Massachusetts Department of ENVIRONMENTAL PROTECTION

2016 DWM ENVIRONMENTAL MONITORING OVERVIEW

(CN 442.0)

A brief overview of the surface water monitoring performed in 2016 by personnel of the MassDEP's Division of Watershed Management (DWM) is presented here. Information pertaining to the individual components of DWM's Surface Water Monitoring Program is presented at http://www.mass.gov/eea/agencies/massdep/water/watersheds/water-quality-monitoring-program.html#1.

The main programmatic objectives of the DWM related to surface water quality monitoring are to:

- Collect chemical, physical and biological data to assess the degree to which designated uses, such as aquatic life, primary and secondary contact recreation, fish consumption and aesthetics, are being met in waters of the Commonwealth;

- Collect chemical, physical and biological data to support analysis and development of implementation plans to reduce pollutant loads to waters of the Commonwealth;

- Screen fish in selected waterbodies for fish tissue contaminants (metals, PCBs and organochlorine pesticides) to provide for public health risk assessment;

- To the extent feasible, locate pollution sources and promote and facilitate timely correction;

- Over the long term, collect water quality data to enable the determination of trends in parameter concentrations and/or loads;

- Develop new or revised standards, which may require short-term research monitoring directed towards the establishment or revision of water quality policies and standards; and to

- Measure the effectiveness of water quality management projects or programs such as the effectiveness of implementing TMDLs or watershed-based plans to control nonpoint source pollution.

Quality assurance is maintained for DWM's watershed monitoring program to ensure implementation of an effective and efficient sampling design, to meet programmatic goals and to provide data meeting specific data quality objectives. The U.S. Environmental Protection Agency (USEPA) has approved a comprehensive Quality Assurance Program Plan (QAPP) that applies to the generation and use of surface water quality data by DWM for a five-year period (2015 – 2019). This five-year *program* QAPP is annually supplemented by project-specific Sampling and Analysis Plans (SAPs), which provide detailed information regarding individual *project* organization, tasks, background, sampling design and non-direct measurements. More information pertaining to the DWM's Quality Management Program and the 2015 – 2019 QAPP can be found on-line at http://www.mass.gov/eea/agencies/massdep/water/watersheds/environmental-monitoring-quality-management-program.html.

In accordance with the DWM's long-range monitoring strategy, the 2016 monitoring program consisted of the ongoing implementation of both probabilistic (random) and deterministic (targeted) sampling networks designed to support the multiple objectives listed above. The EPA encourages states to adopt networks of randomly selected sampling sites that will allow for statistically unbiased assessments that can be applied at larger scales (e.g., statewide). The DWM recently completed (2015) probabilistic monitoring and assessment (MAP2) surveys of Massachusetts' shallow (i.e., "wadable") streams initiated in 2010. In 2016, the DWM surface water monitoring program initiated a new statistically-valid (probabilistic) sampling design for Massachusetts' lakes to be carried out through the year 2018. With the exception of some limited targeted monitoring on specific lakes of special concern (e.g., fish toxics, TMDL development), lake monitoring and assessment had largely been absent from DWM's monitoring program for many years, so the probabilistic lake surveys are filling an existing and longstanding monitoring gap.

Targeted monitoring was also conducted in 2016 to obtain the data and information needed to identify causes and sources of impairments, inform risk assessment activities pertaining to fish edibility, and to develop, implement and measure the effectiveness of water pollution control strategies, such as TMDLs, watershed-based plans and best management practices (BMPs). Finally, monitoring efforts continued at selected sites in the DWM's reference site network (RSN). All of the monitoring activities of the DWM in 2016 are briefly described below.

PROBABILISTIC MONITORING & ASSESSMENT PROGRAM (MAP2) – The goals of the probabilistic survey are to provide an unbiased assessment of the support status of the aquatic life, recreational, fish consumption and aesthetic uses of lakes throughout Massachusetts. The random sampling design allows for the determination, with a known statistical confidence, of the percentage of lake acres supporting and not supporting their designated uses. To implement the survey, the major river basins of Massachusetts were regionally assigned to three groups (i.e., "West", "Northeast" and "Southeast") with each group containing an approximately equal number of lakes. The MAP2 lakes survey is to be implemented over a three year period (2016-2018) with each year focused on one of the regions. The target sample size in each region and year is 25 lakes which will result in a total of 75 lakes statewide at the end of the survey. The "West Group" was the focus of monitoring in 2016 (Table 1). This group includes the Hoosic, Housatonic, Farmington, Westfield, Deerfield, Connecticut, Millers, Chicopee, French and Quinebaug watersheds.

Selected water quality and ecological variables were measured at index (i.e. deep hole) and shoreline sites, as well as throughout the whole lake. These are listed along with their sampling frequencies in Table 2.

Table 1. Location of randomly selected lakes in the western watersheds of Massachusetts that were sampled in 2016 as part of the probabilistic lakes survey.

Site	Watershed	Waterbody	Town
MAP2L-002	Quinebaug	Hamilton Reservoir	Holland, MA

Table 1. Location of randomly selected lakes in the western watersheds of Massachusetts that were sampled in 2016 as part of the probabilistic lakes survey.

Site	Watershed	Waterbody	Town
MAP2L-003	Connecticut	Atkins Reservoir	Shutesbury, MA
MAP2L-004	Westfield	Robin Hood Lake	Becket, MA
MAP2L-006	Westfield	Buckley Dunton Lake	Becket, MA
MAP2L-008	Millers	Lake Monomonac	Rindge, NH
MAP2L-011	Westfield	Pequot Pond	Southampton/Westfield, MA
MAP2L-012	Chicopee	Gaston Pond	Barre, MA
MAP2L-013	French	Buffumville Lake	Charlton, MA
MAP2L-015	Westfield	Damon Pond	Chesterfield, MA
MAP2L-018	Quinebaug	East Brimfield Reservoir	Sturbridge, MA
MAP2L-022	Farmington	Lower Spectacle Pond	Sandisfield, MA
MAP2L-024	Chicopee	Queen Lake	Phillipston, MA
MAP2L-026	Housatonic	Card Pond	West Stockbridge, MA
MAP2L-028	Chicopee	Long Pond	Rutland, MA
MAP2L-029	French	Webster Lake	Webster, MA
MAP2L-032	Chicopee	Quacumquasit Pond	East Brookfield, MA
MAP2L-034	Hudson	Windsor Lake	North Adams, MA
MAP2L-035	Chicopee	Hardwick Pond	Hardwick, MA
MAP2L-036	Deerfield	Hallockville Pond	Plainfield, MA
MAP2L-037	Westfield	Congamond Lakes (South basin)	Southwick, MA

Table 1. Location of randomly selected lakes in the western watersheds of Massachusetts that were sampled in 2016 as part of the probabilistic lakes survey.

Site	Watershed	Waterbody	Town
MAP2L-039	Millers	Tully Pond	Orange, MA
MAP2L-040 [a,b]	Millers	Wrights Reservoir	Gardner, MA
MAP2L-041	Chicopee	Vinica Pond	Wales, MA
MAP2L-042	Housatonic	Ashley Lake	Washington, MA
MAP2L-043	Connecticut	Roaring Brook Reservoir	Conway, MA
MAP2L-044	French	Sargent Pond	Leicester, MA
MAP2L-047	Farmington	Benton Pond	Otis, MA

a – No macrophyte community data
b – No macroinvertebrate community data

Table 2. Sampling frequency of water quality and ecological variables measured at probabilistic lakes.

Location	Variable	Sample Frequency (Minimum)
Index site	Vertical profile (dissolved oxygen, temperature, pH, conductivity)	3
	Secchi disk transparency	3
	Nutrients (total phosphorus, total nitrogen)	3
	Water chemistry (true color, alkalinity, hardness, turbidity, dissolved silica, chloride, dissolved organic carbon)	3
	Chlorophyll a	3
	Phytoplankton community (including Diatoms once in August)	3
Shoreline site	Pathogens (*E. coli*)	5
	Cyanobacteria	3
	Algal toxins (microcystins and anatoxin-a)	3
Whole lake	Littoral macroinvertebrate community	1
	Fish tissue (mercury organochlorine pesticides, metals)	1
	Macrophytes (percent cover, biovolume, exotics)	1
	Aesthetics observations	1
	Human disturbance observations	1
	Bathymetry	1

The various components of the lake surveys are briefly summarized below.

Index Site – Water Quality (Chemical, Biological and Physical)**:** Water quality (vertical DO/temperature/pH/conductivity profile, nutrients, dissolved silica, chlorophyll a, phytoplankton, true color, alkalinity, hardness, turbidity, chloride) samples were collected approximately once a month between June and September (3 sampling events) at the index site of each lake using techniques described in DWM standard operating procedures (SOP). The index site was located at the maximum depth point in each lake. Samples were field-preserved, as appropriate, and delivered to the Senator William Wall Experiment Station in Lawrence (WES) for nutrient (total nitrogen, total phosphorus), chloride, dissolved silica, alkalinity and hardness analyses; the DWM lab in Worcester for chlorophyll a, turbidity and color analyses; PhycoTech (Saint Joseph, MI) for phytoplankton taxonomy, enumeration and biovolume (including Diatoms once); and TestAmerica (Westfield, MA) for the analysis of dissolved organic carbon. A minimum of one duplicate and one blank sample per analyte were tested for QC for each sampling week (approx.10% of the samples).

Shoreline Site – Water Quality (Biological and Microbiological)**:** Water quality (*E. coli*, cyanobacteria and algal toxins) samples were collected at the designated shoreline site for each lake using techniques described in the DWM SOPs. The shoreline site was located at a bathing beach if one were present or at a shoreline point where the lake is easily accessible by the public (e.g. adjacent road or culvert) for recreation. *E. coli* were sampled once a month between May and September (5 sampling events) while cyanobacteria and algal toxins were sampled once a month between July and September (3 sampling events). Samples were field-preserved, as appropriate, and delivered to the Senator William Wall Experiment Station in Lawrence (WES) for algal toxins analyses; the DWM lab in Worcester for *E. coli* analysis; and PhycoTech (Saint Joseph, MI) for cyanobacteria counts. A minimum of one duplicate and one blank sample per analyte were tested for QC for each sampling week (approx.10% of the samples).

Whole Lake – (Bathymetry, Macrophyte and macroinvertebrate community, Fish tissue)**:**

Macrophyte Community – Bathymetry and the macrophyte community (percent cover, biovolume and species composition) were surveyed once during the summer in each lake using protocols described in DWM SOPs. The percent cover and biovolume of macrophytes were estimated using CI BioBase (Navico, Inc., Merrimack, NH). CI BioBase is cloud-based software that automates the processing of depth finder sonar log files to make aquatic vegetation and bathymetric maps. Macrophyte species composition was estimated by identifying macrophyte species from periodic, spatially diverse rake drags within each lake until no new species were identified by the survey crew with the goal of producing a dominant species list. Samples of macrophyte species that could not be identified by the survey crew were delivered to the DWM lab in Worcester for identification.

Littoral Macroinvertebrate Community - The littoral macroinvertebrate community was sampled at all lakes on one occasion during late summer or early fall, using protocols developed for the EPA's 2012 National Lake Assessments (NLA). These organisms can integrate environmental conditions (chemical – including nutrients and toxics; and physical – including shoreline alteration and water level fluctuations) over a long period of time and are an excellent measure of the waterbody's health. Specimens were placed into 2L Nalgene jars, preserved with denatured 95% ethanol and transported to the DWM lab for storage. A contractor will process (i.e. subsample) the macroinvertebrate samples and complete the necessary taxonomic identifications. In addition, habitat evaluations were completed at all lakes sampled for littoral macroinvertebrates.

Fish Tissue - Fish tissue samples were collected at all lakes on one occasion during late spring/early summer using a variety of techniques (electrofishing, gill nets, etc.) described in the DWM SOP. Composite samples of filets from three individuals of edible and legal size from a species were collected for 3-5 target species for the analysis by the WES of mercury, organochlorine pesticides, and metals. In addition, 10-12 individual whole fish from a single species were analyzed for mercury.

DETERMINISTIC ("TARGETED") MONITORING PROGRAM (TMP) – Several waterbodies were selected, or "targeted", for monitoring activities designed to fulfill the needs for specific data and information to support such program elements as TMDL development and implementation, human health risk assessment and climate change. While the probabilistic monitoring described above was focused in the Western Group of watersheds, targeted monitoring activities were carried out in watersheds scattered throughout Massachusetts. More detail pertaining to the targeted monitoring activities of the DWM in 2016 is presented below.

Reference Site Network (RSN): The DWM has identified the need to characterize the reference condition for Massachusetts' surface waters to support multiple program objectives including, but not limited to, the interpretation of biological data obtained from the probabilistic monitoring stream network as well as the development of biocriteria and nutrient criteria. For example, the DWM is currently exploring the development of tiered aquatic life uses that will increase the accuracy of aquatic life use assessments and improve water quality goal-setting processes. An understanding of the temporal variation within the indices of biotic integrity used for assessment is a critical initial step toward the development and implementation of biocriteria and tiered aquatic life use.

Least-disturbed reference sites were selected from the two most prominent Level III ecoregions (Northeastern Highlands, Northeastern Coastal Plain) in Massachusetts through the application of a Human Disturbance Index that was derived from six individual streamflow and landscape disturbance indicators. A total of ten (10) sites were chosen for intensive study, beginning in 2011. New sites were added to the network in subsequent years until, in 2015, a total of 27 sites were sampled. In 2016, however, field and laboratory staff constraints and other monitoring priorities limited the number of RSN sites sampled to 13 (Table 3). The primary objective at each sampling site was to collect sufficient data to continue evaluating year-to-year variation in the biological communities. Monitoring activities included habitat assessment; macroinvertebrate and fish population assessments; and physicochemical sampling. All sampling and QA/QC was performed in accordance with the DWM's standard operating procedures, QAPP and SAP. A list of the water quality and ecological variables measured at each site, along with their sampling frequencies, is presented in Table 4. More detail pertaining to each component of the RSN is presented below.

Table 3. Location of selected "reference/least disturbed" sites that were sampled in 2016 as part of the reference site network.

Site	Watershed	Waterbody	Site Description
PHB01	Nashua	Pearl Hill Brook	[approximately 2775 feet downstream/north from Vinton Pond Road, Townsend]
TR01	Nashua	Trout Brook	[approximately 140 feet upstream of Manning Street, Holden]
WBW01[a,b]	Buzzards Bay	West Branch Westport River	[east of Route 81, Tiverton RI approximately 3500 feet upstream of the inlet of Grays Mill Pond, Little Compton, Rhode Island]

Table 3. Location of selected "reference/least disturbed" sites that were sampled in 2016 as part of the reference site network.

Site	Watershed	Waterbody	Site Description
BCB01	Buzzards Bay	Bread and Cheese Brook	[approximately 980 feet downstream of Route 177, Westport]
RA00	Taunton	Rattlesnake Brook	[approximately 1300 feet upstream/east from Route 24/79 (Amvets Memorial Highway), Freetown]
EB01	Blackstone	Emerson Brook	[approximately 200 feet upstream of the Route 146 southbound off-ramp to Chocolog Road, Uxbridge]
RTB01	Blackstone	Roundtop Brook	[approximately 1400 feet downstream/south from the confluence of Tinkerville Brook, Burriville, Rhode Island (approximately 1600 feet from MA/RI border)]
SAL01	Merrimack	Salmon Brook	[approximately 325 feet upstream/south of the Massachusetts/New Hampshire border, west of High Street, Dunstable]
LIZ01	SuAsCo	Elizabeth Brook	[north of Route 117, Bolton approximately 1400 feet upstream of mouth at inlet of Delaney Pond, Stow]
BOS01[b]	Ipswich	Boston Brook	[approximately 900 feet upstream/west of Liberty Street, Middleton]
MIL01[a]	Parker	Mill River	[approximately 4300 feet upstream/south of Glen Street, Rowley]
NOR01	Concord	North Brook	[approximately 2400 feet upstream/north of Randall Road, Berlin]
KING01	Chicopee	Kings Brook	[Route 67 crossing, Palmer]

a – Fish data not collected
b – Macroinvertebrate data not collected

Table 4. Sampling frequency of water quality and ecological variables measured at RSN sites.

Variable	Sample Frequency (Minimum)
Nutrients (TN,TP, Nitrate/Nitrite, Ammonia)	4
Color	4
Turbidity	4
Chloride	4
Dissolved Oxygen/Temperature Probe Deploys (May-September)	continuous
Habitat Assessment	1
Fish Community	1
Macroinvertebrate Community	1

***Water Quality (Physico-chemical)*:** Water samples were collected from each site monthly from May through August, field preserved as appropriate, and delivered to the Senator William X.

Wall Experiment Station in Lawrence (WES) for nutrient (total phosphorus, total nitrogen, nitrate/nitrite nitrogen and ammonia nitrogen) and chloride analysis and the DWM lab in Worcester for turbidity and color analysis. In addition, data loggers were deployed *in-situ* from May to September to obtain long-term continuous temperature and dissolved oxygen data.

***Biological Monitoring (Macroinvertebrates, Fish, Habitat)*:** Benthic macroinvertebrate and fish community assessments, along with associated habitat evaluations, were performed to assess the *Aquatic Life Use* status and to support multiple program objectives, as described above. These communities integrate environmental conditions (chemical – including nutrients and toxics, and physical – including flow and water temperature) over extended periods of time and are excellent measures of a waterbody's overall "health".

Sampling of the benthic macroinvertebrate community at each site was planned for some time during July or August. However, only six sites were sampled during those months due to low-flow conditions. Five sites were sampled later in the monitoring season (September) when stream flow was higher, and still two sites could not be sampled at all. The benthic macroinvertebrate community was assesed using Rapid Bioassessment Protocols (RBP) III or a modification thereof, depending upon available habitat. For example, typical RBP III kick-sampling protocols could not be used at low-gradient sites so a multi-habitat sampling method (i.e., multiple net sweeps) was employed. Specimens were preserved in the field and transported to the DWM lab for further processing. Sample sorting and taxonomic identifications were performed at a contract laboratory. Where applicable, benthic macroinvertebrate functional feeding group, community composition, biotic index using pollution tolerance, and abundance metrics will be calculated for analysis.

Fish community sampling for the presence/absence of resident fish species was performed once, in August, at 11 of the sites (one site was dry; one site was inaccessible due to depth). Fish were collected within a 100-meter reach using a backpack or tote barge-mounted electro-fishing equipment and held in plastic buckets containing stream water. Fish were identified to species and a minimum of 25 individuals of each species were measured and weighed. Fish were then redistributed throughout the sampled reach.

Effectiveness Monitoring Project (EMP) – 2016 Lake Monitoring: An important component of MassDEP's overall monitoring strategy is the evaluation for measurable improvement of previously impaired waterbodies as the result of completed restoration projects in or near those waterbodies. In 2016, monitoring was carried out at five lakes (Table 5) to evaluate the effectiveness of various remedial actions, funded through sections 319 and/or 604(b) of the Clean Water Act (CWA), in reducing or eliminating in-lake and/or upstream stressors and restoring aquatic life use support in those lakes. Results of this monitoring will be used to assess the current water quality conditions and, by inference, the efficacy of the improvement efforts applied.

Because field and laboratory methods were identical for both monitoring programs, the five EMP lakes were pooled with MAP2 lakes to realize sampling efficiencies in survey and sampling logistics. However, the MAP2 and EMP programs did differ somewhat in parametric coverage. Shoreline sampling, fish tissue assays and littoral macroinvertebrate community assessments were not included as part of the EMP. A list of the water quality and ecological variables measured at each lake, along with their sampling frequencies, is presented in Table 6. The description of the individual variables is the same as that presented above for the MAP2 lakes.

Table 5. Location of five selected lakes that were sampled in 2016 as part of the Effectiveness Monitoring Project.

Site	Watershed	Waterbody	Town
ARCAD	Connecticut	Arcadia Lake	Belchertown, MA
BARED	Nashua	Bare Hill Pond	Harvard, MA
CONGD	Westfield	Congamond Lakes (middle basin)	Southwick, MA
METAD	Connecticut	Metacomet Lake	Belchertown, MA
NASHD	Connecticut	Nashawannuck Pond	Easthampton, MA

Table 6. Sampling frequency of water quality and ecological variables measured at EMP lakes.

Location	Variable	Sample Frequency (Minimum)
Index site	Vertical profile (dissolved oxygen, temperature, pH, conductivity)	3
	Secchi disk transparency	3
	Nutrients (total phosphorus, total nitrogen)	3
	Water chemistry (true color, alkalinity, hardness, turbidity, dissolved silica, chloride, dissolved organic carbon)	3
	Chlorophyll a	3
	Phytoplankton community	3
Whole lake	Macrophytes (percent cover, biovolume, exotics)	1
	Aesthetics observations	1
	Human disturbance observations	1
	Bathymetry	1

Field and Lab Support for the Assessment and Management of Cyanobacteria Blooms: MassDEP continued to provide technical expertise and laboratory support for the investigation of potentially toxic algae (cyanobacteria) blooms. Working from MassDEP's DWM-Worcester and Southeast Regional (SERO) offices, respectively, and in collaboration with MassDPH, staff biologists performed cyanobacteria counts and identifications on water samples to determine whether cell counts exceeded MassDPH advisory levels for recreational waters. In addition, samples were collected and/or analyzed *ad hoc* from lakes in DWM's MAP2 and EMP networks if blooms were observed by DWM sampling crews or if water samples exhibited elevated chlorophyll levels in the lab. Cyanobacteria counts and identifications were forwarded to MassDPH for risk assessment and management. A list of waterbodies from which MassDEP processed samples in 2016 is presented in Table 7.

Table 7. Waterbodies for which MassDEP staff performed cyanobacteria counts and identifications in 2016, either at the request of the MassDPH or as part of ongoing lake monitoring activities of the DWM.

Waterbody (MAP2/EMP site id.)	Municipality	Number of sampling events
Sportsman's Pond	Athol	1
Hamilton Reservoir (MAP2L-002)	Holland	1
Vinica Pond (MAP2L-041)	Wales	1
Lake Monomonac (MAP2L-008)	Winchendon	1
Tully Lake (MAP2L-039)	Orange	1
Buckley-Dunton (MAP2-006)	Becket	3
Buffumville Reservoir (MAP2L-035)	Charlton	1
Indian Lake	Worcester	2
Lake Metacomet (EMP-METAD)	Belchertown	1
Nashawannuck Pond (EMP-NASHD)	Easthampton	3
Webster Lake	Webster	6
Bare Hill Pond (EMP-BARED)	Harvard	3
Atkins Reservoir	Shutesbury	1
Pequot Pond	Westfield	1
South Congamond Lakes (MAP2L-37)	Southwick	2
Flint Pond	Shrewsbury	1
East Brimfield Reservoir (MAP2L-018)	Sturbridge	1
Manchaug Pond	Sutton/Douglas	1
Roaring Brook Reservoir (MAP2L-043)	Conway	1
East Monponsett Pond (TMDL support)	Halifax	23
West Monponsett Pond (TMDL support)	Halifax/Hanson	24
Wampatuck Pond	Hanson	10
Mystic Lake	Barnstable	1
Ashley Lake	Washington	1
Lake Chauncy	Westborough	4
Lake Quinsigamond	Shrewsbury	3
Burncoat Pond	Worcester	1
Lake Cochickewick	North Andover	1
Patches Reservoir	Shrewsbury	1

Phycocyanin measurements were included as part of the cyanobacteria investigations conducted in 2016. Phycocyanin is a pigment found primarily in cyanobacteria. DWM staff are working to try to develop a predictable relationship between the cell count of cyanobacteria and phycocyanin levels so that phycocyanin can be used as a surrogate for cell counts. Cell counts and identifications require more skill and time than does obtaining phycocyanin readings; however, developing the database that is needed to relate cell count densities and phycocyanin readings is also time-consuming.

In 2016, efforts with phycocyanin measurements continued to be focused on calibrating and testing various types of equipment for phycocyanin and chlorophyll determinations. Instruments evaluated were the Turner Designs (Cyclops) probe, the Turner Designs Aquafluor meter and the Beagle Bioproducts FluorQuik meter, the latter of which is on loan from the EPA Region 1. While the Aquafluor and Beagle meters measure both phycocyanin and chlorophyll, the Cyclops probe analyzes phycocyanin only. An initiative is underway by the EPA to involve the New England states, along with citizen organizations, in measuring phycocyanin and chlorophyll concentrations while concurrently examining samples for the type of cyanobacteria present. The 2016 instrument evaluation included the collection, at a 1 m lake depth, of both depth-integrated samples (EPA method) as well as grab samples collected at 0.25 m (MADPH method). All of the samples collected using EPA protocols were delivered to the lab, frozen, and later thawed to break up the cyanobacteria cells before they were analyzed. Counts and taxonomic identifications were performed on most of the samples. Phycocyanin readings using the Cyclops probe were only obtained *in-situ*. The number and kinds of samples that were analyzed in 2016 are presented in Table 8.

Table 8: The number of phycocyanin measurements carried out in the field or laboratory using the various instruments and sampling protocols under evaluation.

Waterbody	Cyclops Probe	Aquafluor		Beagle	
	Integrated	Integrated	Grab	Integrated	Grab
Webster Lake	3	4	2	4	2
Lake Quinsigamond	3	3	1	3	1
Bare Hill Pond	3	4	2	4	2
Lake Chauncy	2	3	1	3	1
Indian Lake	2	2	1	2	1
Flint Pond	2	2	1	2	1
Total sampling events	**15**	**18**	**8**	**18**	**8**

Fish Toxics Monitoring: In addition to the fish toxics monitoring performed at the MAP2 lakes, the DWM completed fish sampling at Great Herring Pond (Bourne/Plymouth) at the recommendation of the Inter-agency Fish Toxics Committee. Edible fillets from fish collected at this waterbody were analyzed for the presence of mercury. If necessary, a health advisory pertaining to fish edibility will be issued by the MassDPH.

Lake Monitoring to Support TMDL Development: Baseline lakes sampling in the summer of 2016 focused on monitoring East and West Monponsett ponds in Halifax to support ongoing TMDL development activities. Sampling consisted of three monthly visits to each lake. Data collection focused on total phosphorus and total nitrogen. Secchi disk transparency, color, chlorophyll *a* and multi-probe data were also collected. Blooms of cyanobacteria were identified and counted and results passed on to MassDPH for evaluation and, where applicable, public advisories against swimming or contact due to toxic cyanobacteria (see Table 7).

Monitoring the Effects on Water Quality of Road-Salt Application: To estimate seasonal chloride levels and dynamics in an urban setting, MassDEP deployed continuous conductivity loggers at six sites in the Concord watershed (four on River Meadow Brook and two in the Concord River) from October, 2015 to September, 2016. This work included the collection of chloride grab samples to check the accuracy of the specific conductance-chloride regression model. Samples were analyzed at EPA's New England Regional Laboratory in Chelmsford, MA. In November, 2016 five continuous conductivity loggers were deployed in the Westfield watershed (Potash Brook) in order to assess the stream for possible chloride impairment due in part to its proximity to a major roadway (I-90).

Monitoring Water Quality in Mount Hope Bay: In 2016, MassDEP acquired two YSI marine water quality monitoring buoys to address data gaps in the Massachusetts waters of Narragansett Bay and its sub-embayment Mount Hope Bay. The deployment of these buoys is intended to expand the existing Narragansett Bay Fixed-Site Monitoring Network (NBFSMN) currently administered by the Rhode Island Department of Environmental Management (RIDEM) and the University of Rhode Island Graduate School of Oceanography (URI). Until now, there were no NBFSMN stations located in the eastern portion of Mount Hope Bay and the Taunton River in Massachusetts. The addition of the two new monitoring buoys in Massachusetts will help to define ambient water quality conditions for dissolved oxygen, nitrate-nitrogen, algal abundance, temperature and other parameters. Specifically, the data will be used to assess trends over time, identify impaired waters, assess the effectiveness of management decisions (i.e. wastewater treatment facilities (WWTF) upgrades, TMDL efforts, and stormwater management) and support refinement, calibration and validation of water quality models.

MassDEP's long-term plan for the two buoy systems is to collect continuous, real-time data seasonally from May-October for the next several years; however, the 2016 "pilot" deployment was considerably shorter (i.e., September–November) due to the timing of the procurement of the buoys. Furthermore, the "pilot deployment" was needed to become familiar with URI's protocols, establish near real-time data retrieval remotely via cellular communication and to troubleshoot technical problems that are inherent in the installation and proper functioning of new monitoring systems. While the buoy systems were deployed, bi-monthly grab water samples were collected periodically for nitrate-nitrite-N analyses at each buoy location within one meter of the deployed probes. MassDEP intends to redeploy the two buoys in the spring of 2017.

Technical Support for the Mystic River Watershed Phosphorus Loading Study: The MassDEP continued to support monitoring activities performed as part of the ongoing Mystic River Watershed Phosphorus Loading Study which is coordinated by the Mystic River Watershed Association (MyRWA) in collaboration with several state and federal agencies. The goals of this study are to develop estimates of phosphorus load by gathering data on flow and concentrations, and to relate those loads to response variables by collecting water column data on total phosphorus, dissolved oxygen and chlorophyll a. The results of this study will contribute to a greater understanding of the phosphorus dynamics in the Mystic River as a first step toward identifying, quantifying and controlling the various internal and external sources of this essential plant nutrient. In 2016, DWM and MyRWA personnel deployed dissolved oxygen/temperature data loggers at six sites in the Mystic Watershed from mid-July through mid-October. Throughout that time the MyRWA conducted periodic attended probe data collections at those deployment sites.

Monitoring to Assess Climate Change: DWM staff continued to monitor air and water temperature and collect macroinvertebrate samples at five sites in Massachusetts as part of an ongoing collaborative effort among multiple federal and state agencies, NGOs, and academic institutions across New York and New England to assess the effects of climate change in the Northeast. Spearheaded by the EPA, this effort is aimed at coordinating temperature and biological data collection across the region. Similar "regional" collaborations have been established across the country.

In Massachusetts the five sites are Hubbard River in Granville, Brown's Brook in Holland, Parker's Brook in Oakham, West Branch Swift River in Shutesbury, and Cold River in Florida. UMass/Amherst and MassWildlife's Division of Ecological Restoration (DER) are the other partners on the "Massachusetts Team." DER has installed flow-gaging equipment at the two sites without USGS gages and is developing flow rating curves for them. UMass is playing a coordinating role and also plans to address the fisheries component.

Bacteria Source Tracking Activities of the Southeast Regional Office (SEROBST): The DWM regional monitoring coordinator, aided by a seasonal employee, used the IDEXX quantitray system on site in the Southeast Region lab, to determine the concentration of "indicator bacteria" (*E.coli* and Enterococcus) in surface water, at stormdrain outfalls and within drainage infrastructure (manholes).

Additional source tracking tools used were:

- Hach test kits: to determine detergent concentrations.
- Ammonia and potassium meters: to determine ammonia/potassium ratios

These data were combined with field observations and in some cases, discussions with local watershed groups and/or municipal officials to refine sampling locations, in an attempt to track and isolate the dry-weather source(s) of *E. coli* and/or Enterococcus bacteria. A small number of opportunities for "Human Marker" analyses (fluorescent whitening agents, DNA, and caffeine) were made available by the WES State Lab. These analyses were utilized in cases where bacteria concentrations were high but no obvious source could be immediately located, in an attempt to determine if the bacteria were from a human or animal source.

Subwatersheds where bacteria source tracking was conducted are presented in Table 9.

Highlights of the 2016 sampling season

- The successful multi-year partnership with the City of Norwood continued with:

    - SEROBST and the City consultant (CDM) conducted an additional dry weather outfall screening investigation at the end of May. This effort covered 16 outfalls located City-wide, which had previously been flagged as suspect during a previous survey. These data enabled the City to refine their focus on areas which still require investigation following a great deal of corrective action, mainly in the form of CIPP lining. A couple of the most serious hotspot outfalls discovered this year were confirmed by the City to be related to "underdrain issues".

    - SEROBST took follow up samples in the Arcadia Road drainage area (tributary to Hawes Brook) to document conditions following recent removal of three direct sanitary sewer house connections to the drain, plus CIPP lining of Fieldbrook Drive. Unfortunately E .coli concentrations were still elevated at the Arcadia outfalls. The City/CDM later confirmed sewage exfiltration into the drain from six houses on Garden Parkway. These sources are currently in the process of being removed.

- The partnership with EPA Region-1 and Rhode Island DEM continued into this year, with the goal of monitoring water quality in the lower section of the Palmer River Watershed. Monitoring was focused in areas that were deemed most vulnerable to agricultural impacts and with the long-term goal of assessing trends over time in correlation to ongoing installation of agricultural BMPs. Samples were collected from May through November at 12 fixed stations on an outgoing tide (weather independent). EPA water quality data sondes with sensors were used to measure temperature, specific conductance and salinity. Grab samples were tested (by EPA lab) for *E.coli* (some analyses run by MassDEP SERO lab), enterococcus, total nitrogen, ammonia, nitrate/nitrite, total phosphorus, orthophosphate and total suspended solids (TSS).

- The successful partnership with the City of Taunton continued:

- An outfall pipe (just upstream of the Plain Street Bridge) was discovered to be discharging water with high concentrations of E. coli. Joint source tracking efforts (SEROBST & City) throughout the drainage area narrowed own the location of the source to “First Street”. Drainage for this street is connected to the City underdrain, consequently the City is currently conducting further investigation to address this source.
- An outfall pipe (draining Ingell Street) was discovered to be discharging water with high concentrations of E. coli. Joint source tracking efforts (SEROBST & City) throughout the drainage area narrowed down the location of the source to a house a short distance away on Ingell Street. City dye testing confirmed that this house had a direct sewer connection to the drain.
- Upon request from the City, additional joint source tracking efforts (SEROBST & City) were conducted in the Weir Street Bridge area, focused on the North side. Part of this request was to document the expected improvements following years’ worth of investigation and source removal in this drainage area. The data indicates steady improvement at outfall MRSD08 since 2008. As a result of source tracking sampling this year it was confirmed that the elevated E. coli concentrations remaining at this pipe are originating from the City underdrain. Consequently the City is currently conducting further investigation to address this source.
- Additional joint source tracking on the South side of the Weir Street Bridge served to confirm two remaining sources located within one block of the bridge. The rest of the street south was confirmed to be clean which is a huge improvement compared to a few years ago. The City is currently addressing the two remaining sources with the use of CIPP lining technology.
- One more additional day of joint source tracking focused on a number of previously suspect areas, most of which have now seen numerous corrections and were shown to be relatively clean.

* A number of “hotspots” were identified within baseline study watersheds:

    - A hotspot was identified on Herring Run Brook (a tributary to the Weymouth Back River) at the pedestrian bridge downstream of the “Commercial Street fish way”. Two stations within the hotspot area were sampled for human marker analyses in the fall. Results have not been published.
    - A hotspot was identified on Third Herring Brook at River Street in Norwell. One station within the hotspot area was sampled for human marker analyses in the fall. Results have not yet been published.
    - A hotspot was identified on a tributary to the lower Coles River just upstream of Pearse Road, Somerset. One station within the hotspot area was sampled for human marker analyses in the fall. Results have not yet been published.
    - A hotspot was identified on the Sevenmile River in the Pitas Ave. area, Attleboro. One station within the hotspot area was sampled for human marker analyses in the fall. Results have not yet been published.

Table 9. Subwatersheds where bacteria source tracking was conducted over the course of approximately 40 sample days. Note: This table includes only the names of those municipalities where sampling took place and new sub-watersheds are highlighted in **bold.**

Name	Basin	Segment	Municipalities sampled	Number of sample days
Speedway Brook	Ten Mile River	52-05_2006	Attleboro	2
Sevenmile River	Ten Mile River	52-08_2006	Attleboro & Pawtucket	3
Palmer River tidal project (incl. Rocky Run Brook and Torrey Creek)	Narragansett Bay	53-05_2006 53-16_2006 53-17_2010	Seekonk & Rehoboth	7
Coles River	Mount Hope Bay	61-04_2006	Swansea	4
Taunton River	Taunton	62-02_2006	Taunton	4
Labor In Vain Creek	Taunton	62-04_2006	Somerset	3
Salisbury Plain River	Taunton	62-05_2006	Brockton	1
Trout Brook	Taunton	62-07_2006	Brockton	2
Salisbury Brook	Taunton	62-08_2006	Brockton	2
Mill River	Taunton	62-29_2006	Taunton	3
Lovett Brook	Taunton	62-46_2010	Brockton	1
Germany Brook	Neponset	73-15_2006	Norwood	3
Hawes Brook	Neponset	73-16_2006	Norwood	1
Plantingfield Brook	Neponset	73-23_2006	Norwood	1
Pecunit Brook	**Neponset**	**73-25_2006**	**Canton**	**2**
Ponkapoag Brook	**Neponset**	**73-27_2006**	**Canton**	**2**
Herring Run Brook	**Weymouth/Weir**	**74-05_2006**	**Weymouth**	**3**
French Stream	South Coastal	94-03_2008	Hanover	2
North River	**South Coastal**	**94-05_2006**	**Hanover**	**2**
Third Herring Brook	**South Coastal**	**94-27_2006**	**Norwell**	**4**
Acushnet River	**Buzzards Bay**	**95-31_2006**	**Acushnet**	**3**