# CHAPTER 5 – VOLUNTEER WATERSHED MONITORING OPTIONS

## *In This Chapter . . .*



There are endless choices as to how to monitor Pennsylvania's waters. Since designing a monitoring program is about making choices that are right for your program, we won't presume to tell you what to do. However, in this chapter, we will help you narrow the universe a bit.

## 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 purposes described in previous chapters. From this point on, we will refer to these indicators as "assessments." We chose these assessments because we know that documentation (manuals) exists and that training is available.

### Assessments In This Handbook

This Chapter contains the following assessments:

**A. Basic Watershed Inventory and Assessment**

- A1. Watershed Inventory
- A2. Condition and Trend Assessment - Wadeable[1] Waters
- A3. Condition and Trend Assessment - Non-Wadeable Waters
- A4. Condition and Trend Assessment - Lakes
- A5. Point Source Impact Assessment
- A6. Nonpoint Source Impact Assessment
- A7. Groundwater Basin Assessment

**B. Advanced Stream Assessment**

- B1. Impairment Screening / Biological Assessment
- B2. Aquatic Life / Designated Uses Assessment - Wadeable Waters
- B3. Aquatic Life / Designated Uses Assessment - Non-Wadeable Waters
- B4. Recreational Waters Uses and Water Supply Assessment
- B5. Advanced Point Source Impact Assessment
- B6. Advanced Nonpoint Source Impact Assessment

[1] "Wadeable" is defined as water in which you can safely walk. We suggest that water above 24", with a velocity of >2.0 feet per second is not safe to wade in.

**C. Advanced Lakes Assessment**

C1. Screening Assessment

C2. Impairment Determination Assessment

C3. Comprehensive Lake Watershed Assessment

**D. Advanced Stream Trends Assessment**

D1. Long Term Monitoring - Wadeable Waters

D2. Long Term Monitoring - Non-Wadeable Waters

**E. Advanced Groundwater Basin Assessment**

These assessments are described in detail in the rest of this chapter.

## How Each Assessment Is Described

Each of the assessments listed above is described in terms of the following elements:

### *What Is It?*

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

### *Why Do This Assessment?*

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

### *Primary Purposes Addressed*

This section lists the purposes that are addressed by this assessment (see Chapter 3 for a full description of each purpose on page 3-2 to 3-3). If this assessment addresses the goal, a check appears in the box preceding it, like this: ☑.

- ☐ Community Education and Awareness
- ☐ Baseline Data Collection
- ☐ Community and / or Watershed Level Assessment
- ☐ State and Federal Agency Assessment

### *Questions Addressed*

This section lists the questions that are addressed by this assessment (see Chapter 4 for a full description of each question). If this assessment addresses the question, a check appears in the box, like this: ☑.

- ☐ Is the water meeting or exceeding state Water Quality Standards?
- ☐ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☐ Where are the threatened waters that should be a high priority for protection? What is causing these threats?
- ☐ What are the present ecological conditions, and how do they change over time?

- ☐ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution) ?
- ☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?
- ☐ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

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

*Menu of Indicators/Tools:* This column lists either indicators (for example, bacteria) or tools (for example, a stream assessment) that would be appropriate for this assessment. 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 assessment. The table does not list all the appropriate methods that could be used to measure the indicator; nor does it imply that only these methods are appropriate. In most cases, there are a number of methods that are appropriate. Rather, 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 section lists things to consider and/or types of sites that will help you locate your specific sampling sites. Site selection is discussed in detail in Chapter 2 (page 2-18 to 2-22).

### *How Frequently and When Should You Monitor?*

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

*Time 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 it is under the least stress, as a benchmark. Consult with your technical committee to determine critical and benchmark sampling periods for your program.

*Time 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:* One of the strengths of volunteer monitoring is the ability to collect frequent samples that can detect changes that might be missed with limited sampling. 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. However, these methods are beyond the scope of this guide. In this handbook, we recommend frequencies that we think are practical and / or those recommended by data users. 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 conditions affect aquatic ecosystems in profound ways -- some reduce stress and some cause stress. Since weather varies with the season, see the preceding section ("Time of Year" on page 5-3) 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 changes can occur without much warning, sampling to capture different weather events is challenging. However, you can learn a lot about how your stream 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 (i.e. what they are compared with to answer the questions addressed by the assessment).

### *Data Reporting Requirements*

This section describes, in very general terms and when applicable, how the data should be reported to meet the needs of the data users.

### *Quality Assurance/Quality Control (QA/QC)*

See Appendix 4 on quality assurance and quality control in this guide. This section highlights QA / QC considerations specific to the assessment.

### *Training Required*

This section describes the field sampling and lab analysis training required to undertake each assessment. In most cases, a service provider should be involved in the initial training. Appendix 5 lists where to find this type of assistance.

## A. Basic Watershed Inventory[2] and Assessment

You have to start somewhere. Getting a handle on what is going on in your watershed and doing some relative, simple monitoring is a good place to begin.

We recommend these assessments for beginning groups and schools with education and awareness as their primary goal.

**A1.** Watershed Inventory

- Research existing information
- Visual field surveys of uses, values and problem areas

**A2.** Condition and Trend Assessment - Wadeable[3] Waters

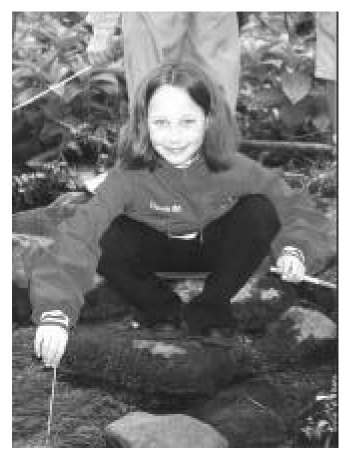
**A3.** Condition and Trend Assessment - Non-Wadeable Waters

**A4.** Condition and Trend Assessment - Lakes

**A5.** Point Source Impact Assessment

**A6.** Nonpoint Source Impact Assessment

**A7.** Groundwater Basin Assessment



[2] Note: information gathered may be used by DEP in its pre-screening of unassessed waters.

[3] "Wadeable" is defined as water in which you can safely walk. We suggest that water above 24", with a velocity of >2.0 feet per second is not safe to wade in.

## A1. Watershed Inventory

### *What Is It?*

A Watershed Inventory 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 agencies.

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

- ♦ *Research:* A compilation of existing information from reports, interviews and possibly public meetings;
- ♦ *Field Surveys:* Easily-gathered visual observations on various watershed characteristics, conditions and activities.

### *Why Do It?*

We suggest the Watershed Inventory as a starting point in your monitoring program. It enables you to get to know your watershed and determine which areas or issues you will focus on for future monitoring.

The Watershed Inventory 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 Purposes Addressed*

- ☑ Community Education and Awareness
- ☐ Baseline Data Collection
- ☐ Community and/or Watershed Level Assessment
- ☐ State and Federal Agency Assessment

Note that the Watershed Inventory is the first step in other assessments that address the last three purposes above.

### *Questions Addressed*

- ☐ Is the water meeting or exceeding state Water Quality Standards?
- ☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?
- ☑ What are the present ecological conditions, and how do they change over time?
- ☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?

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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.

- ☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?
- ☑ Where are the special places with unique ecological, social and economic values that should be protected?

Note that the Watershed Inventory is the first step in other assessments that address several of these questions.

### *Monitoring Options*

The Watershed Inventory is a process of narrowing down the geographic and topical scope of your efforts through research, 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.

Monitoring options are listed in the following table.

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Research existing information:** Literature search for reports, plans and other documents pertaining to the watershed to identify uses, values, threats and conditions | Search the following:<br>EPA Surf Your Watershed<br>DEP Watershed Notebooks<br>DEP Regional Offices – Discharge Monitoring Reports for NPDES permittees<br>Toxic Release Inventory<br>Historical Land Use Records – County Library, Historical Societies, Conservation Districts |
| • **Research existing information:** Uses, values and threats exercise | Hold a meeting where participants locate uses, values and threats on a map (River Network) |
| • **Field survey of river, riparian and watershed characteristics, uses, values and threats** | Visual Assessment (ALLARM, EPA, DEP – Unassessed Waters Protocol)<br>Watershed Field Inventory (Adopt-A-Stream Foundation)<br>River Walk (River Watch Network)<br>Watershed Tour and Stream Walk – Pa. BSP |

Additional notes on the methods are contained in Appendix 2.

### *Relevant Materials*

Alliance for Aquatic Resource Monitoring, 1996 Visual Assessment Handbook, Carlisle, Pa.

River Network and Vt. Department of Environmental Conservation, undated. River Walk (a self-explanatory field data sheet), Montpelier, Vt.

Murdoch, T. and Cheo, M., 1996. The Streamkeeper's Field Guide. Adopt-A-Stream Foundation. Everett, Wash.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

### *Site Location Considerations*

- Sites that contain problem areas which might be a high priority for some corrective action.
- Sites that contain special resource areas.
- Sites that contain threats to human and aquatic life uses of the water.

### *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 urban areas, 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 Nonpoint Source Pollution Impact Assessment for further information on monitoring runoff events.

### *Data Analysis*

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

- Identify areas where data that are needed to make management decisions are lacking;
- Identify and map areas of different land uses in watershed;
- Identify problems and conflicts which need to be resolved by some management decision;
- Identify and provide detailed descriptions of land uses for problem sites;
- 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.

### *Data Reporting Requirements*

No specific requirements.

### *Quality Assurance/Quality Control (QA/QC)*

A Watershed Inventory 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 Appendix 4 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*

Assessors should initially be trained by the organization or agency that developed the assessment or a designated service provider. At or following the training, assessors 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 that may develop. New assessors should be trained by the program coordinator or by an experienced assessor.

## A2. Condition and Trend Assessment - Wadeable[5] Waters

### *What Is It?*

Condition and Trend Assessment for wadeable waters seeks to balance limited time and resources with the goal of sampling as many different aspects of the stream ecosystem as possible. Unlike Advanced Assessments, it need not thoroughly 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 watershed ecosystem indicators 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 streams are waters less than two feet deep, where it is possible to see and access the bottom to collect samples of habitat and aquatic life.

This information may be used by DEP to identify problem areas for further monitoring, if a written Quality Assurance Project Plan is being adhered to. This assessment will also provide an enriching experience for participants and produce information that can be used for education and awareness purposes at the school, community or watershed level.

### *Why Do It?*

We suggest that you undertake this assessment if your primary interest lies in the long term ecological health of your stream and your focus is on use of the results for education and awareness at the community or watershed level.

### *Primary Purposes Addressed*

☑ Community Education and Awareness

☑ Baseline Data Collection

☑ Community and/or Watershed Level Assessment

☑ State and Federal Agency Assessment

### *Questions Addressed*

☐ Is the water meeting or exceeding state Water Quality Standards?

☐ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☐ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

☑ What are the present ecological conditions, and how do they change over time?

☐ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?

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[5] "Wadeable" is defined as water in which you can safely walk. We suggest that water above 24", with a velocity of >2.0 feet per second is not safe to wade in.

☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?

☑ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The basic approach to selecting indicators for the Condition and Trend Assessment is to focus on a number of relatively easy to measure indicators of watershed stress, exposure and response. (See Chapter 2, Step 3 on page 2-9) for an explanation of these.) Select representative indicators from each of these categories and measure them over a relatively long period of time to establish trends.

Monitoring options are listed in the following table. We recommend that you select at least one indicator from the stress, exposure and response categories of indicators. Further, the indicators you select should be related -- e.g. air temperature (stress) can cause increases in water temperature (exposure) which can affect benthic macroinvertebrates (response). Note that some indicators fall into more than one category (e.g. dissolved oxygen).

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| *Stress Indicators* | |
| • **Pollution Source Inventory**<br>Point Sources<br>Nonpoint Sources<br>Eroding Banks / Unstable Channels | Land Use maps at regional planning commissions or Conservation Districts<br>DEP Watershed Notebooks<br>DEP Regional Offices – Discharge Monitoring Reports for NPDES permittees<br>Toxic Release Inventory<br>Historical Land Use Records – County Library, Historical Societies, Conservation Districts |
| • **Rainfall** | Gauges (NWS[6]) |
| • **Stream Flow** | USGS Gauges or Embody Float Method – (EPA, EASI, Pa. BSP) |
| • **Max. Air Temperature** | Direct Measurement or existing NWS data |
| *Exposure Indicators* | |
| • **Fecal and Total Coliform Bacteria**<br>*water sampling and analysis* | Various methods that detect presence-absence or produce an estimate of bacteria density, Coliscan Easygel Method (Delaware Riverkeeper Network) |
| • **Biochemical Oxygen Demand**<br>*water sampling and analysis* | BOD 5-day procedure w/ Modified Winkler Titration w/ a syringe or eyedropper (Pa. BSP, Mitchell / Stapp, Delaware River Keeper) |
| • **Dissolved Oxygen**<br>*water sampling and analysis* | Modified Winkler Titration w/ a syringe or eyedropper (Pa. BSP, Mitchell / Stapp, Delaware Riverkeeper Network) |
| • **Total Phosphorus**<br>*water sampling and analysis* | Persulfate digestion followed by ascorbic acid method and color comparator (EASI, Pa. BSP, Mitchell & Stapp) |
| • **Total Orthophosphate**<br>*water sampling and analysis* | Ascorbic acid method and color comparator |
| • **Conductivity**<br>*water sampling and analysis* | Direct measurement with meter (EASI, EPA Volunteer Methods Manual) or pen (RWNRN) |
| • **Temperature**<br>*water sampling and analysis* | Direct measurement with a thermometer |

[6] National Weather Service.

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **PH** *water sampling and analysis* | Sample collected and measured with a pH meter, pocket meter or litmus paper (ALLARM, EASI, Pa. BSP, Delaware Riverkeeper Network) |
| • **Total Alkalinity** *water sampling and analysis* | Single End Point sulfuric acid titration w/bromcresol green/methyl red using dropper bottle (ALLARM, EASI, Pa. BSP, Delaware Riverkeeper Network) |
| • **Iron** *water sampling and analysis* | Treatment with FerroVer Iron Reagent followed by color comparator (Delaware Riverkeeper Network) |
| • **Total Acidity** *water sampling and analysis* | Phenolphthalein Indicator followed by titration with sodium hydroxide (Delaware Riverkeeper Network) |
| • **Nitrates** *water sampling and analysis* | Cadmium reduction followed by color comparator (ALLARM EASI, PA BSP, Mitchell/Stapp) |
| • **Total Suspended Solids** *water sampling and analysis* | Filtration of sample through glass fiber filter followed by drying and weighing – based on SM #2540D (Delaware River Keeper Network) |
| • **Turbidity** *water sampling and analysis* | Sample collected and measured with a nephelometer and reported as NTU's (RWNRN) or turbidity tube reported in centimeters or inches (or LaMotte units) (Pa. BSP, Delaware Riverkeeper Network) |
| • **Habitat Walk** | Visual assessment of various habitat characteristics (EPA, EASI, Pa. BSP) |
| *Response Indicators* | |
| • **Streamside Benthic Macroinvertebrate Assessment** | Field collection and identification of major groups, assessment based on relative abundance and estimated richness (EPA, EASI, RWNRN, Pa. BSP, Delaware Riverkeeper Network) |
| • **Dissolved Oxygen** *water sampling and analysis* | Modified Winkler Titration w/ a syringe or eyedropper (EASI, Pa. BSP, ALLARM, Mitchell & Stapp) |
| • **Maximum Water Temperature** | Direct measurement with a thermometer |

Additional notes on the methods are contained in Appendix 2.

### *Relevant Manuals*


Alliance for Aquatic Resource Monitoring Methods Manual. Carlisle, Pa.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier, Vt.

Dates, Geoff, and Byrne, Jack, 1997. Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess Your River's Health, River Network, Montpelier, Vt.

Delaware Riverkeeper Network, 1997. Citizen Water Quality monitoring Manual. Washington Crossing, Pa.

Environmental Alliance for Senior Involvement (EASI), Pa. DEP Citizens' Volunteer Monitoring Program, & Schuylkill Center for Environmental Education. Draft 1998. Pa. Senior Environmental Corps Water Quality Monitoring Field Manual. Harrisburg, Pa.

Firehock, Karen. Save Our Streams Volunteer Trainer's Handbook. Izaak Walton League of America, Gaithersburg, Md.

Mitchell, Mark K., and Stapp, William B. 1990. Field Manual for Water Quality Monitoring, Kendall-Hunt Publishers. Ann Arbor, Mich.

Pa. Bureau of State Parks, Draft 1999. Watershed Education Manual. Harrisburg, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

Additional notes on methods are contained in Appendix 2.

### *Site Location Considerations*

Water, habitat and benthic macroinvertebrate sampling should be carried out at a variety of sites that represent a variety of conditions in the watershed. Select as many of the following types of sites as you can (see Chapter 2, Step 6 on page 2-18 for definitions of types of sites):

- Sites on streams of different orders (sizes) and at different altitudes.
- Watershed reference sites.
- Stream impact assessment sites:
  - upstream reference (control) sites
  - impact sites
  - recovery sites
- Benthic macroinvertebrate riffle habitats.
- Tributary impact assessment sites:
  - reference sites
  - impact sites
  - recovery sites
  - integrator sites
- Cold and warm water fish habitat areas (spawning, nursery and resting sites).
- Where possible, sites historically monitored by DEP.

### *How Frequently and When Should You Carry Out the Assessment?*

Condition and Trend Assessment requires as many samples collected under as many different conditions as your resources will allow. A good assessment 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 -- five years at a minimum.

We suggest the following frequency, time of day, time of year and weather conditions for the monitoring options listed in the table above:

#### Pollution Source Inventory

- *Frequency and time of year:* At least once per year.
- *Time of day and weather:* Not a consideration, though field work during high flows should be avoided for safety reasons.

#### Rainfall

- *Frequency and time of year:* Sample hourly during storm events from April-November.
- *Time of day and weather:* Storm events.

**Air Temperature**

- *Frequency and time of year*: Measure during every sampling event.
- *Time of day and weather:* Sample during hottest part of day, typically mid-afternoon.

**Water Sampling and Analysis**

- *Frequency:* Sample at least once 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 low flow and high air temperature conditions – and less stressful periods such as mid-late spring to get a sense of seasonal variation.
- *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 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.

## *Data Analysis*

Basic statistical summaries should be used to summarize the data and to reveal patterns in the data over time and space. We recommend the following fairly simple summaries:

- Seasonal and / or annual averages to show values typical of the data set;
- Seasonal and / or annual medians to show values typical of the data set;
- Maximums to show extreme conditions;
- Minimums to show extreme conditions; and
- Range (maximum - minimum) to show variability.

We recommend comparing results 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.

## *Data Reporting Requirements*

No specific requirements.

## *Quality Assurance/Quality Control (QA/QC)*

Basic Condition and Trend Assessment does not require rigorous QA / QC. We suggest only internal controls (samples collected and analyzed by project field volunteers, staff and lab - see p. A4-2), though external controls (samples collected and analyzed by non-volunteer field staff and "quality control" lab - see p. A4-3) will enhance the credibility of the data and provide a valuable educational experience for participants. Choose specific quality control measures for each indicator from the list in Table 2 in

Appendix 4 (on page A4-6). Chapter 4 also contains information on internal quality controls and how they are assessed.

### *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 the group or agency that uses and supports the method. 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,[7] 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. 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.

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

## A3. Condition and Trend Assessment - Non-Wadeable Waters

### *What Is It?*

Condition and Trend Assessment for non-wadeable waters seeks to balance limited time and resources with the goal of sampling as many different aspects of the river ecosystem as possible. Unlike Advanced Assessments, it need not thoroughly 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 watershed ecosystem indicators as is practical for volunteer monitores, using relatively simple methods:

- Water sampling and analysis; and
- Visual surveys of river uses, values and threats.

Non-wadeable rivers are waters greater than two feet deep, where it is not possible to see and safely access the bottom to collect samples of habitat and aquatic life. This limits the types of monitoring activities that can be practically and safely carried out. It also means that it may be difficult, without a boat, to access the main current of the river. So, we recommend fewer indicators than for wadeable waters.

The information may be used by DEP to identify problem areas for further monitoring, if a written Quality Assurance Project Plan is being adhered to. This assessment will also provide an enriching experience for participants and produce information that can be used for education and awareness purposes at the school, community or watershed level.

### *Why Do It?*

We suggest that you undertake this assessment if your primary interest lies in the long-term ecological health of your river and your focus is on use of the results for education and awareness at the community or watershed level.

### *Primary Purposes Addressed*

☑ Community Education and Awareness

☑ Baseline Data Collection

☑ Community and/or Watershed Level Assessment

☐ State and Federal Agency Assessment

### *Questions Addressed*

☐ Is the water meeting or exceeding state Water Quality Standards?

☐ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☐ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

☑ What are the present ecological conditions, and how do they change over time?

☐ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?

☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?

☑ Where are the special places with unique ecological, social and economic values that should be protected?

### Monitoring Options

The basic approach to selecting indicators for the Condition and Trend Assessment is to focus on a number of relatively easy to measure indicators of watershed stress, exposure and response (see Chapter 2, Step 3 on page 2-9 for an explanation of these). Select representative indicators from each of these categories and measure them over a relatively long period of time to establish trends.

Monitoring options are listed in the following table. We recommend that you select at least one indicator from the stress, exposure and response categories of indicators (see Chapter 2, Step 3 for an explanation of these). Further, the indicators you select should be related – e.g. air temperature (stress) can cause increases in water temperature (exposure) which can affect benthic macroinvertebrates (response). Note that some indicators fall into more than one category (e.g. dissolved oxygen).

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| *Stress Indicators* | |
| • **Pollution Source Inventory**<br>Point Sources<br>Nonpoint Sources<br>Eroding Banks, Unstable Channels | Land Use maps at regional planning commissions or Conservation Districts<br>DEP Watershed Notebooks<br>DEP Regional Offices – Discharge Monitoring Reports for NPDES permittees<br>Toxic Release Inventory<br>Historical Land Use Records – County Library, Historical Societies, Conservation Districts |
| • **Rainfall** | Gauges |
| • **Stream Flow** | USGS Gauges or Embody Float Method (EPA, EASI, Pa. BSP) |
| • **Max. Air Temperature** | Direct Measurement or existing NWS data |
| *Exposure Indicators* | |
| • **Fecal and Total Coliform Bacteria**<br>*water sampling and analysis* | Various methods that detect presence-absence or produce an estimate of bacteria density, Coliscan Easyfgel method (Delaware Riverkeeper Network) |
| • **Biochemical Oxygen Demand**<br>*water sampling and analysis* | BOD 5-day procedure w/Modified Winkler Titration w/a syringe or eyedropper (Pa. BSP, Mitchell/Stapp, ALLARM, Delaware Riverkeeper) |
| • **Dissolved Oxygen**<br>*water sampling and analysis* | Modified Winkler Titration w a syringe or eyedropper (EASI, Pa. BSP, ALLARM, Mitchell/Stapp, Delaware Riverkeeper Network) |
| • **Total Phosphorus**<br>*water sampling and analysis* | Persulfate digestion followed by ascorbic acid method and color comparator (EASI, Pa. BSP, Mitchell, & Stapp) |
| • **Total Orthophosphate**<br>*water sampling and analysis* | Ascorbic acid method and color comparator (ALLARM, EASI, Pa. BSP, Mitchell & Stapp, Delaware Riverkeeper Network) |
| • **Conductivity**<br>*water sampling and analysis* | Direct measurement with meter (EASI, EPA Volunteer Methods Manual) or pen (RN) |
| • **Temperature**<br>*water sampling and analysis* | Direct measurement with a thermometer |
| • **PH**<br>*water sampling and analysis* | Sample collected and measure with a pH meter, pocket meter or litmus paper (ALLARM, EASI, PA BSP, Delaware Riverkeeper Network) |
| • **Total Alkalinity**<br>*water sampling and analysis* | Single End Point sulfuric acid titration w/bromcresol green/methyl red using dropper bottle (ALLARM, EASI., Delaware Riverkeeper Network) |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Iron**<br>*water sampling and analysis* | Treatment with FerroVer Iron Reagent followed by color comparator (Delaware Riverkeeper Network) |
| • **Total Acidity**<br>*water sampling and analysis* | Phenolphthalein Indicator followed by tritration with sodium hydroxide (Delaware Riverkeeper Network) |
| • **Nitrates**<br>*water sampling and analysis* | Cadmium reduction followed by color comparator (ALLARM, EASI, Pa. BSP, Mitchell / Stapp) |
| • **Total Suspended Solids**<br>*water sampling and analysis* | Filtration of sample through glass fiber filter followed by drying and weighing – based on SM #2540D (Delaware Riverkeeper Network) |
| • **Turbidity**<br>*water sampling and analysis* | Sample collected and measured with a nephelometer and reported as NTU's (RN) or turbidity tube reported in centimeters or inches or Lamotte units (Pa. BSP, Delaware Riverkeeper Network) |
| *Response Indicators* | |
| • **Dissolved Oxygen**<br>*water sampling and analysis* | Modified Winkler Titration w a syringe or eyedropper (EASI, Pa. BSP, ALLARM, Mitchell / Stapp) |
| • **Maximum Water Temperature** | Direct measurement with a thermometer |

Additional notes on the methods are contained in Appendix 2.

### *Relevant Manuals:*

Alliance for Aquatic Resource Monitoring, 1998. Water Quality Monitoring Methods Manual. Carlisle, Pa.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier Vt.

Delaware Riverkeeper Network, 1997. Citizen Water Quality Monitoring Manual. Washington Crossing, Pa.

Environmental Alliance for Senior Involvement (EASI), PA DEP Citizens' Volunteer Monitoring Program, & Schuylkill Center for Environmental Education. Draft 1998 Pa. Senior Environment Corps Water Quality Monitoring Field Manual. Harrisburg, Pa.

Mitchell, Mark K., and Stapp, William B. 1990. Field Manual for Water Qulity Monitoring, Kendall-Hunt Publishers. Ann Arbor, Mich.

Pa. Bureau of State Parks, Draft 1999. Watershed Education Manual. Harrisburg, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office Water 4503F, Washington, D.C.

### *Site Location Considerations*

Water sampling should be carried out at a variety of sites that represent a variety of conditions in the watershed. Select as many of the following types of sites as you can (see Chapter 2, Step 6 on page 2-18 for definitions of types of sites):

- ♦ Sites on streams of different orders (sizes) and at different altitudes.
- ♦ Watershed reference sites.
- ♦ Stream impact assessment sites:
  - upstream reference (control) sites
  - impact sites
  - recovery sites

- ♦ Tributary impact assessment sites:
  - reference sites
  - impact sites
  - recovery sites
  - integrator sites
- ♦ Cold and warm water fish habitat areas (spawning, nursery and resting sites).
- ♦ Where possible, sites historically monitored by DEP.

### *How Frequently and When Should You Carry Out the Assessment?*

Condition and Trend Assessment requires as many samples collected under as many different conditions as your resources will allow. A good assessment 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 – five years at a minimum.

We suggest the following frequency, time of day, time of year and weather conditions for the monitoring options listed in the table above:

**Pollution Source Inventory**

- ♦ *Frequency and time of year:* At least once per year.
- ♦ *Time of day and weather:* Not a consideration, though field work during high flows should be avoided for safety reasons.

**Rainfall**

- ♦ *Frequency and time of year:* Sample hourly during storm events from April-November.
- ♦ *Time of day and weather:* Storm events.

**Air Temperature**

- ♦ *Frequency and time of year*: Measure during every sampling event.
- ♦ *Time of day and weather:* Sample during hottest part of day, typically mid-afternoon.

**Water Sampling and Analysis**

- ♦ *Frequency:* Sample at least once 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 low flow and high air temperature conditions – and less stressful periods such as mid-late spring to get a sense of seasonal variation.
- ♦ *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 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.

### Data Analysis

Basic statistical summaries should be used to summarize the data and to reveal patterns in the data over time and space. We recommend the following fairly simple summaries:

- Seasonal and / or annual averages to show values typical of the data set;
- Seasonal and / or annual medians to show values typical of the data set;
- Maximums to show extreme conditions;
- Minimums to show extreme conditions; and
- Range (maximum - minimum) to show variability.

We recommend comparing results 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.

### Data Reporting Requirements

No specific requirements.

### Quality Assurance/Quality Control (QA/QC)

Basic Condition and Trend Assessment does not require rigorous QA / QC. We suggest only internal controls (samples collected and analyzed by project field volunteers, staff and lab - see p. A4-2), though external controls (samples collected and analyzed by non-volunteer field staff and "quality control" lab - see p. A4-3) will enhance the credibility of the data and provide a valuable educational experience for participants. Choose specific quality control measures for each indicator from the list in Table 2, Appendix 4 (on page 4-6). Chapter 4 also contains information on internal quality controls and how they are assessed.

### Training Required

*Sampling:* Initially, the program coordinator and a core group of field samplers should be trained in proper water sample collection techniques. 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,[8] 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. 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.

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

## A4. Condition and Trend Assessment - Lakes

### *What Is It?*

This is a relatively easy assessment that uses water clarity and visual indicators to determine the condition of the lake. Water clarity is measured using a Secchi disk and the results used to determine the lake's trophic state (a measure of biological productivity), using Carlson's Trophic State Index. Visual surveys of several biological indicators are used to supplement the trophic status information and provide visual evidence of impairment.

This is very similar to the Screening Assessment in section C (on page 5-78).

### *Why Do It?*

We suggest this as the first step in a lake assessment effort. It enables you to rapidly and easily find problem areas for further follow-up, either by DEP or your program.

### *Primary Purposes Addressed*

- ☑ Community Education and Awareness
- ☑ Baseline Data Collection
- ☑ Community and / or Watershed Level Assessment
- ☐ State and Federal Agency Assessment

### *Questions Addressed*

- ☐ Is the water meeting or exceeding state Water Quality Standards?
- ☐ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☐ Where are the threatened waters that should be a high priority for protection? What is causing these threats?
- ☑ What are the present ecological conditions, and how do they change over time?
- ☐ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?
- ☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?
- ☑ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The Condition and Trend Assessment for Lakes involves two activities, which should both be carried out at the same time:

| Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Secchi Transparency** | Average of depths at which the disk disappears and reappears: EPA Volunteer Lake Monitoring Manual |

| Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Visual Survey that includes observing and recording the following:**<br>- Aquatic Plant Mapping<br>- Algae Bloom Locations<br>- Erosion Locations<br>- Rainfall<br>- Fish Kills<br>- Goose and Duck Population Locations | EPA Volunteer Lake Monitoring Manual<br>Visual inspection and mapping |

Additional notes on the methods are contained in Appendix 2.

### *Relevant Manuals*


EPA 1991. Volunteer Lake Monitoring: A Methods Manual EPA 440/4-91-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

EPA, 1988. The Lake and Reservoir Restoration and Guidance Manual, EPA 44015-88-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Moore, M.L. 1987. NALMS Management Guide for Lakes and Reservoirs, North American Lake Management Society; Washington, D.C. 42 pp.

Shertzer and Schreffler, 1996. Pennsylvania's Water Quality Network Monitoring Program. Harrisburg, Pa.


### *Site Location Considerations*

Sampling should be carried out at the following locations:

Secchi transparency should be taken at the deepest part of the lake and one other open water location that reflects conditions in an arm or bay and/or receives pollution that might affect water clarity.

Visual surveys should be carried out as follows:

- Aquatic Plant Mapping: locations with extensive plant growth.
- Algae Bloom locations: secchi transparency locations and areas that receive pollution that might cause algae blooms.
- Erosion Locations: entire perimeter of lake if possible.
- Rainfall: anywhere in the vicinity of the lake.
- Fish Kills: note wherever they occur.
- Goose Duck Population Locations: note wherever they occur.

### *How Frequently and When Should You Carry Out the Assessment?*

#### Secchi Transparency

- *Frequency:* Sample at least once per month, from May - October. Sampling must be conducted over a minimum of one year.
- *Time of day:* Sample during the same time of day consistently, in order to minimize variation due to changes in light.
- *Time of year:* In general, sample once during the May-October growing season.

- *Weather:* Sample during "normal" conditions (not after storm events, unless you want to assess storm-produced turbidity).
- The **visual survey** should be conducted together with the secchi transparency.

### Data Analysis

Secchi transparency results are expressed as the average of the depth at which the Secchi disk can no longer be seen as it is slowly lowered into the water column and the depth at which it reappears when gradually raised. This average depth is used to calculate Carlson's Trophic State Index. This index quantifies the relationship between changes in the production of algae (biomass) and changes in the clarity of the water column.

The index is calculated by "log transforming"[9] the Secchi depths and using them in the following equation:

TSI = 60 – 14.41 x log of Secchi depth (in meters)

This results in a number that is interpreted as follows:

| | | |
|---|---|---|
| >50 | - | high productivity (follow-up recommended) |
| 40 – 50 | - | moderate productivity |
| <40 | - | low productivity |

Results of the visual survey are used to confirm possible impairment by locating visual evidence (such as extensive plant growth, algae blooms, fish kills).

### Data Reporting Requirements

No specific requirements.

### Quality Assurance/Quality Control (QA/QC)

Internal quality control measure such as clear documentation, proper training and replicate measurements of Secchi depths are recommended.

### Training Required

Initially, a qualified instructor from the group or agency that uses the method should train the program coordinator and a core group of field samplers and observers in proper Secchi measurement and visual survey techniques. The program coordinator should then designate people from this core group who are qualified to train others.

[9] This involves converting the Secchi depths into their logarithmic values.

## A5. Point Source Impact Assessment

### *What Is It?*

A Point Source Impact Assessment is the collection of selected information to establish the nature and extent of the impact of point source pollution sources (wastewater treatment plants and other permitted discharges) on the stream's ecological health and aquatic life uses. It includes a wide range of monitoring activities that assess as many of the physical, chemical and biological indicators of stream health likely to be affected by these sources as is practical for volunteer monitors, using methods that are relatively quick and easy to use:

- ♦ Water sampling and analysis for indicators of impacts;
- ♦ Benthic macroinvertebrate sampling and analysis and habitat assessment;
- ♦ Discharge permit survey; and
- ♦ Measurements of rainfall and river flow.

These activities occur upstream and downstream of the source 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 the point source.

A Point Source Impact Assessment is geared to produce information that can be used by communities to flag problems at point source pollution sources.

### *Why Do It?*

We suggest that you undertake a Point Source Impact Assessment if your primary interest is in the data being used to flag potential problems.

### *Primary Purposes Addressed*

- ☑ Community Education and Awareness
- ☑ Baseline Data Collection
- ☑ Community and / or Watershed Level Assessment
- ☐ State and Federal Agency Assessment

### *Questions Addressed*

- ☐ Is the water meeting or exceeding state Water Quality Standards?
- ☐ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☐ Where are the threatened waters that should be a high priority for protection? What is causing these threats?
- ☑ What are the present ecological conditions, and how do they change over time?
- ☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?
- ☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?

☑ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The Point Source Impact Assessment involves collecting and analyzing water samples for indicators of the impacts of point source discharges; 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 source.

Following is a menu of monitoring options from which to select indicators and methods appropriate for your stream, and your human and financial resources. Following this menu is a table which suggests indicators by point pollution source:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Discharge Permit Survey** | Review discharge permits and monitoring reports |
| *Aquatic Life and Habitat Monitoring* | |
| • **Streamside Benthic Macroinvertebrate Assessment** | Field collection and identification of major groups assessment based on relative abundance and estimated richness (EPA, EASI, RN, IWLA, Pa. BSP, Pa. DEP) |
| • **Habitat Walk** | Visual assessment of various habitat characteristics (EASI, EPA, Pa. BSP, Pa. DEP) |
| *Water Sampling and Analysis* | |
| • **Fecal Coliform Bacteria** | Various methods that detect presence-absence or produce an estimate of bacteria density (Delaware Riverkeeper Network) |
| • **Biochemical Oxygen Demand** | BOD 5-day procedure w/ Modified Winkler Titration w/ a syringe or eyedropper (Pa. BSP, Mitchell/Stapp, ALLARM) |
| • **Dissolved Oxygen** | Modified Winkler Titration w/ a syringe or eyedropper (EASI, Pa. BSP, ALLARM, Mitchell/Stapp, Delaware Riverkeeper Network) |
| • **Total Phosphorus** | Persulfate digestion followed by ascorbic acid method and color comparator (EASI, Pa. BSP, Mitchell & Stapp) |
| • **Total Orthophosphate** | Ascorbic acid method and color comparator (ALLARM, EASI, Pa. BSP, Mitchell & Stapp, Delaware Riverkeeper Network) |
| • **Conductivity** | Direct measurement with meter (EPA Volunteer Methods Manual) or pen (RN, EASI) |
| • **Temperature** | Direct measurement with a thermometer |
| • **PH** | Sample collected and measured with a pH meter, pocket meter or litmus paper (ALLARM , EASI, Pa. BSP, Delaware Riverkeeper Network) |
| • **Iron** | Reduction of Fe to $Fe^{2}$ followed by color comparator (Delaware Riverkeeper Network) |
| • **Total Acidity** | Phenolphthalein Indicator followed by tritration with sodium hydroxide (Delaware Riverkeeper Network) |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Total Alkalinity** | Single End Point sulfuric acid titration w/bromcresol green/methyl red using dropper bottle (ALLARM, EASI, Pa. BSP, Delaware Riverkeeper Network) |
| • **Nitrates** | Cadmium reduction followed by color comparator (ALLARM, EASI, Pa. BSP, Mitchell/Stapp) |
| • **Total Suspended Solids** | Delaware Riverkeeper Network |
| • **Turbidity** | Sample collected and measured with a nephelometer and reported as NTU's (RN) or turbidity tube reported in centimeters or inches or Lamotte units (Pa. BSP, Delaware Riverkeeper Network) |
| • **Dissolved Oxygen** | Modified Winkler Titration w/ a syringe or eyedropper (EASI, Pa. BSP, ALLARM, Mitchell/Stapp) |
| • **Water Temperature** | Direct measurement with a thermometer |
| *Flow and Rainfall* | |
| • **Stream Flow** | USGS gauges on Embody Float Method (EPA EASI, Pa. BSP) |
| • **Rainfall** | Rain Gage or NOAA Data |

Additional notes on the methods are contained in Appendix 2.

The following table suggests indicators that are appropriate for the different point source pollution types:

| Indicator/Tool | Sewage | Toxics |
|---|---|---|
| Pollution Source Inventory | X | X |
| Streamside Benthic Macroinvertebrate Assessment | X | X |
| Benthic Macroinvertebrate Habitat Assessment | X | X |
| Fecal colif./E. coli Bacteria | X | |
| Total Phosphorus | X | |
| Nitrate Nitrogen | X | |
| Turbidity | X | |
| Dissolved Oxygen | X | |
| Biochemical Oxygen Demand | X | X |
| Temperature | X | |
| PH | X | X |
| Total Alkalinity | X | X |
| Conductivity | X | X |
| Stream Flow | X | X |
| Rainfall | X | X |

## *Relevant Manuals*


Alliance for Aquatic Resource Monitoring, 1998. Water Quality Monitoring Methods Manual. Carlisle, Pa.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier, Vt.

Dates, Geoff, and Byrne, Jack, 1997. Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess Your River's Health, River Network, Montpelier, Vt.

Delaware Riverkeeper Network, 1997. Citizen Water Quality monitoring Manual. Washington Crossing, Pa.

Environmental Alliance for Senior Involvement (EASI), Pa. DEP Citizens' Volunteer Monitoring Program, & Schuylkill Center for Environmental Education. Draft 1998 Pa. Senior Environment Corps Water Quality Monitoring Field Manual. Harrisburg, Pa.

Firehock, Karen. Save Our Streams Volunteer Trainer's Handbook. Izaak Walton League of America, Gaithersburg, Md.

Mitchell, Mark K., and Stapp, William B. 1990. Field Manual for Water Quality Monitoring, Kendall-Haunt Publishers. Ann Arbor, Mich.

Pa. Bureau of State Parks, Draft 1999. Watershed Education Manual. Harrisburg, Pa.

Pa. DEP, 1998. Strategy for Assessing Pennsylvania's Unassessed Surface Waters (Field Biologist version, 4/23/98) Harrisburg, Pa.

Shertzer, Richard and Schreffler, Tammy 1996. Pennsylvania's Surface Water Quality Monitoring Network (WQN), 3600-BK-DEP0636, DEP, Harrisburg, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

### *Site Location Considerations*

Water, habitat and benthic macroinvertebrate sampling should bracket specific pollution sources or groups of pollution sources (see Chapter 2, Step 6 page 2-20 for definitions of types of sites):

- Watershed reference sites.
- Stream impact assessment sites that bracket the source.
  - upstream reference (control) sites
  - impact sites
  - recovery sites
- Where possible, sites historically monitored by the DEP.
- Benthic macroinvertebrate sampling from riffle habitats.
- Sites which are representative of the stream reach of interest.
- Sites which are safely accessible.
- Sites where the main stream current is accessible -- where the water is thoroughly mixed.

### *How Frequently and When Should You Carry Out the Assessment?*

You should conduct enough sampling events at the right time of the year to relate your results to attaining designated uses. DEP recommends a minimum of 24 samples per site to determine impairment. That means at least twice per month, year round, weekly for six months, twice weekly for three months, etc. Here are some general considerations for determining the frequency and timing of your sampling:

**Pollution Source Inventory**

- *Frequency and time of year:* At least once per year.
- *Time of day and weather:* Not a consideration, though field work during high flows should be avoided for safety reasons.

**Water Sampling and Analysis**

- *Frequency:* Sample at least once per month during the chosen time of year, during storms and during dry weather. Sampling must be conducted over a minimum of one year.
- *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:* 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 for safety reasons.

**Field Measurements of Flow and Rainfall**

- *Frequency and time of year:* Measure flows at least as frequently as water sampling, daily if possible. Measure rainfall daily if possible.
- *Time of day:* Not a consideration.
- *Weather:* Measure flow and rainfall before, during and after rainfall events.

## *Data Analysis*

Basic statistical summaries should be used to summarize the data and to reveal patterns in the data over time and space. We recommend the following fairly simple summaries:

- Seasonal and/or annual averages to show values typical of the data set;
- Seasonal and/or annual medians to show values typical of the data set;
- Maximums to show extreme conditions;
- Minimums to show extreme conditions; and
- Range (maximum - minimum) to show variability.

We recommend comparing results 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.

### Data Reporting Requirements

No specific requirements

### Quality Assurance/Quality Control (QA/QC)

Basic Point Source Impact Assessment does not require rigorous QA / QC. We suggest only internal controls (samples collected and analyzed by project field volunteers, staff and lab - see p. A4-2), though external controls (samples collected and analyzed by non-volunteer field staff and "quality control" lab - see p. A4-3) will enhance the credibility of the data and provide a valuable educational experience for participants. Choose specific quality control measures for each indicator from the list in Table 2, Appendix 4 (on page A4-6). Chapter 4 also contains information on internal quality controls and how they are assessed.

### 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 the group or agency that uses and supports the method. 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,[10] 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. 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.

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

# A6. Nonpoint Source Impact Assessment

### *What Is It?*

A Nonpoint Source Impact Assessment is the collection of selected information to establish the nature and extent of the impact of runoff from one or more nonpoint pollution sources on the stream's ecological health and aquatic life uses. It includes a wide range of monitoring activities that assess as many of the physical, chemical and biological indicators of stream health likely to be affected by the runoff from these sources as is practical for volunteer monitors, using methods that are relatively simple and easy to use:

- ♦ Water sampling and analysis for indicators of runoff impacts;
- ♦ Benthic macroinvertebrate sampling and analysis and habitat assessment;
- ♦ Nonpoint source pollution source inventory; and
- ♦ Measurements of rainfall and river flow.

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

A Nonpoint Source Impact Assessment is geared to produce information which can be used by communities to flag problems at nonpoint source pollution problems.

### *Why Do It?*

We suggest that you undertake a nonpoint Source Impact Assessment if your primary interest is in the data being used to flag problems for further monitoring.

### *Primary Purposes Addressed*

- ☑ Community Education and Awareness
- ☑ Baseline Data Collection
- ☑ Community and / or Watershed Level Assessment
- ☐ State and Federal Agency Assessment

### *Questions Addressed*

- ☐ Is the water meeting or exceeding state Water Quality Standards?
- ☐ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☐ Where are the threatened waters that should be a high priority for protection? What is causing these threats?
- ☑ What are the present ecological conditions, and how do they change over time?
- ☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?
- ☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?
- ☑ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The Nonpoint Source Impact Assessment involves research; a visual shoreline survey of uses, values and threats; collecting and analyzing benthic macroinvertebrate samples; assessing benthic macroinvertebrate habitat quality; and collecting and analyzing water samples for indicators of nonpoint source pollution. These activities are carried out above and below the source. 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 and methods appropriate for your stream, and your human and financial resources. Following this menu is a table that suggests indicators by nonpoint pollution source:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| *Research* | |
| • **Research existing information:** Literature search for reports, plans and other documents pertaining to the watershed to identify uses, values, pollution sources and conditions | Search the following:<br>EPA Surf Your Watershed<br>Land Use maps at regional planning commissions or Conservation Districts<br>DEP Watershed Notebooks<br>Historical Land Use Records - County Library, Historical Societies, Conservation Districts |
| • **Uses, values and threats meeting** | Hold a meeting in which participants locate uses, values and threats on a map (River Network) |
| • **Field survey of stream, riparian and watershed characteristics, uses, values and threats** | Visual Assessment (ALLARM, EPA Pa.SP)<br>Watershed Field Inventory (Adopt-A-Stream Foundation)<br>Stream Walk (River Network) |
| *Aquatic Life and Habitat Monitoring* | |
| • **Streamside Benthic Macroinvertebrate Assessment** | Field collection and identification of major groups, assessment based on relative abundance and estimated richness (EPA, EASI, RN, IWLA, Pa. DEP) |
| • **Habitat Walk** | Visual assessment of various habitat characteristics (EASI, EPA, Pa. BSP, Pa. DEP) |
| *Water Sampling and Analysis* | |
| • **Fecal and Total Coliform Bacteria** | Various methods that detect presence-absence or produce an estimate of bacteria density, Coliscan Easygel Method (Delaware Riverkeeper Network) |
| • **Biochemical Oxygen Demand** | BOD 5-day procedure w/ Modified Winkler Titration w/ a syringe or eyedropper (Pa. BSP, Mitchell/Stapp, ALLARM, Delaware Riverkeeper Network) |
| • **Dissolved Oxygen** | Modified Winkler Titration w/ a syringe or eyedropper (EASI, Pa. BSP, ALLARM, Mitchell/Stapp, Delaware Riverkeeper Network) |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Total Phosphorus** | Persulfate digestion followed by ascorbic acid method and color comparator (EASI, Pa. BSP, Mitchell & Stapp) |
| • **Total Orthophosphate** | Ascorbic acid method and color comparator (ALLARM, EASI, Pa. BSP, Mitchell & Stapp, Delaware Riverkeeper Network) |
| • **Conductivity** | Direct measurement with meter (EASI, EPA Volunteer Methods Manual) or pen (RN) |
| • **Temperature** | Direct measurement with a thermometer |
| • **PH** | Sample collected and measured with a pH meter, pocket meter or litmus paper (ALLARM , EASI, Pa. BSP) |
| • **Total Alkalinity** | Single End Point sulfuric acid titration w/ bromcresol green/methyl red using dropper bottle (ALLARM, EASI, Pa. BSP, Delaware Riverkeeper Network) |
| • **Iron** | Treatment with FerroVer Iron Reagent followed by color comparator (Delaware Riverkeeper Network) |
| • **Total Acidity** | Phenolphthalein Indicator followed by titration with sodium hydroxide (Delaware Riverkeeper Network) |
| • **Nitrates** | Cadmium reduction followed by color comparator (ALLARM , EASI, Pa. BSP, Mitchell/Stapp) |
| • **Turbidity** | Sample collected and measured with a nephelometer and reported as NTU's (RN) or turbidity tube reported in centimeters or inches or Lamotte units (Pa. BSP, Delaware Riverkeeper Network) |
| • **Dissolved Oxygen** | Modified Winkler Titration w/ a syringe or eyedropper (EASI, Pa. BSP, ALLARM, Mitchell/Stapp) |
| • **Water Temperature** | Direct measurement with a thermometer |
| *Flow and Rainfall* | |
| • **Stream Flow** | USGS gauges or Embody Float Method (EPA, EASI, Pa. BSP) |
| • **Rainfall** | Rain Gauge or NOAA Data |

Additional notes on the methods are contained in Appendix 2.

The following table suggests indicators that are appropriate for the different nonpoint source pollution types:

| Indicator/Tool | Erosion | Nutrients | Animal Manure | Urban Runoff | Veg. Removal | AMD[11] |
|---|---|---|---|---|---|---|
| Pollution Source Inventory | X | X | X | X | X | X |
| Streamside Benthic Macroinvertebrate Assessment | X | X | X | X | X | X |
| Benthic Macroinvertebrate Habitat Assessment | X | X | X | X | X | X |
| Fecal colif./E. coli Bacteria | | | X | X | | |
| Total Phosphorus | X | X | X | X | X | |
| Nitrates | | X | X | X | | |
| Turbidity | X | | X | X | X | |
| Dissolved Oxygen | | X | X | X | X | |
| Temperature | X | X | X | X | X | |
| pH | | | | X | | X |
| Total Alkalinity | | | | X | | X |
| Conductivity | | | | X | | X |
| River Flow | X | X | X | X | X | X |
| Rainfall | X | X | X | X | X | X |

[11] Abandoned Mine Drainage.

### *Relevant Manuals*

Alliance for Aquatic Resource Monitoring, 1998. Water Quality Monitoring Methods Manual. Carlisle, Pa.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier, Vt.

Dates, Geoff, and Byrne, Jack, 1997. Living Waters: Using Benthic macroinvertebrates and Habitat to Assess Your River's Health, River Network, Montpelier, Vt.

Delaware Riverkeeper Network, 1997. Citizen Water Quality monitoring Manual. Washington Crossing, Pa.

Environmental Alliance for Senior Involvement (EASI), Pa. DEP Citizens' Volunteer Monitoring Program, & Schuylkill Center for Environmental Education. Draft 1998 Pa. Senior Environment Corps Water Quality Monitoring Field Manual. Harrisburg, Pa.

Firehock, Karen. Save Our Streams Volunteer Trainer's Handbook. Izaak Walton League of America, Gaithersburg, Md.

Mitchell, Mark K., and Stapp, William B. 1990. Field Manual for Water Quality Monitoring, Kendall-Hunt Publishers. Ann Arbor, Mich.

Moore, M.L. 1987. NALMS Management Guide for Lakes and Reservoirs, North American Lake Management Society, Washington, D.C. 42 pp.

Pa. Bureau of State Parks, Draft 1999. Watershed Education Manual. Harrisburg, Pa.

DEP – 1998. Strategy for Assessing Pennsylvania's Unassessed Surface Waters (Field Biologist Version, 4/23/98) Harrisburg, Pa.

Shertzer, Richard and Schreffler, Tammy, 1996. Pennsylvania's Surface Water Quality Monitoring Network (WQN), 3600-BK-DEP0636, DEP, Harrisburg, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

EPA 1998. The Lake and Reservoir Restoration and Guidance Manual, EPA 44015-88-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

### *Site Location Considerations*

Water, habitat and benthic macroinvertebrate sampling should bracket specific pollution sources or groups of pollution sources (see Chapter 2, Step 6 for definitions of types of sites):

- Watershed reference sites.
- Stream impact assessment sites:
  - upstream reference (control) sites
  - impact sites
  - recovery sites
- Where possible, sites historically monitored by DEP.
- Benthic macroinvertebrate sampling from riffle habitats.
- Sites which are representative of the stream reach of interest.
- Sites which are safely accessible.

- Sites where the main stream current is accessible -- where the water is thoroughly mixed.

### *How Frequently and When Should You Carry Out the Assessment?*

You should conduct enough sampling events at the right time of year to relate your results to attaining designated uses. DEP recommends a minimum of 24 samples per site to determine impairment that means at least twice per month, year round, weekly for six months, twice weekly for three months, etc. Here are some general considerations for determining the frequency and timing of your sampling.

**Pollution Source Inventory**

- *Frequency and time of year:* At least once per year.
- *Time of day and weather:* Not a consideration, though field work during high flows should be avoided for safety reasons.

**Water Sampling and Analysis**

- *Frequency:* Sample at least two or three times per month during the chosen time of year, during storms and during dry weather. Sampling must be conducted over a minimum of one year.
- *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:* 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.

**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*

Basic statistical summaries should be used to summarize the data and to reveal patterns in the data over time and space. We recommend the following fairly simple summaries:

- Seasonal and / or annual averages to show values typical of the data set;
- Seasonal and / or annual medians to show values typical of the data set;
- Maximums to show extreme conditions;
- Minimums to show extreme conditions; and

- Range (maximum - minimum) to show variability.

We recommend comparing results 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.

### *Data Reporting Requirements*

No specific requirements.

### *Quality Assurance Quality Control (QA/QC)*

Basic Nonpoint Source Impact Assessment does not require rigorous QA / QC. We suggest only internal controls, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Choose specific quality control measures for each indicator from the list in Table 2, Appendix 4 on page A4-6. Chapter 4 also contains descriptions of internal quality controls and how they are evaluated.

### *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 the group or agency that uses and supports the method. 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[12], proper training is essential. We suggest a designated lab coordinator responsible for seeing that all analysts are property trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis. 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.

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

## A7. Groundwater Basin Assessment

### *What Is It?*

Groundwater basins are the watersheds for groundwater. In most cases, their boundaries are closely approximated by surface water boundaries. There are several situations that cause groundwater basin boundaries to diverge from surface water boundaries. These include: 1) a large withdrawal of groundwater near the surface water divide; 2) geologic structures such as tilted rocks that direct groundwater underneath a surface water divide; 3) dissolution channels in carbonate rocks such as limestone; and 4) mining areas and mining drainage tunnels. Despite these possibilities, surface water boundaries are typically a good frame of reference for groundwater boundaries.

This assessment will determine groundwater flow directions and collect new and existing information on conditions of the groundwater through sampling of springs and wells. This information can be used to identify problem areas, to assess the general quality of groundwater that provides stream baseflow in an area and to gauge nonpoint source pollution in the watershed. This assessment can strengthen the understanding of the groundwater influence on the watershed.

A great deal of information is being gathered by DEP and public water suppliers as DEP develops and begins implementation of the Source Water Assessment and Protection Program (SWAPP). Public drinking water sources are being delineated, contamination surveys are being conducted and susceptibility analyses are being performed. All of this information will be available to the public. Such information will be useful for volunteer groups to use in their assessments of watersheds. Over 14,000 sources of public drinking water will need to be assessed. The date for completion of these assessments is expected to be extended to June 2003.

The Groundwater Basin Assessment is an additional step in a comprehensive watershed assessment program. It has two parts:

- ♦ Research: a compilation of existing information from reports and interviews; and
- ♦ Data analysis: review of the data collected.

### *Why Do It?*

We suggest the Groundwater Basin Assessment as a tool for understanding background water quality in a watershed. It enables you to get to know your intrinsic watershed water quality and determine which areas or issues you'll focus on for future monitoring. It also focuses on nonpoint sources of contamination.

The Groundwater Basin 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 Purposes Addressed*

☑ Community Education and Awareness
☐ Baseline Data Collection
☑ Community and/or Watershed Level Assessment
☐ State and Federal Agency Assessment

### *Questions Addressed*

☑ Is the water meeting or exceeding state Water Quality Standards?

☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

☐ What are the present ecological conditions, and how do they change over time?

☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?

☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?

☑ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The Groundwater Basin Assessment is a process of narrowing down the geographic and topical scope of your efforts through research and then focusing on a specific area of the watershed that includes the uses, values and threats that you wish to assess in the field through a groundwater assessment.

Monitoring options are listed in the following table:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • Research existing information: Literature search | Search DEP, USGS, DCNR, university and other sources of existing reports |
| • Research existing information: Uses, values and threats exercise | Meeting participants locate uses, values and threats on a map |
| • Field survey of springs, wetlands and watershed characteristics including wells, quarries, mines, land use, etc. | Field and database assessments |

### *Site Location Considerations*

- Sites that contain problem areas which might be a high priority for some corrective action.
- Sites that contain special resource areas.
- Sites that contain threats to human and aquatic life uses of the water.

### *How Frequently Should You Gather Data?*

Data review should be carried out at least once per year, to track new sources of data.

### *Data Analysis*

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

- Identify areas where data that are necessary to make decisions are lacking;
- Identify problems and conflicts that 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.

### *Data Gathering Requirements*

Although any groundwater study can be useful, specific attention should be paid to parameters such as those listed under the Advanced Groundwater Assessment. Useful parameters can include specific conductance, pH, dissolved oxygen and alkalinity. Major ions and dissolved solids can include calcium, magnesium, sodium, potassium, dissolved solids, chloride, sulfate and total hardness. Nutrient analysis can entail constituents such as nitrite and nitrate nitrogen, ammonium and phosphate. Many studies also analyze iron, manganese, aluminum and coliform bacteria. Such analytes can be useful in evaluating the health of a watershed.

### *Quality Assurance/Quality Control (QA/QC)*

A Basic Groundwater Basin Assessment does not require complex QA/QC since its purpose is primarily problem screening and education and awareness. However, some of the general QC for sampling and analysis in Appendix 4 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 assessors.

### *Training Required*

The organization or agency that developed the assessment or a designated service provider should initially train assessors. At or following the training, assessors 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 that may develop. New assessors should be trained by the program coordinator or by an experienced assessor.

## B. Advanced Stream Assessment

The stream assessments described in this section are designed to assist DEP in locating and assessing streams under sections 303(d) and 305(b) of the Clean Water Act. Pennsylvania reports to EPA and Congress every two years with an assessment of all the waters of the state and the extent to which they support their designated uses under the state water quality standards[13]. This is called the 305(b) report. A subset of these waters which will not meet the water quality standards is identified in the 303(d) list. For these waters, Remediation Plans must be developed in which pollution loading is allocated among various sources through total maximum daily loads (TMDLs).

Not all waters that are listed as impaired on the 305(b) report will necessarily appear on the 303(d) list. There are three reasons why impaired waters might *not* appear on the 303(d) list:

1) The impairment is not being caused by a pollutant as defined in the Clean Water Act. Impairment can result from physical barriers, exotic species, prolonged drought and other sources. DEP does not place these waters on the list since there is no pollutant load to allocate through the TMDL process.

2) Impairments are being, or will be, addressed by required pollution control efforts. DEP determines that eliminating the impairment is better addressed through existing enforcement and compliance pollution control efforts.

3) The waterbody already has an EPA-approved TMDL developed for identified causes of impairment. However, these waters remain in the 305(b) report as impaired until the designated use is fully supported.[14]

The assessments that DEP uses to establish and monitor impairment are described in Appendix 3 on page A3-3.

### *Use of Volunteer Data for the 305(b)/303(d) Process*

Some volunteer monitoring groups would like DEP to use their data to establish whether their streams are impaired and, if so, to have their waters listed as such in the 305(b) report and consequently on the 303(d) list so they will be restored. DEP is required to assemble and evaluate all existing and readily available water quality related data and information for the following types of waters:[15]

1) Water identified as “partially supporting” designated uses, “not supporting” designated uses, or “threatened.”

2) Waters for which dilution calculations or predictive models show that water quality standards will not be attained.

3) Waters where problems have been reported by local, state or federal agencies; members of the public; or academic institutions.

4) Waters identified by the State as “impaired” or “threatened” in a section 319 nonpoint assessment submitted to EPA.

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[13] Chapter 93 – Water Quality Standards and Chapter 16 – Water Quality Toxics Management Strategy.

[14] Source: DEP “Information Sheet – 303(d) List and Existing and Readily Available Water Quality Data and Information, March 16, 1999.

[15] DEP “Information Sheet – 303(d) List of Existing and Readily Available Water Quality Data and Information, March 16, 1999.

DEP may use the following *types of data* to identify impaired waters:

1) Data which show that one or more numeric water quality criteria in the water quality standards have been violated.
2) Data which show that one or more narrative water quality criteria in the water quality standards have been violated.
3) Data which show that a beneficial use is impaired.
4) Technical analysis (e.g. predictive modeling or rapid bioassessment) which shows that criteria will be violated and/or uses not supported.

DEP staff is required to *review* all submitted data and will determine the adequacy of the data based on their best professional judgment. DEP may use the data collected in assessments B2 (on page 5-46), B3 (on page 5-54), B5 (on page 5-66) and B6 (on page 5-73) to place a waterbody of the 303(d) list if its "impaired" status is based on scientifically valid data that meets the following *minimum requirements:*

1) DEP determines that there is enough information to document a water quality standards violation for a specific waterbody.
2) There is information regarding the exact location and extent of the impaired waterbody. There must be an identification of an impaired stream segment or reach with an upstream and downstream limit as opposed to just a single point on a map. The reach may end due to a variety of reasons such as land use change, a point discharge or Abaned Mine Drainage seep.
3) There is information that describes the quality assurance and quality control such that DEP can reasonably assess the available data and determine its applicability.
4) The sampling and analysis protocols are comparable to those used by DEP.

For DEP to use the data, a high level of expertise, thoroughness and rigor of procedures is required of the volunteers. It also requires a degree of DEP oversight, auditing and quality control so that DEP can assess the quality of the data.

### *Assessments In This Section*

The assessments in this section are designed to provide DEP with the kind and quality of information needed to establish whether or not streams are impaired.

The following assessments and their uses by DEP are described in this section:

| Assessment Type | DEP Use |
|---|---|
| B1 Impairment Screening/Biological Assessment - Wadeable Waters | Quickly locates areas that are biologically impaired for more detailed Aquatic Life Assessments (B2 and B3) |
| B2 Aquatic Life/Designated Uses Assessment - Wadeable Waters | 305(b) report and 303(d) listing and evaluation:<br>1) establishes current ecological conditions and impairment<br>2) evaluates the effectiveness of watershed remediation plans |

| | |
|---|---|
| B3 Aquatic Life / Designated Uses Assessment - Non-Wadeable Waters | 305(b) report and 303(d) listing and evaluation:<br>1) establishes current ecological conditions and impairment<br>2) evaluates the effectiveness of watershed remediation plans |
| B4 Recreational Waters Uses and Water Supply Assessment | 305(b) report and 303(d) listing: establishes whether streams are meeting the numeric water quality criteria that support recreational and water supply uses |
| B5 Advanced Point Source Impact Assessment | 303(d) remediation plan development:<br>1) determines the source and impacts of various types of point source pollution for the development of remediation plans<br>2) evaluates the effectiveness of site-specific remediation plans |
| B6 Advanced Nonpoint Source Impact Assessment | 303(d) remediation plan development:<br>1) determines the source and impacts of various types of nonpoint source pollution for the development of remediation plans<br>2) evaluates the effectiveness of site-specific remediation plans |

Assessments B1 (page 5-42), B2 (page 5-46), B3 (page 5-54), B5 (page 5-66) and B6 (page 5-73) are based on the monitoring strategies described in the state's "Unassessed Waters Strategy" (Pa. DEP, 1998). This strategy describes how rapid and detailed assessments will be used to establish impairment and document the nature and impacts of sources. Consistent with this strategy, you might wish to start with assessment B1 (page 5-42) in order to quickly pinpoint areas of concern for more in-depth assessments.

## B1. Impairment Screening/Biological Assessment - Wadeable Waters[16]

### *What Is It?*

This assessment is a rapid biological screening to determine whether aquatic life is impaired, using benthic macroinvetebrates and habitat as indicators. There are two levels of effort:

- ♦ A rapid field collection and identification of benthic macroinvertebrate major groups (mostly order) and a visual habitat assessment; and
- ♦ If needed, a more intensive follow-up which includes collection, preservation and identification of benthic macroinvertebrates to family level and a visual habitat assessment.

Monitoring is carried out at a number of locations at the best available riffle habitats, including the main stem at various locations, the mouths of representative tributaries and upstream and downstream of pollution sources.

### *Why Do It?*

We suggest that you do this assessment if your primary interest lies in identifying potentially impaired waters for further monitoring or action. This assessment may also reveal high quality waters that should be protected.

### *Primary Purposes Addressed*

☑ Community Education and Awareness

☐ Baseline Data Collection

☑ Community and / or Watershed Level Assessment

☐ State and Federal Agency Assessment

### *Questions Addressed*

☐ Is the water meeting or exceeding state Water Quality Standards?

☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

☐ What are the present ecological conditions, and how do they change over time?

☐ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?

☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?

☐ Where are the special places with unique ecological, social and economic values that should be protected?

[16] "Wadeable" is defined as water in which you can safely walk. We suggest that water above 24", with a velocity of >2.0 feet per second is not safe to wade in.

### *Monitoring Options*

Monitoring options are listed in the following table:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| 1) **Rapid Benthic Macroinvertebrate Assessment:** rapid qualitative field collection with a net and identification of benthic macroinvertebrate major groups | • Streamside Biosurvey (EPA, EASI, Pa. BSP)<br>• Streamside Assessment (RWN, PA DEP) |
| 2) **Intensive Benthic Macroinvertebrate Assessment:** intensive semi-quantitative collection with a net, preservation, and identification of benthic macroinvertebrates to family level | • Intensive Stream Biosurvey (EPA, RWN, Pa. DEP)<br>• EPA RBPII (EPA) |
| 3) **Visual Habitat Assessment** | • Stream Habitat Walk (EPA, Pa. BSP)<br>• Intensive Stream Biosurvey (EPA, RWN, Pa. DEP |

Note that the rapid assessment can be carried out first along with the habitat assessment. The intensive assessment can be carried out if needed for quality assurance purposes, comparability with DEP screening for impairment or just to get more information.

### *Relevant Manuals*


Dates, Geoff, and Byrne, Jack, 1997. Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess your River's Health, River Network, Montpelier, Vt.

Delaware Riverkeeper Network – Citizen Water Quality Monitoring Manual. Washington Crossing, Pa.

Environmental Alliance for Senior Involvement (EASI), Pa. DEP Citizens' Volunteer Monitoring Program, & Schuylkill Center for Environmental Education. Draft 1998 Pa. Senior Environment Corps Water Quality Monitoring Field Manual. Harrisburg, Pa.

Mitchell, Mark K., and Stapp, William B. 1990. Field Manual for Water Quality Monitoring, Kendall-Hunt Publishers. Ann Arbor, Mich.

Murdoch, T. and Cheo, M., 1996. The Streamkeeper's Field Guide. Adopt-A-Stream Foundation. Everett, Wash.

Pa. Bureau of State Parks, Draft 1999. Watershed Education Manual. Harrisburg, Pa.

DEP – 1998. Strategy for Assessing Pennsylvania's Unassessed Surface Waters (Field Biologist Version, 4/23/98) Harrisburg, Pa.

Plafkin, James L, et al Rapid Bioassessment Protocols for Use in streams and Rivers: Benthic Macroinvertebrates and Fish. Report #EPA/444/4-89-001. EPA, Washington D.C., May 1989.

Shertzer, Richard and Schreffler, Tammy, 1996. Pennsylvania's Surface Water Quality Monitoring Network (WQN), 3600-BK DEP0636, DEP, Harrisburg, Pa.

Stroud Water Research Center, Unpublished Benthic Macroinvertebrate Manual. Avondale, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.


Additional notes on these methods are contained in Appendix 2.

### *Site Location Considerations*

Sampling should be carried out at a variety of sites that represent a variety of conditions in the watershed:

- Mouths of representative tributaries.
- Main stem reference and impact sites in various locations:
  - headwaters
  - mouth
  - brackets around selected tributaries
- Point source discharges:
  - immediately upstream (control site)
  - in the potential impact zone (impact site)
  - in the downstream recovery zone (recovery site)

### *How Frequently and When Should You Carry Out the Assessment?*

This assessment should be carried out at least once per year at the time of the most stress on aquatic life. This is typically in the late summer or early fall during or after low water and high temperatures. If your resources permit, an assessment in the spring will give you more information about conditions after high flows and low temperatures.

### *Data Analysis*

Results of the rapid assessment will be analyzed using a simple score based on the relative abundance and diversity of organisms in various pollution tolerance groups. Sites that rate “fair” or “poor” will be candidates for an intensive assessment.

Results of the intensive assessment at impact and recovery sites are compared with reference sites, using the EPA RPBII or some other multi-metric site comparison index. Note that, if no reference sites exist in the watershed, results may be compared with regional reference sites established by DEP.

### *Data Reporting Requirements*

Data can be reported in electronic or paper format. The sampling date(s) should be included. Sampling locations must be identified by latitude and longitude or in relation to some identifiable geographic feature such as a named bridge or road. The stream segment or "reach" must be identified.

DEP defines a stream segment as the portion of a stream between an upstream tributary and the next downstream tributary. For headwater sections, the first segment would be from the source to the first tributary. DEP uses United State Geological Survey (USGS) 7.5 minute quadrangle maps (1/24,000 scale) to identify tributaries and the resulting stream segments. The rationale for segmenting streams this way is that loads from tributaries often affect the water quality of the receiving stream and it is much easier for DEP to manage information when it is associated with fixed stream reaches. After identifying a stream segment, the sampling locations should be situated so they reflect the quality of the entire segment. A minimum of two sites is required to assess the quality of the stream segment. One location is just above the upstream tributary to measure the water quality entering the stream segment and the other location is just above the downstream tributarty to measure the water quality as it flows out of the segtment. If you suspect there are land use changes or discharges that may affect the water quality within a segment, then you may choose to establish additional sample locations at these points.

### *Quality Assurance/Quality Control (QA/QC)*

*Streamside Assessment:* Rigorous QA / QC is not required for the Streamside assessment. Internal control measures such as replicates, a field reference collection, and spot field checking of identification by the program coordinator are recommended.

*Intensive Assessment:* Rigorous QA / QC is not required unless the data will be reported to DEP. If not, internal QC measures such as replicate samples, a lab reference collection and archiving all samples is recommended. If the data will be reported to DEP, verification of identifications by a qualified person is strongly recommended.

All data that will be computerized should be validated.

### *Training Required*

Initially, the program coordinator and a core group of field samplers should be trained in proper sample collection, preservation, subsampling and identification techniques by a qualified instructor from the group or agency that uses the method. The program coordinator should then designate people from this core group who are qualified to train others. Official designation of trainers by the program coordinator through a letter or certificate should be considered.

## B2 Aquatic Life/Designated Uses Assessment - Wadeable Waters[17]

### What Is It?

An Aquatic Life Assessment involves documenting pollution sources, aquatic life uses, water sampling and analysis for water quality indicators and aquatic life and habitat monitoring. This information may be used by DEP to determine whether the waters support their aquatic life "*designated uses*", as long as the process in the Unassessed Waters Strategy (see Appendix 3 on page A3-3) is followed. The water monitoring results are compared with the numeric criteria in the water quality standards applicable to aquatic life uses (from Table 3 in Section 93.7 of the Chapter 93, Water Quality Standards). These criteria specify minimum or maximum levels or ranges necessary to support the aquatic life uses. Habitat and benthic macroinvertebrate data are compared with DEP guidelines to determine whether the aquatic community itself is actually impaired.

If the information gathered in this assessment meets DEP's requirements, as described in the introduction to Advanced Stream Assessment section and in the Data Analysis and Data Quality Requirements section below, it may be used to determine whether the waters are impaired and should be placed on the 303(d) list. Waters that are placed on the 303(d) list need remediation plans to restore impaired aquatic life uses.

### Why Do It?

We suggest that you undertake an Aquatic Life Assessment if your primary interest is whether your stream supports its legally designated aquatic life uses and values, and you need to produce data that DEP will use to determine impairment and the need for restoration.

### Primary Purposes Addressed

- ☐ Community Education and Awareness
- ☑ Baseline Data Collection
- ☐ Community and / or Watershed Level Assessment
- ☑ State and Federal Agency Assessment

### Questions Addressed

- ☑ Is the water meeting or exceeding state Water Quality Standards?
- ☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☐ What are the present ecological conditions, and how do they change over time?
- ☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?
- ☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?
- ☐ Where are the special places with unique ecological, social and economic values that should be protected?

[17] "Wadeable" is defined as water in which you can wade. We suggest that water above 24", with a velocity of >2.0 feet per second is not safe to wade in.

## *Monitoring Options*

An Aquatic Life Assessment has three parts:

1) Research or field inventory of pollution sources and aquatic life uses;
2) Collecting water samples (or direct field measurements) and analyzing those samples for the indicators contained in the water quality standards pertaining to aquatic life; and
3) Collecting, preserving and identifying benthic macroinvertebrate samples and an assessment of habitat quality.

Following is a table of the monitoring options for the Aquatic Life Assessment. Note that you don't have to monitor all the indicators -- pick the ones most relevant to your stream. Note also that some indicators (marked "For Sampling Only") are extremely difficult and / or expensive for volunteer monitoring groups to analyze. For these, we recommend that you consider sampling for the indicator, preserving the sample and taking it to a DEP, private or university lab for analysis. The DEP lab analysis must be done as part of a DEP-approved project with a budget that involves the regional DEP biologist. All other labs must be operating under an EPA-approved Quality Assurance Project Plan (QAPP) and use the methods listed.

| **Menu of Indicators/Tools** | **Examples of Methods (Source)** |
|---|---|
| *Uses and Pollution Sources* | |
| • **Research existing information:** Literature search for reports, plans and other documents pertaining to the watershed to identify uses, values, pollution sources and conditions | Search the following:<br>EPA Surf Your Watershed<br>Land Use maps at regional planning commissions or Conservation Districts.<br>DEP Watershed Notebooks<br>DEP Regional Offices – Discharge Monitoring Reports for NPDES permittees<br>Toxic Release Inventory - historical<br>Land Use Records – County Library, Historical Societies, Conservation Districts |
| • **Uses, values and threats meeting** | Hold a meeting in which participants locate uses, values and threats on a map (River Network) |
| • **Field survey of river, riparian and watershed characteristics, uses, values and threats** | Visual Assessment (ALLARM, EPA)<br>Watershed Field Inventory (Adopt-A-Stream Foundation)<br>River Walk (River Network) |
| *Water Sampling and Analysis* | |
| • **Ammonia Nitrogen** | Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or equivalent) |
| • **Dissolved Oxygen** | 1) Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent)<br>2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent) |
| • **Hardness** | Computed from results of calcium and magnesium or titrated (SM #3500Ca, EPA 130.2 a or equivalent) |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **PH** | 1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) |
| • **Temperature** | Direct measurement with a thermometer, thermocouple or thermistor |
| • **Total Alkalinity** | Double end point sulfuric acid titration w/ digital titrator and pH meter (RN or ALLARM manual) |
| • **Total Dissolved Solids** | Gravimetric method, filtrate dried at 180°C. (SM#2540C or equivalent) |
| • **Turbidity** | Sample collected and measured with a nephelometer (SM #2130 or equivalent) |
| • **Total Iron (For Sampling Only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Total Residual Chlorine (For Sampling Only)** | *Sampling*: Consult with DEP regional biologist for sampling method. This is tricky due to TRC's dissipation and flow patterns.<br>*Analysis*: Amperometric Titration Method, SM#4500ClD |
| *Aquatic Life and Habitat Monitoring* | |
| • **Intensive Benthic Macroinvertebrate Assessment** | Intensive semi-quantitative collection with a net, preservation, identification of benthic macroinvertebrates to family level and comparison with reference conditions<br>• Intensive Stream Biosurvey (EPA, RN, SWRC)<br>• EPA Rapid Bioassessment Protocol II<br>• Pa. Unassessed Waters Strategy |
| • **Visual Habitat Assessment** | Measurement or visual estimate of selected riffle habitat characteristics, scoring, and comparison to reference conditions<br>• EPA Rapid Bioassessment Protocol II<br>• PA Unassessed Waters Strategy |

Additional notes on these methods are contained in Appendix 2.

### *Relevant Materials*


Alliance for Aquatic Resource Monitoring, 1996 Visual Assessment Handbook, Carlisle, Pa.

APHA. 1992. Standard Methods for the Examination of Water and Wastewater. 18th ed. American Public Health Association. Washington, D.C.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier, Vt.

Dates, Geoff, and Byrne, Jack, 1997. Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess Your River's Health, River Network, Montpelier, Vt.

Delaware Riverkeeper Network – Citizen Water Quality Monitoring Manual. Washington Crossing, Pa.

Murdoch, T., and Cheo, M., 1996. The Streamkeeper's Field Guide. Adopt-A-Stream Foundation. Everett, Wash.

Plafkin, James L, et al Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. Report #EPA/444/4-89-001. EPA, Washington, D.C., May 1989.

DEP, 1998. Strategy for Assessing Pennsylvania's Unassessed Surface Waters (Field Biologists version, 4/23/98). Harrisburg, Pa.

River Network and Vt. Department of Environmental Conservation, Undated. River Walk (a self-explanatory field data sheet), Montpelier, Vt.

Shertzer, Richard and Schreffler, Tammy, 1996. Pennsylvania's Surface Water Quality Monitoring Network (WQN), 3600-BK DEP0636, DEP, Harrisburg, Pa.

Stroud Water Research Center, Unpublished Benthic Macroinvertebrate Manual. Harrisburg, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

EPA 1993. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

### *Site Location Considerations*

Water, habitat and benthic macroinvertebrate sampling should be carried out at a variety of sites that represent a variety of conditions in the watershed. If you have done an Impairment Screening/Biological Assessment (B1), you may have pinpointed one or more particular problem reaches. Then you may only need to sample a few sites on that reach. However, you will need to establish some sort of reference site if you plan to carry out benthic macroinvertebrate monitoring. If a good one is not present in your reach, you may need to sample one elsewhere in the watershed.

Select as many of the following types of sites as you can (see Chapter 2, Step 6 on page 2-18 for definitions of types of sites):

**Watershed Sites:**

- ♦ Sites on streams of different orders (sizes) and at different altitudes.
- ♦ Watershed reference sites.
- ♦ Stream impact assessment sites:
  - upstream reference (control) sites
  - impact sites
  - recovery sites
- ♦ Benthic macroinvertebrate riffle habitats.
- ♦ Tributary impact assessment sites:
  - reference sites
  - impact sites
  - recovery sites
  - integrator sites
- ♦ Cold and warm water fish habitat areas (spawning, nursery, and resting sites).
- ♦ Where possible, sites historically monitored by DEP.
- ♦ Benthic macroinvertebrate sampling from riffle habitats.
- ♦ Boat launch ramps and fishing access areas.

**Reach Sites:**

- Sites that are representative of the reach of the stream of interest.
- Sites that are safely accessible.
- Sites that the main stream current is accessible -- where the water is thoroughly mixed.

### *How Frequently and When Should You Carry Out the Assessment?*

You should conduct enough sampling events at the right time of year to relate your results to attaining designated uses. DEP recommends a minimum of 24 samples per site to determine impairment that means at least twice per month, year round, weekly for six months, twice weekly for three months, etc. Here are some general considerations for determining the frequency and timing of your sampling.

**Pollution Source Inventory**

- *Frequency and time of year:* At least once per year.
- *Time of day and weather:* Not a consideration, though field work during high flows should be avoided for safety reasons.

**Water Sampling and Analysis**

- *Frequency:* Sample at least once per month during the monitoring season. Sampling must be conducted over a minimum of one year.
- *Time of day:* Sample during critical periods of the day for those indicators that fluctuate daily . For example, dissolved oxygen (DO) and temperature are both typically lowest at sunup and highest in mid-day. 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.
- *Time of year:* For assessing dissolved oxygen suitability for fish, sample during critical periods of stress – such as summer low flow and high air temperature conditions – and less stressful periods such as mid-late spring to get a sense of seasonal variation. Also, try to sample during spawning and rearing periods.
- *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, from November through May.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

## *Data Analysis and Data Quality Requirements*

### Chemical Data

| | |
|---|---|
| • **Data Age** | < five years old (unless justified that it represents current conditions |
| • **Chemical Parameters** | Only those for which a criterion exists in the water quality standards |
| • **Minimum # of Sampling Sites** | None, but must be representative |
| • **Sampling Duration and Frequency** | > one year and at least once per month. Single, one-time grab samples are not acceptable |
| • **Minimum # of Samples for Representativeness** | Preferred: ≥24 samples/site, however, if 25 percent of samples collected monthly over one year exceed a criterion, 12 samples may be acceptable. |
| • **Minimum percent of Samples Exceeding Water Quality Criteria Needed to Document A Water Quality Standard Violation** | For any parameter, if 10 percent of collected samples (>25 percent if less than 24 samples) exceed criterion |

### Bacteria Data

| | |
|---|---|
| • **Date Age** | < five years old (unless justified that it represents current conditions) |
| • **Minimum # of Sampling Sites** | None, but must be representative |
| • **Sampling Duration and Frequency** | For daily sampling: ≥5 days<br>For weekly sampling: ≥5 weeks<br>For monthly sampling: ≥5 months |
| • **Minimum # of Samples for Representatives** | > five samples collected on different days |
| • **Minimum percent of Samples Exceeding Water Quality Criteria Needed to Document a Water Quality Standard Violation** | Single Violation |

### Benthic Macroinvertebrate Data

Benthic macroinvertebrate data are compared with the checklist on the "Unassessed Waters Field Form: Wadeable Streams." This checklist contains 13 statements that get a check in a "yes" or “no” column (e.g. abundance obviously low, seven or fewer families in the sample, stoneflies collectively present, dominant family with a Hilsenhoff of four or less).

Habitat data are compared with the checklist on the "Unassessed Waters Field Form: Wadeable Streams." This checklist contains three statements that get a check in a "yes" or a "no" column (these relate to the scores of different habitat characteristic on the EPA RBP II habitat assessment form).

| | |
|---|---|
| • **Data Age** | < five years old (unless justified that it represents current conditions) |
| • **Minimum # of Sampling Sites** | None, but must be representative |
| • **Sampling Duration and Frequency** | Single, one-time grab samples are acceptable. Data collected over several years is preferable. If data are compared with reference site, both sites must be sampled within same month. |

| | |
|---|---|
| • **Acceptable Data** | Identification to lowest practical taxonomic level, generally to genus with a few families. |
| • **Minimum percent of Samples Exceeding Water Quality Criteria Needed to Document a Water Quality Standard Violation** | Best professional judgment by DEP staff |

### *Data Reporting Requirement*

Data can be reported in electronic or paper format. The sampling date(s) should be included. Sampling locations must be identified by latitude and longitude or in relation to some identifiable geographic feature such as a named bridge or road. The stream segment or "reach" must be identified.

DEP defines a stream segment as the portion of a stream between an upstream tributary and the next downstream tributary. For headwater sections, the first segment would be from the source to the first tributary. DEP uses USGS 7.5 minute quadrangle maps (1/24,000 scale) to identify tributaries and the resulting stream segments. The rationale for segmenting streams this way is that loads from tributaries often affect the water quality of the receiving stream and it is much easier for DEP to manage information when it is associated with fixed stream reaches. After identifying a stream segment, the sampling locations should be situated so they reflect the quality of the entire segment. A minimum of two sites is required to assess the quality of the stream segment. One location is just above the upstream tributary to measure the water quality entering the stream segment and the other location is just above the downstream tributary to measure the water quality as it flows out of the segment. If you suspect there are land use changes or discharges that may effect the water quality within a segment, then you may choose to establish additional sample locations at these points.

### *Quality Assurance/Quality Control (QA/QC)*

An Advanced Aquatic Life Assessment requires rigorous internal (samples collected and analyzed by project field volunteers, staff and lab - see p. A4-2) and external (samples collected and analyzed by non-volunteer field staff and "quality control" lab see p. A4-3) QA/QC. Choose specific quality control measures for each indicator from the list in Table 1 in Appendix 4 (on page A4-4). Also, applicable in Appendix 4 is information on specific internal and external quality controls and how they are assessed. Periodic field and lab audits by qualified service providers are recommended. During these audits, the operation of sampling and analytical procedures is observed. 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 qualified service provider. 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,[18] 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 qualified service provider. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst

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

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.

## B3. Aquatic Life/Designated Uses Assessment - Non-Wadeable Waters

### *What Is It?*

An Aquatic Life Assessment involves documenting pollution sources, aquatic life uses, water sampling and analysis for water quality indicators. This information may be used by DEP to determine whether the waters support their aquatic life designated uses which are to be achieved and protected. The water monitoring results are compared with the numeric criteria in the water quality standards applicable to aquatic life uses (from Table 3 in Section 93.7 of the Standards). These criteria specify minimum or maximum levels or ranges necessary to support the aquatic life uses.

If the information gathered in this assessment meets DEP's requirements, it may be used to determine whether the waters are impaired and should be placed on the 303(d) list. DEP will use the data collected in this assessment if its "impaired" status is based on scientifically valid data meeting the following requirements:

1) DEP determines that there is enough information to document a water quality standards violation for a specific waterbody.
2) There is information regarding the exact location and extent of the impaired waterbody. There must be an identification of an impaired stream segment or reach with an upstream and downstream limit as opposed to just a single point on a map. The reach may end due to a variety of reasons such as land use change, a point discharge or Abandoned Mine Drainage seep.
3) There is information that describes the quality assurance and quality control such that DEP can reasonably assess the available data and determine its applicability.
4) The sampling and analysis protocols are comparable to those used by DEP.

For DEP to even consider or review the data, a high level of expertise, thoroughness and rigor of procedures is required of the volunteers. It also requires a degree of DEP oversight, auditing, training and quality control so that DEP can assess the quality of the waters which are placed on the 303(d) list and need remediation plans to restore impaired aquatic life uses.

### *Why Do It?*

We suggest that you undertake an Aquatic Life Assessment if your primary interest is whether your stream supports its legally designated aquatic life uses and values, and you need to produce data that DEP will use to determine impairment and the need for restoration.

### *Primary Purposes Addressed*

☑ Community Education and Awareness

☑ Baseline Data Collection

☑ Community and / or Watershed Level Assessment

☑ State and Federal Agency Assessment

### *Questions Addressed*

☑ Is the water meeting or exceeding state Water Quality Standards?

☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

- ☐ What are the present ecological conditions, and how do they change over time?
- ☐ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?
- ☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?
- ☐ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

An Aquatic Life Assessment for non-wadeable waters has two parts:

1) Research or field inventory of pollution sources and aquatic life uses; and
2) Collecting water samples (or direct field measurements) and analyzing those samples for the indicators contained in the water quality standards pertaining to aquatic life.

Following is a table of the monitoring options for the Aquatic Life Assessment. Note that you don't have to monitor all the indicators -- pick the ones most relevant to your stream. Note also that some indicators (marked "For Sampling Only") are extremely difficult and / or expensive for volunteer monitoring groups to analyze. For these, we recommend that you consider sampling for the indicator, preserving the sample and taking it to a DEP, private or university lab for analysis. The DEP lab analysis must be done as part of a DEP-approved project with a budget that involves the regional DEP biologist. All other labs must be operating under an EPA-approved Quality Assurance Project Plan (QAPP) and use the methods listed.

Monitoring options are listed in the following table:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| *Uses and Pollution Sources* | |
| • **Research existing information:** Literature search for reports, plans and other documents pertaining to the watershed to identify uses, values, pollution sources and conditions | Search the following:<br>EPA Surf Your Watershed<br>Land Use maps at regional planning commissions or Conservation Districts<br>DEP Watershed Notebooks<br>DEP Regional Offices – Discharge Monitoring Reports for NPDES permittees<br>Toxic Release Inventory<br>Historical Land Use Records – County Library, Historical Societies, Conservation Districts |
| • **Uses, values and threats meeting** | Hold a meeting in which participants locate uses, values and threats on a map (River Network) |
| • **Field survey of river, riparian and watershed characteristics, uses, values and threats** | Visual Assessment (ALLARM, EPA)<br>Watershed Field Inventory (Adopt-A-Stream Foundation)<br>River Walk (River Network) |
| *Documenting Aquatic Life Uses* | |
| • **Habitat Inventory** | |
| • **Creel Surveys** | |
| *Water Sampling and Analysis* | |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Ammonia Nitrogen** | Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or equivalent) |
| • **Dissolved Oxygen** | 1) Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent) surface sample<br>2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent) - measure at surface |
| • **Hardness** | Computed from results of calcium and magnesium or titrated (SM #3500Ca, EPA 130..2 or equivalent) |
| • **Total Iron (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **pH** | 1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) |
| • **Temperature** | Direct measurement with a thermometer, thermocouple or thermistor |
| • **Total Alkalinity** | Double end point sulfuric acid titration w/ digital titrator and pH meter (RN or ALLARM manual) |
| • **Total Dissolved Solids** | Gravimetric method, filtrate dried at 180°C. (SM#2540C or equivalent) |
| • **Total Residual Chlorine (For Sampling Only)** | *Sampling*: Consult with DEP regional biologist for sampling method. This is tricky due to TRC's dissipation and flow patterns.<br>*Analysis*: Amperometric Titration Method, SM#4500ClD |
| • **Turbidity** | Sample collected and measured with a nephelometer (SM #2130 or equivalent) |

Additional notes on these methods are contained in Appendix 2.

### *Relevant Manuals*


Alliance for Aquatic Resource Monitoring, 1996 Visual Assessment Handbook, Carlisle, Pa.

APHA. 1992. Standard Methods for the Examination of Water and Wastewater. 18th ed. American Public Health Association. Washington, D.C.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier, Vt.

Murdoch, T. and Cheo, M., 1996. The Streamkeeper's Field Guide. Adopt-A-Stream Foundation. Everett, Wash.

Pa. DEP, 1998. Strategy for Assessing Pennsylvania's Unassessed Surface Waters (Field Biologists version, 4/23/98). Harrisburg, Pa.

River Network and Vt. Department of Environmental Conservation, Undated. River Walk (a self-explanatory field data sheet), Montpelier, Vt.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

EPA 1993. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

### *Site Location Considerations*

Water, habitat and benthic macroinvertebrate sampling should be carried out at a variety of sites that represent a variety of conditions in the watershed. If your focus is only on a particular reach, then you may only need to sample a few sites on that reach.

To obtain a representative sample from non-wadeable waters, an integrated depth sampler may be used to sample the water column and a rock basket or multiplate sampler may be used for benthic macroinvertebrate samples. This would involve sampling from a bridge or a boat.

Select as many of the following types of sites as you can (see Chapter 2, Step 6 on page 2-20 for definitions of types of sites):

**Watershed Sites:**

- Sites on streams of different orders (sizes) and at different altitudes.
- Watershed reference sites.
- Stream impact assessment sites:
  - upstream reference (control) sites
  - impact sites
  - recovery sites
- Tributary impact assessment sites:
  - reference sites
  - impact sites
  - recovery sites
  - integrator sites
- Cold and warm water fish habitat areas (spawning, nursery and resting sites).
- Where possible, sites historically monitored by DEP.
- Benthic macroinvertebrate sampling from riffle habitats.
- Boat launch ramps and fishing access areas.

**Reach Sites:**

- Sites that are representative of the stream reach of interest.
- Sites that are safely accessible by boat or from a bridge.

### *How Frequently and When Should You Carry Out the Assessment?*

You should conduct enough sampling events at the right time of year to relate your results to attaining designated uses. DEP recommends a minimum of 24 samples per site to determine impairment that means at least twice per month, year round, weekly for six months, twice weekly for three months, etc. Here are some general considerations for determining the frequency and timing of your sampling.

### Pollution Source Inventory

- *Frequency and time of year*: At least once per year.
- *Time of day and weather:* Not a consideration, though field work during high flows should be avoided for safety reasons.

### Water Sampling and Analysis

Composite Sampling: To obtain a water sample that is representative of the horizontal stream stretch (bank to bank), an integrated depth sampler would be used at several location across the stream. The samples would be mixed or composited before analysis. This would involve sampling from a boat or a bridge.

- *Frequency:* Sample at least once per month, during the monitoring season. Sampling must be conducted over a minimum of one year.
- *Time of day:* Sample during critical periods of the day for those indicators that fluctuate daily . For example, dissolved oxygen (DO) and temperature are both typically lowest at sunup and highest in mid-day. 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.
- *Time of year*: For assessing dissolved oxygen suitability for fish, sample during critical periods of stress – such as summer low flow and high air temperature conditions – and less stressful periods such as mid-late spring to get a sense of seasonal variation. Also, try to sample during spawning and rearing periods.
- *Weather:* A variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc.

## *Data Analysis and Data Quality Requirements*

### Chemical Data

| | |
|---|---|
| • **Data Age** | < five years old (unless justified that it represents current conditions |
| • **Chemical Parameters** | Only those for which a criterion exists in the water quality standards |
| • **Minimum # of Sampling Sites** | None, but must be representative |
| • **Sampling Duration and Frequency** | > one year and at least once per month. Single, one-time grab samples are not acceptable |
| • **Minimum # of Samples for Representativeness** | Preferred: ≥24 samples/site, however, if 25 percent of samples collected monthly over one year exceed a criterion, 12 samples may be acceptable. |
| • **Minimum percent of Samples Exceeding Water Quality Criteria Needed to Document A Water Quality Standard Violation** | For any parameter, if 10 percent of collected samples (>25 percent if less than 24 samples) exceed criterion |

**Bacteria Data**

| | |
|---|---|
| • **Date Age** | < five years old (unless justified that it represents current conditions) |
| • **Minimum # of Sampling Sites** | None, but must be representative |
| • **Sampling Duration and Frequency** | For daily sampling: ≥ five days<br>For weekly sampling: ≥ five weeks<br>For monthly sampling: ≥ five months |
| • **Minimum # of Samples for Representatives** | > five samples collected on different days |
| • **Minimum % of Samples Exceeding Water Quality Criteria Needed to Document a Water Quality Standard Violation** | Single Violation |

### *Data Reporting Requirements*

Data can be reported in electronic or paper format. The sampling date(s) should be included. Sampling locations must be identified by latitude and longitude or in relation to some identifiable geographic feature such as a named bridge or road. The stream segment or "reach" must be identified.

DEP defines a stream segment as the portion of a stream between an upstream tributary and the next downstream tributary. For headwater sections, the first segment would be from the source to the first tributary. DEP uses USGS 7.5 minute quadrangle maps (1/24,000 scale) to identify tributaries and the resulting stream segments. The rationale for segmenting streams this way is that loads from tributaries often affect the water quality of the receiving stream and it is much easier for DEP to manage information when it is associated with fixed stream reaches. After identifying a stream segment, the sampling locations should be situated so they reflect the quality of the entire segment. A minimum of two sites is required to assess the quality of the stream segment. One location is just above the upstream tributary to measure the water quality entering the stream segment and the other location is just above the downstream tributarty to measure the water quality as it flows out of the segtment. If you suspect there are land use changes or discharges that may effect the water quality within a segment, then you may choose to establish additional sample locations at these points.

### *Quality Assurance/Quality Control (QA/QC)*

An Advanced Aquatic Life Assessment requires rigorous internal and external QA/QC. Choose specific quality control measures for each indicator from the list in Table 1 in Appendix 4 (on page A4-4). Also, applicable in Appendix 4 is information on specific internal and external quality controls and how they are assessed.

Periodic field and lab audits by qualified service providers are recommended. During these audits, the operation of sampling and analytical procedures is observed. 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 qualified service provider. The program coordinator should then designate people from this core group who are qualified to train others. Official designation 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 qualified service provider. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official designation 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.

# B4. Recreational Waters Uses and Water Supply Assessment

### *What Is It?*

An assessment of Recreational Waters Uses and Water Supply involves water sampling and analysis for water quality indicators used by DEP to determine whether these waters support their *designated recreational and water supply uses.* These are uses of the water by humans 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 these designated human uses. The information gathered in a Recreational Waters Uses and Water Supply Assessment is used by the state 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 Recreational Waters Uses and Water Supply Assessment includes stream water sampling and analysis for selected indicators contained in the criteria in the water quality standards that apply to aquatic life (from Table 3 in Section 93.7 in the Chapter 93, 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 Water Quality Standards.

### *Why Do It?*

We suggest that you undertake a Recreational Waters Uses and Water Supply Assessment if your primary interest is whether your stream supports its legally designated human recreational and water supply uses, and you need to produce data that federal and state agencies will use for their assessment activities.

### *Primary Purposes Addressed*

☑ Community Education and Awareness

☑ Baseline Data Collection

☑ Community and/or Watershed Level Assessment

☑ State and Federal Agency Assessment

### *Questions Addressed*

☑ Is the water meeting or exceeding state Water Quality Standards?

☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

☐ What are the present ecological conditions, and how do they change over time?

☐ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?

☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?

☐ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

A Recreational Waters Uses and Water Supply Assessment is done by collecting water samples (or direct field measurements) and analyzing those samples for the indicators contained in the water quality standards pertaining to aquatic life. Following is a table of the monitoring options for the water quality standards assessment. Note that you don't have to monitor all the indicators -- pick the ones most relevant to your stream or lake. Note also that some indicators (marked "For Sampling Only") are extremely difficult and / or expensive for volunteer monitoring groups to analyze. For these, we recommend the following. Consider sampling for the indicator, preserving the sample and taking it to a DEP, private or university lab for analysis. The DEP lab analysis must be done as part of a DEP-approved project with a budget that involves the regional DEP biologist. All other labs must be operating under an EPA-approved Quality Assurance Project Plan (QAPP) and use the methods listed.

Monitoring options are listed in the following table:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| **Fecal Coliform Bacteria** | Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent) |
| **Iron (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| **Manganese (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| **Sulfate (for sampling only, if method 2 is used)** | 1) Turbidimetric: Ion is converted to a suspension. The resulting turbidity is determined by a nephelometer, and compared to a curve prepared from standard sulfate solutions, EPA #375.4<br>2) Colorimetric, Automated, Methylthymol Blue, using an Autoanalyzer II, EPA #375.2 |
| **Total Dissolved Solids** | Gravimetric method, filtrate dried at 180°C. (SM#2540C or equivalent) |

Additional notes on the methods are contained in Appendix 2.

### *Relevant Manuals*

APHA. 1992. Standard Methods for the Examination of Water and Wastewater. 18th ed. American Public Health Association. Washington, D.C.

EPA 1993. Methods for Chemical Analysis of Water and Wastes. EPA-600 / 4-79-020, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

### *Site Location Considerations*

Samples should be collected at human water use sites and below pollution sources at a minimum. Following are the types of sites to carry out the assessment:

- Designated beaches and areas designated for swimming, wading, diving and water skiing.
- Informal swimming, wading, diving and water skiing areas.
- Boat launch ramps and fishing access areas.

- Below pollution sources.
- Near water supply intakes.
- Where possible, sites historically monitored by DEP.
- Sites that are a representative part of the river of interest.
- Sites that are safely accessible.
- Sites where the main river current is accessible -- where the water is thoroughly mixed.
- Deepest part of the main lake or significant arm or bay.

### *How Frequently and When Should You Carry Out the Assessment?*

For a Recreational Waters Uses and Water Supply 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 of sampling events and when they occur depend on the human uses you are assessing. 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 five times over a 30-day period during the summer season (May 1 through September 30) to enable the calculation of a geometric mean consistent with DEP water quality criterion. Sampling frequency and time of year depends on the spawning and life cycle of the target type of fish.
3) 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 bacteria is six hours in a dark 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 six hour window.

Keeping these considerations in mind, we recommend the following:

- *Frequency:* Sample at least two or three times per month during the monitoring season.
- *Time of year*: For recreational uses, sample during the warmer months, when these uses occur. For water supply, sample year round if possible, or at least during spring runoff and low water periods.
- *Weather:* Consider sampling after storm events.

### *Data Analysis and Data Quality Requirements*

#### Chemical Data

| | |
|---|---|
| • **Data Age** | < five years old (unless justified that it represents current conditions |
| • **Chemical Parameters** | Only those for which a criterion exists in the water quality standards |
| • **Minimum # of Sampling Sites** | None, but must be representative |
| • **Sampling Duration and Frequency** | > one year and at least once per month. Single, one-time grab samples are not acceptable |

| | |
|---|---|
| • **Minimum # of Samples for Representativeness** | Preferred: ≥24 samples/site, however, if 25 percent of samples collected monthly over one year exceed a criterion, 12 samples may be acceptable. |
| • **Minimum percent of Samples Exceeding Water Quality Criteria Needed to Document A Water Quality Standard Violation** | For any parameter, if 10 percent of collected samples (>25 percent if less than 24 samples) exceed criterion |

**Bacteria Data**

| | |
|---|---|
| • **Date Age** | < five years old (unless justified that it represents current conditions) |
| • **Minimum # of Sampling Sites** | None, but must be representative |
| • **Sampling Duration and Frequency** | For daily sampling: ≥5 days<br>For weekly sampling: ≥5 weeks<br>For monthly sampling: ≥5 months |
| • **Minimum # of Samples for Representatives** | > five samples collected on different days |
| • **Minimum percent of Samples Exceeding Water Quality Criteria Needed to Document a Water Quality Standard Violation** | Single Violation |

## *Data Reporting Requirements*

Data can be reported in electronic or paper format. The sampling date(s) should be included. Sampling locations must be identified by latitude and longitude or in relation to some identifiable geographic feature such as a named bridge or road. The stream segment or "reach" must be identified.

DEP defines a stream segment as the portion of a stream between an upstream tributary and the next downstream tributary. For headwater sections, the first segment would be from the source to the first tributary. DEP uses USGS 7.5 minute quadrangle maps (1/24,000 scale) to identify tributaries and the resulting stream segments. The rationale for segmenting streams this way is that loads from tributaries often affect the water quality of the receiving stream and it is much easier for DEP to manage information when it is associated with fixed stream reaches. After identifying a stream segment, the sampling locations should be situated so they reflect the quality of the entire segment. A minimum of two sites is required to assess the quality of the stream segment. One location is just above the upstream tributary to measure the water quality entering the stream segment and the other location is just above the downstream tributarty to measure the water quality as it flows out of the segment. If you suspect there are land use changes or discharges that may effect the water quality within a segment, then you may choose to establish additional sample locations at these points.

## *Quality Assurance/Quality Control (QA/QC)*

An advanced Recreational Waters Uses and Water Supply Assessment requires rigorous internal and external QA/QC. Choose specific quality control measures for each indicator from the list in Table 1 in Appendix 4 (on page A4-4). Also applicable in Appendix 4 is information on specific internal and external quality controls and how they are assessed.

Periodic field and lab audits by DEP-recommended service providers are recommended. During these audits, the operation of sampling and analytical procedures is observed. 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 qualified service provider. 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,[20] 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 qualified service provider. 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.

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

## B5. Advanced Point Source Impact Assessment

### *What Is It?*

An Advanced Rigorous Point Source Impact Assessment is the collection of selected information to establish the nature and extent of the impact of point source pollution sources (wastewater treatment plants and other permitted discharges) on the stream's ecological health and aquatic life uses. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of stream health likely to be affected by the these sources as is practical for volunteer monitors, using methods that are comparable to those used by DEP:

- ♦ Water sampling and analysis for indicators of impacts;
- ♦ Benthic macroinvertebrate sampling and analysis and habitat assessment;
- ♦ Discharge permit survey; and
- ♦ Measurements of rainfall and river flow.

These activities occur upstream and downstream of the source 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 plant) to determine the extent of the impact attributable to the source.

An Advanced Point Source 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, assess the need for changes in plant operation or upgrades.

### *Why Do It?*

We suggest that you undertake an Advanced Point Source Impact Assessment if your primary interest is in the data contributing toward the development of a remediation plan by DEP and communities in your watershed in order to restore the long term ecological health and aquatic life uses of your stream.

### *Primary Purposes Addressed*

☑ Community Education and Awareness

☑ Baseline Data Collection

☑ Community and/or Watershed Level Assessment

☑ State and Federal Agency Assessment

### *Questions Addressed*

☑ Is the water meeting or exceeding state Water Quality Standards?

☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

☐ What are the present ecological conditions and how do they change over time?

☑ What is the impact of various types of land and water use activities on ecological conditions and human uses? (e.g. various types of point and nonpoint source pollution).

☑ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?

☐ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The Advanced Point Source Impact Assessment involves collecting and analyzing water samples for indicators of the impacts of point sources; 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 source. Note that some indicators (marked "For Sampling Only") are extremely difficult and/or expensive for volunteer monitoring groups to analyze. For these, we recommend that you consider sampling for the indicator, preserving the sample and taking it to a DEP, private or university lab for analysis. The DEP lab analysis must be done as part of a DEP-approved project with a budget that involves the regional DEP biologist. All other labs must be operating under an EPA-approved Quality Assurance Project Plan (QAPP) and use the methods listed.

Following is a menus of monitoring options from which to select indicators and methods appropriate for your stream, and your human and financial resources. Following this menu is a table which suggests indicators by nonpoint pollution source:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Discharge Permit Survey** | Review discharge permits and monitoring reports |
| *Aquatic Life and Habitat Monitoring* | |
| • **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 (Pa. DEP Unassessed Waters) (RN Adaptation of EPA RBP II) |
| • **Benthic Macroinvertebrate Habitat Assessment** | Field observation and rating of key habitat characteristic relative to reference condition (Pa. DEP Unassessed Waters, EPA or RN Method) |
| *Water Sampling and Analysis* | |
| • **Fecal Coliform/E. coli Bacteria** | Membrane filtration w/ mTEC with and without confirmation (EPA #1103.1 or equivalent) |
| • **Total Phosphorus** | Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent) |
| • **Ammonia Nitrogen** | Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or equivalent) |
| • **Nitrate Nitrogen** | Cadmium reduction followed by spectrophotometry (SM #4500-NO3-E or equivalent) |
| • **Turbidity** | Sample collected and measured with a nephelometer (RN adaptation of Standard Methods #2130) |
| • **Dissolved Oxygen** | 1) Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent) - surface sample<br>2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent) - measure at surface |
| • **Biochemical Oxygen Demand** | Five-day BOD test (SM #5210-B) using Modified Winkler Titration |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Hardness** | Computed from results of calcium and magnesium or titrated (SM #3500Ca, EPA 130..2 or equivalent) |
| • **Aluminum (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200. |
| • **Temperature** | Direct measurement with a thermometer, thermocouple or thermistor |
| • **Total Dissolved Solids** | Gravimetric method, filtrate dried at 180°C. (SM#2540C or equivalent) |
| • **Total Suspended Solids** | Gravimetric method, dried at 103-105°C. (SM#2540D or equivalent) |
| • **Total Residual Chlorine (For Sampling Only)** | *Sampling*: Consult with DEP regional biologist for sampling method. This is tricky due to TRC's dissipation and flow patterns.<br>*Analysis*: Amperometric Titration Method, SM#4500ClD |
| • **pH** | 1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) |
| • **Total Alkalinity** | Double end point sulfuric acid titration w/ digital titrator and pH meter (RN or ALLARM manual) |
| • **Conductivity** | Direct measurement with a meter (EPA Volunteer Methods manual) |
| *Flow and Rainfall* | |
| • **Stream Flow** | Embody Float Method (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft) |
| • **Rainfall** | Rain Gauge or NOAA Data |

Additional notes on the methods are contained in Appendix 2.

The following table suggests indicators that are appropriate for the different point source pollution types:

| Indicator/Tool | Sewage | Toxics |
|---|---|---|
| Pollution Source Inventory | X | X |
| Intensive Benthic Macroinvertebrate Assessment | X | X |
| Benthic Macroinvertebrate Habitat Assessment | X | X |
| Fecal colif./*E. coli* Bacteria | X | |
| Total Phosphorus | X | |
| Ammonia Nitrogen | X | |
| Nitrates Nitrogen | X | |
| Turbidity | X | |
| Dissolved Oxygen | X | |
| Biochemical Oxygen Demand | X | |

| Indicator/Tool | Sewage | Toxics |
|---|---|---|
| Hardness | | X |
| Aluminum | | X |
| Temperature | X | |
| Total Dissolved Solids | X | |
| Total Suspended Solids | X | |
| Total Residual Chlorine | X | |
| PH | X | X |
| Total Alkalinity | X | X |
| Conductivity | X | |
| Stream Flow | X | X |
| Rainfall | X | X |

### *Relevant Manuals:*

APHA. 1992. Standard Methods for the Examination of Water and Wastewater. 18th ed. American Public Health Association. Washington, D.C.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier, Vt.

Dates, Geoff, and Byrne, Jack, 1997. Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess Your River's Health, River Network, Montpelier, Vt.

Murdoch, T. and Cheo, M., 1996. The Streamkeeper's Field Guide. Adopt-A-Stream Foundation Everett, Wash.

Plafkin, James L, et al Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. Report #EPA/444/4-89-001. EPA, Washington, D.C., May 1989.

DEP, 1998. Strategy for Assessing Pennsylvania's Unassessed Surface Waters (Field Biologists version, 4/23/98). Harrisburg, Pa.

River Network and Vt. Department of Environmental Conservation, undated. River Walk (a self-explanatory field data sheet), Montpelier, Vt.

Stroud Water Research Center, Unpublished Benthic Macroinvertebrate Manual. Avondale, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

EPA 1993. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, Environmental Monitoring and Support Laboratory Cincinnati, Ohio.

### *Site Location Considerations*

Water, habitat and benthic macroinvertebrate sampling should bracket specific pollution sources or groups of pollution sources (see Chapter 2, Step 6 on page 2-20 for definitions of types of sites):

- Watershed reference sites.
- Stream impact assessment sites that bracket the source:
  - upstream reference (control) sites
  - impact sites
  - recovery sites
- Where possible, sites historically monitored by the DEP.

- Benthic macroinvertebrate sampling from riffle habitats.
- Sites that are representative of the stream reach of interest.
- Sites that are safely accessible.
- Sites where the main stream current is accessible -- where the water is thoroughly mixed.

### *How Frequently and When Should You Carry Out the Assessment?*

You should conduct enough sampling events at the right time of year to relate your results to attaining designated uses. DEP recommends a minimum of 24 samples per site to determine impairment. That means at least twice per month, year round, weekly for six months, twice weekly for three months, etc. Here are some general considerations for determining the frequency and timing of your sampling.

#### Pollution Source Inventory

- *Frequency and time of year:* At least once per year.
- *Time of day and weather:* Not a consideration, though field work during high flows should be avoided for safety reasons.

#### Water Sampling and Analysis

- *Frequency:* Sample at least once per month during the chosen time of year, during storms and during dry weather. Sampling must be conducted over a minimum of one year.
- *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:* 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 (before the end of May) and once in late summer or early fall (after October 15).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.
- *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.
- *Time of day:* Not a consideration.
- *Weather*: Measure channel characteristics before and after major storm events.

### *Data Analysis and Data Quality Requirements*

DEP will use the following guidelines to determine if uses are impaired.

**Chemical Data**

| | |
|---|---|
| • **Data Age** | < five years old (unless justified that it represents current conditions |
| • **Chemical Parameters** | Only those for which a criterion exists in the water quality standards |
| • **Minimum # of Sampling Sites** | None, but must be representative |
| • **Sampling Duration and Frequency** | > one year and at least once per month. Single, one-time grab samples are not acceptable |
| • **Minimum # of Composite Samples for Representativeness** | Preferred: ≥24 samples/site, however, if 25 percent of samples collected monthly over one year exceed a criterion, 12 samples may be acceptable. |
| • **Minimum percent of Composite Samples Exceeding Water Quality Criteria Needed to Document A Water Quality Standard Violation** | For any parameter, if 10 percent of collected samples (>25 percent if less than 24 samples) exceed criterion |

**Water Sampling and Analysis Data**

- Data are compared with the applicable criteria in the water quality standards.
- If more than 10 percent of the samples violate the applicable criterion, the waterbody will be considered by DEP to have failed to meet the water quality standards.
- A minimum of 24 samples for each site is required for the data to be considered by DEP to be representative of actual conditions. If more than 25 percent of the samples exceed the applicable criteria, 12 samples may be acceptable.
- Data must be less than five years old and sampling must be conducted over a minimum of one year.

**Benthic Macroinvertebrate Data**

- Data are compared with reference conditions at an upstream control site and, if possible, a watershed reference site or as established by DEP, to determine impairment.
- Results from one sampling are acceptable, though several years are preferable.
- Organisms must be identified to at least family level for the aquatic insects, preferably genus. Higher taxonomic levels are acceptable for worms, crustaceans and mollusks.
- DEP will use best professional judgment to determine if this data documents aquatic life use impairments.

### *Data Reporting Requirements*

Data can be reported in electronic or paper format. The sampling date(s) should be included. Sampling locations must be identified by latitude and longitude or in relation to some identifiable geographic feature such as a named bridge or road. The stream segment or "reach" must be identified.

DEP defines a stream segment as the portion of a stream between an upstream tributary and the next downstream tributary. For headwater sections, the first segment would be from the source to the first tributary. DEP uses USGS 7.5 minute quadrangle maps (1/24,000 scale) to identify tributaries and the resulting stream segments. The rationale for segmenting streams this way is that loads from tributaries often affect the water quality of the receiving stream and it is much easier for DEP to manage information when it is associated with fixed stream reaches. After identifying a stream segment, the sampling locations should be situated so they reflect the quality of the entire segment. A minimum of two sites is required to assess the quality of the stream segment. One location is just above the upstream tributary to measure the water quality entering the stream segment and the other location is just above the downstream tributary to measure the water quality as it flows out of the segment. If you suspect there are land use changes or discharges that may effect the water quality within a segment, then you may choose to establish additional sample locations at these points.

### *Quality Assurance/Quality Control (QA/QC)*

An Advanced Point Source Impact Assessment requires rigorous internal (samples collected and analyzed by project field volunteers, staff and lab see - p. A4-2) and external (samples collected and analyzed by non-volunteer field staff and "quality control" lab - see p. A4-3) QA / QC. Choose specific quality control measures for each indicator from the list in Table 1 in Appendix 4 (on page A4-5). Also, applicable in Appendix 4 is information on specific internal and external quality controls and how they are assessed.

Periodic field and lab audits by qualified service providers are recommended. During these audits, the operation of sampling and analytical procedures is observed. 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 qualified service provider. The program coordinator should then designate people from this core group who are qualified to train others. Official designation 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 qualified service provider. 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.

# B6 Advanced Nonpoint Source Impact Assessment

## *What Is It?*

An Advanced Nonpoint Source Impact Assessment is the collection of selected information to establish the nature and extent of the impact of runoff from one or more nonpoint pollution sources on the stream's ecological health and aquatic life uses. It includes a wide range of monitoring activities that assess as many of the physical, chemical and biological indicators of stream 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 DEP:

- ♦ Water sampling and analysis for indicators of runoff impacts;
- ♦ Benthic macroinvertebrate sampling and analysis and habitat assessment;
- ♦ Nonpoint source pollution source inventory;
- ♦ Estimates or measures of stream channel composition and stability; and
- ♦ Measurements of rainfall and stream flow.

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

An Advanced Nonpoint Source Impact Assessment is geared to produce a great deal of high quality information that can be used by DEP and communities to develop nonpoint source remediation plans.

## *Why Do It?*

We suggest that you undertake an Advanced Nonpoint Source Impact Assessment if your primary interest is in the data contributing toward the development of a remediation plan by DEP and communities in your watershed, in order to restore the long term ecological health and aquatic life uses of your stream.

## *Primary Purposes Addressed*

☑ Community Education and Awareness

☑ Baseline Data Collection

☑ Community and/or Watershed Level Assessment

☑ State and Federal Agency Assessment

## *Questions Addressed*

☑ Is the water meeting or exceeding state Water Quality Standards?

☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

☑ What are the present ecological conditions, and how do they change over time?

☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?

☑ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity and

☑ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The Advanced Nonpoint Source Impact Assessment involves collecting and analyzing water samples for indicators of nonpoint 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 source. 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 and methods appropriate for your stream, and your human and financial resources. Following this menu is a table which suggests indicators by nonpoint pollution source:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Research existing information:** Literature search for reports, plans and other documents pertaining to the watershed to identify uses, values, pollution sources and conditions | Search the following:<br>EPA Surf Your Watershed<br>Land Use maps at regional planning commissions or Conservation Districts<br>DEP Watershed Notebooks<br>DEP Regional Offices – Discharge Monitoring Reports for NPDES permittees<br>Toxic Release Inventory<br>Historical Land Use Records – County Library, Historical Societies, Conservation Districts |
| • **Uses, values and threats meeting** | Hold a meeting in which participants locate uses, values and threats on a map (River Network) |
| • **Field survey of stream , riparian and watershed characteristics, uses, values and threats** | Visual Assessment (ALLARM, EPA )<br>Watershed Field Inventory (Adopt-A-Stream Foundation)<br>River Walk (River Network) |
| *Aquatic Life and Habitat Monitoring* | |
| • **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 (RN) (Adaptation of EPA RBP II) |
| • **Benthic Macroinvertebrate Habitat Assessment** | Field observation and rating of key habitat characteristic relative to reference condition (EPA or RN Method) |
| *Water Sampling and Analysis* | |
| • **Fecal colif./*E. coli* Bacteria** | membrane filtration w/ mTEC with and without confirmation (EPA #1103.1 or equivalent) |
| • **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 (RN adaptation of Standard Methods #2130) |
| • **Dissolved Oxygen** | 1) Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent) - surface sample<br>2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent) - measure at surface |
| • **Temperature** | Direct measurement with a thermometer, thermocouple or thermistor |
| • **pH** | 1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) |
| • **Total Alkalinity** | Double end point sulfuric acid titration w/ digital titrator and pH meter (RN or ALLARM manual) |
| • **Conductivity** | Direct measurement with a meter (EPA Volunteer Methods manual) |
| • **Hardness** | computed from results of calcium and magnesium or titrated (SM #3500Ca, EPA 130..2 or equivalent) |
| • **Total Iron (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Acidity** | Titration with measured amount standard acid to pH of 4.0, EPA#305.1 |
| • **Manganese (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Sulfates (for sampling only, if method 2 is used)** | 1) Turbidimetric: Sulfate ion is converted to a suspension. The resulting turbidity is determined by a nephelometer, and compared to a curve prepared from standard sulfate solutions, EPA #375.4<br>2) Colorimetric, Automated, Methylthymol Blue, using an Autoanalyzer II, EPA #375.2 |
| • **Aluminum (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200. |
| *Stream Channel Composition and Stability* | |
| • **Embeddedness** | Estimated for four 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) |

| | |
|---|---|
| • **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) |
| *Flow and Rainfall* | |
| • **Stream Flow** | Embody Float Method (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft) |
| • **Rainfall** | Rain Gauge or NOAA Data |

The following table suggests indicators that are appropriate for the different nonpoint source pollution types:

| **Indicator/Tool** | **Erosion** | **Nutrients** | **Animal Manure** | **Urban Runoff** | **Veg. Removal** | **AMD*** |
|---|---|---|---|---|---|---|
| Pollution Source Inventory | X | X | X | X | X | X |
| Intensive Benthic Macroinvertebrate Assessment | X | X | X | X | X | X |
| Benthic Macroinvertebrate Habitat Assessment | X | X | X | X | X | X |
| Fecal colif./*E. coli* Bacteria | | | X | X | | |
| Total Phosphorus | X | X | X | X | X | |
| Total Kjeldahl Nitrogen | | X | X | X | X | |
| Nitrates | | X | X | X | | |
| Ammonia | | | X | X | | |
| Turbidity | X | | X | X | X | |
| Dissolved Oxygen | X | X | X | X | X | |
| Temperature | X | X | X | X | X | |
| pH | | | | X | | X |
| Acidity | | | | | | X |
| Total Alkalinity | | | | X | | X |
| Conductivity | | | | X | | X |
| Hardness | | | | X | | X |
| Total Iron | | | | | | X |
| Manganese | | | | | | X |
| Sulfates | | | | | | X |
| Aluminum | | | | | | X |
| Embeddedness | X | | | X | X | |
| Channel cross- sections | X | | | X | X | |
| Bottom Composition | X | | | X | X | |
| Longitudinal Profile | X | | | X | X | |
| River Flow | X | X | X | X | X | X |
| Rainfall | X | X | X | X | X | |

*AMD – Abandoned Mine Drainage

### *Relevant Manuals*

Alliance for Aquatic Resource Monitoring, 1996 Visual Assessment Handbook, Carlisle, Pa.

APHA. 1992. Standard Methods for the Examination of Water and Wastewater. 18th ed. American Public Health Association. Washington, D.C.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier, Vt.

Dates, Geoff, and Byrne, Jack, 1997. Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess Your River's Health, River Network, Montpelier, Vt.

Harrelson, Cheryl C., 1994. Stream Channel Reference Sites: An Illustrated Guide To Field Technique, US Forest Service General Technical Report RM-245, Fort Collins, Colo.

Hunter, Christopher J., 1991. Better Trout Habitat, Island Press. Washington, D.C.

Murdoch, T. and Cheo, M., 1996. The Streamkeeper's Field Guide. Adopt-A-Stream Foundation. Everett Wash.

Plafkin, James L, et al Rapid Bioassessment Protocols for Use in Stream and Rivers: Benthic Macroinvertebrates and Fish. Report #EPA/444/4-89-001. EPA, Washington, D.C., May 1989.

DEP, 1998. Strategy for Assessing Pennsylvania's Unassessed Surface Waters (Field Biologists version, 4/23/98). Harrisburg, Pa.

River Network and Vt. Department of Environmental Conservation, Undated. River Walk (a self-explanatory field data sheet), Montpelier, Vt.

Stroud Water Research Center, Unpublished Benthic Macroinvertebrate Manual. Avondale, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

EPA 1993. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, Environmental Monitoring and Support Laboratory Cincinnati, Ohio.

### *Site Location Considerations*

Water, habitat and benthic macroinvertebrate sampling should bracket specific pollution sources or groups of pollution sources (see Chapter 2, Step 6 on page 2-20 for definitions of types of sites):

- Watershed reference sites.
- Stream impact assessment sites:
  - upstream reference (control) sites
  - impact sites
  - recovery sites
- Where possible, sites historically monitored by the DEP.
- Benthic macroinvertebrate sampling from riffle habitats.
- Sites that are representative of the reach of the stream of interest.
- Sites that are safely accessible.
- Sites where the main stream current is accessible -- where the water is thoroughly mixed.

### *How Frequently and When Should You Carry Out the Assessment?*

You should conduct enough sampling events at the right time of year to relate your results to attaining designated uses. DEP recommends a minimum of 24 samples per site to determine impairment. That means at least twice per month, year round, weekly for six months, twice weekly for three months, etc. Here are some general considerations for determining the frequency and timing of your sampling.

**Pollution Source Inventory**

- *Frequency and time of year:* At least once per year.
- *Time of day and weather:* Not a consideration, though field work during high flows should be avoided for safety reasons.

**Water Sampling and Analysis:**

- *Frequency:* Sample at least two or three times per month during the chosen time of year, during storms and during dry weather. Sampling must be conducted over a minimum of one year.
- *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:* 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, November through May.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

**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.
- *Time of day:* Not a consideration.
- *Weather:* Measure channel characteristics before and after major storm events.

### *Data Analysis and Data Quality Requirements*

**Water Sampling and Analysis Data**

- Data are compared with the applicable criteria in the water quality standards.
- If more than 10 percent of the samples violate the applicable criterion, the waterbody will be considered by DEP to have failed to meet the water quality standards.
- A minimum of 24 samples for each site is required for the data to be considered by DEP to be representative of actual conditions. If more than 25 percent of the samples exceed the applicable criteria, 12 samples may be acceptable.
- Data must be less than five years old and sampling must be conducted over a minimum of one year.

**Benthic Macroinvertebrate Data**

- Data are compared with reference conditions at an upstream control site and, if possible, a watershed reference site as established by DEP, to determine impairment.
- Results from one sampling are acceptable, though several years is preferable.
- Macroinvertebrates must be identified to at least family level for the aquatic insects, preferably genus. Higher taxonomic levels are acceptable for worms, crustaceans and mollusks.

- DEP will use best professional judgment to determine if these data document aquatic life use impairments.

### *Data Reporting Requirements*

Data can be reported in electronic or paper format. The sampling date(s) should be included. Sampling locations must be identified by latitude and longitude or in relation to some identifiable geographic feature such as a named bridge or road. The stream segment or "reach" must be identified.

DEP defines a stream segment as the portion of a stream between an upstream tributary and the next downstream tributary. For headwater sections, the first segment would be from the source to the first tributary. DEP uses USGS 7.5 minute quadrangle maps (1/24,000 scale) to identify tributaries and the resulting stream segments. The rationale for segmenting streams this way is that loads from tributaries often affect the water quality of the receiving stream and it is much easier for DEP to manage information when it is associated with fixed stream reaches. After identifying a stream segment, the sampling locations should be situated so they reflect the quality of the entire segment. A minimum of two sites is required to assess the quality of the stream segment. One location is just above the upstream tributary to measure the water quality entering the stream segment and the other location is just above the downstream tributary to measure the water quality as it flows out of the segment. If you suspect there are land use changes or discharges that may effect the water quality within a segment, then you may choose to establish additional sample locations at these points.

### *Quality Assurance/Quality Control (QA/QC)*

An Advanced Nonpoint Source Impact Assessment requires internal and external QA/QC. Choose specific quality control measures for each indicator from the list in Table 1 in Appendix 4 (on page A4-5). Also applicable in Appendix 4 is information on specific internal and external quality controls and how they are assessed.

Periodic field and lab audits by qualified service providers are recommended. During these audits, the operation of sampling and analytical procedures is observed. 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 qualified service provider. The program coordinator should then designate people from this core group who are qualified to train others. Official designation of trainers by the program coordinator through a letter or certificate should be considered.

*Lab Analysis:* For personnel in the program lab,[22] 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 qualified service provider. 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.

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

# C. Advanced Lake Assessment

The advanced lake assessments described in this section are designed to assist DEP in assessing the impairment of lakes under sections 303(d) and 305(b) of the Clean Water Act. Under section 305(b), Pennsylvania reports to EPA and Congress every two years with a list of all the waters of the state that do not support their designated uses under the state water quality standards. The status of all waters in supporting their designated uses are placed on the 305(b) list. A subset of these waters, which will not meet the water quality standards, is identified in the 303(d) list. For these waters, Remediation Plans must be developed in which allowable pollution loading is allocated among various sources through total maximum daily loads (TMDLs).

These plans are also required by section 314 (known as EPA's Clean Lakes Program). The goal of that program is to restore and/or protect lake water quality based on a thorough watershed study that identifies pollution sources and remediation measures. So, for our purposes, the TMDL process and the Clean Lakes Program are essentially the same thing.

Not all waters that are listed as impaired on the 305(b) list will necessarily appear on the 303(d) list. There are three reasons why this might occur:

1) The impairment is not caused by a pollutant as defined by the Clean Water Act. DEP does not place these waters on the list since there is no pollutant to allocate through the TMDL process;

2) Impairments are being, or will be, addressed through existing enforcement and compliance pollution control efforts; and

3) The waterbody already has an EPA-approved TMDL developed for identified causes of impairment.

The assessments that DEP uses to establish and monitor impairment are described in Appendix 3 (on page A3-3).

Some volunteer monitoring groups would like DEP to use their data to establish whether their lakes are impaired and, if so, to have their waters listed in the 305(b) and/or 303(d) lists so they can be restored. In this section, we describe three assessments that DEP recommends for volunteer monitoring groups that wish to have their results used to identify and address impairment:

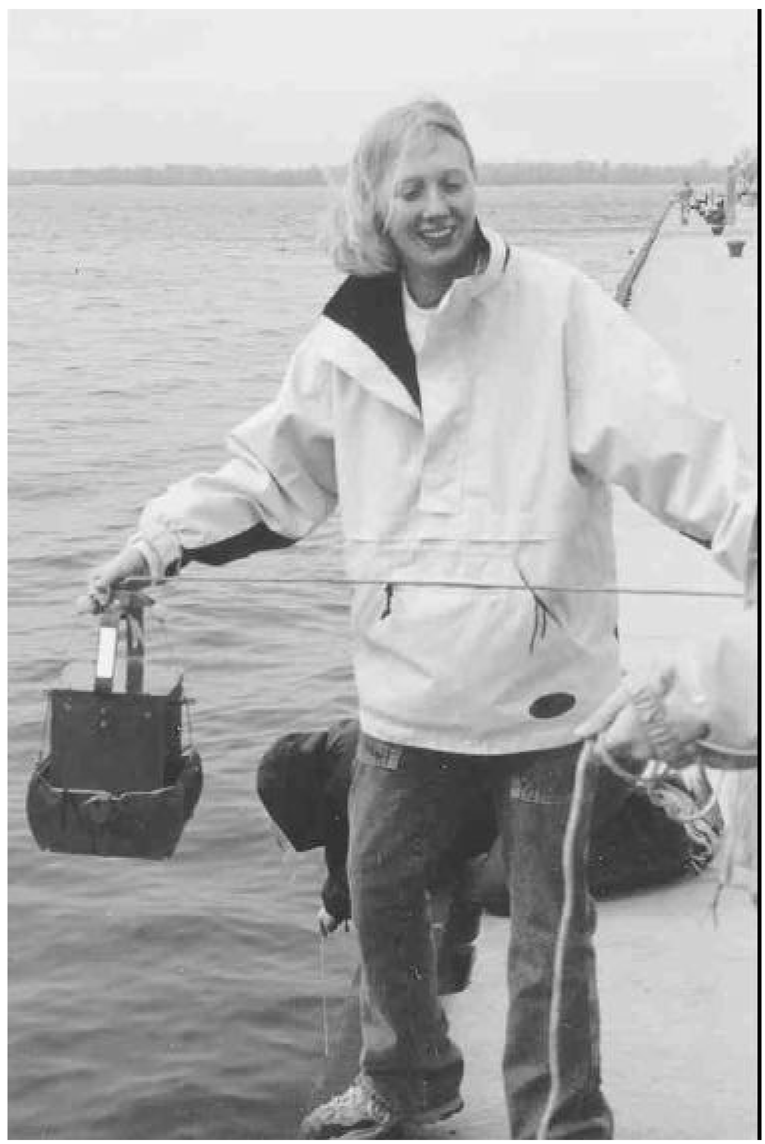
| Assessment Type | DEP Use |
|---|---|
| **C1. Screening Assessment** | Quickly locates lakes for DEP follow-up that are potentially impaired. |
| **C2. Impairment Determination Assessment** | More intensive, yet relatively rapid assessment that establishes impairment under 303(d) and the need for a full watershed assessment<br>Can be used to develop a total maximum daily load (TMDL). |
| **C3. Comprehensive Lake Watershed Assessment** | Intensive sampling and analysis used to establish a management or remediation plan |

Assessment C1 (page 5-82) is a good place to start in order to quickly pinpoint areas of concern for more in-depth assessments. Assessment C2 (page 5-85) is much more in-depth and uses rigorous methods. Assessment C3 (page 5-89) is based on the Phase 1 Diagnostic - Feasibility Study (EPA Clean

Lakes Program) described in Appendix 3 and is used to develop and assess alternative control and restoration methods. It is very comprehensive and rigorous. We recommend assessments C2 (page 5-85) and C3 (page 5-89) only for those groups that have access to laboratory facilities and are capable of a high level of quality assurance.

DEP may use the data collected in assessment C2 (page 5-85) to place a waterbody on the 303(d) list if its "impaired" status is based on scientifically valid data that meets the following requirements:

1) DEP determines there is enough information to document a water quality standards violation for a specific waterbody;
2) There is information regarding the exact location of the impaired waterbody; and
3) There is information that describes the quality assurance and quality control such that DEP can reasonably apply the available data.



# C1. Screening Assessment

### *What Is It?*

This assessment is a rapid screening that uses water clarity and visual indicators to find potential impairment. Water clarity is measured using a Secchi disk and the results used to determine the lake's trophic state (a measure of biological productivity), using Carlson's Trophic State Index. Visual surveys of several biological indicators are used to supplement the trophic status information and provide visual evidence of impairment.

### *Why Do It?*

We suggest this as the first step in a lake assessment effort. It enables you to rapidly and easily find problem areas for further follow-up, either by DEP or your program.

### *Primary Purposes Addressed*

☑ Community Education and Awareness

☐ Baseline Data Collection

☐ Community and / or Watershed Level Assessment

☐ State and Federal Agency Assessment (as a first step)

### *Questions Addressed*

☐ Is the water meeting or exceeding state Water Quality Standards?

☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☐ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

☑ What are the present ecological conditions, and how do they change over time?

☐ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?

☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity and

☐ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The Screening Assessment involves two activities, which should both be carried out at the same time:

| Indicators/Tools | Examples of Methods (Source) |
|---|---|
| 1) Secchi Transparency | Average of depths at which the disk disappears and reappears:<br>• EPA Volunteer Lake Monitoring Manual |
| 2) Visual Survey that includes the following:<br>a. Aquatic Plant Mapping | • EPA Volunteer Lake Monitoring Manual |

| Indicators/Tools | Examples of Methods (Source) |
|---|---|
| b. Algae Bloom Locations<br>c. Erosion Locations<br>d. Rainfall<br>e. Fish Kills<br>f. Goose and Duck Population Locations | |

Additional notes on the methods are contained in Appendix 2.

### *Relevant Manuals*

EPA 1991. Volunteer Lake Monitoring: A Methods Manual EPA 440/4-91-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

EPA, 1998. The Lake and Reservoir Restoration and Guidance Manual, EPA44015-88-002. US Enviornmental Protection Agency, Office of Water, Washington, D.C.

Moore, M.L. 1987. NALMS Management Guide for Lakes and Reservoirs, Washington, D.C. 42 pp.

Shertzer and Schreffler, 1996. Pennsylvania's Water Quality Network Monitoring Program. Harrisburg, Pa.

### *Site Location Considerations*

Sampling should be carried out at the following locations:

♦ **Secchi Transparency** should be taken at the deepest part of the lake and one other open water location that reflects conditions in an arm or bay and/or receives pollution that might affect water clarity.

♦ **Visual Surveys** should be carried out as follows:

- Aquatic Plant Mapping: locations with extensive plant growth and types of plants.
- Algae Bloom Locations: secchi transparency locations and areas that receive pollution that might cause algae blooms.
- Erosion Locations: note problems over entire perimeter of lake if possible.
- Rainfall: anywhere in the vicinity of the lake, recorded weekly, daily or per event.
- Fish Kills: note wherever they occur and approximate extent.
- Goose and Duck Population Locations: note wherever they occur and approximate density.

### *How Frequently and When Should You Carry Out the Assessment?*

**Secchi Transparency**

♦ *Frequency:* Sample at least once per month, from May through October. Sampling must be conducted over a minimum of one year.

♦ *Time of day:* Sample either during the morning or afternoon hours consistently, in order to minimize variation due to changes in light.

- *Time of year:* In general, sample at least once per season during the spring, summer and fall. In the spring and fall, sample during the overturn. In the summer, sample when the lake is most productive (August).
- *Weather:* Sample during "normal" conditions (not after storm events).

The visual survey should be conducted together with the secchi transparency.

### Data Analysis

Secchi transparency results are expressed as the average of the depth at which the secchi disk can no longer be seen as it is slowly lowered into the water column and the depth at which it reappears when gradually raised. This average depth is used to calculate Carlson's Trophic State Index. This index quantifies the relationship between changes in the production of algae (biomass) and changes in the clarity of the water column.

The index is calculated by "log transforming"[23] the secchi depths and using them in the following equation:

TSI = 60 - 14.41 x log of secchi depth (in meters)

This results in a number that is interpreted as follows:

| | |
|---|---|
| >50 | - high productivity (follow-up recommended) |
| 40 - 50 | - moderate productivity |
| <40 | - low productivity |

Results of the visual survey are used to confirm possible impairment by locating visual evidence (such as extensive plant growth, algae blooms, fish kills).

### Data Reporting Requirements

Use an electronic database that is IBM compatible.

### Quality Assurance/Quality Control (QA/QC)

Internal quality control measures such as clear documentation, proper training and replicate measurements of secchi depths are recommended.

### Training Required

Initially, the program coordinator and a core group of field samplers and observers should be trained in proper secchi measurement and visual survey techniques by a qualified instructor from the group or agency that uses the method. 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.

[23] This involves converting the secchi depths into their logrithmic values.

## C2. Impairment Determination Assessment

### *What Is It?*

This assessment involves a variety of monitoring activities, including water sampling and analysis for various physical and chemical indicators, fish and aquatic plant surveys and a rapid watershed visual survey of potential pollution sources. The results can be used to determine impairment for inclusion on the 303(d) list, if it meets DEP's requirements

### *Why Do It?*

We suggest that you undertake this assessment if you wish to confirm suspected lake impairment for 303(d) listing or if you wish to contribute data to the development of a Total Maximum Daily Load (TMDL).

### *Primary Purposes Addressed*

- ☐ Community Education and Awareness
- ☑ Baseline Data Collection
- ☑ Community and/or Watershed Level Assessment
- ☑ State and Federal Agency Assessment

### *Questions Addressed*

- ☑ Is the water meeting or exceeding state Water Quality Standards?
- ☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?
- ☐ What are the present ecological conditions, and how do they change over time?
- ☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?
- ☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?
- ☐ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

An Impairment Determination Assessment has three parts:

1) A rapid visual inventory of pollution sources in the watershed.
2) Collecting and analyzing water samples for (or direct field measurement of) various physical and chemical water quality indicators.
3) Assessment of two biological indictors: fish and aquatic plants (macrophytes). You may want to ask the Pennsylvania Fish and Boat Commission for data on fish.

Recommended indicators/tools and methods are listed in the following table:

| **Menu of Indicators/Tools** | **Examples of Methods (Source)** |
|---|---|
| *Visual Pollution Source Inventory* | |
| • **Pollution Source Inventory**<br>Point Sources<br>Nonpoint Sources<br>Eroding Banks | Visual Windshield Surveys<br>Watershed Walk |
| *Water Sampling and Analysis* | |
| • **Secchi Transparency** | Average of depths at which the disk disappears and reappears:<br>• EPA Volunteer Lake Monitoring Manual |
| • **Dissolved Oxygen** | 1) Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent)<br>2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent)<br>Sample or measure at one meter intervals – lake surface to lake bottom. |
| • **Temperature** | Direct measurement with a thermometer, thermocouple or thermistor<br>Measure at one meter intervals – lake surface to lake bottom. |
| • **pH** | 1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>Sample or measure at one meter intervals – lake surface to lake bottom. |
| • **Total Alkalinity** | Double end point sulfuric acid titration w/ digital titrator and pH meter (RN or ALLARM manual)<br>Sample or measure at one meter intervals – or at surface, mid and bottom depths. |
| • **Total Phosphorus** | Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent)<br>Sample one meter from surface and one meter from bottom |
| • **Total Kjeldahl Nitrogen**<br>(or all the Nitrogen Series) | Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-NO3-E or equivalent)<br>Sample one meter from surface and one meter from bottom |
| • **Chlorophyll *a*** | Pigment extraction followed by spectrophotometry (SM #10200 H) sample at 1/2 the secchi depth; or at 1m below – surface or composite 1m samples from surface to 2x Secchi depth. It is important to be consistent. |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Total Suspended Solids** | Gravimetric Method: sample dried at 103°C (SM #2540D or equivalent)<br>Sample one meter from surface and one meter from bottom |
| *Aquatic Life* | |
| • **Fish** | Existing Pa. Fish and Boat Commission data are used |
| • **Aquatic Plant Survey** | EPA Volunteer Lake Monitoring Manual |

Additional notes on the methods are contained in Appendix 2.

### *Relevant Manuals*

APHA. 1992. *Standard Methods for the Examination of Water and Wastewater.* 18th ed. American Public Health Association. Washington, D.C.

EPA 1993. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, Environmental Monitoring and Support Laboratory. Cincinnati, Ohio.

EPA 1991. Volunteer Lake Monitoring: A Methods Manual EPA 440/4-91-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

### *Site Location Considerations*

Sampling should be carried out at the following locations:

**Water Sampling and Analysis**

All water samples should be collected at the deepest part of the lake (e.g. at dam) and one other open water location that reflects conditions in an arm or bay and/or receives pollution.

**Pollution Source Inventory**

This should be carried out throughout the watershed.

**Aquatic Life**

Fish are assessed by the Pa. Fish and Boat Commission at public lakes only; use their data if available.

Aquatic Plants should be mapped at areas of extensive growth.

### *How Frequently and When Should You Carry Out the Assessment?*

**Water Sampling and Analysis**

- *Frequency:* Sample at least three times per year, between May and October. Sampling must be conducted over a minimum of one year.
- *Time of day:* Sample during critical periods of the day for those indicators that fluctuate daily. For example, dissolved oxygen (DO) and temperature are both typically lowest at sunup and highest in mid-day. Critical (low) levels of DO for fish will likely occur in the early morning. Critical (high) temperature levels for fish in the upper layers will likely occur in mid-afternoon.
- *Time of year:* In general, sample once per season during the spring, summer, and fall. In the spring and fall, sample during the overturn. In the summer, sample when the lake is most productive.
- *Weather:* a variety of weather conditions: storm events, droughts, “normal” conditions, relatively hot weather, relatively cool weather, etc.

The visual pollution source inventory should be conducted once per year.

### *Data Analysis and Quality Requirements*

Impairment is determined when pH, dissolved oxygen and temperature data are compared with applicable criteria in the water quality standards. For other data, staff uses information available on the lake and watershed from other agencies which discuss weed growth, sedimentation, algae blooms, fishery conditions, etc. Examples of relevant information include Pa. FBC lake reports and assessments, bacteria level from municipal parks or DCNR. Others include TSI index calculations based on chlorophyll a total, phosphorus and Secchi readings to indicate or corroborate impairment.

DEP will use the data collected in this assessment to place a waterbody on the 303(d) list if its "impaired" status is based on scientifically valid data that meets the following requirements:

1) There is enough information to document a water quality standards violation for a specific waterbody;
2) There is information regarding the exact location of the impaired waterbody (e.g. latitude and longitude);
3) There is information that describes the quality assurance and quality control such that DEP can reasonably apply the available data. A written quality assurance plan is required; and
4) Samples have been analyzed at a DEP-certified lab.

### *Data Reporting Requirements*

Use an electronic database format that is IBM compatible.

### *Quality Assurance/Quality Control (QA/QC)*

An Impairment Determination Assessment requires rigorous internal and external QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Appendix 4 (on page A4-4). Also applicable in Appendix 4 is information on specific internal and external quality controls and how they are assessed.

Periodic field and lab audits by qualified service providers are required. During these audits, the operation of sampling and analytical procedures is observed. 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. The program coordinator should then designate people from this core group who are qualified to train others. Official designation of trainers by the program coordinator through a letter or certificate should be considered.

*Lab Analysis:* For personnel in the program lab,[24] 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 volunteers should be trained in proper sampling qualified service provider. Analysis should be done in a DEP-certified lab.

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

# C3. Comprehensive Lake Watershed Assessment

### *What Is It?*

This assessment is more intensive and comprehensive than the Impairment Determination Assessment. It includes the following:

- ♦ More intensive sampling of lakes - the addition of another station, a few more indicators and bi-monthly sampling;
- ♦ Sampling at the mouths of major tributaries during various flow conditions and seasonally; and
- ♦ Gathering existing information on watershed land uses and population patterns.

This assessment is meant to be carried out as part of a study to develop a Nonpoint Source management plan. Monitoring includes some types of sampling and analysis and a survey of land uses that are likely beyond the scope and capabilities of most volunteer lake monitoring groups. However, the results of this assessment can be used to supplement a watershed monitoring program in the development of a management plan.

### *Why Do It?*

We suggest that you undertake this assessment if you wish to contribute data to the development of a management plan. Since this is a very intensive assessment, we recommend it only for groups that have access to laboratory facilities and that it be carried out in cooperation with reliable sources of land use information and geographic information systems, such as DEP or a regional planning agency.

### *Primary Purposes Addressed*

☐ Community Education and Awareness

☑ Baseline Data Collection

☑ Community and/or Watershed Level Assessment

☑ State and Federal Agency Assessment

### *Questions Addressed*

☐ Is the water meeting or exceeding state Water Quality Standards?

☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?

☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?

☐ What are the present ecological conditions, and how do they change over time?

☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?

☐ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?

☑ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

A Comprehensive Lake Watershed Assessment has three parts:

1) Gathering of existing watershed information on land uses, population patterns, pollution sources and other information about the watershed described in Appendix 3 (Phase 1 Diagnostic - Feasibility Study on page A3-10).

2) Monthly sampling of lakes at two to three stations for the indicators in the Impairment Determination Assessment plus bacteria and more forms of nutrients. Stream flow into lake and outflow measurements should be done to determine actual residence times.

3) Sampling at the mouths of major tributaries during various flow conditions and seasonally.

Recommended indicators/tools and methods are listed in the following table:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| *Gather Existing Watershed Information* | |
| • Geology<br>• Size and economic structure of population living near lake<br>• Lake users most affected by degradation<br>• Point pollution sources and control actions<br>• Biological resources and ecological relationships<br>• Public access<br>• Historical lake uses<br>• Water use compared with nearby lakes<br>• Description, percent and loadings from each nonpoint pollution source<br>• Physical lake and watershed characteristics (surface area, average depth, watershed area, maximum depth, residence time | Research<br>Municipal/County record<br>Surveys<br>Surveys<br>Research<br>Field survey<br>Surveys, municipal records<br>Municipalities<br>Data research and calculations<br>Present trophic condition<br>Calculated<br>Watershed surveys/walks and data research |
| *Lakes Water Sampling and Analysis* | |
| • **Secchi Transparency** | Average of depths at which the disk disappears and reappears:<br>• EPA Volunteer Lake Monitoring Manual |
| • **Dissolved Oxygen** | 1) Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent)<br>2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent)<br>Sample or measure at one meter intervals from lake surface to bottom |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Temperature** | Direct measurement with a thermometer, thermocouple or thermistor<br>Measure at one meter intervals from lake surface to bottom |
| • **pH** | 1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>Sample or measure at one meter intervals from surface to bottom |
| • **Total Alkalinity** | Double end point sulfuric acid titration w/ digital titrator and pH meter (RN or ALLARM manual)<br>Sample or measure at one meter intervals or at surface, mid and bottom depth. |
| • **Fecal Coliform Bacteria** | Membrane filtration w/ mTEC with and without confirmation (EPA #1103.1 or equivalent)<br>Sample various surface locations |
| • **Total Coliform Bacteria** | Membrane filtration<br>Sample various surface locations |
| • **Total Phosphorus** | Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent)<br>Sample one meter from surface and one meter from bottom |
| • **Total Orthophosphate** | Ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent) one meter from surface, one meter from bottom |
| • **Total Dissolved Phosphorus** | Filtration by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent)<br>One meter from surface, one meter from bottom |
| • **Total Kjeldahl Nitrogen** | Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-NO3-E or equivalent)<br>Sample one meter from surface and one meter from bottom |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Nitrates** | Cadmium reduction followed by spectrophotometry (SM #4500-NO3-E or equivalent)<br>Sample lake surface and bottom |
| • **Ammonia** | Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or equivalent)<br>Sample one meter from surface and one meter from bottom |
| • **Chlorophyll *a*** | Pigment extraction followed by spectrophotometry (SM #10200 H)<br>Sample at 1/2 the secchi depth; or one meter from surface, or composite one meter samples, surface to two times the Secchi depth. |
| • **Total Suspended Solids** | Gravimetric Method: sample dried at 103°C (SM #2540D or equivalent)<br>Sample one meter from surface and one meter from bottom |
| ***Tributary Water Sampling and Analysis*** | |
| • **Fecal Coliform Bacteria** | Membrane filtration w/ mTEC with and without confirmation (EPA #1103.1 or equivalent) |
| • **Total Coliform Bacteria** | Membrane filtration w |
| • **Total Phosphorus** | Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent) |
| • **Total Kjeldahl Nitrogen** | Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-NO3-E or equivalent) |
| • **Total Suspended Solids** | Gravimetric Method: sample dried at 103_C (SM #2540D or equivalent) |
| ***Aquatic Life*** | |
| • **Fish** | Existing Pa. Fish and Boat Commission data |
| • **Aquatic Plant Survey** | EPA Volunteer Lake Monitoring Manual |

Additional notes on the methods are contained in Appendix 2.

### *Relevant Manuals*

APHA. 1992. *Standard Methods for the Examination of Water and Wastewater.* 18th Ed. American Public Health Association. Washington, D.C.

EPA 1993. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

EPA 1991. Volunteer Lake Monitoring: A Methods Manual. EPA 440/4-91-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

EPA, 1988. The Lake and Reservoir Restoration and Guidance Manual, EPA 44015-88-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Moore, M.L. 1987. NALMS Management Guide for Lakes and Reservoirs, North American Lake Management Society: Washington, D.C. 42 pp.

Shertzer and Schreffler, 1996. Pennsylvania Water Quality Network Monitoring Program. Harrisburg, Pa.

### *Site Location Considerations*

Sampling should be carried out at the following locations:

**Lake Water Sampling and Analysis**

- *Frequency:* Sample monthly, between May and October. Sampling must be conducted over a minimum of one year.
- *Time of day:* Sample during critical periods of the day for those indicators that fluctuate daily. For example, dissolved oxygen (DO) and temperature are both typically lowest at sunup and highest in mid-day. Critical (low) levels of DO for fish will likely occur in the early morning. Critical (high) temperature levels for fish in the upper layers will likely occur in midafternoon.
- *Time of year:* In general, sample monthly per season during the spring, summer and fall. In the spring and fall, sample during the overturn. In the summer, sample when the lake is most productive.
- *Weather:* Sample during "normal" conditions (not during or immediately after storms).

**Tributary Water Sampling and Analysis**

- *Frequency:* Sample at least once per month from May through October. Sampling must be conducted over a minimum of one year.
- *Time of year:* Sample during spring, summer and fall.
- *Time of day:* Sample during critical periods of the day for those indicators that fluctuate daily. For example, dissolved oxygen (DO) and temperature are both typically lowest at sunup and highest in mid-day. 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.

For tributary sampling, storm 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).

- *Weather:* Sample during the following conditions, in tributaries only:

during three to six storm events.

during three to six dry / normal flows.

Also, sample during relatively hot weather, relatively cool weather, etc.

Gathering watershed background information should be done once, and then updated annually.

### *Data Analysis and Quality Requirements*

The information is analyzed to define the quality of the lake, including the location and loading characteristics of significant pollution sources. Analysis includes an assessment of phosphorus, nitrogen and total suspended sediment, inflows and outflows and a hydraulic budget (including groundwater). Carlson's Trophic State Index is calculated using Secchi depths, near surface phosphorus and chlorophyll a.

DEP will use the data collected in this assessment in a management plan development process if it is scientifically valid data that meets the following requirements:

1) There is enough information to document a water quality standards violation for a specific waterbody;
2) There is information regarding the exact location and extent of the impaired waterbody (e.g. latitude and longitude); and
3) There is information that describes the quality assurance and quality control such that DEP can reasonably apply the available data. A written quality assurance plan is required.

### *Data Reporting Requirements*

Use electronic database format that is IBM compatible.

### *Quality Assurance/Quality Control (QA/QC)*

A Comprehensive Watershed Assessment requires rigorous internal (samples collected and analyzed by project field volunteers, staff and lab - see p. A4-2) and external (samples collected and analyzed by non-volunteer field staff and "quality control" lab - see p. A4-3) QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Appendix 4 (on page A4-4). Also, applicable in Appendix 4 is information on specific internal and external quality controls and how they are assessed.

Periodic field and lab audits by providers are recommended. During these audits, the operation of sampling and analytical procedures is observed. 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. The program coordinator should then designate people from this core group who are qualified to train others. Official designation of trainers by the program coordinator through a letter or certificate should be considered.

*Lab Analysis:* For personnel in the program lab, proper training is essential. There should be a designated lab coordinator responsible for seeing that all volunteers are properly trained. Initially, the lab coordinator and a core group of volunteers should be trained in proper sampling techniques by a qualified service provider. Analysis should be done in a DEP-certified lab.

## D. Advanced Stream Trends Assessment

Advanced Stream Trends Assessment involves monitoring and assessment of the *stressors* (e.g. pollution sources or a chemical necessary for life), the degree of *exposure* to that stress (e.g. water column concentration of a pollutant) and the biological *response* to exposure to the stressor. It is watershed-wide in scope. It is long-term.

This assessment includes a wide range of monitoring activities that measure as many of the physical, chemical and biological indicators of stream 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 in wadeable streams - waters less than two feet deep, where it is possible to see and access the bottom to collect samples of habitat and aquatic life. However, we also suggest activities appropriate for non-wadeable rivers and lakes.

**D1.** Longterm Monitoring – Wadeable Waters

**D2.** Longterm Monitoring – Non-Wadeable Waters

Advanced Stream Trends Assessment is geared to produce a great deal of high quality information that can be used by a wide variety of watershed managers and decision-makers to assess the ecological conditions over time.

# D1. Long Term Monitoring – Wadeable Waters

### *What Is It?*

Long Term Monitoring for wadeable waters involves long term, on-going monitoring and assessment of the *stressors* (e.g. pollution sources or a chemical necessary for life), the degree of *exposure* to that stress (e.g. water column concentration of a pollutant) and the biological *response* to exposure to the stressor. 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 stream 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;
- ♦ Pollution source inventory; and
- ♦ Field measurements of flow and channel characteristics.

Indicators are strategically selected to yield the most information for the least amount of effort and that can be sustained over a long period of time. Methods are comparable to those used by state agencies.

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

### *Why Do It?*

We suggest that you undertake Longterm Monitoring – Wadeable Waters if your primary interest is in the long-term ecological health of your stream and the effectiveness of management, protection and restoration activities over time. Since the focus is on ecological conditions, this assessment may also detect existing and new aquatic life impairments. The information produced by this assessment may also be useful to federal and state agencies for their on-going assessment activities.

### *Primary Purposes Addressed*

- ☐ Community Education and Awareness
- ☑ Baseline Data Collection
- ☐ Community and / or Watershed Level Assessment
- ☑ State and Federal Agency Assessment

### *Questions Addressed*

- ☑ Is the water meeting or exceeding state Water Quality Standards?
- ☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?
- ☑ What are the present ecological conditions, and how do they change over time?
- ☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?
- ☑ How effective are various strategies (e.g. wastewater treatment. best management practices) in protecting and restoring ecological integrity

☑ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The basic approach to selecting from among the options for the Long Term Monitoring – Wadeable Waters is to focus on a few rich indicators of watershed stress, exposure and response (see Chapter 2, Step 3 (on page A2-9 for an explanation of these) that give you the most information for the least amount of effort. The specific indicators you select will vary depending on the issues and characteristics of your stream. Monitor indicators from each of these categories over a relatively long period of time to establish trends.

Monitoring options are listed in the following table:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| ***Site Indicators*** | |
| • **Pollution Source Inventory**<br>Point Sources<br>Nonpoint Sources<br>Eroding Banks / Unstable Channels | Land Use maps at regional planning commissions or Conservation Districts<br>DEP Watershed Notebooks<br>DEP Regional Offices - Discharge Monitoring Reports for NPDES permittees<br>Toxic Release Inventory<br>Historical Land Use Records - County Library, Historical Societies, Conservation Districts |
| • **Rainfall** | Gauges (NWS[25]) |
| • **Stream Flow** | From USGS Gauges when available or measurement using Embody Float Method (EPA Volunteer Stream Monitoring Methods Manual) |
| • **Maximum Air Temperature** | Direct Measurement or existing NWS data |
| ***Exposure Indicators*** | |
| • **Fecal Colif./E. coli Bacteria**<br>*water sampling and analysis* | Membrane filtration w / mTEC with and without confirmation (EPA# 1103.1 or equivalent) |
| • **Total Phosphorus**<br>*water sampling and analysis* | Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent) |
| • **Total Dissolved Phosphorus**<br>*water sampling and analysis* | Filtration, followed by persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent) |

[25] National Weather Service.

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Nitrogen Series**<br>*water sampling and analysis*<br>• **Total Kjeldahl Nitrogen**<br><br>• **Nitrates**<br><br>• **Ammonia** | <br><br>Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-Norg B or equivalent)<br><br>Cadmium reduction followed by spectrophotometry (SM #4500-NO3-E or equivalent)<br><br>Distillation followed by Nesslerization followed by spectrophotometry (SM #4500NH3 C or equivalent) |
| • **Turbidity**<br>*water sampling and analysis* | Sample collected and measured with a nephelometer (RN adaptation of Standard Methods #2130) |
| • **Dissolved Oxygen**<br>*water sampling and analysis* | 1) Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent) - surface sample<br>2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent) - measure at surface |
| • **Biochemical Oxygen Demand**<br>*water sampling and analysis* | BOD five-day procedure w/ Modified Winkler Titration or meter (SM #52 1 O-B or equivalent) |
| • **Temperature**<br>*water sampling and analysis* | Direct measurement with a thermometer, thermocouple or thermistor |
| • **pH**<br>*water sampling and analysis* | 1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) |
| • **Total Alkalinity**<br>*water sampling and analysis* | Double end point sulfuric acid titration w/digital titrator and pH meter (RN or ALLARM manual) |
| • **Acidity**<br>*water sampling and analysis* | Titration with measured amount standard acid to pH of 4.0, EPA#305.1 Standard Methods |
| • **Conductivity**<br>*water sampling and analysis* | Direct measurement with a meter (EPA Volunteer Methods manual) |
| • **Hardness**<br>*water sampling and analysis* | Computed from results of calcium and magnesium or titrated (SM #3500Ca, EPA 130..2 or equivalent) Standard Methods |
| • **Total Iron (for sampling only)**<br>*water sampling and analysis* | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Manganese (for sampling only)**<br>*water sampling and analysis* | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Sulfates (for sampling only, if method 2 is used)**<br>*water sampling and analysis* | 1) Turbidimetric: Sulfate ion is converted to a suspension. The resulting turbidity is determined by a nephelometer, and compared to a curve prepared from standard sulfate solutions, EPA #375.4<br>2) Colorimetric, Automated, Methylthymol Blue, using an Autoanalyzer II, EPA #375.2 |
| • **Aluminum (for sampling only)**<br>*water sampling and analysis* | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Total Dissolved Solids**<br>*water sampling and analysis* | Gravimetric method, filtrate dried at 180°C. (SM#2540C or equivalent) |
| • **Total Suspended Solids**<br>*water sampling and analysis* | Gravimetric method, dried at 103-105°C. (SM#2540D or equivalent) |
| • **Total Residual Chlorine (For Sampling Only)**<br>*water sampling and analysis* | *Sampling*: Consult with DEP regional biologist for sampling method. This is tricky due to TRC's dissipation and flow patterns.<br>*Analysis*: Amperometric Titration Method, SM#4500ClD |
| ***Response Indicators*** | |
| • **Intensive Benthic Macroinvertebrate Assessment** | Field collection w / net, lab ID. of major groups or families, assess based on comparison to reference<br>• Intensive Stream Biosurvey (EPA, RN, SWRC)<br>• EPA Rapid Bioassessment Protocol II<br>• Pa. Unassessed Waters Strategy |
| • **Benthic Macroinvertebrate Habitat Assessment** | Field observation and rating of key habitat characteristic relative to reference condition (RN Benthic Macroinvertebrate Monitoring Manual - adaptation of EPA RBP II or equivalent) |
| • **Stream Channel Measurements** | |
| – **Embeddedness** | Estimated for four particles at each of 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) |
| – **Longitudinal Profile** | Elevations of channel bottom and water surface ("Stream Channel Reference Sites" USFS or equivalent) |
| – **Bottom Composition** | Pebble Count: Collection and measurement of at least 100 stream bottom particles at 10 cross sections to determine distribution among various size classes. ("Stream Channel Reference Sites" USFS or equivalent) |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Dissolved Oxygen**<br>*water sampling and analysis* | 1) Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent) - surface sample<br>2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent) - measure at surface |
| • **Temperature**<br>*water sampling and analysis* | Direct measurement with a thermometer, thermocouple or thermistor |

Additional notes on the methods are contained in Appendix 2.

### Guide To Selecting Indicators

We recommend that you select at least two indicators from the stress, exposure and response categories. Further, the indicators you select should be related -- e.g. air temperature (stress) can cause increases in water temperature (exposure) which can affect benthic macroinvertebrates (response). Note that some indicators fall into more than one category (e.g. dissolved oxygen). The following table will help you choose:

| | **Stressors** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Indicators** | **Sew** | **Tox** | **Ero** | **Nut** | **Ani** | **Urb** | **Veg** | **AMD** |
| *Stress Indicators* | | | | | | | | |
| Point Source Inventory | X | X | | | | | | |
| Nonpoint Source Inventory | | | X | X | X | X | X | X |
| Eroding Banks / Unstable Channels Inventory | | | X | | | | | |
| Rainfall | X | X | | X | | | | |
| Stream Flow | X | X | | X | | | | |
| *Exposure Indicators* | | | | | | | | |
| Fecal colif. / E. coli Bacteria | X | | | | X | X | | |
| Total Phosphorus | X | | X | X | X | X | X | |
| Total Dissolved Phosphorus | | | X | X | | | | |
| Nitrogen Series | | | | | | | | |
| - Total Kjeldahl Nitrogen | | | | X | X | X | X | |
| - Nitrates | X | | | X | X | X | | |
| - Ammonia | X | | | | | | | |
| Turbidity | X | | X | | X | X | X | |
| Dissolved Oxygen | | | X | X | X | X | X | |
| Biochemical Oxygen Demand | X | X | | | | | | |
| Temperature | X | | X | X | X | X | X | |
| PH | X | X | | | | X | | X |
| Total Alkalinity | X | X | | | | X | | X |
| Acidity | | | | | | | | X |
| Conductivity | X | X | | | | X | | X |
| Hardness | | X | | | | | | |
| Total Iron | | | | | | | | X |
| Manganese | | | | | | | | X |
| Sulfates | | | | | | | | X |
| Aluminum | | | | | | | | X |

| Indicators | Stressors | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sew | Tox | Ero | Nut | Ani | Urb | Veg | AMD |
| Total Dissolved Solids | X | | | | | | | |
| Total Suspended Solids | X | | X | | | X | | |
| Total Residual Chlorine | X | | | | | | | |
| *Response Indicators* | | | | | | | | |
| Intensive Benthic Macroinvertebrate Assessment | X | X | X | X | X | X | X | X |
| Benthic Macroinvertebrate Habitat Assessment | X | X | X | X | X | X | X | X |
| Dissolved Oxygen | | | X | X | X | X | X | |
| Temperature | X | | X | X | X | X | X | |
| Embeddedness | | | X | | | X | X | |
| Channel cross - sections | | | X | | | X | X | |
| Longitudinal Profile | | | X | | | X | X | |
| Bottom Composition | | | X | | | X | X | |

Key to stressors:

Sew = sewage
Tox = toxics
Ero = erosion
Nut = nutrients
Ani = animal manure
Urb = urban runoff
Veg = streamside vegetation removal
AMD = abandoned mine drainage

Additional notes on the methods are contained in Appendix 2.

### *Relevant Manuals:*


Alliance for Aquatic Resource Monitoring, 1996 Visual Assessment Handbook, Carlisle, Pa.

APHA. 1992. Standard Methods for the Examination of Water and Wastewater. 18th ed. American Public Health Association. Washington, D.C.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier, Vt.

Dates, Geoff, and Byme, Jack, 1997. Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess Your River's Health, River Network, Montpelier, Vt.

Harrelson, Cheryl C., 1994. Stream Channel Reference Sites: An Illustrated Guide To Field Technique, U.S. Forest Service General Technical Report RM-245, Fort Collins, Colo.

Hunter, Christopher J., 1991. Better Trout Habitat, Island Press, Washington, D.C.

Murdoch, T. and Cheo, M., 1996. The Streamkeeper's Field Guide. Adopt-A-Stream Foundation. Everett, Wash.

Plafkin, James L, et al Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. Report # EPA/444/4-89-00 1. EPA, Washington, D.C., May 1989.

DEP, 1998. Strategy for Assessing Pennsylvania’s Unassessed Surface Waters (Field Biologists version, 4/23/98). Harrisburg, Pa.

River Network and Vt. Department of Environmental Conservation, Undated. River Walk (a self-explanatory field data sheet), Montpelier, Vt.

Shertzer, Richard and Schreffler, Tammy, 1996. Pennsylvania’s Surface Water Quality Monitoring Network (WQN), 3600-BK-DEP0636, DEP, Harrisburg, Pa.

Stroud Water Research Center, Unpublished Benthic Macroinvertebrate Manual. Avondale, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

EPA 1993. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

### *Site Location Considerations*

Water, habitat and benthic macroinvertebrate sampling should be carried out at a variety of sites that represent a variety of conditions in the watershed. Select as many of the following types of sites as you can (see Chapter 2, Step 6 on page A2-18 for definitions of types of sites):

- Sites on streams of different orders (sizes) and at different altitudes.
- Watershed reference sites.
- Stream impact assessment sites:
  - upstream reference (control) sites
  - impact sites
  - recovery sites
- Benthic macroinvertebrate riffle habitats.
- Tributary impact assessment sites:
  - reference sites
  - impact sites
  - recovery sites
  - integrator sites
- Cold and warm water fish habitat areas (spawning, nursery and resting sites).
- Where possible, sites historically monitored by DEP.
- Stream channel reference sites that are stable and represent different stream types.

### *How Frequently and When Should You Carry Out the Assessment?*

Long Term Monitoring – Wadeable Waters requires as many samples collected under as many different conditions as your resources will allow. A good assessment 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 – five years at a minimum.

We suggest the following frequency, time of day, time of year and weather conditions for the monitoring options listed in the table above:

**Pollution Source Inventories**

- *Frequency and time of year:* At least once per year.
- *Time of day and weather:* Not a consideration, though fieldwork during high flows should be avoided for safety reasons.

**Rainfall**

- *Frequency and time of year:* Sample hourly during storm events from April through November.
- *Time of day and weather:* Storm events.

**Air Temperature**

- *Frequency and time of year:* Sample daily from April through November
- *Time of day and weather:* Sample during the hottest part of the day, typically midafternoon.

**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 (in darkness) 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 low flow and high air temperature conditions - and less stressful periods such as mid-late spring to get a sense of seasonal variation.
- *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.

**Stream Channel Measurements (embeddedness, cross-sections, longitudinal profiles, bottom composition)**

- *Frequency and time of year:* Sample at least once per year during consistent flows and after bankfull flows.
- *Time of day and weather:* Not a consideration, though measuring during dangerously high flows should be avoided.

## *Data Analysis*

**Water Sampling and Analysis Data**

- Results are 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 upstream control or watershed reference sites.
- Basic statistical summaries should be used to summarize the data and to reveal patterns in the data over time and space. We recommend the following fairly simple summaries:
  - Seasonal and / or annual averages to show values typical of the data set;
  - Seasonal and / or annual medians to show values typical of the data set;
  - Maximums to show extreme conditions;
  - Minimums to show extreme conditions; and

- Range (maximum - minimum) to show variability.

**Benthic Macroinvertebrate Data**

- ♦ Data are compared with reference conditions at an upstream control site and, if possible, a watershed reference site for comparable stream types.
- ♦ Results from one sampling are acceptable, though several years are preferable.
- ♦ Basic metrics summaries should be tested to determine their response to the specific stressors over time and space: We recommend testing the following:
  - percent composition of major groups;
  - Total number of taxa and EPT richness;
  - Total number of individuals and relative abundance of EPT taxa;
  - Family biotic index;
  - percent of total sample represented by each functional feeding group;
  - percent of sample represented by dominant taxon;
  - Others as recommended by your technical advisory committee; and
  - A multi-metric index that combines scores for each selected metric.

**Stream Channel Data**

- ♦ Results are compared with reference sites for each stream type.

### *Data Reporting Requirements*

Data can be reported in electronic or paper format. The sampling date(s) should be included. Sampling locations must be identified by latitude and longitude or in relation to some identifiable geographic feature such as a named bridge or road. The stream segment or "reach" must be identified.

DEP defines a stream segment as the portion of a stream between an upstream tributary and the next downstream tributary. For headwater sections, the first segment would be from the source to the first tributary. DEP uses USGS 7.5 minute quadrangle maps (1/24,000 scale) to identify tributaries and the resulting stream segments. The rationale for segmenting streams this way is that loads from tributaries often affect the water quality of the receiving stream and it is much easier for DEP to manage information when it is associated with fixed stream reaches. After identifying a stream segment, the sampling locations should be situated so they reflect the quality of the entire segment. A minimum of two sites is required to assess the quality of the stream segment. One location is just above the upstream tributary to measure the water quality entering the stream segment and the other location is just above the downstream tributary to measure the water quality as it flows out of the segment. If you suspect there are land use changes or discharges that may effect the water quality within a segment, then you may choose to establish additional sample locations at these points.

### *Quality Assurance/Quality Control (QA/QC)*

Advanced Long Term Monitoring – Wadeable Waters requires rigorous internal (samples collected and analyzed by project field volunteers, staff and lab - see p. A4-2) and external (samples collected and analyzed by non-volunteer field staff and "quality control" lab - see p. A4-3) QA/QC. Specific quality control measures for each indicator are listed in Table 1 in Appendix 4 (on page A4-4). Also, applicable in Appendix 4 is information on specific internal and external quality controls and how they are assessed.

Periodic field and lab audits by qualified service providers are recommended. During these audits, the operation of sampling and analytical procedures is observed. 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 and benthic macroinvertebrate sample collection and visual survey techniques by the group or agency that uses and supports the method. 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[26], 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. 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.

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

# D2. Long Term Monitoring – Non-Wadeable Waters

### *What Is It?*

Long Term Monitoring – Non-Wadeable Waters involves long term, ongoing monitoring and assessment of the *stressors* (e.g. pollution sources or a chemical necessary for life), the degree of *exposure* to that stress (e.g. water column concentration of a pollutant) and the biological *response* to exposure to the stressor. 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 stream 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; and
- ♦ Pollution source inventory.

Indicators are strategically selected to yield the most information for the least amount of effort and that can be sustained over a long period of time. Methods are comparable to those used by state agencies.

Non-wadeable waters are waters greater than two feet deep, where it is not possible to see and safely access the bottom to collect samples of habitat and aquatic life. Activities appropriate for wadeable waters are covered in section D1 (on page 5-94).

### *Why Do It?*

We suggest that you undertake Long Term Monitoring – Non-Wadeable Waters if your primary interest is in the longterm ecological health of your stream and the effectiveness of management, protection and restoration activities over time. Since the focus is on ecological conditions, this assessment may also detect existing and new aquatic life impairments. The information produced by this assessment may also be useful to federal and state agencies for their on-going assessment activities.

### *Primary Purposes Addressed*

- ☐ Community Education and Awareness
- ☑ Baseline Data Collection
- ☐ Community and / or Watershed Level Assessment
- ☑ State and Federal Agency Assessment

### *Questions Addressed*

- ☑ Is the water meeting or exceeding state Water Quality Standards?
- ☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☑ Where are the threatened waters that should be a high priority for protection? What is causing these threats?
- ☑ What are the present ecological conditions, and how do they change over time?
- ☑ What is the impact of various types of land and water use activities on ecological conditions and human uses (e.g. various types of point and nonpoint source pollution)?
- ☑ How effective are various strategies (e.g. wastewater treatment, best management practices) in protecting and restoring ecological integrity?

☑ Where are the special places with unique ecological, social and economic values that should be protected?

### *Monitoring Options*

The basic approach to selecting from among the options for the Long Term Monitoring – Non-Wadeable Waters is to focus on a few rich indicators of watershed stress, exposure and response (see Chapter 2, Step 3 (on page A2-9) for an explanation of these) that give you the most information for the least amount of effort. The specific indicators you select will vary depending on the issues and characteristics of your stream. Monitor indicators from each of these categories over a relatively long period of time to establish trends.

Monitoring options are listed in the following table:

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| ***Stress Indicators*** | |
| • **Pollution Source Inventory**<br>Point Sources<br>Nonpoint Sources<br>Eroding Banks / Unstable Channels | Land Use maps at regional planning commissions or Conservation Districts<br>DEP Watershed Notebooks<br>DEP Regional Offices – Discharge Monitoring Reports for NPDES permittees<br>Toxic Release Inventory<br>Historical Land Use Records – County Library, Historical Societies, Conservation Districts |
| • **Rainfall** | Gauges (NWS[27]) |
| • **Stream Flow** | USGS Gauges |
| • **Maximum Air Temperature** | Direct Measurement or NWS data |
| ***Exposure Indicators*** | |
| • **Fecal colif./E. coli Bacteria**<br>*water sampling and analysis* | Membrane filtration w / MTEC with and without confirmation (EPA# 1 103.1 or equivalent) |
| • **Total Phosphorus**<br>*water sampling and analysis* | Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent) |
| • **Total Dissolved Phosphorus** | Filtration, followed by persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent) |
| • **Nitrogen Series**<br>*water sampling and analysis*<br>**Total Kjeldahl Nitrogen**<br>**Nitrates**<br>**Ammonia** | Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-Norg B or equivalent)<br>Cadmium reduction followed by spectrophotometry (SM #4500-NO3-E or equivalent)<br>Distillation followed by Nesslerization followed by spectrophotometry (SM #4500NH3 C or equivalent) |
| • **Turbidity**<br>*water sampling and analysis* | Sample collected and measured with a nephelometer (RWN adaptation of Standard Methods #2130) |

[27] National Weather Service

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Dissolved Oxygen**<br>*water sampling and analysis* | 1) Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent) - surface sample<br>2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent) - measure at surface |
| • **Biochemical Oxygen Demand**<br>*water sampling and analysis* | BOD five-day procedure w/ Modified Winkler Titration or meter (SM #5210-B or equivalent) |
| • **Temperature**<br>*water sampling and analysis* | Direct measurement with a thermometer, thermocouple or thermistor |
| • **pH**<br>*water sampling and analysis* | 1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)<br>2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) |
| • **Total Alkalinity**<br>*water sampling and analysis* | Double end point sulfuric acid titration w/ digital titrator and pH meter (RWN or ALLARM manual) |
| • **Acidity**<br>*water sampling and analysis* | Titration with measured amount standard acid to pH of 4.0, EPA#305.1 |
| • **Conductivity**<br>*water sampling and analysis* | Direct measurement with a meter (EPA Volunteer Methods manual) |
| • **Hardness**<br>*water sampling and analysis* | Computed from results of calcium and magnesium or titrated (SM #3500Ca, EPA 130..2 or equivalent) |
| • **Total Iron (for sampling only)**<br>*water sampling and analysis* | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Manganese (for sampling only)**<br>*water sampling and analysis* | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Sulfates (for sampling only, if method 2 is used)**<br>*water sampling and analysis* | 1) Turbidimetric: Sulfate ion is converted to a suspension. The resulting turbidity is determined by a nephelometer, and compared to a curve prepared from standard sulfate solutions, EPA #375.4<br>2) Colorimetric, Automated, Methylthymol Blue, using an Autoanalyzer II, EPA #375.2Standard Methods |
| • **Aluminum (for sampling only)**<br>*water sampling and analysis* | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7Standard Methods |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Total Dissolved Solids**<br>*water sampling and analysis* | Gravimetric method, filtrate dried at 1800°C. (SM#2540C or equivalent) |
| • **Total Suspended Solids**<br>*water sampling and analysis* | Gravimetric method, dried at 103-105°C. (SM#2540D or equivalent) |
| • **Total Residual Chlorine (For Sampling Only)**<br>*water sampling and analysis* | *Sampling*: Consult with DEP regional biologist for sampling method. This is tricky due to TRC's dissipation and flow patterns.<br>*Analysis*: Amperometric Titration Method, SM#4500ClD. |
| ***Response Indicators*** | |
| • **Intensive Benthic Macroinvertebrate Assessment** | Field collection w/ artificial substrate, lab ID. of major groups or families, assess based on comparison to reference<br>• Intensive Stream Biosurvey (RWNRN) |
| • **Benthic Macroinvertebrate Habitat Assessment** | Field observation and rating of key habitat characteristic relative to reference condition (RWN Benthic Macroinvertebrate Monitoring Manual or EPA Volunteer Stream methods Manual - muddy bottom Assessment adaptation of EPA RBP 11 or equivalent) |
| • **Dissolved Oxygen**<br>*water sampling and analysis* | 1. Modified Winkler Titration with a buret, syringe or digital titrator (SM #4500-OG or equivalent) - surface sample<br>2. Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent) - measure at surface |
| • **Temperature**<br>*water sampling and analysis* | Direct measurement with a thermometer, thermocouple or thermistor |

Additional notes on the methods are contained in Appendix 2.

**Guide To Selecting Indicators**

We recommend that you select at least two indicators from the stress, exposure and response categories. Further, the indicators you select should be related -- e.g. air temperature (stress) can cause increases in water temperature (exposure) which can affect benthic macroinvertebrates (response). Note that some indicators fall into more than one category (e.g. dissolved oxygen). The following table will help you choose:

| | **Stressors** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Indicators** | **Sew** | **Tox** | **Ero** | **Nut** | **Ani** | **Urb** | **Veg** | **AMD** |
| *Stress Indicators* | | | | | | | | |
| Point Source Inventory | X | X | | | | | | |
| Nonpoint Source Inventory | | | X | X | X | X | X | X |
| Eroding Banks/Unstable Channels Inventory | | | X | | | | | |
| Rainfall | X | | X | X | | | | |
| Stream Flow | X | | X | X | | | | |
| *Exposure Indicators* | | | | | | | | |
| Fecal colif./E. coli Bacteria | X | | | | X | X | | |

| | Stressors | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Indicators** | **Sew** | **Tox** | **Ero** | **Nut** | **Ani** | **Urb** | **Veg** | **AMD** |
| Total Phosphorus | X | | X | X | X | X | X | |
| Total Dissolved Phosphorus | | | X | X | | | | |
| Nitrogen Series | | | | | | | | |
| - Total Kjeldahl Nitrogen | | | | X | X | X | X | |
| - Nitrates | X | | | X | X | X | | |
| - Ammonia | X | | | | | | | |
| Turbidity | X | | X | | X | X | X | |
| Dissolved Oxygen | | | X | X | X | X | X | |
| Biochemical Oxygen Demand | X | X | | | | | | |
| Temperature | X | | X | X | X | X | X | |
| pH | X | X | | | | X | | X |
| Total Alkalinity | X | X | | | | X | | X |
| Acidity | | | | | | | | X |
| Conductivity | X | X | | | | X | | X |
| Hardness | | X | | | | | | |
| Total Iron | | | | | | | | X |
| Manganese | | | | | | | | X |
| Sulfates | | | | | | | | X |
| Aluminum | | | | | | | | X |
| Total Dissolved Solids | X | | | | | | | |
| Total Suspended Solids | X | | X | | | X | | |
| Total Residual Chlorine | X | | | | | | | |
| *Response Indicators* | | | | | | | | |
| Intensive Benthic Macroinvertebrate Assessment | X | X | X | X | X | X | X | X |
| Benthic Macroinvertebrate Habitat Assessment | X | X | X | X | X | X | X | X |
| Dissolved Oxygen | | | X | X | X | X | X | |
| Temperature | X | | X | X | X | X | X | |

Key to stressors:

Sew = sewage
Ero = erosion
Ani = animal manure
Veg = streamside vegetation removal
Tox = toxics
Nut = nutrients
Urb = urban runoff
AMD = abandoned mine drainage

### *Relevant Manuals:*


Alliance for Aquatic Resource Monitoring, 1996 Visual Assessment Handbook, Carlisle, Pa.

APHA. 1992. Standard Methods for the Examination of Water and Wastewater. 18th ed. American Public Health Association. Washington, D.C.

Behar, Sharon, 1995. Testing the Waters, River Network, Montpelier, Vt.

Dates, Geoff, and Byrne, Jack, 1997. Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess Your River's Health, River Network, Montpelier, Vt.

Harrelson, Cheryl C., 1994. Stream Channel Reference Sites: An Illustrated Guide To Field Technique, US Forest Service General Technical Report RM-245, Fort Collins, Colo.

Hunter, Christopher J., 1991. Better Trout Habitat, Island Press, Washington, D.C.

Murdoch, T. and Cheo, M., 1996. The Streamkeeper's Field Guide. Adopt-A-Stream Foundation. Everett, Wash.

Plafkin, James L, et al Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. Report # EPA/444/4-89-001. EPA, Washington ,D.C., May 1989.

PA DEP, 1998. Strategy for Assessing Pennsylvania's Unassessed Surface Waters (Field Biologists version, 4/23/98). Harrisburg, Pa.

River Network and Vt. Department of Environmental Conservation, Undated. River Walk (a self-explanatory field data sheet), Montpelier, Vt.

Stroud Water Research Center, Unpublished Benthic Macroinvertebrate Manual. Avondale, Pa.

EPA 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington, D.C.

EPA 1993. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

### *Site Location Considerations*

Water, habitat and benthic macroinvertebrate sampling should be carried out at a variety of sites that represent a variety of conditions in the watershed. Water and benthic macroinvertebrate sampling will involve use of a bridge or boat in non-wadeable waters. Select as many of the following types of sites as you can (see Chapter 2, Step 6 on page 2-20 for definitions of types of sites):

- ♦ Sites on streams of different orders (sizes) and at different altitudes
- ♦ Watershed reference sites.
- ♦ Stream impact assessment sites
  - upstream reference (control) sites
  - impact sites
  - recovery sites
- ♦ Benthic macroinvertebrate run habitats
- ♦ Tributary impact assessment sites
  - reference sites
  - impact sites
  - recovery sites
  - integrator sites
- ♦ Cold and warm water fish habitat areas (spawning, nursery, and resting sites)
- ♦ Where possible, sites historically monitored by DEP

### *How Frequently and When Should You Carry Out the Assessment?*

Long Term Monitoring – Non-wadeable Waters requires as many samples collected under as many different conditions as your resources will allow. A good assessment 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 -- five years at a minimum.

We suggest the following frequency, time of day, time of year and weather conditions for the monitoring options listed in the table above:

**Pollution Source Inventories**

- *Frequency and time of year:* At least once per year
- *Time of day and weather:* Not a consideration, though fieldwork during high flows should be avoided for safety reasons.

**Rainfall**

- *Frequency and time of year:* Sample hourly during storm events from April through November.
- *Time of day and weather:* Storm events

**Air Temperature**

- *Frequency and time of year:* Sample daily from April through November.
- *Time of day and weather:* Sample during the hottest part of the day, typically mid-afternoon.

**Water Sampling and Analysis:**

- *Composite Samples:* To obtain a water sample that is representative of the horizontal stream stretch (bank to bank), an integrated depth sampler would be used at several locations across the stream. The sample would be composited or mixed before analysis. This would involve sampling from a bridge or boat.
- *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 low flow and high air temperature conditions - and less stressful periods such as mid-late spring to get a sense of seasonal variation.
- *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**

- *Artificial Substrate* – Macroinvertebrates should be collected using an artificial substrate such as a multiplate sampler, which is left in the water for a period of time.
- *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.

## *Data Analysis*

**Water Sampling and Analysis Data**

- Results are 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 upstream control or watershed reference sites.
- Basic statistical summaries should be used to summarize the data and to reveal patterns in the data over time and space. We recommend the following fairly simple summaries:

- Seasonal and / or annual averages to show values typical of the data set;
- Seasonal and / or annual medians to show values typical of the data set;
- Maximums to show extreme conditions;
- Minimums to show extreme conditions; and
- Range (maximum - minimum) to show variability.

**Benthic Macroinvertebrate Data**

♦ Data are compared with reference conditions at an upstream control site and, if possible, a watershed reference site for comparable stream types.

♦ Results from one sampling are acceptable, though several years are preferable.

♦ Basic metrics summaries should be tested to determine their response to the specific stressors over time and space. We recommend testing the following:
  - percent composition of major groups;
  - Total number of taxa and EPT richness;
  - Total number of individuals and relative abundance of EPT taxa;
  - Family biotic index;
  - percent of total sample represented by each functional feeding group;
  - percent of sample represented by dominant taxon;
  - Others as recommended by your technical advisory committee; and
  - A multi-metric index that combines scores for each selected metric.

## *Data Reporting Requirements*

Data can be reported in electronic or paper format. The sampling date(s) should be included. Sampling locations must be identified by latitude and longitude or in relation to some identifiable geographic feature such as a named bridge or road. The stream segment or "reach" must be identified.

DEP defines a stream segment as the portion of a stream between an upstream tributary and the next downstream tributary. For headwater sections, the first segment would be from the source to the first tributary. DEP uses USGS 7.5 minute quadrangle maps (1 / 24,000 scale) to identify tributaries and the resulting stream segments. The rationale for segmenting streams this way is that loads from tributaries often affect the water quality of the receiving stream and it is much easier for DEP to manage information when it is associated with fixed stream reaches. After identifying a stream segment, the sampling locations should be situated so they reflect the quality of the entire segment. A minimum of two sites is required to assess the quality of the stream segment. One location is just above the upstream tributary to measure the water quality entering the stream segment and the other location is just above the downstream tributary to measure the water quality as it flows out of the segment. If you suspect there are land use changes or discharges that may effect the water quality within a segment, then you may choose to establish additional sample locations at these points.

## *Quality Assurance/Quality Control (QA/QC)*

Advanced Long Term Monitoring – Non-Wadeable Waters requires rigorous internal (samples collected and analyzed by project field volunteers, staff and lab - see p. A4-2) and external (samples collected and analyzed by non-volunteer field staff and "quality control" lab - see p. A4-3) QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Appendix 4 (on page A4-4).

Also, applicable in Appendix 4 is information on specific internal and external quality controls and how they are assessed.

Periodic field and lab audits by qualified service providers are recommended. During these audits, the operation of sampling and analytical procedures is observed. 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 and benthic macroinvertebrate sample collection and visual survey techniques by the group or agency that uses and supports the method. 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[28], 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. 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.

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

## E. Advanced Groundwater Basin Assessment

### *What Is It?*

An Advanced Groundwater Basin Assessment is the collection and evaluation of information to determine the groundwater quality of a basin. (Here, "basin" is used as the groundwater equivalent to "watershed.") In addition, the assessment may look at the groundwater's discharge to surface water in the watershed. The basin assessment may also measure the impact of nonpoint source pollution on groundwater quality and on the surface water quality in the watershed. Thus, the main activities of the assessment can include the following:

- Water sampling and analysis for chemical indicators of ambient groundwater quality, including the monitoring of groundwater quality over time;
- Inventory of nonpoint source pollution sources;
- Estimates or measures of groundwater contribution to streamflow;
- Determination of the effects of nonpoint source pollution on the quality of regional aquifers and baseflow of streams and rivers; and
- Consideration of changing land use and practices over time, and its effect on groundwater and surface water quality of the watershed.

Monitoring points are chosen that will be typical of groundwater quality in the watershed. These are typically wells and springs with specific geological and land use characteristics. The water sampled is part of the main water cycle of the watershed. Approximations of groundwater quality also can be made at low flow levels on the stream. Results downstream are compared with those upstream to determine the extent of the impact attributable to nonpoint source pollution.

### *Why Do It?*

The volume of groundwater in the United States at any given moment is 20 to 30 times the volume of water in all of the lakes, streams and rivers. Groundwater contributes a major portion of the instream flow of surface streams and rivers. In times of drought, groundwater flow provides nearly all of the sustaining baseflow to streams and rivers. High quality groundwater is essential to the many industrial, agricultural and domestic users. Groundwater is extremely important in Pennsylvania. At least 21 percent of Pennsylvanians depend on self-supplied groundwater as their main supply of water for domestic needs. When community and non-community water systems are included in a tally of groundwater users, the percentage of Pennsylvanians that use groundwater is nearly 50 percent.

We suggest that you undertake an Advanced Groundwater Basin Assessment if your primary interest is the understanding of groundwater's effect on the overall water quality of the watershed and of the nonpoint source nature of groundwater contamination. Groundwater as baseflow greatly influences the ecological health and water quality of your stream, and therefore is important in the surface water quality of the watershed.

### *Primary Purposes Addressed*

☑ Community Education and Awareness

☑ Baseline Data Collection

☑ Community and/or Watershed Level Assessment

☑ State and Federal Agency Assessment

### *Questions Addressed*

- ☐ Is the water meeting or exceeding state Water Quality Standards?
- ☑ Are aquifers in the area meeting or exceeding state Public Drinking Water Standards?
- ☑ Where are the impaired waters that should be a high priority for restoration? What is causing these impairments?
- ☑ What is the contribution of groundwater to the surface water quality?
- ☑ What are the present conditions, and how do they change over time?
- ☑ What is the impact of various types of land and water use activities on groundwater and baseflow conditions and human uses (e.g. various types of point and nonpoint source pollution)?
- ☑ How effective are various strategies (e.g. wastewater treatment, best management practices, etc.) in protecting and restoring groundwater integrity?
- ☑ Where are the special places with specific groundwater value (baseflow, public and private drinking water, industrial use, etc.) that should be protected?

### *Monitoring Options*

The Advanced Groundwater Basin Assessment involves collecting and analyzing water samples for indicators of point and nonpoint source pollution and comparing groundwater quality data with stream quality data. Note that the indicators and methods listed here are appropriate for wells and springs that intercept or contribute flow to the stream.

Following is a menu of monitoring options from which to select indicators and methods appropriate for groundwater and its relationship to the overall watershed quality, within your available human and financial resources. The table focuses on indicators of nonpoint pollution source.

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Pollution Source Inventory**<br>Point and Nonpoint Sources | Maps showing land cover and land use, agricultural areas, sewered areas, known point sources of contamination, facilities that are often associated with contamination, population distribution, etc.<br>GIS coverages;<br>Visual surveys |
| *Water Sampling and Analysis* | |
| • **Estimates of groundwater contribution to surface water** | Estimates can be made from stream-hydrograph separation, various models or other methods |
| • **Fecal colif./E. coli Bacteria** | Membrane filtration w/ MTEC with and without confirmation, EPA # 1 103.1 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<br>2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters, EPA Method 150.1 or equivalent |
| • **Temperature** | Direct measurement with a thermometer, thermocouple or thermistor |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Turbidity** | Sample collected and measured with a nephelometer, RN adaptation of Standard Methods #2130; EPA Method 180.1 (laboratory |
| • **Conductivity** | Direct measurement with a meter, EPA Volunteer Methods manual |
| • **Total Phosphorus** | Persulfate digestion followed by ascorbic acid method and colorimetry, EPA Method 365.3 or equivalent |
| • **Nitrogen**<br>**- Nitrite**<br>**- Nitrate**<br>**- Ammonia** | <br>EPA Method 354.1<br>EPA Method 353.2<br>EPA Method 351.2 |
| • **Total Filterable Residue (dissolved solids)** | Dried at 105° C. |
| • **Total Alkalinity** | Double end point sulfuric acid titration w/ digital titrator and pH meter (R" manual); or EPA Method 310.1 |
| • **Total Hardness ($CaCO_3$)** | Computed from results of calcium and magnesium or titrated, SM #3500Ca, EPA 130..2 or equivalent |
| • **Calcium (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Magnesium (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Sodium (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Potassium (for sampling only)** | Potassium (AA, Direct Aspiration), EPA Method 258.1 |
| • **Chloride** | Chloride (Colorimetric, Automated Ferricyanide using Autoanalyzer II), EPA Method 325.2 |
| • **Sulfate (for sampling only, if method 2 is used)** | 1. Turbidimetric: Sulfate ion is converted to a suspension. The resulting turbidity is determined by a nephelometer, and compared to a curve prepared from standard sulfate solutions, EPA #375.4<br>2. Colorimetric, Automated, Methylthymol Blue, using an Autoanalyzer II, EPA #375.2 |
| • **Silica** | EPA Method 3111.0 |
| • **Arsenic** | EPA Method 206.2 |
| • **Barium** | EPA Method 200.7 |
| • **Cadmium** | EPA Method 200.7 |

| Menu of Indicators/Tools | Examples of Methods (Source) |
|---|---|
| • **Chromium** | EPA Method 200.7 |
| • **Copper** | EPA Method 200.7 |
| • **Iron (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Lead** | EPA Method 239.2 |
| • **Manganese (for sampling only)** | *Sampling:* 500 mL pre-cleaned plastic bottle, iced to 4°C<br>*Analysis:* Inductively Coupled Plasma Atomic Emission Spectrometric Method, EPA #200.7 |
| • **Zinc** | EPA Method 200.7 |

The following table suggests indicators that are appropriate for the different pollution types:

| Indicator/Tool | Animal Manure; Spray Irrigation | Landfills | Mining | Urban Runoff |
|---|---|---|---|---|
| **Pollution Source Inventory** | √ | √ | √ | √ |
| **Fecal colif./*E. coli* Bacteria** | √ | | | √ |
| **Total Phosphorus** | √ | | | √ |
| **Nitrates** | √ | √ | | √ |
| **Ammonia** | √ | √ | | √ |
| **Turbidity** | √ | √ | √ | √ |
| **Dissolved Oxygen** | √ | | | √ |
| **Temperature** | √ | | | √ |
| **PH** | √ | √ | √ | √ |
| **Total Alkalinity** | | | √ | √ |
| **Conductivity** | √ | √ | √ | √ |
| **Sodium** | √ | | | √ |
| **Chloride** | √ | √ | | √ |
| **Iron** | √ | | √ | |
| **Manganese** | | | √ | |
| **Aluminum** | | | √ | |
| **Sulfate** | √ | | √ | |
| **Total Dissolved Solids** | √ | | √ | |
| **Total Hardness** | √ | | √ | √ |
| **Total Organic Carbon** | √ | √ | | |

Note that other parameters such as volatile organic compounds (VOC) and synthetic organic compounds (SOC) such as pesticides are indicators of contamination, but are also very expensive to analyze. We recommend that the contamination survey be used to screen for potential contamination before adding these constituents to your sampling list. Pesticide use surveys and contamination source inventories can establish the magnitude of their threat to the watershed.

### *Design Procedures for Groundwater Monitoring*

The design of the groundwater monitoring effort will depend on the goals of the monitoring. The first step is to determine the basin or watershed of interest. The boundaries of the area can be refined by using 7.5-minute quadrangle maps. The exact boundaries can be drawn on the topographic quadrangles. The boundaries on the maps will typically follow topographic divides. The drawing of the basin boundaries is a judgmental process based upon the contour lines.

After the basin boundaries have been drawn at the 7.5-minute quadrangle scale, you may need to define smaller wedges of groundwater flow. These wedges can be used to determine where sampling locations will eventually be selected. The delineation of these wedges should be based on topography, and similar features such as geology and land use. The use of groundwater in a wedge such as for public water supplies should be considered.

### *Selection of Groundwater Monitoring Sites*

The selection of monitoring points will vary based on the goals of the study. The most fundamental factor of selection is that the water sampled is compatible with the study objectives. Not only should you consider the spatial distribution (map view) of monitoring points, but also the vertical aspect of the aquifer. For example, the quality of groundwater in a deep well may be irrelevant to the shallow groundwater flow that feeds the local streams. The sampling point should serve to represent the groundwater quality conditions for the targeted area. Therefore, this monitoring point should be carefully chosen. The monitoring point should reflect the dominant land use and geology of the area surrounding the well. For example, if the main goal is to sample groundwater from carbonate rocks in an agricultural area, then the monitoring point should be located with those criteria in mind. Consideration should be given to flow paths, well depths and other factors that may influence groundwater quality.

Sampling points may include domestic wells, public water supply wells or upgradient facility wells. The following criteria should be considered when selecting these types of monitoring points.

- Select wells that are actively used.
- Choose wells that are properly constructed (with no visible damage to the casing) with the casing anchored and grouted into bedrock, and properly capped.
- Select wells that have a means to circumvent any pressure tank, water softener or filtering system (or any type of treatment system) so that raw water can be sampled.
- Avoid monitoring points that may have contamination from obvious nearby point sources such as waste disposal sites, petroleum and mining activities, direct road salt or agricultural runoff.
- Use wells that have detailed construction information. At a minimum, well data should include type of construction, size and length of casing, total depth, grouting information, yield, water bearing zones and static water levels, when possible.

It is preferable to choose wells that are in frequent use. This will reduce sampling time and security problems, and avoid the common sampling problems (such as water stagnation) of idle wells. Recently constructed homes or offices that use groundwater as a drinking source are good candidates for sampling. Also, wells with long screen lengths or long open rock intervals should be avoided because they tend to obscure distinct groundwater zones.

Springs and direct groundwater flow contribute large quantities (as much as 100 percent) to the baseflow of streams in Pennsylvania, and discharge to wetlands, lakes and ponds. Because domestic wells may not be available in urban areas, site selection of monitoring points may include springs and suitable surface water points (where wells and springs cannot be found). The following criteria should be considered when selecting such monitoring points:

- Flow from the spring or in the stream should be year-round and have a good rate of flow.  Springs at geological formation contacts or seeps from perched water conditions should be avoided.
- Monitoring points should be dispersed as much as possible to conform to the delineation of wedges to provide coverage of any data gaps.
- Sites should be avoided that may have contamination from a nearby, upgradient facility.
- Conditions should produce water that is representative of the wedge.  Care should be taken to avoid conditions where flow is contributed by excessive discharge from bank storage or infiltration from local recharge, unless that is the goal of the assessment.

### *Additional Site Location Considerations*

- Compare with watershed reference sites and stream impact assessment sites.
- Where possible, use or compare with sites historically monitored by DEP.
- Choose sites that are representative of the targeted groundwater.
- Select sites that are safely accessible.

### *Map and Field Survey*

After the potential monitoring points have been selected, a map and field survey is performed of all the sites (this can be done during the first sampling phase).  The survey group should investigate the 1) geology of the area; 2) surface water and groundwater flow systems; 3) location of the monitoring points with respect to potential sources of pollution; and 4) any other important data.

### *Geology*

Available information on the geology of a basin should be reviewed to determine the areal extent and thickness of the various deposits.  For example, shallow surficial deposits can affect the quality of underlying aquifers.  Information on the geology of an area can be obtained from a site investigation, USGS, Department of Conservation and Natural Resources (Bureau of Topographic and Geologic Survey), soil surveys, geologic reports and other sources. This information will aid in the determination of bedrock types, geologic structure and fracture systems, which may influence groundwater flow and quality.

### *Groundwater and Surface Water Flow Systems*

Groundwater and surface water drainage should be reviewed to determine patterns of flow and to identify regional, intermediate and local flow systems.  Surface water drainage patterns are easily identified using topographic maps.  These drainage patterns can be used to determine the location of potential surface monitoring points.  Such monitoring points may be sampled during times when surface water flow is low and entirely attributable to groundwater discharge.

The designer of the sampling program should consider how the groundwater drainage patterns could impact the watershed.  For example, areas of rapid recharge are typically characterized by a shallow water table with low dissolved solids.  Areas of discharge may have a shallow water table; however, they typically have higher dissolved solids.  Areas in between these flow systems may be quite variable.

Groundwater flow paths in karst areas (where carbonate rocks such as limestone have dissolved along fractures and bedding planes to create complicated underground drainage patterns) are notoriously difficult to recognize.  The locations of springs (especially in these rocks) can be a critical task for understanding groundwater flow.  In some areas, tracers that are injected into the groundwater must be used to find out where groundwater emerges. In well-developed karst areas, a few springs can drain most of the groundwater over a large area.

### *Potential Sources of Pollution*

Unless specific monitoring goals have been defined, the monitoring is meant to define the background groundwater quality for a basin. Care must be taken to avoid sampling points that are influenced by individual sources of pollution in the immediate area. Knowing the location of potential sources of pollution will aid in the selection of monitoring points. Local land use can be an effective indicator of contamination potential. Industrial sites, waste disposal sites, septic systems, salt piles, waste storage impoundments and active mining operations should be considered for the bias that they may introduce**.** However, it is desirable to include groundwater that possibly has been affected by human activities on a regional scale, and is therefore representative of the area.

### *Sampling Wells*

Care must be taken so that raw water is sampled. Private water supplies should be sampled as close to the well as physically practical and prior to any treatment or filtering devices if possible and practical. If collection has to be made from a holding tank, allow water to flow long enough to flush the tank and the lines. If a sample that passes through a treatment tank must be taken, the type, size and purpose of the unit should be noted on the sample data sheet and in the field logbook.

When taking samples from a domestic well, the tap should be opened to allow the water to run for approximately five minutes. This will remove any water that may have been standing in the pipes and allow a fresh sample to be obtained from the well.

After a well has been prepared for sampling, a sample can be collected for analysis. Samples for analysis of the DEP 056 SAC are collected in three 500 mL Plastic (HDPE) plastic bottles. One bottle is analyzed for metals and must be "fixed" by adding five milliliters of 1:1 $HNO_3$ (nitric acid) to adjust the pH to less than 2.0. Water analyzed for ammonia nitrogen, total organic carbon and phosphorus must be fixed by adding five milliliters of 10 percent $H_2SO_4$ to adjust pH to less than 2 with sulfuric acid. The other bottle will be analyzed for other 056 basic inorganic analytes. All samples must be placed on ice and sent to the laboratory for analysis along with the appropriate laboratory forms. If other types of analyses are desired, the laboratory procedures for those analytes should be followed.

### *How Frequently and When Should You Carry Out Sampling?*

Once the design of the basin is done and the monitoring locations have been selected, the sampling can be conducted. Two samples are typically collected per year although monitoring can be done quarterly and possibly monthly. At a minimum, the sampling should attempt to cover seasonal low and high groundwater conditions. Although this will not always be possible because of weather variation, one sample should be taken during low conditions typically July through November. The other sample should occur during high conditions, typically March through June. Sampling under these conditions should provide the widest possible range of analyte concentrations due to seasonal differences. You may wish to sample more frequently, perhaps quarterly (seasonally).

There may be special circumstances where you may wish to sample more frequently than quarterly. For example, if your main concern is flow into sinkholes from agricultural land, you may wish to conduct your field surveys during the seasonal changes or immediately after a period of heavy rain to get a sense of how the parameters you are assessing change in response to precipitation events. See the Nonpoint Source Impact Assessment for further information on monitoring runoff events for surface water.

### *Short Term or Long Term Monitoring?*

Short term monitoring should be done for areas where basic groundwater quality information is needed to gauge a watershed, or where there is little ongoing change to land use or water resources. Additional monitoring can be done later if necessary. Long term monitoring (years) should be planned where long term data will be necessary to understand trends in the watershed. Once started, long term monitoring should be maintained for at least five years (two samples a year would give 10 samples at a minimum) for a proper trend analysis to be performed. Even longer term data collection (10 years or 20 samples) is preferred. Areas selected for long term monitoring will typically be areas where regional changes such as rapid urbanization or other modifications in land use are occurring, or where specific water quality concerns need to be monitored.

### *Data Reporting Requirements*

Although there are no specific data reporting requirements, data collection efforts should be reported to DEP. Reporting of progress and results will allow information to be disseminated to interested parties. In addition, information may have been collected previously in a watershed that could supplement volunteer efforts. Information that should be reported includes monitoring locations, well or spring information and data results including date sampled, data qualifiers and any other pertinent information.

### *Quality Assurance/Quality Control (QA/QC)*

An Advanced Groundwater Basin Assessment requires thorough internal and external QA/QC. Specific quality control measures for each indicator are listed in Table 1 in Appendix 4 (on page A4-4). Appendix 4 also includes information on specific internal and external quality controls and how they are assessed.

Periodic field and lab audits by qualified service providers are recommended. During these audits, the operation of sampling and analytical procedures is observed. 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.

We recommend that the EPA minimum set of data elements are followed for establishing the monitoring point locations. These elements include latitude and longitude (and how obtained); descriptions of the wells including its use, depth, screen or open interval; depth to water; and sample descriptions including QA/QC procedures, parameter measured, concentration or value and any qualifying information about the results or sample.

### *Training Required*

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

*Data Analysis:* The analysis of the data can be complex. In addition, the practice of geology is licensed in Pennsylvania. A licensed geologist with experience in analyzing groundwater data (hydrogeologist) should be sought. It may be helpful to have a hydrogeologist review groundwater sampling locations along with delineated groundwater basin boundaries.

*Lab Analysis:* For personnel in the program lab,[29] proper training is essential. There should be a designated lab coordinator responsible for seeing that all analysts are properly trained. Initially, the

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

lab coordinator and a core group of analysts should be trained in proper water analysis techniques. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official designation by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

### *Relevant Information*

Geology and groundwater quality information:

Department of Conversation and Natural Resources, Bureau of Topographic and Geologic Survey
http://www.dcnr.state.pa.us/topogeo/indexbig.htm
P.O. Box 8453, Harrisburg, PA 17105-8453

DEP monitoring documents can be found at:
http://www.dep.state.pa.us/dep/deputate/watermgt/watermgt.htm Choose Technical Guidances, Bureau of Watershed Management, P.O. Box 8467, Harrisburg, Pa. 17105

| | |
|---|---|
| 383-3000-001 | Groundwater Monitoring Guidance Manual |
| 383-3200-009 | Pennsylvania's Groundwater Quality Monitoring Network Ambient and Fixed Station Network (FSN) Monitoring Programs |
| 383-3200-016 | Quality Assurance Work Plan for Groundwater Quality Monitoring Stations |

U. S. Geological Survey See http://pa.water.usgs.gov/

U. S. Environmental Protection Agency, Definitions for the Minimum Set of Data Elements for Groundwater Quality, EPA 813/B-92-002, July 1992.
http://www.epa.gov/OGWDW/