Merrimack River Initiative

Watershed Connections

VEMN Guide To Volunteer Watershed Monitoring Options In The Merrimack River Watershed

Final Report

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THE MERRIMACK RIVER INITIATIVE

The Merrimack River Initiative began in 1988 as an agreement between the U.S. Environmental Protection Agency, the State of New Hampshire, the Commonwealth of Massachusetts, and the New England Interstate Water Pollution Control Commission to collaborate on water quality issues. This initiated a dialogue to examine issues and problems in the watershed, thereby resulting in a proposal for funding and further work toward expanding the watershed approach. The watershed approach is different from other water resource planning efforts in several ways. First, the approach is "resource based" using the watershed as the management unit rather than looking at a specific portion of a river, as is usually the case. This allows planners to examine the cumulative impact of all activity in the watershed. Second, it strives to be a holistic approach. It considers issues of surface and groundwater quality and quantity along with human use and natural functions in the watershed. Lastly, it builds partnerships. The Initiative brings together public and private groups, state and federal agencies, industry and environmental groups all with a common goal.

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In The Merrimack River Watershed

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CHAPTER I: INTRODUCTION

This document is intended to provide information that groups monitoring fresh water river and lake systems[1] in the Merrimack River Watershed can use to design a monitoring study that meets their own program goals and which serves the larger watershed community. It is meant to be used with another Volunteer Environmental Monitoring Network (VEMN) guidance document: "Guidelines for Subwatershed Groups On Preparing Scientific Study Designs."

The VEMN "Guidelines" document guides you through the *process* of developing a study design. It explains the steps you go through in deciding why, what, how, where, and when you will monitor, who will carry out the tasks, and what your quality assurance measures will be. For each step, it lists the tasks to be done, where to go to get information, and how to write up your study design.

The document you are reading is intended to provide some of the raw material you will need to do a study design in the Merrimack River watershed. It recommends specific indicators and methods, site location considerations, times of day / year and frequency, data analysis, QA / QC measures, and training needed to answer specific questions and meet specific data quality goals.

Together, these two documents should provide you with everything you need to write a study design.

WHY WRITE A STUDY DESIGN?

A study design describes your monitoring effort and the rationale behind it. We cannot emphasize enough the usefulness of preparing a written study design. It serves some very important purposes to your group and to the people you hope will use your data:

- it forces you to focus on what you are trying to accomplish with your monitoring program,
- it prevents waste of time and money on equipment and procedures that are inappropriate for your group or goals,
- it allows you to select the best monitoring strategy to address the issues that are important to you and your community,
- it allows everyone who might use your data to have confidence in the results since you clearly document your sampling and analysis methods and quality assurance procedures,

[1] Note: This booklet focuses primarily on monitoring that addresses issues and questions relating to fresh inland waters. Estuarine and marine waters are complex systems that differ substantially from fresh water, such that monitoring strategies must be tailored specifically to these waters. Estuarine or marine waters are addressed in this document only insofar as they face issues in common with fresh water, and where the sampling methodology does not greatly differ.

- it prevents changes in personnel in your organization from destroying the continuity of your monitoring plan because anyone can read your study design and pick up where the last person left off, and
- it allows your group to reevaluate your monitoring study every year and make changes as needed.

VEMN MONITORING IN THE MERRIMACK RIVER WATERSHED

Volunteer river and lake monitoring groups have been active in the Merrimack Watershed and throughout New England since the 1970s. State and federal agencies have been monitoring these waters for decades. The Merrimack River Initiative (MRI) began in 1988 to examine the watershed as a whole and identify and promote actions to restore and maintain a water quality / water use balance. One of the initial recommendations of the MRI was to establish a watershed-wide citizen environmental monitoring network to collect information that can be used by state and federal agencies for planning, permitting, and flagging compliance actions.

In 1994, the MRI provided funding to develop a coordinated citizen monitoring effort. This became known as Merrimack River Volunteer Environmental Monitoring Network (VEMN). We established two basic goals for the VEMN:

1) To help volunteer monitoring groups generate information that is highly-valued and used by a broad range of environmental decision-makers, from individual property owners and town boards to state and federal agencies.
2) To help citizen groups maintain and enhance the value of their monitoring programs for their own chosen goals and objectives.

In 1997 the MRI produced a management plan for the watershed.[2] This plan has a number of important recommendations for monitoring in the watershed:

- *Survey and evaluate BMPs [Best Management Practices] currently being implemented in the watershed,*
- *Expand water quality monitoring to focus on non-point source impacts,*
- *Expand water quality monitoring programs to focus on preservation of non-impacted waters, and*
- *Coordinate monitoring efforts.*

This document reflects those recommendations and it provides guidance that will enable volunteer and school monitors to respond to them.

[2] Merrimack River Initiative, 1997. Watershed Connections: Merrimack River Initiative Management Plan, New England Interstate Water Pollution Control Commission, Wilmington MA.

MONITORING QUESTIONS ADDRESSED IN THIS GUIDE

A major goal of the VEMN is to provide information that will be useful to decision-makers at all levels. Working with a Steering Committee and relying, to some extent, on other work being done within the Merrimack River Initiative, we identified the questions of watershed-wide scope that volunteer monitors could help answer:

1) Is the river system supporting its uses and values?
2) What are the impacts of human alterations of the river system on human use and ecological integrity?
3) How effective are site specific and watershed-wide water and land management strategies in restoring and protecting human use and ecological integrity?
4) Are permit conditions effective?
5) Where are problem areas that should be a high priority for remediation?
6) Where are special natural and cultural resources?
7) Are conditions changing?

Each of these questions has a subset of more specific questions that monitoring can be geared to answer. These are listed in the VEMN's "Guidelines for Subwatershed Groups On Preparing Scientific Study Designs."

DATA QUALITY GOALS ADDRESSED IN THIS GUIDE

If you gather information that answers these questions, then who will use it and for what purpose? This is a key consideration in deciding what information needs to be gathered on a watershed-wide level and how rigorous the monitoring must be in order to satisfy the decision-makers. The following Data Quality Goals clarify the uses for the data and how rigorous the monitoring must be in order to satisfy the needs of the users.

- *Meets legal, regulatory and scientific peer review requirements.* This is the most rigorous level of monitoring. It provides data that can be used in court cases, regulatory proceedings, or reporting research results in scientific journals. Meeting this goal will require that monitors document a high degree of precision, accuracy, and sensitivity in their methods and that they undertake a rigorous quality control program.

- *Meets evaluation and assessment requirements of state and federal agencies.* Data in this category may be used in State Water Quality Assessments (305(b) reports) to determine if water quality standards are being met, evaluate effectiveness of pollution control programs and projects, and other water quality planning activities. Meeting this goal will require that monitors use methods and quality control measures that are similar to those of state and federal agencies.

- *Meets requirements for evaluation, assessment, and management at the community or watershed level.* Town boards, landowners, the public, regional planning agencies, and other organizations and agencies may use this data in their resource management decisions. Methods may be geared toward identifying gross pollution problems, rather than detecting subtle trends or deviations from water quality standards.

- *Data quality sufficient to increase awareness and knowledge of resource values and conditions.* These relatively simple and low cost programs can help groups and the general public better understand how watersheds function, the condition of a local water body, and how human activities can affect watershed health. These programs do not require rigorous sampling and analysis methods, but should follow sound scientific principles of investigation.

Each of these data quality goals has a subset of more specific users and uses of the data. These are listed in the VEMN's "Guidelines for Subwatershed Groups On Preparing Scientific Study Designs."

THE VEMN MONITORING APPROACH

Given the belief that data from monitoring at any level of rigor will be useful to someone, it was decided that a single watershed-wide monitoring protocol (indicators and methods) that all groups in the watershed could follow would be neither useful nor practical. Rather, we decided to provide a menu of options that address the question at various levels of rigor. Rather than dictating to groups what they must monitor, the VEMN recommends various approaches which are clearly connected to data uses and goals so that groups can decide the level of rigor appropriate to their goals and resources. It will also be clear who will and will not use their data. This will hopefully avoid unrealistic expectations and confusion on the part of the monitors and the decision-makers. However, we do suggest a core monitoring survey be carried out by all groups.

Monitoring Surveys Covered In this Guide

This document is a menu which includes both "core monitoring surveys" which we hope will be carried out by all groups in the watershed, and a set of "optional surveys" geared to the issues, questions, goals, and resources of groups in tributary watersheds or on specific water bodies.

The core monitoring surveys are:

A. **Preliminary Watershed Assessment -** a visual survey and evaluation of some basic watershed characteristics to help identify issues, watershed uses and values, and problem areas to guide field monitoring activities.

B. **Water Contact Health Risk Assessment -** a combination of water sampling for contaminants of concern and data gathering on exposure to contaminants and actual disease occurrence to see if there's a relationship between water quality, exposure, and illness.

C. **Water Quality Standards Assessment** - water sampling and analysis of river or lake water quality indicators that the states of Massachusetts and New Hampshire use to determine how well our waters comply with state standards for their designated uses.

The optional surveys are:

D. **Baseline Monitoring: Rivers and Lakes -** collection of information by various activities about some of the basic physical, chemical and biological conditions. This information is used as a "baseline" or benchmark against which to assess future changes. There are six surveys described that cover rigorous and basic monitoring of wadeable and non-wadeable rivers and lakes. These involve collecting and analyzing water and aquatic life samples, assessing habitat conditions and channel shape, and gathering visual information.

E. **Wastewater Treatment Plant Impact Assessment -** collection of information by various activities about the impact of a wastewater treatment plant on the river's ecological health and human use. There are two surveys described that cover rigorous and basic monitoring of rivers.

F. **Non-point Source Impact Assessment -** collection of information about the impact of runoff from a non-point pollution source on the river's ecological health and human use. There are two surveys described that cover rigorous and basic monitoring of wadeable rivers.

G. **Non-point Source Site Evaluation -** a systematic approach for trained volunteers to visually evaluate the seriousness of non-point source pollution. This evaluation takes place at a particular site and focuses on the production, transport, and control of runoff on the site.

H. **Stormwater Discharge Monitoring -** focuses on locating pipes that discharge stormwater (as opposed to sanitary wastewater) and sampling the effluent coming out of those pipes during dry and wet weather to determine its quality and potential to affect rivers and lakes.

I. **Wastewater Compliance Survey -** the review of discharge monitoring reports to determine whether the discharge complies with the NPDES permit.

Monitoring groups that are interested in optional surveys should undertake an intensive study design process with VEMN staff and partners. This process will help the group select water quality indicators, data quality objectives and requirements, sampling and analytical methods, sampling sites, sampling frequency and times, and quality assurance / quality control measures that match one of the four data quality levels.

HOW TO USE THIS DOCUMENT

Use this document as a source of raw material for your study design if your interests match the questions and data quality goals listed in one of the recommended surveys.

Chapter II briefly describes the study design process. Each step is listed and how the information provided in this guide can help. Detailed guidance is contained in the "Guidelines for Subwatershed Groups On Preparing Scientific Study Designs" available from the VEMN.

Chapter III lists the options for volunteer monitoring in the Merrimack River Watershed and recommends specific sampling procedures. This chapter will be your primary source of information regarding indicators, methods, frequency, and time of day / year for your monitoring effort.

Chapter IV describes the quality assurance / quality control measures you should consider for water and benthic macroinvertebrate sampling and analysis.

Chapter V describes the complementary services that the VEMN provides along with this manual.

Appendix 1 contains general information about watershed indicators and methods. It describes each indicator recommended in the guide and briefly describes the methods for each.

Appendix 2 describes water quality standards in general and those that apply to the Merrimack River Watershed.

We recommend that people who are planning or currently coordinating a monitoring program read all of Chapters II and III. Then consult with the VEMN support team for additional help in writing or updating their own study design, using the Study Design Workbook.

By using this guidance and developing a study design, monitoring groups will learn more about their own programs, find wider audiences for their information, and receive the satisfaction of seeing their work and results affect the management decisions that affect their water bodies.

CHAPTER II: AN OVERVIEW OF THE STUDY DESIGN PROCESS

Designing a river or lake monitoring study is a straight-forward process. This process typically consists of 9 steps. Each of these steps is described briefly below.

STEP 1: GETTING STARTED -- ORGANIZE A TECHNICAL COMMITTEE

Form a technical committee of people who can provide you with advice and assistance in preparing your study design. Several options are presented in this guide. Your technical committee can help you make the choices.

STEP 2: WHY ARE YOU MONITORING?

The next step in your study design is to define the questions you would like to answer by monitoring. Why are you monitoring? What specific water-related questions are you trying to answer? Questions addressed by each of the surveys in this guide are listed in Chapter III.

STEP 3: WHAT WILL YOU MONITOR?

The Merrimack River Watershed is a very complicated system of inter-related physical, chemical, and biological characteristics. The characteristics that are measurable are often referred to as "indicators.[3]" Which indicators you choose to monitor will depend upon the question(s) you are asking as well as your available human and financial resources.

Things To Consider In Selecting Indicators:

Scientific Considerations:

- Does it help answer your question?
- Can you measure and quantify it?
- Does it respond to changes over a reasonable time period?
- Does it respond to the impacts you're evaluating?
- Can you isolate the conditions that cause it to change?
- Does it integrate effects over time and space?
- Does it respond to changes in other indicators?
- Is it a true measure of an environmental condition?
- Is there a benchmark or reference condition against which it can be evaluated?

[3] The Intergovernmental Task Force on Monitoring Water Quality (ITFM) defines "environmental indicator" as follows: "A measurable feature which singly or in combination provides managerially and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality." ITFM, 1993 Report, Technical Appendixes, Appendix A.

- Does it provide early warning of changes?

Practical and Program Considerations:

- Do you have the human and financial resources to measure it?
- How difficult is it to monitor?
- Does it help you understand a major component of the ecosystem?
- Is it understandable/explainable to your target audience?

Some indicators, such as heavy metals and many complex chemical contaminants such as pesticides, are not recommended for volunteer monitoring since they are difficult to sample and require expensive and sophisticated laboratory equipment and procedures to analyze.

Chapter III lists a menu of indicators appropriate for each survey.

STEP 4: WHAT ARE YOUR DATA QUALITY GOALS?

Who is expected to use your monitoring information? How will they use it? How accurate does your information need to be? These are expressed in terms of data quality goals, or your general intentions and hopes for use of your data. They are listed for each survey. The one(s) that the survey addresses are checked.

STEP 5: HOW WILL YOU MONITOR?

Determining how you will monitor involves making choices as to the appropriate monitoring approach, as well as the specific field and lab methods that you will use.

Things To Consider In Selecting Methods:

Scientific Considerations:

- Does it meet your data quality requirements?
  - How accurate is it?
  - How precise (reproducible) is it?
  - How sensitive is it?
- Will it measure the indicator in the range that you need?
- What lab facilities are required?
- What equipment is required?
- Does it yield samples that are representative?
- Is it comparable to methods used by agencies collecting similar information?

Practical and Program Considerations:

- Do you have the human and financial resources to do it?
- How difficult is it?

- How time-consuming is it?
- Will it produce data useful to the target audience?

This guide lists examples of acceptable analytical methods for each water quality indicator for each survey.

STEP 6: WHERE WILL YOU MONITOR?

Sampling locations are selected to answer your question(s). This guide lists site selection criteria for each survey.

STEP 7: WHEN WILL YOU MONITOR?

Next, you will put together your sampling schedule. Since the time of day, holding frequency, and time of year sampled greatly affect your results, consider these when you establish the sampling schedule. This guide suggests the frequency, time of day and year in, and weather conditions for each survey.

STEP 8: WHO WILL MONITOR?

Who is going to collect and analyze the samples? How are volunteers going to be trained? Who will coordinate their activities?

Make a list of all the tasks that need to be done and identify someone to be in charge of each task. Some examples of the necessary jobs are volunteer coordinator, field monitor, lab analyst, lab coordinator, sampling team leader, data manager, quality assurance supervisor, etc.

STEP 9: WHAT ARE YOUR QUALITY ASSURANCE MEASURES?

Quality Assurance (QA) measures are the operating procedures used to assure and assess the quality of the information you collect. QA is assures that the information you collect meets your data quality goals as described in Step 4. This guide suggests quality assurance measures for each indicator for each survey.

A FINAL WORD ABOUT STUDY DESIGN – PUT IT IN WRITING AND EVALUATE IT ANNUALLY

When you've answered the above why, what, how, where, when, and who questions, it's very important to organize and write down the answers in a study design document. This is your program's basic reference document. You will need to re-evaluate and, if necessary, rework your study design annually, considering the results of your previous year's work.

The study design process may seem like a lot of work. However, time spent on designing the study can ultimately save you and your volunteers many hours of wasted effort and frustration by assuring that your monitoring matches your goals and resources.

CHAPTER III. VOLUNTEER WATERSHED MONITORING OPTIONS

Introduction

In the following sections, we have assembled "packages" of indicators and monitoring tools, methods, site selection / timing and frequency guidance , and training required to address specific monitoring questions and data quality goals described in the previous chapter. From this point on, we'll refer to these as "surveys." These surveys are included in this guide because documentation (manuals) exists and training is available.

This guide contains the following surveys:

- A. Preliminary Watershed Assessment
- B. Water Contact Health Risk Assessment
- C. Water Quality Standards Assessment
- D. Baseline Monitoring: Rivers and Lakes
  - D1. Rigorous Baseline Monitoring: Wadeable Rivers
  - D2. Rigorous Baseline Monitoring: Non-Wadeable Rivers
  - D3. Basic Baseline Monitoring: Wadeable Rivers
  - D4. Basic Baseline Monitoring: Non-Wadeable Rivers
  - D5. Rigorous Baseline Monitoring: Lakes
  - D6. Basic Baseline Monitoring: Lakes
- E. Wastewater Treatment Plant Impact Assessment
  - F1. Rigorous Wastewater Treatment Plant Impact Assessment
  - F2. Basic Wastewater Treatment Plant Impact Assessment
- F. Non-Point Source Pollution Impact Assessment
  - F1. Rigorous Non-Point Source Pollution Impact Assessment
  - F2. Basic Non-Point Source Pollution Impact Assessment
- G. NPS Site Evaluation
- H. Stormwater Discharge Monitoring
- I. Wastewater Compliance Survey

These surveys are described in the rest of this chapter. For each survey, we describe the following:

WHAT IS IT?

This contains a basic description of the survey and the type of monitoring activities that are included.

Why Do This Survey?

This section explains why a group should consider undertaking this survey: its purposes, the questions it answers, and what the data is used for.

PRIMARY DATA QUALITY GOALS ADDRESSED

This section lists the data quality goals that are addressed by this survey. These data quality goals are listed as follows:

- ☐ Education, awareness, and problem screening
- ☐ Community & watershed level evaluation, assessment, and management
- ☐ State, interstate, and Federal water quality evaluation and assessment

If this survey addresses the goal, a check appears in the box preceding it, like this: ☑. These goals are discussed in Chapter 1.

MONITORING OPTIONS

This section consists mainly of a table which lists the indicators/tools, analytical methods, and types of sites that could be involved in the survey.

Menu of Indicators/Tools: This column lists either indicators (for example, bacteria) or tools (for example, a habitat assessment) that would be appropriate for this survey. You will likely not do all of these. This is a menu from which you (with the advice of your technical committee would select indicators/tools that address specific pollution types and sources, your organization’s resources, and the nature of your receiving waters.

Examples of Methods (Source): This column lists examples of methods that are appropriate for each indicator/tool in order to meet the data quality goals of the survey. The table does not list all the appropriate methods. In most cases, there are a number of methods that are appropriate. We list the examples as a reference point -- we know the methods listed will meet the stated data quality goals. Equivalent methods are certainly acceptable, if the people or organizations that you expect to use your data approve.

Site Location Considerations: This column lists things to consider or types of sites that will help you locate your specific sampling sites. Site selection is discussed in detail in the VEMN “Guidelines for Subwatershed Groups On Preparing Scientific Study Designs.”

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

This section describes how to figure out a monitoring schedule for each type of activity in the survey. For this, you need to consider the time of year, frequency, time of day, and weather conditions:

Times of Year: Aquatic ecosystems change with the seasons. Water flows, temperatures, chemistry, food sources, and the level of biological activity all vary with seasonal cycles. So, in the ideal study, you would sample during all seasons to determine how your ecosystem varies. However, this is not practical, nor necessary, for most volunteer programs. Consider sampling during critical periods when the ecosystem is under the most stress and perhaps during periods when they are under least stress, as a benchmark. Consult with your technical committee to determine critical and benchmark sampling periods for your program.

Times of Day: Certain indicators, like dissolved oxygen and pH vary according to the time of day. In order to understand this daily variability, you may have to sample these indicators at different times of the day, perhaps even hourly over several 24-hour periods. For others, like benthic macroinvertebrates, the time of day is not important. Consult with your technical committee to determine which indicators should be sampled to determine daily variability.

Frequency: For each of the different conditions described above, you should sample as often as practical for as many years as possible. There are statistical methods to help you determine how many samples from a given area you should collect to be able to quantify the relationships among the different indicators you are monitoring. But these are beyond the scope of this guide. Consult with your technical committee, or a water quality professional who knows these statistical methods to help you determine how frequently you should monitor.

Weather Conditions: Weather affects aquatic ecosystems in profound ways -- some reduce stress and some cause stress. Since weather varies with the season, see the preceding section for the general considerations. Within seasons, however, consider sampling a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc. Since weather can occur without much warning, sampling to capture different weather events is challenging. However, you can learn a lot about how your river or lake responds to these changes.

The schedule for different activities will vary. For example, water sampling and analysis usually happens much more frequently than benthic macroinvertebrate sampling. So, the considerations listed above are addressed for each type of monitoring activity.

DATA ANALYSIS

This section describes, in very general terms, how the data are analyzed -- what they are compared with to answer the questions addressed by the survey. Detailed guidance is contained in the VEMN guidance document: “How To Interpret Monitoring Data.”

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

There is a whole chapter (IV) on quality assurance and quality control in this guide. This section highlights QA / QC considerations specific to the survey.

TRAINING REQUIRED

This section describes the field sampling and lab analysis training required to undertake each survey. In most cases, a VEMN partner should be involved in the initial training. Chapter V lists where to get this type of assistance.

A. PRELIMINARY WATERSHED ASSESSMENT

WHAT IS IT?

A Preliminary Watershed Assessment is the collection of new and existing information on conditions and processes at the watershed level. This information can be used to identify problem areas for corrective action; to decide on whether, where, and what type of monitoring is needed; and to bolster watershed awareness at all levels, from the individual landowner to state and federal permits.

A *preliminary watershed assessment* is the first step in a comprehensive watershed assessment[4] program. It has two parts:

1) *Research:* a compilation of existing information from reports and interviews, and
2) *Field Surveys:* easily-gathered visual observations on various watershed characteristics, conditions, and activities.

WHY DO A PRELIMINARY WATERSHED ASSESSMENT?

We suggest the preliminary watershed assessment as a starting point in your monitoring program. It enables you to get to know your watershed and determine which areas or issues you'll focus on for future monitoring. It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

The main purposes for a preliminary watershed assessment are

- to identify watershed improvement and protection actions,
- to identify existing recreational and other uses,
- to help you decide whether or not to carry out a comprehensive watershed assessment or another intensive type of monitoring, and
- to help you decide those characteristics and areas that are most important for further monitoring.

Questions Answered

The preliminary watershed assessment helps answer two of the VEMN's basic questions:

1) *Where are problem areas that should be a high priority for remediation?*

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[4] *Comprehensive watershed assessment* includes gathering new information through extensive field monitoring of the physical, chemical and biological characteristics of the water column, river channel or lake basin, shoreline, corridor and upland areas.

2) *Where are the special natural and cultural resources?*
3) *Where are recreational and other river uses occurring?*

Data Use

The answers can be used for several things:

- Identify areas where data that are needed to make management decisions are lacking,
- Identify problems and conflicts which need to be resolved by some management decision,
- Identify special areas in need of protection,
- Plan and implement specific projects to address problems identified in the assessment, and
- Provide an educational and awareness-building experience for participants by getting to know their watershed and its important characteristics.

The preliminary watershed assessment also prepares your group for monitoring by identifying issues, characteristics, conditions, processes, human activities, and problem areas that you might wish to monitor. You can then design a program to monitor the selected characteristics that are most important to your watershed, thereby maximizing your group's financial and time resources.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

The Preliminary Watershed Assessment is a process of narrowing down the geographic and topical scope of your efforts through research and then focusing on a specific reach or area of the watershed that includes the uses, values and threats that you wish to assess in the field through a visual survey.

Instructions for carrying out a preliminary watershed assessment are contained in the VEMN Training Manual.[5]

Monitoring options are listed in the following table.

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
1) Research existing information Literature search →	Review existing reports and plans	• Sites that contain problem areas which might be a high priority for some corrective action.
• Uses, values, and threats exercise →	Meeting participants locate uses, values, and threats on a map (River Watch Network)	• Sites that contain special resource areas.
2) Field survey of river, riparian, and watershed characteristics, uses, values, and threats →	Windshield Watershed Survey (Massachusetts Water Watch Partnership Manual) Shoreline Survey for Volunteers (Massachusetts Riverways Programs Adopt-A-Stream Manual) River Walk (River Watch Network "River Walk" form) Watershed Non-point Source Evaluation and Site Assessment (UNH Cooperative Extension "Following the Flow" manual)	• Sites that contain threats to human and aquatic life uses of the water.

ADDITIONAL NOTES ON THE METHODS ARE CONTAINED IN APPENDIX 1.

[5] *Training Manual for Core VEMN Monitoring Parameters and Methods*, available from the Merrimack River Watershed Council,

HOW FREQUENTLY AND WHEN SHOULD YOU CARRY OUT FIELD SURVEYS?

Field surveys should be carried out at least once per year, to track long term changes and trends. Depending on your questions, you may wish to carry them out more frequently, perhaps seasonally or during large runoff events. For example, if your main concern is polluted runoff from agricultural land, you may wish to conduct your field surveys during or immediately after a period of heavy runoff to get a sense of how the characteristics you are surveying change in response. See the Non-point Source Pollution Impact Assessment for further information on monitoring runoff events.

DATA ANALYSIS

The results of the Preliminary Watershed Assessment are a set of qualitative observations. These observations should be mapped in order to reveal and present problem areas for action.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

A preliminary watershed assessment does not require complex QA/QC, since its purpose is primarily problem screening and education and awareness. However, some of the general QA/QC for sampling and analysis and general quality assurance measures for data management in Chapter IV should be reviewed. In addition, photo and/or video documentation of the sites is recommended to serve as visual documentation of problems and processes as well as to provide a tool to train surveyors.

TRAINING REQUIRED

Surveyors should initially be trained by the organization or agency that developed the survey (e.g. MA Riverways for the Adopt a Stream Shoreline Survey) or a designated VEMN partner. At or following the training, surveyors should be observed in the field, gathering data, to assure that they are following procedures correctly. Follow up field audits can also help catch problems which may develop. New surveyors should be trained by the program coordinator or by an experienced surveyor.

B. WATER QUALITY STANDARDS ASSESSMENT

WHAT IS IT?

A water quality standards assessment involves water sampling and analysis for water quality indicators used by the states of Massachusetts and New Hampshire use to determine whether these waters support their *designated uses*. These are uses of the water -- such as swimming, public water supply, fishing, aquatic life habitat, irrigation, and industrial processing and cooling -- that are to be achieved and protected. The water quality standards list *water quality criteria* for each indicator. These criteria specify minimum or maximum levels or ranges necessary to support the designated uses. The information gathered in a water quality standards assessment is used by the states and the US EPA in their biennial reports to Congress which describe the condition of the state's waters relative to the Clean Water Act. This is used for a variety of water resources planning purposes.

The VEMN Water Quality Standards Assessment includes river and lake water sampling and analysis for selected indicators contained in the criteria in the water quality standards. The indicators selected are those that we consider appropriate for volunteer monitors (these indicators are listed in the table in the "Monitoring Options" section). The results are then compared with the criteria for each indicator listed in the MA and/or NH Water Quality Standards.

WHY DO A WATER QUALITY STANDARDS ASSESSMENT?

We suggest that you undertake a Water Quality Standards Assessment if your primary interest is whether your river supports its legally designated uses and values and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

The main purpose for doing a water quality standards assessment is to provide additional data that Massachusetts and New Hampshire can use to assess whether the surface waters in the watershed meet their water quality standards. This assessment is reported in "305(b) reports." This is important because these reports help the states and EPA determine how to allocate their pollution control resources to achieve and protect the human and aquatic life uses of our waters.

Other purposes include:

- to identify problem areas, and
- to identify watershed improvement and protection actions.

Questions Answered

The water quality standards assessment helps answer one of the VEMN's basic questions:

1) *Does the water meet MA and NH Water Quality Standards?*

Data Use

The answers can be used for several things:

- Identify areas where action is needed to enable the water body to support its designated uses,
- Identify problems and conflicts which need to be resolved by some management decision,
- Identify high quality waters which may receive special protection as "outstanding resource waters" or under the "anti-degradation" provisions of the water quality standards,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☑ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

A Water Quality Standards Assessment is done by collecting water samples (or direct field measurements) and analyzing those samples for the indicators contained in the water quality standards. Instructions for collecting and analyzing water samples for the indicators listed above are described detail in the VEMN Training Manual. Following is a table of the monitoring options for the water quality standards assessment.

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
E. coli Bacteria (NH)	Membrane filtration w / mTEC *with* confirmation (EPA# 1103.1 or equivalent)	• Designated beaches and areas designated for swimming, wading, diving, and water skiing.
Fecal Coliform Bacteria (MA)	Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent)	• Informal swimming, wading, diving, and water skiing areas.
Dissolved Oxygen	**1)** Modified Winkler Titration with a buret, syringe, or digital titrator (SM #4500-OG or equivalent) *Rivers*: surface sample *Lakes*: sample at various depths **2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent)** ***Rivers:* measure at surface** ***Lakes:* measure at various depths**	• Boat launch ramps and fishing access areas. • Cold and Warm water fish habitat areas (spawning, nursery, and resting sites). • Near water supply intakes. • Where possible, sites historically monitored by the NH DES or MA DEP. • Sites which are representative of the part of the river of interest.
Turbidity (rivers)	Sample collected and measured with a nephelometer (SM #2130 or equivalent)	• Sites which are safely accessible.
Secchi Transparency (lakes)	Transparency depth measurement using a secchi disk (MassWWP or UNH CE Method)	• Sites where the main river current is accessible -- where the water is thoroughly mixed.
Temperature	Direct measurement with a thermometer, thermocouple, or	• Deepest part of the main lake or significant arm or bay.

	thermistor	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
pH	**1)** Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) **2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)**	**See previous page.**

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

For a water quality standards assessment, you should conduct enough sampling events at the right time of year to relate your results to attaining designated uses. That means that the number sampling events and when they occur depend on the uses you are assessing. The two primary uses that the standards address is water contact recreation and fisheries. Here are some considerations for determining the frequency and timing of your sampling.

1) Sample during the times of year when the designated uses are occurring. For water contact recreational use, that means the warm summer months. For fishing, there is a longer season that spans mid-spring through mid-fall.
2) For water contact recreation, sample for bacteria at least three times over a 60-day period to enable the calculation of a geometric mean consistent with the NH water quality criterion. Sampling frequency and time of year depends on the spawning and life cycle of the target type of fish.
3) For assessing dissolved oxygen suitability for fish, be sure to sample during the stressful low flow, high temperature periods in the summer. Also be sure to sample early in the morning in order to sample theoretical low oxygen levels.[6]
4) Consider daily variations in each indicator. For example dissolved oxygen and temperature are both typically lowest at sunup and highest in mid-day.

[6] The lowest DO levels are typically at sunup, due to the lack of oxygenation from plants at night.

Critical (low) levels of DO for fish will likely occur in the early morning. Critical (high) temperature levels for fish will likely occur in mid-afternoon. So, your sampling schedule might be different for some indicators.

5) Consider the maximum time the sample can be held for each test as well as how much time your lab needs to do the analysis. For example, the maximum holding time for *E. coli* bacteria is 6 hours in a container with ice. If the sample cannot be analyzed within this time frame, the results won't be valid. That means that for a time consuming indicator like bacteria, samples should be collected in the morning and transported to the lab immediately so that the lab has time to run the analysis within the 6-hour window.

Keeping these in mind, we recommend the following:

- *Frequency:* sample at least two or three times per month during the monitoring season.
- *Time of day:* sample during early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability.)
- *Time of year:* Sample during the warmer month, when recreational water contact uses occur.
- *Weather:* For fish, be sure to sample during low flow, high temperature periods in the summer.

DATA ANALYSIS

THE RESULTS ARE COMPARED WITH NUMERICAL CRITERIA IN EACH STATE'S WATER QUALITY STANDARDS. THESE ARE CONTAINED IN APPENDIX 3.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

A Water Quality Standards Assessment requires rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners are recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

TRAINING REQUIRED

Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water sample collection techniques by a VEMN Partner. The Program Coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[7] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[7] This is a lab set up by a watershed group or school

C. WATER CONTACT HEALTH RISK ASSESSMENT

WHAT IS IT?

Assessing the health risk of water contact involves the study of a representative sampling of a population by assessing their exposure to disease-causing agents in the water (including fish contamination) and the actual presence of disease.

Health assessments involve at least two main elements:

- *Collection of water or fish samples and their analysis for the contaminant(s) of interest (for example, E. coli bacteria in water).* This data is used to assess human exposure to the contaminant(s).
- *Information on the behavior and health status of the target group (e.g. a community, a sub-group) of interest or a reasonable substitute.* The types of information collected will typically include indicators of health status, perhaps behaviors associated with exposure to the contaminant(s), and any exposures to other types of contaminants.

The design of a water contact health risk assessment is tailored to the location, issues, problems, and situation in specific areas. There is no one template that will be appropriate for all situations in the watershed. So, VEMN partners will guide volunteer monitoring groups through a generic process[8] to help them develop an approach that will match their goals, needs, and resources. This process will result in specific data gathering tools and procedures that you can use. ***This process should be undertaken with the assistance of a resource person experienced in the design of community health surveys.*** This will help avoid common procedural errors that might needlessly frighten community members and/or bias[9] sampling.

WHY DO A WATER CONTACT HEALTH RISK ASSESSMENT?

We suggest that you undertake a Water Contact Health Risk Assessment if your primary interest is in the human health risks associated with water contact or fish/shellfish consumption and you need to produce data that health officials will act upon.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purpose

The main purpose of this assessment is to evaluate the health risk of coming in contact with the river or lake water -- by swimming or wading in it, eating the fish from it, or ingesting it. Put more simply: if you come in contact with the

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[8] This process is described in the VEMN Training Manual

[9] A statistical sampling error caused by systematically favoring some outcomes over others.

water in any of these ways, what is the risk that you'll get sick? Or, if you got sick, what is the likelihood that it is associated with contact with contaminated water?

Questions Answered

The water quality standards assessment helps answer two of the VEMN's basic questions:

1) Is human water contact recreation a health risk?
2) Is eating the aquatic life a health risk?

Data Use

The answers can be used for several things:

- Identify areas where action is needed to enable safe water contact recreation and fish consumption,
- Identify problems and conflicts which need to be resolved by some management decision,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☐ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

A water contact health risk assessment is done by collecting and analyzing water samples for contaminant(s) of interest and surveying the target population that comes in contact with this water.

Methods for collecting and analyzing water samples for *E. coli* are described detail in the VEMN Training Manual and in brief in the "Water Quality Standards Assessment" section of this guidance document. Sampling and analysis for other contaminants will follow EPA-approved protocols carried out by certified labs.

Methods for surveying the target population will be designed by Cynthia Lopez, a Doctoral Candidate in Epidemiology and Ecology at the Harvard School of Public Health and a consultant to River Watch Network.

Following is a table of the monitoring options for the water quality standards assessment:

Required Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
1) Collection of water or fish samples and their analysis for the contaminant(s) of interest. Options:		**Water/Fish Sampling and Analysis**
E. coli bacteria in water →	Membrane filtration w / mTEC with confirmation (EPA# 1103.1 or equivalent)	• Designated beaches and areas designated for swimming, wading, diving, and water skiing
• Selected contaminants in water →	As recommended by consultant or advisory committee	• Non-designated (Informal) swimming, wading, diving, and water skiing areas
• Selected contaminants in fish or shellfish tissue →	As recommended by consultant or advisory committee	• Boat launch ramps and fishing access areas • Near water supply intakes
2) Information on the behavior and health status of the target group. →	Epidemiological survey per RWN guidance	• Where possible, sites historically monitored by the NH DES or MA DEP **Health Data Gathering from Target Population** • Depends upon the target population

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU COLLECT SAMPLES?

For a water contact health risk assessment, the frequency of water sampling and community health data gathering depends on the nature of exposure to suspected disease-causing agents and type of water contact (e.g. swimming or eating fish), the human population being surveyed, and the nature of the suspected or known health problems. This should be determined on a case-by-case basis. However, if exposure to water-borne fecal contamination is the focus of water sampling, then the following guidelines apply:

1) Sample during the times of year when water contact is occurring. That means the warm summer months.
2) Sample water for bacteria at least three times over a 60-day period to enable the calculation of a geometric mean consistent with the NH water quality criterion.

DATA ANALYSIS

Once checked for errors, the data are ready for statistical analysis. In almost all cases, statistics that describe the data set in various ways will be computed. The selection of appropriate statistics describing associations and risk will depend upon the nature of the data.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

A Water Contact health Risk Assessment requires fairly rigorous QA / QC. Specific quality control measures for bacteria are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners are recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

TRAINING REQUIRED

Community Health Survey Interviewers must be trained by a resource person experienced in the administration of community health surveys to ensure reliability and to avoid bias. This person should be approved by River Watch Network and the state department of health.

Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water and / or fish tissue sample collection techniques by a VEMN Partner or by the professional lab personnel who will do the analysis.. The Program Coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[10] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[10] This is a lab set up by a watershed group or school

D. BASELINE MONITORING: RIVERS AND LAKES

Baseline monitoring of rivers and lakes is the collection of information about some of the basic physical, chemical and biological conditions. This information is used as a "baseline" or benchmark against which to assess future changes. Baseline monitoring is extremely difficult and time consuming because, in order to do it well, you must sample as many indicators under as many different hydrologic conditions as possible.

Even more important, *baseline monitoring is a long-term* commitment. In order to detect trends, understand how your river or lake changes over time or in response to natural or human-caused changes, we suggest that you sample over a period of many years -- 5 at a minimum, preferably 10 or 20. Trends are not established in a year.

We also suggest that you consider monitoring waters that are not impaired by human activities. Monitoring these waters is critical as a reference point against which to assess the impacts of decision affecting these waters. Further, some of these waters may serve as reference points to assess similar waters that have been affected by human activities.

Because of the difficulty in carrying out a truly comprehensive baseline monitoring program, we suggest six options which cover different levels of effort (rigorous and basic) and different types of water bodies (wadeable rivers, and non-wadeable rivers, and lakes):

D1 Rigorous Baseline Monitoring: Wadeable Rivers

D2 Rigorous Baseline Monitoring: Non-Wadeable Rivers

D3 Basic Baseline Monitoring: Wadeable Rivers

D4 Basic Baseline Monitoring: Non-Wadeable Rivers

D5 Rigorous Baseline Monitoring: Lakes

D6 Basic Baseline Monitoring: Lakes

These monitoring options are geared to meet different data quality goals, available resources, and types of water bodies.

Each of these options is described in the following sections.

D1. Rigorous Baseline Monitoring: Wadeable Rivers

What Is It?

Rigorous Baseline Monitoring is the most comprehensive and difficult baseline monitoring covered in this guide. It is watershed-wide in scope. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health as is practical for volunteer monitors, using methods that are comparable to those used by state agencies:

- water sampling and analysis,
- benthic macroinvertebrate sampling and analysis and habitat assessment,
- visual surveys of river uses, values, and threats, and
- field measurements of flow and channel characteristics.

Many of these activities are only possible where rivers are wadeable. Wadeable rivers are waters less than 2 feet deep, where it is possible to see and access the bottom to collect samples of habitat and aquatic life. Activities appropriate for non-wadeable rivers are covered in the next section (D2.)

Rigorous Baseline Monitoring is geared to produce a great deal of high quality information which can be used by state and federal agencies for their assessment efforts.

Why Do Rigorous Baseline Monitoring?

We suggest that you undertake Rigorous Baseline Monitoring if your primary interest is in the long term ecological health of your river and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

The main purposes for a preliminary watershed assessment are

- to establish baseline physical, chemical, and biological conditions against which future changes can be measured,
- to identify problem areas,
- to identify watershed improvement and protection actions, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are conditions changing over time? What? Where? How? Why?

Data Use

The results from Rigorous Baseline Monitoring can be used for several things:

- Identify areas where action is needed to enable the water body to support healthy aquatic life,
- Identify problems and conflicts between human and aquatic life uses which need to be resolved by some management decision,
- Identify waters with significant ecological value, which may need protection as “Class A ,” “outstanding resource waters” or under the “anti-degradation” provisions of the water quality standards,
- Identify waters that can serve as “reference conditions” (least impaired) waters against which progress in restoring impaired waters can be compared,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☑ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

Rigorous Baseline Monitoring for Wadeable Rivers involves collecting and analyzing water and aquatic life samples, assessing habitat conditions and channel shape, and gathering visual information about uses, values, and threats.

You might not need to (or be able to) use all the indicators and tools listed in the table below. Consider it a menu and consult with your technical advisory committee to select the indicators, methods, and sites appropriate for your river and your human and financial resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
E. coli Bacteria (NH)	Membrane filtration w / mTEC *with* confirmation (EPA# 1103.1 or equivalent)	**Sampling throughout watershed as follows:** • Designated beaches and areas designated for swimming, wading, diving, and water skiing.
Fecal Coliform Bacteria (MA)	Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent)	• Informal swimming, wading, diving, and water skiing areas.
Dissolved Oxygen	**1)** Modified Winkler Titration with a buret, syringe, or digital titrator (SM #4500-OG or equivalent) *Rivers*: surface sample *Lakes*: sample at various depths **2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent)** ***Rivers:* measure at surface** ***Lakes:* measure at various depths**	• Boat launch ramps and fishing access areas. • Cold and Warm water fish habitat areas (spawning, nursery, and resting sites). • Near water supply intakes. • Where possible, sites historically monitored by the NH DES or MA DEP. • Sites which are representative of the part of the river of interest. • Sites which are safely accessible
Turbidity (rivers)	Sample collected and measured with a nephelometer (SM #2130 or equivalent)	• Sites where the main river current is accessible -- where the water is thoroughly mixed.
Temperature	Direct measurement with a thermometer, thermocouple, or	• Water sampling from all habitats

	thermistor	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
pH →	1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) 2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)	**(Continued from previous page)** • Benthic macroinvertebrate sampling from riffle habitats • Streams and rivers of different orders (sizes) and at different altitudes • Reference sites in undeveloped or least-impaired areas
Total Alkalinity →	Double end point sulfuric acid titration w/ digital titrator and pH meter (RWN or MassWWP manual)	• Waters located in areas of different land uses (urban, agricultural, forested)
Conductivity →	Direct measurement with meter (SM #2510 B or equivalent)	• Waters receiving point source discharges and polluted runoff
Total Phosphorus →	Persulfate digestion followed by ascorbic acid method and spectrophotometry (EPA Method #365.2 or equivalent)	1) Tributary Impacts: *Reference Sites:* upstream of confluence on main stem
Nitrogen Series • Total Kjeldahl →	Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-Norg B or equivalent)	• *Impact Sites:* downstream of confluence on main stem, downstream of where mixing has occurred *Integrator Sites:* at tributary mouths
• Nitrates →	Cadmium Reduction followed by spectrophotometry (SM #4500-NO3-E or equivalent)	2) **Pollution Source Impacts:** *Reference Sites:* upstream of source
• Ammonia →	Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or	• *Impact Sites:* downstream of source where mixing has occurred - avoid mixing zones

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Intensive Benthic Macroinvertebrate Assessment	Field collection w/ net, lab id. of major groups or families, assess based on comparison to reference condition (RWN Benthic Macroinvertebrate Monitoring Manual - adaptation of EPA RBP II or equivalent)	**See previous page.**
Benthic Macroinvertebrate Habitat Assessment	Field observation and rating of key habitat characteristic relative to reference condition (RWN Benthic Macroinvertebrate Monitoring Manual - adaptation of EPA RBP II or equivalent)	
Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats	Shoreline/Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	
River Flow	Embody Float Method (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft)	
Channel cross - section	Measure elevations at intervals across stream ("Stream Channel Reference Sites" USFS or equivalent)	
Longitudinal Profile	Elevations of channel bottom and water surface("Stream Channel Reference Sites" USFS or equivalent)	

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

Rigorous Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

We suggest the following for each of the activities in Rigorous Baseline Monitoring:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month during the chosen time of year.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability)
- *Time of year*: Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year:* sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year*: sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Field Measurements of Flow and Channel Characteristics

- *Frequency and time of year:* Measure flows at least as frequently as water sampling (even daily if possible). Measure channel characteristics at least twice per year, once after spring runoff, and once during low flows in late summer. Consider more frequent sampling associated with weather.
- *Time of day:* not a consideration

- *Weather*: before and after a variety of flow conditions: storm events, droughts, and "normal" conditions.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Rigorous Baseline Monitoring requires rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners will observe the operation of sampling and analytical procedures. Suggestions for improvements will be discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

TRAINING REQUIRED

Field Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection, visual survey, channel characteristics measurements, and habitat assessment techniques by a VEMN Partner. The Program Coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[11] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[11] This is a lab set up by a watershed group or school

D2. Rigorous Baseline Monitoring: Non-Wadeable Rivers

What Is It?

Rigorous Baseline Monitoring is the most comprehensive and difficult baseline monitoring covered in this guide. It is watershed-wide in scope. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health as is practical for volunteer monitors working in non-wadeable waters, using methods that are comparable to those used by state agencies:

- water sampling and analysis,
- benthic macroinvertebrate sampling and analysis and habitat assessment, and
- visual surveys of river uses, values, and threats.

Non-Wadeable rivers are waters greater than 2 feet deep, where it is not possible to see and access the bottom to collect samples of habitat and aquatic life. Special methods are used to assess these waters.

Rigorous Baseline Monitoring is geared to produce a great deal of high quality information which can be used by state and federal agencies for their assessment efforts.

Why Do Rigorous Baseline Monitoring?

We suggest that you undertake Rigorous Baseline Monitoring if your primary interest is in the long term ecological health of your river and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

The main purposes for a preliminary watershed assessment are

- to establish baseline physical, chemical, and biological conditions against which future changes can be measured,
- to identify problem areas,
- to identify watershed improvement and protection actions, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are conditions changing over time? What? Where? How? Why?

Data Use

The results from Rigorous Baseline Monitoring can be used for several things:

- Identify areas where action is needed to enable the water body to support healthy aquatic life,
- Identify problems and conflicts between human and aquatic life uses which need to be resolved by some management decision,
- Identify waters with significant ecological value, which may need protection as “Class A ,” “outstanding resource waters” or under the “anti-degradation” provisions of the water quality standards,
- Identify waters that can serve as “reference conditions” (least impaired) waters against which progress in restoring impaired waters can be compared,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☑ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

Rigorous Baseline Monitoring for Non-wadeable Rivers is similar to that for wadeable rivers. It involves collecting and analyzing water and aquatic life samples, assessing habitat conditions, and gathering visual information about uses, values and threats.

Monitoring options for non-wadeable waters for most indicators are essentially the same as for wadeable waters (refer to the table in section D1 for the methods). However, benthic macroinvertebrate sampling and habitat assessment are different, given the more difficult access to the river bottom.

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
E. coli (NH) Fecal Coliforms (MA) Dissolved Oxygen Turbidity Temperature pH Shoreline Survey for Volunteers Total Alkalinity Conductivity Total Phosphorus Nitrogen Series	**Same methods as Rigorous Baseline Monitoring for Wadeable Rivers (D1) except as follows:**	**Sampling throughout watershed at same types of sites as Rigorous Baseline Monitoring for Wadeable Waters, but focus is on deep water habitats (riffle and possibly run habitats are missing)**
Intensive Benthic Macroinvertebrate Assessment	Field collection with *rock baskets*, lab id. of major groups or families, assess based on comparison to reference condition (RWN Adaptation of ME DEP Method or equivalent)	
Benthic Macroinvertebrate Habitat Assessment	Use habitat assessment for muddy bottom streams (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft)	

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

Rigorous Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

We suggest the following for each of the activities in Rigorous Baseline Monitoring:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability)
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year:* sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Rigorous Baseline Monitoring requires rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

TRAINING REQUIRED

Field Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection, visual survey, and habitat assessment techniques by a VEMN Partner. The Program Coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[12] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[12] This is a lab set up by a watershed group or school

D3. BASIC BASELINE MONITORING: WADEABLE RIVERS

WHAT IS IT?

Basic Baseline Monitoring seeks to balance limited time and resources with the goal of sampling as many different aspects of the river ecosystem as possible. Unlike Rigorous Baseline Monitoring, it need not cover an entire watershed. The focus may be limited to relatively small areas or even particular reaches. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health as is practical for volunteer monitors, using relatively simple methods:

- water sampling and analysis,
- benthic macroinvertebrate sampling and analysis and habitat assessment, and
- visual surveys of river uses, values, and threats.

Wadeable rivers are waters less than 2 feet deep, where it is possible to see and access the bottom to collect samples of habitat and aquatic life.

Given that the methods used in Basic Baseline Monitoring, for most indicators, are not comparable to those used by state agencies, this information will likely be used by state and federal agencies to identify problem areas for further monitoring, rather than assessment. However, Basic Baseline Monitoring will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level.

WHY DO BASIC BASELINE MONITORING?

We suggest that you undertake Basic Baseline Monitoring if your primary interest is in the long term ecological health of your river and you don’t need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes:

- to educate and raise awareness of the participants and the public regarding some of the river's important physical, chemical, and biological characteristics,
- to identify gross problem areas, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are there gross problem areas?

Data Use

The results from Basic Baseline Monitoring can be used for several things:

- Identify areas where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening
☐ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

Basic Baseline Monitoring for Wadeable Rivers involves collecting and analyzing water and aquatic life samples, assessing habitat conditions, and gathering visual information about uses, values and threats. It assesses many of the same indicators as the Rigorous Baseline Monitoring, but uses simpler methods. Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river and your group's resources:

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Fecal Colif. / *E. coli* Bacteria →	Various methods that detect presence-absence or produce an estimate of bacteria density	**Focus may be limited to relatively small areas of the watershed, a small number of sites throughout the watershed, or to particular reaches.**
Dissolved Oxygen →	Modified Winkler Titration w/ a syringe or eyedropper (Mitchell & Stapp)	**Same types of sites as Rigorous Baseline Monitoring for Wadeable Waters.**
pH →	Sample collected and measured with a pH meter, pocket meter or paper	
Temperature →	Direct measurement with a thermometer	
Total Alkalinity →	Sulfuric acid titration w/ digital titrator and pH meter (RWN)	
Conductivity →	Direct measurement with meter (EPA Volunteer Methods Manual) or pen (RWN)	
Total Phosphorus →	Persulfate digestion followed by ascorbic acid method and color comparator (Mitchell & Stapp)	
Turbidity →	Sample collected and measured with a nephelometer and reported as NTU's (RWN) or turbidity tube reported in centimeters or inches (Australia Water Watch)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Biochemical Oxygen Demand →	BOD 5-day procedure w/ Modified Winkler Titration w/ a syringe or eyedropper (Mitchell & Stapp)	**See previous page.**
Nitrates →	Cadmium Reduction followed by color comparator (Mitchell & Stapp)	
Visual field survey of river, riparian and watershed characteristics, uses, values, and threats →	Shoreline/Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent) and/or photo-documentation	
Streamside Benthic Macroinvertebrate Assessment →	Field collection, identification of major groups, assessment based on relative abundance and estimated richness (RWN Benthic Macroinvertebrate Monitoring Manual)	

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

Basic Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

We suggest the following for each of the activities in Basic Baseline Monitoring:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year:* sample at least once per year, once in the mid-spring or once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Basic Baseline Monitoring does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

TRAINING REQUIRED

Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection and visual survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[13] proper training is essential. We suggest a designated lab coordinator responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

[13] This is a lab set up by a watershed group or school

D4. BASIC BASELINE MONITORING: NON-WADEABLE RIVERS

WHAT IS IT?

Basic Baseline Monitoring seeks to balance limited time and resources with the goal of sampling as many different aspects of the river ecosystem as possible. Unlike Rigorous Baseline Monitoring, it need not cover an entire watershed. The focus may be limited to relatively small areas or even particular reaches. It includes monitoring activities that primarily assess as many of the physical and chemical indicators of river health as is practical for volunteer monitors, using relatively simple methods:

- water sampling and analysis, and
- visual surveys of river uses, values, and threats.

Non-wadeable rivers are waters greater than 2 feet deep, where it may not be possible to see and access the bottom to collect samples of habitat and aquatic life. Unfortunately, non-wadeable waters do not allow a simple method of collecting benthic macroinvertebrate samples or to assess habitat conditions.

Given that the methods used in Basic Baseline Monitoring, for most indicators, are not comparable to those used by state agencies, this information will likely be used by state and federal agencies to identify problem areas for further monitoring, rather than assessment. However, Basic Baseline Monitoring will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level.

WHY DO BASIC BASELINE MONITORING?

We suggest that you undertake Basic Baseline Monitoring if your primary interest is in the long term ecological health of your river and you don’t need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to educate and raise awareness of the participants and the public regarding some of the river's important physical, chemical, and biological characteristics,
- to identify gross problem areas, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are there gross problem areas?

Data Use

The results from Basic Baseline Monitoring can be used for several things:

- Identify areas where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening
☐ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

Basic Baseline Monitoring for Non-wadeable Rivers is similar to that for wadeable waters. It involves collecting and analyzing water and aquatic life samples, assessing habitat conditions, and gathering visual information about uses, values, and threats.

Monitoring options for non-wadeable waters are essentially the same as for wadeable waters (refer to the table in section D3 for the methods). However, benthic macroinvertebrate sampling and habitat assessment are not possible using simple methods, given the lack of access to the river bottom:

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Fecal Colif./*E. coli* Bacteria Dissolved Oxygen pH Temperature Total Alkalinity Conductivity Total Phosphorus Turbidity Biochemical Oxygen Demand Nitrates Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats	**Same methods as Basic Baseline Monitoring for Wadeable Rivers (D3)**	**Focus may be limited to relatively small areas of the watershed, a small number of sites throughout the watershed, or to particular reaches. Same types of sites as Rigorous Baseline Monitoring for Wadeable Waters, but focus is on deep water habitats (riffle and possibly run habitats are missing)**

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

Basic Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

We suggest the following for each of the activities in Basic Baseline Monitoring:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Basic Baseline Monitoring does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

TRAINING REQUIRED

Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water sample collection and visual survey techniques by a VEMN Partner. The Program Coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[14] proper training is essential. We suggest a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

[14] This is a lab set up by a watershed group or school

D5. RIGOROUS BASELINE MONITORING: LAKES

WHAT IS IT?

Rigorous Baseline Monitoring is lake-wide in scope. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of lake health as is practical for volunteer monitors, using methods that are comparable to those used by state agencies:

- water sampling and analysis,
- aquatic weed mapping,
- visual surveys of shoreline uses, values, and threats, and
- lake level measurements.

Rigorous Baseline Monitoring for lakes is focused on the lake itself, though visual surveys may be extended to the watershed. It is geared to produce a great deal of high quality information which can be used by state and federal agencies for their assessment efforts.

WHY DO RIGOROUS BASELINE MONITORING?

We suggest that you undertake Rigorous Baseline Monitoring if your primary interest is in the long term ecological health of your lake and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes:

- to establish baseline physical, chemical, and biological conditions against which future changes can be measured,
- to identify watershed improvement and protection actions, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered:

Are conditions changing over time? What? Where? How? Why?

Data Use

The results from Rigorous Baseline Monitoring can be used for several things:

- Identify areas where action is needed to enable the water body to support healthy aquatic life,

- Identify problems and conflicts between human and aquatic life uses which need to be resolved by some management decision,
- Identify waters with significant ecological value, which may need protection as “Class A ,” “outstanding resource waters” or under the “anti-degradation” provisions of the water quality standards,
- Identify waters that can serve as “reference conditions” (least impaired) waters against which progress in restoring impaired waters can be compared,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☑ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

Rigorous Baseline Monitoring for Lakes involves collecting and analyzing water samples, aquatic vegetation mapping, a visual shoreline survey of uses, values, and threats, and measurement of water clarity and lake level.

You might not need to (or be able to) use all the indicators and tools listed in the table below. For example, some may not be relevant to your lake or you may not have the resources to use them all. Consider it a menu and consult with your technical advisory committee to select the indicators, methods, and sites appropriate for your lake and your human and financial resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
E. coli Bacteria (NH)	Membrane filtration w / mTEC *with* confirmation (EPA# 1103.1 or equivalent)	**Sampling throughout lake** • Deepest part of the lake
Fecal Coliform Bacteria (MA)	Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent)	• Deepest part of significant arms or bays • Mouths of tributaries ("integrator" sites)
Secchi Transparency (lakes)	**Transparency depth measurement using a secchi disk (MassWWP or UNH CE Method)**	• Sites at areas of public use for water contact recreation (e.g. swimming) areas
Temperature	Direct measurement with a thermometer, thermocouple, or thermistor	• Where possible, sites historically monitored by the state water quality agency
Dissolved Oxygen	1) Integrated or multiple depth sample analyzed by Modified Winkler Titration with a buret, syringe, or digital titrator (SM #4500-OG or equivalent) 2) Direct measurement at various depths with a membrane electrode meter (SM #4500-OG or equivalent)	• Waters receiving non-point source discharges and polluted runoff • Outlet • Waters located in areas of different land uses (urban, agricultural, forested) • Near-shore areas for weed mapping

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
pH →	Integrated or multiple depth sample analyzed by a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)	**See previous page.**
Total Alkalinity →	Integrated or multiple depth sample analyzed by double end point sulfuric acid titration w/ digital titrator and pH meter (MassWWP Manual)	
Total Phosphorus →	Integrated or multiple depth sample analyzed by persulfate digestion followed by ascorbic acid method and spectrophotometry (EPA Method #365.2 or equivalent)	
Cholorophyll *a* →	Pigment extraction followed by spectrophotometry (SM #10200 H)	
Aquatic Vegetation Mapping/ Identification →	MassWWP and UNH Coop. Ext. methods	
Visual field survey of lake, riparian, and watershed characteristics, uses, values, and threats →	MassWWP, UNH Coop. Ext., NH DES methods	
Lake levels →	Staff gage anchored to fixed object	

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

Rigorous Baseline Monitoring requires the collection of as many samples under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum. Consider sampling the following to determine variability:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).
- *Time of year:* Sample during critical periods, or lake turnover periods, of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather*: a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc.

Visual Surveys of River Uses, Values, and Threats:

- *Frequency and time of year*: sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high levels should be avoided.

Aquatic Weed Mapping:

- *Frequency and time of year:* survey at least once per year, during mid-summer when plants are well established.
- *Time of day and weather:* Survey when the light is good.

Lake Level Measurements:

- *Frequency and time of year:* Measure at least in conjunction with water sampling, daily if possible.
- *Time of day:* not a consideration.
- *Weather:* before and after a variety of flow conditions: storm events, droughts, and “normal” conditions.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Rigorous Baseline Monitoring requires following rigorous QA / QC protocols. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan, or at the request of the program coordinator.

TRAINING REQUIRED

Field Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water sample collection, secchi, visual survey, and weed mapping techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[15] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[15] This is a lab set up by a watershed group or school

D6. BASIC BASELINE MONITORING: LAKES

WHAT IS IT?

Basic Baseline Monitoring seeks to balance limited time and resources with the goal of sampling the most important and integrative aspects of the lake ecosystem as possible. The focus is limited to one or two areas in the deepest part of the lake. It includes monitoring activities that visually assess physical and biological indicators of lake health:

- measurement of transparency,
- aquatic weed mapping, and
- visual surveys of shoreline uses, values, and threats.

Basic Baseline Monitoring for lakes is focused on the lake itself, though visual surveys may be extended to the watershed. Given the limited scope of this monitoring and the fact that the methods are not as sensitive to change as the ones used by state agencies, the information will likely be used by state and federal agencies to identify problem areas for further monitoring, rather than assessment. However, Basic Baseline Monitoring will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level.

WHY DO BASIC BASELINE MONITORING?

We suggest that you undertake Basic Baseline Monitoring if your primary interest is in the long term ecological health of your lake and you don't need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes:

- to educate and raise awareness of the participants and the public regarding some of the river's important physical, chemical, and biological characteristics,
- to identify problem areas, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are there gross problem areas?

Data Use

The results from Basic Baseline Monitoring can be used for several things:

- Identify areas where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening

☐ Community & watershed level evaluation, assessment, and management

☐ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

Basic Baseline Monitoring for Lakes involves collecting and analyzing water samples, aquatic vegetation mapping, a visual shoreline survey of uses, values, and threats, and measurement of water clarity and water level. It assesses many of the same indicators as the Rigorous Baseline, but uses simpler methods.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your lake and resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Secchi Transparency →	MassWWP or UNH CE Method	**Sampling one or a few representative sites:** • Deepest part of the lake
Aquatic Vegetation Mapping/ Identification →	MassWWP and UNH Coop. Ext. methods	• Near-shore areas for vegetation mapping
Visual field survey of lake, riparian, and watershed characteristics, uses, values, and threats →	MassWWP, UNH Coop. Ext., NH DES methods	• Deepest part of significant arms or bays

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

Basic Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

For a rigorous baseline study, we recommend sampling different times of day, different seasons, and under different weather conditions. For a basic baseline study, we suggest that you consider focusing on sampling *one* of the following to determine variability:

Secchi Transparency:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during the same time of day each sampling event.
- *Time of year*: Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.

- *Weather*: a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc.

Visual Surveys of Lake Uses, Values, and Threats:

- *Frequency and time of year*: sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration.

Aquatic Weed Mapping:

- *Frequency and time of year:* survey at least once per year, during mid-summer when plants are well established.
- *Time of day and weather:* Survey when the light is good.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Basic Baseline Monitoring does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

TRAINING REQUIRED

Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water sample collection, weed mapping, and visual survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[16] proper training is essential. We suggest a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

[16] This is a lab set up by a watershed group or school

E. WASTEWATER TREATMENT PLANT IMPACT ASSESSMENT: RIVERS

Wastewater Treatment Plant Impact Assessment is the collection of information about the impact of a wastewater treatment plant discharge on the river's ecological health and human use. It typically involves *instream* monitoring of various indicators upstream and downstream of the plant using *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the plant) are compared with those at the reference site (upstream of the plant) to determine the extent of the impact attributable to that plant. The indicators are selected based on the nature of the discharge and its likely impacts.

Given the nature of the assessment -- comparison of conditions upstream of the plant with those downstream of the plant -- and the fact that there are no discharges allowed to lakes -- it is limited to rivers.

We suggest two options which cover two different levels of effort (rigorous and basic):

E1 Rigorous Wastewater Treatment Plant Impact Assessment

E2 Basic Wastewater Treatment Plant Impact Assessment

These monitoring options are geared to meet different data quality goals and available resources.

Each of these options is described in the following sections.

E1. RIGOROUS WASTEWATER TREATMENT PLANT IMPACT ASSESSMENT: RIVERS

WHAT IS IT?

A Rigorous Wastewater Treatment Plant Impact Assessment is the collection of selected information about the impact of a wastewater treatment plant on the river's ecological health and human use. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health likely to be affected by the discharge as is practical for volunteer monitors, using methods that are comparable to those used by state agencies:

- water sampling and analysis for indicators of discharge impacts,
- benthic macroinvertebrate sampling and analysis and habitat assessment, and
- visual surveys of river uses, values, and threats.

These activities occur upstream and downstream of the plant at *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the plant) are compared with those at the reference site (upstream of the plant) to determine the extent of the impact attributable to that plant's discharge of treated effluent.

A Rigorous Wastewater Treatment Plant Impact Assessment is geared to produce high quality information which can be used by state and federal agencies and communities to set pollution control priorities, as well as to assess the need for changes in plant operation or upgrades.

WHY DO RIGOROUS WASTEWATER TREATMENT PLANT IMPACT ASSESSMENT?

We suggest that you undertake Rigorous Wastewater Treatment Plant Impact Assessment if your primary interest is in the impact of wastewater discharges on the long term ecological health and human use of your river, and you want to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions, and provide information for the data uses listed below.

Purposes:

- to assess the impact of a wastewater treatment plant on the river's physical, chemical, and biological characteristics,
- to provide information communities can use to assess the need for changes in plant operations or upgrades, and

- to provide information state and federal officials can use to set pollution control funding priorities.

Questions Answered:

1) *What are the impacts of point discharges on human use and ecological integrity of the river system or reach?*

2) *What is the effectiveness of water pollution control facilities (wastewater treatment plants or on-site systems) in restoring and protecting human use and ecological integrity of the river system or specific water bodies?*

Data Use

The results from Rigorous Wastewater Treatment Plant Assessment can be used for several things:

- Identify plants where operational changes or upgrades are needed to enable the water body to support healthy aquatic life or designated human uses,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☑ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

The Rigorous Wastewater Treatment Plant Assessment involves collecting and analyzing water samples for indicators of the impacts of wastewater discharge; collecting and analyzing benthic macroinvertebrate samples; assessing benthic macroinvertebrate habitat quality; and a visual shoreline survey of uses, values, and threats. These activities are carried out above and below the plant. Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the nature of the discharge from the plant, and your human and financial resources:

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Select appropraite indicators/tools for the nature of discharge		
E. coli Bacteria (NH) →	Membrane filtration w / mTEC *with* confirmation (EPA# 1103.1 or equivalent)	• **reference or control site** immediately upstream of the plant
Fecal Coliform Bacteria (MA) →	Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent)	• **impact site** immediately downstream of the alteration (downstream of the mixing zone at a point where the impact is completely integrated with the water)
Dissolved Oxygen →	**1)** RWN adaptation of Modified Winkler Titration (SM #4500-OG) with a digital titrator **2) Direct measurement with a membrane electrode meter (SM #4500-OG)**	• **recovery site** downstream of the impact site (where the water has at least partially recovered from the impact).
Turbidity →	Sample collected and measured with a nephelometer (RWN adaptation of Standard Methods #2130)	• Note: It may be difficult to isolate the treatment plant from other impacts on a river reach -- it may be necessary to bracket a group of impacts together.
Biochemical Oxygen Demand →	5-day BOD test (SM #5210-B) using Modified Winkler Titration	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
pH	1) Sample collected and measured with a meter (MassWWP adaptation of EPA Method 150.1) 2) Direct measurement with a meter (EPA Method 150.1)	**See previous page.**
Conductivity	Direct measurement with a meter (EPA Volunteer Methods manual	
Temperature	**Direct measurement with a thermometer**	
Total Phosphorus	Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent)	
Nitrogen Series • Total Kjeldahl Nitrogen	Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-NO3-E or equivalent)	
• Nitrates	Cadmium reduction followed by spectrophotometry (SM #4500-NH3 C or equivalent)	
• Ammonia	Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or equivalent)	
Chlorophyll *a*	Pigment extraction followed by spectrophotometry (SM #10200 H)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats →	Shoreline/Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	**See previous page**.
Intensive Benthic Macroinvertebrate Assessment →	Field collection w/ net or rock basket, lab id. of families, assess based on comparison to upstream reference site (RWN Adaptation of EPA RBP II)	
Benthic Macroinvertebrate Habitat Assessment →	Field observation and rating of key habitat characteristic relative to upstream reference site (RWN Methods)	

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

In general, we suggest monitoring wastewater treatment plants when they are likely to have the greatest impacts on the aquatic ecosystem and on water contact recreation. This will likely be in the summer months, during periods when people are swimming in the water and when low flows frequently combine with high temperatures to stress aquatic organisms.

Within the summer months, we suggest water sampling during the early morning hours, when dissolved oxygen levels are likely to be at their lowest.

This will vary according to the size of the plant, the nature of its discharge and the nature of the receiving water. Following are some basic considerations:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).

- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment:

- *Frequency and time of year:* sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, although high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats:

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, although high flows should be avoided.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. At a minimum, reference conditions will include the water quality standards and the results from the reference station immediately upstream of the plant. Comparisons to the reference station can be tricky and require statistical analysis to determine whether difference are significant. Your technical advisory committee should help you assess this.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Rigorous Wastewater Treatment Plant Assessment requires following rigorous QA / QC protocols. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

TRAINING REQUIRED

Field Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection, visual survey, and habitat assessment techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[17] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[17] This is a lab set up by a watershed group or school

E2. Basic Wastewater Treatment Plant Impact Assessment: Rivers

What Is It?

A Basic Wastewater Treatment Plant Impact Assessment is the collection of relatively easy-to-gather information about the impact of a wastewater treatment plant on the river's ecological health and human use. It includes monitoring activities that assess the physical, chemical, and biological indicators of river health likely to be affected by the discharge and practical to monitor for schools or groups with limited human and financial resources:

- water sampling and analysis for indicators of discharge impacts,
- benthic macroinvertebrate sampling and analysis and habitat assessment (in wadeable waters only), and
- visual surveys of river uses, values, and threats.

These activities occur upstream and downstream of the plant at *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the plant) are compared with those at the reference site (upstream of the plant) to determine the extent of the impact attributable to that plant.

Given that the methods used in Basic Wastewater Treatment Plant Impact Assessment, for most indicators, are not comparable to those used by state agencies, this information will likely be used by state and federal agencies and communities for education and awareness and to identify problem areas for further monitoring, rather than setting priorities or determining the need for operational changes. However, a Basic Wastewater Treatment Plant Impact Assessment will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level.

Why Do A Basic Wastewater Treatment Plant Impact Assessment?

We suggest that you undertake a Basic Wastewater Treatment Plant Impact Assessment if your primary interest is in the impact of wastewater discharges on the long term ecological health and human use of your river and you don't need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to educate and raise awareness of the participants and the public regarding the impact of a wastewater treatment plant on the river's physical, chemical, and biological characteristics, and
- to identify gross problem areas that might need action or further monitoring.

Questions Answered

1) *What are the impacts of point discharges on human use and ecological integrity of the river system or reach?*
2) *What is the effectiveness of water pollution control facilities (wastewater treatment plants or on-site systems) in restoring and protecting human use and ecological integrity of the river system or specific water bodies?*

Data Use

The results from Basic Wastewater Treatment Plant Assessment can be used for several things:

- Identify plants where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about their wastewater treatment plants and water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening
☐ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

The Basic Wastewater Treatment Plant Assessment involves collecting and analyzing water samples for indicators of the impacts of wastewater discharge; collecting and analyzing and benthic macroinvertebrate samples (wadeable rivers only); and a visual shoreline survey, of uses, values and threats. These activities are carried out above and below the plant. It assesses many of the same indicators as the Rigorous Wastewater Treatment Plant Assessment , but uses simpler methods. Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the nature of the discharge from the plant, and your human and financial resources:

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Select appropraite indicators/tools:		
Fecal Colif./*E. coli* Bacteria →	Various methods that detect presence-absence or produce an estimate of bacteria density	• **reference or control site** immediately upstream of the plant
Dissolved Oxygen →	Modified Winkler Titration w/ a syringe or eyedropper (Mitchell & Stapp)	• **impact site** immediately downstream of the alteration (downstream of the mixing zone at a point where the impact is completely integrated with the water)
pH →	Sample collected and measured with a pH meter, pocket meter or paper	
Temperature →	**Direct measurement with a thermometer**	• **recovery site** downstream of the impact site (where the water has at least partially recovered from the impact).
Total Alkalinity →	**Sulfuric acid titration w/digital titrator and pH meter (RWN)**	
Conductivity →	Direct measurement with meter (EPA Volunteer Methods Manual) or pen (RWN)	• Note: It may be difficult to isolate the treatment plant from other impacts on a river reach -- it may be necessary to bracket a group of impacts together.
Total Phosphorus →	Persulfate digestion followed by ascorbic acid method and color comparator (Mitchell & Stapp)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Turbidity	Sample collected and measured with a nephelometer and reported as NTU's (RWN) or turbidity tube reported in centimeters or inches (no source yet)	**See previous page**.
Nitrates	Cadmium reduction followed by color comparator (Mitchell & Stapp)	
Biochemical Oxygen Demand	**BOD 5-day procedure w/ Modified Winkler Titration w/ a syringe or eyedropper (Mitchell & Stapp)**	
Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats	Shoreline/Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	
Basic Benthic Macroinvertebrate Assessment (wadeable rivers only)	Field collection w/ net. lab id. of major groups, assess based on comparison to upstream reference site (RWN Method)	

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

In general, we suggest monitoring wastewater treatment plants when they are likely to have the greatest impacts on the aquatic ecosystem and on water contact recreation. This will likely be in the summer months, during periods when people are swimming, and when low flows frequently combine with high temperatures to stress aquatic organisms.

Within the summer months, we suggest water sampling during the early morning hours, when dissolved oxygen levels are likely to be at their lowest.

Sampling will vary according to the size of the plant, the nature of its discharge and the nature of the receiving water. Following are some basic considerations:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather*: a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment:

- *Frequency and time of year*: sample at least once per year, once in the mid-spring or once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, although high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats:

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, although high flows should be avoided.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. At a minimum, reference conditions will include the water quality standards and the results from the reference station immediately upstream of the plant. Given the methods used in the basic wastewater treatment plant impact assessment, the comparison with the upstream reference site will be qualitative, rather than statistical. Only large differences in results will be noted.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Basic Wastewater Treatment Plant Impact Assessment does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

TRAINING REQUIRED

Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection and visual survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[18] proper training is essential. We suggest a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

[18] This is a lab set up by a watershed group or school

F. NON-POINT SOURCE POLLUTION IMPACT ASSESSMENT

Non-Point Source Pollution Impact Assessment is the collection of information about the impact of runoff from a non-point pollution source on the river's ecological health and human use. Non-point pollution sources are land-based and diffuse, rather than coming out of a pipe. Examples of potential sources include construction sites, logging operations, agriculture, animal husbandry, on-site septic systems, lawns and gardens, and urban runoff.

This assessment typically involves *instream* monitoring of various indicators upstream and downstream of the source using *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the source) are compared with those at the reference site (upstream of the source) to determine the extent of the impact attributable to that source. The indicators are selected based on the nature of the source, contaminants likely to be found in the runoff, and likely impacts on the river.

Given the nature of the assessment -- comparison of conditions upstream of the source with those downstream of the plant -- it is limited to rivers.

We suggest two options which cover two different levels of effort (rigorous and basic):

- F1 Rigorous Non-Point Source Pollution Impact Assessment
- F2 Basic Non-Point Source Pollution Impact Assessment

These monitoring options are geared to meet different data quality goals and available resources.

Each of these options is described in the following sections.

F1. RIGOROUS NON-POINT SOURCE POLLUTION IMPACT ASSESSMENT

WHAT IS IT?

A Rigorous Non-Point Source Pollution Impact Assessment is the collection of selected information about the impact of runoff from a non-point pollution source on the river's ecological health and human use. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health likely to be affected by the runoff from these sources as is practical for volunteer monitors, using methods that are comparable to those used by state agencies:

- water sampling and analysis for indicators of runoff impacts,
- benthic macroinvertebrate sampling and analysis and habitat assessment,
- visual surveys of river uses, values, and threats,
- estimates or measures of river channel composition and stability, and
- measurements of rainfall and river flow.

These activities occur upstream and downstream of where runoff from the source enters the river at *reference, impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the source) are compared with those at the reference site (upstream of the source) to determine the extent of the impact attributable to that source.

Rigorous Non-Point Source Pollution Impact Assessment is geared to produce a great deal of high quality information which can be used by state and federal agencies and communities to set pollution control priorities, as well as to assess the need for changes in land use and management practices.

WHY DO A RIGOROUS NON-POINT SOURCE POLLUTION IMPACT ASSESSMENT?

We suggest that you undertake Rigorous Non-Point Source Pollution Impact Assessment if your primary interest is in the impact of non-point source pollution on the long term ecological health and human use of your river and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to assess the impact of a specific non-point pollution source on the river's physical, chemical, and biological characteristics,

- to provide information communities can use to assess the need for changes in land use planning and regulation, and
- to provide information state and federal officials can use to set pollution prevention and control priorities.

Questions Answered

1) *What are the impacts of non-point pollution sources on human use and ecological integrity of the river system or reach?*

2) *What is the effectiveness of best management practices (BMPs) to control polluted runoff in restoring and protecting human use and ecological integrity of the river system or specific water bodies?*

Data Use

The results from Rigorous Non-Point Source Pollution Impact Assessment can be used for several things:

- Identify areas where land use and management changes and are needed to enable the water body to support healthy aquatic life and human uses,
- Identify problems and conflicts between human and aquatic life uses which need to be resolved by some management decision,
- Set priorities for funding water non-point source pollution control projects, and
- Evaluate whether best management practices and other pollution control measures are working.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☑ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

The Rigorous Non-Point Source Pollution Impact Assessment involves collecting and analyzing water samples for indicators of non-point source pollution; collecting and analyzing benthic macroinvertebrate samples; assessing benthic macroinvertebrate habitat quality; and a visual shoreline survey of uses, values, and threats. These activities are carried out above and below the plant. Note that the indicators and methods listed here are appropriate for wadeable rivers only.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the nature of the non-point source pollution, and your human and financial resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Select appropraite indicators/tools depending on the NPS source:		
Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats →	Shoreline/Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	• **reference or control site** immediately upstream of the source
Intensive Benthic Macroinvertebrate Assessment →	Field collection w/ net or rock basket, lab id. of major groups or families, assess based on comparison to upstream reference condition (RWN) (Adaptation of EPA RBP II)	• **impact site** immediately downstream of the source (at the point where the impact is completely integrated with the water)
Benthic Macroinvertebrate Habitat Assessment →	**Field observation and rating of key habitat characteristic relative to reference condition (RWN Method)**	• **recovery site** downstream of the source (where the water has at least partially recovered from the impact).
Fecal colif./*E. coli* Bacteria →	membrane filtration w/ mTEC with and without confirmation (EPA #1103.1 or equivalent)	• Note: It may be difficult to isolate a particular pollution source from other pollution sources on a river reach -- it may be necessary to bracket a group of sources together.

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Select appropriate indicators/tools depending on the NPS source:		**See previous page.**
Total Phosphorus →	Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent)	
Nitrogen Series		
• Total Kjeldahl Nitrogen →	Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-Norg B or equivalent)	
• Nitrates →	Cadmium reduction followed by spectrophotometry (SM #4500-NO3-E or equivalent)	
• Ammonia →	Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or equivalent)	
Turbidity →	Sample collected and measured with a nephelometer (RWN adaptation of Standard Methods #2130)	
Embeddedness →	Estimated for 4 particles at each of 11 cross sections at site (EPA EMAP Protocol or equivalent)	
Channel cross-sections →	Measure elevations at intervals across stream ("Stream Channel Reference Sites" USFS or equivalent)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Select appropriate indicators/tools depending on the NPS source:		**See previous page.**
Bottom Composition →	Pebble count ("Stream Channel Reference Sites" USFS or equivalent)	
Longitudinal Profile →	Elevations of channel bottom and water surface ("Stream Channel Reference Sites" USFS or equivalent)	
River Flow →	Embody Float Method (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft)	
Rainfall →	Rain Gage or NOAA Data	

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

In general, we suggest monitoring non-point pollution sources when they are likely to have the greatest impacts on the aquatic ecosystem and on water contact recreation. This will vary according to the nature of its non-point pollution source and the nature of the receiving water. However, it will likely be in the summer months, during and after runoff events. We also suggest monitoring during dry weather conditions as a benchmark.

Storm event related monitoring is a challenge, because it requires being ready to collect and analyze samples on short notice. We suggest the following for each of the activities in Non-point Pollution Source Assessment:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month during the chosen time of year, both during storms and during dry weather.
- *Time of day:* Runoff event sampling is challenging. Ideally samples should be collected at regular intervals before, during and after the storm event. This is likely impractical, so we recommend three samplings for each storm event: at

the onset of the rain event (to establish baseline conditions), during (to catch the "first flush" and establish conditions during rising flows), and after (to establish conditions during high or falling flows).

- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather*: During storm events of various intensity and duration and during dry weather.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year*: sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Visual surveys can be conducted during storm events to locate active runoff channels for non-point source pollution.

Field Measurements of Flow and Channel Shape

- *Frequency and time of year*: Measure flows at least as frequently as water sampling, daily if possible. Measure channel characteristics in association with runoff events (see below)
- *Time of day:* not a consideration.
- *Weather*: Measure channel characteristics before and after major storm events.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. At a minimum, reference conditions will include the water quality standards and the results from the reference station upstream of the non-point pollution source or sources being assessed. Comparisons to the reference station can be tricky and require statistical analysis to determine whether differences are significant. Your technical advisory committee should help you assess this.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Rigorous Non-Point Source Pollution Impact Assessment requires following rigorous QA/QC protocols. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

TRAINING REQUIRED

Field Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection, visual survey, and habitat assessment techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[19] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[19] This is a lab set up by a watershed group or school

F2. BASIC NON-POINT SOURCE POLLUTION IMPACT ASSESSMENT

WHAT IS IT?

A Basic Non-Point Source Pollution Impact Assessment is the collection of relatively easy-to-gather information about the impact of runoff from a non-point pollution source on the river's ecological health and human use. It includes monitoring activities that assess the physical, chemical, and biological indicators of river health likely to be affected by the runoff and practical to monitor for schools or groups with limited human and financial resources:

- water sampling and analysis for indicators of runoff impacts,
- benthic macroinvertebrate sampling and analysis (wadeable rivers only),
- visual surveys of river uses, values, and threats,
- estimates of river channel composition and stability, and
- measurements of rainfall and river flow.

These activities occur upstream and downstream of the plant at *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the plant) are compared with those at the reference site (upstream of the plant) to determine the extent of the impact attributable to that plant.

Given that the methods used in Basic Non-Point Source Pollution Impact Assessment, for most indicators, are not comparable to those used by state agencies, this information will likely be used by state and federal agencies and communities for education and awareness and to identify problem areas for further monitoring, rather than setting priorities or determining the need for land use or management changes. However, Basic Non-Point Source Pollution Impact Assessment will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level. This may inspire voluntary efforts to reduce non-point source pollution.

WHY DO A BASIC NON-POINT SOURCE POLLUTION IMPACT ASSESSMENT?

We suggest that you undertake Basic Non-Point Source Pollution Impact Assessment if your primary interest is in the impact of non-point source pollution on the long term ecological health and human use of your river and you don't need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to educate and raise awareness of the participants and the public regarding the river's physical, chemical, and biological characteristics, and the impacts of non-point source pollution on them, and
- to identify gross non-point source pollution problem areas that might need action or further monitoring.

Questions Answered

1) *What are the impacts of non-point pollution sources on human use and ecological integrity of the river system or reach?*
2) *What is the effectiveness of best management practices (BMPs) to control polluted runoff in restoring and protecting human use and ecological integrity of the river system or specific water bodies?*

Data Use

The results from Basic Non-Point Source Pollution Impact Assessment can be used for several things:

- Identify plants where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about local land use practices and water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening

☐ Community & watershed level evaluation, assessment, and management

☐ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

The Basic Non-Point Source Pollution Impact Assessment involves collecting and analyzing water samples for indicators of non-point source pollution; collecting and analyzing and benthic macroinvertebrate samples; assessing benthic macroinvertebrate habitat quality; and a visual shoreline survey of uses, values, and threats. These activities are carried out above and below the plant. This basic assessment monitors many of the same indicators as the rigorous assessment, but uses simpler methods. Note that the indicators and methods listed here are appropriate for wadeable rivers only.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the nature of the non-point source pollution, and your human and financial resources:

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Select appropraite indicators/tools depending on the NPS source:		
Embeddedness →	Estimated for 4 particles at each of 11 cross sections at site (EPA EMAP Protocol or equivalent)	• **reference or control site** immediately upstream of the source
Bottom Composition	Pebble count ("Stream Channel Reference Sites" USFS or equivalent)	• **impact site** immediately downstream of the source (at the point where the impact is completely integrated with the water)
Basic Benthic Macroinvertebrate Habitat Assessment →	**Field collection w/ net, lad id. of major groups, assess based on comparison to upstream reference site (RWN Method)**	• **recovery site** downstream of the source (where the water has at least partially recovered from the impact).
Fecal Colif./*E. coli* Bacteria →	Various methods that detect presence-absence or produce an estimate of bacteria density	
Orthophosphate →	Ascorbic acid (EPA Method #365.2)	

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Select appropraite indicators/tools depending on the NPS source:		**See previous page.**
Nitrates →	Cadmium Reduction followed by color comparator (Mitchell & Stapp)	
Turbidity →	Sample collected and measured with a nephelometer and reported as NTU's (RWN) or turbidity tube reported in centimeters or inches (no source yet)	
River Flow →	**Embody Float Method (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft)**	
Rainfall →	Rain Gage or NOAA Data	

ADDITIONAL NOTES ON THE METHODS ARE CONTAINED IN APPENDIX 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

In general, we suggest monitoring non-point pollution sources when they are likely to have the greatest impacts on the aquatic ecosystem and on water contact recreation. This will vary according to the nature of its non-point pollution source and the nature of the receiving water. However, it will likely be in the summer months, during and after runoff events. We also suggest monitoring during dry weather conditions as a benchmark.

Storm event related monitoring is a challenge, because it requires being ready to collect and analyze samples on short notice. We suggest the following for each of the activities in Non-point Pollution Source Assessment:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month during the chosen time of year, both during storms and during dry weather.
- *Time of day:* Runoff event sampling is challenging. Ideally samples should be collected at regular intervals before, during and after the storm event. This is likely impractical, so we recommend immediately after storm events (to establish conditions during high or falling flows).
- *Time of year*: Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* During storm events of various intensity and duration, and during dry weather.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year:* sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Visual surveys can be conducted during storm events to locate active runoff channels for non-point source pollution.

Field Measurements of Flow and Channel Shape

- *Frequency and time of year*: Measure flows at least as frequently as water sampling, daily if possible. Measure channel characteristics in association with runoff events (see below)
- *Time of day:* not a consideration.
- *Weather*: Measure channel characteristics before and after major storm events.

DATA ANALYSIS

Results will be compared with various reference conditions during the sampling season, and over time from year to year. At a minimum, reference conditions will include the water quality standards and the results from the reference station immediately upstream of the non-point pollution source. Given the methods used in the basic non-point source assessment, the comparison with the upstream reference site will be qualitative, rather than statistical. Only apparently large differences in results will be noted.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Basic Non-Point Source Pollution Impact Assessment does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

TRAINING REQUIRED

Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection and visual survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[20] proper training is essential. We suggest a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

[20] This is a lab set up by a watershed group or school

G. NON-POINT SOURCE POLLUTION SITE EVALUATION

WHAT IS IT?

A Non-point Source Pollution Site Evaluation is a systematic approach for trained volunteers to evaluate the seriousness of non-point source pollution. Non-point pollution sources are land-based and diffuse, rather than come out of a pipe. Examples of potential sources include construction sites, logging operations, agriculture, animal husbandry, on-site septic systems, lawns and gardens, and urban runoff. This evaluation takes place at a particular site.

For each type of non-point source site to be evaluated there are specific questions on site worksheets that relate to visual indicators, impacts, best management practices (land management activities that minimize polluted runoff), and characteristics of the particular land use activity.

The evaluation covers the following processes at work on a site (working from the site to the receiving water):

- potential for non-point source pollution production,
- evidence of non-point source pollution production,
- control measures,
- potential for export from the site, and
- evidence of export from the site.

Each type of land use activity has its own worksheet and evaluation process.

When combined with river and/or lake monitoring, this evaluation gives a comprehensive picture of the production, transport, and impact of non-point source pollution from a specific site. This information can be used by communities and landowners to assess the need for changes in land use practices and management to protect rivers and lakes from non-point source pollution.

WHY DO A NON-POINT SOURCE POLLUTION SITE EVALUATION?

We suggest that you undertake Non-Point Source Pollution Site Evaluation if your primary interest is in the potential of specific sites to produce polluted runoff which may affect your river or lake and you need to produce semi-quantitative data that will enable communities to take action, or to change land use or management practices. When coupled with Non-point Source Pollution Impact Assessment, you can also assess the impact of these discharges on the river or lake ecosystem.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to assess the potential for land use practices in the watershed to affect waters,
- to assess the on-site effectiveness of best management practices, and
- to establish high priority sites for remediation.

Questions Answered

What is the potential for land use practices in the watershed to affect waters?

Data Use

The results from Non-Point Source Pollution Site Evaluation can be used for several things:

- Identify sites where land use and management changes are needed to enable the water body to support healthy aquatic life and human uses,
- Set priorities for funding water non-point source pollution control projects, and
- Evaluate whether on-site best management practices are working.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

The Non-Point Source Pollution Site Evaluation involves a series of on-site observations of various indicators of the production, transport, and control of polluted runoff. These observations are organized on field sheets, with different pages for different types of land uses (e.g. logging, construction, dairy farming, etc.) that have the potential to cause non-point source pollution problems. Surveyors select the method that assesses the relevant land use:

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Various on-site indicators of production, transporrt, and attenuation of NPS pollution →	UNH Coop. Ext.	• Sites where it is suspected that non-point source pollution may be polluting surface waters.

ADDITIONAL NOTES ON THE METHODS ARE CONTAINED IN APPENDIX 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

We recommend carrying out a Non-Point Source Pollution Site Evaluation at least once per year. Also consider carrying out evaluations after runoff events.

DATA ANALYSIS

Observations made for the evaluation are scored (from 0 - 1.0). Observations and scores are grouped by the following categories:

- potential for NPS production,
- evidence of NPS production,
- effectiveness of control measures,
- potential for export off the site, and
- evidence of export off the site.

Scores for the observations are totaled in each of these categories. Scores are evaluated low, medium, or high.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

A Non-Point Source Pollution Site Evaluation does not require extensive quality assurance. However, some of the general QA/QC for sampling and analysis and general quality assurance measures for data management in Chapter IV should be reviewed. In addition, photo and/or video documentation of the sites is recommended to serve as visual documentation of problems and processes as well as to provide a tool to train surveyors.

TRAINING REQUIRED

In New Hampshire surveyors should initially be trained by the University of New Hampshire Cooperative Extension, who developed the evaluation, or a designated VEMN partner. In Massachusetts, surveyors should be trained by a designated VEMN partner. At or following the training, surveyors should be observed in the field, gathering data, to assure that they are following procedures correctly. Follow up field audits can also help catch problems which may develop. New surveyors should be trained by the program coordinator or by an experienced surveyor.

H. STORMWATER DISCHARGE MONITORING

WHAT IS IT?

Stormwater Discharge Monitoring focuses on locating pipes that discharge stormwater (as opposed to sanitary wastewater) and sampling the effluent coming out of those pipes during dry and wet weather to determine its quality and potential to affect rivers and lakes. The effluent is sampled and analyzed using methods that are comparable to those used by state agencies.

Rigorous Non-Point Source Pollution Impact Assessment is geared to produce high quality information which can be used by state and federal agencies and communities to set pollution control priorities, as well as to assess the need for changes in stormwater management practices.

WHY DO STORMWATER DISCHARGE MONITORING?

We suggest that you undertake Stormwater Discharge Monitoring if your primary interest is in the location and quality of stormwater discharges and you want to produce data that federal and state agencies will use for their assessment activities. When coupled with Non-point Source Pollution Impact Assessment, you can also assess the impact of these discharges on the river or lake ecosystem.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to assess the quality of stormwater discharges,
- to estimate pollution loadings from stormwater,
- to provide information communities can use to assess the need for changes in stormwater management and treatment, and
- to provide information state and federal officials can use to set pollution prevention and control priorities.

Questions Answered

How effective are stormwater management and treatment strategies?

Data Use

The results from Stormwater Discharge Monitoring can be used for several things:

- Identify stormwater discharges that may be receiving sanitary wastewater flows,

- Identify stormwater discharges that have the potential to affect human use and aquatic life,
- Set priorities for funding water combined stormwater/sewer separation projects, and
- Evaluate whether stormwater management measures are working.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☑ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

Stormwater Discharge Monitoring involves an inventory of the stormwater discharge pipes in the area, coupled with collection and analysis of samples of the effluent discharged from the pipes.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the suspected nature of the discharge from the pipes, and your human and financial resources.

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Select appropraite indicators/tools depending on the NPS source:		Stormwater is sampled at outfalls
E. coli Bacteria (NH) →	Membrane filtration w/ mTEC with confirmation (EPA# 1103.1 or equivalent)	
Fecal Coliform Bacteria (MA) →	Membrane filtration w/ mTEC *without* confirmation (EPA# 1103.1 or equivalent)	
Biochemical Oxygen Demand →	**5-day BOD test (SM #5210-B) using Modified Winkler Titration**	
Turbidity →	Sample collected and measured with a nephelometer (SM #2130 or equivalent)	
pH →	1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) 2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Total Dissolved Solids →	Gravimetric methods: Total Solids Dried at 103-105 degrees C (SM #2540 B) and Total Dissolved Solids Dried at 180 degrees C (SM #2540 C)	Stormwater is sampled at outfalls
Temperature →	Direct measurement with a thermometer	
Total Phosphorus →	**Persulfate digestion followed by ascorbic acid (RWN adaptation of EPA Method #365.2)**	
Visual field survey of river, riparian, and watershed characterisitics, uses, values, and threats (including pipe inventory) →	Shoreline / Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	
Conductivity →	Direct measurement with meter (EPA Volunteer Methods Manual) or pen (RWN)	

Additional notes on the methods are contained in Appendix 1.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

We suggest monitoring stormwater discharges during storm events, when they are flowing. Also sample during dry weather if they are flowing. Storm event related monitoring is a challenge, because it requires being ready to collect and analyze samples on short notice.

DATA ANALYSIS

Results should be analyzed according to permit conditions (if applicable), water quality standards, or other water quality criteria or guidance recommended by your technical committee.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Stormwater Discharge Monitoring requires rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan, or at the request of the program coordinator.

TRAINING REQUIRED

Field Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water sample collection and pipe survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[21] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[21] This is a lab set up by a watershed group or school

I. WASTEWATER COMPLIANCE SURVEY

WHAT IS IT?

A Wastewater Compliance Survey focuses on reviewing the discharge monitoring reports from wastewater treatment plants. Discharge monitoring reports summarize the results of periodic testing of the effluent from the plant as required by the plant's NPDES[22] permit. This survey is sometimes known as "the good, the bad, and the ugly."

A Wastewater Compliance Survey examines discharge monitoring reports to see whether nine indicators are within the *effluent limits* set in the plant's permit. Effluent limits specify acceptable levels of pollutants in the discharge. A high percentage of violations signifies a high pollution potential and the possible need for wastewater treatment plant upgrades.

A Wastewater Compliance Survey is geared to produce information which can be used to raise the level of community awareness regarding the performance of their wastewater treatment plants.

WHY DO A WASTEWATER COMPLIANCE SURVEY?

We suggest that you undertake a Wastewater Compliance Survey if your primary interest is in the compliance of a particular plant with their permit and the possible need for an upgrade. When coupled with Wastewater Treatment Plant Impact Assessment, you can also assess the impact of these discharges on the river or lake ecosystem.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to increase public awareness of wastewater treatment issues, and
- to encourage public support for treatment plant upgrades, where needed.

Questions Answered

Is a wastewater treatment plant operating within the limits of its permit?

[22] NPDES = National Pollution Discharge Elimination System. EPA issues NPDES permits, but can delegate this authority to qualifying states. Permits are renewed (and possibly amended) every 5-years. Public hearings are a part of the renewal process.

Data Use

The results from the Wastewater Compliance Survey can be used for several things:

- alert the public to the fact that there are treated discharges to waters and that water quality is still an issue,
- encourage communities to support funding for upgrades to their plants, and
- to provide information communities can use to assess the need for changes in wastewater treatment.

PRIMARY DATA QUALITY GOALS ADDRESSED

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☐ State, interstate, and Federal water quality evaluation and assessment

MONITORING OPTIONS

A Wastewater Compliance Survey involves a review of the effluent limits in a wastewater treatment plant's permit and a review of the plant's discharge monitoring reports for a year. The review focuses on nine indicators:

- Biochemical Oxygen Demand
- Oil and Grease
- Fecal Coliforms or *E. coli*
- Metals
- Flow
- Total Suspended Solids
- Chlorine
- Toxicity[23]
- Temperature

Each instance where the level of an indicator is outside the limits in its permit, it is flagged as a violation.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the suspected nature of the discharge from the pipes, and your human and financial resources.

HOW FREQUENTLY AND WHEN SHOULD YOU MONITOR?

Discharge monitoring reports should be reviewed annually.

[23] Based on tests on representative organism

DATA ANALYSIS

The number of violations for each indicator is divided by the total number of samples for all indicators to come up with a percent violation. A percent violation of <5% is considered “good”, 6-25% is considered “bad”, >25% is considered “ugly”. This analysis does not consider the effectiveness of the permit, only the extent to which the facility complies with its NPDES limits.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

A Wastewater Compliance Survey does not require QA / QC, since it does not involve actual sampling. However, figures transcribed from permits and discharge monitoring reports should be double-checked for accuracy.

TRAINING REQUIRED

The training involved with the Wastewater Compliance Survey is focused on how to read the effluent levels in a permit and how to read discharge monitoring reports. Surveyors should be trained by either MA Riverways or Mass Audubon.

CHAPTER IV. GENERAL QUALITY ASSURANCE MEASURES

This chapter describes quality assurance in general, describes quality assurance measures, and recommends specific quality control measures for each indicator that involves lab analysis recommended in Chapter III. It includes the following sections:

A. About Quality Assurance

B. Quality Assurance for Sampling and Analysis

- Common Internal Quality Controls and How They Are Assessed
- Common External Quality Controls and How They Are Assessed
- Recommended Quality Controls To Meet VEMN Data Quality Goals

C. Quality Assurance for Data Management

A. ABOUT QUALITY ASSURANCE

Quality Assurance (QA) measures are the operating procedures that you use to assure and assess the quality of the information you collect. It's designed to assure that the information you collect meets your data quality goals.

Quality assurance includes procedures for sampling and analysis and data management.

Quality Assurance for Sampling and Analysis includes training, documentation, quality control, and quality assessment.

Quality Assurance for Data Management includes measures to assure that the data are properly recorded on field and lab sheets and accurately transferred to a computer or summary sheet.

B. QUALITY ASSURANCE FOR SAMPLING AND ANALYSIS

Training is a form of quality assurance that has already been covered in this workbook. In the quality assurance section of your study design, you simply describe the training procedures to ensure that your field and laboratory personnel are properly trained. Describe any training workshops or other types of training that volunteers must undergo before they can collect and analyze samples. Some programs even require that program personnel certify in writing that each volunteer has completed a training workshop or series.

Documentation of your field and laboratory procedures is critical for quality assurance. In fact, your study design itself is an example of this type of quality assurance. Other examples include your field and laboratory manuals that the volunteers will use to collect and analyze samples, written directions to the sampling locations, sample labels, and your field and laboratory data recording sheets. This also includes a set of procedures known as "chain of custody." Chain of custody refers to documenting each person that handled the sample. Unless your data is going to be used in some legal or regulatory proceeding, it can be as simple as having places on your field and data sheets for samplers and analysts to sign when they take custody of and complete their work on a sample.

Quality Control (QC) consists of the steps you take during the collection and analysis of your samples to ensure the *accuracy* (how close to the real result you are) and *precision* (how reproducible your results are) of your monitoring. The purpose of quality control procedures is to let you know right away if you have a problem, so that you can correct it. Quality control procedures include both *internal checks* performed by the project field volunteers, staff, and lab and *external checks* performed by non-volunteer field staff and a lab (or "quality control lab"). Common types of quality control samples and how they are assessed are listed in the next two sections.

Quality Assessment is your assessment of how accurate and precise your data actually are after you've collected and analyzed the samples. This involves calculating the accuracy and precision of your quality control samples and comparing them to your data quality requirements (See Step 3 of Part I for definitions of these terms). Assessment of quality control samples is described in the next section.

For some quality control results, the following statistical measures are used:

Standard deviation is used to compare how closely three or more values are clustered around the average value. It is expressed as a ± from the average value. The lower the value, the more precise the results.

Coefficient of Variation: This is the standard deviation as a percentage of the average. The lower the percentage, the more precise the results.

Relative Percent Difference is used to compare how close the result from a water sample is to the true result. It is expressed as either a positive difference (the sample result is higher than the true value) or negative difference (the sample result is higher than the true value). The lower the value, the more precise the results.

% Recovery: This is the percentage of the substance added to a spiked sample (see below) that is detected. It's the difference between the concentration detected in the spiked sample and that detected in the unspiked sample, divided by the concentration of the substance added to the spiked sample.

Your study design should describe the measures you will take if you don't meet your data quality requirements. Examples might include not using some of your data, changing laboratory methods, equipment, or field procedures; requiring more training; changing the field or lab sheets, etc.

COMMON INTERNAL QUALITY CONTROLS AND HOW THEY ARE ASSESSED

These are checks performed by the project field volunteers, staff, and lab.

Trip (Field) Blanks: A trip blank (also known as a field blank) is de-ionized water which is poured into a sample container in the field as if it were a river or lake sample. Trip blanks are usually collected at 10% of the sampling sites. They are used to identify errors or contamination in sample collection and analysis.

Assessment of Results: The results should be "0."

Negative and Positive Plates (For bacteria): *Negative plates* result when the buffered rinse water (the water used to rinse down the sides of the filter funnel during filtration) has been filtered the same way as a sample. This is different from a field blank in that it contains reagents used in the rinse water. There should be no bacteria growth on the filter after incubation. It is used to detect laboratory bacteria contamination of the sample. *Positive plates* result when water known to contain bacteria (such as wastewater treatment plant influent) is filtered the same way as a sample. There should be plenty of bacteria growth on the filter after incubation. It is used to detect procedural errors or the presence of contaminants in the laboratory analysis that might inhibit bacteria growth. Positive and negative plates are usually run before the first water sample is filtered, every ten samples thereafter, and after the last sample has been filtered.

Assessment of Results: The results for negative plates should be "0." The results for positive plates should be "too numerous to count."

Field Duplicates: A field duplicate is a duplicate river or lake sample collected by another sampler or team. Field duplicates are usually collected at 10% of the sampling sites. They are used to determine total (both sampling and laboratory analysis) precision.

Assessment of Results: The results for two samples should be compared using the relative percent difference between them. The results for three or more samples should be compared using the standard deviation among them. Results are compared with data quality requirements.

Lab Duplicates: A lab duplicate is a sample that is split into two or more sub-samples at the lab. Each sub-sample is then analyzed and the results compared. Usually, 10% of the samples are split into lab duplicates. They are used to determine the precision of the laboratory analysis.

Assessment of Results: The results for two samples should be compared using the relative percent difference between them. The results for three or more samples should be compared using the standard deviation among them. Results are compared with data quality requirements.

Equipment Calibration: All analytical equipment should be calibrated according to the manufacturer's instructions. Three common techniques are the calibration blank, calibration standards, and calibration to a reference device:

Calibration Blank: A calibration blank is de-ionized water processed like any of the samples and used to "zero" the instrument. It is the first "sample" analyzed and used to set the meter to zero. This is different from the field blank in that it is "sampled" in the lab. It is used to check the measuring instrument periodically for "drift" (the instrument should always read "0" when this blank is measured). It can also be compared to the field blank to pinpoint where contamination may have occurred.

Assessment of Results: The results of periodic checks should be "0."

Calibration Standards: Calibration standards are used to calibrate a meter. They consist of one or more "standard concentrations" (made up in the lab to specified concentrations) of the indicator being measured, one of which is the calibration blank. Calibration standards can be used to calibrate the meter before running the test, or they can be used to convert the units read on the meter to the reporting units (for example, absorbance to milligrams per liter).

Assessment of Results: The meter should read the expected concentration.

Calibration to Reference Device: A reference device is an instrument known to produce accurate and precise readings The most commonly used reference device is a "precision thermometer" certified by the National Institute of Standards and Technology (NIST). Readings from your thermometers are checked against one that is NIST certified. Readings from your thermometers are corrected depending on how closely they match readings from the precision thermometer.

Assessment of Results: The instrument should read the same result at the reference device. If not, an acceptable correction factor should be applied.

Spike Samples: A sample is split into two subsamples in the lab. One is analyzed according to the specified procedure. The other is treated by adding a known amount and concentration of the indicator being measured, then running the specified procedure. This should increase the concentration in the spiked sample relative to the unspiked sample by a predictable amount. Usually, 10% of the samples are split and spiked. They are used to test the accuracy of the laboratory method.

Assessment of Results: The percent of the indicator "recovered" by comparing the spiked to the unspiked sample is determined. Results are compared with data quality requirements.

COMMON EXTERNAL QUALITY CONTROLS AND HOW THEY ARE ASSESSED

These are checks performed by non-volunteer field staff and a lab (also known as a "quality control lab"). The results are compared with those obtained by the project lab.

Outside Lab Analysis: Some analyses are very difficult for volunteer labs to perform accurately and precisely. For these, the best answer may simply be to send your samples to a professional state or EPA-certified lab. This lab should have an EPA-approve Quality Assurance Project Plan that covers the indicator(s) you wish them to analyze.

External Field Duplicates: An external field duplicate is a duplicate river or lake sample collected and processed by an independent (e.g. professional) sampler or team. It is used to estimate total (sampling and laboratory) analysis accuracy.

Assessment of Results: The results for two samples should be compared using the relative percent difference between them.

Split Samples: A split sample is a sample that is split into two sub-samples at the lab. One sub-sample is analyzed at the project lab and the other is analyzed at the independent lab and the results compared. Usually, 10% of the samples are split.

Assessment of Results: The results for the two samples should be compared using the relative percent difference between them.

Taxonomic Verification (for Benthic Macroinvertebrates): Benthic macroinvertebrate samples identified by volunteers should be preserved and archived. Usually, 10% of these samples are identified to the same taxonomic level as the volunteers by a professional biologist or entomologist. A reference collection should be assembled with representatives of key taxa.

Assessment of Results: The identifications are compared.

Knowns: The quality control lab sends samples for selected indicators, labeled with the concentrations, to the project lab for analysis prior to the first sample run. Usually, three knowns are supplied that contain concentrations at the low end, in the middle, and at the high end of the range likely to be found in the water samples. These samples are analyzed and the results compared with the known concentrations. Problems are reported to the Quality Control Lab.

Assessment of Results: The results for the two samples should be compared using the relative percent difference between them.

Unknowns: The quality control lab sends samples to the project lab for analysis for selected indicators, prior to the first sample run. The concentrations of these samples are unknown to the project lab. Usually, three unknowns are supplied that contain concentrations at the low end, in the middle, and at the high end of the range likely to be found in the water samples. These samples are analyzed and the results reported to Quality Control Lab. Discrepancies are reported to the project lab and a problem-identification and solving process will follow.

Assessment of Results: The results for the two samples should be compared using the relative percent difference between them.

RECOMMENDED QUALITY CONTROLS TO MEET VEMN DATA QUALITY GOALS

The following tables recommend quality controls for indicators requiring some type of lab analysis.

Table 1 lists the controls recommended to meet the state and federal agency water quality assessment data quality goal.

Table 2 lists the controls recommended to meet the education and awareness and the community and watershed assessment data quality goals.

Recommended Quality Control Measures for State and Federal Water Quality Assessment

These tables are guidance only. Many of the measures listed in the table require that you work with a quality control lab. Consult with your technical committee and your quality control laboratory for specific quality control measures for your program. Note particularly the indicators checked in the "Outside Lab Analysis" row. For these indicators, we recommend that you consider having a certified state or professional lab perform the analyses due to the expense and difficulty of the lab analysis.

Table 1: Quality Checks for State and Federal Water Quality Assessment

	FC/EC	DO	Turb	Secchi	T	pH	Alk
Internal Checks							
Field Blanks	√		√				
Field Duplicates	√	√	√	√	√	√	√
Lab Replicates	√♣	√	√			√	√
Positive Plates	√						
Negative Plates	√						
Spike Samples (Std. Add.)							√
Calibration Blank			√		√		
Calibration to Reference Device					√		
Calibration Standard		√*	√			√	
External Checks							
External Field Duplicates	√		√	√		√	√
Split Samples	√		√			√	√
Outside Lab Analysis•	√						
Verification							
Knowns		√	√			√	√
Unknowns		√	√			√	√

Phos=Total/Total Dissolved Phosphorus
Solids=Total/Total Dissolved Solids
* using an oxygen-saturated sample
♣ using subsamples of different sizes
• analysis expensive or difficult - consider analysis by a certified lab instead of the project lab

Table 1 (cont.): Quality Checks for State and Federal Water Quality Assessment

	Cond	Phos	Nitrog	Solids	Chlo	Benthics	Habitat
Internal Checks							
Field Blanks	√	√	√	√	√		
Field Duplicates	√	√	√	√	√	√	√
Lab Replicates	√	√	√	√	√		
Positive Plates							
Negative Plates							
Spike Samples (Std. Add.)		√	√				
Calibration Blank	√	√	√		√		
Calibration to Reference Device							
Calibration Standard	√	√	√				
External Checks							
External Field Duplicates	√	√	√	√	√	√	√
Split Samples	√	√	√		√		
Outside Lab Analysis •		√	√	√	√		
Verification						√	
Knowns	√	√	√			√	
Unknowns	√	√	√			√	

FC / EC=Fecal coliform / E. coli
Chlo=chlorophyll a
Nitrog=all species
• analysis expensive or difficult - consider analysis by a certified lab instead of the project lab *
using an oxygen-saturated sample
♣ using subsamples of different sizes

Recommended Quality Control Measures for Education and Awareness and Community and Watershed Assessment

Quality control for these data quality goals does not necessarily require external checks, so these are not listed in the table. However, you may decide to carry out a few to check your accuracy and precision either for educational purposes or because a local data user requires it.

Table 2: Quality Checks for Education, Awareness, and Problem Screening

	FC/EC	T	pH	Alk	DO	Secchi	Cond	Benthics	Habitat
Internal Checks									
Field Blanks	√						√		
Field Duplicates	√	√	√	√	√	√	√	√	√
Lab Replicates	√		√	√	√		√		
Positive Plates	√								
Negative Plates	√								
Spike Samples (Std. Add.)				√					
Calibration To Ref. Device		√							
Calibration Blank		√					√		
Calibration Standard			√		√*		√		

* using an oxygen-saturated sample

♣ using subsamples of different sizes

C. QUALITY ASSURANCE FOR DATA MANAGEMENT

This includes measures to assure that the data are properly recorded on field and lab sheets and accurately transferred to a computer or summary sheet.

Field and Lab Sheets: These should be laid out clearly with the following information:

- Samplers' Names
- Site #
- Sample Container Type
- Container #
- Time the Sample Was Taken
- Sample Preservation (if any)
- Time the Sample Was Dropped off at the Lab
- Name of the Person Who Checked the Samples In (person transporting samples)
- Results in Analysis Units
- Results in Final Reporting Units
- Analysts Name
- Time Analysis Was Performed

Data Entry and Validation: If a computer is used, data should be entered by one person, if possible. The data entered into the computer must be checked against the raw data from the field and lab sheets to ensure that it has been entered correctly. Ideally, this should be done by someone other that the person who entered the data.

Data Analysis: Even if your results are entered correctly and meet your data quality objectives, you should be on the lookout for numbers which seem to be much higher or much lower than typical results. These are called outliers. Do you have confidence that these numbers are reliable? Verify that these numbers were transcribed or entered correctly.

CHAPTER V. SUPPORT AVAILABLE FROM THE VEMN

The **Merrimack River Initiative** was started in 1988 to promote holistic management of natural resources throughout the Merrimack River Watershed. Participants recognize the dual benefits of developing a watershed-wide base of information and of building a strong watershed constituency by supporting citizen groups who want to conduct their own surveys. To meet these objectives, the **Volunteer Environmental Monitoring Network** (VEMN) was organized.

The VEMN provides services to volunteer environmental monitoring groups in the Merrimack River Watershed. These services include guidance in the form of documents and manuals, training, consulting, and connecting volunteer groups to resources in their communities. The purpose of the VEMN is to coordinate all the volunteer monitoring efforts and to develop a complete picture of water quality throughout the watershed.

The VEMN is developing an array of organizational and training services for new and existing groups. One major aim of the VEMN is to more closely integrate volunteer monitoring programs into environmental management decisions that are made in the Merrimack River Watershed every day at every level of human activity.

The guidelines laid out in this and in other VEMN products, will help citizen groups build effective local programs that also contribute to a watershed-wide view of the health of the Merrimack River Watershed.

Over the past two years, VEMN staff and partners have developed an array of written guidance documents (we call them "tools") that can assist volunteer monitoring groups in the watershed with a wide range of program challenges. They are available in written and, in many cases, electronic form. They are summarized on the following pages.

VEMN Tools

- ***Characteristics of a Successful Volunteer Water Quality Monitoring Program***

  This outline includes organizational and technical characteristics that the VEMN has found to be associated with successful programs. It can be used as a means for volunteer groups to evaluate themselves and plan for future work. The document outlines successful organizational characteristics in the following areas:

  - Mission
  - Community Support
  - Funding
  - Leadership
  - Volunteers
  - Data Use
  - Achievement
  - Community Outreach and Public Education

  It also outlines successful technical characteristics in the following areas:

  - Study Design
  - Quality Control
  - Data Management and Reporting

- ***Guidelines For Subwatershed Groups on Preparing Scientific Study Designs***

  This is a comprehensive guidance document that describes the process by which freshwater river and lake monitoring groups design customized monitoring programs to address issues important to their watersheds. It is one of the most useful products the VEMN offers to volunteer monitoring groups interested in designing studies which will provide data to a wide range of users, from state and federal agencies to local town citizens and businesses.

  Part I of the Study Design Manual will take you through the study design process. It includes worksheets for each part of your study design which you can fill out as you go and you can actually use the compilation of these worksheets as your final study design document. If you start with the three core assessments, you can easily complete the worksheets for Steps 2 through 5 and Step 9 (there are only 9 steps) of your study design. You will still need to determine where and when you will monitor and who will do the monitoring.

  When you are ready to design your study, Parts II and III of the Study Design Manual will help you with the specific steps.

  Part II is a listing of issues and questions that monitoring can address. Seven basic questions with more specific sub-questions are listed. Use this to help with Step 2 in the study design process; to choose questions that best suit your group.

Part III of the Study Design Manual is a guide to choosing users and uses of data and data quality goals that work for your group. Use this part to help you with Step 4 in your study design process.

- ***VEMN Guide To Volunteer Watershed Monitoring Options In the Merrimack River Watershed***

  This document supplies monitoring groups with a menu of monitoring study design options in order to help them design programs which gather information that can be used by a wide range of water management and education entities. It is intended to be an expandable library to which new study designs may be added as they are used in the watershed by volunteer groups. The menu includes study designs for watershed assessment, water quality standards assessment, a health risk assessment, non-point source pollution site evaluation, non-point source pollution impact assessment for agriculture, waste water treatment plant impact assessment, baseline assessments for rivers and lakes, stormwater discharge assessment and wastewater discharge compliance. The study designs explain the questions and issues that each will address, explain who can use the information collected using the study design and for what purpose, describe indicators that should be used and reference the collection and analysis methods, explain the types of water bodies for which each study may be used, describe the necessary quality control, explain site selection considerations, frequency and timing of sampling, and outline training requirement for each study.

- ***VEMN Training Manual of Core Monitoring Parameters and Methods***

  This manual fully describes and documents the procedures and quality control measures needed to do the core assessments recommended by VEMN for all monitoring groups:

  1. *Watershed Assessment* - how to carry out a visual survey and evaluation of the water and surrounding areas in order to gather basic resource information in preparation for other types of monitoring.
  2. *Water Contact Health Risk Assessment* - how to carry out a combination of water sampling and data gathering (by sampling the human population via questionnaires and other techniques) on actual disease occurrence to see if there's a relationship between water quality, water contact and illness.
  3. *Water Quality Standards Assessment* - how to collect and analyze water samples for water quality indicators that the states of Massachusetts and New Hampshire use to determine how well our waters comply with state standards for their designated uses.

These core assessments will help us gather basic information on watershed characteristics, assist communities and water users to assess health risks associated with water contact, and contribute to federal and state information on the quality of our waters.

- ***How To Interpret Monitoring Data***

  This is a quick outline of steps to take once monitoring data has been collected. It takes the reader through the interpretation process so that numeric monitoring results may become meaningful statements that call forth action, assist in planning and make the results palatable for general consumption.

- ***How To Report Monitoring Data***

  This compilation of standardized report forms make reporting data easy and therefore ready to present to data users at all levels.

- ***Volunteer Environmental Monitoring Network Integrated Support System***

  The VEMN support system is intended for use by anyone who is engaged in or interested in water quality monitoring in the Merrimack River Watershed. This includes state, local and federal agencies, businesses and industries, schools, advocacy groups, non-profits, volunteer monitoring groups and individual citizens.

  This document and database was based on interviews with numerous organizations and agencies associated with water quality monitoring or watershed management. Survey participants were asked to provide information on the services they could offer to support the VEMN. After reviewing interview results, the VEMN Steering Committee made several additional recommendations on roles that various government and non-government organizations can play.

  The VEMN Integrated Support System can also help you locate monitoring groups in your area with which you might want to collaborate.

  This 27 page document is organized into seven support system categories:

  - Training
  - Consultation
  - Work
  - Funds
  - In-Kind Support
  - Information Available
  - Expertise

  This product is available in both computer database format (you will need Microsoft Access for Windows to run the database) or report format. Contact the VEMN coordinator on how you may access the database directly.

- ***Report: Status of Existing Volunteer Monitoring Programs in the Merrimack River Watershed and Recommendations for Changes***
  This report provides an overview of the current status of monitoring programs in the Merrimack River basin and a guide for identifying areas in which VEMN can develop an enhanced array of services for new and existing volunteer monitoring groups. The report also informs volunteer groups of the activities of their counterparts throughout the basin. A list of volunteer groups participating in the survey as well as a copy of the survey used to collect the information for this report is included in the Appendix.

- ***Citizen's View Of the Merrimack River Watershed***
  This report compiles the monitoring results and narratives from citizen volunteer groups throughout the Merrimack River Watershed in 1996. It will provide an inventory of active citizen groups in each subwatershed and the water bodies that they monitor, the issues that the groups are working on, what they found, the actions they have taken as a result of their findings and their recommendations for further research. This report will be in the proceedings from the 1st Annual Merrimack River Watershed Volunteer Environmental Monitoring Network Conference.

- ***The VEMN Long Term Strategic Plan***

  The VEMN Steering Committee has worked over the last year to come up with long term goals for its staff. It describes the VEMN mission, the five main goals of the VEMN and an action plan for achieving those goals. The plan also describes how the VEMN will measure its success in reaching its chosen goals.

- ***The VEMN World Wide Web Site***
  can now be reached through the internet. It is part of the Merrimack Web Site and can be found at: **http:\\www.merrimack.org.** Surf by and download all available VEMN products, send your monitoring data to VEMN headquarters or just drop a note to the coordinator. In the future, you will be able to post messages to other monitoring groups in the VEMN on the bulletin board. This is the way the network will communicate and it will also serve as a central data repository for volunteer monitors throughout the Merrimack River Watershed.

TYPES OF ASSISTANCE AVAILABLE THROUGH THE VEMN

Assistance through the VEMN is available both through VEMN staff and through organizations and agencies that have agreed to be service providers. Following is a brief description of the services that the VEMN can provide[24]:

1) TRAINING, CONSULTATION AND WORK

Training gives groups the skills they need to do their own work, *consultation* is advice on particular questions and problems on a one to one basis, and *work* means exactly that; that the organization can do the work for or with the interested party. The comments section under each organization can help specify the types or amounts of assistance available. *Training, consultation* and *work* are available to monitoring groups in the following areas:

a) ***Program planning***

i) *Organizational* - includes designing a mission for the organization with measurable goals and an action plan to achieve those goals, creating a strategic plan, a multiple year budget and a fundraising plan, gaining community support, fostering leadership, and attracting and keeping volunteers.

ii) *Technical* - includes identifying the issues that will be the focus of study, determining the users and uses for the data, choosing monitoring parameters, choosing sampling sites, determining sampling frequency and length of sampling season, defining sampling and analysis methods along with a quality control plan, and writing it all down in a scientific study design.

b) ***Program coordination*** - includes finding and setting up training for volunteers, ordering or locating monitoring supplies, finding or setting up a laboratory for sample analysis and getting a program started.

c) ***Field Work*** - includes all work done in the field such as habitat assessments, shoreline surveys, sampling, sample fixing, etc.

d) ***Lab Work*** - all aspects of sample analysis and quality assurance / quality control (QA / QC).

e) ***Data Management*** - designing an effective system for storage, analysis and retrieval of data for all aspects of a monitoring program, from storing monitors names, addresses and phone numbers, to complex analysis of diversity in a macroinvertebrate study.

f) ***Data Presentation*** - finding the best methods for presenting data in all forms including reports, public displays and public presentations.

[24] A detailed description of services is available in the “Volunteer Environmental Monitoring Network Integrated Support System” document.

g) ***Data Use*** - determining the most effective users and uses of volunteer data and designing monitoring studies and data management systems to best fulfill those uses.

h) ***Manuals and/or Guides*** - written documents available for guidance in all aspects of volunteer monitoring.

2) FUNDS

This includes organizations that can provide funding, those which can help locate sources of funds and those which can collaborate on funding efforts. The comments section under each organization will specify the type of funding assistance that the organization can provide.

3) IN-KIND

In-Kind or non-funding donations are available in the areas of equipment, people (like volunteers), and products or materials. As with the other categories, the comments section will specify the types of in-kind services available. The areas of in-kind donations can be further explained as follows:

a) ***Equipment*** - includes monitoring equipment, computer equipment, lab equipment or any other types of equipment that may be useful. This equipment may be donated or loaned.

b) ***People (non-experts) - Time*** - distinct from experts who can provide technical help, this area of services refers to general people who may perform any type task. They may be volunteers who will participate in monitoring, or it may mean that companies are offering their staff time for clerical help such as putting together mailings, making copies, etc.

c) ***Products/Materials*** - includes donations of goods by organizations. These goods can include anything that is produced or bought by any organization from paper to food to entire computer systems.

4) INFORMATION AVAILABLE

Service providers offer an array of information about their programs as well as their own documentation. The VEMN has compiled a library of this information and can help you figure out what you need.

5) EXPERTISE

This includes people that are experts in various areas of interest for volunteer monitoring groups, from science to policy to organizing and fundraising. The ***Expertise*** category shows all areas in which experts are available. These experts will specify whether they are willing to review and comment on any work or data that a monitoring group produces, whether they are willing to be telephoned and whether they are willing to serve on an advisory committee. The experts are a valuable resource that should be used to the fullest because of their knowledge and experience.

VEMN SERVICE PROVIDERS

VEMN Service providers are organizations and agencies that have agreed to provide consultation, training, and other services to VEMN groups. The VEMN coordinator is the liaison between the organizations listed and volunteer monitoring groups. *Requests for support should be directed to:*

* *Merrimack VEMN Coordinator Merrimack River Watershed Council*, 181 Canal Street, Lawrence MA 01840. Contact Laura Mattei –978-681-5777.

The VEMN Coordinator will negotiate with service providers on your behalf. In most cases, *the degree of assistance must be discussed with the provider* because support is often dependent upon availability of staff, funding, equipment, etc.

The following organizations and agencies have agreed to provide services to VEMN groups:

- *Massachusetts Department of Environmental Protection*, Office of Watershed Management. P. O. Box 116, N. Grafton MA. Contact: Brian Friedmann, 508-792-7470.
- *Massachusetts Water Watch Partnership*. Blaisdell House, University of Massachusetts, Amherst MA 01003. Contact: Jerry Schoen 413-545-2842. 413-545-2304 Fax.
- *Massachusetts Riverways Program*. MA DFWELE, 100 Cambridge Street, Boston MA 02202. Contact: Joan Kimball or Cindy Delpapa, 617-626-1540.
- *NH DES, Volunteer River Assessment Program (VRAP)*, 6 Hazen Drive, Concord NH 03302-0095. Contact: Beth Malcolm, 603- 271-2083
- *River Network*. 153 State Street, Montpelier VT 05602. Contact Geoff Dates, 802-436-2544 or 223-8083.
- *UNH Cooperative Extension*. UNH CES, 109 Pettee Hall, UNH, 55 College Road, Durham, NH 03824-3599. Contact Jeff Schloss, 603-862-3848.
- *US EPA. Region 1*, JFK Building, Boston MA, 02203. Contact: Diane Switzer 617-860-4377

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APPENDIX 1: INDICATORS AND MONITORING METHODS

This appendix contains general information about watershed indicators and methods.

Descriptions of Indicators and Methods Options: Water Sampling and Analysis

This section describes the indicators and methods options for collecting and analyzing water samples. The table below covers basic information about sampling containers, sample sizes, preservation techniques, and holding times.

Sample Handling Requirements (from Standard Methods)

Indicator	Container Type	Minimum Size (mL)	Preservation	Max. Holding Time
Alkalinity	P, G	200	Ref.	24 h
Bacteria	P, G (S)	200	Ref.	6 h
BOD	P, G	1000	Ref.	6 h
Chlorophyll	P, G	500	Dark	30 d
Conductivity	P, G	500	Ref.	28 d
N-Ammonia	P, G	500	ASAP or acidify	7 d
N-Nitrate	P, G	100	ASAP of ref.	48 h
N-Kjeldahl	P, G	500	Ref., acidify	7d
Oxygen	G-BOD	300	Fix	8 h
	Electrode		Immed.	None
pH	P, G	-	ASAP	2h
Phosphate	G(A)	100	Ref.	48 h
Solids	P, G	-	Ref.	7 d
Temperature	P, G	-	Immed.	None
Turbidity	P, G	-	Ref., Dark	24 h

Abbreviations

P = Plastic, G = Glass — Ref. = refrigerate
G(A) = acid-rinsed glass — h = hours, d = days

(S) = sterile

GENERAL INFORMATION ABOUT WATER ANALYSIS METHODS

This section describes the basic laboratory methods used to analyze water samples. These methods are referred to in the next section on methods for each indicator.

- **Titration:** Determining the concentration of an indicator in a sample by adding to it a standard reagent of known concentration in carefully measured amounts until a color change or electrical measurement is achieved, and then calculating the unknown concentration. Common indicators measured this way are dissolved oxygen and alkalinity.
- **Colorimetric:** Determining the concentration of an indicator in a sample by adding to it a reagent that causes a color change in direct proportion to the concentration of the indicator being measured. The intensity of the color (as measured by the extent to which it absorbs or transmits light) is measured using a meter and either read directly in appropriate reporting units or read in "% absorbance" or "% transmittance" units and converted to reporting units. Common indicators measured this way are nutrients.
- **Electrometric:** Determining the concentration of an indicator in a sample by using a meter with an attached electrode which measures the electric potential (millivolts) of the sample. This amount of electric potential is a function of the activity of ions or molecules in the sample and proportional to the concentration of the indicator being measured. The electrode is selected based on its response to specific ions (known as an "Ion Selective Electrode" (or ISE), general ionic activity (conductivity) or molecules (for example, a Membrane Electrode). The meters can either display results in either millivolts (mV) or in appropriate reporting units. Common indicators measured this way are dissolved oxygen, pH, conductivity, and nutrients.
- **Gravimetric:** Determining the concentration of an indicator in a sample by filtering a specified quantity of the sample and determining the weight of the material retained on the filter. Common indicators measured this way are total solids and total suspended solids.
- **Nephelometric:** Determining the clarity of a sample by measuring the intensity of light scattered by particles in the sample and comparing this with a known solution. The higher the intensity of the scattered light, the higher the turbidity, reported in nephelometric turbidity units (NTU's).
- **Membrane Filtration and Incubation:** Determining the bacteria concentration of a water sample by filtering a specified quantity through a specified gridded membrane filter, which retains the bacteria and other particles larger than 0.45 microns. After filtration, the membrane containing the bacterial cells is placed on a specific nutrient medium and

then incubated at a specified temperature for a specified length of time. Colonies growing on the filter are then counted.

WATER QUALITY INDICATORS AND METHODS

Fecal Coliform and *E. coli* Bacteria: Fecal coliforms and *E. coli* are bacteria that are common in the intestines and feces of warm-blooded animals. They are used both as an indicator of the presence of sewage or animal manure in the water and as an indicator of the health risk of swimming and other water contact recreation. Fecal coliforms are used in MA, *E. coli* are used in NH, per their water quality standards.

Analytical Method for E. coli and Fecal Coliforms: Membrane Filtration Using mTEC: EPA method #1103.1
A water sample is collected in a sterile container and analyzed within 6 hours. Several subsamples are filtered through 0.45 micron filters, dry incubated on mTEC nutrient medium in petri plates at 35°C for 2 hours, then incubated at 44.5°C in a water bath for 22 hours. Fecal coliforms can be counted after incubation. *E. coli* can be counted after a 20 minute incubation at room temperature on a urea solution (this is known as a "confirmation" step).[25] The most reliable counts are produced on plates with between 20 and 80 colonies. Counts below 20 may be statistically unreliable. Counts over 80 are subject to overcrowding and are also statistically unreliable. Subsample sizes for filtration are selected to produce these counts. This method is acceptable for federal and state agency assessment.

Analytical Method for Fecal Coliforms: Membrane Filtration Using mFC: Standard Methods #9222 D
Another commonly used method for fecal coliform analysis involves a one-step incubation in a water bath for 24 hours on "mFC" nutrient medium.[26] This is acceptable in MA, but not in NH. We recommend the "mTEC" method per EPA and other guidance[27] noting this method's superior precision and accuracy and because it enables enumeration of both fecal coliforms and -*E. coli* by the same procedure. Plates are counted the same way as the mTEC method described above. This method is acceptable for federal and state agency assessment in Massachusetts only.

Method Variations

There are many variations of membrane filtration that use home-made incubators, one step paddles, different nutrient media, etc. They are too numerous to describe here. All methods but the two listed above are not acceptable for federal and state agency assessment, but are fine for education

[25] For rivers that lie wholly within MA, this step can be omitted.
[26] Standard Method #9222D. This method is used by MA DEP to enumerate fecal coliforms.
[27] EPA document 600/4-85-076 and Pagel

and awareness and some community assessments. In selecting one of these variations, keep two things in mind:

- Does the method produce reliable counts, at the densities produced on the plate or paddle?
- Is the method EPA approved?

Notes on Methods

- Samples must be collected in sterile containers -- either pre-sterilized disposable containers or autoclaved re-usable containers.
- For rivers that flow in both states, use the “mTEC” lab analysis procedure to enumerate both fecal coliforms and *E coli*.
- For rivers that flow only in NH, use the “mTEC” lab analysis procedure to enumerate *E. coli*.
- For rivers that flow only in MA, use the “mTEC” lab analysis procedure to enumerate fecal coliforms. If necessary, you can use the “mFC” procedure, but realize that this is less accurate and precise than the “mTEC” protocol.

Dissolved Oxygen (DO): DO is the presence of oxygen gas molecules in the water. Since it is critical to many biological and chemical processes in the water and essential for aquatic life, dissolved oxygen is an indicator of the capability of the aquatic ecosystem to support life.

Hach or Lamotte Adaptation of Winkler Titration Method: Standard Method #4500-OG (or equivalent)

Samples are collected in 300 mL “BOD” bottles with glass stoppers so that no air bubbles are trapped. In lakes, an integrated sample is collected using a length of garden hose. Samples must be analyzed immediately or fixed and analyzed within 8 hours. The level of oxygen in the sample is “fixed” by adding reagents which produce a chemical reaction producing iodine in direct proportion to the amount of oxygen in the water. Sodium thiosulfate is then added incrementally using a digital titrator (Hach) or syringe (Lamotte). The amount of sodium thiosulfate it takes to turn the solution clear is proportional to the amount of iodine (which has taken the place of the oxygen) in the sample. This method is acceptable for federal and state agency assessment.

Meter (Membrane Electrode) Method: Standard Methods #4500-OG (or equivalent)

The meter directly measures dissolved oxygen from the water. A membrane-covered electrode probe is lowered into the water. The meter electronically measures the diffusion of oxygen from the water across a membrane-covered electrode, which is directly proportional to the DO concentration. This method is acceptable for federal and state agency assessment.

Modified Winkler Titration w/ a syringe or eyedropper (Hach via Mitchell & Stapp)

This is essentially the Modified Winkler Titration described above, with some changes. The titrant is phenylarsine oxide solution and the titrator is an eyedropper. The eyedropper gives less accuracy and sensitivity than other titrators because it dispenses larger drops -- each drop equals 0.5 mg/l. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Notes On Methods

- Water samples for dissolved oxygen will be collected in glass-stoppered BOD bottles so that no air is trapped in the sample.
- If you have more sites than can be monitored within a 2-hour window or you have a limited budget for this indicator (<$300), we recommend that you use the Hach or Lamotte Adaptation of Winkler Titration. The Hach digital titrator dispenses smaller increments of the sodium thiosulfate than the Lamotte syringe and therefore increases the sensitivity. But, it’s more expensive.
- If you have the budget (_$600-800) to purchase a meter, and you have few sites that you can monitor within a 2-hour window, OR you need frequent (or continuous) measurements from a few sites, a meter will work best.

Biochemical Oxygen Demand (BOD): BOD is a measurement of the amount of oxygen consumed by organic matter and associated microorganisms and through chemical oxidation in the water over a period of time, usually 5 days. Measuring the bio-chemical oxygen demand (BOD) of the water tells us whether oxygen demanding wastes might cause low DO levels at times.

Modified BOD-5 Day Method (Hach via Mitchell & Stapp)

Two samples are collected in glass-stoppered BOD bottles (one clear and one black) as in the DO method. The DO is determined for the clear bottle, using Modified Winkler Titration with a syringe or eyedropper. The black bottle in placed in the dark and incubated for 5 days at 68°F. The DO for this sample is then determined the same way. BOD is determined by subtracting the DO level of the black bottle from the clear bottle. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

pH: pH is a measure of the acidity of the water. Since pH affects many biological and chemical reactions in the water and most organisms have a preferred range, it is a good indicator of capability of the aquatic ecosystem to support life.

Electrometric Method

pH is either measured on a collected sample or directly in the water body, using a laboratory-quality meter with an electrode in either case. The Massachusetts Water Watch Partnership adaptation of EPA Method 150.1 involves collecting a sample by completely filling with water a plastic sample bottle (with a screw cap) and refrigerating for no more than 24 hours and measuring with a pH meter immediately after opening. pH can also be measured directly by immersing the probe in the water body. The meter must be equipped with a probe suitable for low ionic strength waters. This method is acceptable for federal and state agency assessment.

Other Electrometric Methods

There are less expensive pH pens or “pocket pals” on the market. These should be checked against a reliable, laboratory-quality meter to establish accuracy and precision. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Colorimetric Method (Hach via Mitchell & Stapp)

This method involves the addition of pH indicator solution to a water sample which changes color according to the pH. The sample color is matched to colors labeled in pH units in a color comparator. The analyst determines the closest color match and records the pH. This should be considered an approximation only. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

pH Paper

This is similar to the colorimetric method, except that a specially coated paper is dipped in the sample and turns color according to the pH. This should be considered an approximation only. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Notes on Methods

- Most waters in the Merrimack River watershed are low in ionic strength. Accurate pH measurements require a probe that will respond in these types of waters.
- pH samples should be collected so that no air is trapped in the sample.
- The colorimetric method is subject to variation in the light source and the judgments of the analyst. It is inherently imprecise.

Total Alkalinity: This is a measure of the water’s ability to neutralize acids -- the higher the alkalinity levels, the more acid-neutralizing capacity the water has. This is important for aquatic ecosystems because it protects against changes in pH, which can harm aquatic life.

Double End-point Titration Method (MassWWP)

Total alkalinity if measured by titrating a sample with a known concentration of sulfuric acid using a method used by the Massachusetts Water Watch

Partnership.[28] In this method, the sample is collected and measured as for pH. It is then titrated with measured amounts of sulfuric acid (using a digital titrator) to a pH of 4.5, then 4.2. The amount of acid added to reach these two points is converted to total alkalinity. This method is acceptable for federal and state agency assessment.

Conductivity: This is a measure of the water's ability to pass an electrical current. This ability depends on the presence of inorganic dissolved solids made up of ions (particles that carry a positive or negative electrical charge). Since it measures a wide range of materials, its primary importance is as an indicator of general pollution, rather than a specific pollutant.

Electrometric Method (EPA Adaptation of Standard Methods 2510 B)

Conductivity is measured directly using a conductivity meter per the US EPA Volunteer Stream Monitoring Methods Manual. This meter contains a probe with two electrodes. The probe is lowered into the water, voltage applied, and the drop in voltage caused by the resistance of the water is measured and converted to conductivity. This method is acceptable for federal and state agency assessment.

Total Phosphorus: Phosphorus is an essential nutrient for plant growth and metabolic reactions in plants ad animals. Together with nitrogen, it is the primary source of food energy in the aquatic ecosystem. Too much phosphorus can cause too much biological activity and cause undesirable effects. Phosphorus occurs in various forms in the water, some of which are more available for plant growth than others. Total phosphorus includes all the forms. It is a good indicator of enrichment from various sources, such as sewage, manure, or fertilizer.

Persulfate Digestion Followed by Ascorbic Acid Method (EPA Method #365.2 or equivalent)

A sample is collected in a phosphorus-free container. A 25 mL sub-sample is boiled, acidified, and oxidized to convert all forms of phosphorus to orthophosphate (persulfate digestion). Orthophosphate is then analyzed by adding ascorbic acid reagent which turns the sample blue (ascorbic acid method). The intensity of the blue color is proportional to the amount of phosphorus in the sample. This blue color is measured using a spectrophotometer or colorimeter and compared with results for a set of standard concentrations. This method is acceptable for federal and state agency assessment.

Temperature: Since temperature affects many biological and chemical reactions in the water and most organisms have a preferred range, it is a good indicator of capability of the aquatic ecosystem to support life.

[28] This method was originally developed by the University of MA Acid Rain Monitoring Project

Direct Measurement (Standard Methods 2550)

Temperature is measured directly in the river with a thermometer, thermometer, thermocouple, or thermistor or a multi-use meter. It is measured in degrees Fahrenheit (°F) or degrees Celsius (°C). This method is acceptable for federal and state agency assessment.

Turbidity (for rivers only): Turbidity describes how the particles suspended in the water affect its clarity by scattering light. It is an indicator of the presence of suspended sediment from erosion, which can decrease biological activity, raise water temperatures, and clog fish gills and gravel spawning areas. Turbidity results are usually reported as nephelometric turbidity units (NTUs).

Nephelometric Method (Standard Methods #2130 or equivalent)

Turbidity is measured by collecting and analyzing a water sample using a nephelometer. A nephelometer consists of a light source that projects a beam of light through the water sample and a photo-electric cell that measures the intensity of light scattered by particles at a 90° angle from its original path. The results are reported as nephelometric turbidity units (NTUs). This method is acceptable for federal and state agency assessment.

Turbidity Tubes (Lamotte)

Two graduated cylinders with black dots on the bottom are filled to a specific volume -- one with sample water the other with turbidity-free water. A reagent is added to the turbidity-free water cylinder, until the visibility of the dot on the bottom is equivalent to that of the cylinder with the sample. The results are reported in unspecified units. This method actually measures absorbance plus scattering, so the results are not actually NTUs. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Turbidity Tubes (Tennessee Valley Authority)

These tubes are marked in increments of NTUs on the side and a wave pattern on the bottom. The sample is poured into the tube until the wave pattern disappears. The NTU increment level of the sample is reported. This method actually measures absorbance plus scattering, so the results are not actually NTUs. In fact, they should be reported in centimeters or inches. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Notes on Methods

- Measure turbidity in rivers.
- Make sure that the meter you purchase is a nephelometer that measures light scattered at a 90° angle.

- Turbidity tubes are not acceptable substitutes for a nephelometer, since they actually measure transparency (light scattering and absorption), rather than just light scattering. Because of this, they are highly unreliable in colored waters, which absorb light, though may not be turbid at all. They are really more analogous to secchi disks, in that your eye responds to absorption. If you use these tubes, report your results as a depth (in centimeters or inches) rather than NTUs.

Nitrogen: Nitrogen is a gas in the atmosphere. It combines with oxygen or hydrogen to produce various compounds -- ammonia, nitrates, and nitrates. Is an essential nutrient for plant growth and metabolic reactions in plants ad animals. Together with nitrogen, it is the primary source of food energy in the aquatic ecosystem. Too much of certain forms of nitrogen can cause too much biological activity and cause undesirable effects. It is also toxic to babies in high concentrations. Nitrogen occurs in various forms, both organic and inorganic in the water, some of which are more available for plant growth than others. In some waters, nitrogen is the nutrient in short supply, so that relatively small amounts can cause impacts. Three forms of nitrogen are recommended as indicators in this guide: ammonia, nitrates, and total.

Ammonia Nitrogen: Ammonia (NH_3-) is produced when organic nitrogen and/or urea break down. It is a byproduct of sewage decomposition. It is naturally present in surface waters, and can be toxic to aquatic life at relatively low concentrations (<1.0 mg/l).

Distillation followed by Nesslerization (Standard Methods #4500-NH3 C or equivalent)

A water sample is first distilled, after buffering with a borate solution, using a distillation apparatus. Distillation involves boiling the sample and collecting the steam. This removes certain interferences. This is followed by a process known as Nesslerization. This involves pretreatment to remove turbidity-producing compounds and adding a nessler reagent. This produces a yellow to brown color that is measured with a spectrophotometer. The reading is compared with a set of standard concentrations and reported as mg/l NH_3-N. This method is acceptable for federal and state agency assessment.

Nitrate Nitrogen: Nitrate (NO_3-) is produced naturally by nitrogen-fixing plants and lightning acting on atmospheric nitrogen or ammonia. Nitrate is a form of nitrogen readily used by plants. In excess, it can cause excessive biological activity in surface waters and can be toxic to infants.

Cadmium Reduction followed by spectrophotometry (Standard Methods #4500-NO_3-E or equivalent)

A cadmium reduction reagent is added to a water sample. This causes a chemical reaction and turns the sample yellow-orange. This color is measured with a spectrophotometer. The reading is compared with a set of standard concentrations and reported as mg/l NO_3-N. This method is acceptable for federal and state agency assessment.

Cadmium Reduction followed by Color Comparator (Hach via Mitchell & Stapp)

This is essentially the same procedure as above, except the color is read using a visual color comparator. The sample color is matched to colors labeled in pH units in a color comparator. The analyst determines the closest color match and records the nitrate concentration. This should be considered an approximation only. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Total Kjeldahl Nitrogen (TKN): This refers to the total of organically bound nitrogen and ammonia. By analyzing samples for both ammonia and total Kjeldahl nitrogen, organic nitrogen can be calculated. This enables you to estimate how much nitrogen is in the system is in organic form, intermediate form (ammonia) and inorganic form (nitrate). It may tell you how much comes from sewage, versus fertilizer, for example.

Digestion followed by Nesslerization followed by spectrophotometry (Standard Methods #4500-Norg B or equivalent)

A water sample is first digested to convert organic and ammonia compounds to ammonia nitrogen. Ammonia is then measured using the Nesslerization Method. This involves pretreatment to remove turbidity-producing compounds and adding a nessler reagent. This produces a yellow to brown color that is measured with a spectrophotometer. The reading is compared with a set of standard concentrations and reported as mg/l TKN. This method is acceptable for federal and state agency assessment.

Chlorophyll *a*: Chlorophyll *a* is a green pigment found in all plants. It is used to quantify the abundance of algae in water. When chlorophyll *a* degrades, it converts to pheophytin. The ratio of chlorophyll *a* to pheophytin is used to determine the health of the algae sampled.

Pigment extraction followed by spectrophotometry (Adapted by Paul Godfrey from Standard Methods # 10200 H)

An integrated water sample is collected using a clean container (at least 1 qt). A subsample is filtered (quantity depends on a secchi reading) using a glass fiber filter and vacuum pump. Filters are either analyzed immediately, frozen, or dried. Pigment is extracted by grinding the filter, steeping the ground mass in 90% acetone, and centrifuging in tubes to de-suspend fibers from the solution. The color is then read with a spectrophotometer and the concentration calculated. Hydrochloric acid is then added to the sample to convert all chlorophyll to pheophytin. The color is then read again with a spectrophotometer and the concentration of pheophytin calculated. This method is acceptable for federal and state agency assessment.

Solids: Solids include materials that are dissolved, suspended, or settled in the water column. *Total solids* include all of these. They affect water clarity and can reduce photosynthesis and higher temperatures. Dissolved *solids* include various ions of calcium, chlorides, nitrate, phosphate, iron, sulfur and others that will pass though a 2 micron pore. These affect the water balance in the cells of aquatic organisms, making it difficult for them to maintain position in the water column.

Gravimetric method: Total Solids Dried at 103-105° C (Standard Methods #2540B)

Total solids are measured by weighing the amount of solids in a water sample. This is done by first weighing a ceramic dish, filling it with a known volume, evaporating the water in an oven at 103-105° C, and then weighing the beaker with the residue. Total solids are calculated by subtracting the weight of the dish from the weight of the dish with residue. Results are reported as mg/l. This method is acceptable for federal and state agency assessment.

Gravimetric method: Total Dissolved Solids Dried at 180°C (Standard Methods #2540C)

Total dissolved solids are measured filtering a sample through a glass fiber filter, weighing a ceramic dish, pouring the filtered sample into the dish, evaporating the water at 180°C, and weighing the dish plus residue. Total solids are calculated by subtracting the weight of the dish from the weight of the dish with residue. Results are reported as mg/l. This method is acceptable for federal and state agency assessment.

Secchi Depth Transparency (for lakes only): Transparency describes scattering and absorption of light by small particles and molecules in the water. This is most commonly expressed as the depth at which a black and white patterned device known as a *secchi disk* disappears from sight. The more transparent the water, the lower the depth at which the disk disappears. Reduced transparency has the same effects as elevated turbidity.

Secchi Disk (MassWWP or equivalent)

Transparency is measured using a secchi disk, a black and white patterned device. This disk is lowered into the water until it disappears from sight and then brought up until it appears again. The average of these two depths is the secchi depth transparency. This method is acceptable for federal and state agency assessment.

Descriptions of Indicators and Methods Options: Field Surveys of Physical Characteristics

Visual Field Surveys: Visual surveys involve observations, inventories, and estimates of river, riparian, lakeshore, and watershed characteristics, uses, values, and threats:

- *A pollution source inventory*
- *Water color, odor, and appearance*
- *Corridor land uses*
- *Evidence of pollution*
- *Habitat types*
- *Pipe Survey*
- *Channel and shoreline vegetation*
- *Bottom composition*
- *Condition of shorelines*
- *Water uses*
- *In-stream or in-lake plant growth*

The area surveyed should include the watershed zones of interest -- the water column, river banks, riparian areas, or upland areas. Typically, the presence or absence of these characteristics is noted, the quantity or extent visually estimated, and location mapped.

Methods Options

There are a variety of visual survey methods available. Sources of these methods include:

* *Massachusetts Department of Environmental Protection, Office of Watershed Management*
* *New Hampshire Department of Environmental Services, Volunteer Lakes Assessment Program*
* *Massachusetts Water Watch Partnership.*
* *Massachusetts Riverways Program*
* *River Watch Network*
* *Volunteer Environmental Monitoring Network*
* *UNH Cooperative Extension*

These agencies and organizations have method that have been field tested and found to produce useful information and can be taught to and carried out by volunteers and schools. Select a method that will provide information useful to your data users and meets your data quality goals.

River Flow: This is the volume of water passing a point expressed in cubic feet or meters per second. Flow affects the rivers physical characteristics, such as erosion and sedimentation, bottom composition, amount of the bottom that's covered with water, etc.

Embody Float Method (EPA Volunteer Stream Monitoring Method Manual)

Flow is measured by first calculating cross-sectional areas (width times average depth) of two transects in a 20-foot section of stream. Then current velocity is measured by measuring how long it takes a float (typically an orange) to travel the length of the 20-foot segment. Flow is calculated by multiplying the average cross sectional area times a constant (or rocky or muddy stream bottoms) times the length (20 ft.) and dividing by how long it takes a float (typically an orange) to travel the length of the 20-foot segment. Flow is reported in cubic feet per second. This method is acceptable for federal and state agency assessment.

Lake Level: Lake level is the elevation of the water surface elevation relative to a fixed elevation. This is typically done by fixing a staff gage (a stick marked in inch or centimeter increments) to an object anchored to the lake bottom, such as a dock or pier support. Levels are read directly off the gage. Frequently, lake level gages are located at lake outlet dams.

Rainfall: Rainfall amounts can be measured using a rain gage, or gotten from the National Oceanic and Atmospheric Administration (NOAA). Rain gages are essentially collection devices marked in inches. The amount collected in the gage is read and recorded at the time interval of interest (daily, hourly, etc.). NOAA data is collected at various locations throughout the country. If one of these stations is in your watershed, this data may serve your needs. However, since rainfall patterns can vary over a region, you may need to set up your own gages that more accurately reflect conditions in your areas of interest.

River Channel Characteristics (wadeable waters only): River channel characteristics are the various physical features of the river channel that reflect geological and hydrological changes over time. The river channel is a dynamic land form that is constantly moving as water erodes the land surface. It also responds to human-caused changes in watershed land use and alterations of the river channel. These characteristics form the physical foundation of the river system and provide habitat for aquatic life. Monitoring these characteristics must be a long term, on-going, effort. Characteristics recommended in this guide are Bottom Composition, Embeddedness, Channel Cross Section, and Longitudinal Profile. These characteristics should be surveyed at both pool (low energy) and riffles (high energy) habitats. These measurements can be done only in wadeable waters.

Bottom Composition (Wolman Pebble Count, US Forest Service Stream Channel Reference Sites Guide)

Bottom composition the percent of the bottom in various size classes: sand, gravel, cobble, and boulder. It is measured using the pebble count procedure. This involves measuring the intermediate axis (neither the shortest nor the longest of the sides) of randomly selected particles on the stream bottom along transects where cross sections are measured. Each particle is placed in a size class, from sand (<2mm) to very large boulders (2048-4096 mm). This data can be plotted in various ways to represent bottom composition. The

USFS recommends plotting cumulative % (cumulatively adding the percent of the total count in each size class percent from smallest to largest) versus particle size. The changes in particle size over time will reflect the effects of erosion and deposition.

Embeddedness (US EPA Environmental Monitoring and Assessment Program)

Embeddedness is the extent to which larger particles (especially cobbles) are surrounded by sand and silt. It is measured by estimating the percentage of the particle surface (the same particle used in the pebble count) that is surrounded by sediment. The area that was buried is typically lighter in color than that which was exposed. Changes in embeddedness can indicate scouring and deposition.

Channel Cross Section (US Forest Service Stream Channel Reference Sites Guide)

A channel cross section is the shape of a "slice" of the channel -- its width and depth. It is also the location where flow and bottom composition are measured. A channel cross section is measured at locations that represent typical channel form, clear channel features, clear indicators of bankfull (top of the bank flow) and active floodplain, clear terraces and a straight reach. It is measured by locating and determining the elevations of endpoints on either side of the channel, measuring the depths (using a surveyors level and rod) from a line stretched across the endpoints to the channel bottom and water surface. The measurements are plotted as distance versus elevation to depict the cross-section. Changes in channel cross-section will reflect scouring, deposition, and channel movement.

Longitudinal Profile(US Forest Service Stream Channel Reference Sites Guide)

A longitudinal profile measures and plots the slope of a 300-500 foot reach of the river. It is measured by first locating and marking important channel and related features (such as terraces, riffles, pools, vegetation changes, etc.). Elevations at the marked features are measured using a surveyor's level and rod. Elevations of the channel bottom, water surface, terraces, and floodplains can all be gathered. The data are plotted as elevation versus distance. Changes in channel cross-section will reflect scouring and deposition.

Descriptions of Indicators and Methods Options: Field Surveys of Biological Characteristics

Benthic Macroinvertebrates: These are critters without backbones that live on the river bottom. They include aquatic insects such as mayflies, mollusks, crustaceans, and worms. They are good indicators of ecological conditions and human impacts, since they are integral to the river's food web and the community present reflects both water and habitat quality.

Four different levels of effort are recommended in this guide:

- Intensive Benthic Macroinvertebrate Assessment: Net Collection
- Intensive Benthic Macroinvertebrate Assessment: Rock Basket Collection
- Basic Benthic Macroinvertebrate Assessment
- Streamside Benthic Macroinvertebrate Assessment

Methods for each are described below.

Intensive Benthic Macroinvertebrate Assessment: Net Collection (River Watch Network)

This guide recommends a metal frame net with an opening of 18" wide by 8" high with 0.6 mm nylon mesh. This mesh size is the standard recommended by the U.S. EPA. This size catches the smaller critters (like midges) but does not quickly plug up with sediment. The collection method is carried out in the field and lab. It involves the collection with the specified net of three composite samples from 2 fast and 2 slow spots in riffle habitats. This sample is preserved in alcohol for later lab identification. Twenty-two habitat characteristics are estimated or measured in the field. Critters are identified to family and counted in the lab. This survey produces a fairly sensitive assessment of conditions based on a number of numerical analyses of community composition, functional feeding groups, pollution tolerance of families, and allows numerical site to site comparisons. It can detect shifts in families within major groups that might result from pollution or habitat alteration. This method is acceptable for federal and state agency assessment.

Intensive Benthic Macroinvertebrate Assessment: Rock Basket Collection (River Watch Network)

Rock Baskets consist of a wire mesh basket filled with similar sized rocks (4 to 12 cm in diameter). This assessment is carried out in the field and lab. It involves a quantitative collection (organisms colonize the rock basket over a period of 5 weeks) of two or three samples from riffle and run habitats. This sample is preserved in alcohol for later lab identification. Twenty-two habitat characteristics are estimated or measured in the field. Critters are identified to family and counted in the lab. This survey produces a fairly sensitive and more quantitative assessment of conditions based on a number of numerical analyses of community composition, functional feeding groups, pollution tolerance of families, and allows more precise numerical site to site comparisons. It can detect shifts in families within major groups that might result from pollution or habitat alteration. This method is acceptable for federal and state agency assessment.

Basic Benthic Macroinvertebrate Assessment (River Watch Network)

This method is carried out in the field and lab. It involves the collection with a specified net (0.6 mm mesh) of one composite sample from 1 fast and 1 slow spot in riffle habitats. This sample is preserved in alcohol for later lab identification. Twenty-two habitat characteristics are estimated or measured in the field. Critters are identified to major group and counted in the lab. This survey produces a somewhat sensitive assessment of conditions based on a number of numerical analyses of community composition, gross pollution tolerance of major groups and allows site to site comparisons (if the communities are different enough to produce dramatically different results). This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Streamside Benthic Macroinvertebrate Assessment (River Watch Network, Izaak Walton League, or equivalent)

This assessment is carried out entirely in the field. It involves the collection of one composite sample from 1 fast and 1 slow spot in riffle habitats. Critters are identified to major group and the relative abundance estimated in the field. Three primary habitat characteristics are estimated or measured. This survey produces a quick estimate of conditions, based on the presence and relative abundance of key indicator organisms. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Benthic Macroinvertebrate Habitat: Benthic macroinvertebrates exist in a wide range of locations in the river:

* Shallow, fast moving, rocky bottom areas known as *riffles.*
* Deeper, slower moving sandy and gravely bottom areas known as *runs.*
* And deep, slow moving muddy-bottom areas known as *pools.*

However, the number and diversity of organisms present is greatest in riffles. Habitat quality must be assessed in order to separate the influence of water column chemistry and biology from habitat on the community. While all of these are affect by human activities, natural variations in habitat might produce changes that might be mistaken for human-caused changes. So, a habitat assessment is a critical part of a benthic macroinvertebrate assessment.

Habitat Assessment (River Watch Network Adaptation of EPA Rapid Bioassessment Protocol II)

A habitat assessment is the estimate and measurement of certain physical characteristics of the river in order to determine the overall quality of the habitat for benthic macroinvertebrates. Examples of these characteristics include the velocity of the current, the composition of the river bottom, depth, the nature and extent of riffles. Together with water quality, these characteristics determine the kinds and numbers of macroinvertebrates that can live there. Both habitat quality and water quality are affected by human activities in the river or on lands in the watershed. This includes physical characteristics of the river that provide habitat for the invertebrates such as bottom composition, sedimentation, current velocity, shading, extent of riffle habitat, and others. Results for each site from the “Benthic Macroinvertebrate Habitat Assessment Field Sheet” are scored, totaled, and compared with the total score from the reference site (least impaired upstream conditions). This method is acceptable for federal and state agency assessment.

Aquatic Vegetation (lakes): Aquatic vegetation is an important part of a lake ecosystem, especially in near-shore areas. They provide habitat for aquatic animals and are an important source of oxygen. Some are nuisance plants, and cause dramatic habitat alterations and interfere with recreational uses. The types, density, diversity, and growth patterns are important characteristics to assess.

Aquatic Vegetation Mapping/ Identification (MassWWP or equivalent)

Aquatic vegetation mapping and identification involves visual observation and mapping and collection of specimens for identification. For mapping, monitors take a tour of the lake shoreline and observe areas of the lake where aquatic vegetation is at or near the surface. The location and extent of vegetation beds is drawn onto a map. For identification, vegetation samples are collected along a transect using a weighted rake. The samples are sorted, a qualitative estimate is made of the percentage and density of each type of plant, and specimens of each type bagged or shipment to a botanist for identification. This method is acceptable for federal and state agency assessment.

Appendix 2: About Water Quality Standards

This appendix describes the water quality standards that apply to the Merrimack River Watershed. They are contained in the "Surface Water Quality Regulations" issued by the NH Department of Environmental Services (NH DES) and the "Surface Water Quality Standards" issued by the MA Department of Environmental Protection (MA DEP).

Uses, Classifications and Criteria

The water quality standards contain *designated uses*, *classifications*, and *criteria*:

Designated uses: The uses of the water -- such as swimming, public water supply, fishing, aquatic life habitat, irrigation, and industrial processing and cooling -- that are to be achieved and protected.

Classifications: All the waters in the watershed are segmented and each segment is assigned to a classification: A or B (in NH) and A, B, or C in (MA). Designated uses are assigned to each classification. It's important to note that the uses assigned to each classification are not necessarily uses that are *actually achieved*. Rather, they are uses *to be achieved* and protected.

Criteria: For each classification, water quality criteria describe the conditions which need to be achieved in order to support the designated uses. These conditions are described for various water quality indicators such as bacteria, temperature, dissolved oxygen, pH, etc. There are two types of criteria: numerical and narrative

* <u>Numerical Criteria</u> specify a level or a range of levels for each indicator needed to support the designated uses for each class. For example, in New Hampshire, Class B waters can contain no more than 406 *Escherichia coli* bacteria per 100 mL to support swimming.
* <u>Narrative Criteria</u> are general statements about the conditions for each indicator needed to support the designated uses for each class. For example, for color and turbidity in Massachusetts for Class B waters: "These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class. "

See *The State Water Quality Standards* section below for a description of the designated uses, classifications, and criteria for Massachusetts and New Hampshire.

Monitored and Evaluated Waters

To determine whether the waters support their designed uses, waters are either *monitored* or *evaluated* for each of the indicators listed in the water quality criteria. Unfortunately, these terms are defined differently in each state. However, the following will serve as basic definitions:

Monitored Waters: The water quality indicators are measured and the results are compared with the numeric criteria.

Evaluated Waters: If monitoring data are not available (or are out of date), the states may determine the level of use support with land use data, pollution source inventories, citizen complaints, fish and game surveys, and predictive models.

Volunteer monitoring programs can be a valuable source of data to determine the extent to which our rivers and lakes actually support their designated uses.

About 305(b) Reports

The US EPA is required by section 305(b) of the Clean Water Act to report to Congress on the status of the Nation's surface water every two years. [29] EPA compiles reports from all the states into a national assessment of whether our surface waters are meeting the requirements of the Clean Water Act. These state and EPA reports are known as "305(b) Reports. "

305(b) reports use the most recent and best available water quality data and compare the results to the criteria in the water quality standards. They assess whether each use in each class is supported by current water quality conditions. The reports consolidate these individual assessments into an overall assessment for each waterbody. Finally, each waterbody is placed in one of the following use support categories:

Fully Supporting: All designated uses are fully supported. In other words, there are no known violations of state water quality standards.

Threatened: One or more designated uses are threatened and the remaining uses are fully supported.

Partially Supporting: One or more designated uses are partially supported and the remaining uses are fully supported. In other words, the actual water quality does not meet the all of the criteria some of the time (e.g. when combined sewer overflows occur).

Not Supporting: One or more designated uses are not supported. In other words, there are known violations of the state's water quality standards.

[29] This will probably be changed to every 5 years when the Clean Water Act is re-authorized.

Not Attainable: The State performs a study and documents that support of one or more designated uses is not achievable due to natural conditions or human activity that cannot be reversed without imposing widespread economic and social impacts.

305(b) reports are used to determine pollution control and management priorities at the state and national level.

Volunteer monitoring programs can be a valuable source of data for these reports, particularly as state and federal resources devoted to monitoring dwindle. According to Greg Comstock (the NH 305(b) Officer), the most important things for volunteer groups to remember when carrying out water quality standards assessments (if they wish their data to be incorporated into 305(b) reports) are:

1. develop and implement effective quality (QA / QC) control measures, and
2. be in touch with state agencies and deliver data to them in a timely manner, and in a format that they can use.

If adequate quality control measures are not used for sampling and lab analysis, state agencies may still be able to use volunteer data for 305(b) reports. However, your river or lake may be considered as *evaluated* rather than *monitored.*

The Massachusetts and New Hampshire Water Quality Standards

In most cases, fresh water volunteer monitoring groups monitor Class B waters (recreational waters that people contact directly as in for swimming). Most of the waters in MA and NH fall into that category. Class A waters are usually designated drinking water supplies and are therefore monitored by the drinking water suppliers. For Massachusetts class C waters are designated so because they are too polluted to risk direct human contact and it would be too costly to clean the water to a point where it could be reclassified as B. Most volunteer groups do not need to bother monitoring Class C waters because they are not usually heavily used for recreation and are not considered as valuable a resource as Class A or B waters.[30] Therefore, the standards shown in the tables below are for Class B waters only.

If your group wishes to know the classification for a water body that you will be monitoring, or the standards for a Class A or C water, in NH call the DES at (603)271-2457 and in MA call the DEP at (508)792-7470.

[30]New Hampshire does not have a C classification for surface waters and Massachusetts does not currently designate any surface waters in the C classification.

New Hampshire Classes, Uses and Criteria

Designated Uses for Class B waters: Acceptable for fishing, swimming and other recreational purposes and, after adequate treatment, for use as a drinking water supply.

Indicators	Criteria
E. coli Bacteria	_ no more than 126 *E. coli* / 100 mL based on a geometric mean of 3 samples obtained over a 60 day period _ no more than 406 *E. coli* / 100 mL in any one sample **In designated beach areas:** _ no more than 47 *E. coli* / 100 mL based on a geometric mean of 3 samples obtained over a 60 day period _ no more than 88 *E. coli* / 100 mL in any one sample
Dissolved Oxygen	_ not less than 75% saturation
pH	_ 6.5 to 8.0 or as naturally occurs
Temperature	_ no increase that would appreciably interfere with the designated uses
Turbidity	_ not to exceed naturally occurring conditions by 10 Nephelometric Turbidity Units (NTUs)

Massachusetts Classes, Uses and Criteria

Designated Uses for Class B waters: These waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. Where designated they shall be suitable as a source of public water supply with appropriate treatment. They shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.

Indicators	Criteria
Fecal Coliform Bacteria	_ no more than 200 fecal coliform bacteria / 100 mL based on a geometric mean in any representative set of samples _ no more than 10% of the plates shall exceed 400 fecal coliform bacteria / 100 mL in any one sample
Dissolved Oxygen	_ not less than 6.0 mg / L in cold water fisheries _ not less than 5.0 mg / L in warm water fisheries unless background conditions are lower _ not below 75% of saturation in cold water fisheries _ not below 60% of saturation in warm water fisheries _ site-specific criteria may apply where background levels are lower than specified levels, to the hypolimnion (bottom layer) of stratified lakes (see temperature section) or where the Director determines that designated uses are not impaired
pH	_ 6.5 to 8.3 _ not more than 0.5 units outside of the background range _ there shall be no change from background conditions that would impair any use assigned this Class

Temperature	_ not to exceed 68_F (20_C) in cold water fisheries _ not to exceed 83_F (28.3_C) in warm water fisheries _ the rise in temperature due to a discharge shall not exceed 3_F (1.7_C) in rivers and streams designated as cold water fisheries _ the rise in temperature due to a discharge shall not exceed 5_F (2.8_C) in rivers and streams designated as warm water fisheries _ the rise in temperature due to a discharge shall not exceed 3_F (1.7_C) in the epilimnion (top layer) of lakes and ponds (see temperature section)
Temperature (cont'd)	_ natural seasonal and daily variations shall be maintained. There shall be no changes from background conditions that would impair any use assigned to this Class, including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms

Turbidity	_ free from turbidity in concentrations that are aesthetically objectionable or would impair any use assigned to this Class