations preventing the collection of macroinvertebrate community data at some sites (Figure 6). Additional information (e.g., confidence intervals) regarding the population estimates is detailed in Figure 6 and Table 7.

*error bars represent the 95% confidence intervals

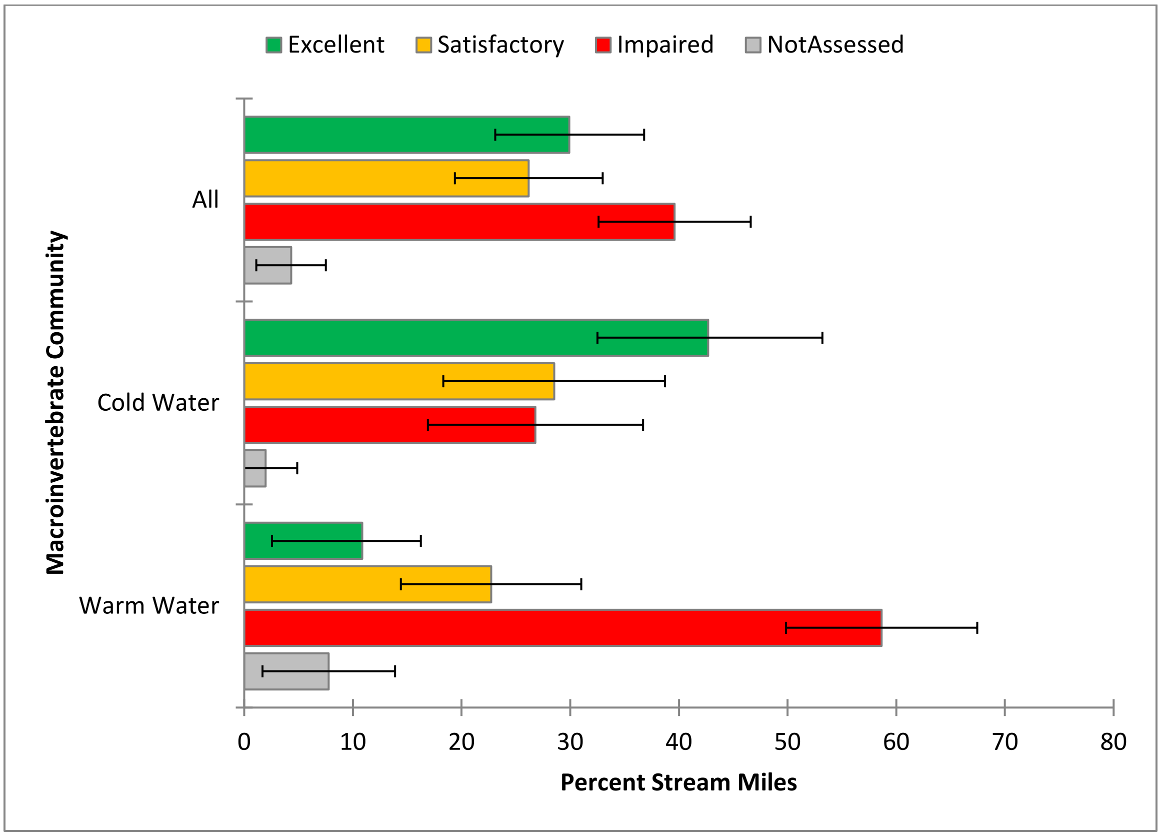


**Figure 6.** Macroinvertebrate community condition (excellent, satisfactory, impaired) in the target population and temperature regime subpopulations.

**Table 7.** Macroinvertebrate community condition (excellent, satisfactory, impaired) in the target population and temperature regime subpopulations.

| Population | Indicator Status | Percent Stream Miles Estimate | Std. Error | Lower 95% CI | Upper 95% CI | Stream Miles Estimate | Std. Error | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| All | Excellent | 29.9 | 3.5 | 23.0 | 36.8 | 903 | 107 | 693 | 1112 |
| | Satisfactory | 26.2 | 3.5 | 19.3 | 33.0 | 790 | 117 | 561 | 1020 |
| | Impaired | 39.6 | 3.5 | 32.7 | 46.6 | 1196 | 129 | 943 | 1448 |
| | Not Assessed | 4.3 | 1.6 | 1.1 | 7.5 | 130 | 52 | 28 | 232 |
| Cold Water | Excellent | 42.7 | 5.4 | 32.2 | 53.2 | 771 | 101 | 574 | 968 |
| | Satisfactory | 28.5 | 5.2 | 18.3 | 38.7 | 515 | 107 | 305 | 725 |
| | Impaired | 26.8 | 5.1 | 16.9 | 36.7 | 484 | 104 | 279 | 688 |
| | Not Assessed | 2.0 | 1.5 | 0.0 | 4.9 | 36 | 28 | 0 | 90 |
| Warm Water | Excellent | 10.9 | 2.7 | 5.5 | 16.2 | 132 | 36 | 61 | 203 |
| | Satisfactory | 22.7 | 4.3 | 14.4 | 31.1 | 276 | 48 | 183 | 369 |
| | Impaired | 58.7 | 4.5 | 49.8 | 67.5 | 712 | 76 | 563 | 861 |
| | Not Assessed | 7.8 | 3.1 | 1.6 | 13.9 | 94 | 47 | 3 | 186 |

## Fish Community

The biotic integrity of the fish community was assessed as impaired in an estimated 23.5% of the stream miles in the target population while 38.0% were in excellent condition. The percentage of stream miles with an impaired fish community was significantly higher in the cold water subpopulation at 30.5% than the warm water population at 13.1% (Table 8). Cold water species are generally more sensitive to human disturbance, particularly those disturbances that increase stream temperature, so it was not unexpected to see a higher level of impairment in this subpopulation even with warm water streams generally having more human disturbance. A portion of the target population was not assessed due to environmental conditions (e.g., high flow events) or resource limitations preventing the collection of fish community data at some sites (Figure 7). Additional information (e.g., confidence intervals) regarding the population estimates is detailed in Figure 7 and Table 8.

*error bars represent the 95% confidence intervals

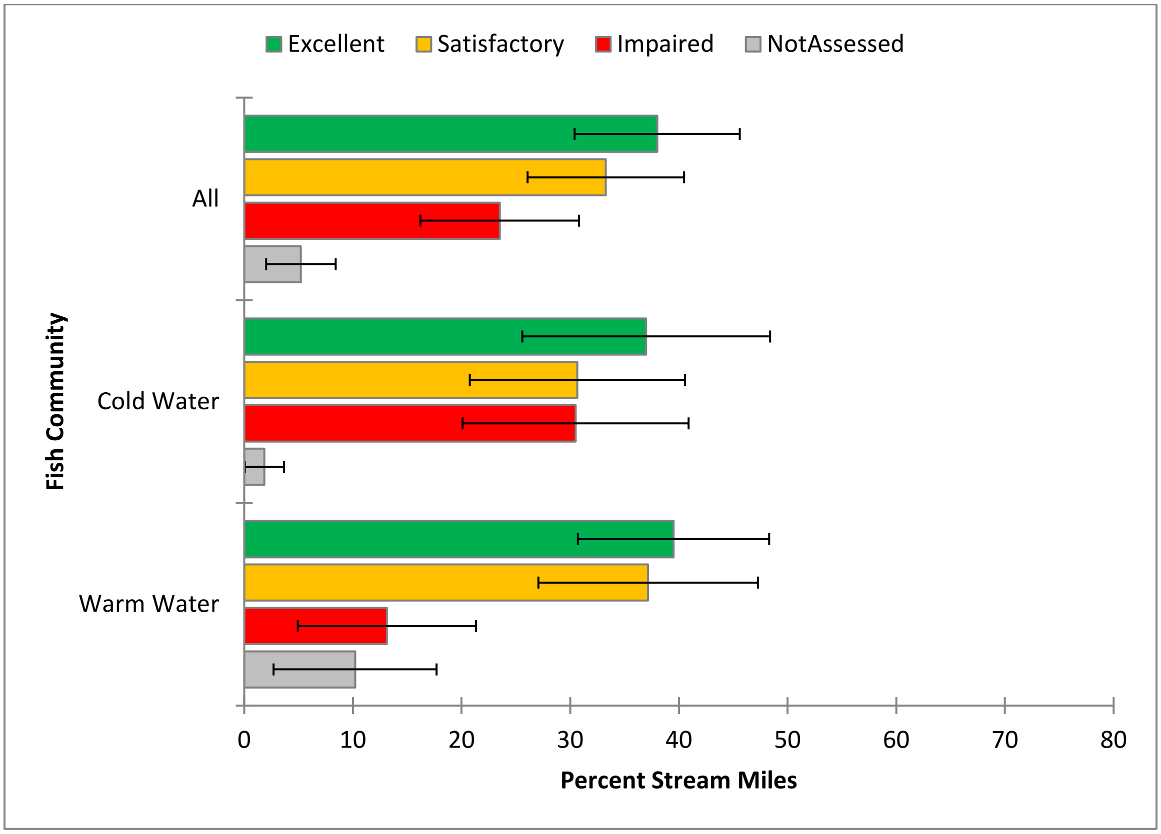


**Figure 7.** Fish community condition (excellent, satisfactory, impaired) in the target population and temperature regime subpopulations.

**Table 8.** Fish community condition (excellent, satisfactory, impaired) in the target population and temperature regime subpopulations.

| | | Percent Stream Miles | | | | Stream Miles | | | |
|---|---|---|---|---|---|---|---|---|---|
| Population | Indicator Status | Estimate | Std. Error | Lower 95% CI | Upper 95% CI | Estimate | Std. Error | Lower 95% CI | Upper 95% CI |
| All | Excellent | 38.0 | 3.9 | 30.4 | 45.6 | 1147 | 133 | 886 | 1408 |
| | Satisfactory | 33.3 | 3.7 | 26.0 | 40.5 | 1004 | 107 | 794 | 1215 |
| | Impaired | 23.5 | 3.7 | 16.3 | 30.8 | 710 | 127 | 461 | 958 |
| | Not Assessed | 5.2 | 1.6 | 2.0 | 8.4 | 157 | 52 | 55 | 260 |
| Cold Water | Excellent | 37.0 | 5.8 | 25.6 | 48.4 | 668 | 124 | 425 | 910 |
| | Satisfactory | 30.7 | 5.1 | 20.7 | 40.6 | 553 | 86 | 384 | 723 |
| | Impaired | 30.5 | 5.3 | 20.0 | 40.9 | 550 | 111 | 332 | 769 |
| | Not Assessed | 1.9 | 0.9 | 0.1 | 3.7 | 34 | 16 | 3 | 64 |
| Warm Water | Excellent | 39.5 | 4.5 | 30.7 | 48.3 | 479 | 51 | 379 | 580 |
| | Satisfactory | 37.2 | 5.2 | 27.1 | 47.3 | 451 | 62 | 329 | 573 |
| | Impaired | 13.1 | 4.2 | 5.0 | 21.3 | 159 | 56 | 49 | 270 |
| | Not Assessed | 10.2 | 3.8 | 2.7 | 17.7 | 124 | 51 | 24 | 224 |

## Stressors

*Aquatic Life Use* in streams can be impacted by chemical and physical stressors. Stressors with available data and defined assessment criteria in the CALM (MassDEP 2018) are the primary focus of this report but some stressors (e.g., RBP habitat quality) for which there are no assessment criteria are also included. Stressors discussed in this report include temperature, dissolved oxygen, habitat quality, pH, nutrient enrichment, metals, chloride and ammonia.

Temperature CALM assessment criteria were violated in an estimated 30.4% of the stream miles in the target population. An additional 7.6% of the stream miles in the target population violated the temperature criteria but the violations were attributed to natural conditions based on CALM guidance criteria (MassDEP 2018). Temperature impaired streams miles in the cold water subpopulation at 49.5% of the subpopulation total were the dominant contributor to the impairment levels observed in the target population overall. Temperature criteria were violated in only a small percentage (1.9%) of stream miles in the warm water subpopulation (Table 9). The temperature criteria were not assessed in a portion of the target population due to probe failures at some of the sites (Figure 8). Additional information (e.g., confidence intervals) regarding the population estimates is detailed in Figure 8 and Table 9.

*error bars represent the 95% confidence intervals

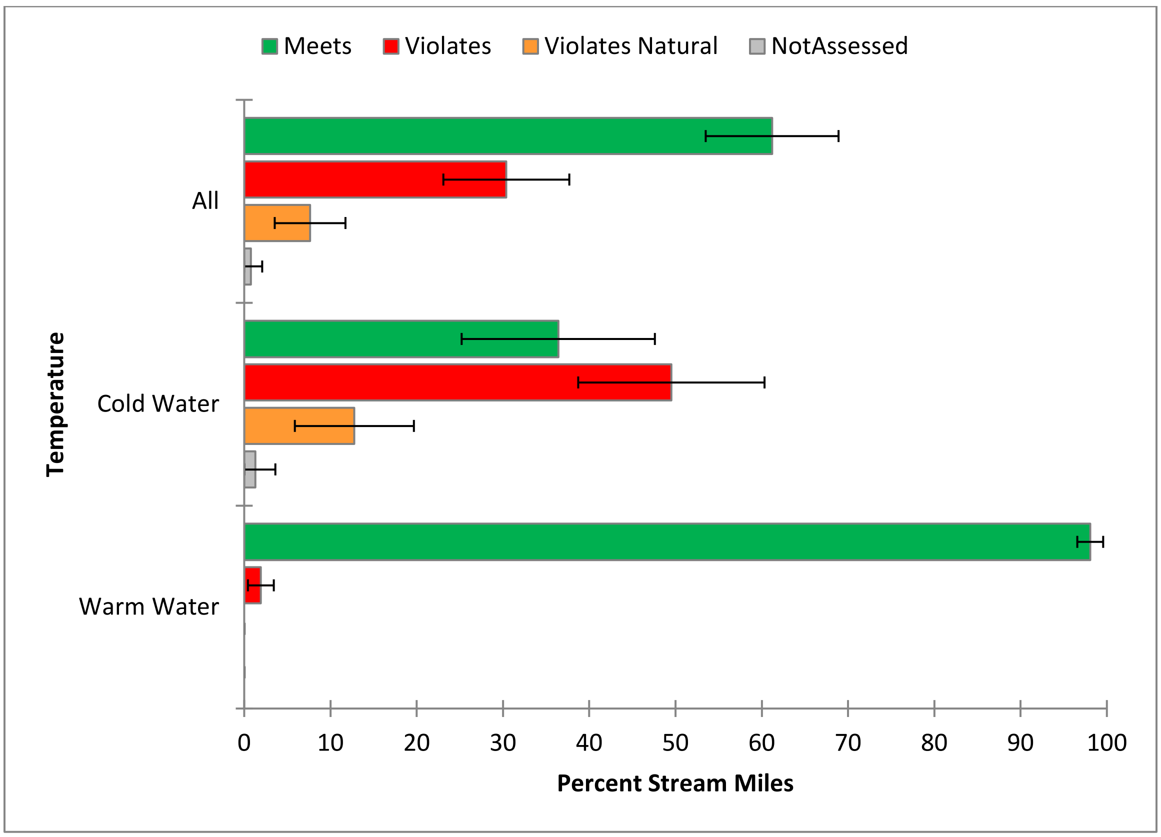


**Figure 8.** Extent of the target population and temperature regime subpopulations violating or meeting CALM assessment criteria for temperature.

**Table 9.** Extent of the target population and temperature regime subpopulations violating or meeting CALM assessment criteria for temperature.

| | | Percent Stream Miles | | | | Stream Miles | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Population** | **Indicator Status** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** |
| All | Meets | 61.2 | 3.9 | 53.5 | 68.9 | 1847 | 159 | 1536 | 2159 |
| | Violates | 30.4 | 3.7 | 23.1 | 37.6 | 917 | 116 | 689 | 1145 |
| | Violates Natural | 7.6 | 2.1 | 3.6 | 11.7 | 231 | 62 | 108 | 353 |
| | Not Assessed | 0.8 | 0.7 | 0.0 | 2.1 | 24 | 20 | 0 | 64 |
| Cold Water | Meets | 36.4 | 5.7 | 25.2 | 47.6 | 657 | 133 | 396 | 918 |
| | Violates | 49.5 | 5.5 | 38.7 | 60.3 | 894 | 106 | 686 | 1101 |
| | Violates Natural | 12.8 | 3.5 | 5.9 | 19.6 | 231 | 63 | 108 | 353 |
| | Not Assessed | 1.3 | 1.2 | 0.0 | 3.6 | 24 | 21 | 0 | 65 |
| Warm Water | Meets | 98.1 | 0.8 | 96.6 | 99.5 | 1190 | 75 | 1044 | 1336 |
| | Violates | 1.9 | 0.8 | 0.5 | 3.4 | 23 | 8 | 7 | 40 |

Dissolved oxygen CALM assessment criteria were violated in an estimated 24.0% of the stream miles in the target population. An additional 5.1% of the stream miles in the target population violated the dissolved oxygen criteria but the violations were attributed to natural conditions based on CALM guidance criteria (MassDEP 2018). The percentage of stream miles violating the dissolved oxygen criteria was significantly higher in the warm water subpopulation at 34.2% than the cold water population at 17.1%. The percentage of stream miles in the warm water subpopulation that naturally violated the dissolved oxygen criteria may be underestimated at 7.8% (Table 10). Many streams in the warm water subpopulation have lower gradients, extensive watershed or riparian wetlands, and higher sediment oxygen demand but the level of human disturbance impacting those streams makes it impossible to definitively conclude the dissolved oxygen violations were a natural condition. The dissolved oxygen criteria were not assessed in a portion of the target population due to probe failures at some of the sites (Figure 8). Additional information (e.g., confidence intervals) regarding the population estimates is detailed in Figure 9 and Table 10.

*error bars represent the 95% confidence intervals

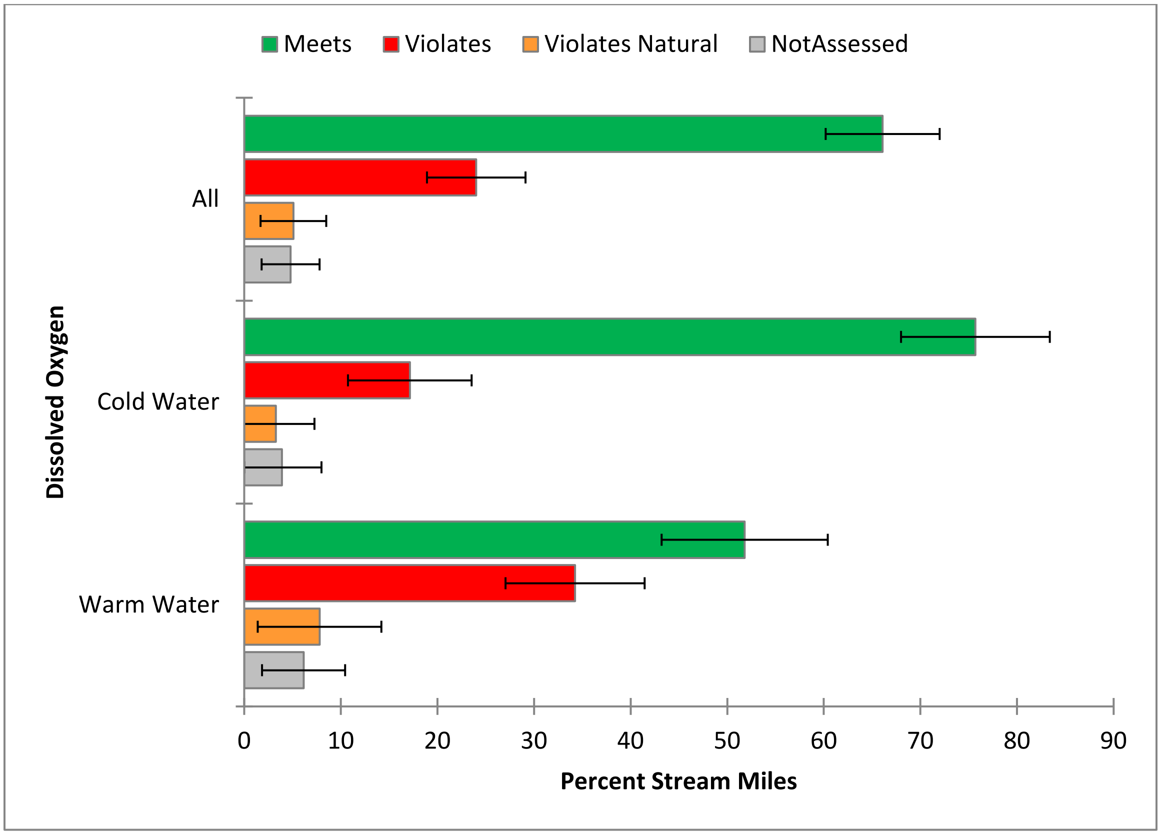


**Figure 9.** Extent of the target population and temperature regime subpopulations violating or meeting CALM assessment criteria for dissolved oxygen.

**Table 10.** Extent of the target population and temperature regime subpopulations violating or meeting CALM assessment criteria for dissolved oxygen.

| | | Percent Stream Miles | | | | Stream Miles | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Population** | **Indicator Status** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** |
| All | Meets | 66.1 | 3.0 | 60.2 | 72.0 | 1995 | 152 | 1697 | 2293 |
| | Violates | 24.0 | 2.6 | 19.0 | 29.1 | 725 | 88 | 552 | 898 |
| | Violates Natural | 5.1 | 1.8 | 1.7 | 8.5 | 154 | 55 | 46 | 262 |
| | Not Assessed | 4.8 | 1.5 | 1.9 | 7.8 | 145 | 46 | 55 | 235 |
| Cold Water | Meets | 75.7 | 4.0 | 67.9 | 83.4 | 1366 | 138 | 1095 | 1637 |
| | Violates | 17.1 | 3.3 | 10.7 | 23.6 | 309 | 64 | 184 | 435 |
| | Violates Natural | 3.3 | 2.0 | 0.0 | 7.3 | 59 | 38 | 0 | 134 |
| | Not Assessed | 3.9 | 2.1 | 0.0 | 8.0 | 70 | 38 | 0 | 144 |
| Warm Water | Meets | 51.8 | 4.4 | 43.2 | 60.4 | 629 | 68 | 496 | 762 |
| | Violates | 34.2 | 3.7 | 27.0 | 41.5 | 416 | 59 | 300 | 532 |
| | Violates Natural | 7.8 | 3.3 | 1.4 | 14.2 | 95 | 41 | 15 | 175 |
| | Not Assessed | 6.1 | 2.2 | 1.9 | 10.4 | 75 | 27 | 22 | 127 |

Habitat quality was impaired in an estimated 36.4% of the stream miles in the target population. The percentage of stream miles with impaired habitat quality was higher in the warm water subpopulation at 46.3% than the cold water population at 29.7% (Table 11). Warm water streams are more commonly found in the eastern portion of the state where human disturbance is higher, so this result was not unexpected. Using the RBP habitat assessment to evaluate habitat quality impairment in the target population may be problematic. The RBP habitat assessment has components that measure both natural variation in habitat quality and variation due to anthropogenic impacts making it difficult to identify situations of naturally poor habitat. A more in-depth analysis of the individual RBP habitat assessment components may provide an improved measure of habitat quality impairment. Additional information (e.g., confidence intervals) regarding the population estimates is detailed in Figure 10 and Table 11.

*error bars represent the 95% confidence intervals

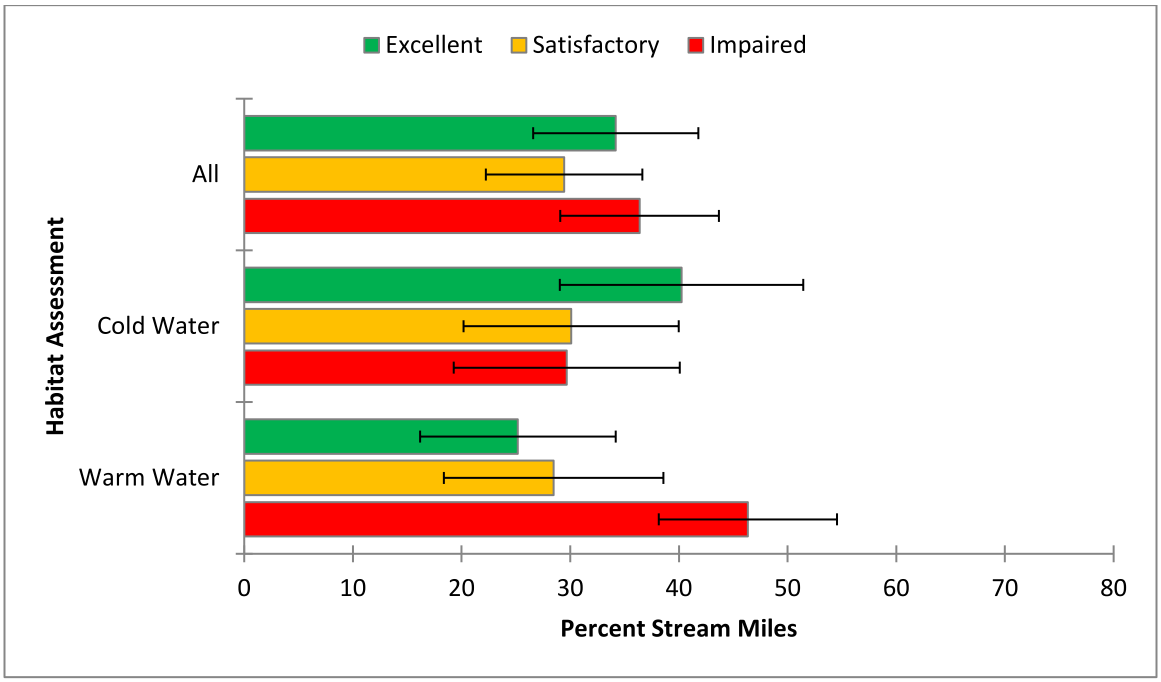


**Figure 10.** Habitat quality (excellent, satisfactory, impaired) in the target population and temperature regime subpopulations.

**Table 11.** Habitat quality (excellent, satisfactory, impaired) in the target population and temperature regime subpopulations.

| | | | Percent Stream Miles | | | | Stream Miles | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Indicator | Population | Indicator Status | Estimate | Std. Error | Lower 95% CI | Upper 95% CI | Estimate | Std. Error | Lower 95% CI | Upper 95% CI |
| Habitat Quality | All | Excellent | 34.2 | 3.9 | 26.6 | 41.8 | 1032 | 133 | 771 | 1293 |
| | | Satisfactory | 29.4 | 3.6 | 22.5 | 36.4 | 889 | 99 | 695 | 1083 |
| | | Impaired | 36.4 | 4.0 | 28.6 | 44.2 | 1098 | 141 | 822 | 1375 |
| | Cold Water | Excellent | 40.2 | 5.7 | 29.1 | 51.4 | 726 | 120 | 492 | 961 |
| | | Satisfactory | 30.1 | 5.2 | 20.0 | 40.2 | 543 | 86 | 375 | 711 |
| | | Impaired | 29.7 | 5.5 | 19.0 | 40.4 | 536 | 114 | 313 | 758 |
| | Warm Water | Excellent | 25.2 | 4.6 | 16.2 | 34.2 | 306 | 59 | 190 | 422 |
| | | Satisfactory | 28.5 | 4.4 | 19.8 | 37.1 | 346 | 51 | 245 | 446 |
| | | Impaired | 46.3 | 5.0 | 36.5 | 56.2 | 562 | 78 | 409 | 716 |

Among the other *Aquatic Life Use* stressors, pH had the highest estimated percentage of stream miles in the target population that violated CALM assessment criteria at 22.1%. Natural environmental factors (e.g., wetlands, geology) can create situations of naturally low pH in surface waters so this percentage could be an overestimation. Nutrient enrichment, metals, chloride, and ammonia had lower percentages of stream miles in the target population that violated CALM assessment criteria at 16.8%, 9.5%, 1.8% and 0%, respectively (Table 12). Violations of the acute copper (Cu) criterion and chronic lead (Pb) criterion, accounted for all the violations of the metals criteria. Since sampling occurred during the summer and the primary source of chloride to waterbodies is road salt application during the winter, the percentage of stream miles violating the chloride criteria may be underestimated in this report, assuming chloride concentrations would typically peak in the winter-spring period. Additional information (e.g., confidence intervals) regarding the population estimates is detailed in Figure 11 and Table 12.

*error bars represent the 95% confidence intervals

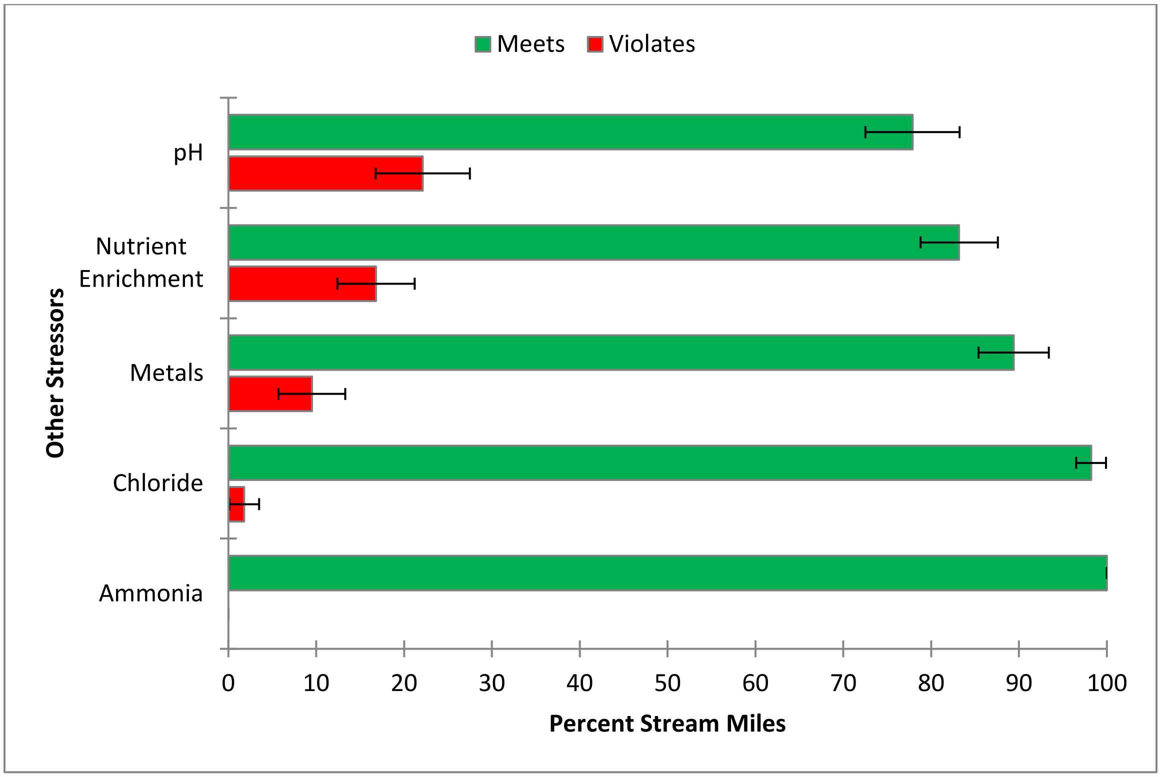


**Figure 11.** Extent of the target population violating or meeting CALM assessment criteria for other *Aquatic Life Use* stressors.

**Table 12.** Extent of the target population violating or meeting CALM assessment criteria for other *Aquatic Life Use* stressors.

| | | Percent Stream Miles | | | | Stream Miles | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Indicator** | **Indicator Status** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** |
| pH | Meets | 77.9 | 2.7 | 72.5 | 83.2 | 2351 | 161 | 2035 | 2667 |
| | Violates | 22.1 | 2.7 | 16.8 | 27.5 | 668 | 91 | 489 | 846 |
| Nutrient Enrichment | Meets | 83.2 | 2.3 | 78.8 | 87.6 | 2511 | 169 | 2180 | 2842 |
| | Violates | 16.8 | 2.3 | 12.4 | 21.2 | 507 | 66 | 379 | 636 |
| Metals | Meets | 89.4 | 2.0 | 85.4 | 93.4 | 2698 | 158 | 2389 | 3007 |
| | Violates | 9.5 | 1.9 | 5.7 | 13.3 | 287 | 60 | 169 | 405 |
| | Not Assessed | 1.1 | 0.8 | 0.0 | 2.7 | 33 | 24 | 0 | 81 |
| Chloride | Meets | 98.2 | 0.9 | 96.5 | 99.9 | 2964 | 153 | 2664 | 3265 |
| | Violates | 1.8 | 0.9 | 0.1 | 3.5 | 54 | 27 | 1 | 107 |
| Ammonia | Meets | 100.0 | 0.0 | 100.0 | 100.0 | 3019 | 152 | 2720 | 3317 |
| | Violates | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | 0 |

## Recreational Use

### Overall

*Recreational Use* is divided into two types of use, primary contact and secondary contact, based on the level of contact with the water (MassDEP 2013d). These categories have different CALM assessment criteria so they must be analyzed separately. *Recreational Use Primary Contact* was assessed as impaired in an estimated 35.1% of the stream miles in the target population while 4.1% of the stream miles were assessed as impaired for *Secondary Contact* (Table 13). Additional information (e.g., confidence intervals) regarding the population estimates is detailed in Figure 12 and Table 13.

*error bars represent the 95% confidence intervals

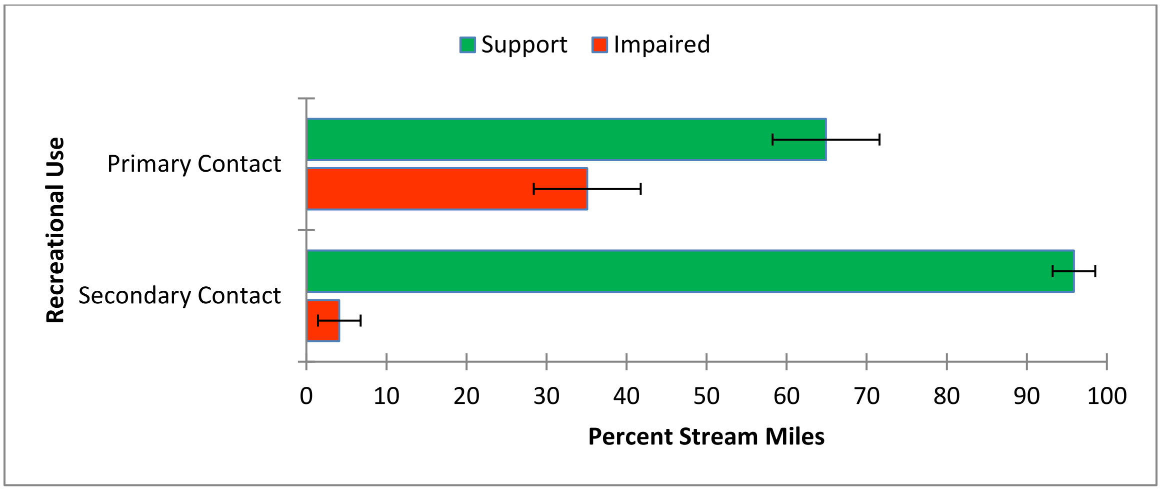


**Figure 12.** *Recreation Use* condition (support, impaired) in the target population.

**Table 13.** *Recreation Use* condition (support, impaired) in the target population.

| Indicator | Indicator Status | Percent Stream Miles Estimate | Std. Error | Lower 95% CI | Upper 95% CI | Stream Miles Estimate | Std. Error | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| Primary Contact | Support | 64.9 | 3.4 | 58.2 | 71.6 | 1960 | 142 | 1681 | 2238 |
| | Impaired | 35.1 | 3.4 | 28.4 | 41.8 | 1059 | 121 | 823 | 1295 |
| Secondary Contact | Support | 95.9 | 1.4 | 93.2 | 98.5 | 2894 | 155 | 2591 | 3197 |
| | Impaired | 4.1 | 1.4 | 1.5 | 6.8 | 124 | 41 | 43 | 205 |

### Stressors

*Recreational Use* in streams is evaluated using two stressors, pathogens (*E. coli* freshwater indicator) and aesthetics (MassDEP 2018). Primary Contact *E. coli* CALM assessment criteria were violated in an estimated 35.1% of the stream miles in the target population while secondary contact CALM assessment criteria were violated in 3.9%. Aesthetics CALM assessment criteria were violated in only 1.5% of the stream miles in the target population and all the stream miles with Aesthetic criteria violations also violated *E. coli* criteria (Table 14). Additional information (e.g., confidence intervals) regarding the population estimates is detailed in Figure 13 and Table 14.

*error bars represent the 95% confidence intervals

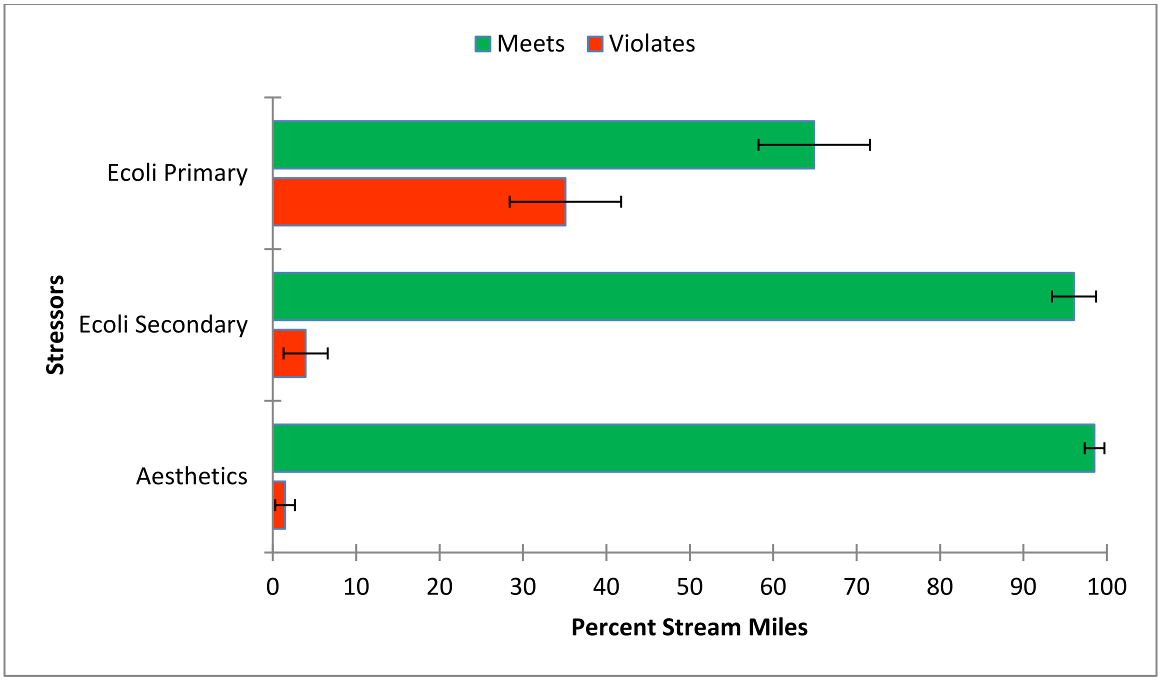


**Figure 13.** Extent of the target population violating or meeting CALM assessment criteria for *Recreation Use* stressors.

**Table 14.** Extent of the target population violating or meeting CALM assessment criteria for *Recreation Use* stressors.

| Indicator | Indicator Status | Percent Stream Miles: Estimate | Std. Error | Lower 95% CI | Upper 95% CI | Stream Miles: Estimate | Std. Error | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| E. coli (Primary Contact) | Meets | 64.9 | 3.4 | 58.2 | 71.6 | 1960 | 142 | 1681 | 2238 |
| | Violates | 35.1 | 3.4 | 28.4 | 41.8 | 1059 | 121 | 823 | 1295 |
| E. coli (Secondary Contact) | Meets | 96.1 | 1.4 | 93.4 | 98.7 | 2900 | 154 | 2597 | 3202 |
| | Violates | 3.9 | 1.4 | 1.3 | 6.6 | 119 | 41 | 39 | 199 |
| Aesthetics | Meets | 98.5 | 0.6 | 97.3 | 99.7 | 2974 | 154 | 2673 | 3275 |
| | Violates | 1.5 | 0.6 | 0.3 | 2.7 | 45 | 18 | 9 | 80 |

## Summary and Next Steps

This assessment of wadeable rivers and streams was a significant sampling and analytical effort by MassDEP, WPP, William X. Wall Experiment Station (WES) and contract laboratories. Over five summers, WPP field crews conducted over 400 sampling surveys (over 2000 individual site visits) to sample or measure multiple indicators at 177 sites along the Commonwealths wide-ranging wadeable rivers and streams. The efforts of the WPP field crews yielded over 3200 water samples (over 18,000 individual analyte results) and nearly 350 biological samples sent to WES and contract laboratories for analysis. In addition, the WPP field crews conducted over 450 probe deployments that resulted in over 500,000 hours of continuous dissolved oxygen or temperature data.

Over the next several years, WPP will also complete similar probabilistic assessments of lakes and coastal waters in the Commonwealth.

Overall, the assessment found that designated uses (*Aquatic Life Use* and *Recreational Use*) in wadeable rivers and streams are being significantly affected and degraded across the Commonwealth.  Over half of the wadeable river and streams miles do not support *Aquatic Life Use* and over a third do not support *Recreational Uses*.  The key stressors that appear to be affecting the designated uses of wadeable rivers and streams the most are pathogens, habitat quality, temperature, dissolved oxygen, and nutrient enrichment.  While a probabilistic survey design provides an unbiased and statistically valid assessment of wadeable rivers and streams in the Commonwealth that can be used to inform the public and direct prioritization or resources allocation, it does not identify the exact location of all the wadeable rivers and streams that are impaired or degraded and require restoration.  Identifying the exact location of all the impaired wadeable rivers and streams can only be accomplished by a resource intensive targeted census of the waterbodies.

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# Appendix A. MAP2 Wadeable Rivers and Streams Survey Design

## Massachusetts Probabilistic Monitoring and Assessment Program (MAP2) Wadeable Rivers and Streams Survey Design 2011-2015

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## Description of Sample Design

The goal of the Massachusetts Probabilistic Monitoring and Assessment Program (MAP2) is to provide a comprehensive assessment of the condition of "waters" in Massachusetts through the implementation of probabilistic sampling designs. As of 2011, wadeable rivers and streams are the only water resource in Massachusetts that has an implemented probabilistic sampling design. It is planned that additional probabilistic sampling designs will be completed and implemented for lakes and estuaries when enough resources are available. The survey design for MAP2 is a stratified five-year basin rotation design with a different group of basins getting sampled each year from 2011 to 2015 to provide state-wide coverage (Figure 1).

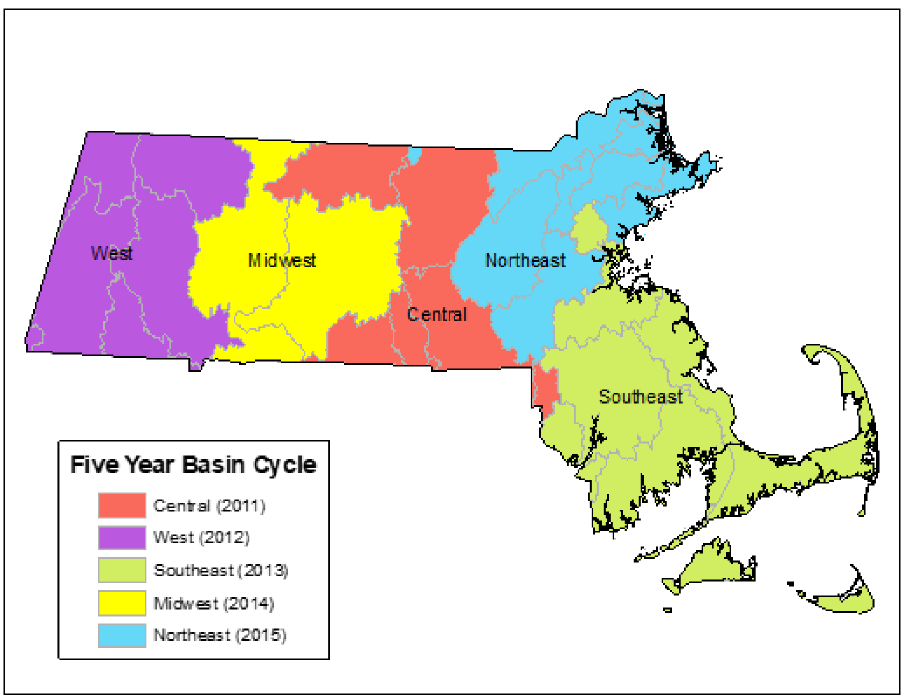


**Figure 1** The five-year basin cycle that will be implemented from 2011-2015.

**Objectives:** The objectives, or design requirements, for the MAP2 project are to produce:

1. An unbiased assessment (Support/Impaired) of aquatic life, recreational and aesthetic uses in wadeable non-tidal perennial streams of Massachusetts.
2. An analysis of long-term trends in aquatic life, recreational and aesthetic use assessments in wadeable non-tidal perennial streams of Massachusetts.

**Target Population:** The target population is all wadeable $1^{st}$ – $4^{th}$ Strahler Order non-tidal perennial rivers and streams within the Commonwealth of Massachusetts.

**Sample Frame:** The sample frame was derived from the National Hydrography Dataset (NHD), in particular NHD (1:24,000). The University of Massachusetts Amherst, under contract to MassDEP, enhanced the NHD, creating feature type (FCODE) subcategories and calculating Strahler stream order for each reach. The feature types were the main instrument used to identify which segments in NHD were included in the sample frame. Table 1 contains a description of each FCODE and indicates whether it was included or excluded from the sample frame.

**Stratification:** The sites were stratified by basin group (central, west, midwest, southeast, northeast)

**Multi-density Categories:** Unequal selection probabilities were used to create multi-density categories and allocate sites equally among Strahler Orders 1st, 2nd, 3rd, and 4th.

**Panels:** Single Panel

**Sample Size:** The expected sample size is 32 sites with an oversample of 128 sites.

**Site Use:** Assume the base design has 32 sites. Sites are listed in siteID order and must be used in that order within each stratum. All sites that occur prior to the last site used must have been evaluated for use and then either sampled or reason documented why that site was not used. As an example, if 32 sites are to be sampled and it required that 61 sites be evaluated in order to locate 32 stream sites able to be sampled, then the first 61 sites in siteID order would be used. It is also permissible to replace sites within each stratum.

**Table 1** Feature types included and excluded from the sample frame.

| Feature Type | FCCODE | New FCODE | New Feature Type | Sample Frame |
|---|---|---|---|---|
| **Connector** | 33400 | 33400 | Connector | Include |
| **Canal/Ditch** | 33600 | 33600-A | Natural Ditch | Include |
| | | 33600-B | Tidal Ditch | Exclude |
| | | 33600-C | Artificial Ditch | Exclude |
| | | 33600-AS | Artificial Swamp Ditch | Exclude |
| **Surface Aqueduct** | 42801 | 42801-A | Natural Surface Aqueduct | Include |
| | | 42801-B | Artificial Surface Aqueduct | Exclude |
| **Elevated Aqueduct** | 42802 | 42802-A | Natural Elevated Aqueduct | Include |
| | | 42802-B | Artificial Elevated Aqueduct | Exclude |
| **Underground Aqueduct** | 42803 | 42803-A | Natural Underground Aqueduct | Include |
| | | 42803-B | Artificial Underground Aqueduct | Exclude |
| **Underground Pipeline** | 42807 | 42807-A | Natural Underground Pipeline | Include |
| | | 42807-B | Artificial Underground Pipeline | Exclude |
| **River** | 46000 | 46000-A | Freshwater river | Include |
| | | 46000-B | Tidal River | Exclude |
| **Intermittent River** | 46003 | 46003 | Intermittent river | Exclude |
| **Perennial River** | 46006 | 46006-A | Freshwater Perennial River | Include |
| | | 46006-B | Tidal Perennial River | Exclude |
| **Artificial Paths (AP)** | 55800 | 55800-A | Wetland/River Artificial Pathway | Include |
| | | 55800-AO | Coastline Artificial Pathway | Exclude |
| | | 55800-AS | Terminus Wetland Artificial Pathway | Exclude |
| | | 55800-B | Lake/Pond/Reservoir Artificial Pathway | Exclude |
| | | 55800-Canal | Canal Artificial Pathway | Exclude |
| | | 55800-D | Tidal Artificial Pathway | Exclude |
| | | 55800-E | Tributary to Mainstem Centerline AP | Exclude |
| | | 55800-F | Man-Made Artificial Pathway | Exclude |
| **Coastline** | 56600 | 56600 | Coastline | Exclude |

Description of Sample Design Output: **The output is provided as a shapefile for the sites. Note that the ".dbf" file may be read in Excel. The attributes are as follows:**

| Variable Name | Description |
|---|---|
| SiteID | Unique site identification (character) |
| x | x-coordinate from map projection (see below) |
| y | y-coordinate from map projection (see below) |
| mdcaty | Multi-density categories used for unequal probability selection |
| weight | Weight (in km), inverse of inclusion probability, to be used in statistical analyses |
| stratum | Strata used in the survey design |
| panel | Identifies base sample by panel name and Oversample by OverSamp |
| EvalStatus | Site evaluation decision for site: TS: target and sampled, LD: landowner denied access, etc (see below) |
| EvalReason | Site evaluation text comment |
| auxiliary variables | Remaining columns are from the sample frame provided |

**Evaluation Process:** The survey design weights that are given in the design file assume that the survey is implemented as designed. Typically, users prefer to replace sites that cannot be sampled with other sites to achieve the sample size planned. The site replacement process is described above. When sites are replaced, the survey design weights are no longer correct and must be adjusted. The weight adjustment requires knowing what happened to each site in the base design and the over sample sites. EvalStatus is initially set to "NotEval" to indicate that the site has yet to be evaluated for sampling. When a site is evaluated for sampling, the EvalStatus for the site must be changed. See the site evaluation SOP (CN 306.0)

**Statistical Analysis:** Any statistical analysis of data must incorporate information about the monitoring survey design. When estimates of characteristics for the entire target population are computed, the statistical analysis must account for any stratification or unequal probability selection in the design. Procedures for doing this are available from the Aquatic Resource Monitoring web site (https://archive.epa.gov/nheerl/arm/web/html/index.html). A statistical analysis library of functions (spsurvey) is available from the web page and the Comprehensive R Archive Network (CRAN) to do common population estimates in the statistical software environment R.

# Appendix B. MAP2 Evaluated Sites 2011 - 2015

| **Evaluation Category Key** |
|---|
| **Target = Sampled,** FE_I = Intermittent, FE_NS = No Stream Channel, FE_A = Artificial, FE_T = Tidal, FE_M = Impounded (man-made), WE = Wetland, NW = Not wadeable, NW_MI = Not wadeable (man-made impoundment), NW_NI = Not wadeable natural impoundment, CB = Cranberry bog ditch, O = Other, APD = Access permission denied, NRL = No response from landowner, PI = Physically inaccessible |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-001 | Primary | FE_I | Trapfall Brook | Central | 1st | 42.70664 | -71.82987 | 57465.46 |
| MAP2-002 | Primary | Target | Mahoney Brook | Central | 1st | 42.56671 | -71.95196 | 57465.46 |
| MAP2-003 | Primary | PI | UNT to Nashua River | Central | 1st | 42.58657 | -71.81623 | 57465.46 |
| MAP2-004 | Primary | Target | Sevenmile River | Central | 3rd | 41.91787 | -71.35216 | 18321 |
| MAP2-005 | Primary | APD | Whetstone Brook | Central | 2nd | 42.54686 | -72.36980 | 42672.81 |
| MAP2-006 | Primary | WE | Warren Tannery Brook | Central | 3rd | 42.36810 | -71.87313 | 18321 |
| MAP2-007 | Primary | Target | Monoosnoc Brook | Central | 3rd | 42.52662 | -71.75692 | 18321 |
| MAP2-008 | Primary | Target | Dark Brook | Central | 2nd | 42.20291 | -71.85617 | 42672.81 |
| MAP2-009 | Primary | NW_MI | Otter River | Central | 4th | 42.59362 | -72.04729 | 11003.01 |
| MAP2-010 | Primary | FE_I | South Meadow Brook | Central | 1st | 42.43379 | -71.72473 | 57465.46 |
| MAP2-011 | Primary | APD | Reedy Meadow Brook | Central | 2nd | 42.65503 | -71.55820 | 42672.81 |
| MAP2-012 | Primary | Target | Mumford River | Central | 3rd | 42.09311 | -71.73709 | 18321 |
| MAP2-013 | Primary | Target | West Gulf Brook | Central | 1st | 42.62532 | -72.19503 | 57465.46 |
| MAP2-014 | Primary | WE | Nutting Stream | Central | 1st | 42.63980 | -71.64921 | 57465.46 |
| MAP2-015 | Primary | Target | Breakneck Brook | Central | 2nd | 42.04216 | -72.09715 | 42672.81 |
| MAP2-016 | Primary | NRL | Wellman Brook | Central | 1st | 42.07688 | -71.70465 | 57465.46 |
| MAP2-017 | Primary | NW | Falls Brook | Central | 2nd | 42.70696 | -72.23572 | 42672.81 |
| MAP2-018 | Primary | Target | Tatnuck Brook | Central | 1st | 42.32658 | -71.86537 | 57465.46 |
| MAP2-019 | Primary | WE | UNT to Falulah Brook | Central | 2nd | 42.63348 | -71.83746 | 42672.81 |
| MAP2-020 | Primary | FE_I | UNT | Central | 2nd | 41.92138 | -71.31367 | 42672.81 |
| MAP2-021 | Primary | FE_I | UNT | Central | 1st | 42.63005 | -71.99668 | 57465.46 |
| MAP2-022 | Primary | APD | Governor Brook | Central | 3rd | 42.43401 | -71.85372 | 18321 |
| MAP2-023 | Primary | Target | Catacoonamug Brook | Central | 3rd | 42.55308 | -71.66947 | 18321 |
| MAP2-024 | Primary | Target | UNT to South Fork River | Central | 3rd | 42.10455 | -71.92880 | 18321 |
| MAP2-025 | Primary | WE | UNT to Dennison Lake | Central | 2nd | 42.64908 | -72.08513 | 42672.81 |
| MAP2-026 | Primary | Target | Quinsigamond River | Central | 4th | 42.20837 | -71.69757 | 11003.01 |
| MAP2-027 | Primary | Target | Cady Brook | Central | 3rd | 42.07674 | -72.02541 | 18321 |
| MAP2-028 | Primary | NW_NI | Miscoe Brook | Central | 3rd | 42.18529 | -71.65057 | 18321 |
| MAP2-029 | Primary | NW | Lawrence Brook | Central | 3rd | 42.66614 | -72.17736 | 18321 |
| MAP2-030 | Primary | Target | Whitman River | Central | 4th | 42.55980 | -71.86605 | 11003.01 |
| MAP2-031 | Primary | Target | Stevens Brook | Central | 2nd | 42.05773 | -72.18752 | 42672.81 |
| MAP2-032 | Primary | Target | Peters River | Central | 3rd | 42.02755 | -71.48301 | 18321 |
| MAP2-033 | OverSamp | Target | Jacks Brook | Central | 1st | 42.61498 | -72.40184 | 57465.46 |
| MAP2-034 | OverSamp | NW_MI | Blackstone River | Central | 4th | 42.23579 | -71.79729 | 11003.01 |
| MAP2-035 | OverSamp | Target | Whitman River | Central | 4th | 42.58213 | -71.90260 | 11003.01 |
| MAP2-036 | OverSamp | FE_I | UNT | Central | 1st | 41.92066 | -71.27675 | 57465.46 |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-037 | OverSamp | Target | UNT to Millers River | Central | 3rd | 42.67731 | -71.94077 | 18321 |
| MAP2-038 | OverSamp | FE_I | UNT | Central | 1st | 42.40841 | -71.81096 | 57465.46 |
| MAP2-039 | OverSamp | PI | Spectacle Brook | Central | 1st | 42.51052 | -71.68941 | 57465.46 |
| MAP2-040 | OverSamp | WE | Little River | Central | 4th | 42.11529 | -71.89483 | 11003.01 |
| MAP2-041 | OverSamp | Target | West Branch Tully River | Central | 4th | 42.64254 | -72.25737 | 11003.01 |
| MAP2-042 | OverSamp | APD | Bixby Brook | Central | 2nd | 42.64846 | -71.70370 | 42672.81 |
| MAP2-043 | OverSamp | Target | West Brook | Central | 1st | 42.12335 | -72.20669 | 57465.46 |
| MAP2-044 | OverSamp | APD | Quinsigamond River | Central | 4th | 42.20228 | -71.69267 | 11003.01 |
| MAP2-045 | OverSamp | Target | Ellinwood Brook | Central | 3rd | 42.55624 | -72.23103 | 18321 |
| MAP2-046 | OverSamp | Target | North Nashua River | Central | 4th | 42.57871 | -71.82996 | 11003.01 |
| MAP2-047 | OverSamp | Target | Little River | Central | 3rd | 42.16427 | -71.94886 | 18321 |
| MAP2-048 | OverSamp | NRL | Muddy Brook | Central | 1st | 42.12452 | -71.56035 | 57465.46 |
| MAP2-049 | OverSamp | Target | North Pond Brook | Central | 2nd | 42.58179 | -72.32696 | 42672.81 |
| MAP2-050 | OverSamp | Target | Middle River | Central | 4th | 42.23909 | -71.82584 | 11003.01 |
| MAP2-051 | OverSamp | WE | UNT | Central | 2nd | 42.68296 | -71.81121 | 42672.81 |
| MAP2-052 | OverSamp | FE_I | UNT to Coles Brook | Central | 1st | 41.88283 | -71.29081 | 57465.46 |
| MAP2-053 | OverSamp | NW | Otter River | Central | 4th | 42.60850 | -72.08809 | 11003.01 |
| MAP2-054 | OverSamp | WE | UNT to Waushacum | Central | 2nd | 42.39514 | -71.77190 | 42672.81 |
| MAP2-055 | OverSamp | Target | Bowers Brook | Central | 3rd | 42.53193 | -71.57911 | 18321 |
| MAP2-056 | OverSamp | WE | Ramshorn Brook | Central | 3rd | 42.17869 | -71.79654 | 18321 |
| MAP2-057 | OverSamp | WE | East Branch Tully River | Central | 4th | 42.67825 | -72.21615 | 11003.01 |
| MAP2-058 | OverSamp | FE_I | UNT | Central | 1st | 42.66932 | -71.73752 | 57465.46 |
| MAP2-059 | OverSamp | Target | UNT to Quinebaug River | Central | 2nd | 42.13693 | -72.10313 | 42672.81 |
| MAP2-060 | OverSamp | Target | Bacon Brook | Central | 3rd | 42.02932 | -71.60542 | 18321 |
| MAP2-061 | OverSamp | APD | Templeton Brook | Central | 3rd | 42.53314 | -72.02372 | 18321 |
| MAP2-062 | OverSamp | FE_NS | UNT to Pierce Pond | Central | 1st | 42.55026 | -71.78524 | 57465.46 |
| MAP2-063 | OverSamp | FE_I | UNT | Central | 1st | 42.13360 | -72.07923 | 57465.46 |
| MAP2-064 | OverSamp | FE_I | UNT | Central | 1st | 41.98699 | -71.35585 | 57465.46 |
| MAP2-065 | OverSamp | FE_I | UNT | Central | 1st | 42.65718 | -72.28399 | 57465.46 |
| MAP2-066 | OverSamp | Target | Kettle Brook | Central | 3rd | 42.23359 | -71.85575 | 18321 |
| MAP2-067 | OverSamp | Target | UNT to Phillips Brook | Central | 1st | 42.59041 | -71.86334 | 57465.46 |
| MAP2-068 | OverSamp | Target | Ten Mile River | Central | 4th | 41.89640 | -71.33321 | 11003.01 |
| MAP2-069 | OverSamp | Target | Millers River | Central | 4th | 42.66741 | -72.00414 | 11003.01 |
| MAP2-070 | OverSamp | NRL | UNT to Quinapoxet Reservoir | Central | 1st | 42.40902 | -71.89941 | 57465.46 |
| MAP2-071 | OverSamp | Target | Wekepeke Brook | Central | 4th | 42.47692 | -71.72379 | 11003.01 |
| MAP2-072 | OverSamp | Target | Wellington Brook | Central | 2nd | 42.14271 | -71.86185 | 42672.81 |
| MAP2-073 | OverSamp | NW | Thousand Acre Brook | Central | 2nd | 42.58693 | -72.16825 | 42672.81 |
| MAP2-074 | OverSamp | O | West Brook | Central | 2nd | 42.29894 | -71.73187 | 42672.81 |
| MAP2-075 | OverSamp | Target | Hatchet Brook | Central | 3rd | 42.06151 | -72.06454 | 18321 |
| MAP2-076 | OverSamp | WE | West River | Central | 3rd | 42.16595 | -71.62831 | 18321 |
| MAP2-077 | OverSamp | Target | Stockwell Brook | Central | 1st | 42.65715 | -72.13291 | 57465.46 |
| MAP2-161 | Primary | APD | Smith Brook | West | 2nd | 42.54614 | -72.81502 | 56446.77 |
| MAP2-162 | Primary | PI | Cold River | West | 3rd | 42.63511 | -73.00083 | 20988.96 |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-163 | Primary | Target | Billings Brook | West | 2nd | 42.54141 | -72.88420 | 56446.77 |
| MAP2-164 | Primary | NRL | Middle Branch Westfield River | West | 4th | 42.34188 | -72.95145 | 13635.03 |
| MAP2-165 | Primary | Target | West Branch North River | West | 3rd | 42.67417 | -72.73353 | 20988.96 |
| MAP2-166 | Primary | Target | Smith Brook | West | 1st | 42.45191 | -73.30162 | 175789.9 |
| MAP2-167 | Primary | Target | West Branch | West | 3rd | 42.40624 | -72.88766 | 20988.96 |
| MAP2-168 | Primary | Target | West Branch Westfield River | West | 4th | 42.23748 | -72.88540 | 13635.03 |
| MAP2-169 | Primary | Target | Green River | West | 4th | 42.59825 | -72.61592 | 13635.03 |
| MAP2-170 | Primary | NW | Town Brook | West | 2nd | 42.50888 | -73.23746 | 56446.77 |
| MAP2-171 | Primary | Target | Hop Brook | West | 2nd | 42.25259 | -73.21912 | 56446.77 |
| MAP2-172 | Primary | Target | Slocum Brook | West | 2nd | 42.04760 | -73.01700 | 56446.77 |
| MAP2-173 | Primary | Target | Cold River | West | 4th | 42.63920 | -72.93808 | 13635.03 |
| MAP2-174 | Primary | APD | West Branch Green River | West | 3rd | 42.64742 | -73.26237 | 20988.96 |
| MAP2-175 | Primary | Target | West Brook | West | 2nd | 42.24776 | -73.28035 | 56446.77 |
| MAP2-176 | Primary | NW | Hubbard Brook | West | 3rd | 42.14804 | -73.39016 | 20988.96 |
| MAP2-177 | Primary | Target | unnamed tributary to Creamery Brook | West | 2nd | 42.51153 | -72.80105 | 56446.77 |
| MAP2-178 | Primary | FE_I | Paint Brook | West | 1st | 42.71547 | -73.01124 | 175789.9 |
| MAP2-179 | Primary | WE | North Branch Swift River | West | 3rd | 42.47003 | -72.87067 | 20988.96 |
| MAP2-180 | Primary | PI | West Branch Westfield River | West | 3rd | 42.30598 | -73.01147 | 20988.96 |
| MAP2-181 | Primary | Target | East Branch North River | West | 4th | 42.73205 | -72.71946 | 13635.03 |
| MAP2-182 | Primary | Target | Kinderhook Creek | West | 3rd | 42.54503 | -73.31275 | 20988.96 |
| MAP2-183 | Primary | APD | Powdermill Brook | West | 1st | 42.16440 | -72.76456 | 175789.9 |
| MAP2-184 | Primary | Target | Pond Brook | West | 2nd | 42.16952 | -72.97368 | 56446.77 |
| MAP2-185 | Primary | NW_MI | East Branch North River | West | 4th | 42.66300 | -72.71580 | 13635.03 |
| MAP2-186 | Primary | Target | East Branch Housatonic River | West | 3rd | 42.47392 | -73.14121 | 20988.96 |
| MAP2-187 | Primary | Target | Clam River | West | 2nd | 42.15946 | -73.12792 | 56446.77 |
| MAP2-188 | Primary | NRL | Seymour Brook | West | 3rd | 42.06375 | -72.85585 | 20988.96 |
| MAP2-189 | Primary | PI | Chickley River | West | 4th | 42.60476 | -72.91432 | 13635.03 |
| MAP2-190 | Primary | APD | Dry Brook | West | 2nd | 42.55503 | -73.07982 | 56446.77 |
| MAP2-191 | Primary | APD | unnamed tributary to Hubbard Brook | West | 1st | 42.16791 | -73.39644 | 175789.9 |
| MAP2-192 | Primary | WE | Ironwork Brook | West | 1st | 42.14774 | -73.30191 | 175789.9 |
| MAP2-193 | OverSamp | Target | South River | West | 3rd | 42.50830 | -72.69871 | 20988.96 |
| MAP2-194 | OverSamp | Target | Hoosic River | West | 4th | 42.66954 | -73.10371 | 13635.03 |
| MAP2-195 | OverSamp | Target | Middle Branch Westfield River | West | 2nd | 42.40227 | -72.97959 | 56446.77 |
| MAP2-196 | OverSamp | APD | West Branch Farmington River | West | 4th | 42.17188 | -73.07471 | 13635.03 |
| MAP2-197 | OverSamp | Target | East Glen Brook | West | 1st | 42.67328 | -72.61264 | 175789.9 |
| MAP2-198 | OverSamp | NW | West Branch Housatonic River | West | 4th | 42.44896 | -73.26323 | 13635.03 |
| MAP2-199 | OverSamp | Target | Munn Brook | West | 3rd | 42.09977 | -72.80864 | 20988.96 |
| MAP2-200 | OverSamp | FE_I | unnamed tributary to Pond Brook | West | 1st | 42.09438 | -73.02141 | 175789.9 |
| MAP2-201 | OverSamp | NRL | Clesson Brook | West | 3rd | 42.58293 | -72.83672 | 20988.96 |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-202 | OverSamp | Target | Green River | West | 4th | 42.70290 | -73.20020 | 13635.03 |
| MAP2-203 | OverSamp | Target | East Brook | West | 2nd | 42.27211 | -73.27398 | 56446.77 |
| MAP2-204 | OverSamp | Target | Umpachene River | West | 2nd | 42.11380 | -73.23231 | 56446.77 |
| MAP2-205 | OverSamp | Target | Hoosic River | West | 4th | 42.66113 | -73.10381 | 13635.03 |
| MAP2-206 | OverSamp | Target | Westfield River | West | 3rd | 42.55161 | -73.01461 | 20988.96 |
| MAP2-207 | OverSamp | Target | Middle Branch Westfield River | West | 4th | 42.26069 | -72.87868 | 13635.03 |
| MAP2-208 | OverSamp | WE | Schenob Brook | West | 3rd | 42.06136 | -73.41041 | 20988.96 |
| MAP2-209 | OverSamp | Target | Webster Brook | West | 3rd | 42.38209 | -72.81255 | 20988.96 |
| MAP2-210 | OverSamp | Target | Cone Brook | West | 3rd | 42.35721 | -73.35414 | 20988.96 |
| MAP2-211 | OverSamp | Target | Westfield River | West | 4th | 42.45247 | -72.87827 | 13635.03 |
| MAP2-212 | OverSamp | Target | Thomas Brook | West | 3rd | 42.24539 | -73.11392 | 20988.96 |
| MAP2-213 | OverSamp | Target | Hinsdale Brook | West | 3rd | 42.62827 | -72.64486 | 20988.96 |
| MAP2-214 | OverSamp | WE | Yokun Brook | West | 1st | 42.37963 | -73.25089 | 175789.9 |
| MAP2-215 | OverSamp | Target | Great Brook | West | 3rd | 42.08622 | -72.72793 | 20988.96 |
| MAP2-216 | OverSamp | FE_I | UNT | West | 1st | 42.09436 | -73.06045 | 175789.9 |
| MAP2-217 | OverSamp | Target | North River | West | 4th | 42.63908 | -72.72437 | 13635.03 |
| MAP2-218 | OverSamp | Target | Hopper Brook | West | 2nd | 42.65789 | -73.20167 | 56446.77 |
| MAP2-321 | Primary | O | UNT | Southeast | 1st | 41.26560 | -69.97728 | 69476.71 |
| MAP2-322 | Primary | Target | Mill River | Southeast | 4th | 41.90038 | -71.09400 | 6671.233 |
| MAP2-323 | Primary | FE_M | Mother Brook | Southeast | 1st | 42.24598 | -71.15132 | 69476.71 |
| MAP2-324 | Primary | CB | East Branch Sippican River | Southeast | 4th | 41.78190 | -70.78371 | 6671.233 |
| MAP2-325 | Primary | PI | UNT to Mary Lee Brook | Southeast | 1st | 42.15948 | -71.03287 | 69476.71 |
| MAP2-326 | Primary | FE_A | UNT | Southeast | 1st | 41.89997 | -70.81745 | 69476.71 |
| MAP2-327 | Primary | Target | Wading River | Southeast | 4th | 41.95255 | -71.22476 | 6671.233 |
| MAP2-328 | Primary | Target | Doggett Brook | Southeast | 4th | 41.72790 | -70.79814 | 6671.233 |
| MAP2-329 | Primary | FE_NS | Old Swamp River | Southeast | 2nd | 42.15962 | -70.92105 | 26848.11 |
| MAP2-330 | Primary | FE_I | UNT to Herring Brook | Southeast | 1st | 42.19680 | -70.76999 | 69476.71 |
| MAP2-331 | Primary | NRL | Runnins River | Southeast | 3rd | 41.79989 | -71.34110 | 18694.05 |
| MAP2-332 | Primary | FE_I | UNT | Southeast | 1st | 41.64706 | -70.99021 | 69476.71 |
| MAP2-333 | Primary | Target | Satucket River | Southeast | 4th | 42.01847 | -70.92253 | 6671.233 |
| MAP2-334 | Primary | FE_A | UNT | Southeast | 2nd | 42.06121 | -70.74685 | 26848.11 |
| MAP2-335 | Primary | Target | Kickamuit River | Southeast | 2nd | 41.74470 | -71.24826 | 26848.11 |
| MAP2-336 | Primary | FE_NS | UNT | Southeast | 2nd | 41.69231 | -70.35747 | 26848.11 |
| MAP2-337 | Primary | FE_A | UNT | Southeast | 2nd | 41.70155 | -70.20004 | 26848.11 |
| MAP2-338 | Primary | PI | Halls Brook | Southeast | 3rd | 42.00453 | -70.74104 | 18694.05 |
| MAP2-339 | Primary | Target | Rumford River | Southeast | 3rd | 42.06113 | -71.21659 | 18694.05 |
| MAP2-340 | Primary | FE_A | UNT | Southeast | 2nd | 41.85070 | -70.77416 | 26848.11 |
| MAP2-341 | Primary | Target | Salisbury Brook | Southeast | 2nd | 42.08240 | -71.03005 | 26848.11 |
| MAP2-342 | Primary | CB | UNT to Whetstone Brook | Southeast | 2nd | 41.91635 | -70.82612 | 26848.11 |
| MAP2-343 | Primary | FE_I | UNT to Canoe River | Southeast | 2nd | 42.01326 | -71.16715 | 26848.11 |
| MAP2-344 | Primary | FE_I | UNT | Southeast | 1st | 41.80942 | -71.08092 | 69476.71 |
| MAP2-345 | Primary | Target | Puddingshear Brook | Southeast | 2nd | 41.90744 | -70.97992 | 26848.11 |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-346 | Primary | NW | Wildcat Brook | Southeast | 2nd | 42.13611 | -70.82264 | 26848.11 |
| MAP2-347 | Primary | Target | Palmer River | Southeast | 4th | 41.84611 | -71.26255 | 6671.233 |
| MAP2-348 | Primary | NRL | UNT to Adamsville Brook | Southeast | 2nd | 41.57286 | -71.12734 | 26848.11 |
| MAP2-349 | Primary | Target | Hockomock River | Southeast | 4th | 41.98837 | -71.03545 | 6671.233 |
| MAP2-350 | Primary | NW | Green Harbor River | Southeast | 4th | 42.08682 | -70.65563 | 6671.233 |
| MAP2-351 | Primary | O | Paint Mill Brook | Southeast | 2nd | 41.39259 | -70.71980 | 26848.11 |
| MAP2-352 | Primary | FE_A | UNT | Southeast | 1st | 41.83051 | -70.63103 | 69476.71 |
| MAP2-353 | OverSamp | FE_I | UNT to Cobbs Pond | Southeast | 2nd | 41.76276 | -70.07338 | 26848.11 |
| MAP2-354 | OverSamp | PI | Winnetuxet River | Southeast | 4th | 41.95187 | -70.84631 | 6671.233 |
| MAP2-355 | OverSamp | NW | Neponset River | Southeast | 4th | 42.15472 | -71.24296 | 6671.233 |
| MAP2-356 | OverSamp | FE_I | UNT | Southeast | 1st | 41.76827 | -70.79725 | 69476.71 |
| MAP2-357 | OverSamp | WE | Trout Brook | Southeast | 2nd | 42.09833 | -71.01417 | 26848.11 |
| MAP2-358 | OverSamp | NW | South Meadow Brook | Southeast | 4th | 41.87392 | -70.77042 | 6671.233 |
| MAP2-359 | OverSamp | FE_NS | UNT | Southeast | 1st | 41.96083 | -71.27197 | 69476.71 |
| MAP2-360 | OverSamp | Target | Fall Brook | Southeast | 3rd | 41.75570 | -70.98313 | 18694.05 |
| MAP2-361 | OverSamp | NRL | Nemasket River | Southeast | 4th | 41.93720 | -70.93212 | 6671.233 |
| MAP2-362 | OverSamp | Target | Poor Meadow Brook | Southeast | 3rd | 42.04239 | -70.89846 | 18694.05 |
| MAP2-363 | OverSamp | Target | Clear Run Brook | Southeast | 2nd | 41.80069 | -71.30434 | 26848.11 |
| MAP2-364 | OverSamp | FE_I | UNT | Southeast | 1st | 41.56093 | -71.02574 | 69476.71 |
| MAP2-365 | OverSamp | Target | Hockomock River | Southeast | 4th | 42.01559 | -71.05266 | 6671.233 |
| MAP2-366 | OverSamp | Target | Pine Tree Brook | Southeast | 3rd | 42.24343 | -71.09438 | 18694.05 |
| MAP2-367 | OverSamp | FE_I | UNT | Southeast | 2nd | 41.70192 | -70.73218 | 26848.11 |
| MAP2-368 | OverSamp | FE_A | UNT | Southeast | 1st | 41.59297 | -70.64119 | 69476.71 |
| MAP2-369 | OverSamp | PI | Lower Pole Dike Creek | Southeast | 3rd | 41.94463 | -70.05493 | 18694.05 |
| MAP2-370 | OverSamp | NW | Winnetuxet River | Southeast | 4th | 41.95736 | -70.85999 | 6671.233 |
| MAP2-371 | OverSamp | APD | Neponset River | Southeast | 4th | 42.16452 | -71.17513 | 6671.233 |
| MAP2-372 | OverSamp | FE_I | UNT to Snipatuit Brook | Southeast | 1st | 41.76936 | -70.87955 | 69476.71 |
| MAP2-373 | OverSamp | Target | Shumatuscacant River | Southeast | 3rd | 42.06812 | -70.91424 | 18694.05 |
| MAP2-374 | OverSamp | CB | UNT to South Meadow Brook | Southeast | 2nd | 41.88039 | -70.75924 | 26848.11 |
| MAP2-375 | OverSamp | WE | Threemile River | Southeast | 4th | 41.94430 | -71.15133 | 6671.233 |
| MAP2-376 | OverSamp | FE_A | UNT | Southeast | 2nd | 41.77901 | -70.93858 | 26848.11 |
| MAP2-377 | OverSamp | NRL | Willow Brook | Southeast | 2nd | 42.02585 | -71.01097 | 26848.11 |
| MAP2-378 | OverSamp | FE_I | Torrey Brook | Southeast | 1st | 42.10700 | -70.86296 | 69476.71 |
| MAP2-379 | OverSamp | Target | Cole River | Southeast | 3rd | 41.77731 | -71.19253 | 18694.05 |
| MAP2-380 | OverSamp | Target | Mattapoisett River | Southeast | 4th | 41.67967 | -70.84083 | 6671.233 |
| MAP2-381 | OverSamp | Target | Mill River | Southeast | 4th | 41.90938 | -71.09812 | 6671.233 |
| MAP2-382 | OverSamp | FE_I | UNT to Aberjona River | Southeast | 1st | 42.49514 | -71.13575 | 69476.71 |
| MAP2-383 | OverSamp | FE_I | UNT | Southeast | 2nd | 41.80697 | -70.79689 | 26848.11 |
| MAP2-384 | OverSamp | Target | Santuit River | Southeast | 3rd | 41.64358 | -70.45337 | 18694.05 |
| MAP2-385 | OverSamp | Target | Herring River | Southeast | 4th | 41.70289 | -70.10478 | 6671.233 |
| MAP2-386 | OverSamp | FE_I | UNT | Southeast | 1st | 41.97999 | -70.74572 | 69476.71 |
| MAP2-387 | OverSamp | WE | Mine Brook | Southeast | 3rd | 42.15120 | -71.25958 | 18694.05 |
| MAP2-388 | OverSamp | CB | Indian Brook | Southeast | 3rd | 41.83752 | -70.75654 | 18694.05 |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-389 | OverSamp | APD | Coweeset Brook | Southeast | 4th | 42.03823 | -71.06230 | 6671.233 |
| MAP2-390 | OverSamp | FE_I | UNT | Southeast | 1st | 41.93398 | -70.84375 | 69476.71 |
| MAP2-391 | OverSamp | Target | UNT to Canoe River | Southeast | 2nd | 41.98950 | -71.17372 | 26848.11 |
| MAP2-392 | OverSamp | FE_I | UNT | Southeast | 1st | 41.69602 | -71.03703 | 69476.71 |
| MAP2-393 | OverSamp | NW | Nemasket River | Southeast | 4th | 41.93592 | -70.94227 | 6671.233 |
| MAP2-394 | OverSamp | PI | UNT to Oldham Pond | Southeast | 2nd | 42.07017 | -70.84408 | 26848.11 |
| MAP2-395 | OverSamp | NW | Palmer River | Southeast | 4th | 41.80300 | -71.27310 | 6671.233 |
| MAP2-396 | OverSamp | Target | UNT to Bread and Cheese Brook | Southeast | 3rd | 41.64181 | -71.07646 | 18694.05 |
| MAP2-397 | OverSamp | FE_I | UNT to Black Brook | Southeast | 2nd | 42.01511 | -71.08567 | 26848.11 |
| MAP2-398 | OverSamp | Target | Weir River | Southeast | 3rd | 42.24223 | -70.85911 | 18694.05 |
| MAP2-399 | OverSamp | WE | Crooked River | Southeast | 1st | 41.74204 | -70.68899 | 69476.71 |
| MAP2-400 | OverSamp | PI | UNT to Muddy Cove | Southeast | 2nd | 41.75866 | -70.66854 | 26848.11 |
| MAP2-401 | OverSamp | PI | Herring River | Southeast | 2nd | 41.95678 | -70.04388 | 26848.11 |
| MAP2-402 | OverSamp | Target | Nemasket River | Southeast | 4th | 41.88142 | -70.90943 | 6671.233 |
| MAP2-403 | OverSamp | NRL | Massapoag Brook | Southeast | 3rd | 42.14532 | -71.14560 | 18694.05 |
| MAP2-404 | OverSamp | Target | Mattapoisett River | Southeast | 4th | 41.72741 | -70.85636 | 6671.233 |
| MAP2-405 | OverSamp | PI | Monatiquot River | Southeast | 4th | 42.19790 | -71.00836 | 6671.233 |
| MAP2-406 | OverSamp | CB | Crane Brook | Southeast | 3rd | 41.86410 | -70.72371 | 18694.05 |
| MAP2-407 | OverSamp | Target | East Branch Palmer River | Southeast | 3rd | 41.86478 | -71.22919 | 18694.05 |
| MAP2-408 | OverSamp | FE_I | UNT | Southeast | 2nd | 41.82163 | -70.96906 | 26848.11 |
| MAP2-409 | OverSamp | NW | Town River | Southeast | 4th | 41.99667 | -70.97664 | 6671.233 |
| MAP2-410 | OverSamp | Target | Pudding Brook | Southeast | 2nd | 42.08658 | -70.75695 | 26848.11 |
| MAP2-411 | OverSamp | NRL | UNT to Poppasquash Swamp | Southeast | 1st | 41.83923 | -71.17090 | 69476.71 |
| MAP2-412 | OverSamp | FE_I | UNT | Southeast | 1st | 41.65783 | -70.86648 | 69476.71 |
| MAP2-413 | OverSamp | Target | Pine Swamp Brook | Southeast | 1st | 41.93252 | -71.07758 | 69476.71 |
| MAP2-414 | OverSamp | Target | Mill Brook | Southeast | 4th | 42.42139 | -71.16905 | 6671.233 |
| MAP2-415 | OverSamp | WE | Double Brook | Southeast | 2nd | 41.84081 | -70.80343 | 26848.11 |
| MAP2-416 | OverSamp | FE_T | UNT | Southeast | 2nd | 41.63124 | -70.39550 | 26848.11 |
| MAP2-417 | OverSamp | FE_I | UNT to Plashes Pond | Southeast | 1st | 41.68041 | -70.21729 | 69476.71 |
| MAP2-418 | OverSamp | NW | Threemile River | Southeast | 4th | 41.88826 | -71.12995 | 6671.233 |
| MAP2-419 | OverSamp | PI | Canoe River | Southeast | 2nd | 42.07561 | -71.19523 | 26848.11 |
| MAP2-420 | OverSamp | APD | Wankinco River | Southeast | 2nd | 41.82941 | -70.70488 | 26848.11 |
| MAP2-421 | OverSamp | WE | Norraway Brook | Southeast | 1st | 42.17828 | -71.05702 | 69476.71 |
| MAP2-422 | OverSamp | CB | Rocky Meadow Brook | Southeast | 3rd | 41.87918 | -70.81955 | 18694.05 |
| MAP2-423 | OverSamp | Target | Rumford River | Southeast | 3rd | 42.00503 | -71.21345 | 18694.05 |
| MAP2-424 | OverSamp | NRL | Mattapoisett River | Southeast | 4th | 41.71646 | -70.84689 | 6671.233 |
| MAP2-425 | OverSamp | FE_NS | UNT | Southeast | 1st | 41.87435 | -70.96027 | 69476.71 |
| MAP2-426 | OverSamp | Target | Accord Brook | Southeast | 2nd | 42.19948 | -70.86207 | 26848.11 |
| MAP2-427 | OverSamp | WE | UNT | Southeast | 2nd | 41.84135 | -71.27306 | 26848.11 |
| MAP2-428 | OverSamp | Target | Paskamanset River | Southeast | 3rd | 41.63338 | -70.98602 | 18694.05 |
| MAP2-429 | OverSamp | Target | Town River | Southeast | 4th | 41.99746 | -70.95387 | 6671.233 |
| MAP2-430 | OverSamp | FE_A | UNT | Southeast | 1st | 41.88010 | -70.54543 | 69476.71 |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-431 | OverSamp | FE_T | Palmer River | Southeast | 4th | 41.77620 | -71.28114 | 6671.233 |
| MAP2-432 | OverSamp | FE_A | UNT | Southeast | 1st | 41.79417 | -70.65571 | 69476.71 |
| MAP2-433 | OverSamp | FE_A | Herring River | Southeast | 2nd | 41.96345 | -70.01043 | 26848.11 |
| MAP2-434 | OverSamp | WE | UNT to Stump Pond | Southeast | 3rd | 41.99853 | -70.88792 | 18694.05 |
| MAP2-435 | OverSamp | FE_I | UNT | Southeast | 1st | 42.19447 | -71.17891 | 69476.71 |
| MAP2-436 | OverSamp | NRL | Sherman Brook | Southeast | 3rd | 41.74265 | -70.82418 | 18694.05 |
| MAP2-437 | OverSamp | Target | Salisbury Plain River | Southeast | 3rd | 42.07543 | -71.00964 | 18694.05 |
| MAP2-438 | OverSamp | WE | UNT | Southeast | 3rd | 41.88355 | -70.79088 | 18694.05 |
| MAP2-439 | OverSamp | Target | Wading River | Southeast | 4th | 41.94946 | -71.17553 | 6671.233 |
| MAP2-440 | OverSamp | FE_I | UNT | Southeast | 1st | 41.70033 | -70.96786 | 69476.71 |
| MAP2-441 | OverSamp | NW | Town River | Southeast | 4th | 42.01159 | -71.01678 | 6671.233 |
| MAP2-442 | OverSamp | PI | UNT to French Stream | Southeast | 1st | 42.11402 | -70.89596 | 69476.71 |
| MAP2-443 | OverSamp | Target | Runnins River | Southeast | 3rd | 41.83046 | -71.32982 | 18694.05 |
| MAP2-481 | Primary | APD | Broad Brook | Midwest | 2nd | 42.20226 | -72.66589 | 38069.37 |
| MAP2-482 | Primary | WE | Dunn Brook | Midwest | 3rd | 42.22705 | -72.07299 | 27196.09 |
| MAP2-483 | Primary | WE | Amethust Brook | Midwest | 1st | 42.41300 | -72.41900 | 56951.98 |
| MAP2-484 | Primary | FE_M | Ware River | Midwest | 4th | 42.39621 | -72.05042 | 14119.28 |
| MAP2-485 | Primary | APD | UNT to Ninemile Pond | Midwest | 1st | 42.14763 | -72.42964 | 56951.98 |
| MAP2-486 | Primary | Target | Mill River | Midwest | 3rd | 42.45656 | -72.63699 | 27196.09 |
| MAP2-487 | Primary | FE_NS | UNT | Midwest | 1st | 42.31856 | -72.67458 | 56951.98 |
| MAP2-488 | Primary | Target | Ware River | Midwest | 4th | 42.34007 | -72.15953 | 14119.28 |
| MAP2-489 | Primary | Target | Quaboag River | Midwest | 4th | 42.21273 | -72.22876 | 14119.28 |
| MAP2-490 | Primary | WE | Lampson Brook | Midwest | 2nd | 42.28243 | -72.43282 | 38069.37 |
| MAP2-491 | Primary | FE_I | UNT to East Branch Ware River | Midwest | 1st | 42.49012 | -71.94414 | 56951.98 |
| MAP2-492 | Primary | Target | Hop Brook | Midwest | 3rd | 42.46999 | -72.32260 | 27196.09 |
| MAP2-493 | Primary | WE | UNT to Ware River | Midwest | 1st | 42.22368 | -72.30771 | 56951.98 |
| MAP2-494 | Primary | WE | Neds Ditch | Midwest | 1st | 42.30109 | -72.63988 | 56951.98 |
| MAP2-495 | Primary | WE | Turkey Hill Brook | Midwest | 3rd | 42.28382 | -71.97658 | 27196.09 |
| MAP2-496 | Primary | Target | Fall River | Midwest | 4th | 42.62273 | -72.54971 | 14119.28 |
| MAP2-497 | Primary | NRL | Still Brook | Midwest | 3rd | 42.03723 | -72.67841 | 27196.09 |
| MAP2-498 | Primary | NW | East Brookfield River | Midwest | 4th | 42.20774 | -72.05506 | 14119.28 |
| MAP2-499 | Primary | Target | Scarboro Brook | Midwest | 2nd | 42.34953 | -72.43149 | 38069.37 |
| MAP2-500 | Primary | Target | UNT to East Branch Ware River | Midwest | 1st | 42.40886 | -71.98179 | 56951.98 |
| MAP2-501 | Primary | Target | Scantic River | Midwest | 4th | 42.04351 | -72.45620 | 14119.28 |
| MAP2-502 | Primary | Target | Cranberry Pond Brook | Midwest | 2nd | 42.50682 | -72.52698 | 38069.37 |
| MAP2-503 | Primary | Target | UNT to North Branch | Midwest | 2nd | 42.26340 | -72.70588 | 38069.37 |
| MAP2-504 | Primary | Target | Muddy Brook | Midwest | 2nd | 42.36092 | -72.23011 | 38069.37 |
| MAP2-505 | Primary | NRL | Quaboag River | Midwest | 4th | 42.16050 | -72.26682 | 14119.28 |
| MAP2-506 | Primary | Target | Roaring Brook | Midwest | 1st | 42.25054 | -72.42623 | 56951.98 |
| MAP2-507 | Primary | WE | UNT to Moccasin Brook | Midwest | 1st | 42.49479 | -72.15047 | 56951.98 |
| MAP2-508 | Primary | Target | UNT to Quabbin Reservoir | Midwest | 3rd | 42.44207 | -72.36869 | 27196.09 |
| MAP2-509 | Primary | Target | Chicopee Brook | Midwest | 4th | 42.09349 | -72.31194 | 14119.28 |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-510 | Primary | Target | Elmer Brook | Midwest | 2nd | 42.27964 | -72.58695 | 38069.37 |
| MAP2-511 | Primary | Target | Shaw Brook | Midwest | 3rd | 42.27317 | -71.97499 | 27196.09 |
| MAP2-512 | Primary | NW | Connecticut River | Midwest | 4th | 42.68767 | -72.47436 | 14119.28 |
| MAP2-513 | OverSamp | Target | UNT to Porter Lake | Midwest | 1st | 42.07983 | -72.56556 | 56951.98 |
| MAP2-514 | OverSamp | Target | West Branch Mill River | Midwest | 3rd | 42.42258 | -72.76956 | 27196.09 |
| MAP2-515 | OverSamp | NRL | Town Lot Brook | Midwest | 1st | 42.39460 | -72.76197 | 56951.98 |
| MAP2-516 | OverSamp | WE | Flat Brook | Midwest | 2nd | 42.28791 | -72.27157 | 38069.37 |
| MAP2-517 | OverSamp | FE_I | UNT to South Branch Mill River | Midwest | 1st | 42.08826 | -72.43841 | 56951.98 |
| MAP2-518 | OverSamp | Target | Mountain Brook | Midwest | 1st | 42.44432 | -72.48988 | 56951.98 |
| MAP2-519 | OverSamp | Target | North Branch Manhan River | Midwest | 3rd | 42.28135 | -72.72940 | 27196.09 |
| MAP2-520 | OverSamp | Target | Ware River | Midwest | 4th | 42.23546 | -72.27899 | 14119.28 |
| MAP2-521 | OverSamp | Target | Quaboag River | Midwest | 4th | 42.22338 | -72.17965 | 14119.28 |
| MAP2-522 | OverSamp | FE_M | Mill River | Midwest | 4th | 42.37081 | -72.60979 | 14119.28 |
| MAP2-523 | OverSamp | Target | Coys Brook | Midwest | 2nd | 42.26215 | -72.10660 | 38069.37 |
| MAP2-524 | OverSamp | WE | Higgins Swamp | Midwest | 1st | 42.43341 | -72.15247 | 56951.98 |
| MAP2-525 | OverSamp | FE_I | UNT to East Brook | Midwest | 1st | 42.07748 | -72.39148 | 56951.98 |
| MAP2-526 | OverSamp | Target | Broad Brook | Midwest | 2nd | 42.25018 | -72.65941 | 38069.37 |
| MAP2-527 | OverSamp | APD | Bell Brook | Midwest | 1st | 42.35627 | -72.08783 | 56951.98 |
| MAP2-528 | OverSamp | APD | Fourmile Brook | Midwest | 2nd | 42.62952 | -72.44551 | 38069.37 |
| MAP2-529 | OverSamp | APD | Fuller Brook | Midwest | 3rd | 42.17802 | -72.49962 | 27196.09 |
| MAP2-530 | OverSamp | Target | UNT to Connecticut River | Midwest | 2nd | 42.55507 | -72.55826 | 38069.37 |
| MAP2-531 | OverSamp | NRL | Beaver Brook | Midwest | 3rd | 42.38661 | -72.68003 | 27196.09 |
| MAP2-532 | OverSamp | NW | Ware River | Midwest | 4th | 42.27143 | -72.21807 | 14119.28 |
| MAP2-533 | OverSamp | Target | Watchaug Brook | Midwest | 3rd | 42.04060 | -72.48486 | 27196.09 |
| MAP2-534 | OverSamp | Target | Pond Brook | Midwest | 2nd | 42.55287 | -72.51950 | 38069.37 |
| MAP2-535 | OverSamp | NW | East Branch Ware River | Midwest | 4th | 42.44248 | -71.96218 | 14119.28 |
| MAP2-536 | OverSamp | WE | Jabish Brook | Midwest | 3rd | 42.27537 | -72.38504 | 27196.09 |
| MAP2-537 | OverSamp | NW | Chicopee Brook | Midwest | 4th | 42.13541 | -72.31501 | 14119.28 |
| MAP2-538 | OverSamp | Target | UNT to Fort River | Midwest | 1st | 42.33802 | -72.55537 | 56951.98 |
| MAP2-539 | OverSamp | Target | Dunn Brook | Midwest | 1st | 42.25263 | -72.05643 | 56951.98 |
| MAP2-540 | OverSamp | Target | West Branch Fever Brook | Midwest | 2nd | 42.47217 | -72.25680 | 38069.37 |
| MAP2-541 | OverSamp | Target | Vinica Brook | Midwest | 3rd | 42.05933 | -72.27160 | 27196.09 |
| MAP2-542 | OverSamp | WE | Hop Brook | Midwest | 4th | 42.35439 | -72.49729 | 14119.28 |
| MAP2-543 | OverSamp | FE_I | Broadmeadow Brook | Midwest | 1st | 42.38544 | -72.14107 | 56951.98 |
| MAP2-544 | OverSamp | WE | East Wait Brook | Midwest | 1st | 42.71884 | -72.49060 | 56951.98 |
| MAP2-545 | OverSamp | Target | UNT | Midwest | 2nd | 42.03730 | -72.69991 | 38069.37 |
| MAP2-546 | OverSamp | Target | UNT to Cranberry River | Midwest | 2nd | 42.20362 | -72.00427 | 38069.37 |
| MAP2-547 | OverSamp | Target | Tucker Brook | Midwest | 2nd | 42.26076 | -72.81804 | 38069.37 |
| MAP2-548 | OverSamp | WE | Mill Brook | Midwest | 1st | 42.29588 | -72.15623 | 56951.98 |
| MAP2-549 | OverSamp | FE_I | UNT | Midwest | 1st | 42.06558 | -72.46255 | 56951.98 |
| MAP2-550 | OverSamp | Target | Long Plain Brook | Midwest | 2nd | 42.47654 | -72.51860 | 38069.37 |
| MAP2-551 | OverSamp | APD | Manhan River | Midwest | 4th | 42.23050 | -72.71282 | 14119.28 |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-552 | OverSamp | Target | Purgee Brook | Midwest | 2nd | 42.38733 | -72.37351 | 38069.37 |
| MAP2-553 | OverSamp | APD | Foskett Mill Stream | Midwest | 3rd | 42.14343 | -72.27004 | 27196.09 |
| MAP2-554 | OverSamp | NW | Batchelor Brook | Midwest | 4th | 42.27479 | -72.50643 | 14119.28 |
| MAP2-555 | OverSamp | FE_I | Canesto Brook | Midwest | 1st | 42.50003 | -72.05262 | 56951.98 |
| MAP2-556 | OverSamp | FE_I | UNT to West Branch Swift River | Midwest | 1st | 42.46974 | -72.36106 | 56951.98 |
| MAP2-557 | OverSamp | NRL | UNT to Chicopee Brook | Midwest | 1st | 42.08958 | -72.30188 | 56951.98 |
| MAP2-558 | OverSamp | Target | Batchelor Brook | Midwest | 4th | 42.27003 | -72.59421 | 14119.28 |
| MAP2-641 | Primary | FE_I | Unnamed Tributary | Northeast | 1st | 42.86472 | -70.88261 | 47002.27 |
| MAP2-642 | Primary | Target | Ipswich River | Northeast | 4th | 42.61693 | -70.99641 | 8540.686 |
| MAP2-643 | Primary | FE_I | Unnamed Tributary | Northeast | 2nd | 42.60500 | -71.24697 | 39206.47 |
| MAP2-644 | Primary | FE_A | Unnamed Tributary | Northeast | 1st | 42.31606 | -71.60954 | 47002.27 |
| MAP2-645 | Primary | WE | East Meadow River | Northeast | 3rd | 42.81592 | -71.03739 | 24083.85 |
| MAP2-646 | Primary | Target | River Meadow Brook | Northeast | 4th | 42.59436 | -71.34067 | 8540.686 |
| MAP2-647 | Primary | FE_I | Unnamed Tributary | Northeast | 1st | 42.41912 | -71.29294 | 47002.27 |
| MAP2-648 | Primary | FE_I | Unnamed Tributary | Northeast | 1st | 42.38137 | -71.66004 | 47002.27 |
| MAP2-649 | Primary | NW | Ipswich River | Northeast | 4th | 42.57540 | -71.07246 | 8540.686 |
| MAP2-650 | Primary | FE_NS | Unnamed Tributary | Northeast | 1st | 42.59184 | -71.17449 | 47002.27 |
| MAP2-651 | Primary | Target | Cold Spring Brook | Northeast | 3rd | 42.22478 | -71.47767 | 24083.85 |
| MAP2-652 | Primary | Target | Charles River | Northeast | 3rd | 42.10498 | -71.45840 | 24083.85 |
| MAP2-653 | Primary | NRL | Muddy Brook | Northeast | 2nd | 42.70787 | -70.95369 | 39206.47 |
| MAP2-654 | Primary | Target | Beaver Brook | Northeast | 4th | 42.67184 | -71.34445 | 8540.686 |
| MAP2-655 | Primary | Target | Elizabeth Brook | Northeast | 4th | 42.42764 | -71.48545 | 8540.686 |
| MAP2-656 | Primary | APD | Charles River | Northeast | 4th | 42.13911 | -71.38732 | 8540.686 |
| MAP2-657 | Primary | Target | Powwow River | Northeast | 4th | 42.86593 | -70.96159 | 8540.686 |
| MAP2-658 | Primary | FE_T | Bass River | Northeast | 2nd | 42.55633 | -70.88867 | 39206.47 |
| MAP2-659 | Primary | FE_I | Pinnacle Brook | Northeast | 1st | 42.62973 | -71.18938 | 47002.27 |
| MAP2-660 | Primary | Target | Whitehall Brook | Northeast | 3rd | 42.25321 | -71.56727 | 24083.85 |
| MAP2-661 | Primary | WE | Unnamed Tributary | Northeast | 2nd | 42.74141 | -71.07000 | 39206.47 |
| MAP2-662 | Primary | FE_I | Unnamed Tributary | Northeast | 1st | 42.58622 | -71.40365 | 47002.27 |
| MAP2-663 | Primary | Target | Hurd Brook | Northeast | 2nd | 42.30494 | -71.23383 | 39206.47 |
| MAP2-664 | Primary | NRL | North Brook | Northeast | 4th | 42.35568 | -71.62830 | 8540.686 |
| MAP2-665 | Primary | Target | Ipswich River | Northeast | 4th | 42.57903 | -70.99154 | 8540.686 |
| MAP2-666 | Primary | FE_A | Heath Brook | Northeast | 1st | 42.59137 | -71.23321 | 47002.27 |
| MAP2-667 | Primary | FE_I | Unnamed Tributary | Northeast | 1st | 42.32485 | -71.43529 | 47002.27 |
| MAP2-668 | Primary | WE | Unnamed Tributary | Northeast | 1st | 42.16831 | -71.38710 | 47002.27 |
| MAP2-669 | Primary | NW | Shawsheen River | Northeast | 4th | 42.62585 | -71.15911 | 8540.686 |
| MAP2-670 | Primary | Target | Stony Brook | Northeast | 4th | 42.62539 | -71.38909 | 8540.686 |
| MAP2-671 | Primary | APD | Dudley Brook | Northeast | 1st | 42.37102 | -71.44132 | 47002.27 |
| MAP2-672 | Primary | FE_I | Unnamed Tributary | Northeast | 1st | 42.15353 | -71.45849 | 47002.27 |
| MAP2-673 | OverSamp | Target | Jackman Brook | Northeast | 1st | 42.73504 | -70.94273 | 47002.27 |
| MAP2-674 | OverSamp | NRL | Unnamed Tributary | Northeast | 1st | 42.70503 | -71.87688 | 47002.27 |
| MAP2-675 | OverSamp | Target | Beaver Brook | Northeast | 3rd | 42.39010 | -71.19672 | 24083.85 |

| SiteID | Panel | Evaluation Category | GNIS Name | Stratum | Strahler Order | Latitude | Longitude | Adjusted Weight |
|---|---|---|---|---|---|---|---|---|
| MAP2-676 | OverSamp | WE | Elizabeth Brook | Northeast | 3rd | 42.46594 | -71.54676 | 24083.85 |
| MAP2-677 | OverSamp | Target | Saugus River | Northeast | 3rd | 42.49581 | -71.03874 | 24083.85 |
| MAP2-678 | OverSamp | WE | Unnamed Tributary | Northeast | 2nd | 42.58139 | -71.49994 | 39206.47 |
| MAP2-679 | OverSamp | WE | Unnamed Tributary | Northeast | 3rd | 42.25481 | -71.33276 | 24083.85 |
| MAP2-680 | OverSamp | Target | Broad Meadow Brook | Northeast | 2nd | 42.34770 | -71.51794 | 39206.47 |
| MAP2-681 | OverSamp | Target | Fish Brook | Northeast | 3rd | 42.63392 | -70.97474 | 24083.85 |
| MAP2-682 | OverSamp | Target | Vine Brook | Northeast | 2nd | 42.50179 | -71.24072 | 39206.47 |
| MAP2-683 | OverSamp | NRL | Hazel Brook | Northeast | 1st | 42.39352 | -71.33891 | 47002.27 |
| MAP2-684 | OverSamp | WE | Unnamed Tributary | Northeast | 2nd | 42.16401 | -71.37344 | 39206.47 |
| MAP2-685 | OverSamp | Target | Shawsheen River | Northeast | 4th | 42.69712 | -71.14400 | 8540.686 |
| MAP2-686 | OverSamp | NRL | Unnamed Tributary | Northeast | 1st | 42.67682 | -71.47239 | 47002.27 |
| MAP2-687 | OverSamp | WE | Unnamed Tributary | Northeast | 1st | 42.42168 | -71.33825 | 47002.27 |
| MAP2-688 | OverSamp | FE_I | Unnamed Tributary | Northeast | 1st | 42.19590 | -71.32535 | 47002.27 |
| MAP2-689 | OverSamp | FE_I | Unnamed Tributary | Northeast | 1st | 42.76763 | -70.93949 | 47002.27 |
| MAP2-690 | OverSamp | FE_I | Unnamed Tributary | Northeast | 2nd | 42.47683 | -71.56542 | 39206.47 |
| MAP2-691 | OverSamp | FE_I | Unnamed Tributary | Northeast | 1st | 42.35522 | -71.28711 | 47002.27 |
| MAP2-692 | OverSamp | Target | Unnamed Tributary | Northeast | 3rd | 42.43570 | -71.57041 | 24083.85 |
| MAP2-693 | OverSamp | Target | Ipswich River | Northeast | 4th | 42.57183 | -71.09625 | 8540.686 |
| MAP2-694 | OverSamp | Target | Nashoba Brook | Northeast | 3rd | 42.52678 | -71.41342 | 24083.85 |
| MAP2-695 | OverSamp | FE_M | Rock Meadow Brook | Northeast | 2nd | 42.25041 | -71.22236 | 39206.47 |
| MAP2-696 | OverSamp | Target | Unnamed Tributary | Northeast | 3rd | 42.29107 | -71.68853 | 24083.85 |
| MAP2-697 | OverSamp | WE | Black Brook | Northeast | 2nd | 42.62803 | -70.86781 | 39206.47 |
| MAP2-698 | OverSamp | Target | Cow Pond Brook | Northeast | 3rd | 42.62973 | -71.50616 | 24083.85 |
| MAP2-699 | OverSamp | WE | Unnamed Tributary | Northeast | 1st | 42.37229 | -71.38893 | 47002.27 |
| MAP2-700 | OverSamp | Target | Mill River | Northeast | 3rd | 42.12177 | -71.36544 | 24083.85 |
| MAP2-701 | OverSamp | NW | Parker River | Northeast | 2nd | 42.72554 | -71.02079 | 39206.47 |
| MAP2-702 | OverSamp | WE | Unnamed Tributary | Northeast | 1st | 42.63803 | -71.26758 | 47002.27 |
| MAP2-703 | OverSamp | Target | Hop Brook | Northeast | 3rd | 42.28713 | -71.65129 | 24083.85 |
| MAP2-704 | OverSamp | NW | Charles River | Northeast | 4th | 42.16381 | -71.33272 | 8540.686 |
| MAP2-705 | OverSamp | Target | Cobbler Brook | Northeast | 2nd | 42.82611 | -70.98401 | 39206.47 |
| MAP2-706 | OverSamp | O | Proctor Brook | Northeast | 1st | 42.53425 | -70.94372 | 47002.27 |
| MAP2-707 | OverSamp | Target | Beaver Brook | Northeast | 4th | 42.66818 | -71.32634 | 8540.686 |
| MAP2-708 | OverSamp | PI | Sudbury River | Northeast | 4th | 42.26655 | -71.57717 | 8540.686 |
| MAP2-709 | OverSamp | FE_I | Unnamed Tributary | Northeast | 1st | 42.61016 | -70.77760 | 47002.27 |
| MAP2-710 | OverSamp | Target | Stony Brook | Northeast | 4th | 42.59759 | -71.44757 | 8540.686 |
| MAP2-711 | OverSamp | FE_I | Unnamed Tributary | Northeast | 1st | 42.28926 | -71.27745 | 47002.27 |
| MAP2-712 | OverSamp | WE | Unnamed Tributary | Northeast | 2nd | 42.40402 | -71.55194 | 39206.47 |
| MAP2-713 | OverSamp | FE_I | Unnamed Tributary | Northeast | 1st | 42.70533 | -70.85661 | 47002.27 |
| MAP2-714 | OverSamp | FE_I | Spring Brook | Northeast | 2nd | 42.49406 | -71.25598 | 39206.47 |
| MAP2-715 | OverSamp | Target | Cochituate Brook | Northeast | 4th | 42.31932 | -71.39558 | 8540.686 |
| MAP2-716 | OverSamp | Target | Bogastow Brook | Northeast | 4th | 42.18702 | -71.37582 | 8540.686 |
| MAP2-717 | OverSamp | Target | Shawsheen River | Northeast | 4th | 42.65219 | -71.15097 | 8540.686 |
| MAP2-718 | OverSamp | Target | Stony Brook | Northeast | 4th | 42.60918 | -71.41168 | 8540.686 |

# Appendix C. MAP2 Target Sampled Sites 2011-2015

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-002 | 2011 Central | W2177 | Millers | Mahoney Brook | [approximately 340 feet downstream from Betty Spring Road, Gardner] | 42.56671 | -71.95196 |
| MAP2-004 | 2011 Central | W2179 | Ten Mile | Sevenmile River | [approximately 440 feet downstream from Roy Avenue, Attleboro] | 41.91787 | -71.35216 |
| MAP2-007 | 2011 Central | W2180 | Nashua | Monoosnuc Brook | [approximately 475 feet downstream from Mechanic Street, Leominster] | 42.52662 | -71.75692 |
| MAP2-008 | 2011 Central | W2181 | Blackstone | Dark Brook | [approximately 620 feet upstream from Inwood Road, Auburn] | 42.20291 | -71.85617 |
| MAP2-012 | 2011 Central | W2182 | Blackstone | Mumford River | [approximately 2580 feet downstream from Main Street, Sutton] | 42.09311 | -71.73709 |
| MAP2-013 | 2011 Central | W2183 | Millers | West Gulf Brook | [approximately 440 feet downstream from Gulf Road, Athol] | 42.62532 | -72.19503 |
| MAP2-015 | 2011 Central | W2184 | Quinebaug | Breakneck Brook | [approximately 5290 feet downstream from MA/CT state line, Sturbridge] | 42.04216 | -72.09715 |
| MAP2-018 | 2011 Central | W2185 | Blackstone | Unnamed Tributary | [unnamed tributary eventually to Tatnuck Brook, approximately 175 feet upstream from Chapin Road, Holden] | 42.32658 | -71.86537 |
| MAP2-023 | 2011 Central | W2186 | Nashua | Catacoonamug Brook | [approximately 40 feet upstream from Pond Street, Shirley] | 42.55308 | -71.66947 |
| MAP2-024 | 2011 Central | W2187 | French | Unnamed Tributary | [unnamed tributary eventually to South Fork, approximately 140 feet from outlet of Granite Reservoir, Charlton] | 42.10455 | -71.9288 |
| MAP2-026 | 2011 Central | W2188 | Blackstone | Quinsigamond River | [Brigham Hill Road, Grafton] | 42.20837 | -71.69757 |
| MAP2-027 | 2011 Central | W2189 | Quinebaug | Cady Brook | [at the confluence with the Quinebaug River, Southbridge] | 42.07674 | -72.02541 |
| MAP2-030 | 2011 Central | W2190 | Nashua | Whitman River | [approximately 200 feet downstream from Route 2A (State Road East), Westminster] | 42.5598 | -71.86605 |
| MAP2-031 | 2011 Central | W2191 | Quinebaug | Stevens Brook | [approximately 510 feet downstream from the Old Stafford Road crossing nearest Howlett Road, Holland] | 42.05773 | -72.18752 |
| MAP2-032 | 2011 Central | W2192 | Blackstone | Peters River | [approximately 1300 feet upstream from Wrentham Road, Bellingham] | 42.02755 | -71.48301 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-033 | 2011 Central | W2193 | Millers | Jacks Brook | [approximately 175 feet upstream from North Street, Erving] | 42.61498 | -72.40184 |
| MAP2-035 | 2011 Central | W2194 | Nashua | Whitman River | [approximately 50 feet upstream from Whitmanville Road, Westminster] | 42.58213 | -71.9026 |
| MAP2-037 | 2011 Central | W2195 | Millers | Unnamed Tributary | [unnamed tributary, outlet Lake Watatic/inlet Lower Naukeag Lake, approximately 70 feet downstream of Cross Road, Ashburnham] | 42.67731 | -71.94077 |
| MAP2-041 | 2011 Central | W2197 | Millers | West Branch Tully River | [approximately 1200 feet downstream from the Tully Road crossing nearest Creamery Hill Road, Orange] | 42.64254 | -72.25737 |
| MAP2-043 | 2011 Central | W2198 | Quinebaug | West Brook | [approximately 600 feet upstream from Palmer Road (Route 20), Brimfield] | 42.12335 | -72.20669 |
| MAP2-045 | 2011 Central | W2199 | Millers | Ellinwood Brook | [approximately 4500 feet upstream from South Athol Road, Athol] | 42.55624 | -72.23103 |
| MAP2-046 | 2011 Central | W2200 | Nashua | North Nashua River | [approximately 200 feet downstream from Mill Pond #1 Dam (MA00877), Fitchburg] | 42.57871 | -71.82996 |
| MAP2-047 | 2011 Central | W2201 | French | Unnamed Tributary | [unnamed tributary to Pikes Pond approximately 650 feet upstream from the Massachusetts Turnpike (Route 90), Charlton] | 42.16427 | -71.94886 |
| MAP2-049 | 2011 Central | W2202 | Millers | North Pond Brook | [approximately 4200 feet upstream of the onramp - Holtshire Road to Route 2 eastbound, Orange] | 42.58179 | -72.32696 |
| MAP2-050 | 2011 Central | W2203 | Blackstone | Middle River | [approximately 1200 feet downstream from Fremont Street, Worcester] | 42.23909 | -71.82584 |
| MAP2-055 | 2011 Central | W2205 | Nashua | Bowers Brook | [approximately 830 feet downstream from West Lancaster Country Road, Harvard] | 42.53193 | -71.57911 |
| MAP2-059 | 2011 Central | W2206 | Quinebaug | Unnamed Tributary | [unnamed tributary eventually to the Quinebaug River approximately 900 feet upstream from the Massachusetts Turnpike (Route 90), Sturbridge] | 42.13693 | -72.10313 |
| MAP2-060 | 2011 Central | W2207 | Blackstone | Bacon Brook | [approximately 700 feet upstream from River Road, Uxbridge] | 42.02932 | -71.60542 |
| MAP2-066 | 2011 Central | W2208 | Blackstone | Kettle Brook | [approximately 425 feet upstream of Stafford Street, Worcester] | 42.23359 | -71.85575 |
| MAP2-067 | 2011 Central | W2209 | Nashua | Unnamed Tributary | [unnamed tributary to Phillips Brook, Potato Hill Road, Westminster] | 42.59041 | -71.86334 |
| MAP2-068 | 2011 Central | W2210 | Ten Mile | Ten Mile River | [approximately 2780 feet downstream from Pond Street, Seekonk] | 41.8964 | -71.33321 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-069 | 2011 Central | W2211 | Millers | Millers River | [approximately 3430 feet downstream from the Route 12 crossing nearest North Ashburnham Road, Winchendon] | 42.66741 | -72.00414 |
| MAP2-071 | 2011 Central | W2212 | Nashua | Wekepeke Brook | [approximately 160 feet upstream of the Route 190 crossing in Lancaster] | 42.47692 | -71.72379 |
| MAP2-072 | 2011 Central | W2213 | French | Wellington Brook | [approximately 1275 feet upstream of Main Street (Route 12), Oxford] | 42.14271 | -71.86185 |
| MAP2-075 | 2011 Central | W2214 | Quinebaug | Hatchet Brook | [Dennison Cross Road, Southbridge] | 42.06151 | -72.06454 |
| MAP2-077 | 2011 Central | W2215 | Millers | Stockwell Brook | [approximately 230 feet upstream of Norcross Road, Royalston] | 42.65715 | -72.13291 |
| MAP2-163 | 2012 West | W2243 | Westfield | Billings Brook | [approximately 1600 feet downstream of Plainfield Road, Hawley/Grant Street, Plainfield] | 42.54141 | -72.8842 |
| MAP2-165 | 2012 West | W2244 | Deerfield | West Branch North River | [approximately 600 feet downstream of Heath Road, Colrain] | 42.67417 | -72.73353 |
| MAP2-166 | 2012 West | W2245 | Housatonic | Smith Brook | [approximately 2200 feet downstream of West Street, Pittsfield] | 42.45191 | -73.30162 |
| MAP2-167 | 2012 West | W2246 | Westfield | West Branch | [approximately 225 feet upstream of Main Road (Route 143), Chesterfield] | 42.40624 | -72.88766 |
| MAP2-168 | 2012 West | W2247 | Westfield | West Branch Westfield River | [north of Russell Street, approximately 2500 feet upstream of Worthington Road (Route 112), Huntington] | 42.23748 | -72.8854 |
| MAP2-169 | 2012 West | W2248 | Deerfield | Green River | [east of Route 91, approximately 3000 feet upstream of Colrain Street, Greenfield] | 42.59825 | -72.61592 |
| MAP2-171 | 2012 West | W2249 | Housatonic | Hop Brook | [southwest of Main Road, approximately 6500 feet downstream of Jerusalum Road, Tyringham] | 42.25259 | -73.21963 |
| MAP2-172 | 2012 West | W2250 | Farmington | Slocum Brook | [east of Colebrook River Road, approximately 4700 feet upstream of the Cranberry Pond Brook confluence, Tolland] | 42.0476 | -73.017 |
| MAP2-173 | 2012 West | W2251 | Deerfield | Cold River | [approximately 1150 feet upstream of Cold River Road, Charlemont] | 42.6392 | -72.93808 |
| MAP2-175 | 2012 West | W2252 | Housatonic | West Brook | [approximately 1300 feet downstream of the Beartown Road crossing nearest the intersection with Beartown Mountain Road, Great Barrington] | 42.24776 | -73.28035 |
| MAP2-177 | 2012 West | W2253 | Deerfield | Unnamed Tributary | [unnamed tributary to Creamery Brook, approximately 1700 feet downstream of West Road, Ashfield] | 42.51153 | -72.80105 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-181 | 2012 West | W2255 | Deerfield | East Branch North River | [approximately 2225 feet upstream of the Route 112 crossing nearest Jesse Wood Road, Colrain] | 42.73205 | -72.71946 |
| MAP2-182 | 2012 West | W2256 | Hudson | Kinderhook Creek | [approximately 1675 feet upstream of Potter Mountain Road, Hancock] | 42.54503 | -73.31275 |
| MAP2-184 | 2012 West | W2257 | Westfield | Pond Brook | [approximately 1450 feet downstream of Otis Stage Road (Route 23), Blanford] | 42.16952 | -72.97368 |
| MAP2-186 | 2012 West | W2258 | Housatonic | East Branch Housatonic River | [approximately 65 feet upstream of Old Windsor Road, Dalton] | 42.47392 | -73.14121 |
| MAP2-187 | 2012 West | W2259 | Farmington | Clam River | [approximately 2150 feet upstream from the confluence of the unnamed tributary from Lower Spectacle Pond, Sandisfield] | 42.15946 | -73.12792 |
| MAP2-193 | 2012 West | W2260 | Deerfield | South River | [approximately 400 feet upstream of Main Street (Route 116), Conway (approximately 200 feet upstream of confluence of Pumpkin Hollow Brook)] | 42.5083 | -72.69871 |
| MAP2-194 | 2012 West | W2261 | Hudson | Hoosic River | [approximately 1900 feet downstream of Hodges Cross Road (Route 8A), North Adams] | 42.66954 | -73.10371 |
| MAP2-195 | 2012 West | W2262 | Westfield | Middle Branch Westfield River | [approximately 200 feet downstream of River Road, Worthington] | 42.40227 | -72.97959 |
| MAP2-197 | 2012 West | W2263 | Deerfield | East Glen Brook | [east of East Glen Road, approximately 4225 feet upstream of the inlet of the Greenfield Reservoir, Leyden] | 42.67328 | -72.61264 |
| MAP2-199 | 2012 West | W2264 | Westfield | Munn Brook | [approximately 550 feet upstream of Loomis Street, Westfield] | 42.09977 | -72.80864 |
| MAP2-202 | 2012 West | W2265 | Hudson | Green River | [approximately 2750 feet upstream of the Eastlawn Cemetery access road, east of Water Street (Route 43), Williamstown] | 42.7029 | -73.2002 |
| MAP2-203 | 2012 West | W2266 | Housatonic | Beartown Brook | [approximately 1500 feet upstream of Meadow Street, Lee] | 42.27211 | -73.27398 |
| MAP2-204 | 2012 West | W2267 | Housatonic | Umpachene River | [east of New Marlborough-Southfield Road, approximately 4325 feet upstream of Norfolk Road, New Marlborough] | 42.1138 | -73.23231 |
| MAP2-205 | 2012 West | W2268 | Hudson | Hoosic River | [approximately 1625 feet upstream of Hodges Cross Road (Route 8A), North Adams] | 42.66113 | -73.10381 |
| MAP2-206 | 2012 West | W2269 | Westfield | Westfield River | [approximately 3675 feet downstream of the River Road crossing nearest Griffin Hill Road, Savoy] | 42.55161 | -73.01461 |
| MAP2-207 | 2012 West | W2270 | Westfield | Middle Branch Westfield River | [approximately 2000 feet upstream of Goss Hill Road, Huntington] | 42.26069 | -72.87868 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-209 | 2012 West | W2271 | Westfield | Webster Brook | [approximately 625 feet downstream of Main Road (Route 143), Chesterfield (approximately 625 feet upstream from the confluence with Page Brook)] | 42.38209 | -72.81255 |
| MAP2-210 | 2012 West | W2272 | Housatonic | Cone Brook | [east of Swamp Road, approximately 475 feet downstream from the Swamp Road crossing nearest Steven Glen Road, Richmond] | 42.35721 | -73.35414 |
| MAP2-211 | 2012 West | W2273 | Westfield | Westfield River | [approximately 2325 feet downstream of the Marine Corps League Highway (Route 9) crossing nearest Mougin Road, Cummington] | 42.45247 | -72.87827 |
| MAP2-212 | 2012 West | W2274 | Farmington | Thomas Brook | [approximately 1025 feet downstream of Werden Road, Otis] | 42.24539 | -73.11392 |
| MAP2-213 | 2012 West | W2275 | Deerfield | Hinsdale Brook | [approximately 3550 feet upstream of Green River Road, Shelburne (and approximately 700 feet downstream of the Stewart Brook confluence)] | 42.62827 | -72.64486 |
| MAP2-215 | 2012 West | W2276 | Westfield | Great Brook | [approximately 175 feet downstream of the Shaker Road crossing nearest the Kellog Brook confluence (which is approximately 600 feet downstream of station), Westfield] | 42.08622 | -72.72793 |
| MAP2-217 | 2012 West | W2277 | Deerfield | North River | [approximately 2725 feet upstream of the Main Road (Route 112) crossing nearest the Johnson Brook confluence (which is approximately 500 feet upstream of station), Colrain] | 42.63908 | -72.72437 |
| MAP2-218 | 2012 West | W2278 | Hudson | Hopper Brook | [approximately 6025 feet upstream of the Hopper Road crossing nearest Bressett Road, Williamstown] | 42.65789 | -73.20167 |
| MAP2-322 | 2013 Southeast | W2372 | Taunton | Mill River | [approximately 220 feet downstream/southeast from Route 44 (Winthrop Street), Taunton] | 41.90038 | -71.094 |
| MAP2-327 | 2013 Southeast | W2373 | Taunton | Wading River | [approximately 340 feet upstream/northwest from Route 123 (West Main Street), Norton] | 41.95255 | -71.22476 |
| MAP2-328 | 2013 Southeast | W2374 | Buzzards Bay | Doggett Brook | [approximately 2380 feet upstream/southwest from Route 105 (Marion Road/Front Street), Rochester/Marion] | 41.7279 | -70.79814 |
| MAP2-333 | 2013 Southeast | W2375 | Taunton | Satucket River | [approximately 1840 feet downstream/west from Washington Street, East Bridgewater] | 42.01847 | -70.92253 |
| MAP2-335 | 2013 Southeast | W2376 | Mount Hope Bay | Kickamuit River | [approximately 1630 feet upstream/east from Bushee Road, Swansea] | 41.7447 | -71.24826 |
| MAP2-339 | 2013 Southeast | W2377 | Taunton | Rumford River | [approximately 675 feet downstream/south from Cocasset Street, Foxborough] | 42.06113 | -71.21659 |
| MAP2-341 | 2013 Southeast | W2378 | Taunton | Salisbury Brook | [west of Carleton Street, just upstream/south of Ellsworth Street, Brockton] | 42.08257 | -71.03008 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-345 | 2013 Southeast | W2379 | Taunton | Puddingshear Brook | [approximately 335 feet downstream/southwest from Clayton Road, Middleborough] | 41.90744 | -70.97992 |
| MAP2-347 | 2013 Southeast | W2380 | Narragansett Bay | Palmer River | [approximately 830 feet upstream/east from Danforth Street, Rehoboth] | 41.84611 | -71.26255 |
| MAP2-349 | 2013 Southeast | W2381 | Taunton | Hockomock River | [at the West Bridgewater/Bridgewater border approximately 600 feet from the confluence with Town River] | 41.98837 | -71.03545 |
| MAP2-360 | 2013 Southeast | W2382 | Taunton | Fall Brook | [approximately 5220 feet upstream/south from Chace Road, Freetown] | 41.7557 | -70.98313 |
| MAP2-362 | 2013 Southeast | W0869 | Taunton | Poor Meadow Brook | [Main Street, Hanson] | 42.04239 | -70.89846 |
| MAP2-363 | 2013 Southeast | W2383 | Narragansett Bay | Clear Run Brook | [approximately 1750 feet downstream/southeast from Miller Street, Seekonk] | 41.80069 | -71.30434 |
| MAP2-365 | 2013 Southeast | W2384 | Taunton | Hockomock River | [approximately 770 feet downstream/west from Manley Street, West Bridgewater] | 42.01559 | -71.05266 |
| MAP2-366 | 2013 Southeast | W2385 | Boston Harbor | Pine Tree Brook | [approximately 500 feet upstream/south from Canton Avenue, Milton] | 42.24343 | -71.09438 |
| MAP2-373 | 2013 Southeast | W2386 | Taunton | Shumatuscacant River | [approximately 3200 feet upstream/northwest of Route 27 (Franklin Street), Whitman] | 42.06812 | -70.91424 |
| MAP2-379 | 2013 Southeast | W2387 | Mount Hope Bay | Cole River | [approximately 2200 feet upstream/east from Hortonville Road, Swansea] | 41.77731 | -71.19253 |
| MAP2-380 | 2013 Southeast | W2388 | Buzzards Bay | Mattapoisett River | [approximately 5250 feet upstream/north of Acushnet Road, Mattapoisett (approximately 350 feet upstream of confluence of unnamed tributary, outlet of Tinkham Pond)] | 41.67967 | -70.84083 |
| MAP2-381 | 2013 Southeast | W2389 | Taunton | Mill River | [approximately 2800 feet upstream/north of Route 140 (Washington Street), Taunton] | 41.90938 | -71.09812 |
| MAP2-384 | 2013 Southeast | W2391 | Cape Cod | Santuit River | [east of Route 130, approximately 1400 feet downstream/south of the outlet of Santuit Pond, Mashpee] | 41.64358 | -70.45337 |
| MAP2-385 | 2013 Southeast | W2392 | Cape Cod | Herring River | [approximately 1400 feet upstream/north of Route 6 (Mid Cape Highway), Harwich] | 41.70289 | -70.10478 |
| MAP2-391 | 2013 Southeast | W2393 | Taunton | Unnamed Tributary | [unnamed tributary to Canoe River, south of Interstate 495, approximately 430 feet downstream/southeast of Newcomb Street, Norton] | 41.9895 | -71.17372 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-396 | 2013 Southeast | W2394 | Buzzards Bay | Unnamed Tributary | [unnamed tributary to Bread and Cheese Brook approximately 75 feet downstream/east of Gifford Road, Westport] | 41.64181 | -71.07646 |
| MAP2-398 | 2013 Southeast | W2395 | Boston Harbor | Weir River | [approximately 110 feet upstream/south of Route 228 (East Street), Hingham] | 42.24223 | -70.85911 |
| MAP2-402 | 2013 Southeast | W2396 | Taunton | Nemasket River | [approximately 1500 feet downstream/north of Interstate 495, Middleborough] | 41.88142 | -70.90943 |
| MAP2-404 | 2013 Southeast | W2397 | Buzzards Bay | Mattapoisett River | [approximately 3350 feet upstream/north of New Bedford Road, Rochester] | 41.72741 | -70.85636 |
| MAP2-407 | 2013 Southeast | W2398 | Narragansett Bay | East Branch (Palmer River) | [approximately 1600 feet upstream/north from Williams Street, Rehoboth] | 41.86478 | -71.22919 |
| MAP2-410 | 2013 Southeast | W2399 | South Coastal | Pudding Brook | [approximately 175 feet upstream/north from Spring Street, Pembroke] | 42.08658 | -70.75695 |
| MAP2-413 | 2013 Southeast | W2400 | Taunton | Pine Swamp Brook | [approximately 1770 feet downstream/east from Route 138 (Broadway), Raynham] | 41.93252 | -71.07758 |
| MAP2-414 | 2013 Southeast | W2401 | Boston Harbor | Mill Brook | [approximately 45 feet downstream/east from Brattle Street, Arlington] | 42.4213 | -71.16909 |
| MAP2-423 | 2013 Southeast | W2402 | Taunton | Rumford River | [approximately 1450 feet upstream/north from the Route 140 ramp to Route 495 north bound, Mansfield] | 42.00503 | -71.21345 |
| MAP2-426 | 2013 Southeast | W2403 | Boston Harbor | Accord Brook | [approximately 2250 feet upstream/south from South Pleasant Street, Hingham] | 42.19948 | -70.86207 |
| MAP2-428 | 2013 Southeast | W2404 | Buzzards Bay | Paskamanset River | [approximately 2500 feet downstream/south from Route 6 (State Road), Dartmouth] | 41.63338 | -70.98602 |
| MAP2-429 | 2013 Southeast | W2405 | Taunton | Town River | [approximately 25 feet upstream/west from Hayward Street, Bridgewater] | 41.99746 | -70.95387 |
| MAP2-437 | 2013 Southeast | W2406 | Taunton | Salisbury Plain River | [approximately 1300 feet downstream/south from Grove Street, Brockton] | 42.07543 | -71.00964 |
| MAP2-439 | 2013 Southeast | W2407 | Taunton | Wading River | [approximately 1150 feet downstream/northeast from Route 140 (Taunton Avenue), Norton] | 41.94946 | -71.17553 |
| MAP2-443 | 2013 Southeast | W2408 | Narragansett Bay | Runnins River | [approximately 50 feet downstream/southwest from Arcade Avenue, Seekonk (upstream of unnamed tributary on northwestern bank)] | 41.83059 | -71.32994 |
| MAP2-486 | 2014 Midwest | W1579 | Connecticut | Mill River | [east of North Street, approximately 1000 feet upstream of the confluence of Esther Brook, Whately] | 42.45656 | -72.63699 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-488 | 2014 Midwest | W1717 | Chicopee | Ware River | [approximately 1400 feet downstream from Red Bridge/Hardwick roads, Hardwick/New Braintree] | 42.34007 | -72.15953 |
| MAP2-489 | 2014 Midwest | W1754 | Chicopee | Quaboag River | [south of Main Street (Route 67), approximately 1300 feet upstream from West Warren Mill Pond Dam (NAT ID: MA00902), Warren] | 42.21273 | -72.22876 |
| MAP2-492 | 2014 Midwest | W1757 | Chicopee | Hop Brook | [approximately 1500 feet upstream of inlet to Quabbin Reservoir, New Salem] | 42.46999 | -72.3226 |
| MAP2-496 | 2014 Midwest | W1778 | Connecticut | Fall River | [approximately 1800 feet upstream from eastern end of Factory Hollow Road, Greenfield (approximately 800 feet upstream of power lines)] | 42.62273 | -72.54971 |
| MAP2-499 | 2014 Midwest | W1805 | Connecticut | Unnamed Tributary | [unnamed tributary to Scarboro Pond, approximately 900 feet upstream/south of Gulf Road, Belchertown] | 42.34968 | -72.43137 |
| MAP2-500 | 2014 Midwest | W1828 | Chicopee | Unnamed Tributary | [unnamed tributary to East Branch Ware River approximately 2000 feet upstream of confluence, north of Cloverdale Lane, Rutland] | 42.40886 | -71.98179 |
| MAP2-501 | 2014 Midwest | W1880 | Connecticut | Scantic River | [approximately 2300 feet downstream/south of Mill Road, Hampden] | 42.04351 | -72.45648 |
| MAP2-502 | 2014 Midwest | W1883 | Connecticut | Cranberry Pond Brook | [approximately 1400 feet north from Reservation Road and the outlet of Cranberry Pond, Sunderland] | 42.50677 | -72.52708 |
| MAP2-503 | 2014 Midwest | W1887 | Connecticut | Unnamed Tributary | [unnamed tributary to North Branch Manhan River north of Pomeroy Meadow Road approximately 3200 feet upstream from confluence, Southampton] | 42.26361 | -72.70605 |
| MAP2-504 | 2014 Midwest | W1892 | Chicopee | Muddy Brook | [approximately 2200 feet upstream/north from Muddy Brook Road, Hardwick] | 42.36092 | -72.23011 |
| MAP2-506 | 2014 Midwest | W1900 | Chicopee | Roaring Brook | [approximately 800 feet upstream/west of Rockrimmon Street, Belchertown] | 42.2504 | -72.42654 |
| MAP2-508 | 2014 Midwest | W2324 | Chicopee | Unnamed Tributary | [unnamed tributary to Quabbin Reservoir, approximately 1200 feet upstream/east from Cooleyville Road (and approximately 500 feet downstream/northwest from Hunt Road), New Salem] | 42.44207 | -72.36869 |
| MAP2-509 | 2014 Midwest | W2350 | Chicopee | Chicopee Brook | [Route 32 crossing nearest Green Street, Monson] | 42.09324 | -72.31183 |
| MAP2-510 | 2014 Midwest | W1989 | Connecticut | Elmer Brook | [approximately 1400 feet downstream/south from Pearl Street, South Hadley] | 42.27963 | -72.58673 |
| MAP2-511 | 2014 Midwest | W2041 | Chicopee | Unnamed Tributary | [unnamed tributary to Turkey Hill Brook, approximately 170 feet downstream/west from Paxton Road, Spencer] | 42.27317 | -71.97499 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-513 | 2014 Midwest | W2081 | Connecticut | Unnamed Tributary | [unnamed tributary eventually to the Connecticut River, approximately 340 feet upstream/southeast from Bowles Fountain Road, Springfield] | 42.07983 | -72.56556 |
| MAP2-514 | 2014 Midwest | W2083 | Connecticut | West Branch Mill River | [approximately 1400 feet upstream from Old Goshen Road, Williamsburg] | 42.42258 | -72.76956 |
| MAP2-518 | 2014 Midwest | W2088 | Connecticut | Mountain Brook | [approximately 1200 feet downstream from Shutesbury Road, Leverett] | 42.44432 | -72.48988 |
| MAP2-519 | 2014 Midwest | W2163 | Connecticut | North Branch Manhan River | [approximately 2500 feet downstream from Loudville Road, Easthampton] | 42.28135 | -72.7294 |
| MAP2-520 | 2014 Midwest | W2164 | Chicopee | Ware River | [approximately 2250 feet upstream from Palmer Road (Route 32), Ware] | 42.23546 | -72.27899 |
| MAP2-521 | 2014 Midwest | W2165 | Chicopee | Quaboag River | [approximately 5550 feet upstream from Old West Brookfield Road, Warren (approximately 500 feet downstream from the confluence of Sullivan Brook)] | 42.22338 | -72.17965 |
| MAP2-523 | 2014 Midwest | W2166 | Chicopee | Coys Brook | [approximately 900 feet upstream from Tucker Road, North Brookfield] | 42.26215 | -72.1066 |
| MAP2-526 | 2014 Midwest | W2219 | Connecticut | Broad Brook | [west of Holyoke Road (Route 141), approximately 2300 feet upstream from mouth at inlet of Nashawannuck Pond, East Hampton] | 42.25021 | -72.65893 |
| MAP2-530 | 2014 Midwest | W2279 | Connecticut | Unnamed Tributary | [unnamed tributary to the Connecticut River, approximately 450 feet downstream from McClellan Farm Road, Deerfield] | 42.55507 | -72.55826 |
| MAP2-533 | 2014 Midwest | W2290 | Connecticut | Unnamed Tributary | [unnamed tributary to Watchaug Brook, approximately 2400 feet downstream from Pease Road, East Longmeadow] | 42.04079 | -72.4849 |
| MAP2-534 | 2014 Midwest | W2453 | Connecticut | Pond Brook | [approximately 675 feet downstream from Lake Pleasant Road, Montague] | 42.55287 | -72.5195 |
| MAP2-538 | 2014 Midwest | W2454 | Connecticut | Unnamed Tributary | [unnamed tributary to Fort River approximately 850 feet upstream from Moody Bridge Road, Hadley] | 42.33802 | -72.55537 |
| MAP2-539 | 2014 Midwest | W2455 | Chicopee | Unnamed Tributary | [unnamed tributary to Perry Pond approximately 5200 feet upstream from Old East Brookfield Road, North Brookfield] | 42.25263 | -72.05643 |
| MAP2-540 | 2014 Midwest | W2456 | Chicopee | West Branch Fever Brook | [approximately 2000 feet upstream of road crossing of the restricted portion of Monson Turnpike, Petersham] | 42.47217 | -72.2568 |
| MAP2-541 | 2014 Midwest | W2457 | Chicopee | Vinica Brook | [approximately 5000 feet upstream from Moulton Hill Road, Monson] | 42.05933 | -72.2716 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-545 | 2014 Midwest | W2458 | Connecticut | Unnamed Tributary | [unnamed tributary coming from and draining to the state of Connecticut, approximately 300 feet upstream from South West Street, Agawam] | 42.0373 | -72.69991 |
| MAP2-546 | 2014 Midwest | W2459 | Chicopee | Unnamed Tributary | [unnamed tributary to the Cranberry River, approximately 300 feet upstream from Cranberry Meadow Road, Spencer] | 42.20362 | -72.00427 |
| MAP2-547 | 2014 Midwest | W2460 | Connecticut | Tucker Brook | [east of Sampson Road, Huntington approximately 2.2 miles from the mouth at the inlet of Tighe Carmody Reservoir, Southampton] | 42.26076 | -72.81804 |
| MAP2-550 | 2014 Midwest | W2461 | Connecticut | Long Plain Brook | [west of Route 63, approximately 2.5 miles upstream/north of Blue Hill Road, Leverett] | 42.47654 | -72.5186 |
| MAP2-552 | 2014 Midwest | W2462 | Chicopee | Purgee Brook | [approximately 200 feet upstream of confluence with Quabbin Reservoir, Pelham] | 42.38733 | -72.37351 |
| MAP2-558 | 2014 Midwest | W2463 | Connecticut | Bachelor Brook | [west of Route 47, approximately 1300 feet upstream of confluence with Connecticut River, South Hadley] | 42.27003 | -72.59421 |
| MAP2-642 | 2015 Northeast | W2506 | Ipswich | Ipswich River | [approximately 200 feet downstream/north of Peabody Street, Middleton] | 42.61693 | -70.99641 |
| MAP2-646 | 2015 Northeast | W2507 | Concord | River Meadow Brook | [approximately 1400 feet upstream/south of Turnpike Road, Chelmsford] | 42.59436 | -71.34067 |
| MAP2-651 | 2015 Northeast | W2508 | Concord | Cold Spring Brook | [approximately 340 feet upstream/south of Clinton Street, Hopkinton] | 42.22478 | -71.47767 |
| MAP2-652 | 2015 Northeast | W2509 | Charles | Charles River | [approximately 1000 feet upstream/south of Route 495, Bellingham] | 42.10498 | -71.4584 |
| MAP2-654 | 2015 Northeast | W2510 | Merrimack | Beaver Brook | [approximately 4800 feet downstream/south of Lakeview Avenue, Dracut] | 42.67184 | -71.34445 |
| MAP2-655 | 2015 Northeast | W2511 | Concord | Assabet Brook | [west of White Pond Road, Stow approximately 4200 feet upstream of mouth at confluence with Assabet River, Stow] | 42.42764 | -71.48545 |
| MAP2-657 | 2015 Northeast | W2512 | Merrimack | Powwow River | [approximately 7200 feet upstream of Newton Road, Amesbury] | 42.86593 | -70.96159 |
| MAP2-660 | 2015 Northeast | W2513 | Concord | Whitehall Brook | [approximately 3500 feet upstream/east of Fruit Street, Hopkinton] | 42.25321 | -71.56727 |
| MAP2-663 | 2015 Northeast | W2514 | Charles | Hurd Brook | [approximately 800 feet downstream/east of Webster Street, Needham] | 42.30494 | -71.23383 |
| MAP2-665 | 2015 Northeast | W2515 | Ipswich | Ipswich River | [approximately 2500 feet downstream/north of Route 114, Middleton/Danvers] | 42.57903 | -70.99154 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-670 | 2015 Northeast | W2516 | Merrimack | Stony Brook | [approximately 450 feet upstream/south of Route 3, Chelmsford] | 42.62539 | -71.38909 |
| MAP2-673 | 2015 Northeast | W2517 | Parker | Jackman Brook | [approximately 1200 feet upstream/south of Jackman Street, Georgetown] | 42.73504 | -70.94273 |
| MAP2-675 | 2015 Northeast | W2518 | Charles | Beaver Brook | [approximately 160 feet downstream/south of Trapelo Road, Waltham/Belmont] | 42.3901 | -71.19672 |
| MAP2-677 | 2015 Northeast | W2519 | North Coastal | Saugus River | [approximately 1600 feet downstream/south of Route 129, Saugus] | 42.49581 | -71.03874 |
| MAP2-680 | 2015 Northeast | W2520 | Concord | Broad Meadow Brook | [approximately 680 feet downstream/south of Route 20, Marlborough] | 42.3477 | -71.51794 |
| MAP2-681 | 2015 Northeast | W2521 | Ipswich | Fish Brook | [approximately 550 feet downstream/south of River Road/Fuller Lane, Topsfield/Boxford] | 42.63392 | -70.97474 |
| MAP2-682 | 2015 Northeast | W2522 | Shawsheen | Vine Brook | [just downstream/west of the Route 62 eastbound ramp to Route 3 northbound, Bedford] | 42.50179 | -71.24072 |
| MAP2-685 | 2015 Northeast | W2523 | Shawsheen | Shawsheen River | [approximately 1300 feet downstream/west of Route 495 crossing nearest the Massachusetts Avenue ramp to Route 495 southbound, Lawrence] | 42.69712 | -71.144 |
| MAP2-692 | 2015 Northeast | W2525 | Concord | Great Brook | [Route 117 crossing nearest the Meadow Road intersection, Bolton] | 42.4357 | -71.57041 |
| MAP2-693 | 2015 Northeast | W2526 | Ipswich | Ipswich River | [approximately 175 feet downstream/east of Chestnut Street, North Reading] | 42.57183 | -71.09625 |
| MAP2-694 | 2015 Northeast | W2527 | Concord | Nashoba Brook | [approximately 4000 feet upstream/west of Main Street (Route 27), Acton] | 42.52678 | -71.41342 |
| MAP2-696 | 2015 Northeast | W2528 | Concord | Unnamed Tributary | [unnamed tributary to Hop Brook, approximately 875 feet downstream/north of Main Boulevard, Shrewsbury] | 42.29107 | -71.68853 |
| MAP2-698 | 2015 Northeast | W2529 | Merrimack | Cow Pond Brook | [approximately 1200 feet downstream/north of Bridge Street, Groton] | 42.62973 | -71.50616 |
| MAP2-700 | 2015 Northeast | W2530 | Charles | Mill River | [approximately 250 feet upstream/south of Miller Street, Norfolk] | 42.12177 | -71.36544 |
| MAP2-703 | 2015 Northeast | W2531 | Concord | Hop Brook | [east of Otis Street, Northborough approximately 2900 feet upstream of mouth at confluence with Assabet River, Northborough] | 42.28713 | -71.65129 |
| MAP2-705 | 2015 Northeast | W2532 | Merrimack | Cobbler Brook | [approximately 100 feet upstream/north of River Road, Merrimac] | 42.82611 | -70.98401 |

| Site ID Google Maps | Year Stratum | Unique ID | Watershed | Water Body | Station Description | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MAP2-707 | 2015 Northeast | W2533 | Merrimack | Beaver Brook | [approximately 50 feet downstream/east of Park Avenue, Dracut] | 42.66818 | -71.32634 |
| MAP2-710 | 2015 Northeast | W2534 | Merrimack | Stony Brook | [approximately 5000 feet upstream/west of Depot Street, Westford] | 42.59759 | -71.44757 |
| MAP2-715 | 2015 Northeast | W2536 | Concord | Unnamed Tributary | [unnamed tributary to Sudbury River locally known as 'Cochituate Brook', approximately 800 feet upstream of School Street (Route 126), Framingham] | 42.31932 | -71.39558 |
| MAP2-716 | 2015 Northeast | W2537 | Charles | Bogastow Brook | [approximately 800 feet downstream/north of Orchard Street, Millis] | 42.18702 | -71.37582 |
| MAP2-717 | 2015 Northeast | W2538 | Shawsheen | Shawsheen River | [approximately 1900 feet upstream/north of Central Street, Andover] | 42.65219 | -71.15097 |
| MAP2-718 | 2015 Northeast | W2539 | Merrimack | Stony Brook | [approximately 200 feet upstream/west of Brookside Road, Westford] | 42.60918 | -71.41168 |

# Appendix D. Summary of CALM Assessment Methodologies, Data Evaluation Procedures, and Criteria

This appendix is a summary of the assessment methodologies, data evaluation procedures, and criteria within the *Massachusetts Consolidated Assessment and Listing Methodology (CALM) Guidance Manual 2018* (MassDEP 2018) that were used to evaluate applicable MAP2 indicator data. The CALM describes the data evaluation procedures and criteria used to assess water quality conditions of surface waters in the state.

## pH

MAP2 pH data were assessed by comparing pH measurements to the SWQS criteria range for pH (6.5 – 8.3 and Δ0.5 outside the natural background range). The magnitude (i.e., >0.5 SU outside the criteria range), and frequency of any excursions (e.g., non-consecutive vs. consecutive low or high pH measurements) from the pH criteria range were used to assess the pH data. If all pH measurements were within the criteria range, pH was determined to meet the CALM assessment criteria. If two or more measurements (>10%) were outside the criteria range, pH was determined to violate CALM assessment criteria. One pH measurement outside of the criteria range was determined to violate the CALM assessment criteria if the excursion was severe (>0.5 SU). Natural conditions (e.g., wetlands dominated sampling area, geology) can create acidic conditions outside the pH criteria range. However, clear guidance on determining if pH violations can be attributed to natural conditions has not been developed for the CALM. Natural conditions were not considered in the assessment of the MAP2 pH data.

## Nutrient Enrichment

MAP2 sites were assessed for nutrient enrichment using <u>*multiple*</u> supporting indicators as potential evidence. Biological indicators of nutrient enrichment (one or more of which is documented as problematic), includes the presence of nuisance growths of primary producers. Secondly, indications of high primary productivity are often observed as changes to certain physicochemical analytes, as well. Taken together, these biological and physicochemical indicators were utilized for assessing nutrient enrichment. The more combinations of these indicators documented, the stronger the case for nutrient enrichment. It should be noted here that while total phosphorus or nitrogen concentration data alone were not currently utilized to assess nutrient enrichment, they were used to corroborate indicator data. Indicators and the guidance thresholds used as evidence in the nutrient enrichment assessment include:

- Filamentous or film algal cover (>40%)
- diel changes in dissolved oxygen (Δ >3 mg/l)
- dissolved oxygen saturation (> 125%)
- pH (>8.3 SU)
- average total phosphorus (>0.1 mg/l flowing waters, >0.05 mg/l for rivers entering a lake/reservoir)

If a <u>*combination*</u> of the indicators exceeded guidance thresholds and strongly suggested high primary productivity, the nutrient enrichment indicators were determined to violate the CALM assessment criteria. If none or only one of the indicators exceeded the guidance thresholds, the nutrient enrichment indicators were determined to meet the CALM assessment criteria.

## Cold Water Determination

The definition of "Cold Water Fishery" in the SWQS is *"Waters in which the mean of the maximum daily temperature over a seven day period generally does not exceed 68°F (20°C) and, when other ecological factors are favorable (such as habitat), are capable of supporting a year-round population of cold water stenothermal aquatic life such as trout (Salmonidae)"* (MassDEP 2013). While many cold water streams are designated as Cold Water (CWF) in the SWQS, it is recognized that many other cold water rivers and streams in the state are not officially designated in the SWQS. However, these streams are protected under the "Existing Use" clause in the SWQS. These streams, identified by the Massachusetts Department of Fish and Game's (MA DFG) Division of Fisheries and Wildlife as Cold Water Fishery Resources (CFRs), are identified as having an "Existing Use" which also merits protection. It was determined that two subcategories of the "Existing Use" would be needed to protect all fish classified as cold water fish by the MA DFG. An evaluation of thermal tolerances of different cold water fish resulted in the development of two cold water "Existing Use" categories: Tier 1 and Tier 2 (see detail below).

**Tier 1 Cold Water Existing Use:** These are waters that have contained at least two fish of either of the following two species and size ranges: *Salvelinus fontinalis* (eastern brook trout or EBT) less than or equal to 140 mm (~5.5"), and/or *Cottus cognatus* (slimy sculpin or SC) of any size during a single sampling event (defined as sampling that took place over a single day) during the months of June through October after November 28, 1975. Larger EBT may also qualify in establishing an Existing Tier 1 use if stocking records indicate that the fish (minimum of 2 fish) were not stocked or did not likely come from a stocked waterbody. Both brook trout and slimy sculpin require clean, cold water habitat.

**Tier 2 Cold Water Existing Use:** These are waters that have been shown (via sampling) to contain at least two fish from any combination of the following categories and size ranges: brook trout, brown trout, rainbow trout and tiger trout less than or equal to 140mm; landlocked salmon less than or equal to 200mm; and any size range of the following fish species: American brook lamprey, Atlantic salmon, lake chub, lake trout, longnose sucker, and slimy sculpin. These species also require clean, cold water habitat, however, the thermal tolerances of all the species (exclusive of brook trout and slimy sculpin) are slightly higher than those listed in Tier 1.

In addition, as a rebuttable presumption, it was assumed that any tributary, perennial or intermittent, entering a Tier 1 or Tier 2 segment upstream of the point where the fish sample used to identify a particular cold water fishery "Existing Use" was collected, is of the same Tier as the water into which it flows.

## Temperature

The guidelines in the CALM for evaluating the temperature data are based on SWQS as well as MassDEP-derived criteria (based on toxicity formulae provided in EPA, 1977 Temperature Criteria for Freshwater Fish: Protocol and Procedures (EPA600/3-77-061), and information from other published and unpublished data sources) for sentinel fish species.

**Evaluating Cold Water streams:** MAP2 continuous temperature data measured in waters designated as Cold Water Fisheries (CWF) in the Massachusetts SWQS and unlisted waters for which Tier 1 or Tier 2 Cold Water Existing Uses have been determined, were evaluated using the appropriate Cold Water criteria based on designated and existing uses. MAP2 continuous temperature data collected during the summer index period (June through September) were assessed by comparing calculated statistics from available long-term datasets to the SWQS chronic criterion (7-day rolling average of the daily maximum temperatures or 7-DADM) or the MassDEP-derived acute criteria (Maximum 24-hour average) and chronic criterion (7-day rolling average of the daily average temperatures or 7-DADA) (Table 1).

**Evaluating Warm Water streams:** MAP2 continuous temperature data measured in designated Warm Water Fisheries (WWF) and other unlisted waters not identified as having a Tier 1 or Tier 2 existing use, were evaluated using the appropriate Warm Water criteria. MAP2 continuous temperature data collected during the summer index period (June through September) were assessed by comparing calculated statistics from available long-term datasets to the MassDEP-derived chronic criterion (7-DADM) and acute criterion (Maximum 24-hour average) (Table 1).

An allowed exceedance (~10%) of the chronic criterion has been calculated as up to 11 times within the June 1st through September 15th index period. This allowed exceedance is considered to be a reflection of the term "generally" in the definition of a Cold Water Fishery in the SWQS ("mean of the maximum daily temperature over a seven day period generally does not exceed…") (MassDEP 2013). No exceedances of the 24-hour average (acute) criteria provided below were allowed.

If all temperature data statistics and/or minima met (i.e., are below) all relevant criteria, temperature was determined to meet CALM assessment criteria. When the criteria were violated, it was first determined if the violations could be attributed to natural conditions. (see Natural Condition Guidance section). If violations of the criteria could not be attributed to natural conditions, temperature was determined to violate CALM assessment criteria.

**Table 1.** Relevant CALM temperature criteria used to evaluate MAP2 continuous temperature data (NA = Not Applicable).

| | Cold Water Criteria (°C) | | | Warm Water Criteria (°C) | |
|---|---|---|---|---|---|
| **Criterion Statistic** | **Designated Cold Water** | **Tier 1 Existing Use** | **Tier 2 Existing Use** | **Designated Warm Water** | **Unlisted Class B** |
| 7-Day Average of Daily Maximum [1] | 20.0 | 20.0 | NA | 27.7 | 27.7 |
| 7-Day Average of Daily Average [1] | NA | NA | 21.0 | NA | NA |
| Maximum 24-hour Average [2] | 23.5 | 23.5 | 24.1 | 28.3 | 28.3 |

[1] Chronic criteria with an allowed 10% exceedance.
[2] Acute criteria with no allowed exceedance.

## Dissolved Oxygen

National criteria for dissolved oxygen (DO) in freshwater (EPA 1986 and 1988) were derived using biological production impairment estimates to protect survival and growth of aquatic life below which detrimental effects are expected. The national criteria accommodate an exposure concept (frequency, magnitude and duration of condition). The national criteria daily minima (1.0 mg/l less than the 7-day mean) were set to protect against acute mortality of sensitive species and they were also designed to prevent significant episodes of continuous or

regularly recurring exposures to dissolved oxygen at or near the lethal threshold. The 1986 EPA national DO criteria for freshwater aquatic life were used as the basis for the CALM and assessing MAP2 continuous DO data, since both frequency and duration were incorporated into the EPA criterion document.
MAP2 continuous DO data were assessed by comparing calculated statistics from the available long-term or short-term DO datasets to the appropriate EPA national dissolved oxygen criteria according to the timing (e.g., presence or absence of early life stages of fish) and frequency of data measurements as well as the water's designated or existing use (Table 2). Continuous DO was measured at MAP2 sites using multiple short-term (4 -5 days) probe deployments from 2011 – 2013 and one single long-term (several months) deployment from 2014 – 2015. Since there was generally minimal variation within the daily DO patterns during the 4-5 day deployments at a given site, any 4-5 day DO sonde deployments were compared against both the 7-day mean and mean minimum criteria.

If all DO data statistics and/or minima met (i.e., are above) all relevant criteria, DO was determined to meet CALM assessment criteria. When the criteria were violated, it was first determined if the violations could be attributed to natural conditions. (see Natural Condition Guidance section). If violations of the criteria could not be attributed to natural conditions, DO was determined to violate CALM assessment criteria.

**Table 2.** Relevant CALM dissolved oxygen criteria used to evaluate MAP2 continuous dissolved oxygen data (NA = Not Applicable).

| | Cold Water Criteria (mg/l) [6] | Warm Water Criteria (mg/l) | | DO Measurement Types |
|---|---|---|---|---|
| **Criterion Statistic** | **Other Life Stages** | **Early Life Stages [1]** | **Other Life Stages** | **Long-term continuous (LC) Short-term continuous (SC)** |
| 30-Day Mean | 8.0 | NA | 6.0 | LC [4] |
| 7-Day Mean [2] | NA | 6.5 | NA | LC, SC [4,5] |
| 7-Day Mean Minimum [2] | 6.0 | NA | 5.0 | LC, SC [4,5] |
| 1-Day Minimum [3] | 5.0 | 5.0 | 4.0 | LC, SC |

[1] anadromous fish runs present (assume present through July in MA coastal streams)
[2] Continuous monitoring data from sondes deployed between 4 to 5 days will also be utilized to evaluate the 7-day mean statistics.
[3] All minima are considered instantaneous concentrations to always be met.
[4] Exclude the first day of the deployment if it does not contain pre-dawn measurements.
[5] A minimum of three continuous (not necessarily consecutive) days with pre-dawn measurements required.
[6] Table does not include *early life stage* cold-water criteria since these life stages of cold water species in Massachusetts do not occur during the summer sampling period.

## Toxic Pollutants

Pollutants, such as metals, ammonia, and chloride are considered toxic to humans, wildlife, and aquatic life when concentrations exceed criteria in the Massachusetts SWQS. The SWQS require that EPA's 2002 National Recommended Water Quality Criteria (NRWQC, EPA-822-R-02-047 or referred to here as EPA's 2002 Criteria) be applied for those pollutants that do not have listed criteria within the SWQS (MassDEP 2013). However, the statement that "all surface water shall be free from pollutants...that are toxic to…aquatic life or wildlife" allows flexibility in applying EPA criteria recommendations issued after 2002 when evaluating any toxic pollutant.

Therefore, the MAP2 water quality data for toxic pollutants (metals, ammonia, and chloride) were compared to their respective aquatic life water quality criteria as of August 2014 as described below (EPA 2014 available at https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table). In general, the EPA recommends both acute (typically expressed as one-hour averages) and chronic (typically expressed as four-day averages) criteria to protect against short- and long-term effects.

MAP2 toxic pollutant (metals, ammonia and chloride) data were evaluated against their respective criterion maximum concentration (CMC or acute criterion) and criterion continuous concentration (CCC or chronic criterion). Ratios of the toxic pollutant concentrations measured in the water column against their respective acute and chronic criteria values (referred to as a "Toxic Unit" or TU calculation) were calculated for samples collected at the MAP2 sites. When the TU is greater than 1.0 the toxicant concentration exceeds its criterion. MAP2 water quality samples for toxicants (metals, ammonia and chloride) were collected using a grab sample technique at 3 (metals) or 5 (ammonia and chloride) independent sampling events. A single grab is representative of an acute exposure period and its pollutant concentrations are therefore compared directly against acute criteria. Multiple independent grab samples are needed to evaluate whether multiple chronic criterion exceedances have occurred during the sampling.

***Metals***

Evaluation of MAP2 metals data was conducted according to the TU method described above. The MAP2 metals data included the dissolved fraction of cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni), silver (Ag), zinc (Zn), Arsenic (As), and Selenium (Se). The acute and chronic criteria for metals with hardness-based criteria (Cd, Cr, Cu, Pb, Ni, Ag, Zn) were calculated using instream hardness (calculated from calcium and magnesium concentration data) values. Metals with criteria expressed as total recoverable concentrations (As and Se) were converted into dissolved criteria using the appropriate conversion factors. It should be noted that the recently developed biotic ligand model for copper was not used to evaluate MAP2 data due to missing analyte components.

If all the metals data met the acute criteria and there were no more than two exceedances of the chronic criteria, metals were determined to meet the CALM assessment criteria. If any metals data exceeded the acute criteria or there were more than two exceedances of the chronic criteria, metals were determined to violate the CALM assessment criteria.

***Ammonia***

According to the EPA (2013) the freshwater acute and chronic criteria for ammonia are dependent on pH and temperature. At lower temperatures (<15.7 °C) the recommended acute criterion is also dependent on the presence or absence of the Genus *Oncorhynchus* (rainbow trout). Since the ammonia criterion is a function of pH and temperature, acute and chronic criteria were calculated using the highest pH and temperature measurements taken at each MAP2 site during the surveys to determine the most conservative acute and chronic ammonia criteria. The concentration data were then compared to these conservative ammonia criteria values. When exceedances of the conservative criteria were found, sample-specific acute and chronic criteria were calculated using pH and temperature measurements at the time of sample collection and the concentration data were compared to these criteria.

If all the ammonia data met the acute criteria and there were no more than two exceedances of the chronic criteria, ammonia was determined to meet the CALM assessment criteria. If any ammonia data exceeded the acute criteria or there were more than two exceedances of the chronic criteria, ammonia was determined to violate the CALM assessment criteria.

***Chloride***

While chloride occurs naturally in aquatic environments, elevated levels of chloride often result from anthropogenic sources. Road deicing salts, urban and agricultural runoff, discharges from municipal wastewater and industrial plants, and drilling of oil and gas wells are the major anthropogenic sources of chloride. The EPA-recommended acute criterion for chloride is 860 mg/L and the chronic criterion is 230 mg/L.

If all the chloride data met the acute criteria and there were no more than two exceedances of the chronic criteria, chloride was determined to meet the CALM assessment criteria. If any chloride data exceeded the acute criteria or there were more than two exceedances of the chronic criteria, chloride was determined to violate the CALM assessment criteria.

## Evaluation Methods for Natural Conditions (Temperature and Dissolved Oxygen)

***Temperature***

Violations of temperature criteria will NOT be considered natural under the following circumstances:

1. Determine which temperature criteria were violated, the warm water or cold water. If the warm water criteria were violated, the temperature violations will not be considered natural.
2. Determine the general nature of the temperature criteria violations. If the violation is the result of isolated spike(s), the temperature violations will not be considered natural.
3. Delineate a complete watershed, proximal (5 km) watershed, and proximal (5 km) 100 m stream buffer (Figure 1) on either side for the site and calculate the percent of natural land, and impervious cover within those delineations (Schiff and Benoit 2007). If the percentages fail to meet the criteria outlined in Table 3, the temperature violations will not be considered natural.
4. Determine the presence of dams upstream of the site and in its contributing watershed and their potential to be the source of the observed temperature criteria violations. If they cannot be reasonably eliminated as the source of the violations, the temperature violations will not be considered natural.
5. Determine the presence of point source discharges (wastewater treatment plants (WWTP), non-contact cooling water, stormwater, etc.) and/or water withdrawals upstream of the site and in its contributing watershed and their potential to be the source of the observed temperature criteria violations. If they cannot be reasonably eliminated as the source of the violations, the temperature violations will not be considered natural.
6. Determine the presence of any localized human disturbances within the riparian area of the site from recorded field sheet observations and GIS. If the present localized human disturbances cannot be reasonably eliminated as the source of the violations, the temperature violations will not be considered natural.
7. Determine if there are any other potential sources of the temperature violations not considered above. If there are any other potential sources, the temperature violations will be not be considered natural.

**If not screened out in any of the above steps, the temperature violations will be considered natural.**

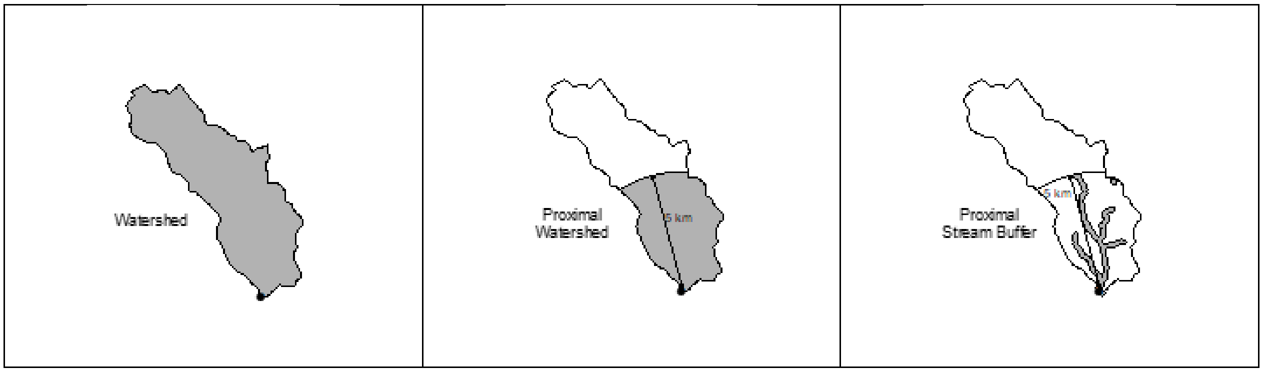


**Figure 1.** Illustration of the different spatial scales used to evaluate the landscape criteria (grey shaded area clips used in calculations).

**Table 3.** Landscape criteria used to evaluate thermal excursions

| Land Cover | Complete and Proximal Watersheds | Complete[2] or Proximal Stream Buffer |
|---|---|---|
| Natural Land[1] | >80% | >90%[3] |
| Impervious Cover | <4% | <2% |

[1]Includes forest, brushland/successional, wetland, and water.
[2]Watersheds <25 $mi^2$
[3]This is best professional judgment of DWM-WPP biologists

***Dissolved Oxygen (DO)***

Violations of the DO criteria may be due to natural conditions, especially in areas where wetlands contribute low DO water to the stream. A study relating natural wetlands and predawn dissolved oxygen in Massachusetts streams reported that wetland areas exceeding 4 percent of the subwatershed within a mile of the sample site was related to a marked drop to 60% dissolved oxygen saturation (Mattson et al., 2007). The study recommended a limit of 7 percent proximal wetland area as a threshold for natural conditions to meet the state's water quality standards. Furthermore, the cause and effect are likely confounded by the co-correlation between impervious cover and stream slope (Waite et al., 2006) where the cause of the low dissolved oxygen may be due to the low gradient hydrologic setting.

Violations of DO criteria will NOT be considered natural under the following circumstances:

1. Determine the general nature of the DO criteria violations. If the violation is the result of isolated spike(s), the DO violations will not be considered natural.
2. Determine the diurnal shift in DO concentration. If the diurnal shift is ever greater than 3mg/l, the DO violations will not be considered natural.
3. Delineate a complete watershed, proximal (5 km) watershed, 100 m stream buffer on both sides including both the intermittent and perennial streams, and proximal (5 km) 100 m stream buffer (Figure 1) on both sides for the site and calculate the percent of natural land, and wetland within those delineations. If the percentages fail to meet the criteria outlined in Table D2, the DO violations will not be considered natural.
4. Determine the presence of dams upstream of the site and their potential to be the source of the observed DO criteria violations. If the present dams cannot be reasonably eliminated as the source of the violations, the DO violations will not be considered natural.

5. Determine the presence of point sources (wastewater treatment plants (WWTP), non-contact cooling water, stormwater, etc.) and water withdrawals upstream of the site and their potential to be the source of the observed DO criteria violations. If the present point sources cannot be reasonably eliminated as the source of the violations, the DO violations will not be considered natural.
6. Determine the presence of any localized human disturbances within the riparian area of the site from fieldsheets and GIS. If the present localized human disturbances cannot be reasonably eliminated as the source of the violations, the DO violations will not be considered natural.
7. Determine if there are any other potential sources of the DO violations not considered above (e.g., spill). If there are any other potential sources, the DO violations will be not be considered natural.

**If not screened out in any of the above steps the DO violations will be considered natural.**

**Table 4**. Landscape criteria used to evaluate DO excursions.

| Land Cover | Complete Watershed | Proximal Watershed | Complete[2] or Proximal Stream Buffer |
|---|---|---|---|
| Natural Land[1] | >80% | >80% | >90%[3] |
| Wetland | NA | >7% | NA |

[1]Includes forest, brushland/successional, wetland, and water.
[2]Watersheds <25 $mi^2$
[3]This is best professional judgment of DWM-WPP biologists

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# Appendix E. Assessment Methodology for Biological and Habitat Indicators

## Macroinvertebrate Community

The MAP2 (2011 – 2015) and Reference Site Network (RSN) (2011 – 2017) macroinvertebrate community samples were scored using three different indices of biotic integrity depending on the geographic location of the sampling site. In 2019, Tetra Tech, under contract with MassDEP, developed indices of biotic integrity (IBI) or biocriteria for macroinvertebrate assemblages in two regions of the state, the Central Hills (CH) and Western Highlands (WH) (Figure 1) (Jessup and Stamp 2019). In addition, all the MAP2 and RSN sites used in this analysis were assigned a human disturbance class using the method outlined in IBI development process to identify reference and highly stressed sites from both datasets (Jessup and Stamp 2019).

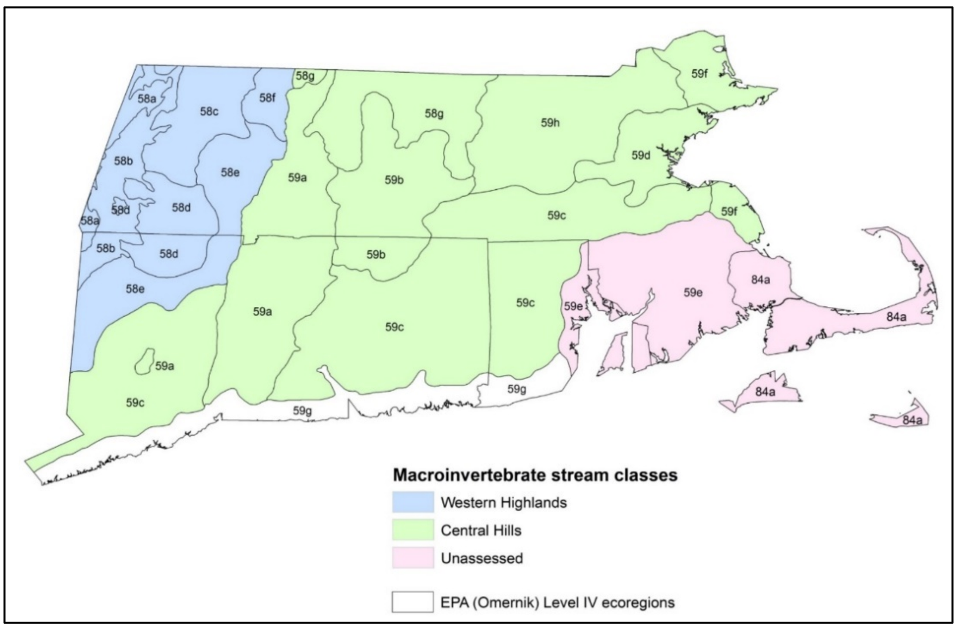


**Figure 1.** Massachusetts site classifications (Jessup and Stamp 2019).

The macroinvertebrate assemblages at the MAP2 and RSN sites in those two regions were scored according to the corresponding index, CHIBI or WHIBI (Table 1 & 2).

**Table 1.** Macroinvertebrate IBI for the Central Hills (CHIBI) (Jessup and Stamp 2019).

| Metric | Category | Scoring formula |
|---|---|---|
| Total Taxa | Richness | 100*(metric-11)/ 23.9 |
| Percent EPT Taxa | Richness | 100*(metric-10.6)/ 43.9 |
| Percent Ephemeroptera Individuals (excluding Families Caenidae and Baetidae) | Composition | 100*(metric)/ 13.9 |
| Percent Collector-Filterer (CF) Individuals | Feeding Group | 100*(79.9-metric)/ 66.9 |
| Percent Predator (PR) Taxa | Feeding Group | 100*(metric)/ 28.5 |
| Percent Intolerant Taxa (tolerance value ≤ 3) | Tolerance | 100*(metric)/ 39.1 |
| | **CHIBI Score** | **Average (metric score)** |

**Table 2.** Macroinvertebrate IBI for the Western Highlands (WHIBI) (Jessup and Stamp 2019)

| Metric | Category | Scoring formula |
|---|---|---|
| Total Taxa | Richness | 100*(metric-21)/ 17.8 |
| Percent Plecoptera Individuals | Composition | 100*(metric)/ 18.3 |
| Percent Collector-Filterer (CF) Individuals | Feeding Group | 100*(50.5-metric)/ 40.7 |
| Percent Shredder (SH) Individuals | Feeding Group | 100*(metric-1.17)/ 21.8 |
| Percent Intolerant Individuals (tolerance value ≤ 3) | Tolerance | 100*(metric-6.09)/ 45.4 |
| Becks Biotic Index* | Tolerance | 100*(metric-12)/ 24.8 |
| | **WHIBI Score** | **Average (metric score)** |

Macroinvertebrate assemblages were collected from the MAP2 and RSN sites using two sampling methologies, single habitat (riffle) and multi-habitat. The single habitat (riffle) method was used at sites with sufficient riffle habitat while the multi-habitat method was used at sites lacking sufficient riffle habitat (MassDEP 2003). Both the CHIBI and WHIBI were calibrated and verified using only sites sampled with the single habitat (riffle) method so their application to MAP2 and RSN sites sampled with the multihabitat method imparts a level of additional uncertainty (Jessup and Stamp 2019). However, the CHIBI scores for reference sites and sites highly stressed by human disturbance in the MAP2 and RSN datasets are similar regardless of sampling methodology (Figure 2). Based on this analyis, it was determined that the CHIBI and WHIBI are the best alternative for any MAP2 sites sampled with the multi-habitat methodology.

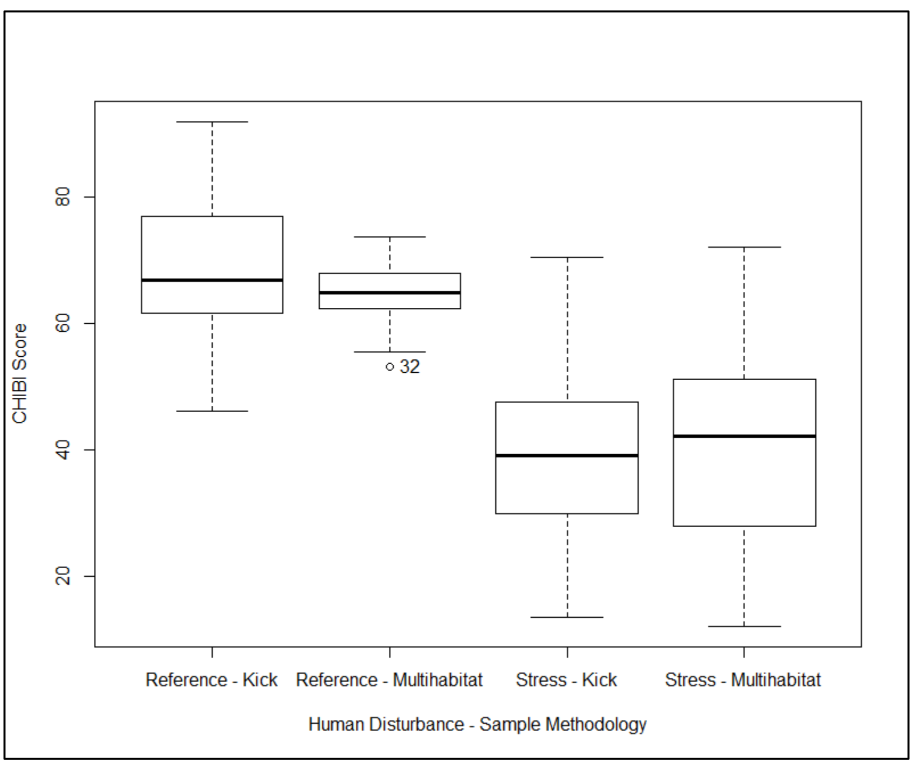


**Figure 2.** Boxplot of CHIBI scores for MAP2 and RSN sites (2011-2017) in the unassessed region by levels of human disturbance and sampling methodology.

The macroinvertebrate assemblages at the MAP2 and RSN sites in the unclassified region of Massachusetts (referred to as “unassessed” in Figure 1.) were scored using the Rhode Island Macroinvertebrate Biological Condition Index (RIMBCI) (Table 3) (Jessup 2012). The RIMBCI was determined to be the best alternative index for the unclassified region based on ecoregional similarities and the index’s capacity to discriminate between reference sites and sites highly stressed by human disturbance in the MAP2 and RSN datasets (Figure 3).

**Table 3.** Score formulas for the Rhode Island Macroinvertebrate Biological Condition Index (RIMBCI) (Jessup 2012)

| Metric | Metric Category | Scoring Formula |
|---|---|---|
| Total Taxa | Richness | 100*metric value/32.8 |
| % Non-insect | Composition | 100*(46.3-metric value)/(46.3) |
| Beck’s Index | Tolerance | 100*metric value/24.8 |
| Clinger Taxa | Habit | 100*metric value/18 |
| % Predators | Feeding Group | 100*metric value/22.7 |
| % Filterers | Feeding Group | 100*(83.1-metric value)/(80.8) |
| | **RIMBCI Score** | **Average (metric score)** |

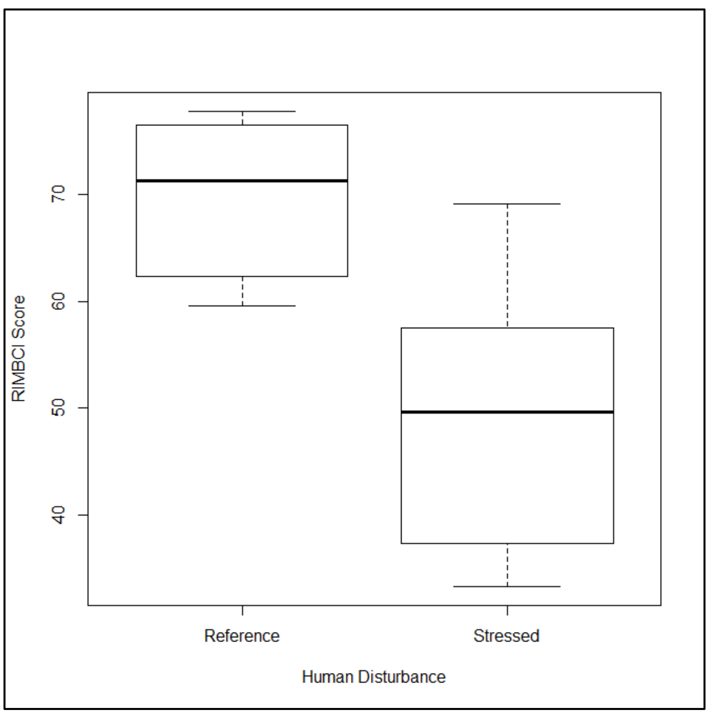


**Figure 3.** Boxplot of RIMBCI scores for MAP2 and RSN sites (2011-2017) in the unclassified region by levels of human disturbance.

It should be noted that the sample size (n=45) was small for this analysis so it does not definitively verify the RIMBCI for use in the unclassified region. There was insufficient data to determine if the RIMBCI should only be applied to one of the sampling methodologies used at the MAP2 sites for macroinvertebrates, so it was applied regardless of the sampling methodology.

The extent of the target population where each IBI and sampling methodology were applied are detailed in Figure 4 and Table 4. Approximately equal portions of the target population were sampled using the two sampling methodologies and the CHIBI was applied to the majority (60.3%) of the target population.

*error bars represent the 95% confidence intervals

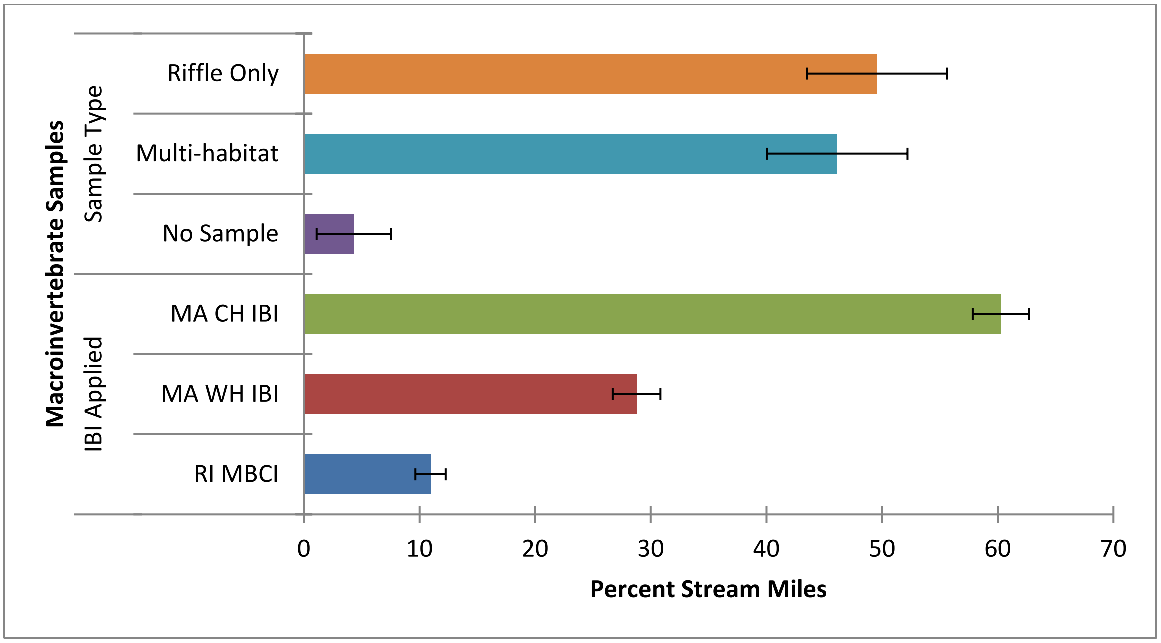


**Figure 4.** Extent of the target population where each IBI and sampling methodology was applied.

**Table 4.** Extent of the target population in each IBI applied and sample type category.

| | | Percent Sample Frame | | | | Sample Frame Miles | | | |
|---|---|---|---|---|---|---|---|---|---|
| Factor | Category | Estimate | Std. Error | Lower 95% CI | Upper 95% CI | Estimate | Std. Error | Lower 95% CI | Upper 95% CI |
| IBI Applied | MA CH IBI | 60.3 | 1.2 | 57.8 | 62.7 | 1820 | 90 | 1643 | 1996 |
| | MA WH IBI | 28.8 | 1.1 | 26.7 | 30.8 | 868 | 129 | 616 | 1121 |
| | RI MBCI | 11.0 | 0.7 | 9.6 | 12.3 | 331 | 42 | 248 | 413 |
| Sample Type | Riffle Only | 49.6 | 3.1 | 43.5 | 55.6 | 1496 | 152 | 1199 | 1794 |
| | Multi-habitat | 46.1 | 3.1 | 40.0 | 52.2 | 1392 | 113 | 1171 | 1613 |
| | No Sample | 4.3 | 1.6 | 1.1 | 7.5 | 130 | 52 | 28 | 232 |

Based on the IBI scores, the macroinvertebrate assemblages at each MAP2 site were categorized into three level of biotic integrity: exceptional, satisfactory and impaired. The IBI score thresholds in each site class for these categories were determined using reference sites from the MAP2 and RSN datasets and the reference condition approach. The 10$^{th}$ or 25$^{th}$ percentile of IBI scores at the reference sites are commonly used to represent the reference condition and set impairment thresholds (Stoddard et.al. 2006). However, considering the additional uncertainty with applying the CHIBI and WHIBI to multihabitat samples and the RIMBCI to the unclassified region, the impairment thresholds were at a lower level for this analysis. The exceptional - satisfactory thresholds were set at the 25$^{th}$ percentile of the reference site scores, and the satisfactory - impaired thresholds were set at one interquartile range (IQR) below the 25$^{th}$ percentile (Table 5).

**Table 5.** Reference site statistics and biotic integrity thresholds for all macroinvertebrate indices.

| Statistic | CHIBI | WHIBI | RIMBCI |
|---|---|---|---|
| Sample Count | 62 | 46 | 10 |
| 75th Percentile | 74 | 62 | 76 |
| 50th Percentile | 67 | 55 | 71 |
| **25th Percentile** | **62** | **46** | **64** |
| 10th Percentile | 56 | 38 | 61 |
| **IQR** | **12** | **16** | **12** |
| Median Absolute Deviation | 6 | 9 | 6 |
| **Exceptional-Satisfactory Threshold (25th)** | **62** | **46** | **64** |
| **Satisfactory-Impaired Threshold (25th - IQR)** | **50** | **30** | **52** |

## Fish Community

The fish assemblages at each site were categorized into three levels of biotic integrity: exceptional, satisfactory and impaired. The thresholds in each stream class (e.g., cold and warm water) for these categories were set using species characteristics (e.g., fluvial vs. macrohabitat generalist) and the composition of individuals in the sample (Table 6). The satisfactory – impaired thresholds were set at the support – impaired thresholds outlined in the Massachusetts CALM document (MassDEP 2018). The exceptional – satisfactory thresholds were set using the same species characteristics as the CALM document used for threshold setting and best professional judgement.

**Table 6.** Biotic integrity thresholds for fish assemblages by stream class

| Stream Class | Biotic Integrity | Threshold Criteria |
|---|---|---|
| **Warm Water High Gradient** | Exceptional | Sample dominated (>=50%) by fluvial (specialist or dependent) individuals from multiple fluvial species. |
| | Satisfactory | Sample dominated (>=50%) by macrohabitat generalist individuals OR individuals from a single fluvial species. |
| | Impaired | Fluvial individuals are absent from sample. |
| **Warm Water Low Gradient** | Exceptional | Sample dominated (>=50%) by fluvial (specialist or dependent) individuals OR intolerant/moderately tolerant individuals with at least one fluvial species present. |
| | Satisfactory | Sample dominated (>=50%) by intolerant/moderately tolerant individuals with no fluvial species present OR macrohabitat generalist and tolerant individuals. |
| | Impaired | Only tolerant macrohabitat generalist or no fish are present. |
| **Cold Water** | Exceptional | Sample dominated by cold water (>=50%) individuals OR sample is 25-50% cold water individuals and dominated by fluvial (specialist or dependent) intolerant or moderately tolerant individuals. |
| | Satisfactory | Sample is less than 25% cold water individuals OR sample is 25-50% cold water individuals and dominated by macrohabitat generalist or fluvial (specialist or dependent) tolerant individuals |
| | Impaired | Reproducing cold water population is absent. |

The extent of the target population in each temperature regime and stream gradient category are detailed in Figure 5 and Table 7. The cold water temperature regime category includes both designated and existing use situations and was determined using CALM document protocols for the MAP2 sites (MassDEP 2018). The RBP habitat assessment form was used to estimate stream gradient for the MAP2 sites. Most of the target population are high gradient cold water streams with approximately 60% of the stream miles in each category.

*error bars represent the 95% confidence intervals

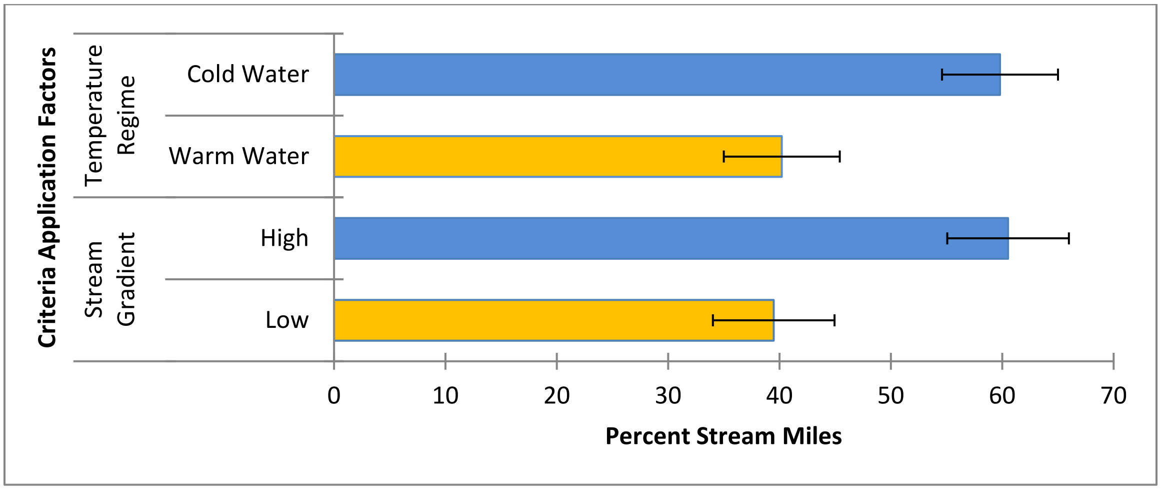


**Figure 5.** Extent of the target population in each temperature regime and stream gradient category

**Table 7.** Extent of the target population in each temperature regime and stream gradient category

| | | Percent Stream Miles | | | | Stream Miles | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Indicator** | **Category** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** | **Estimate** | **Std. Error** | **Lower 95% CI** | **Upper 95% CI** |
| Temperature Regime | Cold Water | 59.8 | 2.7 | 54.6 | 65.0 | 1805 | 151 | 1508 | 2102 |
| | Warm Water | 40.2 | 2.7 | 35.0 | 45.4 | 1214 | 98 | 1022 | 1405 |
| Stream Gradient | High | 60.5 | 2.8 | 55.1 | 66.0 | 1827 | 165 | 1504 | 2150 |
| | Low | 39.5 | 2.8 | 34.0 | 44.9 | 1192 | 92 | 1011 | 1373 |

## Habitat Quality

Rapid Bioassessment Protocol (RBP) habitat assessments were conducted at each fish and macroinvertebrate sampling events and were used to determine habitat quality at the MAP2 (2011 – 2015) and RSN (2011 – 2017) sites (MassDEP 2003). In addition, all the MAP2 and RSN sites used in this analysis were assigned a human disturbance class using the method outlined in IBI development process to identify reference sites from both datasets (Jessup and Stamp 2019).

Based on the habitat assessment scores, the habitat quality at each site were categorized into three level: exceptional, satisfactory and impaired. The RBP habitat assessment score thresholds for these categories were determined using reference sites from both the MAP2 and RSN datasets. The exceptional - satisfactory thresholds were set at the 25$^{th}$ percentile of the reference site scores, and the satisfactory - impaired thresholds were set at one interquartile range (IQR) below the 25$^{th}$ percentile (Table 7). Since the RBP habitat assessment scores are normalized on a 0 – 200 scale, determining different thresholds for stream gradient classes was not necessary.

**Table 7.** Reference site statistics and habitat quality thresholds.

| Statistic | RBP Score |
|---|---|
| Sample Count | 234 |
| 75th | 179 |
| 50th | 171 |
| **25th** | **165** |
| 10th | 153 |
| **IQR** | **14** |
| **Exceptional-Satisfactory Threshold (25th)** | **165** |
| **Satisfactory-Impaired Threshold (25th - IQR)** | **151** |

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