BIOMONITORING RETROSPECTIVE:

Fifteen Year Summary for

Maine Rivers and Streams

By

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Dedication

This work is dedicated to the smallest creatures, existing at the edges of our awareness. Through them we glimpse intricate realities other than our own, and we are reminded to stay humble.

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CHAPTER 2

RELATED BIOLOGICAL MONITORING ACTIVITIES AND PROGRAMS

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Acknowledgements

The seeds for a biomonitoring program were first planted by Charles Rabeni and K. Elizabeth Gibbs, as a result of their original work, in the 1970's, on the Penobscot River. Dr. Gibbs went on to instruct most of the key individuals who were involved in the development of the Program, in aquatic entomology and ecology. The US Environmental Protection Agency has provided crucial financial support, from the earliest years of the Program, and has been an on-going source of encouragement. Michael Winnell of Freshwater Benthic Services, has served the Biomonitoring Program with great loyalty and professionalism since 1985, as our leading contract taxonomist. Bruce Grantham and Rhonda Mendel of Lotic, Inc. have also provided highly skilled taxonomic services to the Department since 1996. The following organizations contributed site data used in this report: National Park Service (Acadia National Park); Acheron Engineering, Inc.; Barr Environmental; Eco-Analysts, Inc.; Lotic, Inc.; Normandeau, Inc.; The Houlton Band of Maliseet Indians; and The Penobscot Indian Nation. Photographs of aquatic organisms are from the North American Benthological Society Freshwater Macroinvertebrate Slide Library. MDEP staff, Larry Comeau, Karen Schuler, and Ruth Ann Burke provided able assistance in copy editing and formatting of the report. Peter Rushton's problem-solving skills and "can do" attitude were indispensable in the final stages of production. Lisa-Kay Keen provided crucial field and data management support in 1998 and 1999. Kathy Hoppe and Nick Archer have provided accurate reconnaissance information and indispensable field support for assessment activities in Aroostook County. We are indebted to the willing services of numerous temporary Conservation Aide field workers and laboratory sample sorting technicians, since 1983. We also thank Allison Tsomides and Benjamin Davies Halliwell for field assistance on the Sandy River on July 24, 1997.

Executive Summary

The following Report provides a summary of the results of biological monitoring of benthic macroinvertebrates in rivers and streams, between 1983 and 1998, in the State of Maine, by the Maine Department of Environmental Protection (MDEP). Part I Chapter 1 is a description of various developmental and implementation aspects of the State's biocriteria program, including development of analytical methods and resulting numeric biocriteria, as well as regulatory and reporting applications of the information. Part I Chapter 2 is a synopsis of biomonitoring activities for other waterbody types (e.g., wetlands, lakes and estuaries) and for specific applications (e.g., assessment of non-point source impacts).

Part II of the Report includes nine chapters, organized by major river basin(s), providing an overview of historical findings, biomonitoring activities and results, current status and planned future activities. Each Basin Chapter has an associated Basin Map and Basin Table that present station location information and biocriteria results. Also provided are eleven case studies that elaborate upon biological and water quality findings and management activities for specific sampling locations, over time.

For most of the State's river basins, biological monitoring has demonstrated significant site-specific improvements in the condition of aquatic life since the early 1980's, as the result of improved point source treatment technologies and management (Case Studies 4 and 7). However, in recent years it has become apparent that significant impairment of aquatic life is occurring as a result of non-point source impacts, particularly in urban streams (Part I Chapter 2; Case Studies 1, 2 and 10). Future priorities for the Biological Monitoring Program include an expanded emphasis on the assessment of non-point source biological impacts, development of periphyton indicators of nutrient, aesthetic and biological impacts, and expanded reliance on spatial data integration and analysis .

Authorship and Credits

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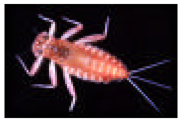
Part I

PROGRAM SUMMARY CHAPTERS

CHAPTER 1

BIOLOGICAL MONITORING

PROGRAM SYNOPSIS



PREFACE

Passage of the revised Water Classification law (38 MRSA, Section 464) in 1986 by the Maine State Legislature established Maine as the first state in the nation to statutorily adopt explicit narrative aquatic life standards for each water classification for the protection of aquatic life (Tables 1 and 2). The federal government has since recognized the valuable contribution of biological information to water quality management programs and has recommended that all states initiate the development of narrative aquatic life standards. (U.S. EPA, 1990; US EPA 1998a; USEPA, 1998b).

The purpose of this document is to present results of fifteen years of biological monitoring efforts on rivers and streams by the Maine DEP Biological Monitoring Program and to summarize biological assessment activities under development by the State, for other water body types such as lakes, wetlands and estuaries (Part I Ch. 2 *Related Biological Monitoring Activities and Programs*, p. 25) . The results presented here are based on the original, 1990 biological criteria linear discriminant model. The report provides the results of statewide biomonitoring activities, in text, maps and tables, organized by major river basin. This report also highlights and details information on status and trends by examining case studies for locations of special interest. A presentation of the current status and trends for overall water quality in Maine may be found in the 1996 "State of Maine Water Quality Assessment", (305b) report (MDEP 1996a).

"Nearly 600 million gallons of wastewater are discharged into Maine's waters every day…..Biological monitoring of river and stream life provides remarkable insight into the functional quality of the environment studied."

Introduction and Background

Program Synopsis: Development of Biological Criteria

The Maine Department of Environmental Protection Biological Monitoring Program began a standardized program of sampling stream invertebrate communities in 1983. This statewide monitoring effort marked the beginning of the program in existence today. Numeric criteria, to assess attainment of the State's narrative aquatic life standards, were derived from a set of 144 samples of baseline biomonitoring data. The analytical approach used multivariate statistical analysis (linear discriminant analysis) and professional biologist expert judgement to identify variables that best predict attainment of aquatic life classification. Numeric criteria were completed by 1990 and have been used as Department policy, since then, for all official determinations of aquatic life class attainment, for issuance of 401 Water Quality Certification, for state and federal reporting and for problem identification. See, *Data Collection and Analysis*, p. 20 Davies et al, 1995, and Davies and Tsomides, 1997 for a more complete discussion of the analytical approach.

In 1998 the original numeric criteria model was re-calibrated to include a total of 373 sampling events, significantly improving its flexibility and robustness. The re-calibration resulted in relatively minor changes to the structure of the original model, involving simplification of the structure of two of the sub-models, the elimination of two poorly performing variables, and changes in model coefficients to account for the new data. The Department proposes that the revised model and established sampling and analytical methods (Davies and Tsomides 1997) be promulgated as the State of Maine numeric biocriteria regulation. All biomonitoring data collected after January 1, 1999 will be analyzed in accordance with the new, re-calibrated model.

Biological Information to Assess Environmental Quality

Currently, nearly 600 million gallons of wastewater are discharged into Maine's waters every day. The State issues over 350 licenses to industries, businesses, municipalities and schools to regulate the quality of these discharges. In addition, tens of millions of acres of land are subject to timber harvesting, agricultural use and urban development, causing the release of pollutants such as sediment, nutrients and toxic materials to the State's surface and groundwater. Also, a legacy of environmental carelessness can be found in the numerous old dumps and hazardous waste sites present across the state. These factors all contribute to concerns for the quality of Maine's waters.

Biological monitoring of river and stream life provides remarkable insight into the functional quality of the environment studied. It can reveal important changes in the composition of biological communities caused by human activities. It asks the question: "Is this aquatic community showing evidence of harm?" The condition of the biological assemblages reveals the results of all the physical, chemical, and biological stressors that an aquatic community encounters. The approach relies on the great diversity of invertebrate life (animals without backbones such as clams, snails, crayfish, leeches and especially, immature aquatic insects) in rivers, streams and wetlands, to determine how suitable a waterbody is for the support of aquatic life. Different types of invertebrate life demonstrate widely differing tolerances to pollution (Figs. 1-5).

Fig. 1: **Immature mayfly nymph**

Fig. 2: **Freshwater Unionids**

Traditional measures of water quality, such as levels of dissolved oxygen or concentrations of toxic contaminants in water, are indirect ways to determine the ecological condition of a waterbody. They allow one to draw inferences concerning expected effects on aquatic life but do not look directly at biological responses in the stream and do not account for interactions when more than one factor is involved. By inventorying the makeup of invertebrate communities and comparing results to those found in pollution-free areas, it is possible to determine whether or not pollution is causing ecological impacts such as the loss of sensitive groups of organisms and the ecological functions they perform (Courtemanch, Davies and Laverty 1989).

The Department's Biological Monitoring Program provides water quality information for a wide array of programs and initiatives including:

- general, long-term ambient monitoring and trend assessment;
- evaluation of water quality classification attainment;
- evaluation of impacts downstream of discharges;
- evaluation of the effects of management activities
- evaluation of the effects of non-point source impacts;
- evaluation of impacts from diffuse toxic contamination through the Surface Water Ambient Toxics Program (MDEP 1993);
- evaluation of the impacts of hydropower activities in fulfillment of requirements for the Clean Water Act SEC. 401 water quality certification process.

In addition, the Program is refining methods and criteria to better assess aquatic biological impacts of poor land use practices on stream and wetland systems, discussed in Part I, Chapter 2.

As of the end of the 1998 field season, a total of 362 biological monitoring stations have been established throughout the State, on 139 different rivers and streams (General Map 1). Many of these stations have been sampled more than once and a few stations have been sampled annually for up to 14 years. Over the years the Biological Monitoring Program has documented numerous examples of dramatic recovery of the biotic community after the implementation of new treatment technologies (Case Study 4). It has also revealed important biological effects that would have gone undetected with traditional chemical monitoring methods (Case Studies 1,3 and 7).

This report contains case studies highlighting the effectiveness and importance of the efforts by industry, municipalities and the State to improve treatment and restore affected aquatic resources (Case Studies 4,6 and 11). Examples include the restoration of the Piscataquis River, downstream of Guilford, from a severely degraded and neglected resource in the early 1980's to a high quality river, exhibiting Class A biological characteristics in some downstream reaches today. The dramatic, positive biological response was the result of construction of the Guilford sewage treatment plant in 1988 (Part II, Basin Chapter 2).

The restoration of Cooks Brook, site of serious cadmium contamination from a metal finishing plant in the early 1980's, is another success story. Sources of groundwater contamination have been removed, transforming Cooks Brook from a stream essentially devoid of aquatic life to a high quality stream supporting brook trout today (Part II Basin Chapter 9).

More discouraging are the several cases of long-standing aquatic life impacts caused by known sources that are poorly responsive to corrective actions (Case Study 5, E. Branch of the Sebasticook River), and the situations where habitat and flow alterations have had obvious detrimental impacts on the biota (see *Hydroelectric Project Re-licensing*, p. 15, and *Biological Effects of Hydropower Impoundment*, p. 16, in this Chapter, and Case Study 11). Biological monitoring provides a wealth of information on the overall success of the State's water quality management efforts, in terms that are imminently meaningful to the tremendous diversity of life that makes up our State's natural heritage.

Fig. 3: Stonefly nymph

Fig. 4: Chironomid midge larvae

Milestone Experiences:

Department biologists have relied on biological assessment of stream benthic macroinvertebrates since the early 1970's, when the value of this approach was first being recognized and evaluated nationally. Early biomonitoring studies included examination of the downstream effects of chlorination below municipal sewage treatment plants (Courtemanch 1977) and several studies on the effects of pesticides used during the spruce budworm outbreak in Maine timberlands in the 1970's (Courtemanch and Gibbs 1980; Gibbs et al, 1984). These and other studies were important in redirecting specific state policies such as better regulation of chlorination, and established the value of biological information in environmental decision-making.

In 1974, the US EPA provided funding for an investigation of the effects of pulp and paper mill waste on the biota of the Penobscot River (Rabeni 1977). This study used rock-filled basket introduced substrates to sample benthic macroinvertebrates in a 100 km section of the Penobscot River from East Millinocket to Costigan. Three of the eleven sampled stations were severely degraded, as evidenced by the dominance of pollution tolerant organisms including sludge worms and chironomid midges (Fig. 4), as described in Case Study 4.

The Penobscot River was re-visited in 1981 to investigate whether the $33 million dollars expended for implementation of secondary wastewater treatment, at area pulp and paper mills, since 1974, had resulted in any improvement in biological conditions (Davies 1987; Rabeni et al 1988). This study, funded by the US EPA, duplicated all of the data collection and analysis methods of Rabeni 1977 and uncovered dramatic improvements at the most severely affected stations from 1974.

Secondary treatment technology instituted at the paper mills, succeeded in decreasing the discharge of total suspended solids and biochemical oxygen demand by 80%. Biomonitoring results demonstrated the environmental benefits gained by the improvements in wastewater treatment. In contrast to conditions prior to implementation of secondary treatment, even the stations in closest proximity to the mills had viable populations of pollution sensitive organisms such as mayflies and stoneflies (Figs. 1and 3).

By 1984, DEP biologists were sufficiently convinced of the importance and usefulness of biological information that they resolved to incorporate explicit standards for the condition of aquatic life into a proposed revision of the water quality classification law. Passage of the law, following numerous revisions, negotiations and legislative committee meetings, was accomplished in 1986 (MRSA Title 38 Article 4-A § 464-465). Maine's narrative aquatic life standards and supporting definitions are shown in Table 1 and described in several peer-reviewed publications (Courtemanch and Davies 1988; Courtemanch 1989; Courtemanch et al 1989; Davies et al 1991; Courtemanch 1995). Concurrent with efforts to pass the new water quality classification law, the Biomonitoring Program established standardized data collection protocols (rock-filled baskets, rock-filled riffle bags and rock-filled cones (Figs. 6,7,8 and 9) and, using these methods, began to amass a statewide, baseline database.

By 1989, a sufficient number of sampling events existed to embark on the development of numeric criteria to support the narrative standards in the law. With the statistical expertise of insect ecologist, Dr. Francis Drummond, at the University of Maine, numerous exploratory multivariate statistical analyses were applied including cluster analysis, correspondence analysis (DeCorAna), two-way indicator species analysis (TWINSPAN) and linear discriminant analysis. The Department, in January of 1990 also convened a technical advisory committee of non-agency scientists to provide peer review and oversight of the biocriteria development process. Individuals chosen had a demonstrated understanding of the technical challenges inherent in the development of numeric criteria and the use of the benthic macroinvertebrate community in water quality assessment. Participants were also selected to provide broad representation from various interest groups and stakeholders, including the pulp and paper industry, independent consulting biologists, environmental advocacy groups, academia and other state natural resource agencies. At the outset it was made clear that the role of the group was technical oversight of the numeric criteria development process. Participants were requested, as far as possible, to refrain from advocacy or debate that did not contribute to the scientific and technical quality of the ultimate biocriteria product. The Technical Advisory Committee was active for about 2 1/2 years and was instrumental to the success of the final product.

Linear discriminant analysis was chosen as the most promising technique to address both the scientific goals and the regulatory and policy goals of the new biocriteria program. The final numeric criteria consist of a set of interrelated linear discriminant functions that use 25 quantitative variables to classify unknown samples, by comparing them to characteristics of the four groups defined by the baseline data. Results are reported in terms of the probability that a sampled station fits the characteristics of its legally assigned class. The original linear discriminant model was completed in 1992 and has served as the Biomonitoring Program's draft numeric criteria since that time. As noted in the Introduction, the model was recalibrated with an additional 229 sampling events in 1998. The upgraded model will go to rulemaking in the spring of 2000.

Fig. 5: Nets of caddisfly larvae

Table 1 Maine's narrative aquatic life and habitat standards for rivers and streams

CLASS	MANAGEMENT	BIOLOGICAL STANDARD
AA	High quality water for recreation and ecological interests. No discharges or impoundments permitted.	Habitat shall be characterized as natural and free flowing. Aquatic life shall be as naturally occurs.
A	High quality water with limited human interference. Discharges limited to noncontact process water or highly treated wastewater of quality equal to or better than the receiving water. Impoundments allowed.	Habitat shall be characterized as natural. Aquatic life shall be as naturally occurs
B	Good quality water. Discharge of well treated effluent with ample dilution permitted.	Habitat shall be characterized as unimpaired. Discharges shall not cause adverse impacts to aquatic life. Receiving water shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community.
C	Lowest water quality. Maintains the interim goals of the Federal Water Quality Act (fishable/swimmable). Discharge of well treated effluent permitted.	Habitat for fish and other aquatic life. Discharges may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving water and maintain the structure and function of the resident biological community.
Impoundments	Riverine impoundments classified as Great Ponds and managed for hydropower generation	Support all species of fish indigenous to those waters and maintain the structure and function of the resident biological community.

Table 2 Definitions of terms used in Maine's Water Classification law**.**

1. **Aquatic life.** "aquatic life" means any plants or animals that live at least part of their life cycle in fresh water.

2. **As naturally occurs.** "As naturally occurs" means conditions with essentially the same physical, chemical and biological characteristics as found in situations with similar habitats, free of measurable effects of human activity.

3. **<u>Community function</u>.** “Community function” means mechanisms of uptake storage and transfer of life-sustaining materials available to a biological community which
determine the efficiency of use and the amount of export of the materials from the community.

4. **<u>Community structure</u>.** “Community structure” means the organization of a biological community based on numbers of individuals within different taxonomic groups and the proportion each taxonomic group represents of the total community.

5. **<u>Indigenous.</u>** “Indigenous” means supported in a reach of water or known to have been supported according to historical records compiled by State and Federal agencies or published in scientific literature.

6. **<u>Natural.</u>** “Natural” means living in or as if in, a state of nature not measurably affected by human activity.

7. **<u>Resident biological community</u>.** “Resident biological community” means aquatic life expected to exist in a habitat, which is free from the influence of the discharge of any pollutant. This shall be established by accepted biomonitoring techniques.

8. **<u>Unimpaired</u>.** “Unimpaired” means without a diminished capacity to support aquatic life.

9. **<u>Without detrimental changes in the resident biological community</u>.** “Without detrimental changes in the resident biological community” means no significant loss of species or excessive dominance by any species or group of species attributable to human activity.

COST ESTIMATES AND RESOURCE REQUIREMENTS

The current Biological Monitoring Program for rivers, streams and wetlands is operated on a budget of $200,000 to $235,000 per year. This figure includes staffing (3 professional biologist full-time equivalents, and 1 summer intern), overhead, contractual services and equipment. This figure represents about 2% of the State’s total expenditure, of about 10 million dollars per year, for water resource management. Chris Yoder, manager of the Ohio Environmental Protection Agency Biological Monitoring Program, has recommended that to be maximally effective, funding for biological monitoring activities should amount to between 5 and 15% of the cost of a state’s overall surface water quality management budget. Ohio EPA’s exceptional biological monitoring program has about 12 full time equivalent staff for rivers and streams and is operated on a budget representing about 9% of total expenditures for Ohio water resource management. Maine's Biological Monitoring Program was staffed with 1.25 full-time equivalent biologists for the first five years. In 1988 a second full-time biologist was hired for the rivers and streams program and a third biologist was added for development of wetland bioassessment methods in 1997. Part-time summer intern assistance has been available for most field seasons. Appendix 4 provides a description of the functional roles of the MDEP Biological Monitoring Program staff and synoptic biographical information. Activities directed to development of bioassessment approaches for lakes and estuaries are performed by staff in the Department's Lakes Program and the Marine Program, respectively.

Numeric Aquatic Life Criteria Development and Program Implementation Costs:

Total staff resources expended, by the Department, to develop narrative and numeric aquatic life criteria was 13.5 full-time equivalents at a total cost of about $600,000, expended over about seven years. Federal grants targeted to water quality planning and standards allowed the Program to contract significant work products, including programming of database management software and multivariate statistical analysis. Contractual services costs for criteria development total approximately $57,000 over the same time period. These services include sample taxonomic work-up, software development and statistical analysis.

Annual Monitoring and Program Maintenance Costs:

The river and stream Biomonitoring Program is currently maintained with two full-time equivalent professional staff and 0.25 full-time equivalent summer intern staff. Collaboration with the Division of Watershed Management provides some additional staffing support. A third river and stream biologist will be added to the staff in 2000. Equipment expenses average $500 to $800 per year. Sample sorting and taxonomic work-up costs about $30,000 for 50 river and stream stations (three samples per station), and an additional $5,000-6,000 for 20 wetland stations. Taxonomic work-up is currently contracted to freshwater invertebrate taxonomist, Michael Winnell, of Petoskey Michigan and to Rhonda Mendel and Bruce Grantham of LOTIC, Inc. in Unity, Maine. Mr. Winnell has identified about 80% of samples over the past 12 years. Quality assurance activities have confirmed the precision and accuracy of the taxonomic services used in the Program. The high level of skill and professionalism of these taxonomists ensures the consistency and accuracy of the taxonomic record in the Biological Monitoring Program database.

USE AND APPLICATIONS

Water Quality Classification

The Department is required to report to the Maine State Legislature on the water quality attainment status of the classified waters of the State and to make recommendations for changes to the legal classification of waters of the State. As established in Maine statute, a classification consists of designated uses (such as swimming or habitat for aquatic life) and criteria (such as for bacteria, dissolved oxygen and aquatic life) which specify levels of water quality necessary to maintain the designated uses. A waterbody must meet the criteria of all three standards to be in attainment of its designated class.

Results of the analysis of biological data provide a determination of whether or not applicable aquatic life standards (Tables 1 and 2) are attained within a sampled stream reach, thus contributing to the determination of overall classification attainment. The statistical protocol for analyzing macroinvertebrate data was developed to yield an objective, easily understandable, pass/fail test of attainment of aquatic life class. The determination is reported as the probability that a sampled site fits the characteristics of its statutorily assigned class. For a complete description of the development of numeric aquatic life criteria (the statistical model) supporting this law refer to Davies et al 1995.

Information about the condition of aquatic life is also useful in the context of numerous other activities and programs throughout the Department including monitoring and assessment; reporting; permitting, licensing and enforcement (Courtemanch 1995).

Monitoring and Assessment

The aquatic communities of the rivers and streams of Maine are subject to detrimental impacts from various types of activities that can be generally categorized as point sources, non-point sources, in-place (toxic) contamination, habitat and hydrologic modification. The Biological Monitoring Program functions to provide monitoring and assessment data to various programs and initiatives, within the Department of Environmental Protection, that are involved in the regulation of these activities. Table 4 presents the relative magnitude of potential impacts to surface water quality in the state.

Table 4. Relative magnitude of potential human impacts to inland waters of Maine

Total State Area=19.8 million acres

Point Sources	**Daily Discharge Volume**
Pulp and paper	350 million gallons/day (MGD)
Publicly owned sewage treatment works (POTW)	190 MGD *(Note: may include significant industrial wastes)*
Combined sewer overflows	8.2 MGD avg. (more than 3 billion gallons total annual volume)
Food processors	4 MGD
Textiles	3 MGD
Non-Point Sources	**Areal Extent**
Timber Harvesting	
commercial timberland	16.9 million acres or 85% of State
acres harvested in 1996	473,000 acres or 2.4%
Agriculture	1.3 million acres or 7% of State
Urbanization	300 site location of development permits per year
In-place (toxic) Contamination	**Number**
Number of water supplies contaminated by leaking petroleum storage tanks	280 (approximate)
Known uncontrolled hazardous waste sites	40-50 (approximate)
Habitat and Hydrologic Modification	**Number of Permits**
Hydroelectric power	104 FERC-licensed storage and generating dams
Water level control	679 licensed dams to regulate water levels
Stream alterations	414 permits for stream alteration or crossing issued by DEP in 1996

Targeted assessments of the impacts of these activities occur as needed, but in general, the Department follows a five-year, rotating basin assessment schedule (Table 5). Currently, the Biomonitoring Unit and non-point source assessment program have the capability to assess 40 to 50 stations per field season. Waterbodies are prioritized for assessment within the targeted basin based on specific concerns about discharger performance or potential enforcement action, re-licensing information needs, concerns about land use practices in the basin, and specific requests from interested stakeholders. Since 1994 the Surface Water and Ambient Toxics program has provided a legislative mandate, funded at approximately ½ million dollars per year, to support a major assessment initiative to identify impacts of toxic substances on Maine's waters, as described below.

Table 5. Every five year rotating basin assessment schedule

Major Basins	Assessment Schedule
Androscoggin	1998; 2003
Kennebec and Mid-Coast	1997; 2002
Penobscot, St. Croix and Downeast Coast	1996; 2001
Piscataqua, Saco and Southern Coast	1995; 2000
St. John; Presumpscot	1994; 1999

Surface Water Ambient Toxics Program (SWAT)

In 1994, the Legislature identified a need to assess the nature, scope, and severity of toxic contamination in the state's surface waters, and to provide for the assessment of the effects of this contamination on human and ecological health. Maine's Surface Water Ambient Toxics Monitoring Program was established to fulfill that need. A five year work plan was developed jointly by Department staff and an independent Technical Advisory Group established by the Legislature to comprehensively monitor the State's rivers, lakes and coastal waters (MDEP, 1993a,b). Results from the first two years have been reported to the Legislature (MDEP, 1996b; 1997).

The program uses techniques including fish and shellfish tissue analysis, sediment analysis, and biomonitoring to evaluate possible health effects on humans and wildlife. The Biomonitoring component measures direct toxic effects on aquatic communities using methods developed by the Biomonitoring Program.

Reporting

The *State of Maine 1996 Water Quality Assessment* is a report required by Congress under Section 305(b) of the Federal Water Pollution Control Act. It provides a summary of the status of the State's water quality. The Biological Monitoring Program provides data to the 305(b) report to list the aquatic life attainment status of all monitored waters. Biomonitoring data is also used to recommend waterbodies for listing on the state's 303(d) list. This federally required report lists waters that are not attaining applicable water quality standards and that require treatment beyond technology-based controls. Approximately 30% of Maine's listed segments have been listed due to aquatic life concerns.

Permitting, Licensing and Compliance Activities

The Biomonitoring Program provides technical review and assistance for Department permitting activities including issuance of wastewater discharge licenses, issuance of 401 Water Quality certificates for hydroelectric project relicensing, technical review of active or potential enforcement cases and management of sites contaminated by hazardous substances. The program also reviews projects referred for evaluation of violations of land-use regulations.

Wastewater Discharge Licensing:

Major and minor wastewater discharge licenses are reviewed and reissued at least every five years. The Department has initiated a watershed-based approach, following the rotation shown in Table 5, with licenses due to be issued the year following assessment.

The Biomonitoring Unit consults with licensing staff in order to establish priorities for sampling within the target basin and provides results of assessment activities. In cases where aquatic life standards are not attained, Biomonitoring staff may work with the licensing staff and the discharger to establish a plan for remediation of the problem and an ongoing monitoring plan (See Case Study 11: Biocriteria as a TMDL modeling endpoint, Presumpscot River).

Hydroelectric Project Licensing:

The Biomonitoring Program plays a significant role in the process of certifying and re-licensing hydroelectric power projects by submitting formal requests for necessary studies, reviewing study plans and results, and evaluating whether or not aquatic life standards can be attained under any proposed changes to the operating regime. Maine's waters are constrained by over 1500 dams with 783 currently licensed by the state or federal government for the purposes of water level control or hydroelectric power generation. Of these, the Federal Energy Regulatory Commission (FERC) has jurisdiction to license 104 dams for hydroelectric power generation or for storage capacity. An additional 31 dams generate power but are exempt from FERC licensing for various reasons. The balance of the flow regulation dams must be registered with the Department but are not subject to extensive environmental review. Because FERC projects are generally licensed for a thirty to fifty year term, and they may have substantial environmental and social consequences, they are subject to an exhaustive review process.

From start to finish, re-licensing activities often span three to five years. Two field seasons of on-site data collection are customary for average projects. Additional years of assessment may be required for problematic projects. The MDEP Bureau of Land and Water Quality is required to certify whether or not a project, due for re-licensing, will meet water quality standards under the proposed operating regime. The Department’s water quality engineering staff focuses on attainment of dissolved oxygen standards under existing and proposed operations as well as minimum flow issues downstream of the dam. The Department’s biological staff evaluates attainment of aquatic life standards. MDEP technical staff rely on several existing policy guidance’s when making minimum flow recommendations. These include:

- the aquatic base flow policy (ABF) of 0.5 cfs per square mile of drainage area from the U.S. Fish and Wildlife Service (Larsen 1981);
- an adaptation of an MDEP "zone of passage" regulation (MDEP Water Quality Regulation Chapter 581) recommending that 75% of the cross-sectional area remain wetted (3/4 wetted policy); and
- a U.S. FWS policy recommending that the ratio of maximum generation flow to base flow be not greater than 10 to 1 (Raleigh, R.F., L.D. Zuckerman, and P.C. Nelson. 1986).

Project specific minimum flow recommendations generally are the greater of the two flows determined for ABF and the ¾ wetted policy. ABF is generally considered to be protective of fishery and other aquatic life requirements while the ¾ wetted policy considers habitat quantity.

Benton Falls Dam, Sebasticook River, Benton , Maine

BIOLOGICAL EFFECTS OF HYDROPOWER IMPOUNDMENT

When the Biomonitoring Program was first conceived and new biologically based water quality standards were adopted in the classification system, the scientific basis for those standards was derived from experience the MDEP had gained from evaluating the effects of point source discharges on aquatic communities. However, the standards were written robustly, to provide a broad basis to address the range of biological response expected to be encountered from different and often complex interactions between human activities and the aquatic community. The advantage and value of biological standards are well expressed when measuring the complex effects of impoundments on our river systems. Using only physical and chemical standards, waters both within and downstream of impoundments often appear to attain water quality standards in the majority of situations, leading to the often-stated assertion that hydropower is a “clean” technology. Measurement of the biological communities associated with impoundments often tells a different story, sometimes revealing severe loss of both the structure and function of the aquatic communities, as described in the following section.

Dams, in general, affect upstream and downstream benthic macroinvertebrate communities differently. Impoundments used for hydroelectric power generation show the most impairment, correlated with the amount of flow regulation associated with the facility. Upstream waste discharges and other sources of contamination can compound the effects of water impoundment. Dams on rivers reduce water velocities, increase depth, reduce re-aeration potential resulting in reduced dissolved oxygen, reduce light penetration, and promote retention of settleable particles in the upstream impoundment. The settled solids alter the benthic habitat and contribute to oxygen demand. Temperature regimes are also dramatically altered, with the degree of the alteration determined by specifics of the shape of the impoundment and the operating regime of the hydro-electric project. In effect, the ponded area assumes some of the characteristics of a lake, but typically the ponded water volume has a much shorter retention time, as compared to a natural lake. Thus the riverine biological community is subjected to quasi-lake conditions for which they are not adapted. Lake-dwelling organisms generally, also find run-of-river impoundment conditions unfavorable. The short retention time precludes the possibility of the development of a planktonic community, the typical food base of lakes. High flow volumes in spring and fall, experienced by the river are also reflected in riverine impoundments, frequently causing scouring of accumulated organic matter on the substrate, and partially restoring the riverine, mineral-based substrate. This constitutes a periodic disturbance of benthic habitat for typical lake-dwelling organisms, resulting in lower production. Biological assessment of impounded benthic communities reveals that the detrimental effects of these unnatural conditions usually results in severe loss of both community structure and function. This is detected in biological metrics as reduced sample abundance and richness, increased Hilsenhoff Biotic Index values (due to loss of sensitive taxa), increased relative Diptera abundance, increased numbers of non-insects and reductions in filter feeding groups. These findings are indicative of the intolerance of lotic-adapted communities to the effects of reduced water velocities and indicate a shift in community function toward a food base of settled organic matter.

Conditions below run of river dams may, depending on the specifics of the project operating regime, offer a subsidy to the aquatic community by stabilizing flows and temperatures and discharging a higher suspended organic matter load than is carried in un-dammed reaches. Typically, under stable downstream flow conditions (such as for projects operated for run-of-river conditions), samples collected within the near-field influence of an upstream dam will exhibit significantly higher numbers of organisms and are dominated by filter-feeding invertebrates such as Hydropsychid caddisflies. However, variable or extreme dam release flows, such as those occurring at peaking-power projects, negatively affect downstream riverine communities when they are unable to adapt to the artificial flow regime and unstable habitat conditions. Predominant effects include disturbance of expected production of filter-feeding organisms (Hydropsychid caddisflies; black flies, etc.); stranding or dessication due to periodic reduced flows; displacement at high flows; and reduced water quality from the impounded water source

Operation of peaking hydro-electric projects may cause a change in the discharge volume by orders of magnitude within a twenty-four hour cycle. In store and release projects the effect may be spread out over a seasonal or annual time scale but still results in an unstable habitat, poorly synchronized to natural life-history demands of native riverine organisms. Nehring and Anderson consider a peak flow of about five times a good aquatic base flow to be acceptable for salmonid survival and production. High to low flow ratios greater than 10 have been found to result in detrimental impacts to fishery resources (Nehring and Anderson 1982, 1983). Comparable results have been observed downstream of Maine peaking projects, with detrimental effects documented when the daily maximum ratio is greater than 10 to 1.

Since 1986, several changes have occurred to account for some of the observed biological effects of these impounded waters. The sampling protocol allows for a 56 day colonization period in the impounded waters, recognizing that colonization may be retarded in these slower, deeper waters. Biological monitoring is only used in impoundments with hard bottom, eroded substrates applicable to the models' design (Davies et al 1995; Davies and Tsomides 1997). The Legislature also modified the biological standards to require, as a minimum, that waters behind riverine impoundments only have to meet the biological standards of Class C (maintain structure and function, protect indigenous fish species) regardless of the statutory water classification they are assigned, and that downstream waters below certain specified generation stations only need to meet the Class C standards. While these changes ruled out some of the non-attainment findings, a number of impounded waters still do not attain the revised standards, pointing out the profound effects that these impoundments have on the resident aquatic communities (*see Table 3*). This has led the MDEP to require changes in the operating regimes of these facilities as part of water quality certification for re-licensing. Recommendations have included changes in the base flows maintained to provide adequate aquatic habitat, limitations on maximum flows to prevent excessive flow alteration, ramping of flows to prevent washout of organisms, and discharge from selected depths in the impoundment. In some cases, reductions in wasteloads to the impoundment are also required to attain minimum aquatic life standards. See Case Study 11 *Biocriteria as a TMDL*

Modeling Endpoint Presumpscot River, for a further discussion of how biological criteria can be used to assess water quality conditions and can be directly used to make recommendations for problem abatement.

The unprecedented breaching of the Edwards Dam on the Kennebec River in Augusta, Maine on July 1, 1999 came about because, for the first time ever, the U.S. Federal Energy Regulatory Commission (FERC) denied the renewal of a license for an operating hydroelectric dam. The FERC ruled that environmental harm caused by the dam, including blockage of anadromous fish passage and detrimental impacts to benthic communities, far outweighed the energy and economic benefits of the dam. The Biomonitoring Program is participating in a two year National Science Foundation grant, with Dr. James Thorp of Clarkson University, to study the effects of dam removal on productivity and energy pathways in the former impoundment, as well as to study resulting changes in benthic community structure. Field observations of samples collected in the former impoundment, within two months following removal of the Edwards dam, already have confirmed the expected but still stunning re-colonization of the river by aquatic organisms that have been absent for 160 years. Information from this study will contribute to the Department's knowledge base and decision-making ability when faced with future proposals to pursue a dam removal option for other projects.

Table 3. Waters not attaining biological standards affected by hydropower impoundments.

Basin	**Segment**	**Statutory Class**	**Recommended changes**
St. John	Squa Pan Stream	A	Minimum/maximum flows, lower water classification
Kennebec	Moxie Stream	AA	Minimum flows
	Dead R below Flagstaff L.	AA	Minimum/maximum flows
	Kennebec R at Bingham	A	Minimum/maximum flows
	Norridgewock impoundment	B	To be determined
	Edwards impoundment	C	Dam removal, raise water classification
	Cobbossee Stream	B	Minimum flows
Androscoggin	Jay impoundment	C	Minimum flows, wasteload reductions
	Otis impoundment	C	Minimum flows, wasteload reductions
	Livermore impoundment	C	Minimum flows, wasteload reductions

Basin	Segment	Statutory Class	Recommended changes
Presumpscot	Cumberland Hills impoundment	B	To be determined
	Smelt Hill impoundment	C	Minimum flows, wasteload reductions, dam removal
Saco	Saco River below West Buxton	A	Minimum flows
	Saco River below Skelton	A	Minimum flows
Salmon Falls	Salmon Falls River	B	Run-of-river flows, wasteload reductions, lower water classification

DATA COLLECTION AND ANALYSIS

Benthic macroinvertebrate data for streams and rivers are collected at two levels of rigor, using two collection protocols. The primary protocol is termed Classification Attainment Evaluation and involves a highly standardized, quantitative methodology. The second is the Non-Point Source Screening Tool, which is rapid and largely qualitative.

Classification Attainment Evaluation

Data Collection Methods

The Biological Monitoring Program uses standardized rock-filled wire baskets, mesh bags or cones (Figures 6, 7 and 8) to sample the benthic macroinvertebrate community to determine whether or not aquatic life standards are attained in a river or stream reach. The three sampling devices have been designed to cover the full range of water depths encountered in the flowing waters of the state. Rock-filled mesh bags are used in small streams and allow standardized sampling access to sites as little as 5 cm in depth. They can be flattened to fit the contours of the stream bed and have been shown to yield results indistinguishable from the standard rock basket method, when deployed in the same location. Rock-filled baskets are used for the majority of wadeable sites in the state. They are described in USEPA 1973 and have been widely applied across the country. The Program's remote-retrievable rock-filled cone sampler provides an extension of the State's standardized sampling unit to non-wadeable rivers (Courtemanch 1984). The device is retrieved by boat using a weighted, funnel-shaped closing apparatus that is dropped down a line to settle over the cone (Figs. 8-9). The base of the cone is fitted with Nytex mesh to prevent loss of organisms on retrieval. The cone device has been shown to provide comparable results to the rock-basket methods, as well. All sampler types are customarily placed on the stream bottom for four weeks, though a eight week colonization period is sometimes used in impoundments. These samplers provide a fresh, standardized habitat of stream cobble, and resident and drifting organisms readily colonize them. The sampling season is restricted to July through September to assess the community during times of maximal stress due to high temperatures, low dissolved oxygen concentrations and low flows.

On retrieval, biologists collect and preserve all accumulated material from the samplers and identify the sample of organisms to the lowest level possible (usually genus or species). Davies and Tsomides (1997) provide a detailed account of field methods used by the Biological Monitoring Program.

The Department has collected aquatic life samples from upstream and downstream of all major licensed wastewater discharges in the state, from waters downstream of hydroelectric facilities, and from a number of non-point source impacted waters. The database also includes a large number of relatively undisturbed and unpolluted waterbodies. These sampling locations represent a wide range of water quality conditions in Maine. Samples taken from upstream of a source of pollution establish expected biological conditions in the absence of the pollution source. The pollution-impacted locations are selected to represent the presumed "worst-case" conditions, after mixing, and recovery zones of the rivers and streams sampled.

Fig. 6. Rock-filled baskets

Fig. 7. Rock-filled riffle bag for sampling streams less than 10 cm deep

***Figs. 8-9.* Remote-retrievable rock-filled cone and retrieval funnel for sampling non-wadeable rivers**

Data Analysis Methods:

Experience examining changes in the makeup of benthic macroinvertebrate communities, across a range of water quality conditions, convinced Department biologists that these changes are predictable and quantifiable. The specific language describing the aquatic life characteristics of the four water quality classes (AA, A, B, C), in the Water Classification law, is an outgrowth of this experience (Table 1*)*. The law actually contains only three separate, allowable aquatic life standards because the narrative standard, "as naturally occurs", applies to both Class AA and Class A. Communities with very poor aquatic life characteristics comprise a fourth observable aquatic life group that represents non-attainment of minimum standards. These four *a priori* groups served as the basis for developing the predictive models (linear discriminant functions) currently in use by the Biomonitoring Program.

Extensive multivariate statistical analysis of statewide biomonitoring data confirmed that the four groups observed by the biologists and described in the narrative standards are, in fact, statistically distinct groups. Statistical analysis directed the selection of the 25 most significant variables contributing to group definition. A list of the variables used in the models appears in Appendix 1 and a complete account of the development of the linear discriminant functions may be found in Davies et al (1995).

Quality Assurance:

Much attention has been given to data quality assurance and quality control including:

- minimum qualifications for field and laboratory personnel;
- standardized, documented field collection procedures, performed under the direct supervision of a senior biologist;
- whole sample work-up, with a standardized level of effort for all field collections and sub-sampling procedures; (Courtemanch 1996)
- supervised sample sorting in the laboratory, with a proportion re-sorted by another person to determine sorting efficiency;

- consistent taxonomic work-up (over 80 percent of samples identified by the same taxonomist), with identifications to species whenever possible.

Data quality is assured by rigorous data entry and data editing protocols during transfer of raw data to the computerized database management system. Taxonomic records are entered using a bar code reader to ensure accurate transfer of taxonomic codes. All data is proofed by an MDEP senior biologist prior to final acceptance into the permanent database.

A relational database (FOXPRO) stores the taxonomic code table and all sampling event data, computes analytical variables, and computes and reports results of the linear discriminant models. An example report of the data output produced by the Biomonitoring Program, termed the Aquatic Life Classification Attainment Report, is provided in Appendix 2. Plans are underway to migrate data management and reporting functions to a more current database system such as Oracle and to manage data in combination with an integrated spatial data analysis platform in ArcInfo.

Non-Point Source Screening Tool:

Data Collection Methods

The non-point source screening tool has been developed as a cooperative effort between two divisions of the Bureau of Land and Water Quality: the Division of Environmental Assessment and the Division of Watershed Management. This tool is designed, primarily, to discover and prioritize non-point source impacts. A more complete discussion of the approach, and case studies, are presented in Part I Chapter 2.

Assessments for waters with a high potential to be impacted by non-point sources are conducted at a regional or statewide scale. Initially, waters at high risk of impact are listed. Information derived from percent watershed impervious surfaces and the Watershed Pollution Potential Index (WPPI) method will provide a regional scale screening tool (see Part I Ch. 2 *Biological Assessment of Non-point Source Impacts*). Anecdotal observations of stream and watershed conditions reported or collected by DEP, other state or federal agencies, or the general public, is another important source of information to identify waters of high potential risk.

Streams from this list, which are identified as high risk, are sampled using a rapid, qualitative method. This screening tool is a modification of North Carolina's standard bioassessment technique (Lenat 1988). It is comprised of a 1 meter square kick, a one minute sweep (bank area), a leaf pack sample, and a collection made by visual inspection. These samples are sorted in the field for all the different types of organisms (Richness). They are preserved and identified in the lab to the lowest level possible. In addition, 2 one square foot kick samples (1 minute each) are taken and all organisms are preserved and identified in the lab. A habitat assessment of the stream reach is completed when the samples are collected.

Data Analysis Methods:
The biological information is reviewed and stations of concern are referred for evaluation by the standard, more rigorous protocol termed Classification Attainment Evaluation, which requires quantitative data for use in the multivariate statistical model.

Note: The non-point source screening tool is relatively new (first used in Spring of 1996) and the selected method or methods may be modified, depending on the specific type of non-point source impact, the degree of resolution a specific method may offer, and for what purpose the biological information is being collected.

Geographic Information System
A Geographic Information System (GIS) is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e., data identified according to their locations. A GIS makes it possible to link or integrate information that is difficult to associate through any other means. It can use combinations of mapped variables to build and analyze new variables.

With a GIS one can "point" at a location, object, or area on the screen and retrieve recorded information about it from off-screen files. This type of analytical function in a GIS helps one to draw inferences or conclusions about a given area by recognizing and analyzing the spatial relationships among mapped phenomena.

A critical component of a GIS is its ability to produce graphics on the screen or on paper that convey the results of analyses, helping viewers to understand the results of analyses or simulations of potential events. Each basin described in this report contains such a mapped graphic (Basin Maps Section) . The Biological Monitoring Program has mapped 362 sampling stations in ArcView 3.0 with links to data from 525 sampling events. ArcView shape files have been created for each 8 digit United States Geological Survey Hydrologic Unit Code river basin, with some basins combined for presentation purposes. Additional GIS data coverages used in this report include major dams, municipal and industrial discharges, town polygons, 100k hydrography and legal classifications of rivers and streams. A description of data sources for coverages used in this report precedes the Basin Maps on p. 160. As noted above, future Program directions include expanding spatial data analysis and management capabilities by creating real-time linkages between the relational and the spatial databases.

Part I

PROGRAM SUMMARY CHAPTERS

CHAPTER 2

RELATED BIOLOGICAL MONITORING ACTIVITIES AND PROGRAMS

PREFACE

The major focus of this report is a summary of results from fifteen years of monitoring of rivers and streams with the standard MDEP Biological Monitoring Program sampling and analytical methods. However, other related biological monitoring initiatives are underway in the State, to assess other waterbody types and to refine methods to better address specific categories of biological impact. The opening section of this chapter discusses efforts by the Biological Monitoring Program and the Division of Watershed Management to refine and focus existing biological assessment methods, and to develop new methods, to evaluate impacts of non-point sources on small streams. The remaining three sections examine initiatives that are underway or planned, to apply biological monitoring approaches to other waterbody types, including wetlands, lakes, and near-shore estuarine ecosystems.

Limited biological sampling of the benthic macroinvertebrate community using the multi-habitat screening tool method and the standard rock bags has shown that stations located in urbanized or highly disturbed watersheds are often significantly impacted. Classification attainment of aquatic life and percent watershed imperviousness appear to be related.

Biological Assessments of Nonpoint Source Impacts on Streams

Introduction and Background

Over the last fifteen years water quality monitoring of rivers and streams has focused on those waterbodies impacted by point source discharge, primarily the larger streams and rivers. Recently, biological monitoring has expanded to include streams impacted by nonpoint source (NPS) pollution, through a joint effort of the Biomonitoring program and Division of Watershed Management's Watershed Assessment unit and under the Surface Water Ambient Toxics (SWAT) program which was initiated in 1994. The focus of the nonpoint source effort is the smaller and lower order waterbodies or those waterbodies where nonpoint sources predominate as the cause of water quality threat or impairment.

Nonpoint source pollution is defined as pollution that originates from diffuse sources as opposed to a single discharge. Land use activities due to development (urbanization), agriculture, forestry activities, transportation and mining, as well as atmospheric deposition all may cause nonpoint source pollution. Effects occur due to changes in watershed hydrology in addition to increased concentration of pollutants in the runoff and resultant ecosystem and habitat effects. The specific effects from land use activities are dependent on the types and extent of land use occurring in the watershed. Development associated with urbanization is the greatest threat to water quality, since it accounts for the greatest land use and continues to increase, as opposed to other land uses that may be stable or declining. It is also typically an irreversible type of land use change. As a watershed is cleared and impervious surface area increases, there are resultant hydrological changes. The amount of stormwater runoff increases in direct proportion to the amount of watershed imperviousness and there is a greater amount of the stream flow from surface runoff rather than from base flow or groundwater. The results are higher and more frequent high flow events and lower flow or no flow during dry weather conditions. Higher flows and rate of flow result in an increase in bank erosion and channel scouring. As a result of hydrologic changes, the geometry of the stream changes (becoming wider and shallower) and sediment loading from bank erosion and watershed sources increases. In addition, the concentration of pollutants in the runoff increases. Pollutants of concern include nutrients, bacteria, toxics, suspended materials, and organic loading. Temperature effects may also be present due to both runoff and loss of riparian vegetation.

Thus, aquatic resources may be under stress posed by a multitude of practices within a watershed. Changes in the instream biological community can result from these types of stressors . The biological community provides an ideal response indicator serving as a measure of endpoint response pertinent to water quality goals and it can be used as a measure of Maine's program effectiveness.

Purpose

Biological monitoring and habitat assessment of NPS impacted streams is being used to accelerate Maine's NPS management base program by efficiently identifying waters that are threatened or impaired by NPS pollution and will contribute resource information to facilitate prioritization of water resources. Biological monitoring and habitat assessment techniques also are used as tools to evaluate the effectiveness of pollution control actions that are implemented to restore or improve water quality or stream habitat.

The assessment of NPS impacts on streams uses a three level approach. The first level is a regional screening by river basin using information derived from percent watershed imperviousness and the Watershed Pollution Potential Index (WPPI). This WPPI model relies on the assumption that the relative level of nonpoint impact is a function of watershed disturbance and sensitivity. A watershed disturbance factor is determined from population, road, and land cover data layers and a watershed sensitivity factor developed using soil and slope information. The intent of the level one screening is to provide a ranking of streams based on potential impact of nonpoint source.

Level two assessment is a rapid bioassessment field screening of waterbodies identified by percent watershed imperviousness and the WPPI as being impacted by nonpoint source. This bioassessment screening tool is currently being developed and modified. The intent is to identify streams that have a high likelihood of biological impact as a result of nonpoint source pollution. The Level II biological assessment method under development is a modification of the multi-habitat method developed by Lenat (1988) and Eaton and Lenat (1991). A standardized qualitative collection includes one square meter kick sample, one sweep sample, one leaf-pack sample, and a visual collection. These samples are picked in the field and composited. Two quantitative one square foot kick samples are also taken and picked in the lab . All organisms are identified to genus where possible. In addition to biological monitoring, field assessment includes physical description of the stream and visual assessment of channel, streambank and corridor conditions. A habitat assessment using Barbour and Stribling-Visual Based Habitat Assessment is also completed. (Barbour and Stribling 1991). The screening tool has generally been used to evaluate streams in the fall. Streams identified as having probable impacted reaches are referred to a level three evaluation, described below.

The third level of assessment is the biological monitoring program's Classification Attainment Evaluation which uses rock-filled bags (Fig. 7) to sample the benthic macroinvertebrate community to determine whether or not aquatic life standards are attained in a river or stream reach. The standard protocols to determine classification attainment are described in Part I, Chapter 1 and in Davies and Tsomides (1997).

Priority Waterbodies

Under the Comprehensive Watershed Protection Program (5 MRSA § 3331 (7)), the Maine Land and Water Resources Council is directed to establish a priority waterbody list. The intent of the list is to establish priorities for directing resources to the management of waterbodies based on the degree of threat or impairment to water quality and aquatic habitat that exists due to nonpoint source pollution; the value of the waterbody; the likelihood of successfully restoring or protecting water quality; and the degree of local public support for watershed management. In October 1998, the Maine Land and Water Resources Council approved a list of priority watersheds including 55 river and stream watersheds. This list will be reviewed annually by the Maine Watershed Management Committee and recommendations made to the Council to revise the list. Additional stream monitoring results obtained from the monitoring program may be used as a source of information to the Committee on the degree of threat or impairment to water quality and aquatic habitat.

The priority watersheds list is used to direct resources toward these priority areas. Resources may be technical assistance (i.e. assistance with watershed surveys, management plans) and/or financial assistance to develop a watershed management plan. Along with this, the Nonpoint Source Program administers the grants program that provides assistance for a variety of projects including watershed surveys, management plans, nonpoint source implementation and restoration projects and implementation of management plans.

NPS Biomonitoring Activities

Since 1996, a total of 62 stations on 42 first to fourth order streams have been monitored for nonpoint source impacts or established as reference stations using rock bag substrates. These bags have enabled the program to sample smaller streams while utilizing the quantitative methods established for the standard rock basket or cone samplers. In addition, the multi-habitat screening tool, which is currently being developed, has been used on over one-third of the established 62 stations.

In the past three years, the major sampling efforts have been concentrated in the Presumpscot, Lower Penobscot, and the Lower Androscoggin river basins. These three basins account for 43 of the 62 established NPS stations. Of the 15 stations sampled in the Presumpscot River basin, and the 13 stations established in the Lower Penobscot River basin, 6 stations in each basin are not meeting the standards of their assigned aquatic life classification. Evaluation is not yet complete for the 15 stations sampled on the Lower Androscoggin River basin in 1998. Non-attaining stations in the Presumpscot and Lower Androscoggin basins have been listed on Maine's Section 303(d) Waters (1998) list. Section 303(d) of the Clean Water Act requires the State of Maine to identify waterbody segments that do not attain water quality standards or are imminently threatened, and are not expected to meet state water quality standards even after the implementation of technology-based controls for both point sources and non-point sources of pollution.

Limited biological sampling of the benthic macroinvertebrate community using the multi-habitat screening tool method and the standard rock bags has shown that stations located in urbanized or highly disturbed watersheds are often significantly impacted. Classification attainment of aquatic life and percent watershed imperviousness appear to be related. In general, small streams in urban areas support biological communities low in generic richness and are depleted of pollution-sensitive insects. Typically, the benthic macroinvertebrate communities in these streams consist of highly tolerant non-insect taxa such as leeches, amphipods, worms and mollusks. More sampling is needed in the lower order urban waterbodies, for these aquatic resources have less assimilative capacity and are subjected to a multitude of stressors.

CASE STUDY 1

Urban Nonpoint Source Impacts: Classification Attainment and Percent Watershed Imperviousness

Biological monitoring of the benthic macroinvertebrate community in urbanized watersheds has revealed severe degradation in the lower order streams. Streams with greater than 10% impervious cover appear to be the most affected. These results are comparable to Maxted (1996) where a threshold detrimental effect appeared to exist once the watershed reached 10-15% impervious cover.

Jeff Dennis, of the Division of Watershed Management, has been directing efforts to estimate imperviousness for urbanized watersheds in Maine. As part of a graduate study project by Chandler Morse and Dr. Alexander Huryn, at the University of Maine, the imperviousness of seventeen stream watersheds was measured using detailed analysis of current, large format aerial photos with considerable ground-truthing in residential areas. Three of the streams monitored by MDEP for benthic macroinvertebrates, Long Creek, Kimball Brook, and Trout Brook, were included in this set. The imperviousness for many of the other monitored watersheds was estimated, by Jeff Dennis, using a linear regression of the imperviousness of seventeen watersheds, with the density of urban land use for those watersheds indicated by the watershed land cover extractions developed for the Watershed Pollution Potential Index (WPPI). The algorithm derived by that regression was used to predict the imperviousness of the Little River, Royal River, Pleasant River, Frost Gully, Collyer Brook, Cold Spring Brook, Johnson Brook, Clark Brook, Farm Brook, Tannery Brook, and Beaver Dam Brook watersheds. Since the urban land cover classification of the LANDSAT image was only valid for western Maine, the remaining streams in the Bangor, Exeter, and T5R9 NWP were roughly estimated from 7.5 minute USGS Quadrangles.

Biological information from 27 streams was evaluated in relation to watershed imperviousness. Nineteen streams were sampled using rock bag artificial substrates and the benthic macroinvertebrate data were run through the Biological Monitoring Program's linear discriminant models to predict aquatic life attainment. The other 8 streams were sampled using the multi-habitat method. Best Professional Judgement (BPJ) was used to assign aquatic life classification attainment for multi-habitat samples. Eight of the eleven streams with estimated imperviousness of 10% or greater did not meet the State minimum aquatic life standards while the other three streams only met the Class C aquatic life standards. All streams with estimated imperviousness of less than 3% met the Class A aquatic life standards (Table 6). Further work must be done on these streams with highly disturbed watersheds, for it is clear that the habitat degradation and the resulting hydrological changes, as well as an increase in pollutants to the waterbody are causing significant loss of sensitive taxa and a change in the resident biological community causing loss of structure and function.

Table 6 Relationship between watershed imperviousness and aquatic life classification determinations from biomonitoring of some urban streams in Maine

Stream	Town	% Impervious	Class	Model	BPJ
Stinking Brook	T5R9 NWP	<3	A	x	
Footman Stream	Exeter	<3	A	x	
Babel Brook	T5R9 NWP	<3	A	x	
Ashworth Brook	T5R9 NWP	<3	A	x	
Allen Stream	Exeter	<3	A	x	
French Stream	Exeter	<3	C	x	
Little River	Gorham	5	A	x	
Royal River	New Gloucester	5	B	x	
Pleasant River	Windham	7	A	x	
Frost Gully (above)	Freeport	7	A	x	
Collyer Brook (above)	Gray	7	A	x	
Kimball Brook	S. Portland	7	NA	x	
Cold Spring Brook	Gorham	8	B		x
Johnson Brook	Gorham	9	B		x
Frost Gully (below)	Freeport	9	B	x	
Collyer Brook (below)	Gray	9	B	x	
Meadow Brook	Bangor	10	NA	x	
Clark Brook	Westbrook	11	NA		x
Farm Brook	Gorham	12	C		x
Tannery Brook	Gorham	13	C		x
Trout Brook	S. Portland	13	NA	x	
Beaver Dam Brook	Westbrook	13	NA		x
Concord Gully	Freeport	14	C		x
"Valley Ave." Stream	Bangor	15	NA	x	
Long Creek	S. Portland	17	NA		x
"Pushaw" Stream	Bangor	20	NA	x	
"Ohio" Stream	Bangor	30	NA	x	

Biological Standards
A =aquatic life as naturally occurs
B = only non-detrimental changes in community composition allowed
C = change in community composition but structure and function maintained
NA = non-attainment, impaired, structure or function not maintained

CASE STUDY 2

Urban Non-point Source Impacts:
***Capisic Brook above and below urban Portland, Maine*.**

Capisic Brook is a small first and second order stream which originates in a spring or wetland near Westbrook College in Portland. The control site, Station 256, is in a relatively undisturbed wooded area in the Evergreen Cemetary, in Portland, and is the upstream-most available sampling area. Reconnaissance upstream of the cemetary was impossible as it originates in a dense industrial/commercial area and is largely culverted or filled. The existence or extent of inputs of urban toxic substances to the control is unknown. From the cemetary the brook continues through an area of dense residential and industrial development and is subject to culverting and diversion throughout its length. The aesthetic appearance of the brook, as well as several key water quality parameters change dramatically between the control and the urbanized locations (Table 7). In particular, water temperature, conductivity, total phosphorus, and total dissolved solids reflect the impacts of industrialization and urbanization. Day-time dissolved oxygen is much higher at the downstream site due to greatly increased algal and macrophyte biomass, caused by nutrient enrichment. Although not measured, it can be assumed that there is a diurnal drop in dissolved oxygen overnight, due to algal respiration.

The upstream site, Sta. 256 meets Class C aquatic life standards. The benthic community is low in pollution-sensitive taxa from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (EPT) but they have been replaced by relatively sensitive organisms in the order Diptera. The Hilsenhoff Biotic Index is a measure of the contribution of pollution insensitive taxa to community make-up. The higher the value the more the biological community is considered to be affected by organic pollution. Figure 10 reveals the loss of sensitive organisms that has occurred from the upstream (Sta. 256) to the downstream location (Sta. 257). Figure 11 illustrates that while both sites have a low percentage of EPT, the percentage of pollution-tolerant non-insects in the community increases from 6% at the upstream site to 87% at the downstream site. These very tolerant non-insect organisms include worms, leeches, and amphipods. A combination of causes had probably contributed to the dramatic change in community composition. Non-point source runoff from residential and industrial areas, temperature elevation due to increased impervious surfaces and reduction in canopy cover, combined sewer overflows, and possible groundwater contamination along the urban setting of the stream are probably the major causes of impact. More sampling of these small urban streams is needed to elucidate the reasons for observed changes in community structure.

Figure 10 Box plots showing values of the Hilsenhoff Biotic Index for Capisic Brook above and below urbanized areas in Portland, Maine. Values are compared to the distribution of all values for all sampling events within a given class in the Maine DEP Biological Monitoring Program database.
($N=490$ $N_{(A)}=115$ $N_{(B)}=162$ $N_{(C)}=123$ $N_{(Non\text{-}Attainment)}=90$)

Sta. 256 ***(511)***= above Portland Sta. 257 ***(512)***= below Portland

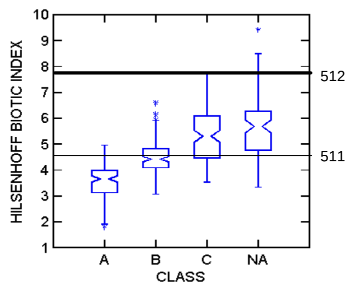
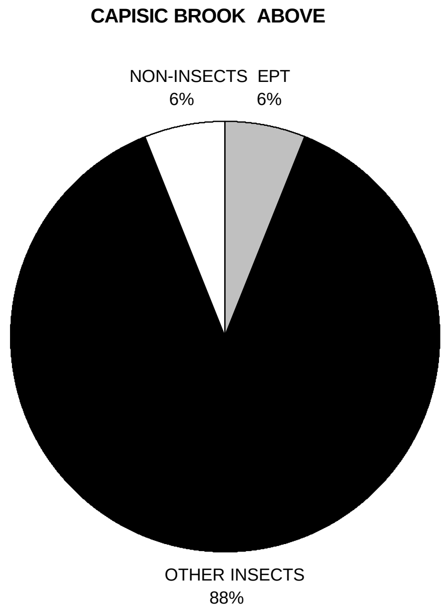


Figure 11 Comparison of differences in community structure in Capisic Brook above and below urbanized areas in Portland, Maine.



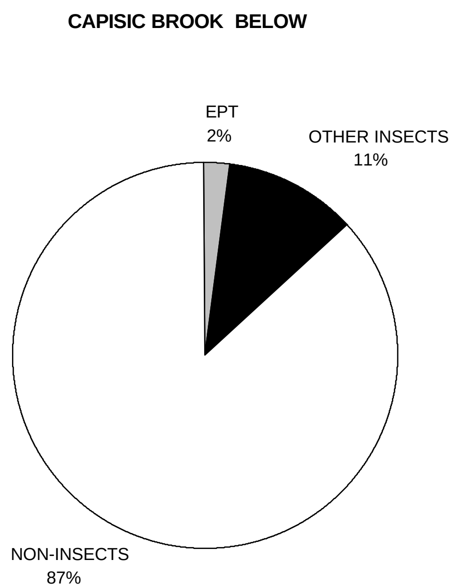


Table 7. Values for water chemistry parameters in Capisic Brook above and below Portland, Maine

Parameter	**Capisic Brook above Portland** August 24,1995	**Capisic Brook below Portland** August 24,1995
Temperature	14.5 C	**23 C**
Dissolved Oxygen	9.5 ppm	**14.6 ppm**
Conductivity	73 mmhos	**341 mmhos**
	ppm	**ppm**
Cadmium	ND .0003	ND .0003
Lead	ND .002	ND .002
Zinc	0.002	0.004
Total Phosphorus	0.022	**0.043**
Ammonia Nitrogen	NR	NR
Total Kjeldahl Nitrogen	K.1	0.4
Nitrate+ Nitrite-N	0.22	0.18
Total Dissolved Solids	46	**169**
Suspended Solids	2.5	1.6
Dissolved Organic Carbon	11	6
Gasoline	ND	ND
MTBE	ND	ND

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Biological assessment provides a direct, objective measure of wetland condition and can be used to evaluate impacts from human activities.

Biological Assessment of Freshwater Wetlands

Introduction and Background

In 1997, the Biological Assessment of Wetlands Workgroup (BAWWG) was established, to improve methods and programs to assess the biological integrity of wetlands. The group consists of wetland scientists from Federal and State agencies and universities, and is coordinated by the EPA Headquarters Office of Wetlands, Oceans and Watersheds in partnership with the EPA Office of Science and Technology, in Washington, D.C. Ongoing BAWWG topics include development of assessment methods, study design, data analysis techniques and wetland classification. BAWWG also provides a forum for peer review and collaborative projects. In 1998, a New England workgroup (NEBAWWG) was formed under the guidance of EPA New England in Boston to develop a regional wetland biomonitoring network, to sponsor and oversee regional state pilot projects, and to coordinate with and complement efforts of other biomonitoring groups. Maine DEP staff actively participate on both the EPA Headquarters and New England BAWWG workgroups.

The Need for Wetland Bioassessment

Until recently, State agencies in Maine have relied largely on functional assessments to evaluate wetlands for regulatory and planning purposes. This approach involves identifying wetland functions and values that are likely to exist based on maps, field indicators and best professional judgement. Wetland "functions" are characteristics or processes that are presumed to exist independent of their value to human society, such as flood storage, nutrient cycling, sediment and toxicant retention, groundwater recharge or discharge and wildlife habitat. Wetland "values" to society are also evaluated during this process, which may include recreation potential, educational value, historical significance and scenic/aesthetic quality. Two functional assessment methods commonly used in Maine are the "New Hampshire Method" (Ammann and Stone 1991), and the U.S. Army Corps of Engineers "Highway Methodology" (US Army Corps of Engineers 1995).

The New Hampshire Method was designed to provide basic information about wetland functions and values for planning, education and inventory purposes. It is useful for comparing a number of wetlands within a local study area, generally a town or watershed, but is not recommended for assessing individual wetlands, for impact analysis, or in legal proceedings. In the New Hampshire Method, 14 "functional values" are numerically scored from 0 to 1.0, then weighted based on wetland size. The method is open-ended, since functional values may be added or removed from the evaluation process. The Highway Methodology is a qualitative, descriptive approach designed to characterize wetlands for the Federal wetland permitting process. Evaluators use best professional judgement to determine which of 13 functions and values are exhibited, listing applicable "considerations and qualifiers" that serve as criteria for this determination. Functions and values are designated as "principal" if they comprise an important physical component of the wetland ecosystem, or are of special value to society. Similar to the New Hampshire Method, functions, values and supporting criteria used in a Highway Methodology assessment may be modified.

Functional assessment methods such as these are important tools for wetland planning and management, however they do not directly measure the ecological health of wetlands or the effects of human activities on wetland biota. Moreover, since functional assessment criteria are flexible and incorporate human value judgements, results are subjective and often highly variable depending on the evaluator and focus of the assessment. For many purposes, supplemental methods that employ a more rigorous scientific approach are needed. Biological assessment provides a direct, objective measure of wetland condition and can be used to evaluate impacts from human activities. The following are potential applications of wetland bioassessment that are not adequately addressed through functional assessment methods:

- Detecting ecological impairment for screening-level inventories, site-specific impact assessments and long-term trend analysis;
- Diagnosing physical, chemical and biological stressors, including toxics, nutrient enrichment, non-point source pollution, hydrologic changes, and introduced species;
- Evaluating the effectiveness of wetland protection activities;
- Developing performance standards for restoration and mitigation projects;
- Identifying ecological linkages among wetlands and other water bodies to refine water quality modeling;
- Developing and supporting wetland biocriteria and water quality standards; and

- Tracking wetland condition for the Maine Water Quality Assessment Report to Congress required under Section 305(b) of the Clean Water Act.

Wetland Biological Assessment Pilot Project

The Maine Department of Environmental Protection (MDEP) is currently developing methods to evaluate the biological integrity of freshwater wetlands. With support from EPA, the Biomonitoring Program has undertaken a pilot study in the Casco Bay watershed to develop biological sampling protocols, and to identify potential indicators (metrics) of wetland condition. The following are major objectives of the pilot project:

1. To develop biological sampling protocols for non-tidal wetlands

2. To measure wetland attributes across a gradient of human disturbance in a pilot watershed

3. To identify candidate metrics/indicators of biological integrity on a watershed basis

The pilot study area is located in southern Maine where development pressure and threats to wetlands are high, and therefore provides a good location to examine the effects of human activities. The Casco Bay watershed encompasses a wide range of wetland types and potential sources of wetland impact. The pilot project has focused on non-tidal wetlands having permanently or semi-permanently flooded water regimes. The project is designed to compliment other planning and assessment efforts in the watershed to produce a more comprehensive understanding of wetland ecosystems. Existing spatial data for this region were enhanced by the ongoing Casco Bay Estuary Project, and are much more complete than in other portions of the State. The availability of a well-developed Geographic Information System (GIS) has greatly aided the selection of wetlands for the biological assessment pilot study. A landscape-level wetland prioritization project for the watershed is also currently in progress. This effort is being led by the Maine State Planning Office, and will produce valuable wetland characterization data that may provide a means to focus future assessment activities.

<u>Methods</u>

Initial field work for the bioassessment pilot project began in August 1998. Wetlands were targeted on a watershed basis using existing GIS data, professional knowledge and field surveys to encompass a range of human disturbance, including potential reference (minimally-disturbed) sites. Study sites were confined to non-tidal wetlands having permanently or semi-permanently flooded water regimes.

During the first season, MDEP staff collected macroinvertebrates from 20 wetland sites (General Map 2). Two different sampling approaches were tested. The first was designed to produce a quantitative sample. In this method, a stovepipe sampler was used to enclose 3 replicate sample plots to restrict the movement of organisms. Water, vegetation and surface sediments were then agitated, and a standard volume of water was removed into a sieve bucket. Vegetation and detritus contained in the samples were retained. Samples were preserved in the field for later sorting and taxonomic analysis.

A qualitative, multihabitat sampling approach was also tested, with the goal of developing a screening level assessment tool. A D-frame net was used to sample all inundated microhabitats within the immediate vicinity of each site, including emergent vegetation, aquatic macrophyte beds, pools and channels. Organisms were “picked” or sorted from detritus in the field. One to several organisms representing each different taxon found were placed into a vial of alcohol until no “new” taxa were observed.

Algae and diatoms were sampled as part of a collaborative project undertaken by Dr. R. Jan Stevenson of Michigan State University. This project is supported through an EPA Headquarters Cooperative Agreement. Water samples for quantitative phytoplankton analysis were collected, in addition to qualitative sediment, epiphyte, macroalgae and multihabitat samples. In the multihabitat method, water, sediment, plant material, soil and woody debris from various microhabitats were composited and preserved in the field.

Physical/chemical parameters analyzed in water samples include nutrients, chlorophyll *a*, anions and cations, dissolved organic carbon, true color, alkalinity, pH, and acid neutralizing capacity. Sediments were analyzed for a suite of metals, total organic carbon and percent moisture. Habitat descriptions, dominant plant species, water temperature, dissolved oxygen and conductivity were recorded in the field.

Data from 1998 are currently being analyzed to identify wetland attributes that show predictable changes in response to human activities such as development. These attributes will later be tested on a broader geographic scale for potential use as biological metrics. During the summer of 1999, DEP collected additional wetland samples in the Casco Bay watershed and continued to refine protocols for macroinvertebrates and algae.

It is anticipated that the methods developed during the pilot project will support the creation of a statewide wetland bioassessment program consistent with the objectives of the Clean Water Act. Such a program would include development of biological criteria to assess and track the ecological health of wetlands, and to evaluate impacts from human activities. This information may then be applied to pollution control efforts, planning, restoration and reporting.

Regulatory Context

Wetlands are regulated by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency under Section 404 of the Clean Water Act, which pertains to dredge and fill activities, and also by the State of Maine under the Natural Resources Protection Act (NRPA). In 1995, changes were made to the state and federal regulatory programs in Maine to improve consistency and to streamline the permitting process. Applicants may now submit a single application form to MDEP to obtain both state and federal permits. In Maine's unorganized territories, which comprise approximately 52% of the State, the Maine Land Use Regulation Commission (LURC) is responsible for wetland regulation. MDEP and LURC technically have dual jurisdiction over wetlands in unorganized areas, however legislation has been introduced to shift responsibility entirely to LURC. Unlike other portions of the State where all wetlands are regulated, regulation in LURC jurisdiction is generally restricted to wetlands that appear on the National Wetlands Inventory maps and are at least 15,000 square feet in size.

In addition, Section 401 of the Clean Water Act requires applicants to obtain a certification or waiver from the appropriate state water pollution control agency for federally permitted or licensed activities that may result in a discharge to waters of the United States, including wetlands. The state agency may review the proposed project with respect to state water quality standards, and may grant or deny certification. States may also place conditions on water quality certification, or may waive their certification authority. In Maine, Section 401 certification is issued by MDEP concurrently with wetland alteration permits approved under the NRPA, although the State currently has no wetland-specific water quality standards. MDEP also evaluates potential wetland impacts during the review process for hydropower and National Pollutant Discharge Elimination System (NPDES) license applications. Since existing standards for surface waters do not reflect the range of natural conditions exhibited by wetlands, they are not adequate as a basis for water quality certification and licensing decisions. The development of wetland biocriteria would enhance the Department's ability to assess project impacts.

The current approach to wetland regulation differs from that used for other waters in that permitted activities such as draining and filling often result in significant ecological impairment or physical loss of the protected resource. For projects impacting large wetland areas or for those affecting wetlands of special significance, compensation for lost wetland functions is generally required. This may include restoration of previously altered wetlands, enhancement of existing functions and values, creation of new wetlands, or preservation of wetlands and/or adjacent upland sites that may be threatened by development. In 1997, the Maine Legislature authorized MDEP to implement wetland mitigation banking and to develop a compensation fee program in conjunction with the State Planning Office, subject to federal approval. Under this legislation, developers may obtain credits for compensation projects to offset future wetland impacts of up to 25 acres per year, or may pay a fee in lieu of compensation. The resulting fund will enable the State to undertake large scale compensation projects and target high priority sites on a watershed basis, however the quality of these projects will hinge on improved understanding of wetland ecology and development of better tools to monitor success. An excellent opportunity exists to apply biological monitoring in developing project goals and performance standards, and to refine restoration techniques and best management practices.

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Maine is home to almost 6000 lakes and ponds most of which became part of the landscape by glacial activity some 12,000 years ago. Fish wiers dating back 7000 years indicate that our lakes have been an integral part of the regional economy for a lot longer than most of us are aware.

Biological Assessment of Lakes

Introduction and Background

Maine is home to almost 6000 lakes and ponds most of which became part of the landscape by glacial activity some 12,000 years ago. Fish wiers dating back 7000 years indicate that our lakes have been an integral part of the regional economy for a lot longer than most of us are aware. Over the past century, Maine's lakes have provided a wide range of economic and recreational opportunities to residents and non-residents alike. Recent studies reveal that millions of dollars are received from our lake related tourist economy annually.

Maine's lakes tend to be quite diverse with no two lake ecosystems quite alike. They vary in size, depth, biota, position in the landscape and water quality. Maine's lake management program tends to focus on trophic aspects of water quality. The trophic status of a lake can be directly related to nutrient levels in the water column. Sources of nutrients include point source discharges, non-point sources and previously accumulated nutrients in lake sediments. Fortunately there are very few (4) known point source discharges to Maine lakes, and internal recycling of accumulated nutrients occurs in a low percentage of lakes (<5%). Thus, management of nutrient inputs is primarily a matter of management of non-point sources and stormwater runoff.

Legislative Considerations

The Maine Legislature has declared that it is the State's objective to restore and maintain the chemical, physical and biological integrity of the State's waters and to preserve certain pristine waters. To manage this objective in lakes, they have provided in the classification system (Table 8) that all Maine lakes are classified as Great Ponds-A (GPA) (Title 38 Section 465-A).

Table 8. The classification of Maine lakes, Title 38 Section 465-A

*1. **Class GPA waters**. Class GPA shall be the sole classification of great ponds and natural ponds and lakes less than 10 acres in size.*

A. Class GPA waters shall be of such quality that they are suitable for the designated uses of drinking water after disinfection, recreation in and on the water, fishing, industrial process and cooling water supply, hydroelectric power generation and navigation and as habitat for fish and other aquatic life. The habitat shall be characterized as natural.

B. Class GPA waters shall be described by their trophic state based on measures of the chlorophyll "a" content, Secchi disk transparency, total phosphorus content and other appropriate criteria. Class GPA waters shall have a stable or decreasing trophic state, subject only to natural fluctuations and shall be free of culturally induced algal blooms which impair their use and enjoyment. The number of Escherichia coli bacteria of human origin in these waters may not exceed a geometric mean of 29 per 100 milliliters or an instantaneous level of 194 per 100 milliliters

C. There may be no new direct discharge of pollutants into Class GPA waters. Aquatic pesticide treatments or chemical treatments for the purpose of restoring water quality approved by the department are exempt from the no discharge provision. Discharges into these waters licensed prior to January 1, 1986, are allowed to continue only until practical alternatives exist. No materials may be placed on or removed from the shores or banks of a Class GPA water body in such a manner that materials may fall or be washed into the water or that contaminated drainage therefrom may flow or leach into those waters, except as permitted pursuant to section 480-C. No change of land use in the watershed of a Class GPA water body may, by itself or in combination with other activities, cause water quality degradation that would impair the characteristics and designated uses of downstream GPA waters or cause an increase in the trophic state of those GPA waters.

The attainment of the trophic aspects of the GPA classification has been accomplished with the evaluation of the specific parameters listed in paragraph B in addition to a few others (dissolved oxygen, color, specific conductance, and alkalinity). These results are evaluated from a statewide perspective. One drawback to this approach is the appearance that assume all lakes have the potential of attaining the same optimum water quality. Other aspects of the GPA class have been evaluated on a limited basis. For example, Paragraph A under Title 38 Section 465-A, ends with the condition that 'the habitat be characterized as natural'. Currently, lakes that have wide water level fluctuations due to hydropower drawdowns are determined as violating this aspect of GPA because of the impact to natural communities in the littoral zone.

Bioassessment Opportunities

In reality, it is likely that not only size and depth influence water quality, but also location in the landscape or 'ecoregion'. So there is a need to better establish 'best possible' or reference conditions for lake types in various regions of the state. This approach would allow a more realistic evaluation of the degree to which the water quality has departed from historical conditions. This '
approach has been implemented in a number of other northern lake states with some success and is a commonly encountered element of establishing reference conditions for the development of stream biocriteria. Another approach that may prove viable is to compare a lake to its condition 100-150 years ago. This can be done using paleolimnological techniques that compare surface sedimented diatom assemblages to assemblages found deeper in lake sediments.

There are other habitat considerations that could be incorporated into our assessment strategy. For example, recent literature suggests that the trophic condition of lake water is closely linked with the biological community. The assessment of both components could be used to more precisely evaluate attainment of GPA standards. Knowledge of the biological community structure may also reveal biological approaches to lake restoration strategies applicable in situations when GPA standards are not being met.

Bioassessment Pilot Project

Because opportunities exist to incorporate a bioassessment approach into Maine's management of lakes, the DEP chose to take advantage of an opportunity offered by EPA to test their Draft Lake and Reservoir Bioassessment and Biocriteria Technical Guidance Document (U.S. EPA, 1998c). The test, conducted on historical lake data, focused on lake classification, selection of reference lakes and the evaluation of potential metrics for water column plankton communities (phytoplankton and zooplankton). The dataset used in this pilot test for the lake classification and reference lake selection portion, had a reasonable amount of data from which to draw preliminary conclusions about how Maine lakes behave regionally. The biological dataset was limited in the total number and distribution of lakes across Maine's landscape. However, a number of biological metrics did appear to hold promise for evaluating trophic conditions.

Lake Classification Results. The classification effort focused on 451 lakes which had complete datasets. Cluster analysis was utilized on a combination of morphometric and chemical variables summarized in Table 9. These selected variables have adequate geographical and lake-type coverage and should have some basis, at least in theory, for either influencing lake biology or measuring biological conditions. The ecoregion approach suggested in the EPA guidance resulted in 3 'modified' ecoregions, based on Omernik (1987), each having two lake classes. Surface area and the depth variables were primarily responsible for the clustering. Three concerns were evident from this portion of the pilot test: 1) how to handle outlier lakes (i.e., very large lakes), 2) how to incorporate additional lakes as data becomes available, and 3) the inherent bias of selection of those monitored lakes that are represented in the datasets.

Table 9 Summary of variables used for the trial lake classification analysis and reference lake selection.

Morphological/Physical	Chemical	Trophic
Surface Area	Apparent Color	Grand Mean - Secchi Transparency
Maximum Depth	Alkalinity*	TSI calculated from Secchi Transparency.*
Mean Depth	Specific Conductance*	Grand Mean - Chlorophyll *a**
Drainage Area*		Grand Mean - of Secchi Transparency . having 5 months of data/year
Flushing Rate**		*
Elevation		
Watershed Disturbance Ranking		
* indicates a small amount of missing data		
** lakes with flushing rates > 50 times per year were excluded from the analysis		

Selection of Reference Lakes. Each of the lakes in the dataset was assigned a development ranking derived from GIS 1990 Census Data. Rankings from a subset of these lakes were found to be similar to rankings derived from the examination of United States Geological Service (U.S.G.S.) topographic maps. Lakes having low development rankings were screened by professionals to eliminate lakes impacted by activities unrelated to population. Box and whisker plots were used to compare trophic status of reference lakes to non-reference lakes in each lake class. These comparisons often showed little separation between reference and non-reference lakes. This may be partially explained by the disproportionate number of reference and non-reference lakes. The technique used to choose reference lakes may need refinement but appears to be compatible with the guidance emphasis on using readily available information.

Biological Parameters. Maine examined metrics from phytoplankton and zooplankton data to evaluate their potential utility. Forty-six phytoplankton metrics were examined. Thirteen metrics showing potential utility were reduced to the four listed in Table 10, after the elimination of redundant metrics.

Table 10 Four suitable phytoplankton metrics.
Total cell volume
Percent volume Cyanophyta
Percent volume Chrysophyta
Ratio of Cyanophyta volume to Desmid volume

Seven out of nineteen zooplankton metrics showed potential utility in screening for trophic increases. Metrics with inherent redundancy were eliminated. Cumulative distribution plots for reference sites and non-reference sites were utilized to determine potential scoring levels for two metrics: total abundance and the ratio of cladocera to copepods (Table 11).

Table 11 Scoring for two viable zooplankton metrics.

Metric	Metric Levels	Score
Total Abundance	<7,500	5
	7,500-28,750	3
	>28,750	1
Ratio of Cladocera to Copepods	<0.5	5
	0.5-2.25	3
	>2.25	1

Current Bioassessment Development

The pilot project was valuable in elucidating what data were needed to continue developing statewide lake bioassessment techniques. It was recognized that there is enormous potential for the development of biological metrics to assess biological assemblages from numerous lake or lake watershed habitats. However, since Maine lake management targets water column trophic state, it was decided initially to continue the focus on water column primary producers and their consumers (phytoplankton and zooplankton). In particular, better characterization of lakes is needed to designate *reference lakes* or *lakes having minimum* disturbance in terms of both their biological and chemical composition.

Since 1996, biological samples have been collected from approximately 300 lakes in addition to an expanded list of chemical and physical parameters. In 1996, 100 candidate reference lakes were visited; 200 lakes that can serve as test lakes were visited in 1997 and 1998. Chemical parameters include cations, anions, ANC, pH, DOC, specific conductance, apparent color, alkalinity, total phosphorus, and chlorophyll *a*. The biological samples consisted of phytoplankton, zooplankton and surface sedimented diatoms.

Phytoplankton samples were obtained from the epilimnion using a minimum of 3 integrated tube samples (cores) and were preserved in Lugol's solution in opaque, 60 ml. Nalgene bottles. Zooplankton samples were obtained with an 80-micron Wisconsin net. Depending on the depth of the lake, either 3 or 5 tows were obtained from one meter above the sediment to the water surface. Samples were anesthetized using one half of an Alka Seltzer table for approximately 225 ml. of sample. Samples were preserved in sugared formalin in 250 ml. clear Nalgene bottles. Surface sedimented diatoms were obtained using a Hongvie type sediment corer. The top centimeter of sediment from two cores was collected using a turkey baster and stored in a labeled whirlpac.

The highest priority is to better characterize reference conditions in regions of the state that are receiving the highest pressure from non point sources. Zooplankton samples from 100 reference lakes have species analysis completed and another 50 test lakes are currently being analyzed. Due to the expense of surface sedimented diatom analysis, 80 of the reference samples and 20 test samples are currently being analyzed. Phytoplankton identifications from this latter set of lakes will be made as soon as arrangements are made with the analyst. It is anticipated that analysis of this data will begin in autumn of 1999. If the results are favorable and funds become available, it is anticipated that the remaining samples will be evaluated. Short sediment cores may be obtained from a few reference lakes and a few test lakes during the winter of early 2000 from which to evaluate a paleolimnological approach.

Future Considerations

Over the next few years, Maine will be analyzing this biological data and further developing bioassessment techniques. Maine will also be exploring the usefulness of a regional or 'ecoregion' approach to lake management. EPA is currently attempting to establish nutrient criteria for lakes in the northeast and it is likely that their effort will also have some effect on how Maine manages its lake resources or a subset thereof. Regardless, the incorporation of additional assessment techniques will provide varying levels of assessment intensity for use at both state and local levels.

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The Marine Environmental Monitoring Program uses the framework of Maine's Water Classification Program to make general assessments of the biological community as well as site specific assessments for permitting, licensing, or enforcement.

The Marine and Estuarine Biological Community

Introduction and Background

Forty three percent of Maine's population lives in the coastal region. This population pollutes directly and indirectly by driving vehicles, heating houses and businesses, generating sewage, disturbing soils, spilling oil and hazardous chemicals, applying pesticides and fertilizers and paving surfaces. Regulated discharges from industries, businesses, and municipalities, contaminants released from old industrial sites, underground tanks and dumps, and air pollutants from the eastern seaboard and the Midwest add to this pollutant mix. Stormwater picks up pollutants from the land and delivers them to coastal waters. On the ocean side, oil spills, dredging, discharges from boats, direct deposition of air pollutants, some seafood harvesting activities, and old underwater dumps and sawdust deposits can impact the marine and estuarine waters. Also, there are hundreds of alterations to coastal wetlands that are permitted each year through the Maine's Natural Resources Protection Act (38 MRSA, Sections 480-A to 480-Z) or Permit by Rule (38 MRSA, Section 480-H & 341-D) that have the potential to impact coastal habitat quality.

The Marine Environmental Monitoring Program (MEMP)

Marine monitoring within the Maine Department of Environmental Protection (MDEP) began informally in 1986 as a collaborative project with the Maine Audubon Society, the Department of Marine Resources and the University of Maine. The program set a course beginning with clarifying chemical processes within the near coastal system, to understanding near coastal physical habitats, to understanding the biological resources and ultimately concluding at an ecological level.

When the Marine Environmental Monitoring Program (MEMP) was formally established by the Legislature in 1988, chemical contamination was identified as its priority. Because toxic contaminants, especially metals and halogenated hydrocarbons, can cause more persistent environmental problems than nutrient enrichment, the first years of the program were devoted to addressing toxics. Furthermore, in the 1980s the MDEP already had evidence of toxic contamination in areas such as Boothbay Harbor, Blue Hill, and Portland Harbor. Nutrient enrichment and eutrophication were not yet a known concern on the coast of Maine.

In the 1990s, however, concern over nutrient enrichment and its consequent hypoxia and nuisance algal blooms prompted the program to begin assessing this potential problem. For both toxic contamination and nutrient enrichment, the intent was to first document the severity and extent of the problem. In order to interpret the results, the MEMP had to describe patterns of natural variability.

It soon became obvious, that information on natural variability was the most useful and therefore important data that the MEMP was gathering. The near coastal environment is much more complex than inland waters because it includes variables that affect the chemistry, habitat and thus the biology of these areas. These range from natural phenomena such as tides, salinity gradients, and multidirectional currents, to human disturbances such as commercial dragging, boating activity, dredging and filling and direct and indirect impacts from removing (i.e., harvesting) selected species from the biological community.

Separating human disturbances from natural forces is a challenge. Developing biological criteria amidst this uncertainty is premature. Rather, the MEMP has emphasized understanding natural variability. This approach has worked well for reviewing specific projects and conducting ecological impact assessments. The MEMP uses the framework of Maine's Water Classification Program to make general assessments of the biological community as well as site specific assessments for permitting, licensing, or enforcement.

Marine Biological Assessment

Maine's revised Water Classification law (38 MRSA, Section 465-B) of 1986 has explicit narrative aquatic life standards for the classification and protection of aquatic life in estuarine and marine waters (Table 12). This aquatic life language is almost identical to the wording for the aquatic life standards for rivers and streams 38 MRSA, Section 464 (Table 1). Like freshwater, the diversity of invertebrate life (e.g., animals without backbones such as clams, snails, lobsters, and worms) in marine and estuarine waters indicates how suitable a waterbody is for the support of aquatic life. Although freshwater and marine biological communities are very different, their response to pollutants is somewhat similar.

Table 12 Maine's Water Quality Classification System for Marine and Estuarine Waters

CLASS	MANAGEMENT	BIOLOGICAL STANDARD
SA	High quality water with limited human interference. Discharges limited to noncontact process water or highly treated wastewater equal to or better than the receiving water.	Habitat natural. Aquatic life as naturally occurs.
SB	Good quality water. Discharge of well-treated effluent with ample dilution permitted.	Habitat unimpaired. Ambient water quality sufficient to support life stages of all indigenous aquatic species. Only non-detrimental changes in community composition allowed.
SC	Lowest water quality. Maintains the interim goals of the Federal Water Quality Act (fishable/swimmable). Discharge of well treated effluent permitted.	Ambient water quality sufficient to support life stages of all indigenous fish species. Change in community composition may occur but structure and function of the community must be maintained.

A major problem in developing marine and estuarine biological standards is the lack of a reference or natural condition. Physical disturbance of the ocean floor by activities such as dragging nets or dredges disrupts the biological community. Unlike in freshwater, it is legal to practice this type of disruptive activity. Much of the bottom of Maine's coastal waters has been dragged for scallops, mussels, or fish. In some areas, the harvest of important predators or grazers (e.g., sea urchins) has resulted in major changes in the natural biological community. Also, salinity, water temperature, sediment composition, currents, depth, tides, and the presence of rockweed, kelp or eelgrass are some of the natural factors that must be considered when making a biological assessment. Toxic contaminants and dredging of harbors for navigation further complicates the evaluation.

Still, it is possible to make biological assessments using best professional judgement based on:

- site visits and sampling;
- examination of quantitative data sets from various places in Maine;
- species records from Maine;
- studies on disturbance and recovery of biological communities; and
- information on species distributions, sensitivities, life histories, seasonality, and feeding types.

Applications of Marine Biological Assessments in Maine

Salmon Pen Aquaculture Monitoring

In 1991, Maine enacted an Aquaculture Monitoring Program (12 MSRA, Section 6077). This law made the Department of Marine Resources (DMR) responsible for establishing and maintaining a comprehensive information base pertaining to all aspects of the siting, development and operation of finfish aquaculture facilities within the State. The law states that information on the geo-physical site characteristics, including currents and bathymetry; benthic habitat characteristics and effects, including changes in community structure and function; water column effects, including water chemistry and plankton; feeding and production data sufficient to estimate effluent loading; smolt and broodstock introduction and transfer data; and disease incidence and use of chemical therapeutics must be collected. The salmon industry pays DMR a fee of one cent per pound of whole fish harvested to fund the monitoring program (12 MSRA, Section 6078). This is the only State program that requires semi-annual, standardized assessments of the biological community for the purposes of siting and management.

The MEMP reviews the monitoring results and makes recommendations to DMR. The biological assessment includes a video survey and analysis of benthic invertebrates from cores taken under and around the salmon pens. Conditions such as hyperdominance, excessive build-up organic material, or *Beggiatoa* mats are considered to be unacceptable impacts to the biological environment. If these conditions occur, the owner of the salmon pens are asked or required to take mitigation measures to correct the problem.

Functional Assessments for Maine's Resources Protection Act (NRPA) Permitting

A two-year project to provide functional assessment guidelines for NRPA permitting is complete. Alison Ward, a NOAA Coastal Fellow has been working with the MEMP and produced a report entitled Maine's Coastal Habitats: Types, Values, and their Assessment in the fall of 1999. This report includes sections on the coastal geology of Maine, the functions and values of intertidal and subtidal habitats, case histories, and intertidal assessment guidelines.

Functional assessment guidelines are adapted to specific proposed activities (e.g., dredging, lobster pounds, piers) within a coastal wetland. The guidelines, designed for use by professional consultants, include a survey checklist, methods for benthic sampling and analysis, habitat mapping and photography guidelines, a semi-quantitative field card, and a comprehensive list of biological, geological, physical, chemical, commercial, recreational, and educational considerations for the marine environment. The checklist requests information about the applicant and the site; the type, nature and extent of the proposed activity; detailed descriptions of the geology and biology; historical information; impact assessment; recommendations; and potential restoration sites. The benthic sampling protocol specifically outlines the number of samples required, the sampling technique, and the analysis procedure for each habitat type. The considerations are a comprehensive list of questions that address the functions and values of marine systems as well as addressing potential impacts that may be caused by alteration of the natural environment.

At present, the functional assessments that are submitted to the MDEP range from extremely qualitative surveys to quantitative sampling. Most are not of a quality that allows for a reasonable assessment of the data. There is a great need to standardize the assessment methodology practices and educate the MDEP permitters, consultants and regional biologists about all the marine and estuarine habitat functions and values, survey techniques and habitat distributions in Maine.

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Part I I

RIVER BASIN SUMMARY

CHAPTERS

The St. John, Aroostook, and Meduxnekeag River basins have received a low level of sampling effort relative to their importance, their size and the amount of detrimental activities in the region.

Introduction

Geography

The St. John River is the largest river basin in Maine, covering 7,286 square miles within the State. About two thirds of the St. John drainage basin is in Maine with the balance in Quebec and New Brunswick, Canada. The river begins at Fifth St. John Pond, and flows through northern Maine, parallel to the Quebec boundary, through an extensive semi-wilderness area, for about 117 miles. It then turns east, to the Allagash River headwaters, where it ultimately forms the boundary of Maine and New Brunswick, Canada. The river passes through the developed areas of Fort Kent, Madawaska, and Van Buren, Maine. It exits Maine near Hamlin, eventually discharging into tidewaters of New Brunwick, Canada at St. John Bay. The total length of the river in Maine, from Fourth St. John Pond to Hamlin is approximately 214 miles.

The Aroostook River basin is the largest tributary of the St. John River and covers 2,301 square miles. The Aroostook is formed by the union of Munsungan and Millinocket Streams in township of T8R8, approximately 21 miles northeast of the headwaters of the East Branch of the Penobscot River. It follows a winding path to the northeast mostly through undeveloped areas prior to reaching the Presque Isle region in Aroostook County. It passes through the municipalities of Masardis, Ashland, Presque Isle, Caribou, and Fort Fairfield before emptying into the St. John River in New Brunswick. The total length of the mainstem, ending at the Maine/New Brunswick border is approximately 104 miles.

The Meduxnekeag River basin drains about 200 square miles in Maine, much of which is agricultural crop and pasture land. The Meduxnekeag River originates on Meduxnekeag Lake just west of New Limerick, and flows east through the developed areas of New Limerick and Houlton, before turning north for approximately 8 miles, exiting Maine's eastern border east of Littleton. The South Branch of the Meduxnekeag begins in

Cary, about 9 miles south of Houlton and flows north through agricultural areas and the town of Hodgdon before joining the mainstem. The Meduxnekeag North Branch flows from an area approximately 17 miles northwest of Houlton, through the town of Monticello, and joins the mainstem in Canada. Total length of the mainstem ending at the Maine/New Brunswick border is about 20 miles.

The Allagash and the Fish Rivers contribute the remaining flow volume to the St. John River. The Biomonitoring Program has no aquatic life sampling stations on these tributaries. Water quality of the Allagash is expected to be good because of the protected status conferred by the Allagash Wilderness waterway. The Fish River drainage is characterized by many large lakes. The upper drainage is largely forested while the lower drainage flows through more developed areas and shows impacts of agricultural non-point.

Basin Summary Statistics

Biomonitoring Activities in the Basin	**Period of Record**: 1983-1994 **Waterbodies Sampled**: Total of 23 waterbodies (St. John R. mainstem: 5; Aroostook R. basin: 15; Meduxnekeag R. basin: 3) **Established Stations**: Total of 40 stations for all basins combined **Number of Sampling Events**: St. John R.: 7; Aroostook R. basin: 36; Meduxnekeag R. basin: 9;
Wastewater Discharges	**St. John R. Basin**--1 paper mill in the United States, 1 pulp mill in Canada; 6 municipal treatment plants serving a population of approx. 16,100 in the U.S. **Aroostook R. Basin**-- 7 municipal treatment plants serving a Population of approximately 37,200; 2 food processors and 2 minor industrial discharges. **Meduxnekeag R. Basin**--1 food processor and 2 municipal treatment plants serving a population of approx. 8,700.
Other Sources	Extensive agricultural and forest harvesting land use in the entire St. John River basin.
Flow Regulation *****(Total Capacity)	**Aroostook R. Basin**--Water levels controlled by approx. 27 dams including 3 FERC hydro-electric projects: 2 are <2000 KW*; 1 peaking-power and storage project. **St. John R. Basin**—Water level controlled by 3 dams: No FERC regulated hydro-projects.

	Meduxnekeag R. Basin—Water level controlled by 14 dams: No FERC regulated hydro-projects.
Quality	Variable, with outstanding water quality and ecological resources in the upper St. John River and Allagash River watersheds, to fair to poor in some parts of the Meduxnekeag and Aroostook basins, due to non-point and point source impacts.

Drainage area	Average Annual Discharge	Wastewater Flow Volume (Major Industrial and all Municipal Discharges Only)	Mainstem Average Dilution
St. John R: 8236 mi^2 (near Hamlin)	St. John R.: 9740 cfs (at Ft. Kent)	St. John R. 27.2 mgd (42.2 cfs)	St. John R: 335:1 (pro-rated for Hamlin)
Aroostook R.: 2301 mi^2 (at Ft. Fairfield)	Aroostook R: 2665 cfs (at Washburn)	Aroostook R.: 10.8 mgd (16.8 cfs)	Aroostook R.: 221:1 (pro-rated for Ft. Fairfield)
Meduxnekeag R: 175 mi^2 in Maine (near Houlton)	Meduxnekeag R: 301 cfs (near Houlton)	Meduxnekeag R.: 2.2 mgd (3.4 cfs)	Meduxnekeag R.: 88:1 (pro-rated for Houlton)

Overview of Biological Monitoring Activities

The Aroostook County region was sampled in the 1999 field season, in preparation for the next round of NPDES licensing activities in 2000. The St. John, Aroostook and Meduxnekeag basins have received a low level of sampling effort relative to their importance, size and amount of detrimental activities in the region. The Fish River basin was not sampled until 1999 and the Allagash River basin has received no sampling effort. Only a few stations in the region have been sampled more than once. The Houlton Band of Maliseet Indians has recently entered into a partnership with the MDEP Biological Monitoring Program to collect biological data from the Meduxnekeag River basin. Similar to the arrangement with the Penobscot Indian Nation on the Penobscot River (Part II Basin Chapter 3, p. 71) the Maliseets collect and analyze biological and water quality data following recommended DEP protocols and utilizing the same taxonomic experts. Five new stations were established on the

Meduxnekeag, by the Maliseets, in 1998 and one was established on the Mattawamkeag (not mapped), for collection of benthic macroinvertebrate and periphyton data.

Of 40 stations in the three combined basins, 4 do not attain the aquatic life standards of their assigned class (Basin Table 1, p. 133; Basin Map 1, p. 161). All are in the Aroostook sub-basin. The existing monitoring effort has uncovered no stations that fail to attain at least Class C standards. Seven stations (two or three in each basin) exhibit aquatic communities that exceed the standards of their assigned class. To date most of the monitoring effort has focused on assessment of municipal and industrial point source impacts in the region. There is a need to refine assessment methods and establish new biological monitoring stations in order to better detect impacts of agricultural and forest harvesting activities. New methods for detection of non-point source impacts to small streams will be applied in this region during the summer of 1999 (Part I Chapter 2, p. 27). Additionally, the Biological Monitoring Program has begun development of algal indicators of nutrient enrichment. The Meduxnekeag River has been chosen as one site to pilot this work. Algal indicators will provide new and supporting information about stream condition to complement the existing benthic macroinvertebrate program. They have the potential to provide a more sensitive tool for problem identification (nutrient enrichment; aesthetic problems, etc.) and evaluation of management success. Algal biomass measures are better correlated with public perceptions of problems than actual nutrient concentrations in streams. Algae has been shown to respond more quickly to certain types of stressors than the macroinvertebrate community and in some cases may show a response where macroinvertebrates show no response. Algal indicators are expected to be a useful tool for development of nutrient Total Maximum Daily Loads (TMDLs). Modeling for improvements and assessing community response in the instream algal condition may be a more successful and direct approach than modeling for changes in nutrient concentrations.

Case Study 3

Suspected Toxic Impacts of Agriculture, Dudley Brook

Dudley Brook (Sta. 215) exhibits community characteristics suggestive of toxic impacts from agricultural activities when compared to Pattee Brook (Sta. 212) another Aroostook County stream of similar size and physical habitat structure. The Dudley Brook watershed is 60-75% cropland in a potato and grain (oats and/or barley) rotation. Management of these crops involves the application of large amounts of herbicides and pesticides. Dudley Brook is managed as Class B but biomonitoring results indicate it is only attaining Class C standards for aquatic life. Pattee Brook also has agricultural activity within the watershed but to a lesser extent than Dudley. Pattee Brook is the water supply for Fort Fairfield and attains aquatic life standards for Class B.

Presented in Figure 12 is a graphical representation of three measures of pollution sensitive organisms, placing Pattee Brook and Dudley Brook within the context of the overall Maine Biological Monitoring Program database. Appendix 2 provides an explanation of the distribution information presented in box plots. The four "boxes" represent the distributions of all the sites falling within a given class in the Biomonitoring database. Variables displayed are: *Generic Richness*, a measure of the overall number of different types of organisms in the sample; *EPT*, a measure of the number of genera within the three pollution-sensitive orders, **E**phemeroptera (mayflies), **P**lecoptera (stoneflies), and **T**richoptera (caddisflies); and *EP* 14, a measure of numbers of mayfly plus stonefly genera, relative to the maximum number occurring at clean water reference sites in the baseline database.

In comparison to Pattee Brook, Dudley has only half the overall number of genera and 55% the number of genera of pollution sensitive taxa (Figure 12). Toxic impacts frequently result in depressed production across all groups of organisms. Dudley Brook had 1/3 the total number of individuals that occurred in Pattee Brook. For these reasons it is concluded that the Dudley Brook benthic macroinvertebrate community is exhibiting evidence of detrimental toxic impacts causing it to fail to attain its assigned water quality classification.

The effects of agricultural run-off

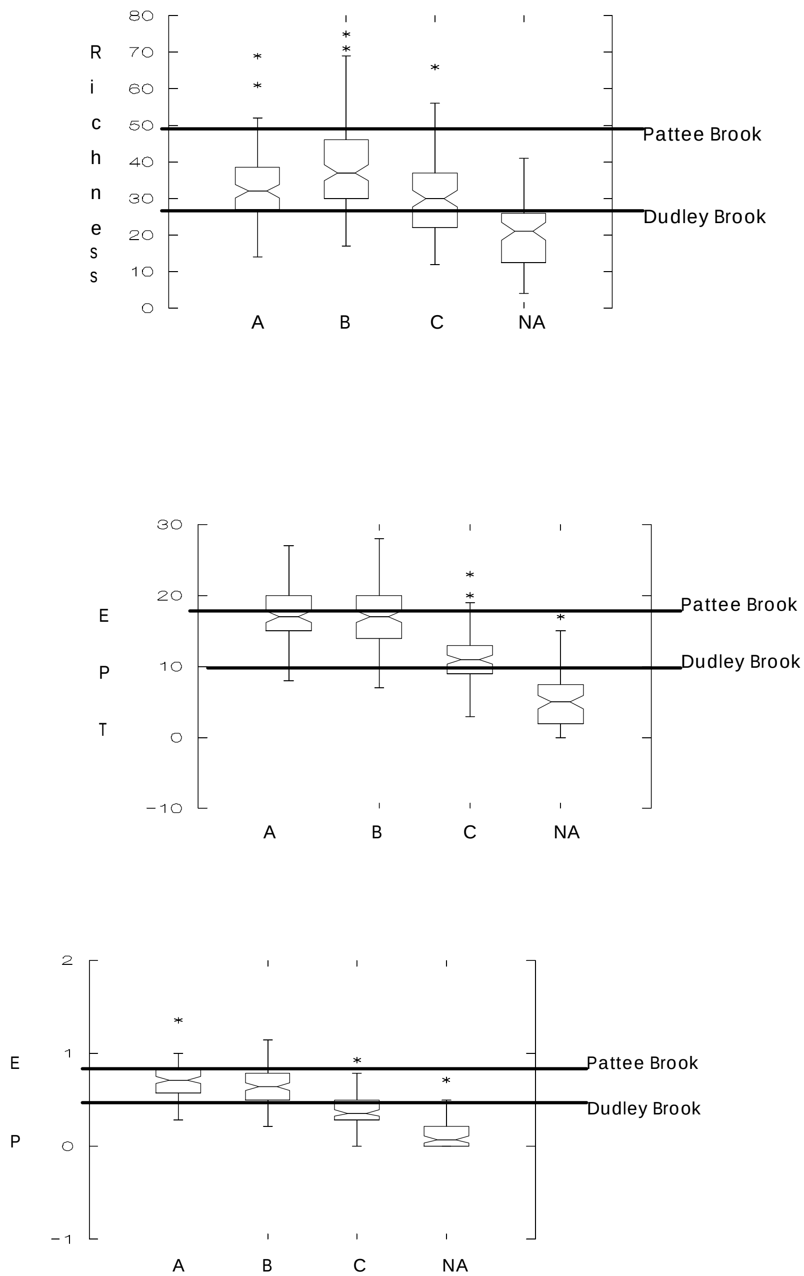


Figure 12 Box plots showing values of the variables Richness, EPT and EP for Pattee Brook and Dudley Brook as compared to the distribution of all values for all sites within a given class in the Maine DEP Biological Monitoring Program database.

N=414, $n\text{-}_{Class\ A}$=99; $n\text{-}_{Class\ B}$=133; $n\text{-}_{Class\ C}$=103; $n\text{-}_{Non\text{-}Attainment}$=79

The Mattawamkeag and Piscataquis Rivers are both tributaries to the Penobscot, entering in the vicinity of Lincoln, Maine. They are nearly identical in terms of drainage area and average annual discharge. Both rivers contribute high quality water to the Penobscot, though the Piscataquis River has a history of degraded water quality, supports the larger human population base and has one significant municipal-industrial discharge.

Introduction

Geography

The Mattawamkeag River basin covers 1,507 square miles. The West Branch of the Mattawamkeag River begins on Mud Lake and Duck Pond in the township of T6R6 on the Penobscot-Aroostook County border. It flows north-northeast for a short distance and then turns south through undeveloped territory before passing through the town of Island Falls. It continues moving southeast to Haynesville, draining Upper and Lower Mattawamkeag Lakes and extensive wetlands along the way. The East Branch originates approximately 14 miles northeast of the W. Branch headwaters in the township of T7R3. It flows in a southerly direction through Smyrna Mills and Oakfield, passes through the Pleasant Lake watershed, and then continues on through undeveloped territory before joining the W. Branch at Haynesville. The mainstem flows south-southwest through several small towns and extensive wetlands for approximately 47 miles before joining the Penobscot River in the town of Mattawamkeag.

The Piscataquis River basin covers 1,459 square miles. Both the East and West Branches of the Piscataquis River begin in wetlands several miles southwest of Greenville. Both flow south for a short distance through wetlands and undeveloped land before joining at Blanchard. The mainstem flows through developed regions continuing southeast to Guilford-Sangerville, and easterly through Dover-Foxcroft and Milo before joining the Penobscot at Howland. The total length of the mainstem is approximately 62 miles

Basin Summary Statistics

Biomonitoring Activities in the Basin

Period of Record: 1984-1997
Waterbodies Sampled: 12
Established Stations: Mattawamkeag R. sub-basin: 2;
Piscataquis R sub-basin: 17
Number of Sampling Events: 33

Wastewater Discharges

Mattawamkeag R. Basin: 2 municipal treatment plants serving a population of approx. 3000 and one starch manufacturing facility;

Piscataquis R. Basin: 4 municipal treatment plants serving a population of approx. 10,400, including one major municipal-industrial plant in Guilford-Sangerville, discharging to the Piscataquis River, that receives effluent from a textile mill.

Other Sources

One aquaculture discharge to Schoodic Stream near Milo; agriculture in the lower Piscataquis basin.

Flow Regulation

Mattawamkeag R. Basin --Water level controlled by 8 dams: No FERC licensed hydro-projects.

Piscataquis R. Basin--Water levels in the basin controlled by approximately 28 dams including 1 FERC licensed project at the confluence of the Piscataquis and the Penobscot Rivers (Howland Dam). Most dams are less than 2000 KW (total capacity).

Quality

Predominantly high quality for both basins though the Piscataquis does not attain dissolved oxygen standards in the impoundment at Dover Foxcroft.

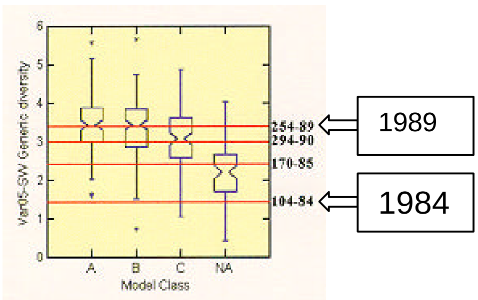
Drainage area	Average Annual Discharge	Wastewater Flow Volume (Major Industrial and all Municipal discharges)	Mainstem Average Dilution
Mattawamkeag R.: 1,418mi^2 (near Mattawamkeag)	Mattawamkeag R: 2,512 cfs (near Mattawamkeag)	Mattawamkeag R: 0.17 mgd (0.26 cfs)	9,662:1
Piscataquis R.: 1,162mi^2 (at Medford)	Piscataquis R: 2,362 cfs (at Medford)	Piscataquis R: 2.1 mgd (3.3 cfs)	716:1

Overview of Biological Monitoring Activities

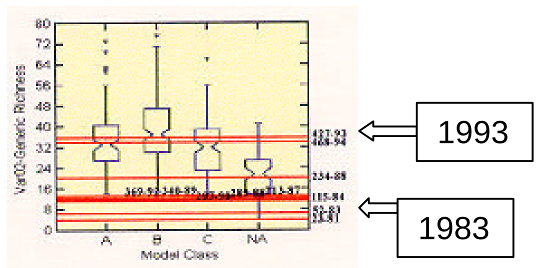
Both sampled stations in the Mattawamkeag River basin exceed assigned Class B standards and attain Class A standards (Stas. 88 and 89). Much of the Mattawamkeag basin was upgraded from Class B to Class A in 1999. Of fifteen stations in the Piscataquis River basin, one third exceed the aquatic life standards of their assigned statutory classification (Basin Table 2, p. 136; Basin Map 2, p. 162). All remaining stations, except 3 (Stas. 94; 281; 286), attain classification standards. Of the three non-attaining stations, two are in the vicinity of Katahdin Iron Works (KIW), an historic site of iron mining and smelting activity. Blood Brook (Sta. 281) drains the region of the iron ore deposit and is essentially devoid of life. It does not attain the minimum aquatic life standards for the State. Although there has been no mining activity in this area for many decades, Blood Brook still shows very high levels of iron and sulfate. Station 286 is downstream of Blood Brook and the old

KIW smelter on the W. Br. of the Pleasant River. The statutory classification of the West Branch is Class AA but this station only attains Class B standards. The cause may either be lingering contamination from the mining activity or mild enrichment of the river from an upstream lake or from forest cutting activity. The third station (Sta. 94) is also in non-attainment of Class A standards but does attain Class B standards. Station 94 is located at the outlet of Sebec Lake and attainment is no doubt affected both by enrichment from release of plankton from the lake as well as habitat effects (deep, slow-moving outlet stream).

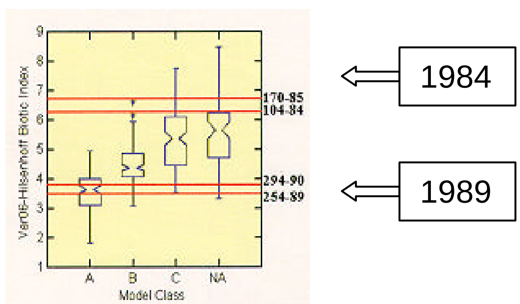
The Piscataquis River near Guilford is a remarkable success story. In the early 1980's the river received untreated manufacturing waste from a local textile mill, as well as untreated domestic sewage. Benthic macroinvertebrate samples collected in 1984 and 1985, downstream of the textile mill (Stas. 84 and 85) revealed a severely degraded community, dominated by highly pollution tolerant organisms such as *Cricotopus* (Diptera: Chironomidae), *Physa* (Gastropoda: Physidae), and Tubificidae (Oligochaeta). Pollution sensitive taxa such as stoneflies (Plecoptera) and mayflies (Ephemeroptera) were absent. The site did not attain the lowest aquatic life standards allowed by the state, according to the Department's statistical decision model. In 1988 a new sewage treatment plant was completed to treat mill manufacturing waste, as well as domestic sewage. The textile mill waste comprises nearly 75% of the total discharge volume of the treatment plant. The mill effluent was found to be very toxic with a 'no observed acute effect level' (NOAEL) of less than 1% effluent in 1984. The new treatment plant lagoons were constructed to have a very long retention time (70 days) to allow for breakdown of toxic components in the effluent. The average annual discharge of the river allows for a dilution ratio of about 14:1. The combination of long retention time and adequate dilution precludes the necessity for any special treatment techniques to reduce toxicity. The result of these efforts was an immediate, dramatic improvement in the downstream benthic communities (Fig. 13). The three measures shown are used, along with 6 other variables, by MDEP in the First Stage linear discriminant model to assign aquatic life classification attainment (see Appendix 2 for an interpretation of box plot data). By the next summer following improved treatment, pollution-sensitive taxa were found to be abundant, including four taxa recognized as indicators of the highest water quality class: <u>Ephemeroptera</u> : *Serratella (*Ephemerellidae); *Leucrocuta* (Heptageniidae); <u>Trichoptera</u>: *Brachycentrus* (Brachycentridae) and *Glossosoma* (Glossosomatidae). The number of different types of organisms in the pollution-sensitive orders Ephemeroptera, Plecoptera and Trichoptera (EPT) had increased from zero in 1984 to 17 in 1989. The statistical decision model for the 1989 samples revealed that the downstream site had improved by <u>*three classes*</u>, from non-attainment of minimum Class C standards to attainment of Class A aquatic life standards. Recovery of this segment was hastened by the presence of high quality (Class A) waters above this reach. Upstream locations presumably served as a refuge for pollution intolerant organisms that rapidly recolonized the area through drift. The segment from Guilford to Dover Foxcroft was upgraded from Class C to Class B in 1999.



Generic Diversity



Generic Richness



Hilsenhoff Biotic Index

Fig. 13. Box plots showing values for 3 biological community variables from Sta. 84, the Piscataquis River below Guilford, between 1984 and 1990, as compared to the distribution of all values for all sites within a given class in the MDEP Biological Monitoring Program database

The Penobscot River is the largest river wholly contained in Maine and the second largest river basin in New England, following the Connecticut River. The basin encompasses 8,595 square miles and drains approximately one quarter of the state.

Introduction

Geography

The East Branch of the Penobscot originates in East Branch Pond, above Grand Lake Matagamon. The West Branch originates in Seboomook Lake, the confluence of the North and South Branches of the Penobscot, in northern Piscataquis and Somerset Counties. The confluence of the East and West Branches is in Medway, forming the mainstem. The mainstem flows through a series of small developed and industrial towns and cities including Lincoln, Old Town and Orono, before passing through the cities of Bangor and Brewer, then becoming saline at Hampden from the tidal influence of Penobscot Bay. The total length of mainstem, to the mouth at Bucksport, is approximately 98 miles. The Piscataquis and Mattawamkeag Rivers are major tributaries to the Penobscot, discussed in Basin Chapter 2.

Basin Summary Statistics

Biomonitoring Activities in the Basin

Period of Record: *Mainstem*: 1974-1997; *Other Stations*: 1984-1997
Waterbodies Sampled: 18
Established Stations: 47
Number of Sampling Events: 82

Wastewater Discharges

The West Branch and mainstem receive wastewater discharges from 5 pulp and paper mills, 10 municipal or combined municipal and industrial treatment plants. The 1995 estimated combined population of Piscataquis and Penobscot Counties is 164,000.

Other Sources

Contaminated woolen mill site; fish hatcheries; miscellaneous industrial waste discharges; timber harvesting; combined sewer overflows (CSO's);

Flow Regulation

84 dams control flows throughout the basin; 18 are licensed by FERC for storage or generation of hydroelectric power.

Quality

Although the Penobscot receives a relatively large volume of wastewater, overall water quality in the basin is good to outstanding, even on the mainstem. This is due to both the large available dilution volume and the remote nature of much of the basin.

Drainage Area (at Eddington)	Average Annual Discharge (at Eddington)	Wastewater Flow Volume (Major Industrials and all Municipal Discharges)	Mainstem Average Dilution
7,764 mi^2	14,110 cfs	163.9 mgd (254 cfs)	56:1

Overview of Biological Monitoring Activities

Forty-seven biomonitoring stations are established in the Penobscot River Basin, excluding the Piscataquis and Mattawamkeag sub-basins (described in Basin Chapter 2). The majority of monitoring effort has been devoted to the mainstem and tributaries affected by pulp and paper mills, with 57% of stations occurring on the mainstem, the East and West Branches and Millinocket Stream (Basin Table 3, p. 138; Basin Map 3, p. 163). The basin was intensively sampled in 1996, in accord with the National Pollutant Discharge Elimination System rotation licensing schedule (Table 5).

The Penobscot River mainstem is one of the State's most comprehensively monitored rivers for aquatic life, due to research projects in the 1970s and 1980s (see below) and to the efforts of the Penobscot Indian Nation (PIN). The Penobscot Tribe has established an extensive monitoring program on the mainstem and tributaries. In 1991 the Water Resources Program of the Nation requested to meet with Department of Environmental Protection staff to develop a water quality monitoring workplan which would provide data acceptable for use by the Department. Their interest was to contribute to water quality information on sections of the Penobscot and tributaries flowing through tribal lands. They had applied for and received a grant from the US EPA to initiate a monitoring program and they began field data collections in 1992.

A network of stations has been established for basic chemical monitoring, including dissolved oxygen, temperature, bacteria, and biochemical oxygen demand, among other parameters. In 1993, biologists from MDEP accompanied PIN technical staff in the field to train them in biological sampling methods and to set up monitoring stations in the same locations as earlier, MDEP-sponsored, studies (Rabeni 1974; Davies 1987). Since that time PIN has added to its monitoring network to bring their total number of mainstem stations up to 50 for basic physical/chemical assessments. An additional 25 tributary stations are sampled as well. Benthic macroinvertebrate monitoring by PIN staff has occurred at about 15 stations. PIN contracts with the same taxonomist as MDEP to insure comparability of the taxonomic record. Data is submitted to MDEP for editing, coding and data entry into the Biomonitoring Program database. Of the Department's stations on the mainstem, PIN has provided about 75% of the biological data collected since 1992.

In 1991, three stations were established on Kenduskeag Stream to evaluate impacts of agricultural activities and urbanization on this stream. The stream and tributaries in it's watershed were revisited in 1997, in a cooperative study between the Biological Monitoring Program, the MDEP Division of Watershed Management and Dr. Alexander Huryn of the Department of Biological Sciences at the University of Maine in Orono. MDEP has sampled the stream and tributaries using the qualitative multihabitat method developed to screen for non-point source biological impacts (Part I, Ch. 2)**,** as well as using the traditional, quantitative, introduced substrate methods of the Biological Monitoring Program. Dr. Huryn has applied methods developed to examine differences in leaf litter processing rates in streams of differing nutrient content.

Historical Perspective

Milestone Events in the Basin

YEAR	WATERBODY	AFFECTED STATIONS	EVENT
1970-1985	Mainstem and West Branch	Mainstem stations above Orono	West Branch assigned **Class D**; Mainstem assigned **Class C** but much of the river failed to attain water quality standards and was federally listed as **"Water Quality Limited"**
1974	Mainstem	124, 125, 126, 127, 128, 129, 130, 131, 132, 133	Rabeni samples above and below paper mills with primary wastewater treatment, finding severe aquatic life impacts from poor water quality
1976-1979	Mainstem	All mainstem stations	Millinocket mills (2), Lincoln mill and Town of Millinocket convert to secondary treatment
1981	Mainstem	124, 125, 126, 127, 128, 129, 130, 131, 132, 133	Davies repeats Rabeni study; finds dramatic improvement in condition of aquatic life downstream of improved treatment plants

YEAR	WATERBODY	AFFECTED STATIONS	EVENT
1986	Statewide	East and West Branches	Water Quality Standards revised: elimination of Class D; merger of Class B-1 and B-2 into new Class B and creation of new Class AA
1986	East Branch		Upgraded to Class AA
1990	Mainstem	47 miles or 59% of mainstem length in segments	Statutory water quality classification upgrade from **Class C** to **Class B** for mainstem segments with improved water quality
1993	Mainstem and selected tributaries		Penobscot Indian Nation initiates water quality monitoring program
1999	Mainstem		Upgrade of entire mainstem to **Class B,** from the Mattawamkeag to tidewater (excluding a 1 mile segment in the Enfield impoundment to remain Class C)

As noted in the above table, water quality in the Penobscot River has improved to the extent that the statutory classification was upgraded in 1990 to Class B for 59% of the length of the mainstem. In the 1999 Legislative session, the entire mainstem (excepted a 1 mile impounded segment) was upgraded to Class B. The Biological Monitoring Program has an unusually extensive record of the changes in the biological communities of the Penobscot mainstem, in relation to changes in water quality, dating back to 1974. At that time the river was listed as a Federal Water Quality Limited Segment from Millinocket, on the West Branch, to the Weldon Dam near Mattawamkeag, because it was not attaining minimum federal water quality standards.

Water quality downstream of the Lincoln pulp and paper mill was also severely degraded. The period from 1974 through 1977 was marked by aggressive treatment plant construction activities on the Penobscot, with the result that by 1977 total suspended solids and biochemical oxygen demand loads to the river were reduced by about 80%. Gradual improvement in discharger performance and implementation of secondary treatment for smaller dischargers has continued to the present.

Case Study 4

Long-Term Monitoring of Water Quality Improvement, Penobscot River Mainstem

Between 1974 and 1981, an estimated 33 million dollars was spent by industry, state and federal sources to implement primary and secondary wastewater treatment technology on facilities discharging into a 100 km section of the Penobscot River between Millinocket and Costigan, Maine. These expenditures resulted in an 80% reduction in the load of biochemical oxygen demand and total suspended solids discharged from the kraft and sulfite pulp and paper mills in the study area. The benthic macroinvertebrate community in the river in 1974 was determined to be highly degraded at three stations in closest proximity to pulp and paper effluents (Stas.129, 131, 133). An additional two sites, somewhat downstream of pollution outfalls (Stas. 125, 126) were determined to be degraded (Rabeni 1977). The benthic community of the study area has been re-evaluated several times following the major water quality changes of the 1970s, with the conclusion that the investments have resulted in dramatic improvements in the river's ability to support aquatic life.

Station 129 was designated "Highly Polluted" in 1974. It is located 4 km downstream of the Lincoln Pulp and Paper Company outfall. Figure 14 provides a graphical summary (box plot) of changes in significant measures of aquatic community structure for the period of record at Station 129. Appendix 2 provides an explanation of box plot display of data. The nine measures shown are used by DEP in the First Stage linear discriminant model to assign aquatic life classification attainment. In 1974 the substrate at Station 129 was covered with sewage bacteria (*Sphaerotilus*) and the invertebrate community was restricted to worms, leeches and pollution tolerant midge larvae. Numbers of individuals were very high, indicating a "bloom" of tolerant, opportunist organisms. Diversity and richness values were very low and there was a complete absence of pollution-sensitive mayflies and stoneflies (Fig. 14: *283-74*). In terms of aquatic life classification, this station did not meet minimum state or federal standards.

By 1981 dramatic improvements were seen in the benthic macroinvertebrate community (Davies 1987). Total abundance was down, richness and diversity were improved and the proportion of tolerant midge larvae was lower (Fig. 14: *273-81*). Low numbers of stoneflies and mayflies were also present. Overall attainment had improved to Class C standards. The station has been sampled four times since 1981, each time meeting Class B standards and showing continued improvement in community structure, including high diversity and richness and healthy stonefly and mayfly populations. This long-term dataset provides a valuable example of the responsiveness of the biota to water quality improvements. It also highlights the unique usefulness of biological monitoring to document and summarize the real world benefits of responsible stewardship of the State's aquatic resources.

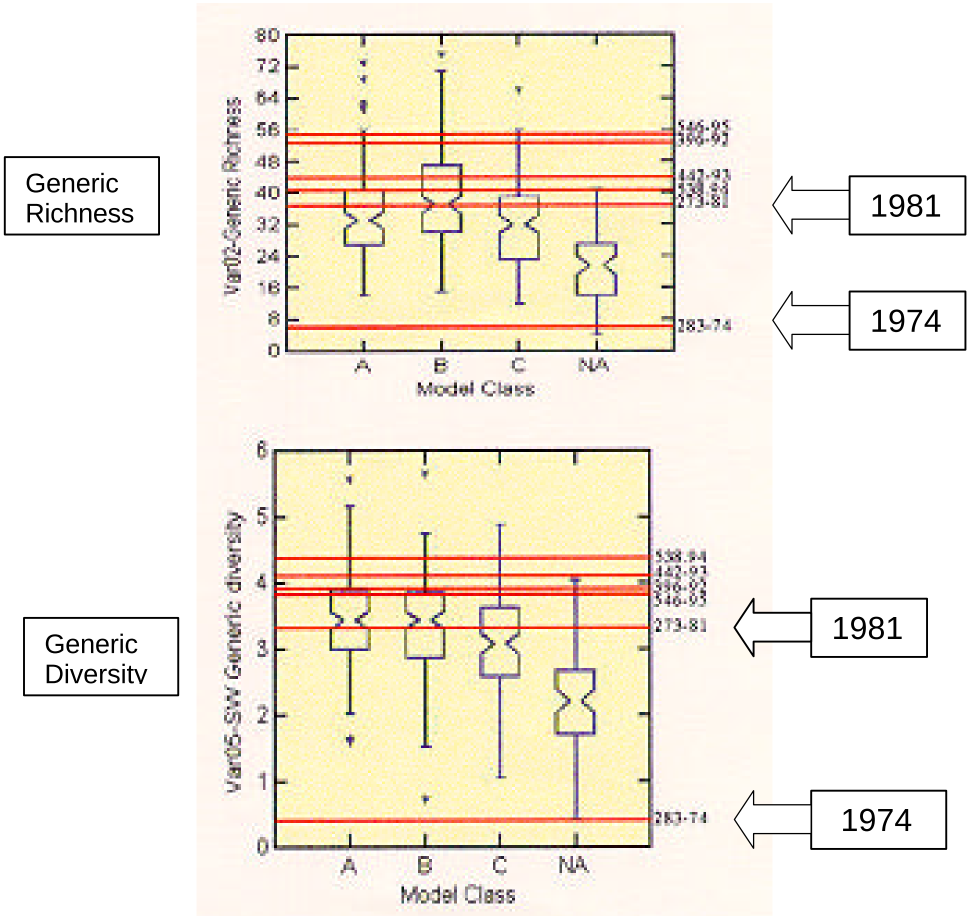


Figure 14 Box plots showing values for 2 biological community variables from Sta. 129, the Penobscot River below Lincoln Pulp and Paper, between 1974 and 1996, as compared to the distribution of all values for all sites within a given class in the MDEP Biological Monitoring Program database

Current Status and Issues

Ten sampled stations in the Penobscot basin are now failing to attain applicable aquatic life standards (Stations 283, 284, 285, 290, 291, 310, 311, 312, 313, and 314 Basin Table 3, p. 138; Basin Map 3, p. 163). Several are new stations on small, non-point source affected streams, sampled during the 1996 and 1997 field seasons. On the mainstem and West Branch, 9 out of 18 stations are exceeding the aquatic life standards of their statutory class. One station (Station 277) on the West Branch below Bowater's Great Northern Pulp and Paper mill and the Millinocket POTW exceeded its assigned Class C standard by two classes in 1996, actually attaining Class A standards. All stations sampled on the West Branch and mainstem since 1986, except two (125 and 173), are attaining at least Class B standards; and three attain Class A standards. The two stations not attaining at least Class B standards both occur in impoundments. Station 125 is located in the impoundment created by the West Enfield Dam and Station 173 is in the Medway Dam impoundment. Both are attaining Class C standards. Station 176, located in the Veazie impoundment has attained Class B standards since 1992, though it only attained Class C standards in 1985. This demonstrates that with improvements in water quality, attainment of riverine standards is a realistic goal, even in the slow moving waters of impoundments. Evidence supporting this is provided by provisional data obtained from water quality sampling on the Penobscot mainstem during the summers of 1996 and 1997. A marked improvement in dissolved oxygen concentrations in the river, including the impoundments, was noted, as compared to data collected in 1986 and 1988 (Paul Mitnik, MDEP, personal communication).

Station 132 is the only station established on the East Branch of the Penobscot River. It is located just upstream of the confluence of the East and West Branches, in the town of Medway. It has not been sampled for aquatic life since 1981. At that time the station was only attaining Class C standards, though sampling in 1974 showed it attaining current Class B standards. Comparisons of available physical and chemical data from 1974 and 1981 indicated a decline in certain water quality parameters including, dissolved oxygen, conductivity and turbidity. Since there are no significant point sources to the East Branch it is possible that these declines, and the associated condition of aquatic life is a result of non-point source impacts of forestry activities in the watershed. No data is available to indicate the current status of this station.

Future Needs

The very large areal extent and remote nature of much of the Penobscot River Basin has resulted in rather sparse coverage of all but mainstem locations. The basin is not due for intensive NPDES sampling by MDEP until 2001. However, with the exception of the lower East Branch and small streams in the greater Bangor region, all aquatic life sampling in the basin has yielded very favorable results. Streams high in the watershed, in general, are not threatened by point sources, but may be vulnerable to forest harvesting activities. This should be evaluated, as MDEP staff resources allow.

The cooperative study between MDEP and Dr. Huryn at the University of Maine, on the Kenduskeag Stream watershed, is ongoing and should yield valuable information regarding the needs of urban and agriculturally impacted streams. The results will be of statewide value. The East Branch should be sampled prior to the next scheduled NPDES rotation, to determine whether or not it is currently attaining standards.

Breaching of the Edwards Dam, July 1, 1999

The Kennebec River is the third largest river in Maine consolidating the flows from many large lakes in north-central Maine, then flowing south through agricultural areas and small towns and cities of the central part of the state to merge with the Androscoggin River at Merrymeeting Bay.

Introduction

Geography

The Kennebec River originates at Moosehead Lake flowing 145 miles to Merrymeeting Bay where it joins the Androscoggin River, then to the Atlantic Ocean at Phippsburg and Georgetown. The upper Kennebec flows from Moosehead Lake about 4 miles before reaching Indian Pond, the first of many impoundments. Flowing out of Indian Pond through Harris Dam, a major hydroelectric station, its passes through the Kennebec gorge then runs south draining into Wyman Lake, and through Wyman Dam, another large hydroelectric impoundment. From there it passes through urban and industrial areas of Madison, Skowhegan, Waterville-Winslow, and, with the removal of the Edwards Dam in Augusta in July, 1999, the Kennebec head of tide now occurs between Augusta and Sidney. The river eventually empties into Merrymeeting Bay in Richmond. Six major tributaries enter the river: the Moose River is the major tributary of Moosehead Lake, Dead River, Sandy River, Sebasticook River, Messalonskee Stream and Cobbosseecontee Stream. The basin covers approximately 5,893 square miles with approximately 3,850 miles of rivers and streams.

Basin Summary Statistics	
Biomonitoring Activities in the Basin	Period of Record: 1983-1997 Waterbodies Sampled: 19 Established Stations: 55 Number of Sampling Events: 85
Wastewater Discharges	Six paper mills (two recently closed, three discharge waste through municipal treatment facilities), one tannery, two textile mills (both recently closed), eighteen municipal waste treatment facilities
Other Sources	Agricultural activity; urban non-point sources, combined sewer overflow (CSO's), eutrophic lakes, fish hatcheries, contamination from hazardous waste areas
Flow Regulation	31 dams . 21 FERC licensed hydro-projects.
Quality	Overall quality is good and improving

Drainage area	Average Annual Discharge
Kennebec Basin: 5,893 mi^2	At North Sidney 9,015 cfs
Sandy R. 516 mi^2	Sandy R. @ Mercer 976 cfs
Sebasticook R. 572 mi^2	Sebasticook R. @ Pittsfield 962 cfs

Overview of Biological Monitoring Activities

Considerable biomonitoring activity began in the Kennebec basin during the first years of the Biomonitoring Program and over half of all the stations in the basin were established in 1983. Basin-wide biological monitoring was last conducted in 1997. General water quality in the basin is good with 35 stations (64%) presently attaining their statutory classification and 6 stations (11%) have communities representative of standards higher than their statutory classification (Basin Table 4 p. 142; Basin Map 4, p. 164 and 165). Among these sites with higher classed communities are Wilson Stream in Wilton, West Branch

Sebasticook River at Pittsfield and the Kennebec River at Benton. These are all Class C segments, attaining Class B aquatic life standards, that might be considered for upgrade after review of other water quality data. The East Branch Sebasticook River at Corinna (Station 194) has a long history of water quality problems and, in 1997, attained Class C standards for only the second time since 1983, due to closure of a woolen mill (see Case Study 5). A number of smaller waterbodies sampled in 1997 for the first time including Cobbossee Stream in Gardiner, Mill Stream in Norridgewock, Cold Stream in Skowhegan and Outlet Stream in Vassalboro. Many other nonattainment waters are associated with hydroelectric impoundments such as the Kennebec River at Bingham below Wyman Dam (Station 165), Kennebec River at Norridgewock above the Weston Dam (Station 174), and the Kennebec River at Augusta above the former Edwards Dam (Station 29). See the special discussion on hydropower effects on riverine aquatic life in Part I Chapter 1, page 16.

Historical Perspective

The Kennebec basin has shared some of the same water quality history as many other waters in the state. Dams were constructed in the 19th and early 20th century and were followed with settlement and industrialization in the basin. Until the late 1970s, the Kennebec had many notable water quality problems. Most towns and industries did not provide treatment of their wastes. A now closed pulp and paper mill in Winslow dumped wastes, in the 1970's, reportedly equivalent to the raw sewage of two million people. This pollution left the lower river chronically anoxic during the summer with fish kills commonly occurring. Additionally, the river was used as the primary means to bring pulp logs to the mills and for wood storage, thus leaving the river inaccessible for other uses and leaving substantial bark and wood deposits on the bottom. While the effects of the pulp and paper industry were severe, many other industries contributed wastes sufficient to cause additional problems particularly on the smaller tributaries. The worst of these included tanneries on the West Branch Sebasticook River and Wilson Stream, textile mills on the East Branch Sebasticook River and Messalonskee Stream, dairy and potato processing on the East Branch Sebasticook River and poultry processing plants on the Kennebec River. Water quality in the basin is also stressed by a number of eutrophic lakes that affect downstream waters.

Many events in the 1970s and early 1980s resulted in substantial water quality improvements, especially implementation of the Clean Water Act. The pulp mill in Winslow closed and a new pulp and paper facility was built 10 miles upriver with modern waste treatment in 1978. Pulpwood drives were terminated on the river in 1976. The poultry industry collapsed in the late 1970s resulting in the closure of those plants. One of the tanneries and the dairy and potato processors have gone out of business. Waste treatment facility construction was completed in the basin by 1985 for all significant towns and industries. In the last five years, other industries have closed including two paper mills and both textile mills.

Current Status and Issues

The upstream portion of the Kennebec as well as many of the major tributaries (Dead, Carrabassett, Sandy) are classified A and AA. Water quality in these segments is good and supports high quality aquatic communities. Problems have been detected associated with the many hydropower facilities that affect the habitat quality of the river downstream of the impoundments (see Part I Chapter 1 discussion on hydropower). This is particularly true at sites used for peaking power (e.g. Wyman dam) or where flows are highly variable. The river below Wyman dam (Station 165) was found to be nonattainment of the lowest state standards for aquatic life presumably due to extreme flow manipulation that causes daily flooding, followed by dewatering, of a significant portion of the channel, precluding establishment of a persistent aquatic community. Populations of invertebrates are uncharacteristically low for a lake outlet location such as this. The benthic community lacks the filter-feeding organisms that would typically be associated with locations downstream of lakes. Information from the Biomonitoring Program has been used to recommend new operating limits at this site through the relicensing process for this dam (Section 401 water quality certification).

Downriver, the classification of the mainstem changes to Class B from Anson-Madison all the way to tidewater except for a segment from Skowhegan to Waterville below a large pulp and paper mill that is Class C. The river attains classification except for two impounded segments at Norridgewock and the lower portion of the Edwards impoundment (both are nonattainment presumably due to habitat effects of the impoundments). Repeated sampling at Station 29 above the Edwards dam has been consistently in nonattainment since 1985. The Legislature has recently raised the classification of the lower Edwards impoundment from Class C to B in anticipation of the improved habitat that will occur because the dam has been removed.

Tributaries of the Kennebec are variable in quality. While remaining water quality impacts on the mainstem are associated with habitat modifications or other water quality factors associated with hydropower dams, many documented effects on the tributaries are associated with wastewater discharges and other contamination sources in these smaller receiving waters. The Sebasticook River and Messalonskee Stream are both eutrophic as a result of municipal and industrial wastes and nonpoint source pollution going to those waters. The effects are most pronounced in the impounded parts of those waters.

Future Needs

A number of management changes are occurring in the Kennebec basin that require follow-up monitoring to measure aquatic life response. These include the re-licensing of several hydropower dams that will impose new flow regimes for these facilities to enhance the quality of downstream aquatic life. Improved treatment and restoration of the East Branch Sebasticook River, recently designated a federal Superfund site, should also provide an opportunity to demonstrate aquatic life response to water quality improvements (see Case Study 5). The removal of the Edwards dam in Augusta provides a unique opportunity to assess the revival of a river that has been altered by impoundment for over 160 years. The Department is presently engaged in a study with researchers from Clarkson University to follow the changes that will occur in the lower Kennebec following the breach of the dam. Interest in the lower river may also push interest to better understand and assess the tidal freshwater segment below Augusta.

CASE STUDY 5

<u>Long Term monitoring of a toxic point source, East Branch Sebasticook River</u>

In 1983, as the biomonitoring program was first being designed and organized, the Department selected the East Branch Sebasticook River (Class C) at Corinna as a waterbody for study. The Department has repeated annual biological monitoring in this segment for 9 of the years from 1983-1997. This river segment had been the focus of considerable attention for many years due to persistent water quality problems associated with municipal and industrial discharges. The Town of Corinna had constructed a treatment plant in 1969 to treat wastes from the town and a woolen mill. Additionally, untreated domestic sewage was discharged from the Town of Dexter about 7 miles upriver until 1985. The river also receives runoff from numerous farms in the watershed and the Town of Corinna has five combined sewer overflows that deliver stormwater and wastewater to the river during runoff events. Habitat of the river has been critically altered as it passes under the mill and through the town. More recently, it has been discovered that a significant pool of dichlorobenzene and other chemicals used by the woolen mill had been dumped at the mill site and could be found in very high concentrations in the hyporheic zone of the river and presumably enters the surface water during certain flow conditions.

In 1981, the Department had issued a new wastewater license to the treatment facility that presumably would correct the water quality problems in this segment. The license incorporated discharge limits for all known contaminants based on EPA's water quality criteria. Biological monitoring in 1983 found a seriously degraded aquatic community (total of 11 organisms, 4 Diptera taxa). The initial concern was that at low flow, chlorine from the disinfection process might be having this extreme effect, however a trial where chlorine was removed from the process did not yield any improvement (total of 15 organisms, 7 Diptera or non-insect taxa). The new license obviously was not working. The toxic effect of the chemicals from the mill was too complex and could not be regulated adequately in the current license to protect the aquatic life in the river.

Over the years, a number of improvements were made at the mill and at the treatment facility to lessen the toxicity problems. The community responded with incremental improvements (Figures 15, 16 for Station 20). Despite recruitment of organisms and taxa, the community structure and function remained poor and was assessed as non-attainment until 1993, when it attained Class C for the first time. At that time, the mill was operating sporadically until November, 1996 when it permanently shut down. Biological monitoring found non-attainment conditions again in 1994 and then attainment of Class C in 1997 following the closure of the mill. Until 1989, the community was dominated by Diptera larvae and non-insect (snails, leeches). In 1989, significant numbers of filter-feeding Hydropsychidae were collected, an important feeding function that had been lacking in the stream. In 1992, the community began to have some less tolerant organisms such as Ephemeroptera collected, although Plecoptera, a very intolerant group, has never been collected at the site. During the same period of study, Station 90 located below the mill but above the treatment outfall has consistently maintained a Class C community. This segment is affected by all the aforementioned sources of contaminants except the treatment plant outfall. In 1999 the Eastland Woolen mill site in Corinna was designated a federal Superfund site. A number of management actions have been initiated for the East Branch since the closure of the mill, including remediation of the hazardous waste site at the mill (including proposed relocation of the stream bed away from the contaminant source area), removal and treatment of the combined sewer overflows, and redirection of the wastewater treatment plant effluent to a land disposal site.

The Corinna case was particularly important in the evolution of Maine's biological monitoring program. It became the leading example, presented to the Legislature in 1986, why the state needed to have biologically based water quality standards and criteria. The complexities of water quality management in waters like the East Branch required the state to have tools that could integrate and express the effects of multiple stressors on the aquatic community, something that cannot be efficiently accomplished through narrowly focused management tools like wastewater discharge licensing.

Corinna Sewer District outfall, E. Br. Sebasticook River, about 1980

Fig. 15. Changes in total abundance values in the East Branch of the Sebasticook River (Station 20) from 1983-1997.

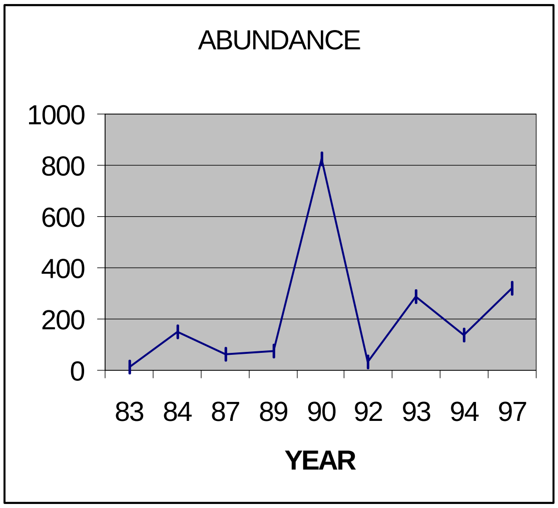
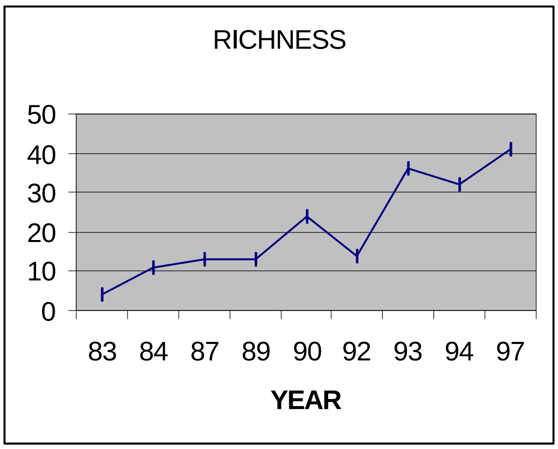


Fig. 16. Changes in richness values in the East Branch of the Sebasticook River from (Station 20) 1983-1997.



The Androscoggin River is the fourth largest river in Maine, draining 3,450 square miles or about 10% of the state. In comparison to the other three rivers, available dilution on the Androscoggin mainstem is fairly low.

Introduction

Geography

The Androscoggin River originates at the outlet of Umbagog Lake near Errol, New Hampshire where it flows for the first fifty miles before entering the State of Maine through Gilead. The river traverses the developed and industrial towns and cities of Rumford, Dixfield, Jay, Livermore Falls, Lewiston-Auburn and Brunswick before emptying into Merrymeeting Bay. The total length of the mainstem from Umbagog Lake to Brunswick is approximately 162 miles. There are also 22 other sampled streams of the Androscoggin River basin listed in Basin Table 5.

Basin Summary Statistics

Biomonitoring Activities in the Basin	Period of Record: 1983 – 1998 Waterbodies Sampled: 23 Established Stations: 70 Number of Sampling Events: 126 (34 sampling events in 1998) (Note: 1998 data not yet available)
Major Discharges	2 paper mills and 1 textile manufacturer in Maine, 1 paper mill in New Hampshire, and 12 municipal treatment plants serving a human population of about 100,000.
Other Sources	Miscellaneous industrial waste discharges; agriculture and animal waste from livestock and egg farms; combined sewer overflows (CSO's); urban runoff.
Flow Regulation	Basin hydrology is highly altered by the existence of 104 dams; the mainstem has 15 FERC licensed dams for hydropower generation or storage, impounding approximately 37 miles of river.

Quality Characterized by high water quality and sparse human disturbance in the upper watershed. Water quality declines as the river flows south through the state because of urban development and industrial discharges.

Drainage area (near Auburn)	Average Annual Discharge (near Auburn)	Wastewater Flow Volume (Major Industrials and all Municipal Discharges)	Mainstem Average Dilution
3,263 mi^2	6,156 cfs	110.9 mgd (171.9 cfs)	36:1

Overview of Biological Monitoring Activities

The Biological Monitoring Program has established 70 discrete monitoring stations on 23 different waterbodies draining to the Androscoggin River Basin, since 1983. The basin was intensively sampled in 1998 to prepare for National Pollutant Discharge Elimination System (NPDES) relicensing activities. Stations newly established in 1998 are recorded on Basin Table 5, p. 146 and Basin Map 5, p. 166, but data work-up is incomplete. The Androscoggin will next be due for basin-wide sampling in 2003, in preparation for license renewals in 2004. Stations within the basin have been sampled sporadically since 1983 with the greatest sampling emphasis directed to higher-risk waterbodies. The majority of sampling events (sixty four percent) occur on waters of statutory Class C. The upper mainstem, in the vicinity of the Rumford and Jay pulp and paper mills, has received a proportionately greater emphasis, with 13 locations accounting for 24% of all sampling events in the basin. Much of the data on the mainstem near Jay has been collected and submitted to the Department by the International Paper Company and their biological monitoring contractor, EcoAnalysts of Bath, Maine. Other locations of significance include Thompson Lake Outlet Stream, site of long-standing toxicity problems downstream of a textile mill; several small streams in Turner receiving groundwater leachate from a major egg farm; and the upper Little Androscoggin River, site of a former tannery.

Historical Perspective

Milestone Events in the Basin

YEAR	WATERBODY	AFFECTED STATIONS	EVENT
1985	Little Androscoggin, So. Paris	43, 44, 45, 46, 79	Closure of A.C Lawrence Tanning Co.
1984-90	Thompson L. Outlet, Oxford	76, 77, 78	Toxicity reduction efforts at Robinson Mfg.
1992	Gulf Island Pond on the mainstem		MDEP orders IP to correct low dissolved oxygen in GIP by an oxygen diffuser at Twin Bridges, Turner
1989	Martin Stream, Turner Lively Brook, Turner House Brook, Turner	104, 105, 184, 185, 189 188	MDEP takes enforcement action Decoster Egg Farm for water quality violations
1995-1997	Mainstem, Canton to Livermore Falls	61, 82, 222, 233, 244, 260, 261, 263, 264, 265	Relicensing of Riley-Jay-Livermore and Otis Hydroelectric dams

Within the period of record, non-attainment of applicable aquatic life standards has occurred at 15 stations in the Androscoggin River Basin with 9 stations in non-attainment as of the most recent available data (Basin Table 5). In the early to mid 1980s several inadequately treated point sources contributed significantly to non-attainment of standards. These include the South Paris Utilities District, the Robinson Manufacturing Company and the mainstem pulp and paper mills. In addition, groundwater contamination and agricultural runoff from the Decoster Egg Farm has had long-standing detrimental impacts to two small streams in Turner (Case Study 6).

Mainstem impoundments in the vicinity of the International Paper Company mill in Jay have also contributed to persistent non-attainment of standards. However, in spite of some lingering problems, water quality in the Androscoggin River basin has improved markedly over the past 10 years. Discharges of oxygen consuming wastes and organic solids, in the mainstem especially, have decreased by as much as 90% since the early 1990’s due to improvements in wastewater treatment at the major industries. Ten years of toxicity reduction efforts at Robinson Manufacturing are finally bringing positive results for the Thompson Lake Outlet Stream in Oxford (Case Study 7) and with the closure of A.C. Lawrence Tanning Company in 1985, the problems on the Little Androscoggin River in South Paris are resolved (Case Study 8).

CASE STUDY 6

Detection of Impacts of Contaminated Groundwater, Lively and House Brooks, Turner

Decoster Egg Farm, the largest producer of brown eggs in New England, is located in Turner, Maine. The Farm has a long history of environmental concerns including levels of ammonia and nitrates in violation of drinking water standards. This case study presents a unique example of the detection of biological impacts in a stream attaining surface water quality standards but affected by polluted groundwater recharge. High nutrient levels, caused by poor manure and chicken carcass waste management practices, resulted in contaminated leachate entering ground water on the Decoster property. Surface water violations were not recorded. In 1989 the Department brought enforcement action against Decoster Egg Farm to prohibit any further spreading of manure on the property, and to enforce proper management of other animal waste products. In 1991, the company was required to evaluate the condition of the aquatic life in surface waters affected by leachate or groundwater upwelling including two Class B streams, Lively Brook and House Brook. Field investigations included probes of the hyporheic zone (the water flowing through the stream substrate) to measure the conductivity of the upwelling groundwater. Conductivity is a measure of the ionic strength of water and is a very good means of detecting certain types of pollutants. The streambed investigation uncovered several areas of contaminated groundwater recharge to the stream. Aquatic life sampling, completed in 1992, confirmed impacts to the benthos at three stations affected by groundwater upwelling on Lively Brook and one station on House Brook. Station 188, on House Brook, is located downstream of a failing treatment system that receives waste from the egg washing operation. The waste stream is severely contaminated by nitrates. That station failed to attain minimum Class C aquatic life standards in 1992. Repeat sampling in 1997 resulted in attainment of Class C standards but the stream still fails to attain it's assigned Class B status. Biomonitoring information was used to issue a consent order requiring termination of manure spreading practices and improved treatment of the products of the egg washing facilities. The egg washing facility has been removed.

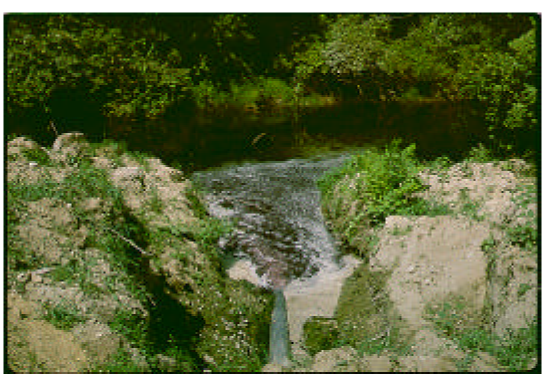
CASE STUDY 7

Adaptive Management Feedback Loop to Reduce Toxicity, Thompson Lake Outlet Stream

Robinson Manufacturing Company is situated just downstream of the Thompson Lake Dam in Oxford and discharges effluent produced during the manufacture of textiles, into Thompson Lake Outlet Stream. The facility was plagued with serious toxicity problems through the 1980s with consequent detrimental impacts to aquatic life in the stream. Three aquatic life sampling stations were established in 1984 (Stas. 76, 77, 78). Station 76 is upstream of the Robinson outfall; station 77 is at the initial point of complete mixing, about 70 m below the outfall; and station 78 is, about 0.35 km downstream of the outfall. Station 77 was discontinued in 1988. In 1984 an average of only 22 individual organisms were collected per sampler at Station 78, with only 8 different kinds of organisms. Given the high quality of the physical habitat sampled, these findings were considered to be clearly indicative of impacts of toxic conditions. Aquatic life findings triggered efforts by the industry, the Department and EPA to reduce the toxicity of the effluent. The problems with the effluent were very challenging, however, and in spite of evidence of gradual improvements in community composition, the station continually failed to attain Class C aquatic life standards, through 1992.

Management intervention at the Robinson Manufacturing Company occurring in the late 1980s and early 1990s has addressed wastewater treatment, manufacturing processes and general mill practices. Treatment changes include the construction of an equalization system to prevent large slugs of effluent from overwhelming the plant. The aeration capacity was also greatly increased. The industry hired a well-qualified, full time, treatment plant operator to run the upgraded plant, and also hired general environmental staff to holistically address environmental concerns at the mill. Within the textile mill, chemical process substitutions were initiated in an effort to reduce effluent toxicity through the use of less hazardous materials, and waste handling changes were instituted to decrease the incidence of spills and dumping.

All remedial actions combined have resulted in the discharge of a much higher quality effluent to Thompson Lake Outlet Stream. The incidence of violations of licensing limits has decreased to a fraction of violations that were recorded in the 1980s and no recent violations have occurred as a result of lack of treatment capacity. Remaining problems have tended to be associated with spills and mill operations, rather than treatment problems. Unfortunately, the stream itself has been slower to respond to cleanup efforts. As noted, the stream consistently failed to attain the minimum aquatic life characteristics for Class C standards between 1984 and 1992. Yet a closer look at the community characteristics reveals a classic trend of improving response, with recruitment of increasingly sensitive organisms. The 22 organisms in 1984 were nearly all snails (Physa). The dramatically increased numbers in the 1985 samples were comprised of over 90% worms, leeches and midge larvae (Chironomidae), with the pollution-tolerant midge larvae considered to be a favorable trend as compared to the extremely pollution-tolerant non-insects. In 1988 the very first observation of a few mayflies (7 individuals) was recorded in the downstream station (78). The 1992 samples revealed an average of 45 mayflies per sampler and filter-feeding caddisflies and black flies made up 93% of the total number of organisms (1576) colonizing the samplers. Conditions were next evaluated in 1996, following completion of the above-mentioned improvements. For the first time in the period of record, both the upstream and the downstream stations attained Class C aquatic life standards. Because 1996 was an extremely high-flow year, allowing for higher than normal dilution ratios, optimism about the long-term health of the stream must be somewhat guarded. But field observations of samples collected in 1998 suggest that standards may have once again been attained. It is clear that major improvements in water quality have been accomplished and there is justifiable hope for the future.



Robinson MFG. Co. discharge to Thompson Lake Outlet Stream, circa 1984

Thompson Lake Outlet Stream, below Robinson MFG Co., April 1999

Current Status and Issues

Available information for the Androscoggin River Basin indicates that water quality gains have been made with the result that the aquatic life classification of five stations in the basin (Stas. 41; 46; 261; 76; 78) show signs of an improvement in aquatic life condition over the period of record. (Basin Map 5 and Basin Table 5). Issues of non-attainment or provisional attainment of standards are known to currently exist in some impounded sections of the mainstem below Jay (Sta. 265). However, reduction in solids discharges from the International Paper Company is having a demonstrated beneficial effect on aquatic life in these impoundments. Expectations are high that aquatic life standards can be attained there. These findings are discussed in Case Study 11 in Basin Chapter 8, *Biocriteria as a TMDL Modeling Endpoint, Presumpscot River*, because insights gained on the Androscoggin River were directly applicable to problems on the Presumpscot River.

Applications for renewal of the Federal Energy Regulatory Commission licenses for the four hydroelectric dams in Jay (Riley, Jay, Livermore and Otis) were filed in the fall of 1997. Extensive environmental assessments of the impacts of operations of these run-of-river dams by International Paper and MDEP have been underway in the study area since 1995. The Town of Jay has also been an active participant in monitoring and decision-making. Three field seasons of benthic macroinvertebrate data have been collected by International Paper's project consulting firm, EcoAnalysts, of Bath, Maine as part of re-licensing investigations (1995, 1996 and 1997). Results from 1995 indicate non-attainment of standards for all stations between downstream sections of the Jay impoundment through the Livermore Falls bypass reach. 1995 was an unusually dry summer with flows below 7Q10, intermittently, throughout July and August. The summer of 1996 was unusually wet. Low flow conditions in 1996 met or exceeded the highest flows experienced in the summer of 1995. Between the late 1980's and 1992, by taking advantage of improved treatment technologies and attention to pollution prevention, the International Paper Mill in Jay had reduced the discharge of oxygen-consuming waste (BOD) and solids to the Androscoggin River by about 60%. On a trial basis, during the 1996 field season, the industry voluntarily reduced the input of solids discharged to the river by an additional 30% because it was concluded that excessive settled solids was the primary cause of aquatic life non-attainment. Benthic samples indicated a marked improvement of biological community characteristics in 1996 but interpretation of the results from both years must take into account that two different flow extremes were sampled. Several stations were successfully re-sampled in 1997 while for others results are indeterminate due to sampling error. For acceptable 1997 samples only one station in the Otis impoundment (Sta. 265) was found to be still failing to attain aquatic life standards. One other station exceeded standards of it's assigned classification and showed gains in pollution sensitive taxa, increased numbers of individual organisms and improvements in the structural characteristics of the community. Basin Table 5 reports 1995 results as they reflect a conservative estimate of aquatic life attainment due to the low flows that year. Ongoing monitoring is required as a condition of re-issuance of these hydropower licenses, in order to ensure that license conditions provide for attainment of aquatic life standards through the term of the new license. The mill is currently discharging about 2-3,000 lbs. of solids per day, as compared to licensed discharge limits of 17,000 lbs. per day in 1991.

Environmental problems remain on the Decoster Egg Farm property, with no quick and easy remedies available. Although still not attaining assigned Class B standards, data from the 1997 field season shows that Lively Brook and House Brook both attain Class C aquatic life standards and appear to be responding positively to decreases in levels of nutrients in the groundwater and changes in waste management practices.

CASE STUDY 8

Expert Judgement Determination of Alteration due to Natural Causes, Little Androscoggin River, South Paris

Several stations (Stas. 43, 44, 46) in the vicinity of the Paris Utilities District (PUD) were initially sampled for benthic macroinvertebrates in 1983 (Basin Map 5). At that time the PUD was receiving effluent from the A.C Lawrence Tanning Company and in-stream and in-situ bioassays were underway to determine the level of chromium toxicity of the effluent flowing to the Little Androscoggin River. Return visits in 1984 sampled an additional station, directly downstream of the effluent diffuser (79). Stations upstream of the POTW outfall (43 and 44) attained Class A standards while stations downstream attained either Class C standards (46) or failed to attain the minimum standards of Class C (79). The A.C Lawrence Tanning Company continued to discharge through the summer of 1985, finally ceasing operation in November of that year. Station 46, about 2 km downstream of the PUD outfall, maintained Class C standards in 1985 but when re-visited in 1986, nine months after cessation of the tannery discharge, the aquatic community had rebounded sufficiently to attain Class B standards.

Findings for 1987 are quite interesting. On April 1, 1987 a 500 year flood was experienced across most of the state. Maximum discharge on the Little Androscoggin River, at 9,340 cfs, was the highest ever recorded for the river, in dramatic contrast to average March/April flows of about 300 cfs. August sampling in 1987 provided results showing a decline in attainment of standards for both the station above the discharge (Sta. 43) and the one below the discharge (Sta. 46, Basin Map 5). Both attained only Class C standards. Field staff observed that the rather sandy stream channel at the site had been dramatically re-shaped as a result of the major flooding. A close inspection of community structure revealed that the flood event caused a decrease in typical long-lived, large bodied organisms that cling to the surface of the substrate (mayflies and stoneflies, beetles, etc). Instead of the expected preponderance of clinging, long-lived organisms, the communities were 75% to 80% fly larvae (chironomid midges). These organisms are rapid colonizers and are commonly found in new, unstable or degraded habitats.

The river reach was not re-visited until 1992, at which time the downstream station had improved to the highest quality yet recorded, attaining Class A aquatic life standards. The upstream station had rebounded to attainment of Class B standards. Recruitment of more specialized, longer lived organisms, contributed to attainment of the higher aquatic life standards.

Combined Sewer Overflow discharging to the Androscoggin River in Auburn (1984, approx.)

Future Needs

The Androscoggin River Basin was intensively sampling during the 1998 field season with twenty new stations established to better represent this region. In general, most mainstem and tributary stations in the lower basin, below Lewiston-Auburn, had not been sampled for aquatic life since 1984. Ongoing issues at Thompson Lake Outlet Stream, Lively and House Brooks and the mainstem in Jay are likely candidates for continued monitoring of the success of water quality management efforts. Each year an effort is made to expand the database to include not only stations expected to show the impacts of human activities but also pristine, reference stations to insure that our understanding of the native potential of each region is adequate. 1998 sampling added a number of poorly represent tributaries to the mainstem between Bethel and Jay. The Nezinscott River watershed has no aquatic life sampling stations and should be surveyed, to establish a baseline condition, during the next rotation through this basin.

St. Croix and North Coastal basins cover a large, sparsely populated geographic area. This region of the state has a higher proportion of waterbodies of statutory Class AA and Class A than the more populated areas in the central and southern parts of the state. Due to the problems with travel distances and limited staff resources this region of the state is relatively under-sampled by the Biological Monitoring Program.

Introduction

Geography

The St. Croix River basin covers 1,630 square miles (Basin Map 6). Approximately 20 miles south of Houlton, the St. Croix River flows out of North Lake on the border between Maine and New Brunswick, Canada. It runs generally south, forming the southern portion of Maine's eastern border. The upper part is mostly a succession of lakes (Chiputneticook Lakes). The St. Croix River mainstem forms at the towns of Vanceboro and St. Croix, the first developed area along its course, before continuing to flow south through miles of wetlands and wilderness. The lower portion of the St. Croix River basin eventually is influenced by a pulp and paper mill in Woodland. It then flows through Baring, and Calais, before emptying into Passamaquoddy Bay. The total length from North Lake to the Bay is about 95 miles.

The North Coastal Region covers 3,466 square miles and encompasses a number of minor river basins (Basin Map 6, p. 167). Three of the largest rivers in this region are the Union River, the Narraguagus River, and the Machias River. The West Branch of the Union River begins in Great Pond, north of Ellsworth, and runs approximately 17 miles before entering Graham Lake. The mainstem, starting at Graham Dam flows 4 miles to tidewater in Ellsworth, emptying into Union River Bay. The Narraguagus River, begins in Deer Lake, approximately 8.5 miles northeast of Great Pond. It runs south for approximately 42 miles, to the town of Cherryfield (tidewater), emptying into Narraguagus Bay 5 miles below Cherryfield at Milbridge. The Machias River headwaters begin as a series of lakes (Machias Lakes). From First Machias Lake the river flows south-southeast through hills, ridges, and wetlands for about 46 miles before reaching the developed regions near Machias. Here it joins the E. Machias River and empties into Machias Bay. Besides the Narraguagus, there are four other sampled streams in this basin.

Basin Summary Statistics	
Biomonitoring Activities in the Basin	Period of Record: 1984-1998 Waterbodies Sampled: 16 Established Stations: 30 Number of Sampling Events: 38
Wastewater Discharges	**St. Croix R. Basin**--1 paper mill and 4 municipal treatment plants serving a population of approximately 7,000 in the U.S. **North Coastal Region**--3 municipal treatment plants, 1 on the Union R. and 2 on the Machias River. **Note:** There are 20 other municipal treatment plants in this basin discharging into tidal waters. These impacts are not measured by the Biological Monitoring Program.
Other Sources	Agricultural runoff (pesticides); peat mining; BOD from fish hatchery; in-place contamination (old mining site and a Superfund site).
Flow Regulation	**St. Croix R. Basin**--Water level controlled by approximately 29 dams including 4 FERC-licensed projects and 1 International Joint Commission (Canada and US) licensed dam. **North Coastal Region**--Water level controlled by approx. 120 dams (87 for hydropower generation) including 4 FERC-licensed hydro-projects
Quality	Generally high quality water except for localized impacts from fish hatchery, agricultural activities and pulp mill discharge.

Drainage area	Average Annual Discharge	Wastewater Flow Volume (Major Industrials and All Municipal Discharges Only)	Mainstem Average Dilution
St.Croix---1,374mi2 (at Baring) North Coastal—N/A	St.Croix---2,639cfs (at Baring) N/A	41.8 mgd (64.8 cfs) N/A	41:1 N/A

Overview of Biological Monitoring Activities

These two basins cover a large, sparsely populated geographic area (Basin Map 6, p. 167). This region of the state has a higher proportion of waterbodies of statutory Class AA and Class A than the more populated areas in the central and southern parts of the state. Unfortunately the St. Croix and North Coastal basins are scheduled for NPDES Five Year rotational sampling during the same field season as the entire Penobscot River basin (Chapter 1, Table 5, p. 14). Due to the problems with travel distances and limited staff resources this region of the state is relatively under-sampled by the Biological Monitoring Program (Basin Table 6, p. 150). It was last sampled for NPDES re-licensing in 1996. Only 3 new stations were added by MDEP in 1996, but a cooperative arrangement with National Park Service has added 6 additional stations in Acadia National Park, on Mt. Desert Island, in the past 3 years. Of the thirty stations established in these two basins, ten (all in the North Coastal region) are failing to attain assigned aquatic life standards. Causes are varied and include aqua-culture (Basin Table 6, Stas. 235; 236 and 113) and in-place contamination (Stas. 150 and 297) as well as agricultural and mining non-point sources. Two stations on the St. Croix mainstem and 2 in the North Coastal region exceed standards of their assigned class. The region is next due for intensive sampling in 2001.

The North Coastal basin is notable for containing five of the seven rivers designated in the Atlantic Salmon Conservation Plan (ASCP) (Maine State Planning Office 1998). These rivers are the Dennys, the Machias, the East Machias, the Narraguagus and the Pleasant. The other two rivers covered by the Plan are the Sheepscot (Chapter 7); and the Ducktrap, between Camden and Belfast (not sampled by the Biomonitoring Program).

The ASCP is a five-year, comprehensive directive of conservation actions designed to protect, restore and promote the success of wild Atlantic salmon in the above listed seven rivers in Maine. The Plan resulted from the work of a task force convened by Maine Governor Angus King in 1998. Over twenty federal and state agencies and public and private organizations are included as partners in the Plan. Partners include: the US Fish and Wildlife Service, US EPA, the Atlantic Salmon Federation, the Maine State Planning Office, the Maine Department of Inland Fisheries and Wildlife, the Maine Department of Environmental Protection, Champion International, Cherryfield Foods and local Watershed Councils, among others. The Plan is intended to address existing, known threats to Atlantic salmon survival as well as a broad range of potential threats. Pursuant to addressing potential threats, the Plan places a significant emphasis on encouragement of best management practices in forestry and agriculture, monitoring of pesticide use, adoption of water use management plans, protection of riparian habitat, establishment of buffers and the prevention of potential negative impacts from cultured fish. The MDEP has participated in the Plan by providing summaries of existing, baseline information on these important rivers and by providing technical support related to monitoring and water quality management.

Site remediation is currently in progress for the hazardous waste site located in Meddybemps on the Dennys River. This site has a variety of contaminants, especially PCB‘s. Repeat sampling in 1999 at Station 297 did not indicate a noticeable improvement in the community compared to 1997, however, processing of these samples is incomplete at this time.

The Sheepscot River at the North Whitefield provides the most complete record of biological monitoring data of any site sampled by the Biological Monitoring Program. Because the North Whitefield site is located in close proximity to a USGS flow gaging station it provides a wealth of information about natural variability in the benthic macroinvertebrate

Introduction

Geography

The Sheepscot River basin covers 1,056 square miles. The Sheepscot River originates out of the hills of Montville, approximately 26 miles northeast of Augusta. The river runs southwest through the small towns of Palermo, Somerville, and Whitefield where it joins the West Branch. The West Branch begins in Palermo, above Branch Pond, and also flows southwest for approximately 17 miles through China and Windsor before joining the mainstem above North Whitefield. The mainstem reaches tidewater in Alna. The total length of the mainstem to tidewater is about 34 miles. The Sheepscot tidal waters continue for another 20 miles before emptying into Sheepscot Bay just east of the mouth of the Kennebec River. There are two other sampled tributaries within this basin listed in Basin Table 7, p. 152.

Basin Summary Statistics	
Biomonitoring Activities in the Basin	Period of Record: 1984-1998 *(1998 data not yet available)* Waterbodies Sampled: 4 Established Stations: 7 Number of Sampling Events: 23
Wastewater Discharges	None. **Note:** There are seven municipal treatment plants and one electronics industry in this basin discharging into tidal waters. These impacts are not measured by the Biological Monitoring Program.
Other Sources	Agricultural activity; stormwater run-off
Flow Regulation *(Total Capacity)	Water level controlled by approx. 54 dams. No FERC licensed hydro-projects.
Quality	Excellent except for some enrichment from non-point sources

Drainage area	Average Annual Discharge	Wastewater Flow Volume (Major Industrials and All Municipal Discharges Only)	Mainstem Average Dilution
Sheepscot--145mi2 (at N. Whitefield)	Sheepscot.---248cfs (at N. Whitefield)	N/A	N/A

Overview of Biological Monitoring Activities

Of the eight stations established in the Sheepscot River basin, four are considered low risk and have not been sampled since 1984 (Stas. 59; 60; 86 and 87). The remaining four stations are on the mainstem and the West Branch of the Sheepscot and are monitored for the effects of non-point sources and as permanent ambient monitoring stations (Basin Table 7, p. 152, Basin Map 7, p. 168). The two mainstem stations in North Whitefield and Whitefield (Stas. 74 and 75) periodically do not attain assigned Class AA standards due to enrichment effects from non-point sources, as well as probable lake outlet effects (Basin Map 7). Dissolved oxygen and bacteria problems have been recorded in the mainstem and some tributaries, also attributable to non-point sources. The West Branch station (Sta. 268) is relatively new, established in 1995 to serve as a second, annual ambient monitoring site, to provide information on the natural variability of small, headwater reaches (See Case Study 10, below). That station has consistently attained Class A biological standards.

The Sheepscot River is one of the seven designated Atlantic salmon rivers addressed under the state Atlantic Salmon Conservation Plan (See Basin Chapter 6, p. 95) and as such has received considerable interest from local watershed groups and Atlantic salmon interest groups. Several monitoring and best management practices (BMP) demonstration projects are underway in the basin. A watershed restoration project to address non-point source related water quality problems in the basin was funded by US EPA in 1999.

Case Study 9

Natural Variability at a Long-term Ambient Monitoring Station, Sheepscot River at North Whitefield

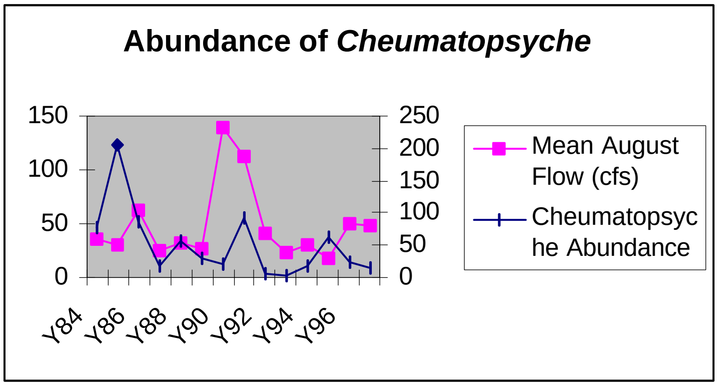
Station 74, the Sheepscot River at the North Whitefield USGS gaging station, provides the most complete record of biological monitoring data of any site sampled by the Biological Monitoring Program. Because the North Whitefield site is located in close proximity to a USGS flow gauging station it provides a wealth of information about natural variability in the benthic macroinvertebrate community. The North Whitefield site hosts a borderline biological community between Class A and Class B, indicative of the enriching effects of non-point sources from agriculture and road crossings. Of the fourteen sampling years between 1984 and 1997, 6 attained Class A aquatic life standards and 8 attained Class B standards (Basin Map 7, p. 168). Table 12 provides summary statistics for several biological community variables for all Station 74 sampling events, in comparison to the same statistical summary for the entire biomonitoring dataset. Figure 18 shows annual variation in selected community structure variables for the Sheepscot River in comparison to variation in mean August flows for the same years. Figures 19a and 19b provide a graphical representation of the distribution of variable values for all Station 74 monitoring years (n=14) as compared to the distribution of variable values for the set of all sampling events within each water quality class in the complete dataset. Refer to Appendices 1 and 2 for a description of the variables and an explanation of box plot data.

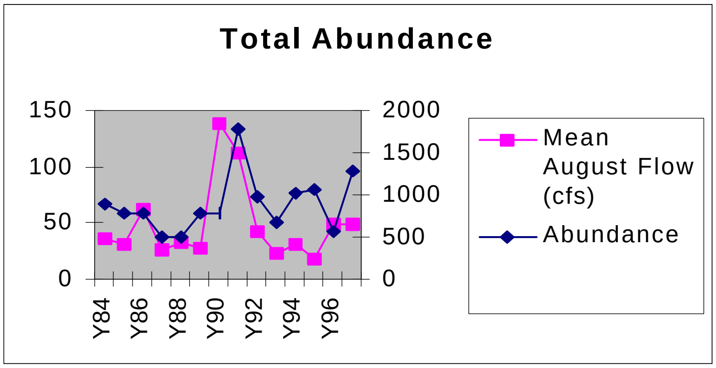
The Biological Monitoring Program intends to continue annual sampling of Stations 74 (North Whitefield) and 268 (on the West Branch in Weeks Mills) to provide a long-term record of annual variability and long-term response to enrichment.

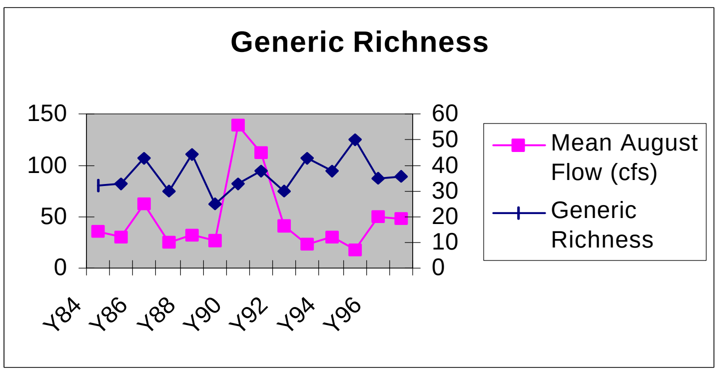
Table 13 Summary Statistics for selected variable for the Sheepscot River at North Whitefield, 1984-1997 and complete biomonitoring dataset.

Variable Name	Summary Statistics	Complete Dataset N=538	Sheepscot Dataset N=17
Total Abundance	Max	9080	1780
	Min	3	299
	Mean	697	816
	Std. Dev.	981	339
	C.V.	1.409	0.416
Generic Richness	Max	88	52
	Min	4	25

Variable Name	Summary Statistics	Complete Dataset	Sheepscot Dataset
Generic Richness	Mean	33	38
	Std. Dev.	13	8
	C.V.	0.381	0.21
S-W Diversity	Max	4.89	4.13
	Min	0.42	2.63
	Mean	3.1	3.34
	Std. Dev.	0.828	0.449
	C.V.	0.268	0.134
Hilsenhoff Biotic Index	Max	8.5	4.8
	Min	1.8	2.9
	Mean	4.6	3.9
	Std. Dev.	1.12	0.52
	C.V.	0.24	0.13
EPT Generic Richness	Max	29	22
	Min	0	14
	Mean	14	19
	Std. Dev.	5.9	2.15
	C.V.	0.43	0.11







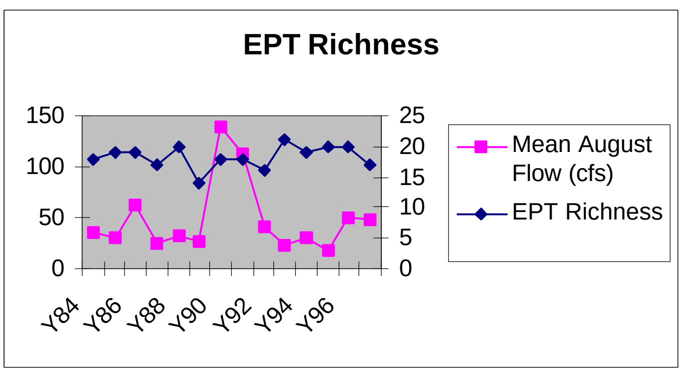


Figure 17 Sheepscot River at North Whitefield: Annual variability in selected biological community attributes and mean August flows between 1984 and 1997

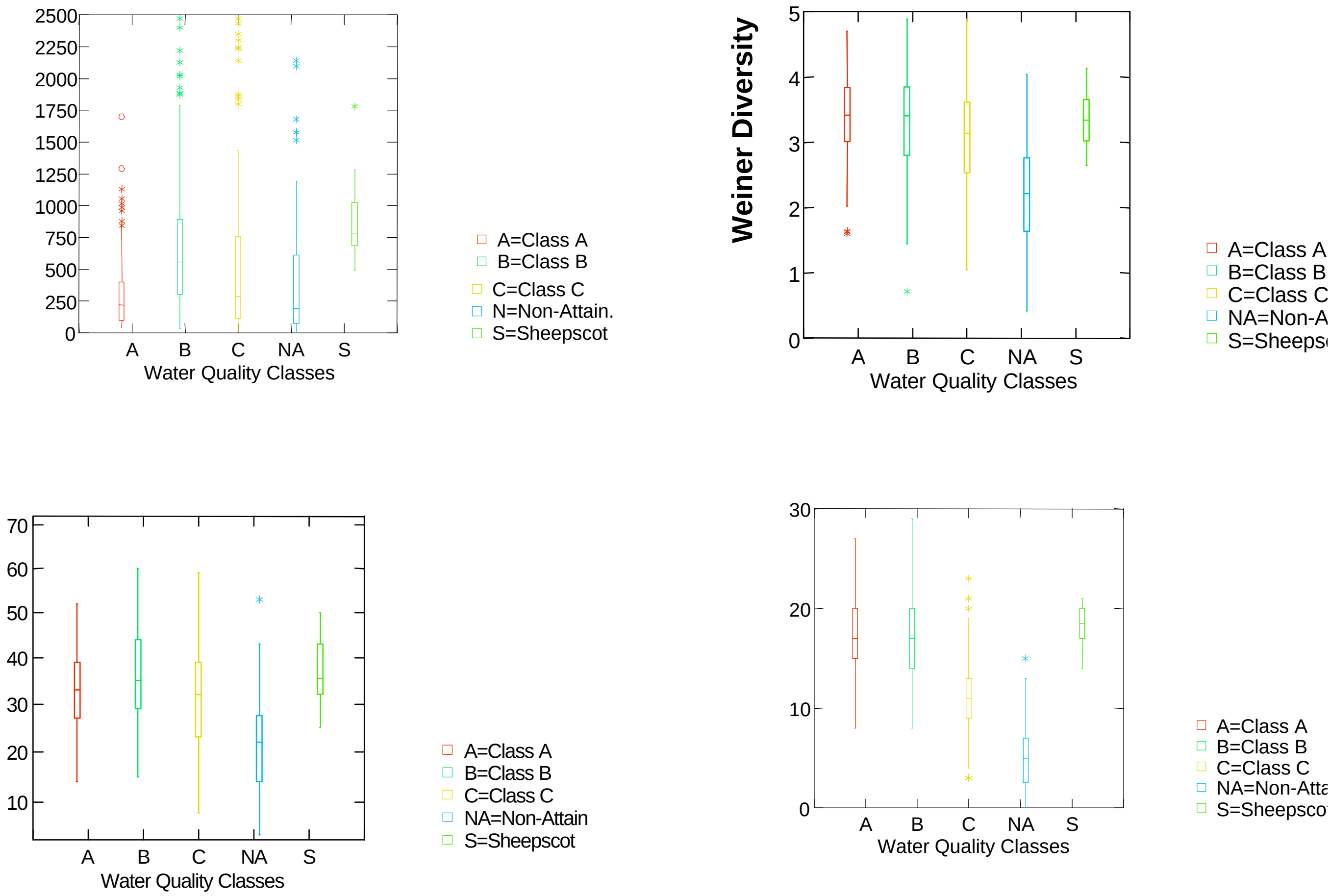


Figure 18a Variability of selected community structure attributes for the Sheepscot River at North Whitefield, 1984-1997 as compared to variable distributions for four water quality classification clusters (see Appendices 1 and 2).

N=538 n_A=119 n_B=182 n_C=145 n_{NA}=78 n_S=14

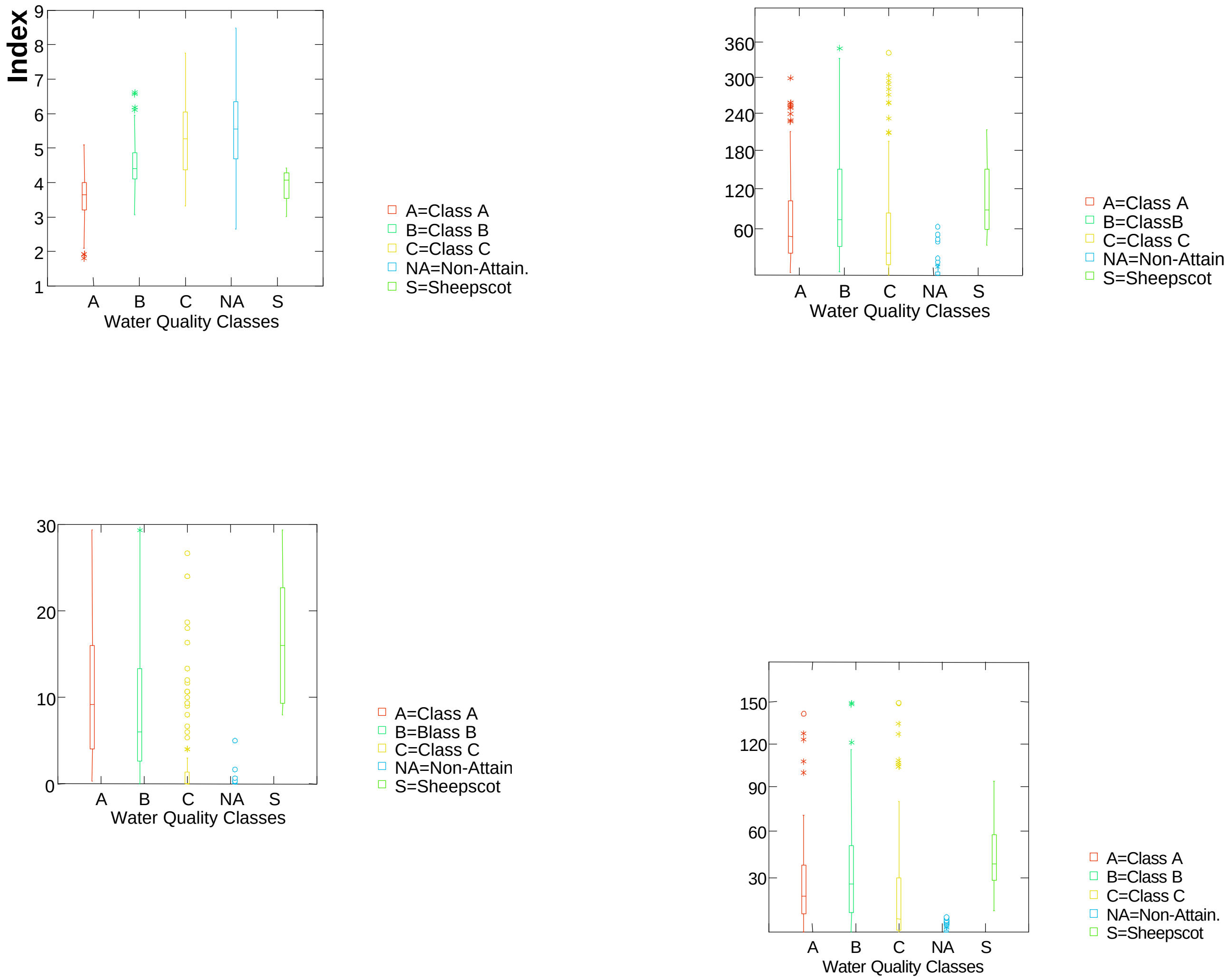


Figure 18b Variability of selected community structure attributes for the Sheepscot River at North Whitefield, 1984-1997, as compared to variable distributions for four water quality classification clusters (see Appendices 1 and 2).

N=538 n_A=119 n_B=182 n_C=145 n_{NA}=78 n_S=14

Because the Presumpscot River basin is one of the most highly urbanized basins in the state, the growing recognition of the serious biological impacts of urbanization on small streams will direct increased assessment activities to these systems. These streams are typically small, with a large percentage of their watershed covered by impervious surfaces, resulting in rapid, unattenuated delivery of stormwater runoff.

Introduction

Geography

The Presumpscot River basin contains approx. 1,070 sq. miles of surface area and 1,124 linear miles of rivers and streams. The second largest lake in the state, Sebago Lake, serves as both the headwaters for the Presumpscot River and as a drainage basin for the Crooked River. Three miles south of Bethel, the Crooked River begins meandering southward out of Songo Pond towards Sebago Lake. It passes through the forests, hills, and alder swamps of Albany Township, Waterford, and Harrison before flowing into the developed Long Lake/Sebago Lake watershed at the north end. The total length of this river mainstem is approximately 58 miles. On the eastern side of Sebago Lake in Standish, just outside of the developed area of North Windham, the Presumpscot River begins its journey southward towards the very developed areas of Westbrook and the major coastal city of Portland. The Pleasant River enters in Windham, having originated out of an area 8 miles East of Sebago Lake. The Presumpscot River runs through a mixture of rural, urban and heavy urban areas along its route before emptying into Casco Bay. A third significant river within this basin is the Royal River which rises out of Sabbathday Lake in New Gloucester 9 miles northeast of Sebago Lake. It runs east, north, and then south in that town, and continues southward through the developed town of Gray and into the very developed coastal areas of North Yarmouth and Yarmouth. There are ten other sampled streams within this basin listed in Basin Table 8, p. 153.

Biomonitoring Activities in the Basin

Period of Record: 1984 – 1997
Waterbodies Sampled: 18
Established Stations: 52
Number of Sampling Events: 86

Wastewaster Discharges	One paper mill and two municipal treatment plants. (Pulping portion of mill closed in 1999) **Note:** There are also 9 other municipal treatment plants discharging into tidal waters in this basin. These impacts are not measured by the Biological Monitoring Program.
Other Sources	Biochemical Oxygen Demand from fish hatcheries; a naval air station; miscellaneous industrial discharge; urban runoff; combined sewer overflows.
Flow Regulation	Water level controlled by approx. 65 dams including 8 FERC hydro projects, all <10,000 KW (total capacity). Flows on the mainstem of the Presumpscot are highly regulated by Eelweir Dam on Sebago Lake.
Quality	Good to excellent in the upper basin but overall decline in many stations proceeding towards Casco Bay.

Drainage area	Average Annual Discharge	Wastewater Flow Volume (Major Industrials and All Municipal Discharges Only)	Mainstem Average Dilution
Presum.---641mi2 (at Smelt Hill Dam)	Presum.---639 cfs (at Smelt Hill Dam)	25.5 mgd (39.5 cfs)	16:1

Overview of Biological Monitoring Activities

Biological monitoring activities in the Presumpscot River basin may be categorized as addressing four primary issues: mainstem dams and point sources; non-point sources including urban and agricultural impacts; toxic contamination and fish hatcheries.

In all, 55 stations have been established in the basin, 12 of which occur on the mainstem. Much of the biological monitoring data from the basin was collected within the last three years and nearly all stations have been visited within the last five years. Four new stations were established in 1998 (Stas. 337, 338, 339, 348). The next round of intensive NPDES data collection is scheduled to occur during the 1999 field season in preparation for permit renewals in 2000.

Eighteen stations are falling below the standards of their assigned aquatic life classification according to the most recent sampling event available. Six stations are exceeding assigned aquatic life standards and attaining the standards of the next higher classification (Basin Table 8, p. 153; Basin Map 8, p. 169). Two stations have improved over the period of record, raising attainment to the next higher classification (Basin Map 8, Stas. 66 and 70).

The primary point source issue is the S.A.P.P.I Company S.D. Warren paper mill in Westbrook (Stas. 71, 72, 238, 295, 296). Because the discharge from the paper mill is five to ten times greater in volume than any other discharge in the basin, it has been the focus of much monitoring and regulatory activity (see Case Study 11: *Biocriteria as a TMDL Modeling Endpoint, Lower Presumpscot River* and Current Status and Issues). A further issue associated with the S.A.P.P.I mill is the operation of five dams owned by the company beginning with Eelweir Dam on Sebago Lake. These dams are currently in the second stage of the relicensing process. A discussion on the biological effects of flow alteration such as is caused by the construction of dams, may be found in Part I Chapter 1, p. 16.

Capisic Brook (Stas. 256, 257) flows through a highly urbanized area and is monitored to assess urban non-point sources. Monitored waterbodies that are affected by agricultural NPS and/or urban runoff include Cole Brook, Trout Brook, the Pleasant River, the Royal River, and the Crooked River.

Evaluation of potential or known in-place contamination (toxic materials) is the focus in Mare Brook, Goosefare Brook and Red Brook. Fish hatcheries are found on Eddy Brook and Hatchery Brook. Additional stations in the Presumpscot River Basin are monitored to assess background ambient conditions or as regional reference stations.

Historical Perspective

Milestone Events in the Basin

YEAR	WATERBODY	AFFECTED STATIONS	EVENT
1730	Mainstem	72, 295, 296	Construction of the first dam at Presumpscot Falls (site of current Smelt Hill dam)
1898	Mainstem	72; 295; 296	Hydor-electric generating capabilities added at Smelt Hill dam
1993	Mainstem	72, 295, 296	Floodwaters temporarily breach the Smelt Hill Dam and destroy generating capabilities
1990	Basin	All stations	Casco Bay Watershed National Estuary Project funded by US EPA

1997	Goosefare Brook	48, 49, 50, 271, 272, 337, 338, 339	S.W.A.T. funded Univ. of Maine study to investigate biological impacts of in-place contamination and interstate crossings
1998	Mainstem	72, 295, 296	TMDL approved by EPA for control of TSS and BOD

Current Status and Issues

Biological Impacts Associated with Human Activities:

Alteration of hydrologic regime is the cause of many changes to the benthic biological community in the Presumpscot River basin. In particular, the mainstem dam (Smelt Hill) below the South African Pulp Paper Industry (SAPPI) paper mill further serves to exacerbate the detrimental effects of the mill discharge. See Part I Chapter 1 p. 16, for a general discussion of biological impacts of dams in rivers.

Samples of the benthic macroinvertebrate community collected within impoundments in the Presumpscot River generally reflect the unfavorable ponded conditions by revealing low numbers of organisms, a reduced number of different types of organisms, and a greater or lesser loss of typical riverine organisms, with replacement by sediment dwelling organisms having faster generation times. Impounded situations where water quality conditions are generally good, typically result in attainment of Class C aquatic life standards (MRSA Section 464.10: structure and function is maintained; some replacement of sensitive taxa by taxa more tolerant of altered conditions), for example Stations 325-329. However, input of an excessive pollutant load into an impoundment often results in conditions sufficiently compromised to result in non-attainment of minimum aquatic life standards (see Case Study 11, and Basin Map and Basin Table 8, Stations 72 and 296). Biological Monitoring Program sampling protocols allow for a longer exposure time for samplers in impoundments (56 days versus the typical 28 days) to accommodate the slower organism recruitment rate in impoundments.

Urban non-point source impacts have been assessed in several streams in the lower Presumpcot River basin, including Capisic Brook, Trout Brook and Kimball Brook. These streams are typically small, with a large percentage of their watershed covered by impervious surfaces, resulting in rapid, unattenuated delivery of stormwater runoff (including a heavy sediment load and toxic substances) to the stream. Removal of tree canopy cover results in increased solar gain and elevated temperature regimes. In Capisic Brook continuous temperature recording during August of 1996 revealed that the urbanized site (Sta. 257) had an average temperature nearly 10 degrees warmer than the upstream reference site (Sta. 256). See Case Study 1, p. 31, for a synopsis of findings in Capisic Brook. The resulting community in a severely impacted stream like Capisic Brook typically consists of highly tolerant non-insect taxa like leeches, worms and mollusks. Insect taxa are lost due to altered physical (temperature, habitat, flow volume) and chemical (dissolved solids, toxics, low oxygen, etc.) conditions.

Fish hatcheries are found on several spring-fed streams draining to the Pleasant River, north of Gray, Maine (Sta. 142 and 220). Fish hatcheries were formerly considered quite benign and, though licensed, were not held to strict discharge limits for solids and biochemical oxygen demand. Biological monitoring of benthic communities downstream of fish hatcheries has revealed detrimental impacts, however, due to enrichment effects of high nutrients and suspended organic solids. These inputs typically cause a significant increase in the abundance of organisms, with a predominance of filter-feeding caddisflies and black fly larvae. While this effect may be considered beneficial in terms of the ability of the down-stream reaches to produce fish, it should be borne in mind that the aquatic life indigenous to Maine's naturally nutrient-poor streams are not adapted to such enriched conditions. The alteration tips the balance in favor of opportunistic, generalist taxa that may out-compete and displace indigenous, rare and specialized organisms. The Department is in the process of relicensing all the hatcheries in the State and will be imposing stricter limits for biochemical oxygen demand, total suspended solids and, in some cases, for phosphorus.

Hatchery Bk. downstream of MDIFW Dry Mills Fish Hatchery, August, 1999

Future Needs

Because the Presumpscot River basin is one of the most highly urbanized basins in the state, the growing recognition of the serious biological impacts of urbanization on small streams will direct increased assessment activities to these systems. Streams monitored for urban non-point source pollution in the Presumpscot basin to date include Capisic Brook, Frost Gully Brook, Trout Brook, Kimball Brook, and Goosefare Brook. Most of the monitored stations are failing to attain the aquatic life standards of their assigned classification. The Presumpscot River TMDL (Case Study 11) directs that the license limits for total suspended solids and biochemical oxygen demand for the SAPPI pulp and paper mill are provisional until it can be demonstrated that the biological community is in attainment of applicable standards. Therefore, the State and the mill will work collaboratively to annually monitor the effects of the changes in discharge quality on the benthic community, for several years. Overshadowing all these negotiations however, is the announcement by the S.A.P.P.I Company of its plans to eventually shut down the pulping operations at the Westbrook mill. Current plans call for continued paper-making at the mill. This change in operations would eliminate the prevailing water quality problems in the mill effluent as well as in the Presumpscot River itself. A related factor is the proposed removal of the Smelt Hill Dam. The Corps of Engineers has drawn down the Smelt Hill impoundment, temporarily, during the summer of 1999, in order to facilitate investigations related to subsequent dam removal. This temporary activity, as well as the probable, permanent removal of the dam, have major positive implications for the status of the river's aquatic community. With the granting of state and federal approval to remove the actively generating Edwards Dam on the Kennebec River in Augusta (see Part I Chapter 1 p. 19), a national precedent has been set directing responsible parties to seriously consider dam decommissioning as an alternative to relicensing, if the power generation benefits are out-weighed by the environmental or ecological damage caused by the dam. The Edwards Dam was breached in a public ceremony attended by the Governor of the State of Maine and the Secretary of the United States Department of the Interior, in July of 1999. It should be a State priority to thoroughly document the biological consequences of these major restorations of the hydrologic regime of two of the State's significant rivers.

Case Study 10

Investigation of Impacts from Multiple Sources of Toxic Contamination, Goosefare Brook

Goosefare Brook is a small stream that originates in The Heath in Saco and empties into Saco Bay. The Maine Turnpike crosses the stream in several locations resulting in extensive culverting and relocation of the original stream bed. The stream also flows through an area of extensive industrial development which includes Saco Defense, Inc., Saco Steel and some smaller businesses.

Goosefare Brook is classified as Class B. The control site (Sta. 48), located upstream of the Maine Turnpike, attains Class B aquatic life standards. Examination of the raw data and computed variables reveals a high diversity of pollution sensitive taxa (Fig. 19-c *Line #505*; Fig 20-*Above*). Appendix 1 provides a description of the variables and Appendix 2 explains box plot data summaries. No other sampled locations downstream of the control site (Stas. 49; 50; 271 and 272) attain standards for their statutory classification, Class B. Examination of community structure results at stations 49 and 271 indicate toxic impacts, probably from a combination of point and non-point sources, when compared to the control site (Sta. 48), located above the Maine Turnpike. This can be seen in the extremely low number of organisms (Fig.19-a, *Line #506 & 507*) and the sparse richness (Fig.19-b, *Line #506*; Fig 20). Station 271 is the most severely impacted location and fails to meet the minimum provisions of the State's aquatic life standards due to low total abundance of organisms (Fig.19-a *Line # 506)*. This location is an isolated, undisturbed wooded area immediately downstream of the Saco Steel property and about 1/4 mile downstream of a major culverting and relocation of the stream under the Maine Turnpike and Exit 5. Visually, the water quality of the stream changes from clear and colorless above the Turnpike to opaque, dusky orange at Station 271, to opaque dusky grey at Station 49. Iron bacteria was evident at both these stations. Conductivity is a useful, measure of non-specific contaminants in water that carry an electrical charge, such as ions and dissolved solids. This can be caused by dissolved metals or salts. The conductivity at Station 271 is 6 times higher than at the control site, Station 48 (Table 14). High levels continue downstream all the way to the Old Orchard Rd. site. Field investigations in September, 1995 revealed the existence of a small tributary to Goosefare Brook having iron levels seven times higher than the chronic toxic standard for aquatic life (Table 14). This tributary enters the Brook about 75 yards upstream of Station 271. However, levels of iron were also slighty over the chronic level at a point apparently upstream of Saco Steel property surface water drainage, but downstream of the interstate system. Conductivity was also high at this location. The downstream-most site (Station 272) revealed a significant rebound in numbers of organisms and richness of taxa (Fig 19a & b- *Line #508*; Fig. 20) although it still fails to attain Class B standards due to poor representation by pollution-sensitive taxa (Fig. 19-c *Line #508*). The distribution and abundance of taxa at this station suggests, though, that toxic contamination is no longer a factor in determining community structure .

A combination of causes have probably contributed to the severe impact on the aquatic community in the vicinity of Exit 5 of the Maine Turnpike. Saco Defense Inc. discharged heavy metals into the stream prior to May 1987, and volatile organic carbons were detected by MDEP in a groundwater discharge to surface water. This discharge is currently being mitigated by a barrier well system. A number of semi-volatile organic compounds have been detected below the Maine Turnpike but above Saco Defense Inc. property. Saco Steel Company is upstream of Saco Defense, Inc. and just upstream of the sampled tributary to Goosefare Brook. There is known groundwater and soil contamination by metals and hydrocarbons, including PCBs on this property. It was operated as a junkyard between the 1970's and 1980's, and in May 1990 received a license to be operated as a metal processing facility. Violations of environmental protection provisions of this license have been documented since its issuance. A number of other non-point sources below the Maine Turnpike are probable contributors to the Brook.

Because of the complicated convergence of multiple stressors on this waterbody, funding was secured in 1997, through the Surface Water Ambient Toxics Program, to further investigate aquatic life and water quality impacts. Dr. Alexander Huryn and graduate student, Thomas Woodcock, of the University of Maine, Orono Campus, conducted benthic macroinvertebrate and leaf decomposition studies during the 1997 and the 1998 field seasons. The goal of this effort is to investigate changes in secondary production and to more clearly define the stressor:response relationships in this stream. The implications of significant impacts from the interstate system alone, as distinct from the site specific problems in Goosefare Brook watershed, make this an important question to resolve especially in light of plans to widen the Maine Turnpike. Preliminary approval for additional funding to the University of Maine has been granted through a US EPA supplemental grant program for watershed restoration. The focus of this work will be development of a Total Maximum Daily Load (TMDL) model for Goosefare Brook.

Table 14 Values for water chemistry parameters in Goosefare Brook in the vicinity of Exit 5 of the Maine Turnpike in Saco, Maine.

PARAMETER	**LOCATION**				
	Above ME. Turnpike	**Trib to GFB**	**above Saco Steel; below Pike**	**below Saco Steel; below Pike**	**Old Orchard Rd**
Conductivity	111			**685**	**369**
Lead	ND .002	ND .002	ND .002	ND .002	
Zinc	0.003	0.008	0.008	0.008	
Iron	0.21	**7.2**	**1.1**	**1.5**	
Chromium	ND .0005	ND .0005	ND .0005	ND .0005	

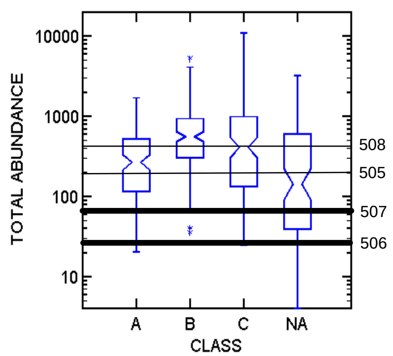
Figure 19

Box plots showing values of community structure variables (a.) total abundance; b.) richness; c.) EPT) for the Goosefare Brook at four sites above and below the Turnpike and industrialized areas in Saco. Values are compared to the distribution of all values for all sampling events within a given class in the Maine DEP Biological Monitoring Program database.

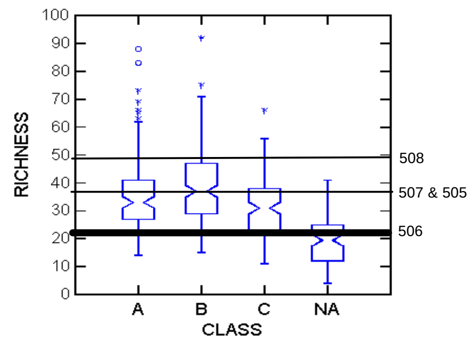
N=490 n_A=115 n_B=162 n_C=123 n_{NA}=90

505= Control (Sta.48) **506= Below Turnpike (Sta.271) 507= Below I-195 and industries** (**Sta.49**) 508= Recovery (Sta.272)

a.)



b.)



c.)

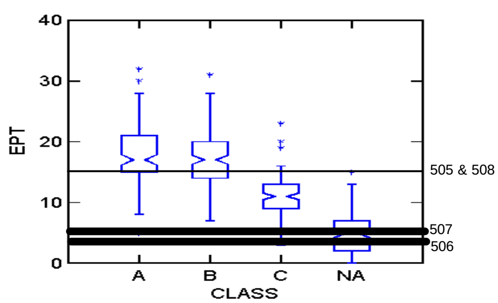
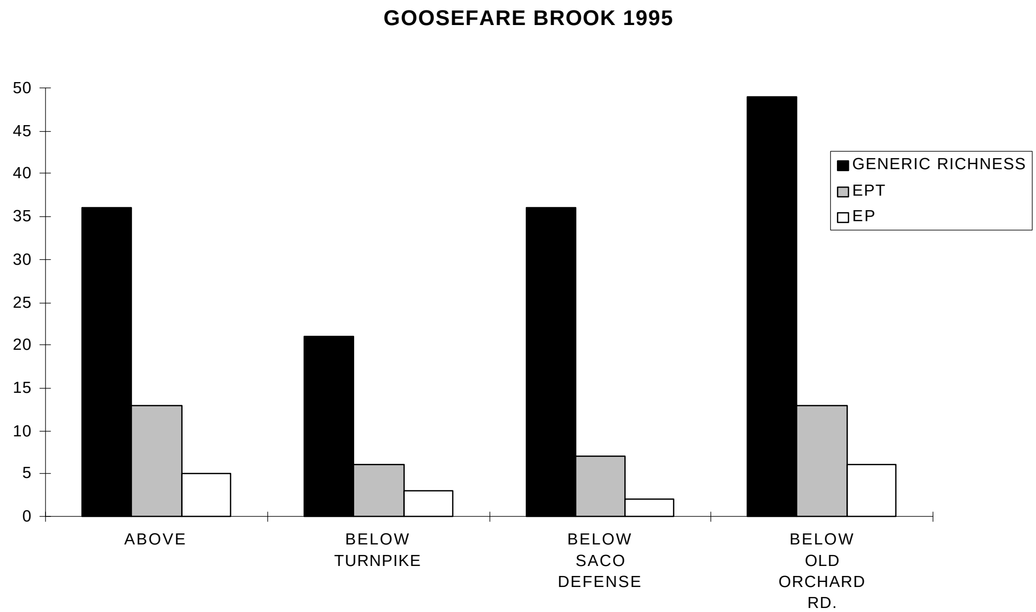


Figure 20 Community structure differences between sites on Goosefare Brook above and below industrial development and the Maine Turnpike in Saco, Maine



CASE STUDY 11
Biocriteria as a TMDL Modeling Endpoint, Lower Presumpscot River

The Presumpscot River exhibits non-attainment of aquatic life standards in several locations. In recent years EPA has required that a Total Maximum Daily Load (TMDL) be established for impaired river systems, such as the Presumpscot, for which existing, required pollution controls are inadequate to attain applicable water quality standards. In December, 1998 the Headquarters office of the Environmental Protection Agency, in Washington, D.C., approved a Total Maximum Daily Load (TMDL) finding, prepared by Maine Department of Environmental Protection, for the Presumpscot River. This approval was significant for several reasons: it is the first TMDL to be approved in Region I EPA (the New England States); and it is the first time in New England and in the Nation, that biocriteria and bioassessment findings have been used to identify a specific pollutant stressor and to serve as the quantitative response variable, from which to develop a pollutant discharge limit. The wastewater discharge license that has resulted from this effort requires an initial 30% reduction in the discharge of total suspended solids and biochemical oxygen demand from the SAPPI, S.D. Warren Pulp and Paper mill in Westbrook. Provisions are included in the license for further reductions (up to 61%) if the initial levels still fail to provide for attainment of aquatic life standards. The Department was able to apply this innovative approach to improving water quality and aquatic life conditions in the Presumpscot River because of the convergence of several factors:

- The State has a sound legal basis for use of biological monitoring findings to force action because clearly defined aquatic life standards exist in the Water Quality Classification law and technically defensible numeric criteria have been established by the Department;

- Data essential to the modeling of the recommended total suspended solids load reductions on the Presumpscot River, had been collected to assess aquatic life issues on the Androscoggin River, under State requirements for a 401 Water Quality certification for a hydropower license renewal;

- Teamwork and collaboration between MDEP water quality modelers and aquatic biologists resulted in an approach that integrated technical information and expertise from both disciplines, and provided a means for the Department to control a stressor for which the State has no standards.

The Presumpscot River, the outlet of Maine’s largest lake, Sebago Lake, flows through the most densely populated county in the State of Maine. As the State’s industrial receiving waters go, the Presumpscot is a very small river, having a drainage area of 641 square miles, less than 1/10th that of the Penobscot River. It is these unfortunate circumstances that contribute to the very poor water quality in the lower Presumpscot River. The average mainstem dilution ratio (available river volume to combined major industrial and municipal wastewater flow volume) to assimilate industrial and municipal waste inputs is only about half that available on the Penobscot or Kennebec Rivers. The Department of Environmental Protection issues wastewater discharge licenses that set the allowable amounts of pollutants that industries may discharge to waters of the State. These limits are scientifically determined in order to preserve water quality sufficient to maintain all designated uses and criteria established, by law, for the river. Typically, the wasteload allocation is based on complex engineering models of the projected effect of the discharge on dissolved oxygen levels. Dissolved oxygen sags due to input of oxygen-consuming wastes are one of the most important negative effects of wastewater discharges. However, major advances in our ability to detect changes in instream biological communities are revealing detrimental effects caused by stressors that might previously have been unrecognized or thought insignificant. This is one of the greatest strengths of biological monitoring: to detect real instream, ecological problems caused by unmonitored and unrecognized stressors. This case study explores one such stressor, total suspended solids (TSS) and the means by which the Department developed a TMDL, based on findings about the biological community.

Biological monitoring in the Presumpscot River in Westbrook, below the SAPPI S.D. Warren Pulp and Paper mill discharge (Stas. 72, 296), has consistently revealed non-attainment of Class C aquatic life standards (1984, 1994, 1995, 1996) using standard Department methods (rock basket artificial substrates). Upstream samples (1996) indicate attainment of Class C aquatic life standards. The MDEP numeric aquatic life criteria are based on statewide data collections over a 14 year period with analysis of over 400 sampling events. The criteria are in the form of a statistical model (linear discriminant model) that yields the probability that a test sample belongs to one of four statistical classes that correspond to the aquatic life standards in the Water Quality Classification law (Class AA/A; Class B; Class C and Non-attainment of standards). Probabilities equal to or greater than 60% are required for a sample to be considered in attainment of a given class (Part I Chapter 1).

The Presumpscot River biological monitoring samples reveal a shift in the benthic macroinvertebrate community from 90% insects above the mill to about 50% insects below the mill, with 15%-35% loss of taxonomic richness and 46%-60% loss of the sensitive Ephemeroptera-Plecoptera-Trichoptera (EPT) groups. Pollution-sensitive insect taxa were replaced, in the downstream samples, by a predominance of snails and worms, adapted to utilization of settled solids. The SAPPI mill accounts for 80% of the total suspended solids load, at low flow, in the Presumpscot River. Below the mill the dilution ratio is only 9:1 during low flow (7Q10) conditions. In comparison to other paper mills in the State, the SAPPI mill effluent is considered high strength for solids. Calculated mean ambient concentrations of total suspended solids in the Presumpscot below the mill were 32% to 39% greater than ambient levels on the Androscoggin river below two different paper mills, with the same documented values for background TSS concentrations. For the most part the incremental TSS increase on the Androscoggin River, due to paper mill discharges, is within 1 ppm of background, while on the Presumpscot the mill discharge resulted in a three times greater increase. Direct observations in the river during macroinvertebrate and fish tissue sampling revealed a heavy suspended and settled solids load. Samplers and gill nets were coated with flocculent fibers and water clarity was dramatically reduced. Upstream of the SAPPI outfall, it was possible to see samplers on the river bottom at 2.5 meters of depth while in the effluent plume, just 600 m downstream, visibility was less than 0.5 meter. Visibility at a sampling station 3.2 km downstream of the outfall remained significantly impaired. Data collected during the same time period as the biological monitoring indicated there were no violations of criteria for dissolved oxygen or toxic materials. The Department concluded that the cause for non-attainment of aquatic life standards was excessive loading of solids from the SAPPI discharge.

The conclusion that a heavy solids load was the cause of non-attainment of aquatic life standards was supported by data and observations from the Androscoggin River during re-licensing investigations for four hydropower dams in the vicinity of the International Paper (IP) mill in Jay, Maine. In both the Presumpscot and the Androscoggin Rivers, paper mill discharges are to impoundments with similar hydraulic properties such as velocity and depth. The rivers upstream of both mills are also impounded by two or more dams, yet all upstream impoundments attain at least Class C aquatic life standards. Low flow conditions exacerbate the impacts of heavy solids loads to the benthic community because the solids settle to the river bottom, rather than being carried, in suspension, downstream. As was the case on the Presumpscot River, aquatic life standards were similarly not met in the impoundments downstream of the IP discharge outfall in 1995, a low flow year. In 1996, increased dilution of IP's discharge was gained from a wetter than normal summer and in addition, the mill experimented with polymer addition that resulted in a reduction of TSS discharge of about 63%. Biological monitoring data collected the summer of 1996 revealed a dramatic positive response in the benthic macroinvertebrate community, resulting in the attainment of aquatic life standards throughout the study area. As compared to 1995, the abundance of individuals in 1996 was three times higher; the proportion of insects increased from 9% to 88**%;** richness was doubled; and EPT tripled in the impoundment directly downstream of the IP outfall. Further confirmation of solids as the probable cause for non-attainment the previous year was made by SCUBA diver observations of the accumulation of a flocculent deposit of solids on the substrate during the low flow/high solids load year (1995) in the Androscoggin River impoundments. Solids did not accumulate in 1996 when discharge of TSS was reduced.
To determine the appropriate TSS limits for the SAPPI discharge on the Presumpscot River a method was developed that considered both the Androscoggin River data and Presumpscot River data. The decision was based on two years of sampling on the Presumpscot River and 3 years of sampling on the Androscoggin. The method used aquatic life attainment versus non-attainment status, river flows during macroinvertebrate sampler colonization periods, and mill discharge of TSS during sampler colonization periods (the summer low flow period). The mill TSS mass effluent loads were prorated to 10 year low flow conditions in order to compute sufficiently protective TSS limits. These values were then plotted against aquatic life attainment or non-attainment results for each river. They are summarized in Table 15 and Figures 21 and 22. The Androscoggin River plot showed that attainment occurred at loads under 7,000

lbs/day of TSS. In the Presumpscot River, with much lower dilution available, non-attainment conditions were documented at about 5,900 lbs/day. From this analysis it was concluded that it would require a maximum TSS load of, at most, 5500 lbs/day on the Presumpscot to begin to see any improvement in the resident biological community. This figure represents a 61% reduction in the then-existing license limits for solids and will be imposed in July of 2001 if aquatic life attainment has not been achieved by the initial 30% reduction. An additional 10% reduction will be imposed if standards are not achieved by July of 2003.

The 5,500 lbs/day monthly TSS average on the new SAPPI mill license is a seasonal limit only, applicable between May 1 and September 30. It was allowed that limits this low might not be necessary during cold, higher flow winter months, when there is a lower level of biological activity. Winter limits were set at past demonstrated performance or a monthly average of 9,950 lbs/day from October 1 through April 30. The TMDL, and thus the license, are written as a phased approach, requiring on-going, annual monitoring of the benthic macroinvertebrate community to determine if attainment is achieved at the initial recommended levels. There are provisions to further decrease the allowable TSS limits if attainment is not achieved, or to lock in levels that successfully result in aquatic life attainment.

Table 15 Summary of TSS TMDL Calculations for the Presumpscot River

	SDW 1995	SDW 1996	IP 1995	IP 1996	IP 1997
Aquatic Life Status	N/A	N/A	N/A	A	A
Months	June-Aug	Aug-Sept	June-Aug	Aug-Sept	June-Aug
Flow (cfs)	418	463	2114	2982	4116
30Q10 Flow (cfs)	330	330	1900	1900	1900
30Q10 Dilution	10.1	10.1	24.0	24.0	24.0
TSS Discharged	7454	8795	19804	5750	13495
TSS Prorated 30Q10	5885	6269	17800	3663	6229

Figure 21
International Paper Loads Prorated to Androscoggin River 30Q10
1900 cfs

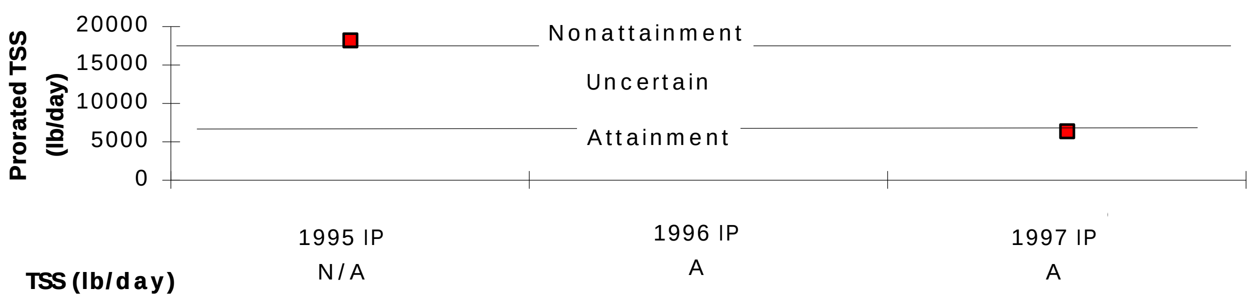
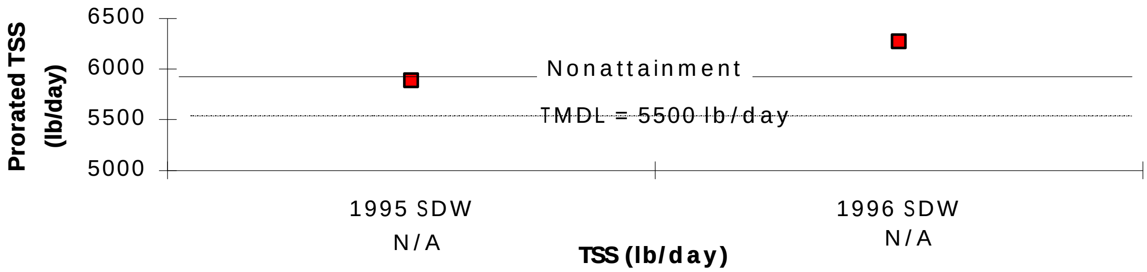


Figure 22
SDW Loads Prorated to Presumpscot River 30Q10
330 cfs



Mousam River near Sanford, Maine

The majority of sampling effort in the Salmon Falls basin has focused on stations on the mainstem affected by dams and wastewater discharges. The Salmon Falls River has been managed as Class B for many years but has experienced continual problems attaining Class B standards for dissolved oxygen, bacteria and aquatic life, in the lower reaches,. All aquatic life monitoring stations downstream of the Berwick sewage treatment plant fail to attain assigned Class B standards.

Introduction

Geography

The Saco River basin covers 1,696 square miles. The River originates at Saco Lake just north of Crawford Notch, New Hampshire and flows through the Mt. Washington Valley. About half of the drainage area is in the State of New Hampshire. Just east of Conway, New Hampshire it crosses into Maine, near Fryeburg, winds northeast for a short distance, and then meanders south-southeast through the mountains and hills of Western Maine. The Saco River continues southeast towards the urban coastal areas of Biddeford and Saco before emptying into Saco Bay. The total length from the Maine/New Hampshire border is approximately 85 miles. There are four other sampled streams in the Saco River basin listed in Basin Table 9.

The Piscataqua/Salmon Falls River basin covers 1,356 sq. miles. The Piscataqua River is the tidal portion of the Salmon Falls River. The Biological Monitoring Program has not conducted any sampling in the tidal portions of the river so the remainder of this report will focus on the Salmon Falls River. For its entire length, including below head of tide, the River forms the Maine/New Hampshire border. A little more than half of the drainage area is in New Hampshire. A dam at Milton Pond, the headwaters of the Salmon Falls, regulates flows for the entire river. The lower section of the Salmon Falls is essentially entirely impounded by four dams within the last five miles of river, before head of tide at South Berwick. The Great Works River, the largest tributary to the Salmon Falls, enters just south of South Berwick, Maine. The Mousam R. is another sampled river within this basin. It flows through the industrialized and urban areas of Sanford and coastal Kennebunk before joining the Gulf of Maine above the mouth of the Piscataqua. There are three other sampled streams within the Salmon Falls/Piscataqua River basin listed in Basin Table 9.

Basin Summary Statistics	
Biomonitoring Activities in the Basin	**Period of Record**: 1984-1995 **Waterbodies Sampled**: Total of 13 (Saco basin: 5; Salmon Falls basin: 8) **Established Stations**: Total of 30 for both basins combined **Number of Sampling Events**: Saco basin: 14; Salmon Falls: 25
Wastewater Discharges	**Saco River. Basin**--3 municipal treatment plants; 1 energy recovery facility. **Salmon Falls River Basin**--5 municipal treatment plants (3 of which are in New Hampshire) **Note:** There are also 4 other municipal treatment plants in the Saco R. basin and 5 municipal treatment plants in the Piscataqua R. basin discharging into tidal waters. These impacts are not measured by the Biological Monitoring Program.
Other Sources	Contaminated tannery site; urban runoff; CSO's; NPS nutrients
Flow Regulation *(Total Capacity)	**Saco R. Basin**--Water level controlled by approximately 47 dams including 11 FERC-licensed hydro-electric projects: 9 are greater than 10,000KW* **Salmon Falls R. Basin**--Water level controlled by approximately 38 dams including 12 FERC-licensed hydro-electric projects, all less than 10,000KW*.
Quality	**Saco River**: good except for impacts of hydrologic alteration from multiple dams **Salmon Falls River**: fair to good in the upper reaches; poor in impoundments and the estuary below Berwick, Maine

Drainage Area	**Average Annual Discharge**	**Wastewater Flow Volume (Major Industrials and All Municipal Discharges Only)**	**Mainstem Average Dilution (approx.)**
Salmon Falls R.--326 mi^2 (at So. Berwick)	Salmon Falls R 110 cfs (min. flow requirement at Somersworth, NH)	Salmon Falls R.: 2.61mgd * (4.04 cfs) (*current actual point source flows)	27:1

Overview of Biological Monitoring Activities

The Saco and Salmon Falls River basins were last scheduled for intensive NPDES monitoring in 1995 and are due again in the 2000 field season. In 1995 one new station was added in the Saco and 6 new stations were added in the Salmon Falls basin. Of eleven stations in the Saco River basin eight meet or exceed assigned aquatic life standards (Basin Table 9, p. 157; Basin Map 9, p. 170). Station 120 on Cooks Brook was sampled only once in 1987, and has since been discontinued. It is downstream of a site of groundwater contamination that has since been cleaned up. Monitoring at Station 68, upstream of Station 120, nearer the zone of influence of the contaminated groundwater, showed improvement from non-attainment of minimum standards in 1987 to Class A by 1993, as a result of remediation activities. A return visit to Station 68 in 1995 revealed that Class A standards are still met in Cooks Brook. It is probable that non-attainment on Deep Brook can be explained by slow moving flows and a shifting, unstable habitat, but the stream should be re-sampled, with an effort made to establish a new sampling station in a riffle area. The remaining attainment problems in the Saco River basin are in the vicinity of mainstem dams (Stas. 166 and 167). Aquatic life monitoring for water quality certification, as a requirement of dam re-licensing, uncovered attainment problems downstream of the Skelton Dam in Dayton and downstream of the West Buxton Dam in Standish. Non-attainment was attributed to release of inadequate minimum flows from these dams. Re-licensing negotiations have resulted in higher minimum flow requirements and provisions for on-going monitoring of the benthic macroinvertebrate community to assess aquatic life attainment under the new operating regime.

Monitoring in the Salmon Falls basin includes stations on a number of small streams (Adams, Branch, and Carpenter Brooks, etc.) as well as a series of stations on the Mousam Rver and the Salmon Falls mainstem (Basin Table 9, p. 157; Basin Map 9, p. 170). Carpenter Brook was sampled to determine if impacts were detectable from in-place chromium contamination from the site of a former tannery. Although the upstream site only attained Class C standards, it is likely that a soft-bottom, slow moving habitat is the cause. Station 217, located below the tannery degreasing lagoons attained Class B standards.

The Mousam River was sampled in 3 locations for the first time in 1995 (Stas. 258; 259; 275). The upstream-most station (Sta. 258) did not attain minimum standards of Class C. This station is located within about 150 meters downstream of the Mousam Lake Dam. Because of the high concentration of suspended organic matter associated with lake outlet flows, macroinvertebrate communities downstream of dams are typically dominated by filter-feeding caddis flies and blackflies. These organisms “bloom” as a result of the abundant available food source. Station 258 was non-attainment due to the fact that the community was 77% filter-feeding Hydropsychid caddisflies. This hyperdominance of one type of organism is considered to be a natural, lake outlet phenomenon. The two remaining stations on the Mousam attain Class C standards but the station downstream of the Sanford sewage treatment plant was ruled as borderline between Class C and non-attainment. Only about 100 organisms were collected, with a low abundance of sensitive and filter-feeding taxa that are usually associated with the enriched conditions downstream of sewage treatment plants. The Department has been monitoring the plant due to toxicity limits set for the license (ammonia, aluminum and copper). Station 259 is located downstream of the Sanford landfill and was sampled to assess detrimental effects of landfill contamination. During the 1999 field season additional stations were established on the Mousam, to provide additional information to sort out environmental conditions on this river. Some new stations serve as local, upstream references, relative to the landfill and the treatment plant.

The majority of sampling effort in the Salmon Falls basin has focused on stations on the mainstem affected by dams and wastewater discharges. The sequence of stations from upstream to downstream, beginning with Station 51, above the Great Falls Upper Dam impoundment in Berwick is Station 51; 276; 52; 273; 274; and 243. See Basin Table 9, p. 157 and Basin Map 9, p. 170, for sampling locations. The Salmon Falls River has been managed as Class B for many years but has experienced continual problems attaining Class B standards, for dissolved oxygen, bacteria and aquatic life, in the lower reaches. All aquatic life monitoring stations downstream of the Berwick sewage treatment plant fail to attain assigned Class B standards. There are five sewage treatment plants on the Salmon Falls between Milton, New Hampshire and head of tide in South Berwick and collectively they account for about 20% of the river flow. The Berwick and the Somersworth, New Hampshire plant combined, contribute about 80% of the effluent load. Non-point sources account for only about 10% (Mitnik, P.J. 1999). The detrimental effect of the considerable load is exacerbated by the fact that discharges are to impoundments in the river. The resulting stagnation of flow eliminates re-aeration and contributes to conditions favorable for excessive algae growth. Algal respiration further contributes to dissolved oxygen problems in the river. Toxicity from ammonia, discharged by the largest treatment plants, further degrades the river's ability to support aquatic life. The Department has been involved in extensive negotiations with the State of New Hampshire, affected towns in Maine and New Hampshire, and the EPA, to develop a phased Total Maximum Daily Load (TMDL) for the Salmon Falls to bring the river into attainment of dissolved oxygen standards. It has been concluded that Class B standards are unattainable, without dam removals, for a five mile segment between the Route 9 bridge in Berwick and head of tide in South Berwick. A public hearing was held in January, 1999, to commence a Use Attainability Analysis, with the recommendation that it be legally downgraded to Class C. The Maine State Legislature approved the downgrade of the river from Class B to Class C in May, 1999. The US EPA formally approved the TMDL for the Salmon Falls River in November, 1999. Ongoing monitoring of the benthic macroinvertebrate community, following implementation of the provisions of the TMDL, will track the degree of improvement in aquatic life conditions resulting from river management activities.

GENERAL MAPS

BASIN TABLES

Basin Table 1. St. John, Aroostook and Meduxnekeag Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Aroostook Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Aroostook River	5	Caribou	0.3 km above Caribou dam	B	B			**83**
Aroostook River	6	Caribou	below Caribou POTW	C	C		Municipal	**83**
Aroostook River	7	Ft. Fairfield	1.4 km below Ft. Fairfield POTW	C	A		Municipal	**83**
Aroostook River	118	Masardis	45 m below confluence with St. Croix Stream	AA	A		Reference	**87**
Aroostook River	160	Ashland	below Little Machias River	B	A			**81**
Aroostook River	161	Ashland	above Sheridan dam	B	A			**81**
Butterfield Brook	204	Caswell	Loring Air Force Base; .7 km below Butterfield Brook dam	B	B			**93**
Caribou Stream	95	Caribou	15.2 m above Rt. 1 bridge	B	**C**			85, **94,** 99
Caribou Stream	96	Caribou	7m below Rt. 164 bridge	B	B		Urban NPS	85, **91,** 99
Dudley Brook	215	Chapman	below West Chapman Rd.	B	**C**		Agricultural NPS	**94,** 99
Greenlaw Brook	205	Limestone	Loring Air Force Base; 1.4 km below Malabean Lake dam	B	B		In-place contamination	**93**
Greenlaw Stream	117	Garfield Plantation	18 m below Pinkham Rd.	A	A		Reference	**87**
Limestone Stream	12	Limestone	.8 km north of confluence with Silver Spring Brook	B	B			**83**
Limestone Stream	47	Limestone	2.4 km below Limestone POTW	B	B		Municipal	**83**
Little Madawaska River	153	Caribou	above Loring Air Force Base	A	A			91, **92**
Little Madawaska River	177	Caribou	above Nichols Brook; below Loring Air Force Base	B	**C**		In-place contamination	**92**
Little Madawaska River	229	Caribou	above Loring Air Force Base STP	A	A		Reference	**94**
Little Madawaska River	230	Caribou	below Loring Air Force Base STP	B	B		Municiple; In-place contamination	**94**
Machias River	119	T11R7 WELS	100 m upstream of Pinkham Rd. (above Round Pond)	AA	A		Reference	**87**
Millinocket Stream	134	T1R8 WELS	below Millinocket Lake dam (below Round Pond)	B	B		Hydro	**91**

Basin Table 1. St. John, Aroostook and Meduxnekeag Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Millinocket Stream	138	T1R8 WELS	below Millinocket Lake dam	AA	A		Hydro	**91**
North Branch Presque Isle Stream	10	Mapleton	above Mapleton	B	B			83, **94**

Aroostook Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
North Branch Presque Isle Stream	11	Mapleton	.2 km below Mapleton POTW	B	B		Municipal	83, **94**
Pattee Brook	212	Ft. Fairfield	1.6 km down Sam Everett Rd.	B	B		Agricultural NPS	**94**
Presque Isle Stream	197	Presque Isle	below Presque Isle POTW	B	B		Municipal	93, **94**
Presque Isle Stream	211	Presque Isle	above Presque Isle POTW	B	B			**94**
Salmon Brook	213	Washburn	above Woodland Rd.	B	B			**94**
Salmon Brook	214	Washburn	below Washburn; 1.4 km below McCain Foods Inc.	B	B		Industrial	**94**
Squa Pan Outlet Stream	154	Masardis	.1 km below Squa Pan Lake dam	C('92)***	C		Hydro	**91**
Wolverton Brook	206	Caswell	above Loring Air Force Base	A	A		Reference	**93**

St. John Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
St. John River	8	Ft. Kent	Above Ft. Kent; .48 km above US/CAN bridge	A	A		Reference	83, **85,** 99
St. John River	9	Ft. Kent	Below Ft. Kent POTW	B	B		Municipal	**83,** 99
St. John River	97	Hamlin	Below Frasier Paper	C	B		Industrial	**85**
St. John River	186	Van Buren	41 km below Frasier Paper	C	B		Industrial	**88,** 99
St. John River	187	Grand Isle	17 km below Frasier Paper	C	C		Industrial	**88,** 99

Basin Table 1. St. John, Aroostook and Meduxnekeag Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Meduxnekeag Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Meduxnekeag	1	Houlton	Below Houlton POTW	B	A		Municipal	83, **91, 98,** 99
Prestile Stream	3	Blaine	Below Mars Hill POTW	B	B		Municipal	83, **94,** 99
Prestile Stream	4	Easton	Above Mars Hill POTW	A	A			**83,** 99
Prestile Stream	99	Mars Hill	Above Mars Hill POTW; .18 km below Mars Hill dam	B	B			**94,** 99
South Branch Meduxnekeag River	2	Houlton	Above Houlton POTW	B	A			83, **91**

Bold Date indicates year of reported model result

Bold Model Result indicates aquatic life class predicted does not meet legal class.

* Discontinued station

** Best Professional Judgement.
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*** Indicates year of statutory classification change

Basin Table 2. Mattawamkeag and Piscataquis Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Mattawamkeag Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Fish Stream	88	Island Falls	20 m above Rt. 159 bridge	B	A		Reference	**84**
West Branch Mattawamkeag River	89	Island Falls	2 km below National Starch	B	A		Industrial	**84**

Piscataquis Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Ashworth Brook	307	T5R9 NWP	Above Ebeemee Rd. crossing	A	A		Reference	**97**
Babel Brook	305	T5R9 NWP	Above Rt. 11 crossing	A	A		Reference	**97**
Blood Brook	281	Katahdin Iron Works	Above KI Rd. crossing	A	**NA**		In-place contamination	**96**
No Name Stream	280	Katahdin Iron Works	Below KIW	A	A		In-place contamination	**96**
Piscataquis River	318	Howland	Above dam	C	B		Hydro	**97**
Piscataquis River	83	Abbot Village	0.45 km above Rt. 16 Bridge	A	A	Stable	Reference	84, 85, 89, 90, **96**
Piscataquis River	84	Guilford	0.80 km below Guilford Industries; above Guilford / Sangerville POTW	B('99)***	A	Improved	Industrial	84, 85, 89, 90, **96**
Piscataquis River	85	Guilford	Above Rt. 23 bridge; 1.2 km below Guilford Industries of Me. Inc.	B('99)***	NA		Industrial	**84***
Piscataquis River	135	Sangerville	0.48 km below Guilford / Sangerville POTW	B('99)***	B	Improved	Municipal	89, 90, **96**
Piscataquis River	151	Dover-Foxcroft	0.24 km below Lower dam: above Dover - Foxcroft POTW	B	A	Stable		91, 93, **95**
Piscataquis River	152	Dover-Foxcroft	1 km below Dover - Foxcroft POTW	B	A	Stable	Municipal	91, 93, **95**
Sebec River	93	Milo	Below Milo POTW	B	C		Municipal	**85**
Sebec River	94	Milo	Above Milo POTW	A	B**	Lake Outlet		**85**
Stinking Brook	306	T5R9 NWP	Above Rt. 11 crossing	A	A		Reference	**97**

Basin Table 2. Mattawamkeag and Piscataquis Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Piscataquis Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Sucker Brook	282	Katahdin Iron Work	Above KI Rd. crossing; Below Sucker Brook Pond	A		Habitat; Low Numbers		**96**
West Branch Pleasant River	121	Katahdin Iron Works	Above Katahdin Iron Works	AA	A		Reference	**87**
West Branch Pleasant River	286	Katahdin Iron Works	Below KI Rd. crossing	AA	**B**		In-place contamination	**96**

Bold Date indicates year of reported model result

Bold Model Result indicates aquatic life class predicted does not meet legal class.

* Discontinued station

** Best Professional Judgement.
Allowances made to account for documented evidence of conditions which resulted in uncharacteristic findings.

*** Indicates year of statutory classification change

Basin Table 3. East, West, and Lower Penobscot Basins: Site Descriptions and Aquatic Life Criteria Attainment.

East Penobscot Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
East Branch Penobscot River	132	Medway	1 km above the confluence with the West Branch	AA	**C**			74, **81**

West Penobscot Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Millinocket Stream	63	Millinocket	1 km below Great Northern Pulp and Paper	C	B		Industrial	**84**
Millinocket Stream	279	Millinocket	Below GNPP, above Millinocket POTW, above Dolby Pond	C	B		Industrial	**95**
Millinocket Stream	287	Millinocket	Above town	B	B			**96**
Millinocket Stream	288	Millinocket	Below town; above GNP	C	B			**96**
West Branch Penobscot River	115	Nesowadnehunk	0.48 km above Nesowadnehunk Falls	B	B		Reference	**87**
West Branch Penobscot River	116	Abol Deadwater	Below Abol Bridge	A('99)***	B		Reference	**87**
West Branch Penobscot River	133	Medway	Below Medway Dam, 1 km above confluence with East Branch	C	B	Improved		74, 81, **95**
West Branch Penobscot River	173	Medway	Above Medway Dam; Rockabema Impoundment	C	C		Impoundment	**92**
West Branch Penobscot River	277	Millinocket	Below Millinocket POTW, below GNPP, above Dolby Pond	C	A	Improved	Municipal; Industrial	95, **96**

Basin Table 3. East, West, and Lower Penobscot Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Lower Penobscot Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Allen Stream	308	Exeter	Below Rt. 11/43 crossing; .35 km below Downing Rd.	B	A		Agricultural NPS	**97**
Birch Stream	266	Argyle	Alton Bridge	A	A		Reference	**93**
Footman Brook	309	Exeter	Below Rt. 11/43 crossing; at Stubbs Corner	B	A		Agricultural NPS	**97**
French Stream	310	Exeter	Tibbetts Rd. crossing; 8 km south of Stubbs Corner	B	**C**		Agricultural NPS	**97**
Kenduskeag Stream	145	Kenduskeag	Higginsville below Lower Cross Rd. Bridge	B	B		Agricultural NPS	91, **96**
Kenduskeag Stream	146	Kenduskeag	Above Rt 15 bridge near Lancaster Brook Rd.	B	A		Agricultural NPS	91, **96**
Kenduskeag Stream	147	Bangor	0.7 km above I-95	C	B		Urban NPS	**91**
Kenduskeag Stream	289	Bangor	0.1 km below I-95	C	B		Urban NPS	**96**
Mattamiscontis Stream	182	Mattamiscontis	just above confluence with Penobscot	A('99)***	A			**93**
Mattamiscontis Stream	183	T2R8 NWP	0.5 km above confluence with Penobscot R.	A('99)***	A		Reference	**93**
Mattanawcook	91	Lincoln	Below Lincoln Pulp and Paper (cooling water); 100 m above confluence with Penop	C	C		Industrial	**85**
Meadow Brook	314	Bangor	Below I-95 crossing	B	**NA**		Urban NPS	**97**
Meadow Brook	315	Bangor	Above Rt 2 crossing	B	B		Urban NPS	**97**
Mill Stream	283	South Orrington	Below Johnson Rd. crossing; above Rt. 15	B	**C**		Agricultural NPS	**96**
Mill Stream	284	South Orrington	Below Rt. 15	B	**C**		Agricultural NPS	**96**
Ohio St. Stream	312	Bangor	Below Ohio St. crossing	B	**NA**		Urban NPS, airport	**97,** 99
Penobscot River	62	Orono	1.2 km above confluence with Stillwater R.	B	A	Stable	Industrial	84, 93, **94**
Penobscot River	100	Veazie	Below Bangor Hydro and Veazie Dam	B('99)***	C		Hydro	**85**

Basin Table 3. East, West, and Lower Penobscot Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Lower Penobscot Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Penobscot River	124	Costigan	10 km above Old Town; 40 km below Lincoln Pulp and Paper Mill	B	B	Stable	Industrial	74, 81, 93, **94**
Penobscot River	125	Enfield	15 km below Lincoln Pulp and Paper; 5 km upstream of Enfield dam	C	C	Stable	Industrial	74, 81, 93, **94**
Penobscot River	126	Howland	1 km below Enfield Dam	B('99)***	B		Industustrial	74, **81**
Penobscot River	127	Howland	0.5 km below confluence with Piscataquis R.	B('99)***	B	Improved		74, 81, **95**
Penobscot River	128	South Lincoln	4 km below Lincoln Pulp and Paper, west bank (out of plume)	B('99)***	B	Stable	Industrial	74, 81, 92-**94**
Penobscot River	129	Lincoln	4 km below Lincoln Pulp and Paper, east bank (in plume)	B('99)***	B	Improved	Industrial	74, 81, 92-**95**
Penobscot River	130	North Lincoln	3 km above Lincoln Pulp and Paper	B('99)***	A	Improved		74, 81, 92, **93**
Penobscot River	131	Medway	10 km below Bowater-Great Northern Pulp and Paper	C	C	Improved	Industrial	74, **81**
Penobscot River	176	Veazie	Above Bangor Hydro and Veazie Dam	B('99)***	B	Improved	Impoundment	85, 92, 93, **94**

Basin Table 3. East, West, and Lower Penobscot Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Lower Penobscot Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Penobscot River	180	So. Lincoln	Below Mahackanock Island and confluence of Mattamiscontis Stream	B('99)***	B		Industrial	92, **95**
Penobscot River	207	Milford	Above Milford Dam; 0.8 km below Indian Island POTW	B('99)***	B		Municipal	93, **94**
Penobscot River	208	Enfield	Mohawk Rapids	B('99)***	B			93, **94**
Penobscot River	246	Howland	150m below Howland POTW	B('99)***	B		Municipal	**95**
Penobscot River	278	Orono	Basin Mills Rips	B('99)***	A			**94**
Pushaw Stream	311	Bangor	Pushaw Rd.	B	**NA**		Urban NPS	**97**
Silver Lake Outlet	285	Bucksport	Below Bucks Mill Rd. bridge	B	**C**		In-place contamination; Urban NPS	**96**
Souadabscook Stream	290	Hampden	above Sawyer Landfill	AA(99)***	**B**			**96**
Souadabscook Stream	291	Hampden	below Sawyer Landfill	AA(99)***	**B**		In-place contamination	**96**
Valley Ave Stream	313	Bangor	Below Valley Ave.; above Kenduskeag Bridge	B	**NA**		Urban NPS	**97**

Bold Date indicates year of reported model result

Bold Model Result indicates aquatic life class predicted does not meet legal class.

* Discontinued station

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*** Indicates year of statutory classification change

Basin Table 4. Upper and Lower Kennebec and Dead River Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Dead Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Dead River	203	T3R4 BKP WKR	1.0 km below Long Falls dam: Big Eddy	A	B**	Lake Outlet	Hydro	**93**
Dead River	209	T3R4 BKP WKR	1.1 km above confluence with Spencer Stream; above Grand Falls	AA	A		Hydro	**93**
Dead River	210	T3R4 BKP WKR	Below Grand Falls	AA	B**	Lake Outlet	Hydro	**93**
Dead River	245	T3R4 BKP WKR	2.6 km below Long Falls dam; below Big Eddy	AA	A		Hydro	**93**

Upper Kennebec Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Kennebec (Moosehead Lake Outlet Stream)	139	Big Squaw TWP	East outlet of Mooshead Lake	AA	B**	Lake Outlet		**89**
Kennebec River	333	T1R6 BKP EKR	.3 km below Harris Dam	AA	B**	Lake Outlet	Hydro	**97**
Kennebec River	334	T1R6 BKP EKR	.45 km below Harris Dam	AA	B**	Lake Outlet	Hydro	**97**
Kennebec River	335	T1R6 BKP EKR	Below Harris Dam; above Carry Brook	AA	B**	Lake Outlet	Hydro	**97**
Kennebec River	336	T1R6 BKP EKR	Below Harris Dam; below Fish Pond Stream	A	B**	Lake Outlet	Hydro	**97**
Moose River	37	Jackman	Directly below outlet of Wood Pond	A	B**	Lake Outlet		**83**
Moose River	38	Jackman	.6 km below Rt. 201 crossing	B	**C**		Municipal	**83**
Moxie Stream	162	The Forks	.3 km below Moxie Pond dam	AA	B**	Lake Outlet	Hydro	**91**

Basin Table 4. Upper and Lower Kennebec and Dead River Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Lower Kennebec Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Bond Brook	30	Augusta	24 m above I-95 overpass	B	B	Stable		83, 91, 92, **97**
Bond Brook	31	Augusta	40 m above Rt. 27 bridge crossing	B	B		Urb--NPS	83, 92, **97**
Carrabassett River	15	Kingfield	3.2 km above Rt.16 bridge crossing	AA('99)***	A		Reference	83, **97**

Lower Kennebec Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Carrabassett River	16	Kingfield	0.9 km below Rt. 16 bridge crossing	A	A			83, **97**
China Lake Outlet Stream	298	East Vassalboro	60 m below Lumber Yard at Rt. 32	B	**C**		NPS	**97**
Cobbossee Stream	253	Gardiner	Below Rt. 126/9 bridge crossing	B	**C**		Hydro; NPS	**97**
Cold Stream	255	Showhegan	30 m below dam; below Rt. 201 crossing	B	**C**		NPS	**97**
East Branch Sebasticook	20	Corinna	0.13 km below Corinna POTW	C	C		Industrial; Municipal	83, 84, 87-90, 92-94, **97**
East Branch Sebasticook	25	Dexter	0.13 km below Wassookeag Lake dam	B	**C**		Impoundment	**83**
East Branch Sebasticook	26	Dexter	50 m above Moody Mills Rd. bridge	B	B		Municipal	**83**
East Branch Sebasticook	90	Corinna	60 m above Corinna POTW	C	C			84, 88, 90, 92-94, **97**
East Branch Sebasticook	194	Corinna	0.12 km below Eastland Woolen Mill	C	C		In-place contamination	93, 94, **97**
East Branch Sebasticook	252	Detroit	Above Rt. 69 bridge crossing	C	B		Municipal	**97**
Kennebec River	21	Madison	1.6 km above Rt. 148 bridge	A	B			83, **88**

Basin Table 4. Upper and Lower Kennebec and Dead River Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Lower Kennebec Basin (continued)

Waterbody	**Station**	**Township**	**Site Description**	**Legal Class**	**Model Result**	**Comments**	**Pollution Source**	**Dates Sampled**
Kennebec River	22	Madison	6.3 km below Anson-Madison POTW	B	A		Municipal	83, **97**
Kennebec River	23	Skowhegan	0.5 km below Skowhegan POTW	B	B		Municipal	**83**
Kennebec River	24	Hinckley	9.7 km below S.D. Warren discharge; 0.3 km above Shawmut dam	C	C		Industrial	**83**
Kennebec River	29	Augusta	0.4 km above Edwards dam	B('99)***	**NA**		Impoundment	83, 85, 88, 90, **92,** 99
Kennebec River	32	Augusta	3.9 km below Augusta POTW	C	B		Municipal	83, **90**
Kennebec River	39	Bingham	0.48 km below Bingham POTW	A	**C**		Municipal	**83**
Kennebec River	40	Bingham	1.1 km above Bingham POTW	A	B			**83**
Kennebec River	98	South Gardiner	1.8 km below Gardiner POTW	C	C		Municipal	**85**
Kennebec River	165	Bingham	0.3 km below Wyman dam	A	**NA**		Hydro	91, **92**
Kennebec River	168	Sidney	Sidney Gage: 18.8 km above Edwards dam	B	B	Stable		89, 90, **92**
Kennebec River	169	Sidney	7 Mile Island; 7.6 km above Edwards dam	B	**C**			**92**
Kennebec River	174	Norridgewock	1.7 km above Weston dam; 5.8 km below Norridgewok POTW	B	**NA**		Municipal; Impoundment	92, **97**
Kennebec River	181	Bingham	0.76 km below Wyman dam	A	B		Hydro	**92**
Kennebec River	195	Skowhegan	4.1 km above S. D. Warren Co.	B	B			**92**
Kennebec River	196	Benton	10.3 km below S.D. Warren Co.	C	B		Industrial	92**, 97**
Kennebec River	234	Hallowell	2.3 km below Augusta POTW; directly east of Hallowell boat launch	C	C		Municipal	**85**
Kennebec River	239	Winslow	1.8 km below Kennebec POTW	B	**C**		Municipal	**90**
Messalonski Stream	35	Oakland	0.94 km below Snow Pond dam	C	B		Hydro	**83**
Messalonski Stream	36	Oakland	2.5 km below Oakland POTW	C	C		Municipal	**83**
Mill Stream	231	Winthrop	0.15 km below Maranacook Lake Upper dam: above Carlton Woolen Mill	B	**NA**			**84**

Basin Table 4. Upper and Lower Kennebec and Dead River Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Lower Kennebec Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Mill Stream	232	Winthrop	0.67 km below Maranacook Lake Upper dam; below Carlton Woolen Mill	B	**NA**		Industrial	**84**
Mill Stream	254	Norridgewock	Below Pion Rd. crossing	B	**C**		In-place contamination	**97**
Sandy River	17	Phillips	2 km above Rt. 142 crossing	A	A		Reference	**83**
Sandy River	18	Phillips	0.8 km below Tory Hill Rd. crossing	B	B			**83**
Sandy River	19	Farmington	3.5 km below Rt. 43 bridge	B	**C**		Municipal	83, **97**
Sebasticook River	27	Pittsfield	2.1 km below Rt.100 crossing	C	B			**83**
Sebasticook River	28	West Palmyra	6.6 km below Hartland POTW; below Rt.2 crossing	C	C		Municipal	**83**
Sebasticook River	241	Burnham	0.91 km above Burnham dam	C	C		Impoundment	**92**
Sebasticook River	299	Benton	.18 km below dam	C	C		Hydro	**97**
Sebasticook River	300	Burnham	90 m Below Burnham Dam	C	B		Hydro	**97**
Sebasticook River	319	Palmyra	Below Hartland POTW ; Rt. 152	C		Low Numbers; Disturbed	Municipal	**97**
Togus Stream	13	Chelsea	0.1 km above Hallowell Rd.	B	**C**			83, **91**
Togus Stream	14	Chelsea	20 m above Windsor Rd.	B	B		Municipal	83, **91**
Wilson Stream	33	Wilton	0.3 km below Wilson Pond Outlet	C	B			83, 91, **97**
Wilson Stream	34	Wilton	0.96 km below Wilton Tannery (closed) discharge	C	B		Industrial; Municipal	83, 91, **97**

Bold Date indicates year of reported model result

Bold Model Result indicates aquatic life class predicted does not meet legal class.

* Discontinued station

** Best Professional Judgement.
Allowances made to account for documented evidence of conditions which resulted in uncharacteristic findings.

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Basin Table 5. Upper and Lower Androscoggin Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Upper Androscoggin Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Cupsuptic River	360	Upper Cupsuptic	1.5 km above Big Falls	AA			Reference	98
Rangley River	136	Oquossoc	Above Atlantic Salmon Hatchery	B	**C**			89, **90**
Rangley River	137	Oquossoc	Below Atlantic Salmon Hatchery	B	A		Industrial	89, **90**
Rapid River	248	Upton		AA	B**	Lake Outlet	Hydro	**96**
Rapid River	249	Upton	Below Lower Dam	AA	B**	Lake Outlet	Hydro	**96**
Rapid River	250	Township C	Below Middle Dam	A	B**	Habitat	Hydro	**96**
Rapid River	251	Richardsontowm	Below Upper Dam	A	B**	Lake Outlet	Hydro	**96**

Lower Androscoggin Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Androscoggin River	41	Mexico	4.2 km below Boise Cascade mill	C	B	Improved	Industrial	83, **94**, 98
Androscoggin River	42	Rumford Point	20 m below Rt 232 bridge, above Boise Cascade mill	B	B	Stable		83, **94,** 98
Androscoggin River	55	Lewiston	Above Lewiston/Auburn POTW	C	C			**84**, 98
Androscoggin River	56	Lewiston	0.3 km below L/A POTW	C	C		Municipal	**84**
Androscoggin River	57	Lewiston	2.1 km below L/A POTW	C	C		Municipal	**84**
Androscoggin River	58	Pejepscott	0.32 km below mill and dam	C	C		Industrial	**84**
Androscoggin River	61	Brunswick	Below Brunswick POTW	C	C		Municipal	**84**
Androscoggin River	82	Jay	Upper Otis impoundment, below IP mill	C	**NA**		Impoundment; Industrial	84, **95**-97
Androscoggin River	222	Livermore Falls	Livermore dam lower bypass reach	C	B		Industrial	**94**
Androscoggin River	233	Livermore Falls	Livermore dam, upper bypass reach	C	**NA**		Industrial	**85**
Androscoggin River	244	Livermore Falls	Livermore impoundment	C	**NA**		Impoundment; Industrial	**95,** 96
Androscoggin River	247	Jay	Middle Jay impoundment	C	C		Impoundment	**96**, 97
Androscoggin River	260	Canton	Upper Riley impoundment above IP mill	C	A		Impoundment	**95**

Basin Table 5. Upper and Lower Androscoggin Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Lower Androscoggin Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Androscoggin River	261	Canton	Lower Riley impoundment, above IP mill	C	C		Impoundment	**95,** 96
Androscoggin River	262	Jay	Upper Jay impoundment, above IP mill	C	B		Impoundment	**95,** 96
Androscoggin River	263	Jay	Lower Jay impoundment, below IP mill	C	**NA**		Impoundment; Industrial	**95**-97
Androscoggin River	264	Jay	Jay dam bypass reach	C	**NA**		Industrial	**95**
Androscoggin River	265	Jay	Lower Otis impoundment, below IP mill	C	**NA**		Impoundment; Industrial	**95**-97
Androscoggin River	355	Bethel	Rt.2 ; 1.6 km below confluence w/ Sunday River	B	B		Municipal	**98**
Androscoggin River	358	Durham	Durham Public Boat Launch	C	B		Municipal	**98**
Aunt Hannah Brook	343	Dixfield	15 m below Rt. 142 crossing	B	A		Reference	**98**
Bean Brook	349	Rumford	Above Rt. 2 crossing	B	A		Urban NPS	**98**
Bird Brook	340	Norway	Above Rt.117 crossing	B			Urban NPS	98
Dill Brook	341	Lewiston	Below Goddard Rd. crossing	B	**C**		Urban NPS	**98**
Ellis River	101	North Rumford	5.6 km upstream of confluence with Androscoggin (above No. Rumford Bridge)	A	A		Reference	**87**, 98
House Brook	188	Turner	Below Decoster Egg Farm	B	**C**	Improved (Provisional)	Agricultural NPS	92, **97**
House Brook	190	Turner	below Decoster Egg Farm	B			Agricultural NPS	92
House Brook	324	Turner	Above Decoster Egg Farm	B	**C**			**97**
Lake Auburn Outlet	357	Auburn	Above River Rd. crossing	B			NPS	98
Little Androscoggin River	43	South Paris	45 m above POTW	B	B	Stable		83, 85-87, **92**, 98
Little Androscoggin River	44	South Paris	Rt 26 USGS gaging cable, Bisco Falls	B	A		Reference	83, **84**
Little Androscoggin River	45	South Paris	Below Norway and So. Paris POTW at Rt 26	C	B	Improved	Municipal	**83**

Basin Table 5. Upper and Lower Androscoggin Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Lower Androscoggin Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Little Androscoggin River	46	South Paris	Above Norway POTW, below So. Paris POTW at Oxford St. gravel pit	C	A	Improved	Municipal	83-87, **92**
Little Androscoggin River	64	Auburn	Near Littlefield Corner, above Pioneer Plastics	C	B	Improved		84, **93**, 98
Little Androscoggin River	65	Auburn	Near Littlefield Corner, below Pioneer Plastics	C	B	Improved	Industrial	84, **98**
Little Androscoggin River	79	South Paris	70 m below So. Paris POTW	C	**NA**	Improved	Municipal	**84**, 98
Little Androscoggin River	92	Oxford	Below Thompson Lake outlet, 0.8 km below Robinson MFG. outfall.	C	C		Industrial	**85**
Little Androscoggin River	122	Mechanic Falls	0.2 km above Sawyer Bridge	C	A	Improved	Industrial	88**, 98**
Little Androscoggin River	123	Mechanic Falls	3.2 km below Rt 11/121 Bridge	C	**NA**		Industrial	**88**
Little Androscoggin River	344	Minot	45 m below Hacket Mills Hydo Plant	C			Municipal; Hydro	98
Lively Brook	184	Turner	Below Decoster Egg Farm, below Tidswell Rd.	B	**C**	Improved (Provisional)	Agricultural NPS	**92**
Lively Brook	185	Turner	Below confluence with House Bk., below Decoster Egg Farm	B	**C**	Improved (Provisional)	Agricultural NPS	92, **97**
Lively Brook	189	Turner	Outlet of Pleasant Pd.	B	**C**	Improved (Provisional)	Agricultural NPS	**92**
Martin Stream	104	Turner	Below Decoster Egg Farm	B	B		Agr-NPS	87, **92**
Martin Stream	105	Turner	Above Decoster Egg Farm	B	B			**87**
Merrill Brook	350	Newry	Above Monkey Rd. bridge crossing	A	A		NPS	**98**
Merrill Brook	351	Newry	15 m above confluence w/ Sunday River	A	A		NPS	**98**
Sabattus River	170	Lisbon	Below Maine Electronics, 40 m below dam	C	C		Industrial	92, **98**

Basin Table 5. Upper and Lower Androscoggin Basins: Site Descriptions and Aquatic Life Criteria Attainment.

Lower Androscoggin Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Sabattus River	359	Sabattus	50 m below Crowley Bridge crossing	C			NPS	98
Stetson Brook	356	Auburn	65 m below Stetson Rd. crossing	B	A		NPS	**98**
Sunday River	352	Newry	30 m above confluence w/ Merrill Brook	A			Reference	98
Sunday River	353	Newry	20 m below confluence w/ Merrill Brook	A			NPS	98
Sunday River	354	Bethel	60 m above Martin Rd.	A			NPS	98
Swift River	345	Rumford	Hosomer Park	B			Urban NPS	98
Swift River	346	Roxbury	Rt. 17	A('99)***			Reference	98
Thompson Lake Outlet	76	Oxford	Above Robinson MFG, 70 m below dam	C	C	Improved		84, 85, 88-90, 92, **96**, 98
Thompson Lake Outlet	77	Oxford	70 m below Robinson MFG outfall	C	**NA**		Industrial	84, **88***
Thompson Lake Outlet	78	Oxford	0.35 km below Robinson outfall, 50 m below Rt 121 Bridge	C	C	Improved	Industrial	84, 85, 87, 89, 92, **96**, 98
Thompson Lake Outlet	140	Oxford	0.29 km below Robinson Outfall, 10 m above Rt 121 Bride	C	C	Improved	Industrial	**90**
Unamed Brook	347	Lisbon Falls	60 m below Rt. 196 crossing	B			Urban NPS	98
Whitney Brook	342	Canton	40 m below Rt. 140 bridge	B			NPS	98
Wild River	102	Batchelders Grant	4 km above confluence with Androscoggin R.	A	A		Reference	**87**, 98
Wild River	103	Gilead Gage	1 km above confluence with Androscoggin R.	A	A		Reference	**87**

Bold Date indicates year of reported model result

Bold Model Result indicates aquatic life class predicted does not meet legal class.

* Discontinued station

** Best Professional Judgement.
Allowances made to account for documented evidence of conditions which resulted in uncharacteristic findings.

*** Indicates year of statutory classification change

Basin Table 6. St. Croix and North Coastal Basins: Site Descriptions and Aquatic Life Criteria Attainment.

St. Croix Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
St. Croix	198	Woodland	1.2 km below Woodland Dam and Georgia Pacific Corp.	C	C		Industrial	**91**
St. Croix	199	Baring	7.25 km below Woodland Dam and Georgia Pacific Corp.	C	B		Industrial	91, **97**
St. Croix	200	Calais	14 km below Woodland Dam and Georgia Pacific Corp.	C	B		Industrial	**91**
St. Croix	201	Woodland	0.8 km below Woodland Dam, above Georgia Pacific outfall	C	C			**92**
St. Croix	202	Baring	6.4 km below Woodland Dam and Georgia Pacific Corp.	C	C		Industrial	**92**

North Coastal Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Bog Brook	292	Beddington	0.5 km below Bog Brook Dam	A	B**	Lake Outlet	Agricultural NPS	**96**
Bog Stream	235	Deblois	Above OPI	B	**NA**			**89**
Bog Stream	236	Deblois	Below OPI	B	**NA**		Industrial (hatchery)	**89**
Cannon Brook	320	Acad. Natl. Park	Above Rt. 3 crossing	AA	A		Reference	**97,** 98, 99
Carleton Stream	149	Blue Hill	Below Third Pond; 12 m above Rt. 176-15 crossing	B	A		Reference	91, **96**
Carleton Stream	150	Blue Hill	Below Second Pond : below mine site	B	**C**		In-place contamination	91, 94, **96**
Chase Mills Stream	113	East Machias	Below Connor's Fish Hatchery	B	**C**		Industrial	87-**89**
Chase Mills Stream	114	East Machias	Above Connor's Fish Hatchery	B	B			87-**89**
Denny's River	297	Meddybemps	150 m below Meddybemps Lake	AA	**C**		In-Place Contamination	**97,** 99
Duck Brook	322	Acad Natl. Park	New Eagle Lake Rd.	AA	A		Reference	97, **98**, 99
Heath Brook	361	Acadia Natl. Park	Below Seal Cove Rd. crossing	AA	C**	Habitat	Reference	**98**, 99
Hunter's Brook	321	Acad. Natl. Park	Above Rt. 3 crossing; Park Loop Road	AA	A		Reference	97**, 98**, 99

Basin Table 6. St. Croix and North Coastal Basins: Site Descriptions and Aquatic Life Criteria Attainment.

North Coastal Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Lurvey Spring Bk.	362	Acadia Natl. Park	Inlet to Echo Lake	AA	B		Reference	**98**, 99
McCoy Brook	193	Deblois	35 m above confluence with Narraguagus River	A	**C**		Industrial	**93**
Narraguagus River	80	Cherryfield	0.53 km below Cherryfield dam	B	B			84, **93**
Narraguagus River	81	Cherryfield	0.65 km above Rt. 1 bridge	B	**C**		Industrial	84, **93**
Narraguagus River	111	Deblois	0.16 km above Rt. 193 bridge crossing	AA	**B**		Agricultural NPS	87, 89, **96**
Narraguagus River	112	Beddington	Directly above Rt. 9 bridge	AA	A			**87**
Narraguagus River	191	Deblois	30 m above confluence with McCoy Bk.	AA	A			**93**
Narraguagus River	192	Deblois	30 m below confluence with McCoy Bk.	AA	A		Industrial	**93**
No Name Brook	294	T18MD	Above Ridge Rd. crossing	A	**NA**		Agricultural NPS	**96**
Pleasant River	293	Deblois	Above Ridge Rd. crossing at Crebo Flat	AA	A		Agricultural NPS	**96**
Stanley Brook	323	Acad. Natl. Park	Above Rt. 3; Park Loop Road	AA	A		Referemce	97**, 98**, 99
Tunk Stream	148	Cherryfield	Downing pond outlet; 30 m below Rt.182 crossing	B	B		Reference	**91**
Tunk Stream	159	T10SD	Tunk Lake Outlet: 10 m below Rt. 182 crossing	B	A		Reference	**91**

Bold Date indicates year of reported model result

Bold Model Result indicates aquatic life class predicted does not meet legal class.

* Discontinued station

** Best Professional Judgement.
Allowances made to account for documented evidence of conditions which resulted in uncharacteristic findings.

*** Indicates year of statutory classification change

Basin Table 7. Sheepscot Basin: Site Descriptions and Aquatic Life Criteria Attainment.

Sheepscot Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Medomak River	59	Medomak	Above Medomak Canning (closed)	B	A			**84**
Medomak River	60	Medomak	Below Medomak Canning	B	A		Industrial	**84**
Quiggle Brook	86	South Hope	Above Union Chemical; below Rt 17 and So. Hope Dam	B	C			**84**
Quiggle Brook	87	South Hope	Below Union Chemical (closed)	B	A		Industrial	**84**
Sheepscot River	73	Coopers Mills	Below Coopers Mills Dam, above Rt. 32	B	A			84, **91**
Sheepscot River	74	North Whitefield	Above Rt. 126 Bridge at USGS gage	AA	A	Stable	Reference; Agricultural NPS	84-**98**, 99
Sheepscot River	75	Whitefield	Below Rt 194 Bridge in Whitefield	AA	**B**		Agr-NPS	84, **97**
West Branch Sheepscot River	268	Weeks Mills	Above Dirigo Rd crossing	AA	A		Reference	95-**98**, 99

Bold Date indicates year of reported model result

Bold Model Result indicates aquatic life class predicted does not meet legal class.

* Discontinued station

** Best Professional Judgement.
Allowances made to account for documented evidence of conditions which resulted in uncharacteristic findings.

*** Indicates year of statutory classification change

Basin Table 8. Presumpscot Basin: Site Descriptions and Aquatic Life Criteria Attainment.

Presumpscot Basin

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Capisic Stream	256	Portland	Evergreen Cemetery (Stevens Ave.)	C	A			95, **96,** 99
Capisic Stream	257	Portland	50 m below Lucas St. bridge crossing	C	C		Urban NPS	95, **96,** 99
Cole Brook	316	Gray	Above	B	B		Reference	97, **98,** 99
Cole Brook	317	Gray	Below Weymouth Rd. crossing	B	B		Agricultural NPS	97, **98,** 99
Collyer Brook	227	Gray	50 m below Merrill Rd. crossing	B	A			**94**
Collyer Brook	228	Gray	.19 km above confluence with Royal River	B	A		In-place contamination	**94**
Crooked River	158	North Waterford	Above Rt. 118; 1.6 km east of Rt.35 crossing	AA	A		Reference	**91**
Crooked River	237	Edes Falls	50 m above Edes Falls Rd. crossing	AA	A		Reference	**89**
Eddy Brook	141	New Gloucester	100 m above IF&W fish hatchery	B	A		Reference	91, **92,** 99
Eddy Brook	142	New Gloucester	30 m below IF&W hatchery outfall	B	**C**		Industrial (hatchery)	91, **92,** 99
Frost Gully	303	Freeport	Above	A	**B**		Urban NPS	97, **98**
Frost Gully	304	Freeport	Below	A	**B**		Urban NPS	97**, 98**
Goosefare Brook	48	Saco	75 m below Jenkins Rd. Crossing	B	B			84, 86, 94, 95, **98**
Goosefare Brook	49	Saco	0.5 km below I-195; Below Saco Defense	B	**C**		Industrial	84, 86, 94, **95**
Goosefare Brook	50	Saco	50 m above Rt.1 bridge	B	**NA**		Industrial	**84**
Goosefare Brook	271	Saco	80 m above Industrial Park Rd. crossing; Below Saco Steel Co.	B	**NA**		Urban NPS	95, **98**
Goosefare Brook	272	Saco	20 m below Old Orchard Rd. crossing	B	**C**		Urban NPS	**95**
Goosefare Brook	337	Saco	Below Maine Turnpike crossing	B	B		NPS	**98**
Goosefare Brook	338	Saco	Moody Road	B	**NA**		In-place contamination; NPS	**98**

Basin Table 8. Presumpscot Basin: Site Descriptions and Aquatic Life Criteria Attainment.

Presumpscot Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Goosefare Brook	339	Saco	Across from Saco Steel Co.	B	**C**		In-place contamination; NPS	**98**
Hatchery Brook	220	Gray	40 m below Weymouth Rd. crossing; below Dry Mills Hatchery	B	**C**		Industrial	**94,** 99
Kimball Brook	301	South Portland	Below Stillman St. crossing	C	**NA**		Urban NPS	**97**
Libby Brook	221	Gray	50 m below Weymouth Rd. crossing	B	B		Agricultural NPS; Indusrial (hatchery)	**94**
Little River-North Branch	69	Standish	Above GTE; 0.4 km above bridge at Shaw Mills.	B	B			84, **94**
Little River-North Branch	70	Standish	Below GTE; 10 m below culvert at Shaw Mills crossing	B	B		Industrial	84, **94**
Mare Brook	143	Brunswick	Above Brunswick Naval Air Station (BNAS); 60 m below Rt 123 road crossing	B	B			91, 95, **97**
Mare Brook	144	Brunswick	Below BNAS; 50 m above New Gurnet Rd. crossing	B	**C**		In-place contamination; Urban NPS	91, 95, **97**
Mare Brook	330	Brunswick	Below Picnic Pond	B	**NA**		In-place contamination; NPS	**97**
Mare Brook	331	Brunswick	Below Emergency Pt. Runway	B	B		NPS	**97**
Mare Brook	332	Brunswick	Golf Course Drainage	B	**NA**		NPS	**97**
Merrill Brook	348	Freeport	30 m above Desert Rd. crossing	B	**C**		In-place contamination	**98**
Pleasant River	155	Windham	Above Pope Rd. bridge	B	A			91, **92,** 99
Presumpscot River and Casco Bay	71	Westbrook	0.3 km above Saccarappa Dam	B	**C**		Impoundment	84, 89, 95, **97**

Basin Table 8. Presumpscot Basin: Site Descriptions and Aquatic Life Criteria Attainment.

Presumpscot Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Presumpscot River and Casco Bay	72	Westbrook	3.2 km below S D Warren Co.; just above Rt. 302 (Riverton) Bridge	C	**NA**		Industrial	84, 94-**96**
Presumpscot River and Casco Bay	223	North Windham	.4 km below Rt. 35 crossing (river proper)	A	**B**			**94**
Presumpscot River and Casco Bay	224	South Windham	70 m below Mallison dam	B	B			**94**
Presumpscot River and Casco Bay	238	Westbrook	.17 km above Cumberland Mills dam	C	**NA**		Impoundment	**89**
Presumpscot River and Casco Bay	295	Westbrook	.1 km above Westbrook POTW	C	C			**96**
Presumpscot River and Casco Bay	296	Westbrook	.5 km below S.D. Warren Co.	C	**NA**		Industrial	**96**
Presumpscot River and Casco Bay	325	Windham	Below Dundee Dam	C	C		Hydro	**97**
Presumpscot River and Casco Bay	326	Windham	Gambo Impoundment	C	C		Hydro	**97**
Presumpscot River and Casco Bay	327	Windham	Below Gambo Dam	C	C		Hydro	**97**
Presumpscot River and Casco Bay	328	Windham	Little Falls Impoundment	C	C		Hydro	**97**
Presumpscot River and Casco Bay	329	South Windham	Below Little Falls Dam	C	C		Hydro	**97**
Red Brook	218	Scarborough	Above Running Hill Rd. and RWS Landfill	C	C			**94,** 99
Red Brook	219	Scarborough	50 m below Running Hill Rd. crossing; below RWS Landfill	C	C		In-place contamination	**94,** 99
Royal River	156	New Gloucester	.15 km below Bald Hill Rd. crossing	A('99)***	B			**91**
Royal River	157	New Gloucester	25 m above Cobbs Bridge Rd. crossing	A('99)***	B		Agricultural NPS	**91**
Royal River	225	New Gloucester	8 m below Penny Rd. crossing	A('99)***	B			**94**

Basin Table 8. Presumpscot Basin: Site Descriptions and Aquatic Life Criteria Attainment.

Presumpscot Basin (continued)

Waterbody	Station	Township	Site Description	Legal Class	Model Result	Comments	Pollution Source	Dates Sampled
Royal River	226	Gray	.6 km below Depot Rd. crossing	B	B		In-place contamination	**94**
Royal River	242	Yarmouth	90 m below Bridge St. dam	B	B		Urban NPS; Agricultural NPS	**92**
Stroudwater River	66	Gorham	From Rt 22, about 150 m below Maine Metal Finishing site	B	B		In-place contamination	84, **92**
Stroudwater River	67	Gorham	0.25 km above Maine Metal Finishing site	B	B	Stable		84, 85, **92**
Stroudwater River	240	Gorham	From Rt. 22, about .4 km below Maine Metal Finishing site	B	B		In-place contamination	**92**
Trout Brook	302	South Portland	25m above Highland Ave. crossing	C	**NA**		Urban NPS	**97,** 99

Bold Date indicates year of reported model result

Bold Model Result indicates aquatic life class predicted does not meet legal class.

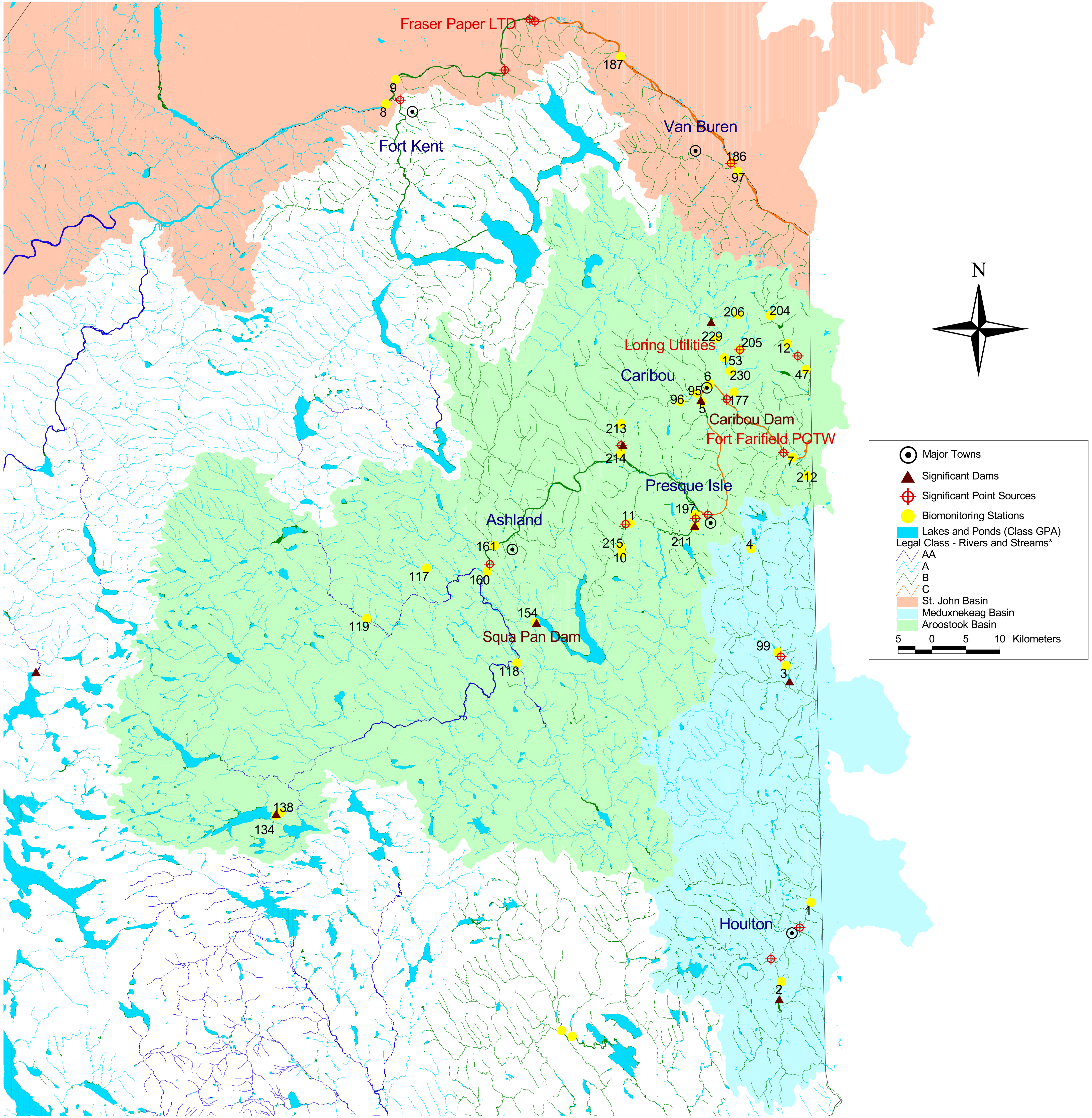
* Discontinued station

** Best Professional Judgement.
Allowances made to account for documented evidence of conditions which resulted in uncharacteristic findings.

*** Indicates year of statutory classification change

BASIN MAPS

Basin Map 1
St. John, Aroostook & Meduxnekeag Aquatic Life Criteria Attainment

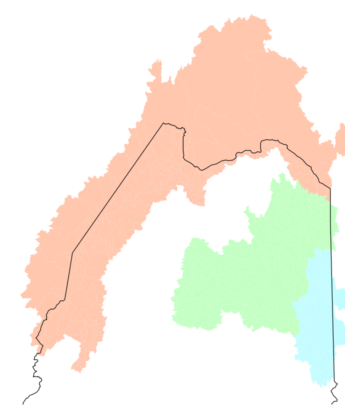


Aquatic Life Model Results

Class A or AA
Class B
Class C
Non-attainment

Year Sampled

Station Number		81	83	85	87	88	91	92	93	94
Aroostook River	5		B							
	6		C							
	7		A or AA							
	118				A or AA					
	160	A or AA								
	161	A or AA								
Butterfield Brook	204								B	
Caribou Stream	95			B						C
	96			A or AA			B			
Dudley Brook	215									C
Greenlaw Brook	205								B	
Greenlaw Stream	117				A or AA					
Limestone Stream	12		B							
	47		B							
Little Madawaska River	153						A or AA	A or AA		
	177							C		
	229									A or AA
	230									B
Machias River	119				A or AA					
Meduxnekeag	1		B				A or AA			
Millinocket Stream	134						B			
Millinocket Stream-mps Co.	138						A or AA			
North Branch Presque Isle Stream	10		A or AA							B
	11		B							B
Pattee Brook	212									B
Penobscot River	99			C						
Presque Isle Stream	197								A or AA	B
	211									B
Prestile Stream	3		C							B
	4		A or AA							B
Salmon Brook	213									B
	214									B
South Branch Meduxnekeag River	2		B				A or AA			
Squapan Outlet Stream	154						C			
St. John River	8		A or AA	A or AA						
	9		B							B
	97			B						
	186					B				
	187					C				
Wolverton Brook	206								A or AA	



Maine DEP, 1999

* Legal class designations depicted for rivers and streams do not include 1999 revisions.

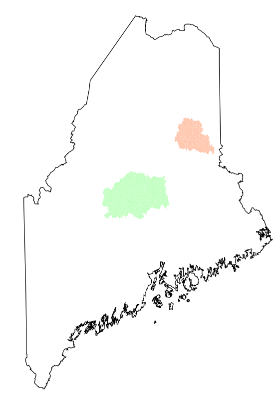
Basin Map 2
Mattawamkeag & Piscataquis Aquatic Life Criteria Attainment.

Aquatic Life Model Results

Legend: Class A or AA (blue); Class B (green); Class C (orange); Non-attainment (dark red)

Year Sampled

Station	Station Number	84	85	87	89	90	91	93	95	96	97
Ashworth Brook	307										Class A or AA
Babel Brook	305										Class A or AA
Blood Brook	281									Non-attainment	
Fish Stream	88	Class A or AA									
Piscataquis River	83	Class A or AA	Class A or AA		Class A or AA	Class B				Class A or AA	
	84	Non-attainment	Non-attainment		Class A or AA	Class B				Class A or AA	
	85	Non-attainment									
	135				Class A or AA	Class A or AA				Class B	
	151						Class B	Class B	Class A or AA		
	152						Class A or AA	Class B	Class A or AA		
	318										Class B
Pleasant River, West Branch	121			Class A or AA							
	286									Class B	
Sebec River	93		Class C								
	94		Class B								
Stinking Brook	306										Class A or AA
Sucker Brook	282									Class C	
Unamed Stream	280									Class A or AA	
West Branch Mattawamkeag River	89	Class A or AA									



- Major Towns
- Significant Dams
- Significant Point Sources
- Biomonitoring Stations
- Lakes and Ponds (Class GPA)

Legal Class - Rivers and Streams*
- AA
- A
- B
- C
- Piscataquis Basin
- Mattawamkeag Basin

5 0 5 Kilometers

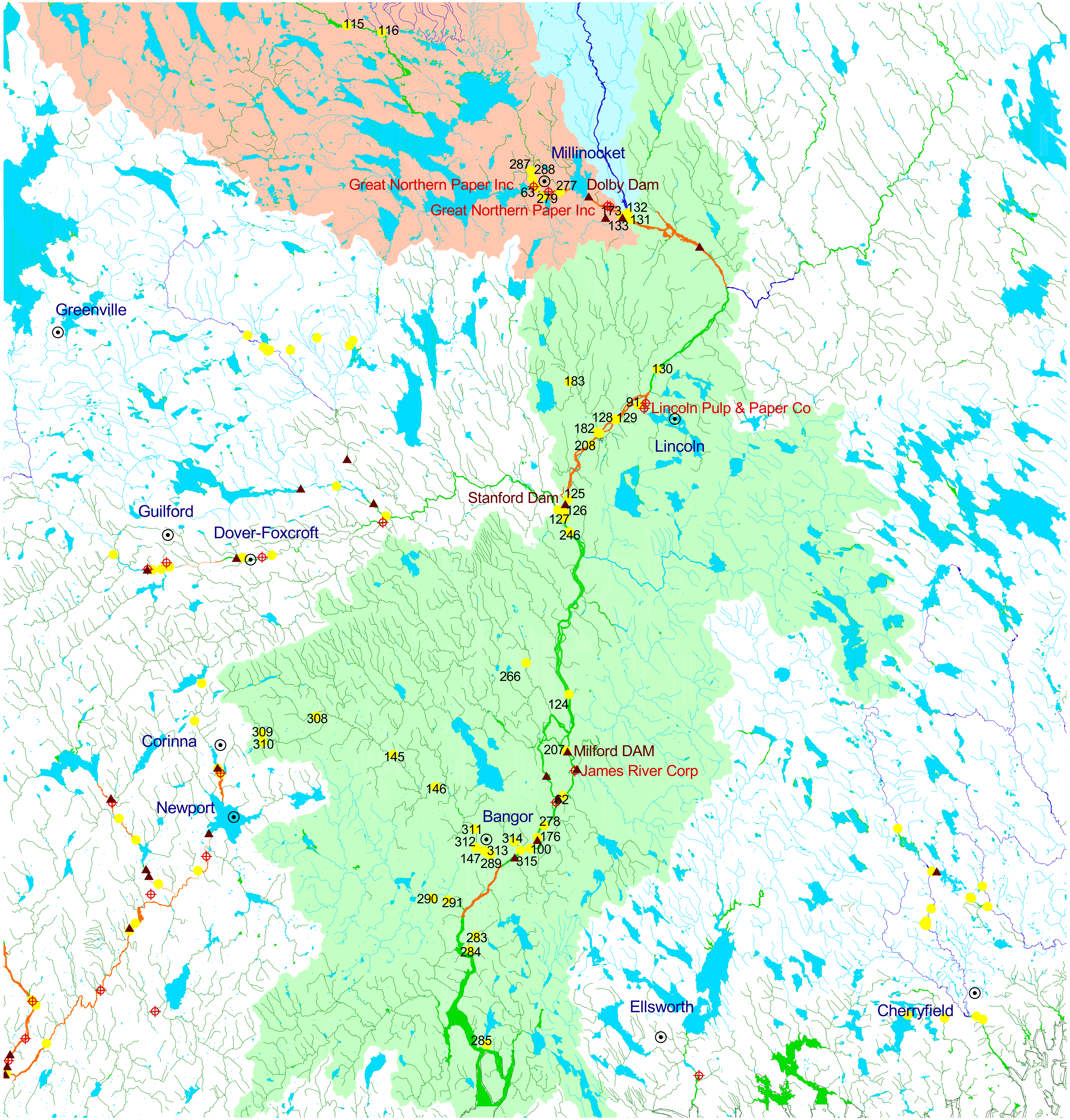
N

Maine DEP, 1999

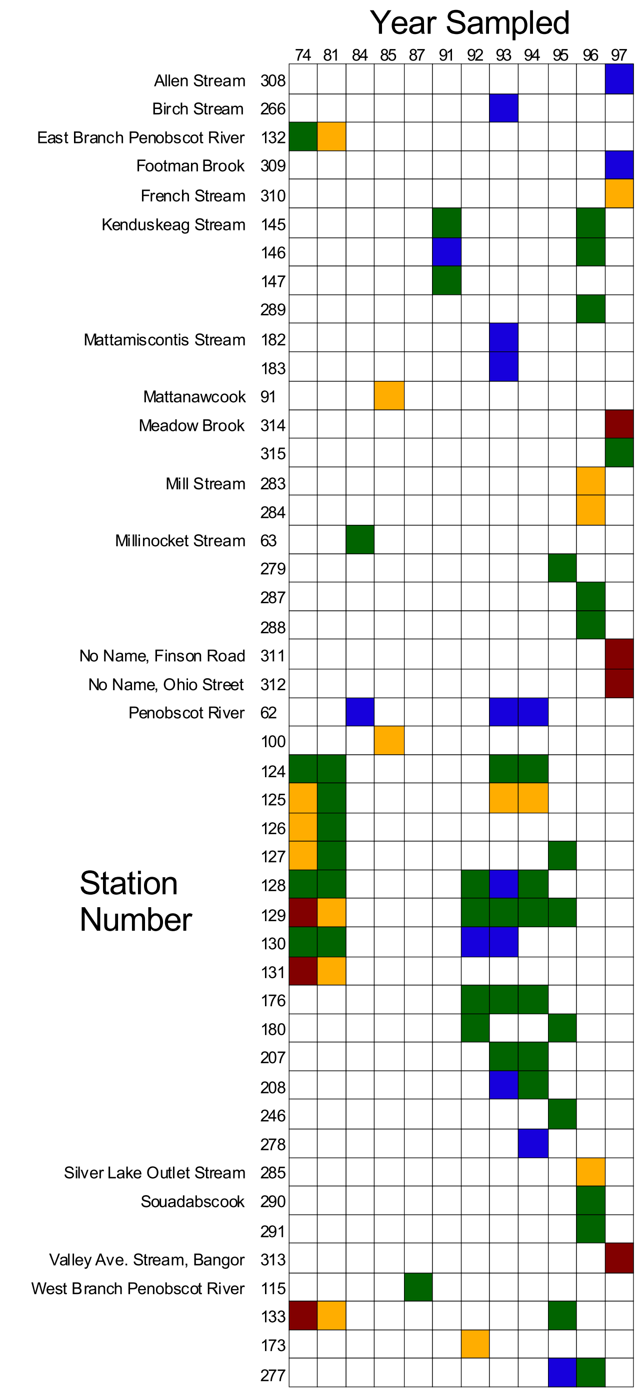
* Legal Class designations depicted for rivers and streams do not include 1999 revisions.

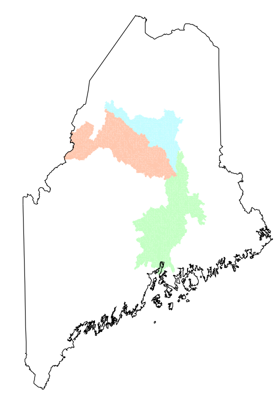
Basin Map 3
East, West & Lower Penobscot
Aquatic Life Criteria Attainment

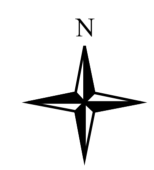
Aquatic Life Model Results



- Class A or AA
- Class B
- Class C
- Non-attainment



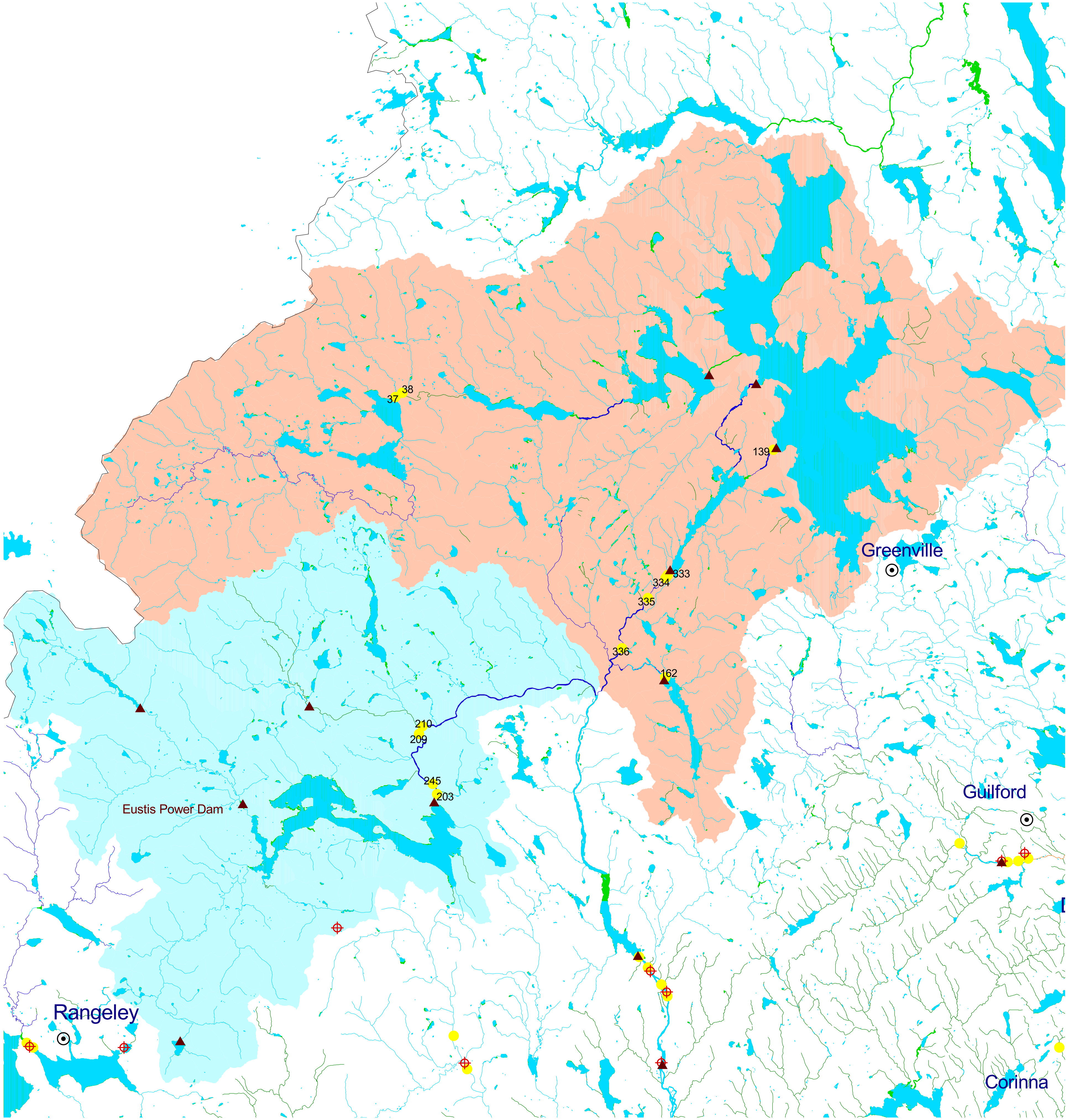




Maine DEP, 1999

* Legal class designations depicted for rivers and streams do not include1999 revisions.

Basin Map 4a
Upper Kennebec & Dead River
Aquatic Life Criteria Attainment



Aquatic Life Model Results

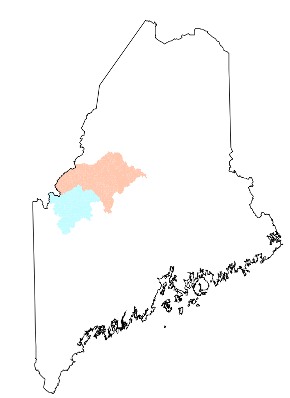
- Class A or AA
- Class B
- Class C
- Non-attainment

Year Sampled

Station	Number	83	89	91	93	97
Dead River	203				Class B	
	209				Class A or AA	
	210				Class B	
	245				Class A or AA	
East Outlet Of Moosehead Lake	139		Class B			
Kennebec River	333					Class B
	334					Class B
	335					Class B
	336					Class C
Moose River	38	Class C				
Moxie Stream	162			Class B		

Major Towns
Significant Dams
Significant Point Sources
Biomonitoring Stations
Lakes and Ponds (Class GPA)
Legal Class - Rivers and Streams
AA
A
B
C
Dead Basin
Upper Kennebec Basin

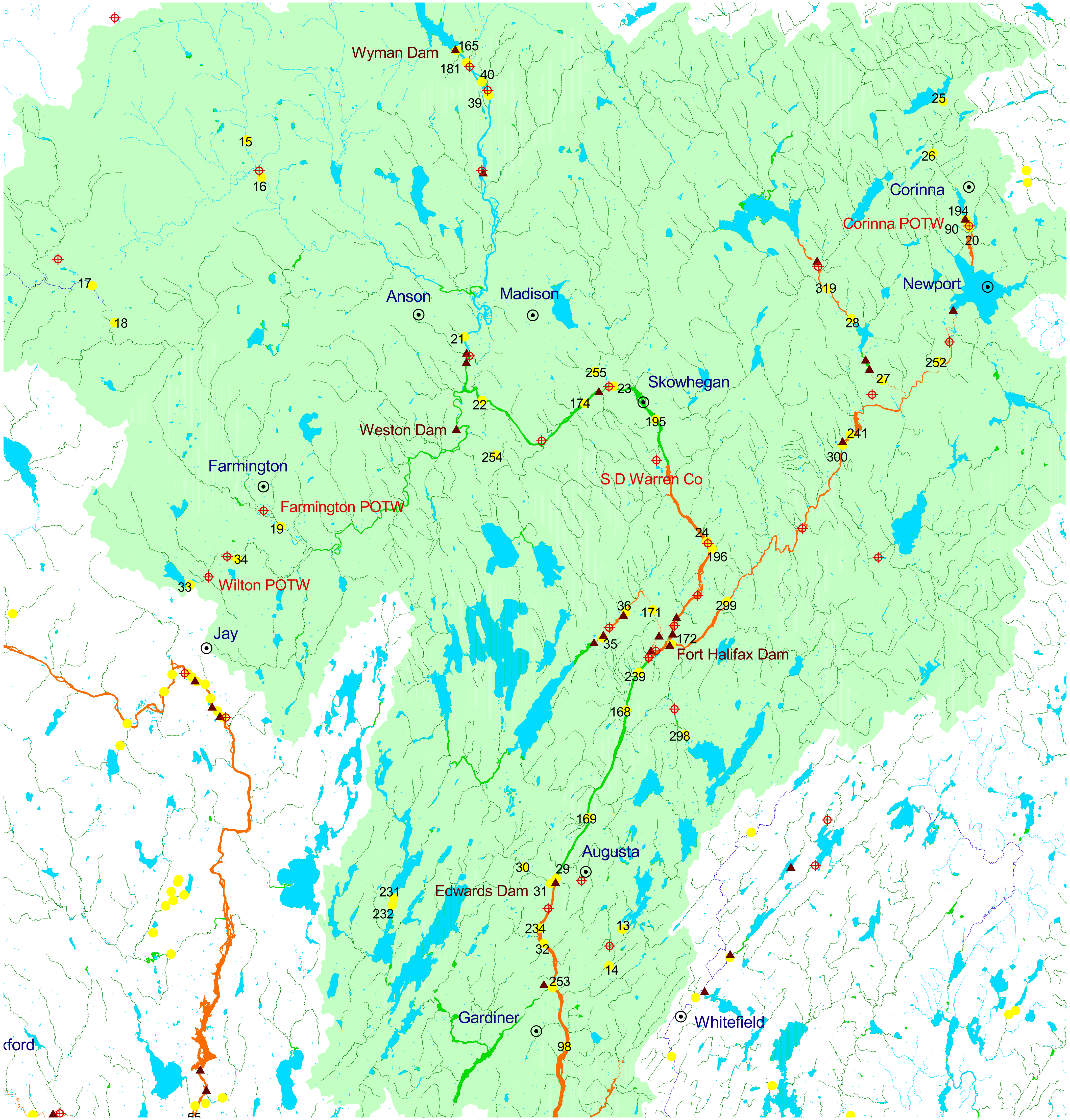
10 0 10
Kilometers



N

Maine DEP, 1999

* Legal class designations depicted for rivers and streams do not include1999 revisions.



Basin Map 4b
Lower Kennebec
Aquatic Life Criteria Attainment

Aquatic Life Model Results

Class A or AA
Class B
Class C
Non-attainment

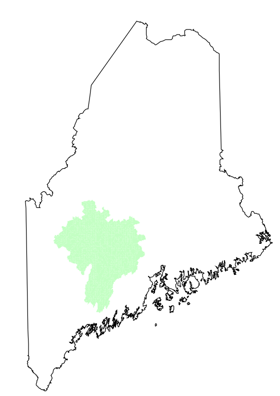
Year Sampled

Station Number

	Station	83	84	85	87	88	89	90	91	92	93	94	97
Bond Brook	30	Class B							Class B	Class B			Class B
	31	Class C								Class B			Class B
Carrabassett River	15	Class A or AA											Class A or AA
	16	Class A or AA											Class A or AA
Cobbosseecontee Stream	253												Class C
Cold Stream, Skowhegan	255												Class C
East Branch Sebasticook	20	Non-attainment	Non-attainment		Non-attainment	Non-attainment	Non-attainment	Non-attainment		Non-attainment	Class C	Non-attainment	Class C
	25	Class C											
	26	Class B											
	90		Class C			Class C		Class C		Class C	Class C	Class C	Class C
	194										Class C	Non-attainment	Class C
	252												Class B
Kennebec River	21					Class B							
	22	Class B											
	23	Class B											
	24	Class C											
	29			Non-attainment		Non-attainment		Non-attainment		Non-attainment			
	32							Class B					
	39	Class C											
	40	Class B											
	165								Class C	Non-attainment			
	168						Class B	Non-attainment		Class A or AA			
	169									Class C			
	174									Non-attainment			
	181									Class B			
	195									Class B			
	196									Class B			
	234			Class C									
	239							Class C					
Messalonski Stream	35	Class B											
	36	Class C											
Mill Stream	254												Class C
Outlet Stream	298												Class C
Sandy River	17	Class A or AA											
	18	Class B											
	19	Class B											Class C
Sebasticook River	27	Class B											
	28	Class C											
	241									Class C			
	299												Class C
	319												Class C
Togus Stream	13	Class B							Class C				
	14	Class B							Class B				
Wilson Stream	33	Class C							Class B				Class B
	34	Class C							Class B				Class B

Major Towns
Significant Point Sources
Significant Dams
Biomonitoring Stations
Lakes and Ponds (Class GPA)
Legal Class - Rivers and Streams*
AA
A
B
C
Lower Kennebec Basin

5 0 5 Kilometers



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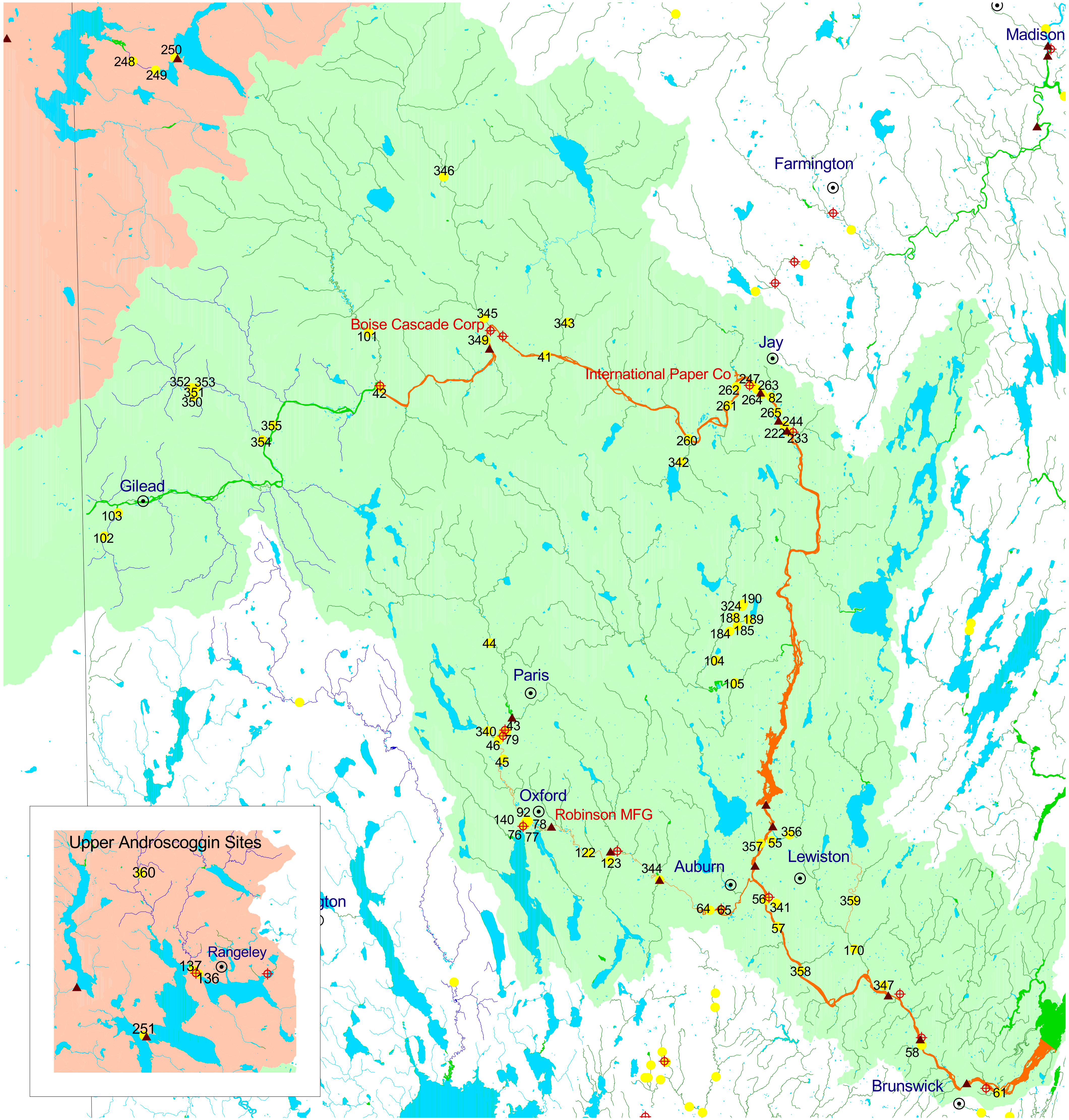
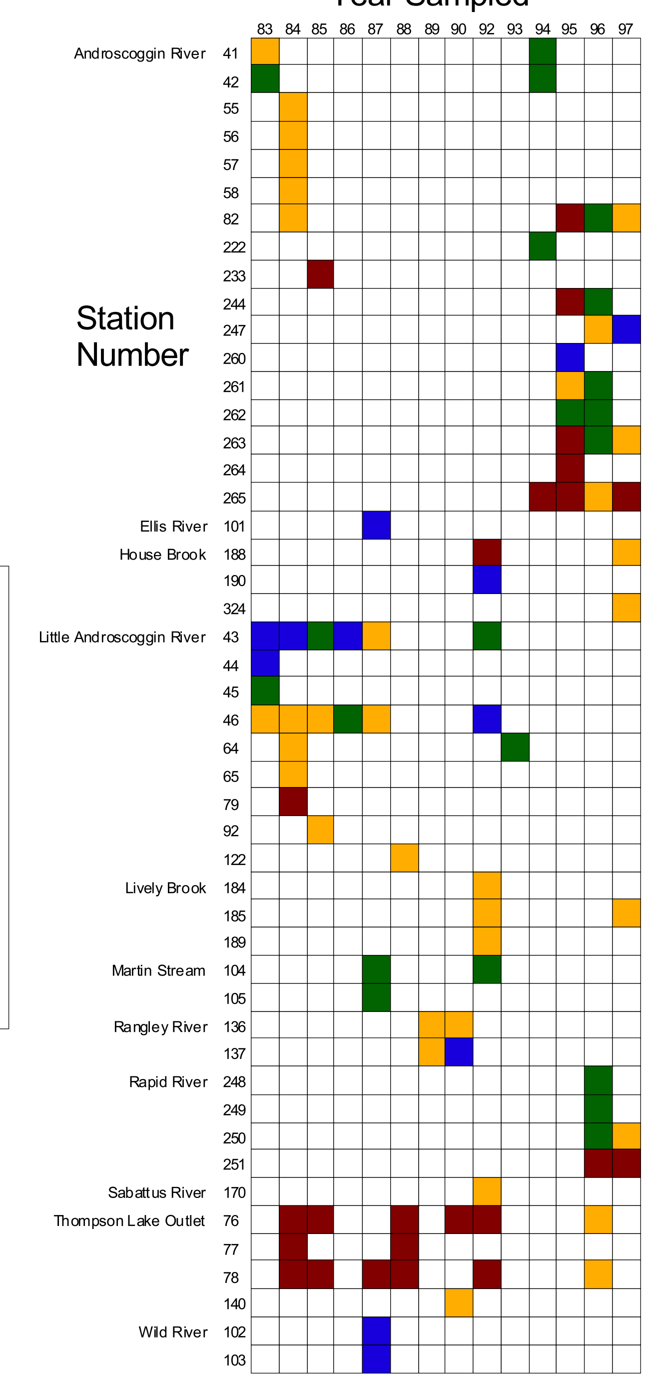
Maine DEP, 1999

* Legal class designations depicted for rivers and streams do not include1999 revisions.

Basin Map 5. Upper and Lower Androscoggin Aquatic Life Criteria Attainment.



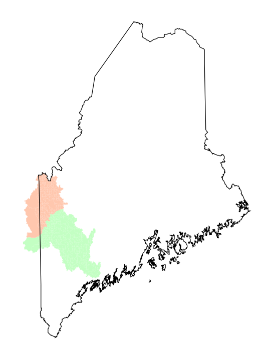
Aquatic Life Model Results



- Class A or AA
- Class B
- Class C
- Non-attainment

- Major Towns
- Significant Dams
- Significant Point Sources
- Biomonitoring Stations
- Lakes and Ponds (Class GPA)
- Legal Class - Rivers and Streams*
  - AA
  - A
  - B
  - C
- Lower Androscoggin Basin
- Upper Androscoggin Basin

5 0 5 Kilometers



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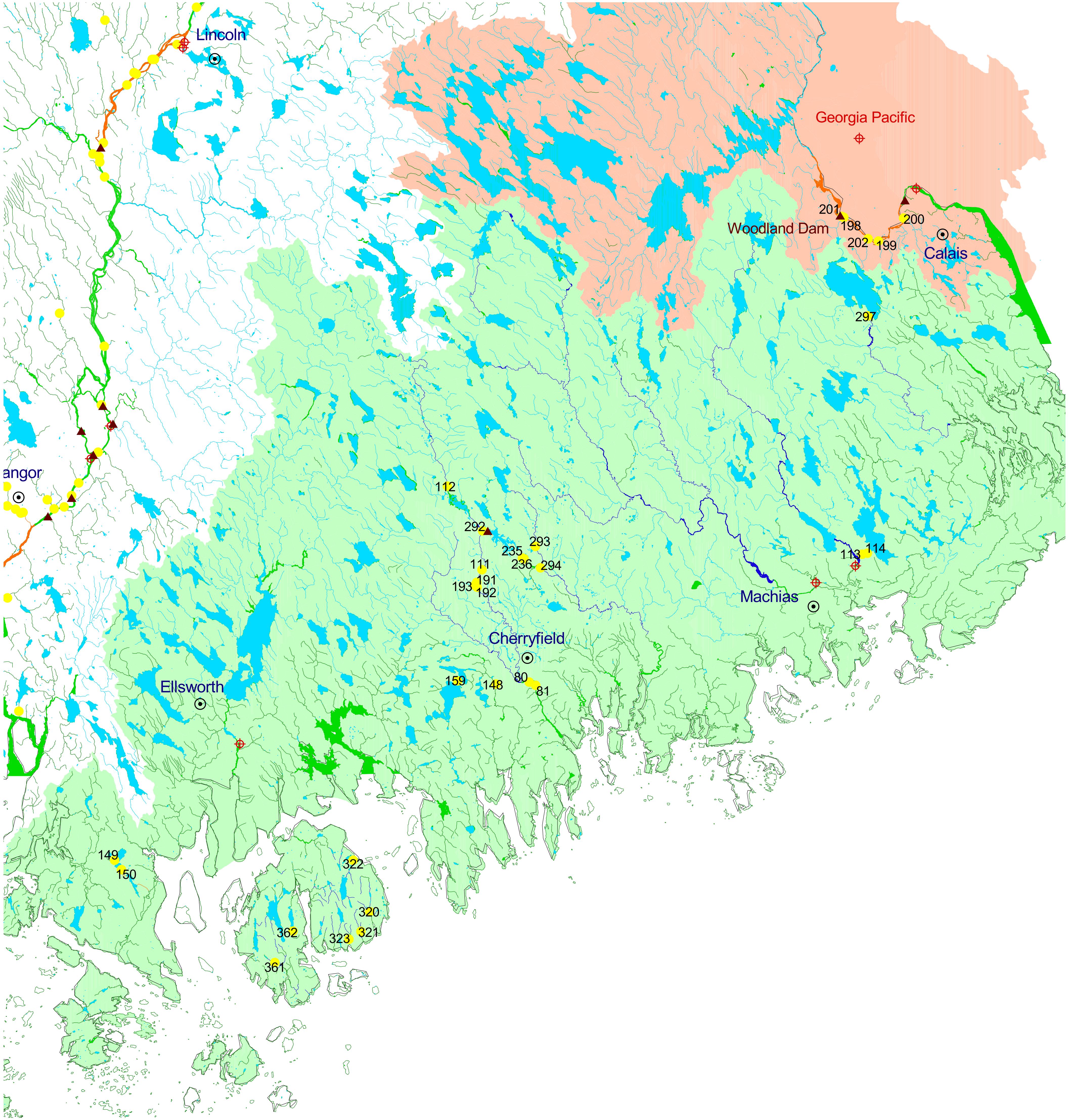
Maine DEP, 1999

* Legal class designations depicted for rivers and streams do not include1999 revisions.

Basin Map 6. St. Croix and North Coastal Aquatic Life Criteria Attainment.



- Major Towns
- Significant Dams
- Significant Point Sources
- Biomonitoring Stations
- Lakes and Ponds (Class GPA)
- Legal Class - Rivers and Streams*
  - AA
  - A
  - B
  - C
- North Coastal Basin
- St. Croix Basin

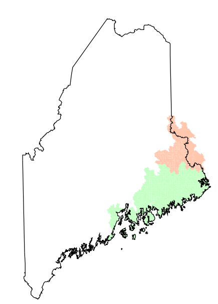
10 0 10 Kilometers

Aquatic Life Model Results

Legend: Class A or AA; Class B; Class C; Non-attainment

Station Number / Year Sampled

Station	Number	84	87	88	89	91	92	93	94	96	97
Bog Brook, Beddington	292									Class B	
Bog Stream, Deblois	235				Non-attainment						
	236				Non-attainment						
Cannon Brook, Mount Desert	320										Class C
Carleton Stream	149					Class A or AA				Class A or AA	
	150					Non-attainment			Class C	Non-attainment	
Dennys River	297										Class C
Duck Brook	322										Class A or AA
East Machias River	113		Class B	Class C	Class C						
	114		Class B	Class B	Class B						
Hunter Brook, Mount Desert	321										Class A or AA
Mccoy Brook	193							Class C			
Narraguagus River	80	Class B						Class B			
	81							Class C			
	111		Class A or AA		Class B					Class B	
	112		Class A or AA								
	191							Class A or AA			
	192							Class A or AA			
St. Croix River	198					Class C					
	199					Class B					Class B
	200					Class B					
	201						Class C				
	202						Class C				
Stanley Brook, Mount Desert	323										Class A or AA
Tunk Stream	148					Class B					
	159					Class A or AA					
Unamed Brook, T18 Md Bpp	294									Non-attainment	



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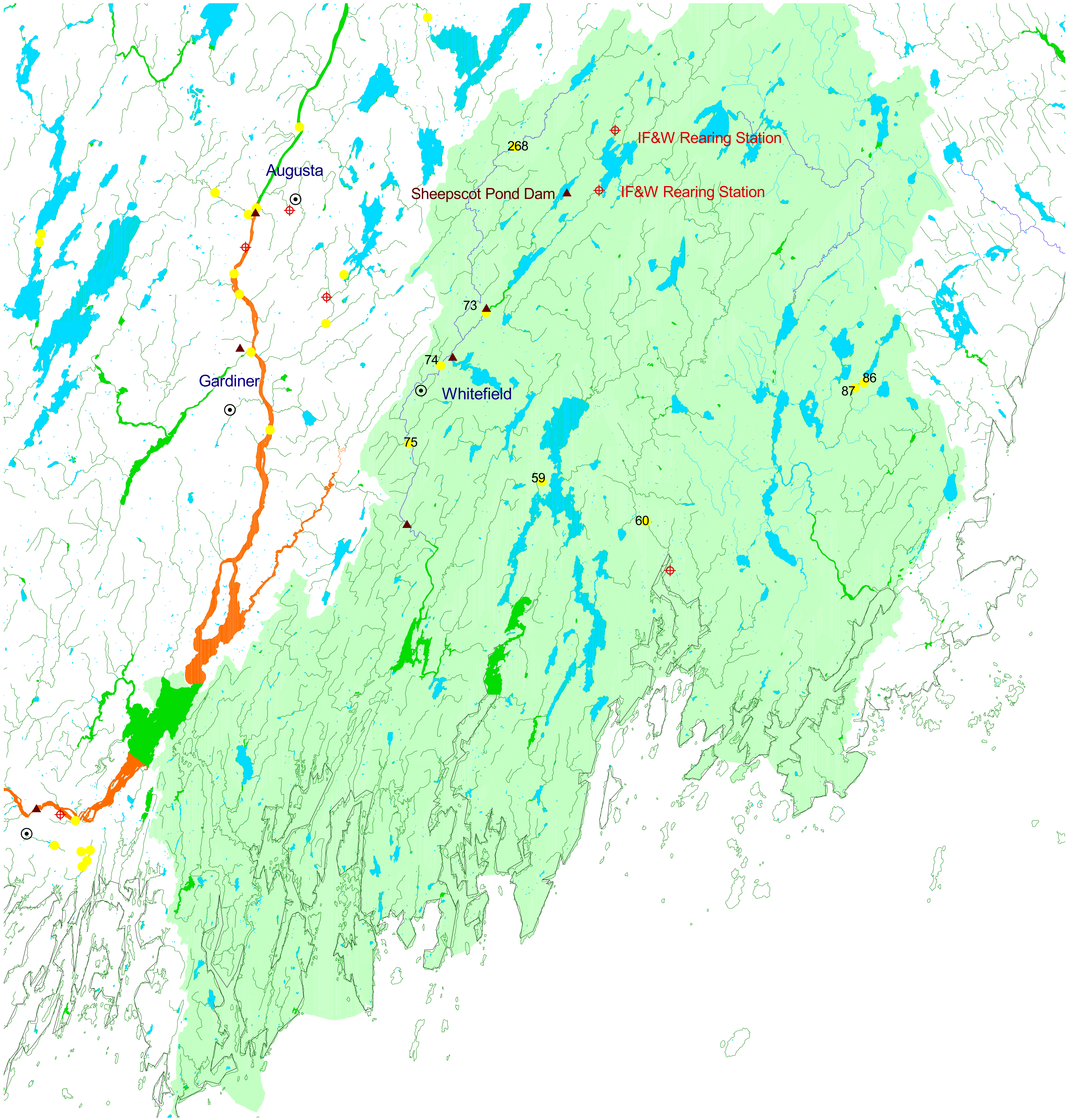
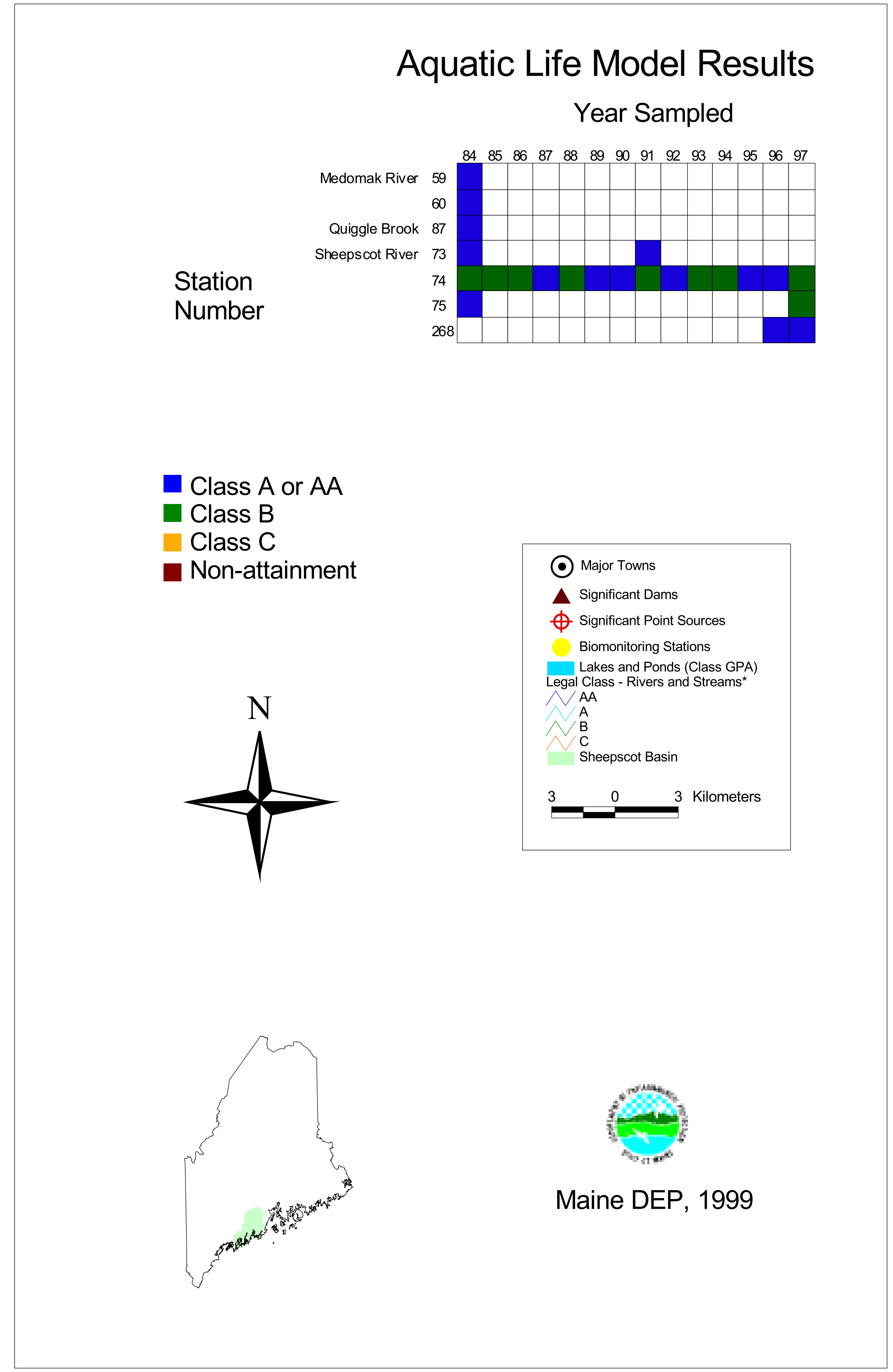
Maine DEP, 1999

* Legal class designations depicted for rivers and streams do not include1999 revisions.

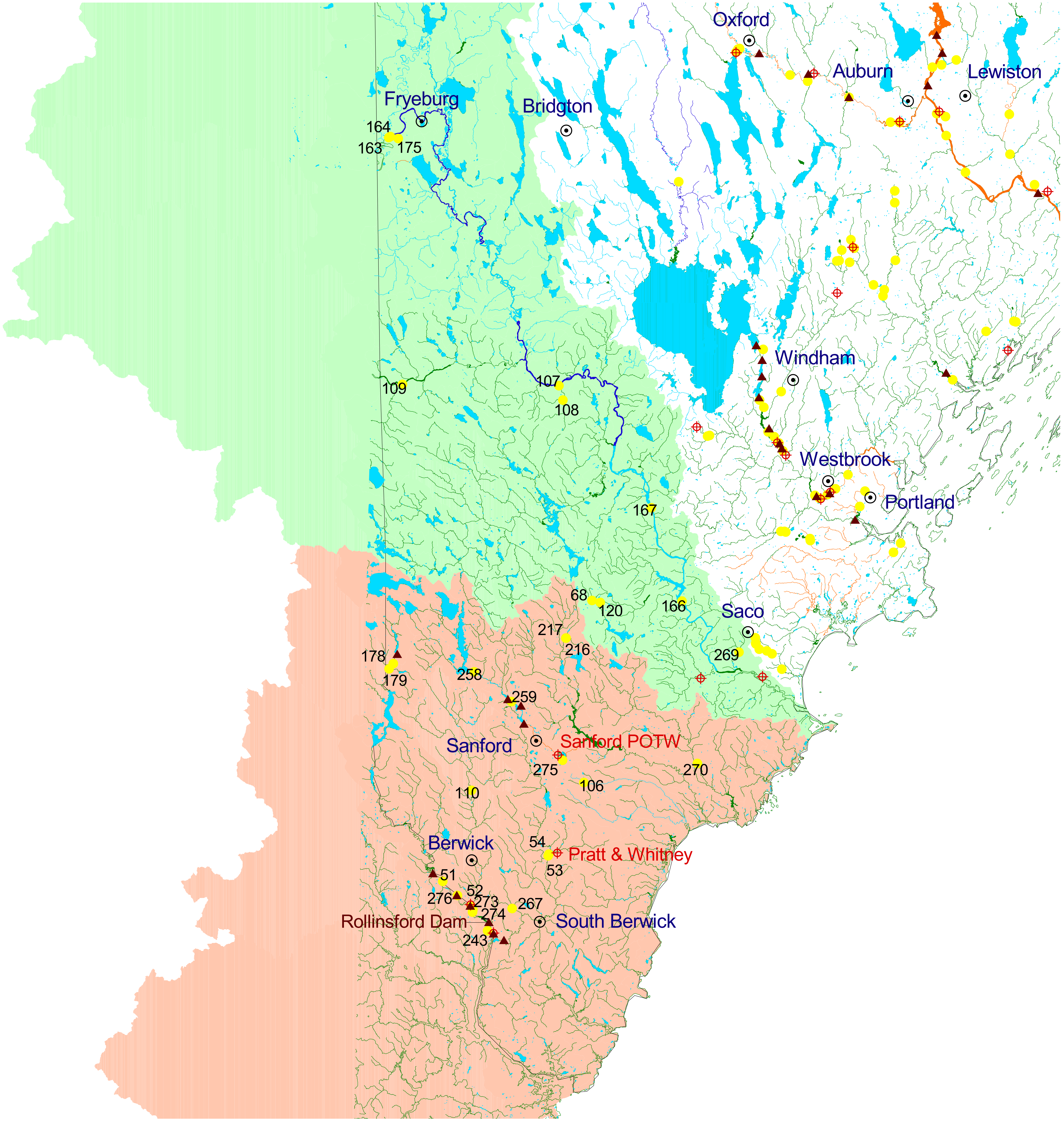
Basin Map 7
Sheepscot Aquatic Life Criteria Attainment





* Legal class designations depicted for rivers and streams do not include1999 revisions.

Basin Map 9
Saco and Piscataqua
Aquatic Life Criteria Attainment.



- Class A or AA
- Class B
- Class C
- Non-attainment

Station Number

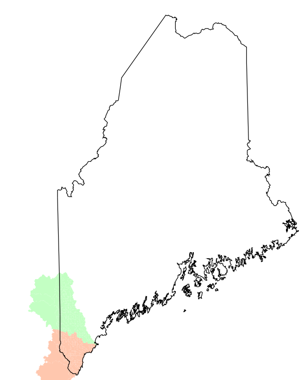
- Major Towns
- Significant Dams
- Significant Point Sources
- Biomonitoring Stations
- Lakes and Ponds (Class GPA)
- Legal Class - Rivers and Streams*
  - AA
  - A
  - B
  - C
- Piscataqua Basin
- Saco Basin

10 0 10
Kilometers

Aquatic Life Model Results

Year Sampled

		84	87	91	92	93	94	95
Adams Brook	267							Class C
Back Brook	107		Class A or AA					
	108		Class A or AA					
Branch Brook	106		Class A or AA					
Carpenter Brook	216						Class C	
	217						Class B	
Cooks Brook	68	Non-attainment	Non-attainment			Class A or AA		Class A or AA
	120		Non-attainment					
Deep Brook	269							Non-attainment
Great Works River	53	Class B						Class C
	54	Class B						Class C
Kennebunk River	270							Class B
Little River	110		Class A or AA					
Mousam River	258							Non-attainment
	259							Class C
	275							Class C
Ossipee River	109		Class B					
Saco River	163			Class A or AA				
	164			Class A or AA				
	166			Non-attainment				
	167			Non-attainment				
	175				Class A or AA			
Salmon Falls River	51	Class C			Class C			Class B
	52			Class C	Class C			Class C
	178				Class A or AA			
	179				Class B			
	243				Class C			
	273							Class C
	274	Class C						Class C



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Maine DEP, 1999

* Legal class designations depicted for rivers and streams do not include 1999 revisions.

APPENDICES

Appendix 1-a

METHODS FOR THE CALCULATION OF INDICES AND MEASURES OF COMMUNITY STRUCTURE USED IN THE ORIGINAL1992 LINEAR DISCRIMINANT MODELS

Variable
Number

1 **Total Abundance**

Count all individuals in all replicate samples from one site and divide by the number of replicates to yield mean number of individuals per sample.

2 **Generic Richness**

Count the number of different genera found in all replicates from one site.

Counting Rules for Generic Richness:

1) A family level identification with less than or equal to one taxon identified to a lower taxonomic level (i.e. one genus or species) will be counted as a separate taxon in Generic Richness counts.

2) A family with more than one taxon identified to a lower taxonomic level will not be counted towards Generic Richness. Counts will be split proportionately among the genera that are present.

3) Higher level taxonomic identifications (Phylum, Class, Order) are not counted toward Generic Richness unless they are the only representative.

4) Pupae are ignored in all calculations.

5) All population counts at the species level will be aggregated to the generic level.

3 **Plecoptera Abundance**

Count all individuals from the order Plecoptera in all replicate samples from one site and divide by the number of replicates to yield mean number of Plecopteran individuals per sample.

4 **Ephemeroptera Abundance**

Count all individuals from the order Ephemeroptera in all replicate samples from one site and divide by the number of replicates to yield mean number of Ephemeropteran individuals per sample.

5 **Shannon-Wiener Generic Diversity (Shannon and Weaver 1963.)**

After adjusting all counts to genus as described under "Counting Rules for Generic Richness":

$$\bar{d} = \frac{c}{N}\left(N \log_{10} N - \sum n_i \log_{10} n_i\right)$$

where: $\bar{d}$ = Shannon-Wiener Diversity
c = 3.321928 (converts base 10 log to base 2)
N = Total Abundance of Individuals
n_i = Total Abundance of Individuals in the i^{th} taxon

6 **Hilsenhoff Biotic Index (Hilsenhoff 1987.)**

$$BI = \sum \frac{n_i a_i}{N}$$

where: BI = Biotic Index
n_i = number of individuals in the i^{th} taxon
a_i = tolerance value assigned to that taxon
N = total number of individuals, with a tolerance value, in sample

7 **Relative Abundance Chironomidae**

Find abundance of Chironomidae (as for abundance of Ephemeroptera) and divide by Total Abundance of individuals.

8 **Relative Richness Diptera**

Count the number of different genera from the order Diptera (follow counting rules for Generic Richness) and divide by Generic Richness.

9 ***Hydropsyche* Abundance**

Count all individuals from the genus *Hydropsyche* in all replicate samples from one site, and divide by the number of replicates to yield mean number of *Hydropsyche* individuals per sample.

11 ***Cheumatopsyche* Abundance**

Count all individuals from the genus *Cheumatopsyche* in all replicate samples from one site and divide by the number of replicates to yield mean number of *Cheumatopsyche* individuals per sample.

12 **EPT Generic Richness Divided by Diptera Richness**

Find EPT Generic Richness (Variable 19) and divide by Diptera Generic Richness.

13 **Relative Abundance Oligochaeta**

Find abundance of Oligochaetes (as for abundance of Ephemeroptera) and divide by Total Abundance of individuals.

15 **Perlidae Abundance (Family Functional Group)**

Count all individuals from the family Perlidae (Appendix 1-c) in all replicate samples from one site and divide by the number of replicates to yield mean number of Perlidae per sample.

16 **Tanypodinae Abundance (Family Functional Group)**

Count all individuals from the subfamily Tanypodinae (Appendix 1-c) in all replicate samples from one site and divide by the number of replicates to yield mean number of Tanypodinae per sample.

17 **Chironomini Abundance (Family Functional Group)**

Count all individuals from the tribe Chironomini (Appendix 1-c) in all replicate samples from one site and divide by the number of replicates to yield mean number of Chironomini per sample.

18 **Relative Abundance Ephemeroptera**

Find abundance of Ephemeroptera (Variable 4) and divide by Total Abundance of individuals.

19 **EPT Generic Richness**

Count the number of different genera from the order Ephemeroptera (E), Plecoptera (P), and Trichoptera (T) (Follow counting rules for Generic Richness, Variable 2).

21 **Summed Abundance's of**: ***Dicrotendipes, Micropsectra, Parachironomus and Helobdella***

Find abundance of the 4 genera (as for abundance of Ephemeroptera Variable 4) and sum them.

23 **Relative Plecoptera Richness**

Find Plecoptera Richness and divide by Generic Richness.

24 **Relative Abundance *Brachycentrus***

Find abundance of *Brachycentrus* (as for Abundance of Ephemeroptera) and divide by Total Abundance of individuals.

25 **Summed Abundance's of: *Cheumatopsyche, Cricotopus, Tanytarsus and Ablabesmyia***

Find abundance of the 4 genera (as for abundance of Ephemeroptera, Variable 4) and sum them.

26 **Summed Abundance's of: *Acroneuria and Stenonema***

Find abundance of the 2 genera (as for the abundance of Ephemeroptera, Variable 4) and sum them.

28 **EP Generic Richness/14**

Sum Ephemeroptera Generic Richness plus Plecoptera Generic Richness and divide by 14 (maximum expected for Class A).

29 **Dominant A Indicator Taxa/5**

Find the 5 most abundant taxa in the community and calculate the proportion that are A indicator taxa as listed in Appendix 1-b

30 **Presence of A Indicator Taxa/7**

Count the number of A indicator taxa, as listed in Appendix 1-b, that are present in the community and divide by 7 (total possible number).

Appendix 1-b

Indicator Taxa: Class A

Brachycentrus (Trichoptera: Brachycentridae)
Serratella (Ephemeroptera: Ephemerellidae)
Leucrocuta (Ephemeroptera: Heptageniidae)
Glossosoma (Trichoptera: Glossosomatidae)
Paragnetina (Plecoptera: Perlidae)
Eurylophella (Ephemeroptera: Ephemerellidae)
Psilotreta (Trichoptera: Odontoceridae)

Appendix 1-c

FAMILY FUNCTIONAL GROUPS

PLECOPTERA

Perlidae

Acroneuria
Attaneuria
Beloneuria
Eccoptura
Perlesta
Perlinella
Neoperla
Paragnetina
Agnetina

CHIRONOMIDAE

Tanypodinae

Ablabesmyia
Clinotanypus
Coelotanypus
Conchapelopia
Djalmabatista
Guttipelopia
Hudsonimyia
Labrundinia
Larsia
Meropelopia
Natarsia
Nilotanypus
Paramerina
Pentaneura
Procladius
Psectrotanypus
Rheopelopia
Tanypus
Telopelopia
Thienemannimyia
Trissopelopia
Zavrelimyia

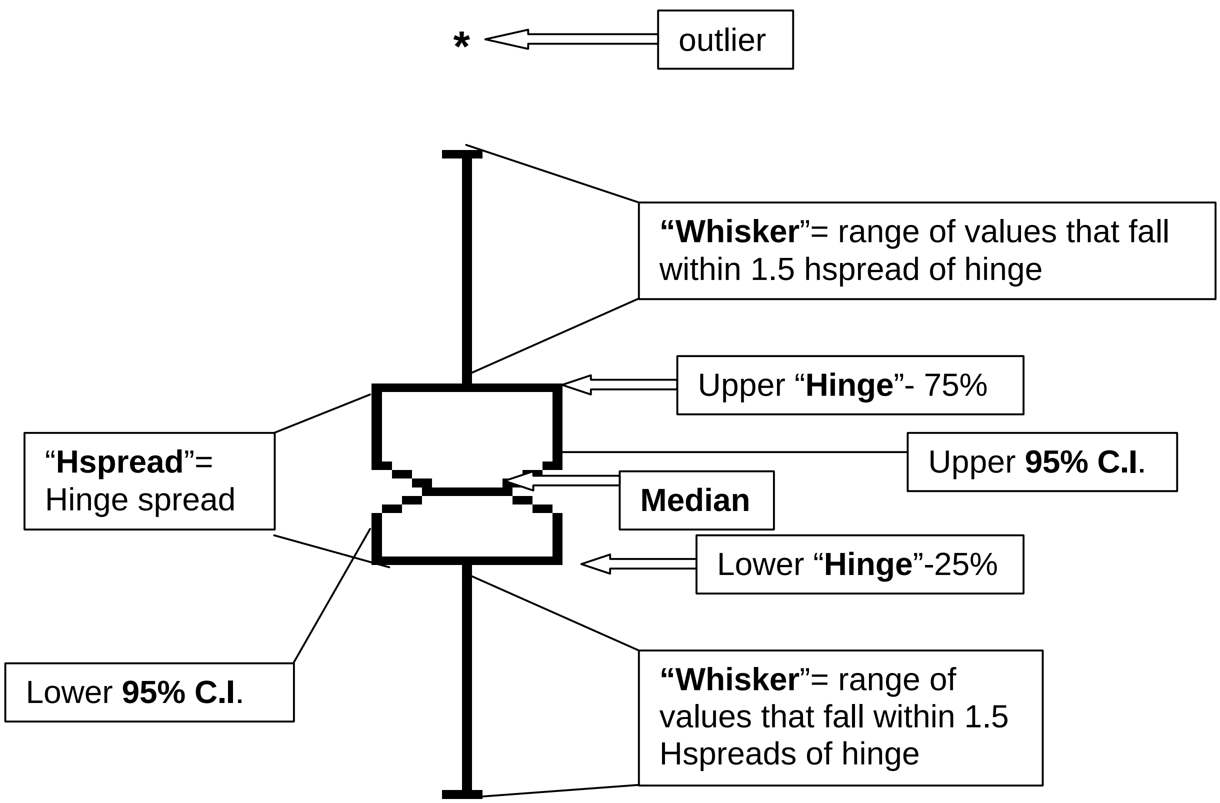
Appendix 1-c

FAMILY FUNCTIONAL GROUP
(continued)

Chironomini

Pseudochironomus
Axarus
Chironomus
Cladopelma
Cryptochironomus
Cryptotendipes
Demicryptochironomus
Dicrotendipes
Einfeldia
Endochironomus
Glyptotendipes
Goeldichironomus
Harnischia
Kiefferulus
Lauterborniella
Microchironomus
Microtendipes
Nilothauma
Pagastiella
Parachironomus
Paracladopelma
Paralauterborniell
Paratendipes
Phaenopsectra
Polypedilum
Robackia
Stelechomyia
Stenochironomus
Stictochironomus
Tribelos
Xenochironomus

Appendix 2 Interpretation of box plot data



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Appendix 4

Division of Environmental Assessment

The Division of Environmental Assessment is responsible for overall monitoring and evaluation of the quality of Maine's surface waters and groundwater.

Director David Courtemanch
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Email: dave.l.courtemanch@state.me.us

Biological Monitoring Program Staff

Program Manager Susan Davies
Phone: (207) 287-7778
Email: susan.p.davies@state.me.us

- **Monitoring and Environmental Indicators Technical Assistance**
- **Program Reporting**
- **Co-ordination with other Programs** (Hydro-power reviews; monitoring effects of Sec. 319 watershed management activities ; biomonitoring component of Surface Water Ambient Toxics program; biological indicators for development of Total Maximum Daily Loads; co-ordinating group lead for Land and Water Bureau management of small streams)
- **Collaboration with National Biocriteria Program Office**, under a co-operative agreement with US EPA Office of Science and Technology, Washington, DC
- **Technical Support for Development of Algal Indicators of River and Stream Condition**, Pilot Project in collaboration with Div. of Watershed Management

Rivers and Streams Sub Section Leader Leon Tsomides
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- **Non-point source impacts to small streams**
- **Hydro-power licensing review and biological impact assessment**
- **Data analysis, data access and data management co-ordinator**
- **Site-specific reporting and technical assistance**
- **Supervision of data management, laboratory and field services staff**

Wetlands Sub Section Leader

Jeanne DiFranco
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- **Development of wetland bioassessment methods**
- **Casco Bay Wetland Prioritization Pilot Project**- technical assistance
- **State Planning Office liason-** technical assistance for wetland assessment activities
- Liason to **US EPA Headquarters Biological Assessment of Wetlands Work Group** (BAWWG) and to EPA New England BAWWG

Leon Tsomides and Susan Davies

Jeanne DiFranco

David Courtemanch

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