Report to the U.S. Environmental Protection Agency

State of Maine
Department of Environmental Protection

Comprehensive Surface Water Ambient Water Quality Monitoring and Assessment Strategy

2015-2025

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List of Acronyms

Acronym	Meaning or Definition
ADB	Assessment DataBase
ALU	Aquatic Life Use
ATTAINS	Assessment, TMDL Tracking And ImplementatioN System
AU	Assessment Unit
BCG	Biological Condition Gradient
BMP	Best Management Practice
BWQ	Bureau of Water Quality
CBEP	Casco Bay Estuary Partnership
CaCO3	Calcium Carbonate
CBI	Courtesy Boat Inspection
CDX	Central Data Exchange
CO2	Carbon Dioxide
CWA	(Federal) Clean Water Act
DEA	Division of Environmental Assessment
DO	Dissolved Oxygen
EGAD	Environmental and Geographic Analysis Database
FOCB	Friends of Casco Bay
FTE	Full Time Equivalent
GAP	Gap Analysis Program
GIS	Geographic Information System
IASU	Invasive Aquatic Species Unit
IBI	Index of Biological Integrity
IPP	Invasive Plant Patrol
LAS	Lake Assessment Section
LSM	Lake Stewards of Maine
LSM-VLMP	Lake Stewards of Maine Volunteer Lake Monitoring Program
MECDC&P	Maine Center for Disease Control & Prevention
MEDEP	Maine Department of Environmental Protection
MEDHHS	Maine Department of Health and Human Services
MEDIF&W	Maine Department of Inland Fisheries & Wildlife
MEDMR	Maine Department of Marine Resources
MEG	Maximum Exposure Guideline
MEMP	Marine Environmental Monitoring Program
MHB	Maine Healthy Beaches
MIMIC	Marine Invader Monitoring and Information Collaborative
MOCA	Maine Ocean and Coastal Acidification (partnership)
M.R.S.	Maine Revised Statutes
MU	Marine Unit

Acronym	Meaning or Definition
NCCA	National Coastal Condition Assessment
NECAN	Northeast Coastal Acidification Network
NGO	Non-Governmental Organization
NHD	National Hydrography Dataset
NLA	National Lakes Assessment
NWQI	National Water Quality Initiative
OIT	(Maine) Office of Information Technology
QAPP	Quality Assurance Project/Program Plan
QMP	Quality Management Plan
QMS	Quality Management System
QMSC	Quality Management Steering Committee
PAH	Polycyclic Aromatic Hydrocarbon
PBT	Persistent Bioaccumulating Toxins
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanesulfonic Acid
PPCP	Pharmaceuticals and Personal Care Products
PRAWN	Program tracking, beach Advisories, Water quality standards, and Nutrients (database)
PTE	Part Time Equivalent
RP	Reasonable Potential
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SOP	Standard Operating Procedure
SWAT	Surface Water Ambient Toxics
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
UMCE	University of Maine Cooperative Extension
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
VRMP	Volunteer River Monitoring Program
WBD	Waterbody Divide
WET	Whole Effluent Toxicity
WMU	Watershed Management Unit
WQS	Water Quality Standards
WQX	Water Quality Exchange

Summary

This Comprehensive Surface Water Ambient Water Quality Monitoring and Assessment Strategy provides a framework describing existing monitoring and assessment efforts by staff in the Bureau of Water Quality (BWQ), Division of Environmental Assessment (DEA) at the Maine Department of Environmental Protection (MEDEP) and other monitoring partners, and, describes elements of a monitoring program needed to meet objectives set forth by the Department. The strategy describes specific monitoring goals and objectives, and the types of monitoring designs and methods used to achieve these goals. Included are sections that characterize all aspects of this process, from monitoring to final reporting.

Although difficult to predict what the future may hold, this document describes anticipated monitoring and program development milestones over the next 10 years. These milestones will only be realized if adequate resources are available to meet the challenge. Projected needs are summarized by infrastructure element within the document. The document also attempts to capture emerging issues. This strategy is intended to be a dynamic document that will be referred to and updated in an on-going manner to meet the needs of the department.

1. Strategy Introduction

This ambient surface water quality monitoring program strategy provides a framework describing existing monitoring and assessment efforts by the MEDEP and other monitoring partners, and describes elements of a monitoring program needed to meet objectives set forth by the MEDEP. The strategy:

- Describes specific monitoring goals and objectives;
- Describes the types of monitoring designs and methods used in Maine;
- Provides a list of anticipated monitoring and program development milestones;
- Recommends core and supplemental water quality indicators;
- Provides detail and references on quality assurance procedures;
- Provides information on data management methods and protocols;
- Provides general data analysis and assessment procedures;
- Describes required federal and state reporting and provides recent references;
- Recommends methods for periodic review of this monitoring program;
- Provides estimates of current resources and necessary resources for full program implementation.

The needs for acquisition of monitoring information are varied. Monitoring programs are required by various state and federal directives, notably the Clean Water Act (CWA), which requires states to characterize the baseline quality or status of waters, understand water quality trends, and determine what factors or stressors may be influencing water quality. This is critical planning information for water quality management. Significant emphasis is currently being placed on determining whether waters are complying with applicable water quality standards (WQS) and criteria. Such decisions carry significant regulatory consequences, hence the need for a robust and scientifically defensible assessment framework. While the current water quality management approach forces scientists and managers to think about monitoring in the framework of use-support, impaired water listings/de-listings, and Total Maximum Daily Load (TMDL) preparation, there are other, equally important goals that must be met by monitoring activities. Among these are the understanding of what is unique about a waterbody, how the monitoring information fits within the context of acquisition methodology, and how waterbodies respond to management actions. These objectives provide for improved protection and efficient remediation of waters. Additionally, the monitoring program provides the means of discovering new or previously unknown, water quality problems. Finally, the monitoring program provides tangible documentation about water quality that can be used by the public for a wide variety of personal and societal decisions.

Maine's water quality monitoring program continues to allocate significant monitoring resources toward impact and fate measures [e.g. invertebrate biomonitoring in rivers, cyanotoxin and sediment geochemistry assessment in lakes, tissue contamination in all waters]. The best means to assess and prioritize environmental problems is to quantify the biological effects that various stressors impose on a system rather than indirectly assessing water quality by measuring the stressors (e.g. water chemistry). Maine's Biomonitoring Unit's development of numeric

biocriteria (streams, rivers, and wetlands) and use of results within the Surface Water Ambient Toxics Program exemplify this approach to monitoring. The one technological addition to our data collection methods is more routine use of continuous monitoring devices, which may be deployed for weeks at a time.

To be most effective, the general design of a water quality monitoring program must consider spatial, temporal, and analytical variability. In addition, monitoring designs must describe, control, or reduce inherent bias in any monitoring program, to describe, control, and reduce the uncertainty in the information generated. Water quality assessments generally require comparative analysis, either to a water quality standard, to a reference condition, to a trend, or some other defined management objective. Maine strives to collect the best quality data with the resources available.

Throughout this document, the terms "waters" and "water resources," refer to surface waters including rivers and streams, lakes and ponds, marine and estuarine waters, and wetlands. The term "monitoring" is intended to address measurement or estimation of ambient water quality conditions. Groundwater is not addressed in this strategy, nor is monitoring activity related to permit compliance or in-facility monitoring. This strategy is intended to be a dynamic document, reflecting the ever-improving methods available for water quality monitoring and changing program needs. It describes a range of activities that are currently used and identifies other monitoring activities that could be implemented based on availability of resources. This strategy is intended to have a lifespan of ten years, and allows for annual and mid-year changes that reflect new and immediate demands on the monitoring program.

While this is a MEDEP strategy, clearly ambient monitoring responsibilities extend to other government agencies, tribes, non-governmental organizations (NGOs), and volunteer groups. This strategy considers their current and projected involvement (see Tables 2-7) but does not assess specific resources that these other groups have or specifically assign any roles. The strategy goals/objectives herein encompass many of the same general goals/objectives of these other monitoring groups, although their priorities may differ from MEDEP in that they are often more single-issue oriented and locally focused. The MEDEP has been successful in engaging these other groups through various means: (1) financial support through grants or contracts that allow for staff support and acquisition of equipment, (2) training and other logistical support (e.g. quality assurance project plan development) provided by MEDEP staff, (3) data management, analysis, and utilization, and (4) cooperative agreements to partition workloads on various projects. The MEDEP maintains continuous involvement with these groups, which are included in our Integrated Report, and could not maintain our monitoring program without their accompanying support.

This Monitoring Strategy makes no attempt to address monitoring of waters outside of those identified as current state priorities. For example, the state GIS (Geographic Information System) system has identified approximately 32,257 polygons as being lakes or ponds. Of these, approximately 29,000 are less than one acre in surface area, and in the past relatively few were monitored. However, the Biomonitoring Unit occasionally monitors small shallow ponds in conjunction with wetland monitoring. Similarly, intermittent streams are not routinely monitored by the MEDEP. However, if a contaminant were to be traced up-gradient to a source associated

with an ephemeral water, that water would be identified in the TMDL process due to its location in the watershed.

Soft bottom (muck) streams may be monitored by the Rivers & Streams section, and low gradient streams are monitored by the Biomonitoring Unit if they have appropriate wetland habitat. Wetland monitoring has only recently begun to focus on certain types of wetlands (e.g., forested wetlands and wetlands having very little standing water). Vernal pools have yet to be monitored for water quality although the Maine Department of Inland Fisheries & Wildlife (MEDIF&W) focuses volunteer efforts on species enumeration. Marine waters offshore of exposed coastline as well as estuarine waters not subject to point source discharges are less well characterized due to dedication of staff and financial resources toward monitoring in point source influenced estuaries. Coastal wetlands have been the subject of research within the state but have only been recently targeted for monitoring due to documented declines in eelgrass acreage. Given current levels of support and personnel, it is unlikely that these marine waters will be more extensively monitored in the foreseeable future. However, additional parameters characterizing marine habitat and the benthic community may enable an improved understanding of stressor-response relationships in selected, representative locations.

2. Monitoring Goals and Objectives

General goals of Maine's surface water program include documentation of the condition of Maine's waters and protection of these resources in collaboration with other entities through cooperative studies and the fostering of community stewardship at local and statewide levels. Specific goals and objectives are listed in the following bulleted lists.

Goal 1: Monitor and predict the condition of Maine's water resources to:

1. Provide information essential to protecting, maintaining and/or restoring the physical, chemical and biological integrity of Maine's water resources;
2. Provide information on the quality of waters in relation to WQS, reference conditions, or other measures of comparison;
3. Provide information necessary to develop new, or amend existing WQS;
4. Identify water quality conditions, impairments, causes, and sources;
5. Provide information on the trends observed in water quality;
6. Identify new or emerging problems before they become widespread or irreversible;
7. Evaluate the success of current policies and programs.

Objectives for Goal 1:

A. Identify the status of Maine's water resources, including high-quality waters in need of protection;
B. Identify trends in the condition of Maine's water resources;
C. Identify existing and emerging threats to Maine's water resources and prioritize the management of these threats and problems;
D. Identify contamination sources or other stressors that impact water resources at the waterbody and watershed level;

E. Provide information to support and evaluate MEDEP planning, management and regulatory programs (including land, air and hazardous waste programs);
F. Provide information to support and evaluate MEDEP planning and management of non-regulatory and volunteer programs (including non-point source controls);
G. Provide information to support the development of environmental indicators;
H. Determine environmental and public health effectiveness of pollution control programs, or other agency or voluntary programs;
I. Provide necessary monitoring support involving citizen complaints and emergency situations;
J. Determine and report compliance with Maine's WQS, and identify where standards are exceeded and warrant protection through anti-degradation, or where they may need to be modified to account for natural conditions;
K. Develop methods that increase the capacity and efficiency to address these objectives.

Goal 2: Communicate, collaborate and coordinate with organizations, agencies, and the general public to:

1. Increase public knowledge of and involvement in water resource monitoring, assessment, and management;
2. Promote efficient and effective monitoring and assessment programs;
3. Develop effective and timely reporting;
4. Collect and disseminate useful data, of standardized quality, to supplement state monitoring and assessment programs;
5. Provide information on water quality status and trends to water resource management bodies (e.g. Maine legislature, natural resource agencies, regulated community, local NGO conservation entities).

Objectives for Goal 2:

A. Develop a comprehensive and inclusive monitoring and assessment program in Maine;
B. Identify water resource data needs and develop mechanisms to enable volunteer monitoring/assessment programs and other partners (e.g. tribes) to collect data that are of high quality and relevant to those needs;
C. Communicate with other state and federal agencies to assure complementary monitoring programs;
D. Support volunteer monitoring programs;
E. Develop and maintain a statewide database of water quality data and information that attains state data quality objectives.

3. Monitoring and Assessment Programs

A. Monitoring and Assessment Approaches

Maine can be characterized as a water-rich, heavily forested state that is relatively unpopulated for the northeast region of the country. These three characteristics present a challenge in the design of an assessment strategy that is both comprehensive and cost effective. Aerial estimates

of the proportion of Maine covered by surface water, including non-forested wetland, river/stream, lake/pond and estuarine environs, ranges between 20 – 30%. The Maine GAP (Gap Analysis Program) Land Cover and Vegetation Dataset, a GIS based characterization of land cover derived from Landsat imagery, indicates that the predominant land cover is forest (89%). Despite inherent resolution errors in these estimates, this information is considered to be reasonably representative of general conditions within the state. Because of these characteristics, MEDEP's assessment strategy uses a tiered monitoring system.

i) Identification Tier

The first-tier examination of classification attainment status in Maine waters is generally an evaluation of ambient water quality data for a water body, which is compared to specific criteria (e.g., transparency in lakes to determine trophic state, dissolved oxygen (DO) in rivers, etc.). GIS spatial data may be used as a first-tier tool to identify watersheds having a percent impervious surface greater than a specific threshold to identify streams most-at-risk for effects from non-point stressors associated with urban development. Such waters may be targeted for further monitoring. Such waters may be screened using a census-based, targeted approach or be included in a stratified probability design.

ii) Screening Tier

Second-tier screenings are conducted by volunteers and/or by professionals often using approaches that collect simple measures at limited frequency or using rapid assessment techniques. If attainment status is in question, more specific monitoring may be warranted. When results reveal that the water is in non-attainment (impaired and listed under Section 303(d) – requiring a TMDL study), monitoring will likely become more frequent and extensive, focusing on specific stressors and associated sources.

Screening level assessments are conducted using several approaches. Origin and persistence of a stressor are paramount considerations in determining where to allocate monitoring resources. For example, airborne stressors (e.g., mercury) are likely to be found across the entire state regardless of local population densities and land uses. In the mid-1990s, Maine undertook a fish tissue assessment to determine extent and magnitude of mercury contamination in Maine lakes (Regional EMAP project, Fish Tissue Contamination in Maine Lakes). A probability-based (stratified random) approach was chosen to assess fish tissue statewide in a randomly chosen subset of lakes determined by the MEDIF&W to have a significant recreational fishery. Fish collections were obtained from 125 lakes in addition to routinely collected water quality data. Results allowed conclusions to be drawn regarding the population of approximately 1800 lakes that support sport fish across the state. Further examination of the data revealed that warm water species typically had greater concentrations of mercury. This insight allowed researchers to target warm water species in subsequent sampling designs. One unforeseen benefit from this study was that the statistically valid design allowed results to be used as a 'yardstick' in the evaluation of monitoring effectiveness of other approaches to the collection of water quality data. In a current effort, a similar probability-based approach has been undertaken to evaluate the risk posed by the cyanotoxin microcystin in Maine lakes.

On the other hand, stressors associated with specific point source discharges are most likely to be found downstream of such discharges (e.g., dioxin associated with paper mills, pharmaceuticals and nutrients with municipal treatment plant discharges, bacteria with combined sewer overflows). Thus, waters downstream of discharges are targeted for monitoring in non-tidal areas. In estuaries and coastal waters, monitoring locations are chosen based on proximity to a discharge in the direction of ebb and flood tidal flow. A rotating basin approach (see map at right) assures screening evaluation of a statewide resource on a regular basis. The Biomonitoring Unit utilizes this rotating basin approach for routine sampling.

Rotating Basin approach used by the Biomonitoring Unit

Stressors associated with non-point sources generally transported to surface waters by stormwater runoff are most often found in the developed and agricultural areas of the state; examples are nutrients & pesticides from agricultural and urban/suburban areas, and assorted contaminants from heavily urbanized or industrialized neighborhoods. Screening may be accomplished in these situations using several approaches. Citizen monitoring activity has the inherent bias of being most likely to occur in heavily populated regions of the state, and thus in areas likely for non-attainment issues. Citizen monitoring in Maine is thus categorized as statewide screening, targeted with respect to population, yet opportunistic in that a certain percent of stations (estimated 20%) may be in flux in any given year.

iii) Intensive Tier

Third-tier or intensive monitoring approaches are generally implemented when screening results indicate that a waterbody may not be attaining classification standards for one or more designated uses. Intensive monitoring may include multiple-parameter evaluations to identify stressor(s), increased monitoring frequency of parameters identified as or associated with stressor(s), and/or biological monitoring. A combination of approaches is generally used when monitoring an impaired water in conjunction with the development of a TMDL or a watershed-based management plan. Restoration effectiveness is often evaluated in a similar manner.

iv) Other Monitoring

The MEDEP engages in a variety of other monitoring activities directly related to water quality assessments. Examples include monitoring of water quality in the Maine's Ecological Reserve network or other protected areas (state & national parks), assisting with projects conducted by other State agencies (e.g. MEDIF&W, Department of Marine Resources [MEDMR]), monitoring in cooperation with hazardous waste remediation sites (e.g. administered under the Resource

Conservation and Recovery Act (RCRA) the Superfund Amendments and Reauthorization Act (SARA)), or in support of water research associated with state academic institutions. These activities are normally not part of a regular monitoring plan but may account for significant additional monitoring resources.

B. Rivers and Streams

i) Overview

The Rivers and Streams Unit is responsible for the statewide water quality assessment of classified rivers and streams. Non-attainment waters are addressed through the TMDL or permitting process. These tasks are accomplished through various programs and involve data collection, compilation and analysis, as well as technical review and modeling.

ii) Brief Project Descriptions:

- Point source TMDL studies – Data collected for purposes of developing waste load models (e.g. QUAL2E) applicable to TMDL reports for Category 5 listed impaired waters.
- Surface Water Ambient Toxics (SWAT) – statewide program assesses toxic contaminants in surface waters using fish tissue, sediment and biomonitoring. Program also supports method development. Information used for fish consumption advisories and ecological health assessment.
- Monitoring for development and implementation of an Index of Biological Integrity (IBI) for fish populations in wadeable streams.
- Monitoring Atlantic salmon habitat to characterize and assess salmon waters with the goal to restore and enhance endangered populations of this species.
- River/stream nutrient criteria – statewide monitoring of reference quality and affected waters to develop nutrient criteria.
- Urban stream restoration projects – follow-up monitoring on urban impaired waters with completed TMDLs.
- Water Quality Standards assessment – traditional water quality analysis (e.g. DO, pH, enteric bacteria) used for attainment of Water Quality Standards in Maine's Water Classification Program.
- Temperature monitoring – establish and monitor ambient temperature of wadeable streams in each of the Department's regions.

iii) Program Needs

Staff –

- Environmental Technician for assistance in fish collection/analysis, and water quality monitoring.

C. Biomonitoring (Rivers, Streams, Wetlands)

Overview – The Biomonitoring Unit collects data to assess the condition of resident biological communities in rivers, streams, and wetlands. Narrative biocriteria (aka, aquatic life criteria) in WQS apply to all aquatic life in all fresh surface waters. Numeric biological criteria are complete using macroinvertebrates for rivers and streams (Davies et al., 2016). Numeric criteria for stream algae (Danielson et al., 2011, 2012) and wetland macroinvertebrates and algae are in development.

Brief Project Descriptions:

- Classification Assessment – Statewide monitoring to assess attainment of biocriteria.
- SWAT – Macroinvertebrate data collected from stream and rivers for identification and assessment of toxics problems.
- Wetland Macroinvertebrates – Development of statewide biocriteria for freshwater wetlands using macroinvertebrates.
- Stream and Wetland Algae – Development of statewide criteria using algae.
- Vegetative Indicators - Develop assessment methodology and vegetative indicators for wetland habitats.
- Stream Fish – Assist with development of bioassessment model (IBI).
- Watershed Plans and TMDLs – Macroinvertebrate and algae data collected to determine stressors.
- Ecological Reserves – Biological characterization and baseline documentation of protected reference quality waters in the state.
- Watershed Assessment Approach – Development of watershed level assessment models using spatial data calibrated with biological data for rivers, streams, lakes and ponds.
- Wetland Mitigation Assessment – Develop approaches to apply biological monitoring approach to evaluate the success of wetland mitigation projects.
- Cooperative Projects with the United States Environmental Protection Agency (USEPA) and New England States and Tribes – Includes national water quality condition surveys and regional monitoring networks.

Program Needs:

Staff –

- Stable funding for two existing Wetland Biologists (Biologist II, Biologist I);
- Funding for seasonal help: Conservation Aide (17-week position) and 2 MCC AmeriCorps positions.

Monitoring Equipment -

- Continuous Monitoring Equipment (temperature, conductivity, DO)

Analysis –

- Water chemistry analysis, wetland soils metals analysis

D. Lake Assessment

Overview – The Lake Assessment Section (LAS) is responsible for the statewide water quality classification attainment assessment of Maine's lakes and ponds. Non-attainment waters are addressed through the TMDL process. Additionally, the section mission is "To promote the protection of Maine's lakes through research, collection and management of sound scientific data, identification of threats to lake ecosystems and dissemination of information to those concerned with lake water quality."

Brief Project Descriptions:

- Lake Stewards of Maine Volunteer Lake Monitoring Program (LSM-VLMP) – The LAS partially funds this private, non-profit entity, provides quality assurance oversight, data management and reporting assistance, and, utilizes data collected on over 400 lakes for water quality assessments, prioritization of resources and reporting to state and federal entities.
- Special Study Lakes – The LAS examines a small number of lake systems annually with respect to water level issues, possible impairment, and other lake specific investigations.
- Lake Baseline Sampling – The LAS acquires water quality data and samples for analyses from approximately 100 lakes over a four to six-week period in late August of each year. These data are used to help interpret data collected by the volunteers and cooperators, to make determinations regarding attainment status and to document conditions on reference waters.
- Littoral Habitat Metric Development – The LAS is refining an assessment method similar to the physical habitat component of USEPA's NLA to assess the condition of near-shore areas (littoral and shoreline) to help predict which lakes are at risk of not meeting water quality standards due to habitat loss. Over the long-term, we expect to develop metrics for a multi-metric model including macrophytes and macroinvertebrates, integrate results with those from other indicators, develop a scorecard and eventually incorporate into a BCG model for lakes.
- Cyanotoxin Sampling – The LAS has been conducting a probability-based sampling of lakes greater than 150 acres in surface area in populated counties of the state to evaluate the risk of cyanotoxin production by cyanobacteria. In addition, samples from subset of lakes known to produce cyanobacteria blooms on an annual basis are collected to obtain 'worst-case scenario' conditions within the state.
- Special Studies with University of Maine – The LAS supports graduate-level research through the University of Maine on topics of interest and/or the development of educational resources. Past projects have included analysis of the economic value of lakes, investigations into lake sediment aluminum/iron/phosphorus dynamics, and development of techniques to assess riparian and littoral attributes on developed and undeveloped shorelines.
- Reference Lake Monitoring – Since 2001, the LAS has been documenting water quality conditions and planktonic biota in lakes located on state-owned public lands designated as Ecological Reserves; in 2005 the monitoring expanded to include littoral habitat, aquatic plant communities, minnows, crayfish and macroinvertebrates. A Floristic Quality Index for lakes will be developed for inclusion in the Lakes BCG,

similar to those developed by our Wetlands Biomonitoring group and Maine's Natural Areas Program.

- National Lakes Assessment (NLA) – The LAS has participated in probabilistic lake surveys in conjunction with USEPA and expects to participate in similar future surveys.

Program Needs:

Staff -

- Two seasonal positions (Conservation Aid or AmeriCorps position and intern) to support field work
- One Biologist II position, which will be vacated in the spring of 2019 due to retirement. The biologist in this position will need to have laboratory skills, and expertise in cyanotoxin research and other public health issues.
- Dedicated support to help manage data (data entry, proofing) and attend to some of the more administrative aspects of the program.
- Training for staff to develop skills and knowledge to better serve the needs of local lake organizations, shorefront property owners and municipal officials.

Monitoring Equipment -

- Two multi-parameter sondes with budget for annual maintenance (replacement probes easily cost more than $1,500).
- Continuous monitoring devices for temperature and oxygen are necessary to track regional long-term changes to lakes, including four existing long-term monitoring sites as well as additional sites to better represent the geographic and climatic diversity in Maine.
- Budget for regular maintenance, repair and replacement of monitoring equipment.
- One of each of the more common YSI dissolved oxygen meters to provide model-specific assistance to volunteers through the Volunteer Lake Monitoring Program.
- Equipment for loaning to volunteers with the means to collect and process samples (e.g., filtration apparatus for chlorophyll samples, meters).
- Budget to produce training videos to free-up staff time and assure consistency and long-term continuity in volunteer-collected lakes data.
- Replacement of analytical instruments in the biology lab because parts are no longer available (e.g. 3+ decade-old conductivity meter).
- A second lightweight canoe to better facilitate access to remote sites.
- Resources to replace life jackets used when recertifying volunteers.
- Cold weather gear (float coats and/or survival coats) for safe monitoring during cold water conditions
- Equipment to collect depth data to create more accurate bathymetric maps so that we can train volunteers to collect the necessary data.

Analysis -

- Budget for eDNA techniques to better monitor species occurrence, particularly in reference lakes.
- Budget to support ELISA-based microcystin testing method. Budget to support more advanced analysis to determine concentrations of all cyanotoxins.

- Resources to expand water testing to include emerging contaminants (e.g., pharmaceuticals, PFAS, optical brighteners) that may be identified as occurring in lakes.
- Funding for processing and taxonomic analysis of macroinvertebrates, zooplankton and phytoplankton for the development of Biocriteria.

E. Invasive Aquatic Species

Overview -- Maine's 120th legislature created the Invasive Aquatic Species Program in 2001 to:

1) prevent introductions of invasive aquatic species through education and boat inspections;
2) facilitate early detection through the training of volunteers who survey water bodies for invasive species; and
3) manage existing infestations within state waters with efforts ranging from rapid response to small, new infestations to multi-year removal of large, established infestations.

The MEDEP Invasive Aquatic Species Unit (IASU) concentrates on invasive aquatic plant species but also collaborates as needed with MEDIF&W on invasive animal issues. Funded by a dedicated, non-lapsing fund generated from $10 fees on in-state boat registrations and $20 fees for out-of-state boats using inland waters, the program employs three full-time staff at MEDEP who collaborate with outside cooperators to execute major objectives such as boat inspections, plant survey training and provision of small grants. Objectives to enhance public awareness and encourage invasive species prevention have resulted in significant rapport between program staff and citizens including annual news media coverage.

Brief Project Descriptions:

- Courtesy Boat Inspection (CBI) Program – Maine's first line of defense is preventing spread of invasive aquatic plants and other species through voluntary boat inspections by paid and volunteer inspectors trained through an agreement with Lakes Environmental Association in Bridgton, Maine. The number of annual inspections has increased from a few thousand in the first few years of the program to greater than 80,000 in at least three consecutive years. The IASP awards grants to lake associations and municipalities coordinating local boat inspection programs.
- Invasive Plant Patrollers – The IASU provides most funding for the LSM-VLMP's Invasive Plant Patrol (IPP) workshops, a program to build citizen-based early detection system to screen Maine lakes for invasive aquatic plants and other species. Since the first IPP workshop in 2002, the LSM has trained thousands of individuals to screen Maine waters for aquatic invaders.
- Rapid Response – The IASU developed along with MEDIF&W Maine's Rapid Response Plan for Invasive Aquatic Plants, Fish and other Fauna in 2006. IASP staff have conducted rapid response to incipient infestations of several invasive aquatic plants including Eurasian watermilfoil (*Myriophyllum spicatum*) and hydrilla (*Hydrilla verticillata*). Rapid response projects may include public meetings and outreach, frequent monitoring (including diving by IASU staff) for plant presence and

efficacy of control efforts, containment screens to prevent downstream spread, manual and chemical control techniques, and temporary restrictions on use of the affected water to facilitate control.

- Long-term Plant Control – The IASU provides guidance and grants to lake associations working to manage well-established infestations of invasive aquatic plants. Lake associations contribute significant in-kind and cash match to these projects that in some cases have existed for more than a decade. The IASU may conduct or assist with screening surveys of infested lakes and lakes hydrologically connected or in close geographic proximity to infested lakes.
- Plant Community Surveys – The IASU supports and participates in aquatic plant community survey projects designed to document aquatic plant habitat communities and species while screening for invasive and threatened/rare/endangered species.
- Interagency Task Force on Invasive Aquatic Plants and Nuisance Species – The Task Force was established to advise state agencies on matters pertaining to research, control and eradication of invasive aquatic plants and nuisance species. IASU staff chairs the biannual Task Force deliberations on issues such as invasive aquatic species spread prevention, efforts to control invasive aquatic plants and nuisance fish, and enforcement of invasive aquatic species laws.

Program Needs:

Staff –

- 1 FTE to assist with all aspects of program (currently a position is vacant but lacking sufficient funding to refill).

Increased Funds for Grants to Lake Organizations

- Annual requests for local invasive aquatic plant prevention and plant removal programs exceed available grant funds. Additional grant funds are needed to address current shortfall and future needs.

Monitoring Equipment –

- Underwater communication system is needed for safety and improved efficiency of dive operations.

Analysis –

- Aquatic plant genetic sequencing and exploring the use of eDNA as an early detection tool for zebra mussel and other mollusks, the latter in collaboration with Alison Watts from the University of New Hampshire. (Note: Colleagues from NH, VT, MA and CT have expressed interest in participating in the eDNA project.)

F. Marine

Overview – The Marine Unit (MU) is responsible for the statewide water quality standards assessment of classified estuarine and coastal waters of Maine. Non-attainment waters are addressed through the TMDL process if determined to be of non-natural causes, or through wastewater licensing. Monitoring and assessment are accomplished through MU actions as well as collaborative efforts with external organizations, and entail project development, sample collection and processing, and data review relative to water quality standard attainment.

The addition of marine community and benthic habitat characterizations, as well as coastal acidification parameters to monitoring efforts has long been an aspiration of the MU. Beginning in 2019, the MU intends to pilot a more comprehensive strategy under the Marine Environmental Monitoring Program (MEMP; see bullet below and Table 5) that most closely resembles a screening level, stratified assessment of marine waters of the state. Complete adoption of the comprehensive monitoring strategy is projected to begin in 2020. The monitoring design will utilize five rotating regions, or segments, of the coast, to include Southern Maine, Casco Bay, Mid-coast Maine, Penobscot Bay and Downeast Maine 1, and Downeast Maine 2. Region monitoring would occur in the direction of the south/west to the north/east.

The 2019 pilot will determine feasibility of monitoring four sites within each of three estuaries within a particular region in a given year, with repeated visits to each estuary from May-October. The estuaries within each region will be chosen based on perceived magnitude of anthropogenic influence such that the 1) most influenced would contain at least a major point source and notable year-round population, the 2) intermediately influenced would contain at least minor point sources and regular seasonal population, and the 3) least influenced would be unimpacted by direct point source discharge and be subject to a small year-round population and only minor seasonal tourism influx. The four sites within each estuary would be situated to characterize ambient conditions 1) at or just below the Head of Tide, 2) in the mid-estuary, 3) at the mouth of the estuary, and 4) at a defined distance offshore from the mouth. To account for inter-annual effects of weather events (drought, e.g.) and climate shifts (temperature increase, e.g.) on monitoring data, one site in each of two regions will be maintained every May-October. For all sites in all regions, an effort will be made to incorporate previously-monitored water quality sites, including those from National Coastal Assessment (NCA)/National Coastal Condition Assessment (NCCA) surveys, into study plans.

Sampling to occur at each site on each event will include parameters currently measured as part of the MEMP, and once per sampling period, will additionally include water column grabs for ocean acidification parameters (total alkalinity, dissolved inorganic carbon, e.g.) and sediment grabs for benthic infauna identification and enumeration, sediment grain size analysis, and total organic carbon concentration. At the time of sediment grab sampling, underwater photos will be taken of the benthic surface at each site to assess epifaunal and epifloral functional groups, and presence and identification where possible of conspicuous invasive species. Where sediments are too coarse for grab sampling, the underwater photos will enable at least a qualitative assessment of grain size and any epifaunal and epifloral community. Additional parameters that may be included upon each sampling event or once-per-season monitoring include enterococci counts and sediment sulfide concentration, respectively. If resources permit, one to two unattended sondes would be deployed for some portion of the sampling period in each estuary. Finally, low tide aerial photography will be acquired over each entire shoreline segment during a

given year, from head of tide to the outer coast, to document eelgrass presence and percent cover.

Brief Project Descriptions:

- Marine Environmental Monitoring Program (MEMP) – The MU studies estuaries and coastal areas influenced by industrial contaminants and pollutants to determine compliance with and attainment of water quality standards. Monitoring foci include water column condition with an emphasis on dissolved oxygen, nutrient concentrations and light attenuation, and biological indicators including phytoplankton biomass and eelgrass distribution and health metrics.
- SWAT – The MU monitors toxic contaminants, including some emerging contaminants, in mussel and clam tissues, lobster tomalley and meat, and historically in cormorants, seals, and sediment. Marine Unit staff collaborate with the MEDMR and Maine Center for Disease Control & Prevention (MECDC&P) to determine sampling priorities based on shellfish area harvest status.
- Gulfwatch Contaminant Monitoring (program of the Gulf of Maine Council on the Marine Environment) – Each northeast state, including Maine, and Canadian provinces bordering the Gulf of Maine, monitors toxic contaminants in mussels at selected sites. The MU completes the Maine component of Gulfwatch, which enables intrastate (SWAT) and regional comparisons.
- National Coastal Condition Assessment (NCCA) http://www.epa.gov/national-aquatic-resource-surveys/ncca – The MU coordinates Maine participation for the NCCA and contributes to the NCCA Steering Committee. The survey estimates the condition of coastal resources on a regional and national basis using a variety of metrics based on water, sediment and tissue samples at preselected sampling sites using a probabilistic survey design.
- Friends of Casco Bay (FOCB) – This citizen science organization has been monitoring the water quality in Casco Bay since 1993. FOCB staff and volunteer monitors conduct surface and water column profile sampling and collect grab samples for nutrient analyses at long term sites, and engage in special projects like stormwater contaminants sampling, mudflat surveys to assess impacts of coastal acidification, and observations of bloom-forming macroalgae distribution. The MU collaborates on projects of mutual interest to further monitoring and research goals.
- Marine Invader Monitoring and Information Collaborative (MIMIC) program – Managed by the Massachusetts Office of Coastal Zone Management and locally coordinated by the Wells National Estuarine Research Reserve, the MU conducts monthly assessments during summer at a long-term monitoring location to document presence/absence and relative quantity of marine invasive species.
- Maine Legislative Resolve 2007, Chapter 49 – This piece of legislation required the MEDEP to initiate development of statewide marine nutrient criteria, with a focus on Casco Bay. Documents summarizing progress from 2007-2012 are present at: http://www.maine.gov/dep/water/nutrient-criteria/index.html. The MU continues to gather and assess data relative to nutrients and relevant indicators, most notably eelgrass, and collaborates with MEDEP modelers to address the need for nutrient reductions via the discharge permit renewal process (Reasonable Potential (RP) analysis).

- Technical support -- The MU supports a variety of coastal volunteer monitoring groups, especially the FOCB, Casco Bay Estuary Partnership (CBEP), Maine Coastal Observing Alliance, Kennebec Estuary Land Trust, and Boothbay Region Land Trust. Such external groups complete marine studies across the state using either established or under development, Department-approved quality management documentation, and submit data to the MU for use in monitoring planning, discharge permit reviews, and/or 303(d) assessments.

Program Needs:

Staff –

- Four FTEs (one Biologist II, two Biologist I, one Environmental Technician) to accomplish the goals of the comprehensive MEMP strategy, including coastwide eelgrass mapping and coastal acidification parameter monitoring.

Monitoring Equipment –

- Six water quality sondes capable of measuring temperature, salinity, dissolved oxygen and pH. Along with two such sondes already in use by the MU, the sondes will be deployed unattended in candidate estuaries during regional rotations between May and October. The cost of these five sondes is estimated at $30,000.

Analysis –

- With the addition of benthic infauna sampling, funding assistance will be critical to facilitate sorting of grab sample organisms and taxonomic identification. Processing of 15 samples per year would meet the goals of benthic community characterization. Some cost savings may be realized under a cooperative agreement with the Maine Coastal Program (DMR) to co-employ a taxonomist.
- Funding will be required to facilitate laboratory analysis of coastal acidification parameter grab samples for total alkalinity and/or dissolved inorganic carbon.
- Funding assistance will be needed for plane-based aerial surveys to map the distribution and percent cover of eelgrass along each shoreline segment during annual surveys.

G. Watershed Management

Overview – The Watershed Management Unit (WMU) is responsible statewide for local efforts focused on stressor identification in impaired or threatened streams and lakes. The Unit works closely with other DEA units leveraging their monitoring tools and protocols as well as conducting some of their own monitoring and assessment through staff and volunteers.

Brief Project Descriptions:

- Maine Volunteer River Monitoring Program (VRMP) – Supports local entities (river associations, land trusts, Conservation Commissions) in monitoring streams and rivers of local and state interest. The WMU provides equipment, training, Quality Assurance/Quality Control (QA/QC) oversight, data management and reporting.
- Stressor Identification – Often working with local entities (municipal, NGOs, Soil and Water Conservation Districts - SWCDs), the WMU works to identify the non-point source (NPS) stressor(s) driving an impairment in marine waters, streams and

lakes. Results are used to develop restoration plans (watershed based plans) and restoration efforts (Federal Clean Water Act (CWA) 319 grant funding). Stressor identification utilizes a variety of tools including but not limited to watershed surveys, stream habitat walks, bacteria source tracking, water chemistry, and fluvial geomorphology evaluation.

- Watershed Project Results/Effectiveness – The WMU works with local partners to monitor and/or evaluate the effectiveness of NPS watershed projects in protecting and restoring water quality. Involves monitoring to determine if water quality standards are being met and document improvements over time.
- National Water Quality Initiative (NWQI) – Working with the United States Department of Agriculture's (USDA's) Natural Resource Conservation Service and the USEPA, the WMU provides monitoring and assessment in targeted NWQI watersheds.
- Non-point source TMDL – Data collected for purposes of developing load allocations for TMDL reports for Category 5 listed impaired waters.
- Bacteria – Conduct bacteria monitoring and/or source tracking in targeted watersheds to support the Maine Healthy Beaches Program, for urban stream assessment, or for watershed-based plan development or implementation.
- Long Term Temperature Monitoring – Work with Stream Temperature Work Group (United States Fisheries and Wildlife Service et al.) on monitoring stream temperature using continuous monitoring devices. Due to interest in looking at long term trends, higher QA/QC standards based on United States Geological Survey (USGS) recommendations will be used (beyond the Stream Temperature Work Group protocols).

Program Needs:

Staff –

- Additional biologist or environmental specialist to help expand the VRMP, develop stream stewardship networks and support stream stressor field monitoring and data analysis.
- Additional ES III to provide oversight of the TMDL program.

Monitoring Equipment –

- Continuous monitoring equipment (e.g., Onset hobo loggers) that MEDEP could lend out to partners to collect additional data for stressor identification and watershed project results monitoring.
- Idexx bacteria monitoring supplies to provide to Maine Healthy Beaches and/or VRMP volunteers to support stressor identification and other watershed unit activities.

Analysis –

- Aquatic biologist expertise to help interpret macroinvertebrate monitoring data and identify stressors driving stream impairments and threats.
- Funding for macroinvertebrate taxonomic analysis to support stressor identification in impaired and threatened streams.

H. Maine Healthy Beaches (MHB) Program

Overview - The MHB Program is a statewide effort to monitor water quality and protect public health on Maine's coastal beaches The MHB Program provides a quality-assured, unified structure to assess risk and identify pollution sources; improve water quality by building local capacity to address issues; and to educate and engage citizens. Through 2018, MHB has been administered by MEDEP with day-to-day program delivery carried out by the University of Maine Cooperative Extension (UMCE). In 2019, MEDEP plans to take over administration of all aspects of the program.

Brief Project Descriptions:

- Provide policy oversight & coordinate the involvement of MEDEP and state agency staff (e.g. MEDMR, Maine Department of Health and Human Services - MEDHHS) for program improvements and/or local remediation work.
- Maintain MHB data in EGAD and ensure the quality and proper submission of monitoring, notification, and location data into the USEPA Central Data Exchange - CDX (Water Quality Exchange – WQX; PRogram tracking, beach Advisories, Water quality standards, and Nutrients - PRAWN). Disseminate data via requests, reporting purposes, etc.
- Coordinate all monitoring, assessment and public notification components for approximately 60 beaches (Kittery to Mount Desert Island). Serve as primary liaison to local beach managers, monitors and partners; oversee local implementation of the program and provides ongoing support & technical assistance.
- Train a cadre of local beach managers, staff, and volunteers (approx. 200 annually); develop and update monitoring, laboratory, notification and training protocols & materials.
- Advise towns/parks in making beach postings and management decisions; coordinate resampling and notification efforts, and corrective actions when appropriate.
- Ensure that quality assurance objectives and protocols (monitoring, notification, data management) are met; seek support from partners as needed. Quality check all monitoring, notification and location data before submission into EGAD, assist MEDEP in quality checks before EPA submission.
- Design and implement enhanced monitoring and pollution source identification/remediation efforts.
- Develop risk assessment tools; research innovative pollution source tracking techniques; seek partnerships as needed.
- Build local capacity to address pollution issues; bring together diverse partners with a focus on sharing resources and solving problems.

Program Needs:

Staff –

- Additional Environmental Specialist to support and expand Program capacity to recruit and retain volunteers, implement pollution source identification/remediation projects, risk assessments, etc.

Monitoring Equipment –

- IDEXX bacteria supplies to support enhanced pollution source identification projects within targeted watersheds impacting coastal marine beaches.
- Supplies to support microbial source tracking (MST) studies (e.g., sterile bottles, coolers, gloves).
- DO meters for use in source tracking projects and to be lent out to partners conducting additional monitoring and source tracking activities.

Analysis –

- Funding to support enhanced monitoring to better inform management decisions including the expansion of monitoring locations to address additional priority areas and for pollution assessment following heavy rainfall, increased monitoring frequency at high risk beaches, expansion of analytical methods to address a broader range of illness symptoms, and increased frequency of sanitary surveys.
- Funding for PCR/qPCR equipment, analyses, and expertise to provide more rapid detection of harmful pathogens and pathogen indicators in coastal waters in support of public health.

Technology –

- Replace and upgrade field season Program database to increase functionality, improve transfer of data to EPA databases, and improve communication with volunteers, beach managers, laboratories, and the public.
- Funding for a smart device for Program Coordinator to be able to check e-mail and program database as needed, regardless of time of day or location of Coordinator.

The following six tables (Tables 1-6) summarize specific attributes for monitoring projects conducted by each section or unit. Various groups are indicated under the group of columns identified as "Collaborators". For the purposes of these tables, a collaborator is defined as a group of active participants rather than a source of funding for the project. "Geographic Extent" includes choices that characterize the spatial extent of a project. Attributes listed under "Focus" indicate the general purpose of each project. "Approach" refers to aspects of the project design that address sample site selection. "Frequency" attributes characterize how often a site or set of sites are visited. Selections included under "Parameters" indicate the breadth of the monitoring design. Not included in these tables is an indication of the project duration. Most monitoring occurs as long as needed; however, in certain studies the duration is appropriate to accomplish a specific short-term task.

Nearly all water quality data collected are used for attainment assessment and reporting under state and federal mandates, the exception being data which do not meet the program or project quality assurance standards. Biological data collected from rivers, streams and wetlands are also used to assess attainment status for reporting purposes. Biological data from lakes are currently collected for developing assessment tools to be used in future attainment assessments. Biological data from marine waters are projected for collection within the monitoring period covered by this document, for eventual development of benthic biocriteria and attainment assessments. See Section 8 for further information regarding reporting of results.

Table 1. Monitoring Designs Used for Assessment of Rivers and Streams.

Project Name	Collaborators*						Geographic Extent				Focus			Approach						Frequency								Parameters								
	Federal	Interstate	State & Tribal Gov't	Univ. or College	Local Organizations	Citizen	Statewide	Major Drainage Basin	Specific Waters	# Stations/year	Screening	Trend	Intensive	Probability based	Stratified	Census	Fixed Station	Targeted	Opportunistic	Weekly	Bi-weekly	Monthly	Quarterly	Seasonally	Annual	Opportunistic	Rotating Basin (# yrs)	Physical	Chemical	Biological	Microbiological	Priority Organics	Tissue	Sediment	Toxics	Other
Point Source Discharge Studies (TMDL or Alternative)			X		X[1]	X	X		X	25			X				X	X						S		X	P	X	X	X					TMDL Depen	
Surface Water Ambient Toxics			X	X			X		X		X		X				X	X							X		X	X	X	X		X	X	X	X	X
IBI			X				X		X		X					X									X			X	X	X						X
NonPoint Source Restoration & Protection Studies (TMDL, Alternative, or other approaches)		X[2]	X				X		X	X		1	X				X	X			X	X		X		S		X	X	X	X			X		M
Atlantic Salmon Habitat Monitoring	X		X	X	X			X	X	V	X	X	X			X	X	X		X	X	X	X	X	X			X	X	X							
River/Stream Nutrient Criteria (incl. Ref. sites), RP analysis		X[2]	X				X		X		X							X						X				X	X	X				X			
Urban Stream Restoration Project	X		X		X	X			X				X			X	X					X		S				X	X	X							W
Ecological Reserves			X						X			X	X			X	X	X						S			X	X	X	X							
Data used in Assessment (QA & Priority)	All data used in Assessments.																																				
Comments	River/Stream Nutrient Criteria Development uses nutrient data collect from all projects listed in this table and collected from Rivers/Stream sites monitored by the Biomonitoring Unit. Seasonally: S=stormwater; Other: M=metals, W=watershed, V=variable [1] Help of Tribes, River groups, treatment plant operators whenever possible; [2] Tool Development *Includes active participation, not funding sources																																				

Table 2. Monitoring Designs Used for Biomonitoring Assessment of Rivers, Streams, and Wetlands.

Project Name	Collaborators*						Geographic Extent				Focus			Approach						Frequency								Parameters								
	Federal	Interstate	State & Tribal Gov't	Univ. or College	Local Organizations	Citizen	Statewide	Major Drainage Basin	Specific Waters	# Stations/year	Screening	Trend	Intensive	Probability based	Stratified	Census	Fixed Station	Targeted	Opportunistic	Weekly	Bi-weekly	Monthly	Quarterly	Seasonally	Annual	Opportunistic	Rotating Basin (# yrs)	Physical	Chemical	Biological	Microbiological	Priority Organics	Tissue	Sediment	Toxics	Other
NARS Project (w/EPA)	X	X	X				X			?				X				X	X							X		X	X	X						X
Stream Macroinvertebrate (Agricultural & Urban)			X				X	X	X	15	X	X	X				X	X	X						X		5	X	X	M						X
Stream Algae (Agricultural & Urban)			X	X			X	X	X	45	X	X	X				X	X	X						X		5	X	X	A						X
Surface Water Ambient Toxics (SWAT)			X				X	X	X	40	X	X	X				X	X	X						X		5	X	X	M		X			X	X
Biological Monitoring of Wetlands			X				X	X	X	25	X	X	X				X	X	X						X		5	X	X	X						X
Ecological Reserve Biomonitoring			X				X	X	X	0-5	X	X	X				X	X	X							X		X	X	X						X
Data used in Assessment (QA & Priority)	All data used in Assessments.																																			
Comments	Biological: M=macroinvertebrates, A=algae *Includes active participation, not funding sources																																			

Table 3. Monitoring Designs Used for Assessment of Lakes.

	Federal	Interstate	State & Tribal Gov't	Univ. or College	Local Organizations	Citizen	Statewide	Major Drainage Basin	Specific Waters	# Stations/year	Screening	Trend	Intensive	Probability based	Stratified	Census	Fixed Station	Targeted	Opportunistic	Weekly	Bi-weekly	Monthly	Quarterly	Seasonally	Annual	Opportunistic	Rotating Basin (# yrs)	Physical	Chemical	Biological	Microbiological	Priority Organics	Tissue	Sediment	Toxics	Other
Lake Stewards of Maine Volunteer Lake Monitoring Program (LSM-VLMP)		X	X		X	X	X		x	450	X	X					X		X		X							X	X							
MEDEP Lake TMDL Studies			X	X	X	X			X	2		X	X				X	X				X						X	X	X						H
MEDEP Lake Special Studies			X	X	X	X			X	15		X	X				X	X				X						X	X	X				X		H
MEDEP Baseline Sampling			X	X		X	X		X	100	X		X				X	X	X						Aug			X	X	X				X		H
Univ. of Me, Special Studies		X	X	X			X		X	V	X	X	X	X	X	X								X				X	X							
Ecological Reserves			X						X	15		X	X			X	X	X						S			5	X	X	X				X		H
National Lake Assessment	X						X				X	X		X	X												5	X	X	X	X	X		X	X	H
Littoral Habitat Metric Development	X				X	X	X			20[1]																										
Surface Water Ambient Toxics (SWAT)			X				X	X	X	15	X	X	X				X	X	X						X	X				X				X	X	X
Cyanobacteria/cyanotoxin monitoring (SWAT & 106)	X						X			35	X	X		X	X			X	X			X			X			X	X	X				X		
Data used in Assessment (QA & Priority)	Data collected through the LSM, TMDL Studies, Special Studies, Baseline & Ecological Reserve Sampling are used for assessment.																																		
Comments	*Includes active participation, not funding sources. [1]20 lakes=200 stations. V=varies. H=habitat.																																		

Table 4. Monitoring Designs Used in Invasive Aquatic Species Program

Project Name	Collaborators*						Geographic Extent				Focus			Approach						Frequency								Parameters								
	Federal	Interstate	State & Tribal Gov't	Univ. or College	Local Organizations	Citizen	Statewide	Major Drainage Basin	Specific Waters	# Stations/year	Screening	Trend	Intensive	Probability based	Stratified	Census	Fixed Station	Targeted	Opportunistic	Weekly	Bi-weekly	Monthly	Quarterly	Seasonally	Annual	Opportunistic	Rotating Basin (# yrs)	Physical	Chemical	Biological	Microbiological	Priority Organics	Tissue	Sediment	Toxics	Other
Courtesy Boat Inspection	X	X	X		X	X	X				X									X*															X
Invasive Plant Patrol		X	X	X	X	X	X			50+	X												X	X	X					X						X
Rapid Response	X		X		X	X	X			1-2	X														X					X						X
Long-term Plant Control			X		X	X	X		X	5		X	X				X	X				X			X					X						X
Plant Community and Screening Surveys			X	X	X	X	X			10	X							X							X					X						X
Data used in Assessment (QA & Priority)																																				
Comments	*Inspections occur daily.																																			

Table 5. Monitoring Designs used for Assessment of Estuarine and Marine Waters.

Project Name	Collaborators[1]						Geographic Extent				Focus			Approach						Frequency								Parameters								
	Federal	Interstate	State & Tribal Gov't	Univ. or College	Local Organizations	Citizen	Statewide	Major Drainage Basin	Specific Waters	# Stations/year	Screening	Trend	Intensive	Probability based	Stratified	Census	Fixed Station	Targeted	Opportunistic	Weekly	Bi-weekly	Monthly	Quarterly	Seasonally	Annual	Opportunistic	Rotating Region Region (#	Physical	Chemical	Biological	Microbiological	Priority Organics	Tissue	Sediment	Toxics	Other
Marine Environmental Monitoring Program (MEMP) (incl. coast-wide eelgrass mapping, nutrient criteria development)	X	X	X	X	X	X	X		X	V	X	X	X	X	X	X	X	X	X		X	X		X	X	X	5[2]	X	X	X			X	X		
Surface Water Ambient Toxics (SWAT) Program			X				X			V	X	X						X							X			X			X	X	X	X	
Gulfwatch Contaminants Program	X	X		X			X			V		X						X							X			X			X	X		X	
National Coastal Condition Assessment (NCCA)	X		X				X			40[3]	X			X											5[3]			X	X	X	X		X	X	X	
Friends of Casco Bay (FOCB)	X			X	X	X			X	V	X	X				X	X	X	X		X	X				X		X	X	X				X	X	
Marine Invader Monitoring and Information Collaborative (MIMIC)	X								X	1		X					X					X		X						X						
Data used in Assessment (QA & Priority)	Data collected through the MEMP, SWAT, external organizations with approved QAPPs including independent volunteer-based groups and those supported by the Volunteer River Monitoring Program (VRMP)																																		
Comments	[1] Includes active participation, not funding sources. V=varies. [2] Rotating region monitoring design anticipated to begin in 2020. [3] In 2015 and 2020, sites sampled per year = 40. Frequency of survey pending after 2020.																																		

Table 6. Monitoring Designs used by the Watershed Management Unit and Maine Healthy Beaches Program.

Project Name	Collaborators*						Geographic Extent				Focus			Approach						Frequency								Parameters								
	Federal	Interstate	State & Tribal Gov't	Univ. or College	Local Organizations	Citizen	Statewide	Major Drainage Basin	Specific Waters	# Stations/year	Screening	Trend	Intensive	Probability based	Stratified	Census	Fixed Station	Targeted	Opportunistic	Weekly	Bi-weekly	Monthly	Quarterly	Seasonally	Annual	Opportunistic	Rotating Basin (# yrs)	Physical	Chemical	Biological	Microbiological	Priority Organics	Tissue	Sediment	Toxics	Other
Long Term Temperature	X	X	X				X			20		X																X	X							
National Water Quality Initiative (NWQI)	X		X						X			X					X								X	X		X	X	X					W
Stream Stressor Identification	X		X	X	X	X			X	20	X	X	X			X	X	X	X		X	X		X		X		X	X	X				X	W
Watershed Project Results/Effectiveness				X	X	X			X	5		X					X	X						X	X				X	X					
VRMP			X		X	X	X		X		X	X					X	X	X	X	X	X						X	X		X					
Bacteria Monitoring			X	X	X	X			X		X	X					X	X			X			X					X		X					
Maine Healthy Beaches	X	X	X	X	X	X			X		X	X					X	X	X	X	X	X		X		X		X	X		X					X
Data used in Assessment (QA & Priority)	Data collected through the VRMP, Stream Stressor Identification, NWQI are used for assessment.																																			
Comments	*Includes active participation, not funding sources																																			

I. Emerging Issues

Overview: Emerging issues may be the subject of a relatively new monitoring design, or yet to be elevated to a status requiring a specific monitoring design. Table 7 indicates which monitoring programs are likely to be impacted by each issue.

Brief Issue Descriptions:

- Pharmaceuticals and Personal Care Products (PPCPs) have been identified as potential contaminants below municipal point sources particularly in low dilution scenarios, and possibly in smaller lakes having low flushing rates and many adjacent septic systems located on permeable soils or fractured bedrock with their watershed.
- Persistent Bioaccumulating Toxins (PBTs) other than those routinely monitored are likely to be targeted for monitoring at some time in the future.
- Perfluorooctanoic Acids (PFOA) and Perfluorooctanesulfonic Acids (PFOS) are chemicals that are part of a larger group of perfluoroalkyl substances that have shown up on some drinking water supplies. MEDEP is working with USEPA on appropriate actions to respond to the presence of these chemicals in drinking water.
- Cyanotoxins: Cyanotoxins have been measured in Maine lakes that support cyanobacterial blooms. MEDEP has moved from screening surveys to statistically valid surveys and targeted monitoring to better characterize cyanotoxin occurrence in Maine lakes. Cyanotoxins may also be produced in rivers experiencing algal blooms.
- Cyanobacteria Picoplankton: Picoplankton blooms, thought to be cyanobacteria, have occurred over the past 4 years in Highland Lake (Windham). A collaborative research team began monitoring the lake intensively in 2108 to try to determine if the cause is related to warmer water temperatures, a longer ice-free season, fishery management or a combination thereof. Although picoplankton are found in all lakes, picoplankton blooms are not common in Maine. It is important to understand causal mechanisms in case other Maine lakes develop similar blooms.
- Longer ice-free season: In Maine, ice-on dates have been later in the year and ice-out dates earlier in the year over the last 20 years as compared to long-term records, resulting in a longer ice-free season. This will likely change the timing of phenological events critical to lake ecosystems, which could result in conditions that violate water quality standards.
- Extreme weather events: Over the past few decades, Maine has experienced an increasing number of extreme weather events. These events have impacted water quality through erosion of stream banks and sedimentation resulting in loss of habitat and higher nutrient loads that contribute to algal blooms in lake watersheds MEDEP staff are working with researchers at the University of Maine about modelling effects of such events to better predict which lakes are at risk.
- Other toxics: Maine Lakes are susceptible to effects from toxins generated within the lake (cyanobacteria), transported via atmospheric deposition, and entering from stormwater runoff. It is very likely that a new substance will be identified over the next decade, that will require monitoring resources.

- Invasive Organisms: MEDEP has focused most of its resources on invasive aquatic plants in lakes and streams. Fauna invasive to lakes and streams, and invasive flora and fauna in wetland and marine environs are likely to require future resources at this and/or other state agencies. Marine invasive species recently documented as having notable impacts on native biota include the green crab (*Carcinus maenas*) and Japanese red alga (*Dasysiphonia japonica*). Freshwater invasive macroinvertebrates and algae are also a concern in wetlands, streams, and rivers.
- Eelgrass Loss: Citizen reports of possible commercial fisheries impacts on eelgrass, scientist accounts of disappearance of transplanted eelgrass and invasive species effects on bed resilience, and the loss of a Maine state agency-led coast-wide eelgrass mapping program justify the sustained need for annual surveys to revise outdated information about eelgrass distribution and coverage. Coast-wide mapping using the rotating shoreline segment approach will enable mapping of each segment once every five years, while regular small scale eelgrass surveys, including in beds in proximity to major point source discharges and at long term monitoring sites, will assist with determination of forcing factors on eelgrass health and enable detection of change over greater time scales.
- Nuisance and Harmful Algal Blooms: Blooms of nuisance macroalgae on marine intertidal and subtidal flats have become more conspicuous and may be indicative of plentiful nitrogen availability. Phytoplankton species not previously prolific in Maine's coastal waters are becoming more abundant and resulting in shellfish harvest closures and causing detrimental impacts to marine life. Algal blooms are also showing up more frequently in streams, rivers and wetlands.
- Native Biological Community Shifts: Changes in native communities have already been observed and are hypothesized to be largely a result of an increase in water temperature, periodic freshening of estuaries due to increasingly frequent large storm events, and/or increasing dominance of invasive species. In order to accurately characterize the "native biological community", more regular assessments of fauna and flora will be incorporated into both freshwater and marine monitoring activities.
- Coastal and Ocean Acidification: Awareness of coastal vulnerability to acidification has increased in recent years and garnered attention in the Maine legislature (http://www.maine.gov/legis/opla/Oceanacidificationreport.pdf), been the subject of bond proposals to fund research initiatives, and resulted in formation of the Northeast Coastal Acidification Network (NECAN) and Maine Ocean and Coastal Acidification (MOCA) partnership. Given improving technologies to monitor acidification parameters and accessibility of analytical labs, assessments of acidification impact on water chemistry and marine life will become a higher priority in the near term.
- Coastal Wetlands including fringing marsh: Coastal marshes, particularly fringing marshes, are being lost by fragmentation due to shoreline development (dock, piers, etc.). Monitoring of this resource has been limited and needs to be expanded. The Gulf of Maine program monitoring subgroup has identified this habitat as a priority habitat to monitor.

- Chloride: Use of deicing materials on parking lots and roadways is impacting small stream biological communities and has been identified in a few Maine streams as the main stressor. Use of traditional LID practices may accelerate or exacerbate base flow impacts. There is a need to rethink both winter maintenance techniques and stormwater Best Management Practices (BMPs).
- Polycyclic Aromatic Hydrocarbons (PAHs): Nationally PAHs from coal tar sealant is garnering attention in urban impaired streams as a possible stressor to the biological community. PAHs will need to be considered when identifying stressors in Maine's urban impaired streams.
- Calcareous Bedrock pH/Phosphorus: A recent study indicates that in regions of the state with high calcareous bedrock the groundwater maybe super saturated with calcium carbonate ($CaCO_3$) that when exposed to the atmosphere, carbon dioxide (CO_2) is driven off raising the natural pH of the stream. Groundwater discharging around 7.0 and rising as high as 8.5 may be driving the release of phosphorus from sediments resulting in high available phosphorus especially in base flow conditions. Further study is needed to determine if changes should be made to recommended treatment practices/BMPs as well as to the State's pH criteria.
- Viruses. Viral pathogens are the leading causative agents of recreational waterborne illnesses. The USEPA is currently investigating the use of coliphages (instead of traditional fecal indicator bacteria) in the identification of recreational use impairments. If USEPA develops Recreational Water Quality Criteria for viruses/coliphages, these organisms may be targeted for monitoring at some time in the future.

Table 7. Emerging Issues.

Resource or Section Emerging Issue	Rivers & Streams	Biomonitoring of Rivers, Streams & Wetlands	Lakes – Water Quality	Lakes – Invasive Aquatic Species	Estuaries and Marine	Watershed Management
Water Use	X	X	X			
PPCPs	X	X	X		X	X
PBTs	X	X	X		X	
PFOA/PFOS	X	X	X		X	X
Cyanotoxins	X		X			
Cyano-picoplankton			X			
Longer ice-free seasons			X			
Extreme weather events	X	X	X		X	X
Other toxics			X			
Invasive Organisms		X		X	X	
Eelgrass Loss					X	
Nuisance and Harmful Algal Blooms		X			X	
Native Biological Community Shifts		X	X		X	
Coastal and Ocean Acidification					X	
Coastal Wetlands including fringing marsh		X			X	
Chloride	X	X				X
PAH	X	X				X
Calcareous Bedrock pH/Phosphorus	X	X				X
Viruses						X

J. Program Development

Monitoring is expected to continue at some level in association with most of the projects listed in Tables 1-6 above, however the reality of unpredictable funding makes it extremely difficult if not impossible to predict how quickly new parameters will be added to existing projects or how quickly program development progresses. The following tables (Tables 8-14) illustrate anticipated monitoring and program development milestones along a 10-year timeline.

Table 8. Rivers & Streams: Projected Program and Monitoring Elements.

YEAR Program / Project Element	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Nutrient Criteria Development										
Reference site monitoring – largely complete	X	X	X	X	X	X	X	X	X	X
Revised Draft				X						
Final Draft					X					
Identification of Water Quality Response Variables [nutrient & physical]	X	X	X	X	X	X	X	X	X	X
Data Analysis										
Toxics	X	X	X	X	X	X	X	X	X	X
Toxics Rule (adoption pending) Evaluation		X	X							
PPCPs, PBTs & PFOA/PFOS	X	X	X	X	X	X	X	X	X	X

Table 9. Biomonitoring (Rivers, Streams & Wetlands): Projected Program and Monitoring Elements.

YEAR Program / Project Element	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Develop and refine tolerance values and diagnostic metrics (wetlands and streams)	X	X	X	X	X	X	X	X	X	X
Finalize model to predict aquatic life criteria attainment for wetlands	X	X	X							
Incorporate numeric aquatic life criteria for wetlands into water quality standards				X	X	X	X	X	X	X
Algae										
Develop and refine tolerance values and diagnostic metrics (wetlands and streams)	X	X	X	X	X	X	X	X	X	X
Develop and finalize models to predict aquatic life criteria attainment for wetlands	X	X	X	X	X					
Incorporate numeric aquatic life criteria into water quality standards (wetlands and streams)				X	X	X	X	X	X	X
Plants										
Develop and refine indicators and diagnostic metrics	X	X	X	X	X	X	X	X	X	X
Fish										
Develop and refine biological assessment model (IBI, in collaboration with Rivers/Streams Section)	X	X	X	X	X	X	X	X	X	X
Develop and refine tolerance values and diagnostic metrics	X	X	X	X	X	X	X	X	X	X

Table 10. Lakes: Projected Program and Monitoring Elements.

YEAR Program / Project Element	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Lakes Biological Condition Gradient Development										
Pelagic Index Development (zooplankton & phytoplankton)										
Metric Development & Testing	X	X	X	X						
Multivariate Model Development			X	X	X	X				
Model Testing & Refinements					X	X	X	X		
Littoral Habitat Index Develop. (habitat, disturb., plants)										
Data collection & database development	X	X	X	X	X					
Metric Development & Testing		X	X	X	X	X				
Multivariate Model Development				X	X	X	X			
Model Testing & Refinements					X	X	X	X		
Littoral Index Develop. (macroinvertebrates, minnows)										
Data collection & database development	X	X	X	X	X					
Taxonomic Analyses (macroinvertebrates, fish)		X	X	X	X	X				
Metric Development & Testing			X	X	X	X	X			
Multivariate Model Development				X	X	X	X			
Model Testing & Refinements					X	X	X	X		
Integration with other indicators							X	X	X	X
Scorecard Development		X	X	X	X	X	X	X	X	X
Merging of Pelagic and Littoral Model Results – BCG								X	X	X
Lake Internship Program (as funding allows)	X	X	X	X	X	X	X	X	X	X
Cyanotoxin Monitoring										
Probabilistic monitoring	X	X	X	X	X	X	X	X	X	X
Targeted monitoring	X	X	X	X	X	X	X	X	X	X
Development of In-State analyses	X	X	X	X						
Development of Cyanotoxin Advisory (with MECDC&P)	X	X	X	X						
Toxics Screening (PPCPs, PBTs & PFOA/PFOS in high risk lakes)				x	x					

Table 11. Invasive Aquatic Species Program: Projected Program and Monitoring Elements.

YEAR Program / Project Element	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Courtesy Boat Inspection	X	X	X	X	X	X	X	X	X	X
Invasive Plant Patrol	X	X	X	X	X	X	X	X	X	X
Rapid Response	X	X	X	X	X	X	X	X	X	X
Evaluation of Long Term Plant Control	X	X	X	X	X	X	X	X	X	X
Plant Community and Invasive Plant Screening Surveys	X	X	X	X	X	X	X	X	X	X
Invasive Organisms, esp. Small-Bodied Organisms	X	X	X	X	X	X	X	X	X	X

Table 12. Estuarine & Marine: Projected Program and Monitoring Elements.

YEAR Program / Project Element	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Marine Environmental Monitoring Program (MEMP)										
Data collection (sources and impacts)	X	X	X	X	X	X	X	X	X	X
Eelgrass survey and interpretation	X	X	X	X	X	X	X	X	X	X
Monitoring parameter development (benthic community and habitat characterization, coastal acidification)				X	X					
Toxics Monitoring										
Surface Water Ambient Toxics (SWAT) Program	X	X	X	X	X	X	X	X	X	X
Gulfwatch Contaminants Program*	X			X	X	X	X	X	X	X
National Coastal Condition Assessment (NCCA)										
Maine survey coordination					X					X
Collaborative Projects										
Friends of Casco Bay	X	X	X	X	X	X	X	X	X	X
Other organizations	X	X	X	X	X	X	X	X	X	X
Marine Invader Monitoring and Information Collaborative (MIMIC)										
Data collection (presence/absence and relative quantity)			X	X	X	X	X	X	X	X
Nutrient Criteria Development										
Nutrient and indicator data collection	X	X	X	X	X	X	X	X	X	X
Data management and database population	X	X	X	X	X	X	X	X	X	X
Reasonable Potential analysis	X	X	X	X	X	X	X	X	X	X
Data analysis and model development**	X	X	X	X	X	X	X			
Criteria establishment**						?				

** As program funding is uncertain at this time, future of involvement is uncertain.*

*** Model and criteria development will occur as appropriate given Reasonable Potential analysis, focused estuary/embayment studies, and possible EPA support (N-STEPS program)*

Table 13. Watershed Management: Projected Program and Monitoring Elements.

YEAR Program / Project Element	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Long-term Temperature Monitoring										
Site reconnaissance and selection		X								
Data collection and management		X	X	X	X	X	X	X	X	X
National Water Quality Initiative (NWQI)										
Meduxnekeag River - post-BMP monitoring				X	X					
Unity Pond – ongoing and post-BMP monitoring			X	X						
New NWQI Watershed(s) – pre-BMP monitoring				X	X					
New NWQI Watershed(s) – post-BMP monitoring									X	X
Stream Stressor Identification*	X	X	X	X	X	X	X	X	X	X
Long-term algae biomonitoring in agricultural watershed			X	X	X	X	X	X	X	X
Watershed Project Results/Effectiveness	X	X	X	X	X	X	X	X	X	X
Volunteer River Monitoring Program	X	X	X	X	X	X	X	X	X	X
Bacteria Monitoring	X	X	X	X	X	X	X	X	X	X
Maine Healthy Beaches	X	X	X	X	X	X	X	X	X	X
Long-term Chloride Biomonitoring Study			X	X	X	X	X	X	X	X
Calcareous Bedrock pH/Phosphorus Study										
Water quality monitoring in Amsden Brook		X	X							
Water quality monitoring in similar agricultural & non-ag. streams			X	X						

*PAHs, PFOA/PFOS, chloride and other emerging contaminants of concern will be monitored as needed as part of the Stream Stressor Identification process.

Table 14. Other Division-wide Elements Not Directly Supported.

YEAR Program / Project Element	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
EGAD maintenance, including data uploads to WQX	X	X	X	X	X	X	X	X	X	X
Development of Landscape Level Disturbance Variables (GIS)	X	X	X	X	X	X	X	X	X	X
Technical Support to Indian Nations, Conservation Entities, Volunteer Groups (ongoing need)	X	X	X	X	X	X	X	X	X	X
Ecological Reserve Monitoring (monitoring, taxonomy, data analysis, reports)	X	X	X	X	X	X	X	X	X	X
Watershed Level Integration of BCGs for all Surface Waters			?	?	X	X	X	X	X	X

4. Indicators

A. Maine Water Quality Standards Program

The quality of Maine waters is described in terms of physical, chemical and biological characteristics associated with the state's Water Classification Program. Established in Maine statute (38 M.R.S. Sections 464-470), the Water Classification Program includes Water Quality Standards for each class of water consisting of 1) designated uses (e.g. drinking water supply, recreation in and on the water, habitat for fish and other aquatic life), 2) narrative or numeric criteria (e.g. bacteria, DO and aquatic life) and characteristics (e.g. natural, free flowing) that specify water quality characteristics necessary to maintain the designated uses, and 3) an anti-degradation statement which limits activities that can occur within a classification, such as which types of discharges are allowed. All State waters have a classification assignment (Lakes: GPA. Rivers and streams: AA, A, B, C. Marine and estuarine: SA, SB, SC. Wetlands assume the classification of the related waterbody).

Maine's classification system is goal based. Instead of reflecting current water quality conditions, the state establishes a target level of quality for that water to achieve. Maine's classification system can also be characterized as risk-based in addition to quality-based. In a risk-based classification system, the difference in water quality between the various classes is not large, however, activities within each class are restricted based on the risk that those activities could degrade water quality and threaten designated uses.

In addition to the Maine water quality classification system, the requirements of the Federal Clean Water Act (CWA) establish national goals (designated uses) and interim goals of swimmable-fishable ("wherever attainable ... of ... the protection and propagation of fish, shellfish and wildlife ... [and] recreation in and on the water"). Maine's interpretation of the levels of protection afforded by Maine state WQS relative to the CWA "protection and propagation goal," places Maine river and stream Class C and marine-estuarine Class SC at the Federal Interim Goal and all other classes, including lake Class GPA, above the Interim Goal.

B. Assessment Indicators

The following tables (Tables 15-17) provide the designated use categories and the criteria (with references) used to assess a water's attainment of the use. A determination of non-attainment is only made when there is documented evidence (e.g. monitoring data) indicating that one or more criteria are not attained. Such data are also weighed against evidence that there are plausible human-caused factors that may contribute to the violation of criteria (38 M.R.S. Section 464.4.C).

Maine places its highest emphasis for monitoring on impact (effect) and fate types of measures. Impact measures are those that measure the outcome of conditions affecting a system. Biomonitoring provides such a measure of impact and is effective at identifying a wide array of stressors (chemical, physical and biological). Maine also invests a proportion of its monitoring

resources in fate measurements (tissue contamination) which assesses biological uptake and transfer of contaminants.

Table 15. Assessment Indicators for Rivers and Streams and associated wetlands.

Designated Use	Criteria for Attainment
Drinking water supply after disinfection / treatment	Ambient Water Quality Criteria (MEDEP Chapter 530.5 and 584) General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A) MECDC&P's Maximum Exposure Guidelines (MEGs)
Aquatic life use support	Biomonitoring - lotic benthic macroinvertebrates: numeric biocriteria (MEDEP Rule Chapter 579) Biomonitoring – stream and wetland algae: narrative aquatic life use criteria (38 M.R.S. Section 465) and expert judgment evaluation of structure and function of the resident biological community Biomonitoring - wetland macroinvertebrates: narrative aquatic life use criteria (38 M.R.S. Section 465) and expert judgment evaluation of structure and function of the resident biological community Habitat suitability [38 M.R.S. Sections 464(13), 465(1-4)] Dissolved oxygen [38 M.R.S. Sections 464(13), 465(1-4)] Ambient Water Quality Criteria (MEDEP Rule Chapters 530 and 584) Support of indigenous species Wetted habitat (MEDEP Rule Chapter 581) General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)
Fishing	Support of indigenous fish species Absence of fish consumption advisory (established by MECDC&P) General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)
Recreation in and on the water	E. coli bacteria (38 M.R.S. Section 465, geometric mean) Water color (38 M.R.S. Section 414-C) General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)
Navigation, hydropower, agriculture / industrial supply	General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)

Table 16. Assessment Indicators for Lakes and Ponds and associated wetlands.

Designated Use	Criteria for Attainment
Drinking water supply after disinfection / treatment	Ambient Water Quality Criteria (MEDEP Chapter 530.5 and 584) General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)
Aquatic life use support	Trophic state (38 M.R.S. Section 465-A, MEDEP Chapter 581) Ambient Water Quality Criteria (Maine MEDEP Chapter 530.5 and 584) Aquatic life (38 M.R.S. Section 465-A, 464.9) Biomonitoring (wetland habitats) - wetland algae and macroinvertebrates: narrative aquatic life use criteria (38 M.R.S. Section 465) and expert judgment evaluation of structure and function of the resident biological community General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A) Hydropower GPA impoundments [38 M.R.S. Section 464.9]
Fishing	Support of indigenous fish species Absence of fish consumption advisory (established by MECDC&P) General provisions: floating/settleable solids, pH, radioactive substances, (38 M.R.S. Section 464.4.A)
Recreation in and on the water	E. coli bacteria (38 M.R.S. Section 465-A, geometric mean) Trophic state (38 M.R.S. Section 465-A, MEDEP Chapter 581) General provisions: floating/settleable solids, pH, radioactive substances, (38 M.R.S. Section 464.4.A)
Navigation, hydropower, agriculture / industrial supply	General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)

Table 17. Assessment Indicators for Estuarine and Marine Waters.

Designated Use	Criteria for Attainment
Marine life use support	Ambient Water Quality Criteria (MEDEP Chapter 530 and 584) Dissolved oxygen (38 M.R.S. Section 465-B) Narrative biological standards (38 M.R.S. Section 465-B) General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)
Shellfish propagation and harvest	Fecal indicator bacteria criteria (National Shellfish Sanitation Program, assessed by MEDMR) Absence of shellfish consumption advisory (established by MECDC&P) General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)
Aquaculture	General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)
Fishing	Support of indigenous fish species Absence of fish consumption advisory (established by MECDC&P) General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)
Recreation in and on the water	*Enterococcus* Bacteria Criteria (38 M.R.S. Section 465-B) General provisions: floating/settleable solids, pH, radioactive substances (38 M.R.S. Section 464.4.A)
Navigation, hydropower, industrial supply	General provisions: floating/settleable solids, pH, radioactive Substances (38 M.R.S. Section 464.4.A)

C. Indicator Needs

The MEDEP recognizes the need to move toward the establishment of biological endpoints indicative of structure and function at the community level. The Biomonitoring Unit has successfully completed this with the establishment of biological criteria using evaluation of macroinvertebrates in rivers and streams. Additional biological metrics are currently under development in all waters. The Biomonitoring Unit has developed draft criteria for wetland macroinvertebrates and stream and wetland algae. See Table 9 for a for a projected timeline for these efforts. The Lake Assessment Section is working on planktonic (phytoplankton and zooplankton) and littoral indicators (habitat, aquatic macrophytes, macroinvertebrates), along with which shoreline disturbance indicators are documented. The Marine Unit will develop benthic invertebrate-based indicators, begin to assess water carbonate chemistry for potential impacts on relevant infauna and epifauna, and will continue to assess phytoplankton biomass and eelgrass vitality metrics as indicators for nutrient criteria development. An Index of Biological Integrity is being developed for fish in wadeable streams along the water quality classifications.

5. Quality Assurance

A. Quality Management Plan

MEDEP operates under a Quality Management Plan (QMP) that documents the flow of information used in the environmental decision-making process. The current plan, dated June 20, 2017, is updated periodically as required under performance partnership agreements with USEPA. MEDEP organizes and oversees Quality Management System (QMS) functions with a Quality Management Steering Committee (QMSC), which has at least one representative from each bureau and each regional office, and two members from senior management. Oversight of QMS activities by the QMSC assures that quality issues are integrated throughout the MEDEP, including periodic internal program audits. The QMP is the foundation on which monitoring and assessment projects are implemented, each with their specific Quality Assurance Program or Project Plan (QAPP) which is reviewed annually, updated as needed and revised every five years. All current and 'retired' QMPs are kept on file to enable tracking of past requirements at any time.

B. Quality Assurance Program/Project Plans, Sampling and Analysis Plans & Standard Operating Procedures

QAPPs are developed at either the Program or Project level, depending on which avenue provides the best fit for the monitoring effort. Sampling and Analysis Plans (SAPs) are developed as needed, usually annually, to document specific sampling efforts or to complement QAPPs when any of the elements planned for a specific project deviate from the contents of the QAPP. Standard Operating Procedures (SOPs) for specific monitoring efforts or procedures generally exist at the program level and often are included in the appendices of QAPPs. These documents may be found on the department's computer network. SOPs are distributed as necessary. Development and revision of QAPPs and SOPs under the current departmental QMP is largely complete. The Appendix includes both Program and Project QAPPs.

6. Data Management

A. Water Quality and Biological Data

Data collected in conjunction with MEDEP monitoring programs and quality assured volunteer-based programs are primarily stored in an Oracle database called the Environmental and Geographic Analysis Database (EGAD). Some historic data as well as all lake assessment data currently still reside in other electronic formats such as Foxpro, Access and Excel; these data will over time also be moved into EGAD. In the meantime, lake data and summary reports are available through the Lakes of Maine website, which is part of the LSM-VLMP. EGAD handles electronic data imports, data storage, data output in a variety of formats, and data analysis. Regular data transfers from EGAD to USEPA's WQX data system occur for most programs in the DEA. EGAD is fully integrated with the state GIS system to facilitate spatial analysis. The database was built in-house and is supported by Maine Office of Information Technology (OIT)

staff as well as a MEDEP dedicated data manager, a set-up that enables complete database customization to meet all staff needs as well as timely and competent technical support, provided OIT can dedicate enough resources to EGAD.

New data from MEDEP scientists or outside entities, including laboratories, are loaded into EGAD in a standardized format using a process that includes extensive data validation and verification procedures; this process ensures continued data integrity. All data are routinely backed up using the services of OIT. MEDEP maintains a series of SOPs for field data collections made by all staff, cooperators and laboratories with which we contract. These are updated regularly and are linked to either program or project level QAPPs. Annual SAPs are required under our QMP and QAPPs. Data are evaluated according to data validation specifications included in these documents. Data that do not meet these specifications are either flagged or never entered in the system. In 2017, Phase 1 of a QC Report tool in EGAD was completed to assist staff with automated QA/QC of laboratory data.

Support Needs:

Staff –

- One additional staff person to migrate old data files (both digital and hard copy) into EGAD, so that older data are not lost as staff retire and to assist with migrating additional programs and day to day staff support.
- Training in R or other programs that could be used to complement EGAD for data analysis and reporting.
- Funding for travel to regional or national conferences hosted by EPA or other organizations with a focus on environmental data management.

Technology –

- Programming to create new, more efficient and simple system to transfer data stored in EGAD to EPA WQX database.

B. Geographic Information System (GIS)

MEDEP is committed to the development of projects and spatial layers pertinent to environmental monitoring and protection of our States resources. Collaboration with other agencies remains a priority. Considerable data are routinely received in GIS format, complete with metadata (e.g., shellfish closure data from the Department of Marine Resources), allowing the department spatial access to the information. The demand for the development of mobile data collection applications by GIS staff has recently increased, with several units (Lakes, Marine, Invasives) deploying Esri Collector and Survey 123 apps in the field. This allows for streamlining the geospatial data collection and storage processes. MEDEP's EGAD database and the USEPA's Assessment Database are linked to our GIS system. Progress within these programs continues with ongoing GIS improvements and refinements. MEDEP actively cooperates with the stewardship of Maine's USGS National Hydrography Dataset (NHD) and Watershed Boundary Dataset (WBD), and incorporates use of these national programs into our strategic water quality goals. Continued development of spatial data and applications that link

water quality data, improvements, and attainment status (as stored in the Assessment Database or future ATTAINS system) to spatial layers remains a priority.

Support Needs:

Staff –
- Training to address upcoming changes in GIS technology utilized by MEGIS (to include but not limited to ArcGIS 10.6, ArcGIS Pro, ArcGIS Online).
- Support for attendance at out of state national and regional GIS and Geospatial technology conferences and events.

Monitoring Equipment –
- Mobile devices such as tablets and smartphones for development, testing, and deployment of mobile data collection apps.
- Up-to-date GPS units.

Analysis –
- Training in Python, R, and other third party tools that integrate with GIS to improve and expedite data analysis and statistics.

C. Assessment Data

The Department has implemented the USEPA's Assessment DataBase (ADB) for rivers and streams, lakes and wetlands data to document and track assessment determinations for each Integrated Report cycle. Marine assessment determinations are tracked in Excel files. Metadata are requested for all data that is used to make attainment determinations. Attainment decisions are made using only data collected under an approved QAPP, SAP or equivalent. With the replacement of the ADB by the new ATTAINS (Assessment, TMDL Tracking and Implementation System) database, MEDEP will switch to using ATTAINS for the 2018 reporting cycle.

MEDEP has submitted the Integrated Report assessments in ADB format to USEPA since the 2006 reporting cycle. MEDEP GIS staff has developed a custom data editing tool that presents Maine's river and stream and lakes assessment units (AUs), as stored in ADB, spatially in GIS via the NHD. This tool eliminates an extremely time-consuming translation step and delivers more spatial data quality control to the assessment data manager. Efforts are underway to complete spatial representation of marine AUs and begin representation of wetland AUs. The mechanism to be used for continued GIS work based on ATTAINS remains to be determined.

7. Data Analysis

A. Data Interpretation Principles

A complete and consistent water quality data set is uncommon; therefore, some interpretation of data is required in making a final assessment. Data from unique events such as a spill, an accident, a short-duration license exceedance, or a drought or flood are not used in an assessment determination. The following general principles for each criteria type, which are used in making

an assessment, are presented in the Data Interpretation section of each Integrated Report. The text below is largely reflective of the Data Interpretation section of the 2016 Integrated Report. For the 2018 Report, MEDEP will expand the principles applied when basing assessment decisions on continuous data for dissolved oxygen and pH.

Biological Criteria: River, stream, and wetland benthic macroinvertebrate and algal samples are collected in accordance with the Biomonitoring Program Quality Assurance Project Plan. Stream macroinvertebrate assessments are based on a statistical model that predicts attainment of tiered aquatic life uses (Classes AA/A, Class B, and Class C). The stream macroinvertebrate model is described in MEDEP Rule Chapter 579: *Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams*. For streams and rivers, aquatic life criteria are deemed to be attained when the applicable biocriterion is met with probability equal to or greater than 0.60 if there are no other data indicating non-attainment. Final determination of attainment may in some cases be made by professional judgment, applied in accordance with the procedures described in MEDEP Chapter 579 and elsewhere in Department statutes and rules.

The Biological Monitoring Program recently completed an algal bioassessment model applicable to wadeable streams and rivers with rocky substrates. The Program also recently completed provisional algae and macroinvertebrate bioassessment models for freshwater emergent and aquatic bed wetlands, including fringing wetlands associated with rivers, streams, lakes and ponds. The stream and wetland algal models and wetland macroinvertebrate models have not yet been implemented. For the 2016 Integrated Report, Department biologists used expert judgment to evaluate structure and function of the stream algal and wetland macroinvertebrate communities to assess attainment of narrative aquatic life criteria (38 M.R.S.A Section 465). Chapter 579 will be amended to include the stream algal and wetland macroinvertebrate models, following standard public review protocols, after they have been adequately tested. Ambient water quality criteria, whole effluent toxicity (WET) testing, and other biological sampling are also used to determine if other components of the biological community, such as fish, meet the aquatic life uses.

Lake Trophic State: Assessment is based on measures of transparency, chlorophyll a, total phosphorus and color (see Table 18). When lakes lack this information, a trophic determination made by the Maine Department of Inland Fisheries & Wildlife (MEDIF&W) is used, if available. MEDIF&W determinations are more subjective and generally apply to the lake system as a whole including adjacent wetlands and fisheries productivity. Trophic determination has been tracked by source (MEDEP or MEDIF&W) in the ADB and will be similarly tracked in ATTAINS in the future.

Table 18. Numerical Guidelines for Evaluation of Trophic Status in Maine (note: dystrophy is rarely evaluated separately from the trophic categories below).

	Trophic Status [3]		
Parameter [1]	Oligotrophic	Mesotrophic [2]	Eutrophic
Secchi Disk Transparency [3]	> 8 meters	4-8 meters	< 4 meters
Chlorophyll_a	< 1.5 ppb	1.5 – 7 ppb	> 7 ppb
Total Phosphorus [3]	< 4.5 ppb	4.5 – 20 ppb	>20 ppb
Trophic State Index [3,4]	0-25	25-60	>60 and/or repeated algal blooms

[1] Secchi Disk Transparency, Chlorophyll_a, and Total Phosphorus based on long-term means.
[2] No chronic nuisance algal blooms.
[3] When color is > 30 Standard Platinum Units (SPU) or is unknown, best professional judgment is used to assign trophic category in conjunction with Chlorophyll a concentration and dissolved oxygen data.
[4] Trophic State Indices are calculated when adequate data exists and color is at or below 30 SPU.

Support of Indigenous Species: Assessment based on the known absence of a species that previously was documented as indigenous to a waterbody in historical records collected by state or federal agencies or through published scientific literature; or based on non-attainment of water quality criteria, absence of critical habitat necessary to support indigenous species, or presence of conditions known to prevent support of indigenous species.

Dissolved Oxygen: Assessment is based on the results of repeated measurements, collected over time. Single excursions of the criterion or excursions within the range of sampling or instrument error (as established in a Quality Assurance Project Plan) may not be used in every case unless there is corroborating evidence of reasonable potential for impairment of a use. Factors to be taken into account when considering corroborating evidence include, but are not limited to: time of data collection; in-stream characteristics; site characteristics (e.g. land use, velocity, canopy cover); water temperature; extent of excursion; algal community; measurement method. Assessment may also be based on the use of water quality models (e.g. WASP) based on present or expected loadings. Legislation provides that dissolved oxygen in certain deeper waters of a riverine impoundment may not be used for measurement of water quality attainment.

Ambient Water Quality Criteria: Assessment is based on measured exceedance of Statewide Water Quality Criteria as established by *Surface Water Quality Criteria for Toxic Pollutants*, 06-096 CMR 584 (effective July 29, 2012) (or Site-specific criteria where they may exist), or reasonable potential to exceed the criteria following EPA's Principle of Independent Applicability and Technical Support Document. Single excursions of the criterion or excursions within the range of sampling or instrument error (as established in a Quality Assurance Project Plan) may not be used in every case unless there is corroborating evidence of reasonable potential for impairment of a use. Factors to be taken into account when considering corroborating evidence include, but are not limited to: in-stream characteristics; land use; extent of excursion; analysis method; hardness; pH, temperature or dissolved organic carbon. Assessment may also be based on the use of water quality models (e.g. dilution models) based on present or expected loadings.

Nutrient/Eutrophication Biological Indicators: Excessive nutrient enrichment (eutrophication) can cause negative environmental impacts to surface waters, such as blooms of algae or bacteria in the water or on the substrate, low dissolved oxygen concentrations, fish kills, generation of cyanotoxins, and alteration of community structure. In 2012, the Department prepared a new draft of Chapter 583: *Nutrient Criteria for Surface Waters* in preparation for a rulemaking process. The USEPA indicated their support of the new version of the draft rule. Chapter 583 focused on freshwater systems and described how the Department would use total phosphorus (TP) concentrations and environmental response indicator measurements in a decision framework to determine attainment of designated uses (e.g., recreation, aquatic life support). The proposed rule also described how the Department would use the attainment determinations for the establishment of nutrient discharge limits in National Pollutant Discharge Elimination System permits.

Chapter 583 will eventually include nutrient criteria for marine waters, which will include thresholds for total nitrogen (TN) as well as environmental response indicators to determine attainment of designated uses in estuarine and coastal waters. Marine nitrogen criteria are currently under development. For more information on both freshwater and marine nutrient criteria, please visit the following website: http://www.maine.gov/dep/water/nutrient-criteria/index.html.

Narrative listing criteria for this cause of Aquatic Life Use (ALU) impairment consist of documentation of abnormal biological findings that indicate nutrient enrichment in rivers and streams as well as marine waters. Excess nutrients impair ALU through alteration of habitat, creation of diurnal dissolved oxygen sags caused by excessive plant and algae growth, abundant epiphytic growth resulting in decreased light availability to submerged vegetation, and alteration of benthic macroinvertebrate assemblage structure.

Bacteria: Assessment is based on repeated measurements (generally at least six) to establish a geometric mean over 90 days. Single sample measures are highly variable and not a reliable indicator of continuous impairment or attainment, but the statistical threshold value provides a benchmark for use in interpreting Maine's water quality standards. Impairment decisions are made using diagnostic procedures that determine the probability of a human or domestic animal source of bacteria; bacteria of wildlife origin do not violate Maine's standards (38 M.R.S.A Section 465, 465-A, 465-B).

Water Color: Assessment based on repeated measurements of discharge performance data and compliance with 38 M.R.S. Section 414-C for pulp and paper discharges only. In lakes and ponds, color may mitigate high phosphorus concentrations and potential algal blooms.

General Provisions: pH based on repeated measurement (between 6.0 and 8.5 for freshwaters; 7.0 and 8.5 for marine waters), however, certain naturally occurring waterbody types (e.g. bogs, aquifer lakes, high elevation lakes) or events may naturally have low pH and affect downstream waters. Use impairment from solids is subjectively determined. Radioactivity in surface water is not presently monitored.

B. Data Analysis Considerations

Specific procedures used to analyze project data are beyond the scope of this strategy. Project-specific data analysis approaches are commonly spelled out in QAPPs, although data analysis is often an adaptive task, where results of one analysis lead to subsequent analyses. For the purposes of use support assessment or enforcement, however, the following considerations regarding data quality and statistical analyses are relevant.

When used for assessment or enforcement, data employed must be of known quality and should be representative of the water's condition. All data generated in conjunction and compliance with any active and/or approved QAPP are considered readily available and reliable data, and are considered in determining use support. Data can be rejected from consideration if they do not meet data quality objectives established by individual QAPPs. Guidance and assistance regarding quality assurance is also provided from the USEPA Region 1 Laboratory.

For data provided by organizations other than MEDEP, a QAPP is required or the MEDEP must approve methods prior to considering using data in the determination of use support. The MEDEP also provides training and data management in some cases. Data of unknown or unquantifiable quality are only used as general information until data of known quality can be obtained.

MEDEP has expertise in various statistical methods and contracts with consultants if needed. In most instances, it cannot be decided a-priori what type of statistical analysis may be used to assess use support, except for experimentally designed studies. For certain data types, long-term trend detection using linear, non-linear, or non-parametric regression approaches is appropriate. For designed studies aimed at determining the level of use support in an experimental framework (e.g., waters that are likely to display elevated fish tissue mercury concentrations), parametric or non-parametric analyses of variance, covariance, and/or linear discriminant analysis are most appropriate. To classify waterbodies into meaningful biological groupings to compare biometrics to reference biological communities, linear discriminant analysis, principal components and factor analysis, canonical correspondence and non-metric multidimensional scaling analysis are appropriate. Simple T-tests and ANOVA or Kruskal-Wallis tests are appropriate where data are being compared to a criterion value or to a set of reference waters. Consequently, these last two tests are more commonly or routinely performed during MEDEP assessment efforts. Where a statistically parametric method is used to evaluate hypotheses concerning standards attainment, consideration is accorded as to whether "attainment" is established as the null or alternative hypothesis.

MEDEP does not find that a pre-determined proportion of samples exceeding a criterion value automatically equates to impairment, particularly where the total number of samples is low. The proportion of violations or frequency of exceedance in an array of data are treated and used by MEDEP on an individualized and case-specific basis to determine use support.

In general, MEDEP believes waters must be proven to be impaired, and thus statistical hypothesis tests, when necessary, are most often structured in that fashion. Nonetheless, in the interest of maintaining solidly defensible and repeatable use support decisions, where the cost of

erroneous decisions is high, a decision call of impairment will be accorded to the null or alternate, depending on which test provides the greatest statistical power while maintaining the type-I error rate to a pre-established level (typically 5% to 10%).

8. Reporting

Monitoring data are used for many purposes, including the preparation of numerous reports to satisfy federal or State mandates covering all surface waters (i.e., Integrated Water Quality Monitoring and Assessment Report – Integrated Report, Surface Water Ambient Toxics Monitoring Program Report). Topic or program specific reports are also prepared as needed. Report drafts requiring public comment are posted on the departmental web site; final reports are similarly available. As appropriate, MEDEP staff also directly notifies stakeholders of draft or final reports. Maps that provide a visual display of attainment status and other pertinent information are included in such reports. Most of these reports are available on the department's web site. The References section lists numerous examples of recent reports typical of Maine's program.

A. Integrated Assessment Reporting

MEDEP prepares a biennial Integrated Water Quality Monitoring and Assessment Report in fulfillment of Sections 305(b), 303(d) and 314 of the CWA. These reports are due to USEPA during even-numbered years. These reports also serve to fulfill the MEDEP's mandate to summarize water quality status for the State of Maine Legislature (38 M.R.S. Sections 464.3.A). Drafts are available on the MEDEP public comment webpage for review by Maine citizens. MEDEP's responses to comments are incorporated into a final draft report which is submitted to USEPA for approval. Final reports are posted on the MEDEP webpage (http://www.maine.gov/dep/water/monitoring/305b/). Quality assured data used in preparation of these reports come from state agencies, non-governmental and volunteer organizations, and Tribal Nations. Waters assessed as 'Impaired' and requiring a TMDL under CWA Section 303(d) are included in these integrated reports.

B. TMDL Reports

Impaired waters listed under Section 303(d) of the Clean Water Act are required to have TMDLs developed for them if the impairment is caused by a pollutant. As part of the biennial Integrated Water Quality Monitoring and Assessment Report, MEDEP provides a schedule for TMDL development that is approved by USEPA Region I. Draft TMDLs are posted on the MEDEP public comment web site during the review period and final TMDL reports are posted on the TMDL web page (http://www.maine.gov/dep/water/monitoring/tmdl/tmdl2.html).

C. Surface Water Ambient Toxic (SWAT) and Dioxin Reports

The SWAT report is issued biannually and includes a summary of all data gathered and analyzed by the SWAT program during the past two years. The SWAT program was enacted to determine the nature, scope and severity of toxic contamination in the surface waters and fisheries of the

State; SWAT projects are implemented on lakes, rivers, streams and marine/estuarine waters on an ongoing basis. The program incorporates testing for suspected toxic contamination in biological tissue, sediment, and the water column; it also conducts biological monitoring of individual organism health that may serve as an indicator of toxic contamination. Since 2008, the SWAT report has included results of annual monitoring for dioxins (previously reported on separately). The reports are available on the MEDEP web page http://www.maine.gov/dep/water/monitoring/toxics/swat/.

D. Other Reports

i) Rivers and Streams

Numerous non-TMDL river study reports have been prepared from data collected by the agency and cooperators. Refer to the list of References for specific recent reports.

ii) Biomonitoring

In addition to the numerous recent biomonitoring reports listed in the References section, the Biomonitoring Unit has implemented a GIS-based search capability that is accessible via the department's website. Using a Google Earth platform, this site provides the locations of biomonitoring sampling stations and monitoring results (http://www.maine.gov/dep/gis/datamaps/lawb_biomonitoring/lawb_biomonitoring.kml).

iii) Lakes

The Lake Assessment Section prepares an Annual Lake Water Quality Report (approximately 3000 pages) that provides data summaries for each monitoring station. The raw data and summary data included in these reports are posted on the worldwide web (https://www.lakesofmaine.org/). The Section also extracts many of the summary data elements that are included in Lake Stewards of Maine-Volunteer Lake Monitoring Program reports. Reports are also prepared as needed to summarize results from specific studies, or to provide lake specific additional information for citizen training. Educational resources that utilize lake data are also developed.

iv) Estuarine and Marine

Marine Environmental Monitoring Program reports are prepared as needed to summarize results from specific studies. Eelgrass mapping results for each shoreline segment will be presented annually in a GIS layer and change analysis report. The Marine portion of the SWAT report is included in the report discussed in Section 8.C. A Gulfwatch Contaminants report has not been produced since 2010 (http://www.gulfofmaine.org/library/gulfwatch/) and due to uncertain funding for sample analysis and reporting, additional reporting is uncertain. The National Coastal Condition Assessment (NCCA) program produces periodic reports that are available on USEPA's website http://www.epa.gov/national-aquatic-resource-surveys/ncca, the most recent of which was released in December 2015 for the 2010 survey. The Casco Bay Estuary Partnership (http://www.cascobayestuary.org/resources/publications/), Friends of Casco Bay (https://www.cascobay.org/), Maine Coastal Observing Alliance, and other partners issue periodic reports based on long term monitoring or specific study data.

v) Watershed Management

The Maine Volunteer River Monitoring Program prepares an annual VRMP report for each volunteer group in the program. The report includes summaries of results, graphs and recommendations. The reports are available on the MEDEP website: www.maine.gov/dep/water/monitoring/rivers_and_streams/vrmp/index.html.

Watershed Based Management Plans funded under 604(b) Planning Grants include water quality summary information, including data collected by Watershed Management Staff. Primarily this is urban stream water quality data collected as part of the stressor identification process. Stream water quality data may also be reported in mini-reports for MEDEP use, as well as shared with municipalities.

9. Program Evaluation

A. Annual Review

MEDEP annually reviews progress in monitoring waters considering the recommendations contained in this strategy. Priorities for the following year may be readjusted based on availability of resources and/or competing needs for monitoring information. Changes will be incorporated into annual workplans, and the Performance Partnership Agreements. As part of ongoing Quality Management Planning efforts, the QAPP archive is updated annually, and individual QAPPs are scheduled for revision at that time as appropriate. Individual SOPs for monitoring are updated annually as needed.

B. Annual Workplans

The monitoring strategy is revisited annually as part of the development of annual workplans for each of the units (e.g. lakes, marine, rivers and streams, etc.). Progress in meeting the milestones will be determined by resources and/or competing needs.

10. General Support and Infrastructure Planning

A. Current Program Support

This report provides support information based on MEDEP staff and funding resources as of FY18. Since Maine is a small state with limited staff resources, many staff fulfill multiple functions such as field monitoring, assessment, reporting, and information management. Monitoring is supported by the State General Fund (8 full time equivalents - FTE), State dedicated revenue funds (3 FTE), Federal Section 106 (8 FTE), Section 104(b)(3) (2 FTE), Section 319 (3 FTE; includes nonpoint source monitoring activity that was not included in 2005 Strategy), Maine Ground and Surface Water Clean-up and Response Fund (0.5 FTE), Maine Healthy Beaches (0.5 FTE) and Section 604(b) (0.5 FTE).

The MEDEP receives primary operating revenues for monitoring and assessment from:

- State General Fund which supports Surface Water Ambient Toxics (SWAT) program, Atlantic Salmon Habitat Monitoring program, and Lakes Management program;
- Dedicated revenue sources including the Invasives Control Program and Maine Ground and Surface Water Clean-up and Response Fund;
- Section 106 funds which supports both base program and Supplemental Monitoring activity;
- Section 104(b)(3) for wetlands program support (Note that 104(b)(3) funds are awarded through a competitive grant program and are highly unpredictable, so long-term planning is difficult. In addition, grants may only be used for specific program development activities and there is currently no funding source to implement a fully functional wetland monitoring and assessment program.);
- Section 319 for nonpoint source evaluation;
- Maine Healthy Beaches funds;

The following description addresses only the MEDEP FTEs supporting ambient monitoring. The FTEs cited are approximations.

i) Field Monitoring

The combination of all current field monitoring programs utilizes approximately 14 FTE of staff time. At this level of support, the monitoring program is functional, but limited. Monitoring staff often relies upon other Department staff with varying skills to conduct field operations safely and efficiently. Unanticipated high-priority monitoring needs and/or underfunded participation in larger-scale monitoring projects (e.g. regional studies) can result in loss of core program functionality at this staffing level. Complete implementation of an array of monitoring designs, such as probabilistic studies, long term monitoring projects, waterbody and watershed scale studies along with high-profile event-based monitoring is usually beyond the scope of monitoring staff resources.

ii) Laboratory Services

Laboratory services are provided on a fee-for-test basis from the Maine Department of Health and Human Services, Health and Environmental Testing Lab and other local and regional laboratories. The Department does maintain field and sample preparation facilities in the Augusta office and at the three regional offices. Additionally, MEDEP contracts with outside private laboratories for specialized analysis associated with the SWAT Program, low detection level nutrient, chlorophyll concentration and coastal acidification grab sample analyses for marine waters, and for taxonomic analysis of aquatic macroinvertebrate and algae samples collected by the Biomonitoring Program.

iii) Assessment, Listing, and Reporting

The current assessment, listing and reporting functions are supported by DEA staff. These functions are supported at approximately 8 FTE. These levels are sufficient to support the basic assessment and reporting requirements required for reports and lists such as 305(b), 303(d), TMDLs, river modeling, annual lake and biomonitoring assessments. However, analysis is not

always as extensive as the data might allow. Fulfillment of all guidance elements regarding the Integrated Reporting method and monitoring program strategy development have imposed numerous unanticipated tasks. Development of new and expanded reporting tools such as the use of GIS will continue to increase need.

iv) Information Management

Depending on skill level, program staff require varying degrees of assistance with EGAD-related information management tasks, which range in sophistication from simple (e.g. preparing data for import into the database; exporting data from the database into automated reports) to intermediate (e.g. incorporating exported data into ad-hoc reports) to highly advanced (e.g. doing spatial analyses of large datasets). In addition, there is also on-going maintenance of EGAD in response to evolving program needs. Information management tasks for EGAD are handled by 3 department-wide FTE OIT staff (1 programmer/analyst, as well as 1 senior programmer/analyst and 1 database administrator who both only spend a small part of their time on EGAD) and 2 dedicated, bureau-specific staff (1FTE data manager; 1 FTE project manager who only spends a small part of her time on EGAD). Generally, this staffing level meets current EGAD information management needs, but requires that MEDEP has sufficient funds to maintain both MEDEP and OIT staff. Increased use of EGAD, especially for large-scale, sophisticated analyses as anticipated under this strategy, may require additional support for future project execution.

The BWQ currently has one GIS Coordinator providing technical skills and assisting with the management and implementation of the NHD for Department programs, as well as the development of mobile GIS applications. The Bureau also employs one Environmental Specialist III with GIS skills who also guides and provides Bureau staff with strategic GIS data and spatially based programs.

v) Monitoring and Assessment Program Planning and Other Functions

Planning for future years' monitoring and assessment priorities and program development is supported by 3 FTE, including in-house staffing for TMDL pollution planning. Quality assurance and WQS planning also requires significant staff-time.

B. Projected Needs

(This section summarizes needs also described by program in sections 3.B. – 3.H. above)

i) Staffing

To continue the core monitoring program, stable support is necessary. In recent years, several critical positions have become vacant due to retirements and have been left unfilled due to federal funding cuts or restrictions. These positions include an Environmental Specialist (ES) III responsible for bacteria monitoring and TMDL development; an Environmental Technician responsible for boats and field equipment maintenance as well as monitoring activity including fish collection; and a seasonal Conservation Aide responsible for supporting field work in the Biomonitoring Unit. The loss of these positions has led to reductions in the DEA's monitoring capabilities. Concern exists that there could be further staff reductions for wetlands biomonitoring work, which currently relies on 2 FTEs funded through a competitive 104(b)(3) grant. While this funding has been available to support development of wetlands biomonitoring criteria, it is not a stable funding source that can be relied upon in the future. A recent cut to the

grant award amount will make it difficult to sustain both FTEs beyond 2018. Maine has also had to refuse or severely restrict participation in USEPA-sponsored National Aquatic Resource Survey studies when such participation would disrupt core monitoring program needs. In the near term, additional support of 5 FTEs is recommended, just to return to the monitoring capabilities DEA has had in the recent past. Another 4 FTEs are needed to support marine monitoring and assessment, 2 FTEs to help support participation in National Aquatic Resource Surveys (high priority) and 1 FTE to provide data management support.

ii) Equipment

The MEDEP is modestly equipped to complete its present monitoring projects. Much of the field equipment is older and while still functional, requires additional maintenance and is prone to more frequent breakdowns. Since back-up equipment is often limited, this can lead to program delays. The MEDEP needs to replace existing equipment over the next few years. These include various field meters, sondes, sampling devices, integrative samplers, snowmobile, boats, motors and trailers. Sondes in particular are in need of periodic maintenance that needs to be built into the operating budget. In addition to updating equipment, the MEDEP needs additional sondes that can be used as equipment backup and as "loaners" for volunteer groups or project partners. Lack of additional equipment is a limiting factor for using additional volunteer support. Purchase of new equipment for real time measurement of relevant parameters that are currently being assessed at much lower spatial and temporal resolution via grab samples (nutrient species, e.g.), is cost prohibitive despite the long term financial and data quality benefits. (high priority)

The MEDEP would like to build capacity for long-term deployment of sampling devices, sondes or fixed station monitors. This could be accomplished in cooperation with the USGS. (Medium priority)

iii) Laboratory Resources

The Bureau has a small biological field support laboratory in the Augusta office. Physical space limitations for storage of field equipment and archived samples continue to be a challenge.

Outside laboratory services currently support the needs of the present monitoring program strategy reasonably well. A long-term commitment to implement this strategy will necessitate increased funding to support rising costs of analysis associated with advances in laboratory technology. There is no in-state capability to do high resolution organic analysis. As emphasis on PBT chemicals, PPCPs, nanoparticles, and other emerging contaminants increases, the state needs to establish capacity for this kind of analysis. (High priority)

Another limitation to analyses of environmental samples is the State's requirement that samples be analyzed by a 'certified' laboratory. Many out-of-state accredited labs have demonstrated capacity to accurately analyze environmental samples, but are unwilling to pay the rather high fees to become 'certified' for the State of Maine. At present, even analyses done at an EPA lab technically would not meet the State's certification requirement. This legislation would best serve our needs if it were modified. As stipulated by State of Maine laboratory certification requirements (http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/professionals/labCert.shtml) for data to be utilized for regulatory purposes,

availability of labs that can complete marine waters analyses at desired low detection limits with documented quality control procedures is minimal. In-state resources are insufficient to meet needs for marine nutrient parameters, and use of out-of-state academic or private labs can result in prolonged data-delivery timelines and excessive analytical costs to assure compliance with regulatory-dictated hold times. Additionally, for marine waters samples, availability of an in-house technician certified to fluorometrically analyze marine chlorophyll would significantly reduce the financial burden incurred by contracting with a very limited number of State-certified labs. With availability of an in-house technician, limited monitoring funds would then be availed for new parameters of importance (total alkalinity, dissolved inorganic carbon for coastal acidification monitoring, e.g.). (Medium priority)

The MEDEP identifies a pending lack of taxonomic services in the future as other states build biomonitoring capacity. Presently, the MEDEP relies on three contractors for macroinvertebrates and two contractors for algae who have gone through extensive quality assurance checks and cross-checks to assure taxonomic standardization. Other available taxonomic services appear limited if one or more of these contractors became unavailable. As USEPA promotes biomonitoring approaches, there needs to be coinciding support to develop taxonomic expertise either within agencies or by outside contract. Also, there is a national need to standardize taxonomic identifications among labs. For wetland biological monitoring, there is a growing need for taxonomic support from an expert botanist to assist with plant community surveys and identify unknown specimens and voucher samples. This support would enable the Biomonitoring Program to assess the condition of additional wetland types using vegetative indicators. MEDEP envisions these services would be performed through a contractor or agreement with another state agency, however there is no funding at this time to accomplish this work. (High priority)

iv) Information Technology Resources

Information technology resources are presently generally sufficient to meet the needs of this strategy. Current support for EGAD (see section 10.A.iv for details) must at least be maintained to continue support for programs currently utilizing EGAD, as well as for developing new functionality to meet evolving program needs and migrating additional datasets into EGAD. One additional part time equivalent (PTE) position would allow for more timely project completion (including migration of more legacy data) and enhanced staff support for both day-to-day operations and more sophisticated analyses. (Low priority)

Efforts must continue to enhance the NHD to facilitate its role as the primary spatial reference layer for current and legacy water quality and monitoring data and related metadata. The NHD steward should regularly request and acquire updated GIS data on stream locations and watershed boundaries from MEDEP staff that conduct fieldwork and are familiar with the state's hydrography, particularly in headwater, urban, and developing areas. GIS staff should also regularly participate in regional conference calls regarding stewardship, attend trainings and conferences, and remain proficient in the use of NHD editing tools offered by USGS. (High priority)

To complement and leverage the national and regional efforts of NHD, staff utilizing GIS with MEDEP need to be enabled and encouraged to compile and report spatial data to GIS staff for

incorporation into NHD. Spatial data relevant to the public's growing demand for knowledge and services, such as the impact from extreme weather events, coastal inundation, and other environmental events require strategic abilities to serve our future GIS needs.

Several units are using mobile data collection applications on iPad tablets and smartphones. These apps are developed and implemented by the GIS Coordinator. As this is a rapidly developing area of technology, the GIS Coordinator should be prepared to implement changes to the applications resulting from updates to both the software and the mobile devices. The GIS Coordinator should also provide continued support for managing the data from the devices. Increased efficiencies from the use of mobile devices for data collection and management is increasing the demand for these devices.

Over the years, the USGS has reduced the number of flow gauge sites in the state. There is an increasing demand for flow information for TMDLs, discharge-effect modeling, wastewater licensing including nutrient loading calculations, water withdrawal, and habitat assessments related to biomonitoring. Support for USGS to provide these data should be increased either through cooperative agreements or fund transfer. Data on small unregulated streams, river discharges to priority estuaries, as well as water level measurements on lakes are particularly needed. (High priority)

The MEDEP would like to build a system of in-place monitors with real-time data feed capability particularly for high profile water quality situations. The TMDL for the Androscoggin River points to a need to be able to intensively monitor certain waterbodies to display data that provides feedback to the regulated community so they can more finely tune their treatment and the supplemental oxygen system, provide assurance that WQS are being attained, and provide the interested public with a demonstration. Such systems might also be deployed where intensive or complex management is required. (Medium priority)

In the future, the MEDEP would also like to develop new monitoring strategies and partnerships that could enable remotely sensed imagery by plane or drone, or satellite acquired imagery (e.g., to map seagrass over large portions of marine shoreline). The MEDEP has made modest use of these types of resources in the past but they have never been incorporated beyond specific project needs. Strategies such as this would probably necessitate implementation at least at a regional scale with USEPA and neighboring states to build technical capacity and expertise, and gain economies of scale. These strategies may be attractive for monitoring large water resources over large geographic areas. MEDEP has directed a portion of 106 Supplemental Monitoring funds toward this strategy. (Medium priority requiring cooperative partners)

11. Conclusion

MEDEP remains committed to maintaining baseline monitoring of our surface waters and will continue to look for opportunities to improve the quantity and quality of data collected in order to meet the goals as listed in Section 2. New technology in monitoring equipment will be utilized where feasible. Data will be utilized to support development of a biological condition gradient for lakes; biocriteria for algae and fish in rivers and streams; and aquatic life criteria in wetlands. Data will also contribute to the development of freshwater and marine nutrient criteria. Existing resources will be utilized and additional resources sought, to support current and additional monitoring of surface waters to assess the impacts of climate change, particularly from coastal acidification.

An effective statewide monitoring and assessment program will require resources. Costs for personnel and equipment maintenance/replacement are increasing. Meanwhile, over the past ten years, overall funding for the program has declined, resulting in fewer staff assigned to a greater number of tasks. MEDEP will continue to prioritize the core monitoring activities described in this report, but without additional funding support, a decline in the effectiveness of some aspects of the program can be expected.

12. References

Danielson, T. J., C. S. Loftin, L. Tsomides, J. L. DiFranco, and B. Connors. 2011. Algal bioassessment metrics for wadeable streams and rivers of Maine, USA. Journal of the North American Benthological Society 30 (4):1033-1048.

Danielson, T. J., C. S. Loftin, L. Tsomides, J. L. DiFranco, B. Connors, D. L. Courtemanch, F. Drummond, and S. P. Davies. 2012. An algal model for predicting attainment of tiered biological criteria of Maine's streams and rivers. Freshwater Science 31 (2):318-340.

Davies, S.P. and S.K. Jackson. 2006. The Biological Condition Gradient: a descriptive model for interpreting change in aquatic ecosystems. Ecological Applications, 16(4), 2006, pp. 1251–1266

Davies, S.P, F. Drummond, D.L. Courtemanch, L. Tsomides, T.J. Danielson. 2016. Biological water quality standards to achieve optimal biological condition in Maine rivers and streams: science and policy. Maine Agricultural and Forest Experimental Station Technical Bulletin 208. http://digitalcommons.library.umaine.edu/maineaes techbulletin/205/

Lake Stewards of Maine. Maine Lake Reports (2013 most recent) available here: https://www.lakestewardsofmaine.org/maine-lake-report/

Maine DEP. TMDLs approved by EPA, available at: https://www.maine.gov/dep/water/monitoring/tmdl/tmdl2.html

Maine DEP. May 2015. Quality Management Plan, Approved Revision No. 1. Maine Department of Environmental Protection

Maine DEP. Integrated Water Quality Monitoring and Assessment Reports (2016 most recent) available here: https://www.maine.gov/dep/water/monitoring/305b/index.html.. Maine DEP, Surface Water Ambient Toxics Monitoring Program Reports (2015-16 most recent) available here: https://www.maine.gov/dep/water/monitoring/toxics/swat/index.htm.

Appendix

Quality Assurance Project Plans

Name of Project or Activity	EPA Contact	DEP Contact	Completion Status	QAPP Priority	Status / MEDEP Comments
Lakes Assessment Program	Rob Reinhart,	Linda Bacon	A: 4/05; A(R): 4/11 A(R): 11/15	H	No changes in 2017.
Biomonitoring Program QAPP	Robert Reinhart	Beth Connors	A(R): 6/14	H	5-year update (2014-2018) completed. No substantive changes in 2017.
Maine NPS and TMDL Streams	Robert Reinhart, Stacey Johnson	Mary-Ellen Dennis; Wendy Garland	A: 1/13/11 A(R) : 2/17	H	Draft completed June 14, 2016. 5-year renewal approved by EPA February 7, 2017.
QAPP For River Water Quality Surveys	Robert Reinhart, Stacey Johnson	Rob Mohlar	A: 7/09 A(R): 5/17	H	5-year renewal approved by EPA 5/25/17.
QAPP for Model Simulations	Robert Reinhart, Stacey Johnson	Rob Mohlar	A: 6/17	H	New version approved by EPA 6/8/17.
Volunteer River Monitoring Program (VRMP)	Stacey Johnson	Mary-Ellen Dennis	A: 6/09 A(R): 4/4/14	M	No changes in 2017.
NPS Lake and Stream Watershed Surveys QAPP	--	Mary-Ellen Dennis; Wendy Garland	A: 12/09 A(R): 4/8/15	M	No changes in 2017.
Marine Environmental Monitoring Program QAPP	Robert Reinhart	Angela Brewer	A: 4/17	M	This QAPP does not include state-funded toxics programs, i.e. it excludes lobster, clam and mussel documents. New version approved by EPA 4/17/17.

Name of Project or Activity	EPA Contact	DEP Contact	Completion Status	QAPP Priority	Status / MEDEP Comments
Maine Healthy Beaches Monitoring QAPP	Nora Conlon, Alicia Grimaldi	Susanne Meidel, Tracy Krueger	A(R): 7/5/2016	M	Renewal of 2008 QAPP. No changes in 2017.
Friends of Casco Bay Bay's Environmental Monitoring Program QAPP	Nora Conlon; Matt Liebman	Angela Brewer	A: 6/00; A(R): 4/11; 10/13; 7/17	---	Revision approved by DEP and EPA in July 2017.
319 Program (non-monitoring projects)	Sandra Fancieullo	Wendy Garland	A: 2/06; A(R): 12/11 A (DEP): 12/17	---	Approved by DEP 12/21/17; sent to EPA for final approval 12/27/17.
Mt. Desert Island Biological Laboratory Environmental Health Lab QAPP for Volunteer Monitoring Projects	--	Jane Disney/ Angela Brewer	A: 6/19/07 A(R): 5/4/16	--	December 2017: Official DEP approval documentation not yet sent out.
Marine Environmental Research Institute's Blue Hill Bay Coastal Monitoring Program QAPP	Nora Conlon	Angela Brewer	A: 2/12		No DEP involvement. Remove from inventory.
Long Creek Water Quality Monitoring	--	Kate McDonald (CCSWCD)	A: 4/1/11; A(R): 1/9/14	--	Cumberland County Soil & Water Conservation District project. ME DEP reviewed/approved.
Spruce Creek Volunteer WQ Monitoring	--	Angela Brewer	A(R): 6/11	---	Volunteer water quality monitoring not currently occurring.
Saco, Ossipee, and Little Ossipee Rivers	--	Dennis Finn, Saco River Corridor Comm.	A: 3/05; A(R): 6/11 A(R): 3/15	---	Approved by EPA and NH DES in August 2014, by ME DEP in March 2015.

Name of Project or Activity	EPA Contact	DEP Contact	Completion Status	QAPP Priority	Status / MEDEP Comments
George's River Tidewater Association's Water Quality Monitoring Program QAPP	--	Jon Eaton/ Angela Brewer	A: 6/12/12 A(R): 6/14	--	Group defunct, no activity in 2017.
Cumberland County SWCD QAPP for Monitoring Rivers and Streams	--	Wendy Garland	A: 7/14	_	No changes in 2017.
Generic QAPP for Maine Stream Corridor Survey	--	Mary-Ellen Dennis	A: 1/13	--	No changes in 2017.
Sheepscot Valley Conservation Association QAPP	--	Jody Jones/ Susanne Meidel	A(R): 2/14	--	No changes in 2017. SVCA became part of Midcoast Conservancy on 1/1/2016,
Kennebec Estuary Land Trust, Volunteer Water Sampling Program	--	Angie Brewer	A(R): 5/4/16	--	December 2017: Official DEP approval documentation not yet sent out.
Spruce Creek Watershed-Scale Bacteria Monitoring	--	Kristin Feindel	A: 9/15	--	No changes in 2017.
Ogunquit River Watershed-Scale Bacteria Monitoring	-	Kristin Feindel	A: 6/16	-	No changes in 2017.
Topsham Fair Mall Stream Water Quality Monitoring QAPP	-	Kristin Feindel	A: 4/13		No changes in 2017.
York County SWCD QAPP for Monitoring Rivers and Streams	-	Wendy Garland	A: 8/17		QAPP approved in August 2017.