2.2
Designing the Stream Study

Training Volunteer Monitors

Before beginning a stream monitoring study, volunteer program officials should develop a design or plan that answers the 10 basic questions listed below. Without answers to these questions, the monitoring program might well end up collecting data that do not meet anyone's needs.

Answering these 10 questions is not easy. A planning committee composed of the program coordinator, key volunteers, scientific advisors, program supporters, and data users should resolve these questions well before the project gets under way. Naturally, the committee should also address other planning questions less directly related to monitoring design, such as how to recruit volunteers and how to secure funding for the project. Answers will likely change as the program matures. For example, program coordinators might find that a method is not producing data of high enough quality, data collection is too labor-intensive or expensive, or additional parameters need to be monitored.

1. Why is the monitoring taking place?

Typical reasons for initiating a volunteer monitoring project include:

- Developing baseline characterization data
- Documenting water quality changes over time
- Screening for potential water quality problems
- Determining whether waters are safe for swimming
- Providing a scientific basis for making decisions on the management of a stream or watershed
- Determining the impact of a municipal sewage treatment facility, industrial facility, or land use activity such as forestry or farming
- Educating the local community or stream users to encourage pollution prevention and environmental stewardship
- Showing public officials that local citizens care about the condition and management of their water resources

Of course, an individual program might be monitoring for a number of reasons. However, it is important to identify one or two top reasons and develop the program based on those objectives.

2. Who will use the monitoring data?

Knowing your data users is essential to the program development process. Potential data users might include:

- State, county, or local water quality analysts
- The volunteers themselves
- Fisheries biologists
- Universities
- Schoolteachers
- Environmental organizations
- Parks and recreation staff
- Local planning and zoning agencies
- State environmental agencies
- State and local health departments
- Soil and water conservation districts
- Federal agencies such as the U.S. Geological Survey or U.S. Environmental Protection Agency

Each of these users will have different data requirements. Some users, such as government analysts and planning/zoning agencies, will have more stringent requirements than others and will require higher levels of quality assurance. As the volunteer monitoring project is being designed, program coordinators should contact as many potential information users as possible to determine their data needs. It is important to have at least one user committed to receiving and using the data. In some cases that user might be the monitoring group itself.

3. How will the data be used?

The range of uses of volunteer data is limited only by the imagination. Volunteer data could be used, for example, to influence local planning decisions about where to site a sewage treatment facility or to publicize a water quality problem and seek community solutions. Collected data could also be used to educate primary school children about the importance of water resources. Other data uses include the support of:

- Local zoning requirements
- A stream protection study
- State preparation of water quality assessments
- Screening waters for potential problems
- The setting of statewide priorities for pollution control

Each data use potentially has different data requirements. Knowing the ultimate uses of the collected volunteer data will help determine the right kind of data to collect and the level of effort required to collect, analyze, store, and report them.

Table 2.1

Some types of monitoring approaches and their application

Type	Approach	Applications*
Physical Condition	Watershed survey	Determine land use patterns; determine presence of current and historical pollution sources; identify gross pollution problems; identify water uses, users, diversions, and stream obstructions
	Habitat assessment	Determine and isolate impacts of pollution sources, particularly land use activities; interpret biological data; screen for impairments
Biological condition	Macroinvertebrate sampling	Screen for impairment; identify impacts of pollution and pollution control activities; determine the severity of the pollution problem and rank stream sites; identify water quality trends; determine support of designated aquatic life uses.
Chemical condition	Water quality sampling	Screen for impairment; identify specific pollutants of concern; identify water quality trends; determine support of designated contact recreation uses; identify potential pollution sources
* Beyond education and promoting stewardship		

4. What parameters or conditions will be monitored?

Determining what to monitor will depend on the needs of the data users, the intended use of the data, and the resources of the volunteer program. If the program's goal is to determine whether a creek is suitable for swimming, for example, a human-healthrelated parameter such as fecal coliform bacteria should be monitored. If the objective is to characterize the ability of a stream to support sport fish, volunteers should examine stream habitat characteristics, the aquatic insect community, and water quality parameters such as dissolved oxygen and temperature. Alternatively, if a program seeks to provide baseline data useful to state water quality or natural resource agencies, program designers should consult those agencies to determine which parameters they consider of greatest value.

Money for test kits or meters, available laboratory facilities, help from state or university advisors, and the abilities and desires of volunteers will also clearly have an impact on the choice of parameters to be monitored. For characterization studies, EPA usually recommends an approach that integrates physical, chemical, and biological parameters.

5. How good does the monitoring data need to be?

Some uses require high-quality data. For example, high-quality data are usually needed to prove compliance with environmental regulations, assess pollution impacts, or make land use planning decisions. In other cases the quality of the data is secondary to the actual process of collecting it. This is often the case for monitoring programs that focus on the overall educational aspects of stream monitoring.

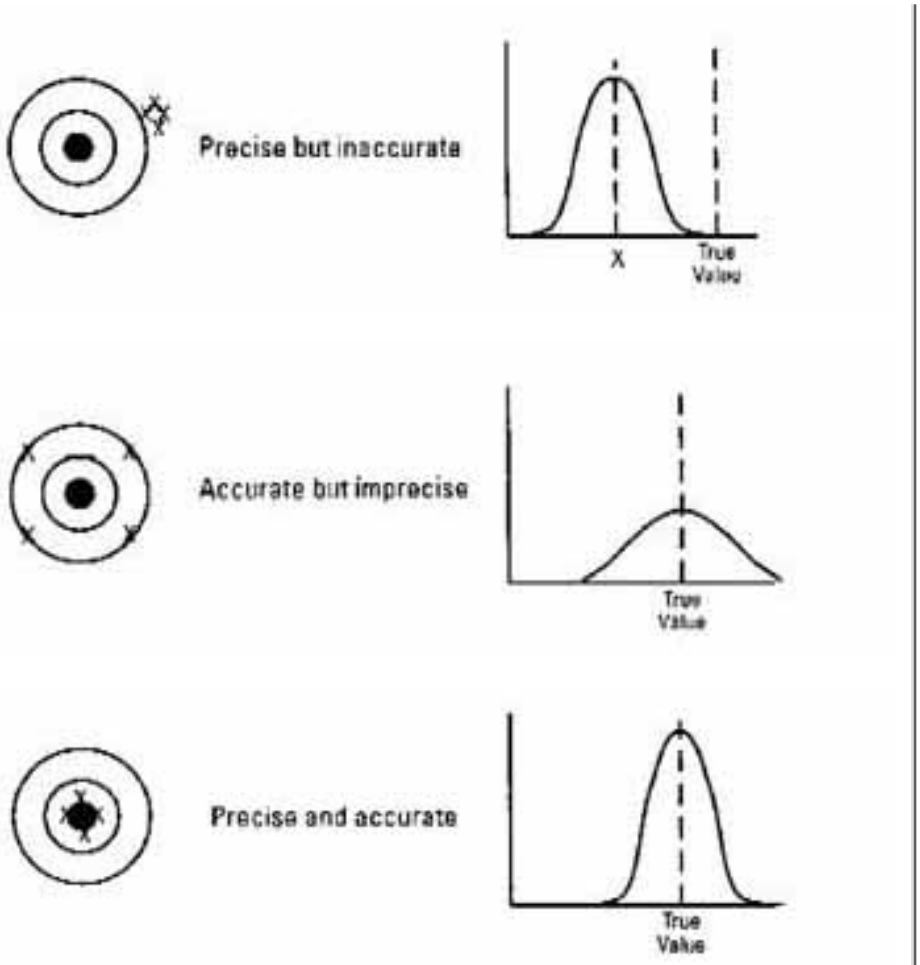
Data quality is measured in five ways accuracy, precision, completeness, representativeness, and comparability (see box Data Quality Terms).

Data Quality Terms

- ***Accuracy*** is the degree of agreement between the sampling result and the true value of the parameter or condition being measured. Accuracy is most affected by the equipment and the procedure used to measure the paramter.
- ***Precision,*** on the other hand, refers to how well you are able to reproduce the result on the same sample, regardless of accuracy. Human error in sampling techniques plays an important role in estimating precision.
- ***Representativeness*** is the degree to which collected data actually represent the stream condition being monitored. It is most affected by site location.
- ***Completeness*** is a

measure of the amount of valid data actually obtained vs. the amount expected to be obtained as a specified in the original sampling design. It is usually expressed as a percentage. For example, if 100 samples were scheduled but volunteers sampled only 90 times due to bad weather or broken equipment, the completeness record would be 90 percent.

- ***Comparability*** represents how well data from one stream or stream site can be compared to data from another. Most managers will compare sites as part of a statewide or regional report on the volunteer monitoring program; therefore, sampling methods should be the same from site to site.



6. What methods should be used?

The methods adopted by a volunteer program depend primarily on how the data will be used and what kind of data quality is needed. There are, of course, many sampling considerations including:

- How samples will be collected (e.g., using grab samples or measuring directly with a meter)
- What sampling equipment will be used (e.g., disposable Whirlpak bags, glass

bottles, 500-micron mesh size kick net, etc.)

- What equipment preparation methods are necessary (such as container sterilization or meter calibration)
- What protocols will be followed (such as the Winkler method for dissolved oxygen, intensive stream bioassessment approach for habitat and benthic macroinvertebrates, etc.)

Analytical questions must also be addressed such as:

- Will volunteers return to a lab for macroinvertebrate identification or dissolved oxygen titration procedures or conduct them in the field?
- Will a color wheel provide nitrate data of needed quality, or is a more sophisticated approach needed?
- Should visual observation and habitat assessment approaches be combined with turbidity measures to best determine the impact of construction sites? While sophisticated methods usually yield more accurate and precise data (if properly carried out), they are also more costly and timeconsuming. This extra effort and expense might be worthwhile if the goal of the program is to produce high-quality data. Programs with an educational focus, however, can often use less sensitive equipment and less sophisticated methods to meet their goals.

7. Where are the monitoring sites?

Sites might be chosen for any number of reasons such as accessibility, proximity to volunteers' homes, value to potential users such as state agencies, or location in problem areas. If the volunteer program is providing baseline data to characterize a stream or screen for problems, it might wish to monitor a number of sites representing a range of conditions in the stream watershed (e.g., an upstream "pristine" area, above and below towns and cities, in agricultural areas and parks, etc.). For more specific purposes, such as determining whether a stream is safe to swim in, it might only be necessary to sample selected swimming areas. To determine whether a particular land use activity or potential source of pollution is, in fact, having an impact, it might be best to monitor upstream and downstream of the area where the source is suspected. To determine the effectiveness of runoff control measures, a paired watershed approach might be best (e.g., sampling two similar small watersheds, one with controls in place and one without controls).

A program manager might also select one or more sites near professionally monitored sites in order to compare the quality of volunteer-generated data against professional data. It might also be helpful to locate some sites near U.S. Geological Survey gauging stations, which can provide useful data on streamflow. Certainly, for any volunteer program, safety and accessibility (both legal and physical) will be important in determining site location. No matter how sampling sites are chosen, most monitoring programs will need to maintain the same sites over time and identify them clearly in their monitoring program design.

When selecting monitoring sites, ask the following questions. Based on the answers, you may need to eliminate some sites or select alternative locations that meet your criteria:

- Are other groups (local, state, federal agencies; other volunteer groups; schools or colleges) already monitoring this site?
- Can you identify the site on a map and on the ground?
- Is the site representative of the watershed?
- Does the site have water in it during the times of year that monitoring will take place?
- Is there safe, convenient access to the site (including adequate parking) and a way to safely sample a flowing section of the stream? Is there access all year long?
- Can you acquire landowner permission?
- Can you perform all the monitoring activities and tests that are planned at this site?
- Is the site far enough downstream of drains or tributaries? Is the site near tributary inflows, dams, bridges, or other structures that may affect the results?
- Have you selected enough sites for the study you want to do?

Once you have selected the monitoring sites, you should be able to identify them by latitude and longitude. This location information is critical if your data will potentially be used in Geographical Information Systems (GIS) or in sophisticated data management systems (See Appendix C).

8. When will monitoring occur?

A program should specify:

- What time of day is best for sampling. (Temperature and dissolved oxygen, for example, can fluctuate naturally as the sun rises and aquatic plants release oxygen.)
- What time of year is best for sampling. (For example, there is no point in sampling fecal coliform bacteria at swimming beaches in the winter, when no one is swimming, or sampling intermittent streams at the height of summer, when because of dry conditions the streams hold little water.)
- How frequently should monitoring take place? (It is possible, for example, to conduct too many biological assessments of a stream and thereby deplete the stream's aquatic community. A program designed to determine whether polluted runoff is a problem would do well to monitor after storms and heavy rainfalls.)

In general, monthly chemical sampling and twiceyearly biological sampling are considered adequate to identify water quality changes over time. Biological sampling should be conducted at the same time each year because natural variations in aquatic insect population and streamside vegetation occur as seasons change. Monitoring at the same time of day and at regular intervals (e.g., at 2:00 p.m. every 30 days) helps ensure comparability of data over time.

9. How will monitoring data be managed and presented?

The volunteer program coordinator should have a clear plan for dealing with the data collected each year. Field and lab data sheets should be checked for completeness, data should be screened for outliers, and a database should be developed or adapted to store and manipulate the data. The elements of such a database should be clearly explained in order to allow users to interpret the data accurately and with confidence.

Program coordinators will also have to decide how they want to present data results, not only to the general public and to specific data users, but also to the volunteers themselves. Different levels of analysis might be needed for different audiences. A volunteer group collecting data for state or county use should consult with the appropriate agency before investing in computerized data management software because the agency could have specific needs or recommendations based on its own data management protocols.

10. How will the program ensure that data are credible?

Developing specific answers to questions 19 is the first step in ensuring that data are credible. Credible data meet specific needs and can be used with confidence for those needs. Other steps include:

- Properly training, testing, and retraining volunteers
- Evaluating the program's success after an initial pilot stage and making any necessary adjustments
- Assigning specific quality assurance tasks to qualified individuals in the program
- Documenting in a written plan all the steps taken to sample, analyze, store, manage, and present data

A written plan, known as a quality assurance project plan, can be elaborate or simple depending on the volunteer program's goals. Its essential feature, however, is that it documents how the data are to be generated. Without such knowledge, the data cannot be used with confidence. It is also important for educating future volunteers and data users about the program and the data. People might be analyzing the data 5 or 10 or more years later to study trends in stream quality. (Note: EPA requires that any monitoring program sponsored by EPA through grants, contracts, or other formal agreement must carry out a quality assurance/quality control program and develop a quality assurance project plan.)

Put It in Writing

When you and the volunteer program planning committee have answered the ten project design questions to everyone's satisfaction, your next critical step is to put it all in writing. The written plan, including sampling and analytical methods, sites, parameters, project goals, and data quality considerations, is your bible. With a written plan you:

- Document the particulars of your program for your data users
- Educate newcomers to the program
- Ensure that newcomers will use the same methods as those who came before them
- Keep an historical record for future program leaders, volunteers, and data users

Your written plan may simply consist of a study design and standard

- operating procedures such as a monitoring and lab methods manual. You may, however, prefer to develop a more comprehensive quality assurance project plan. The quality assurance project plan is a document that outlines the procedures you will use to ensure high quality data when conducting sample collection and analysis in your program.

By law, any water quality monitoring program that receives EPA funding is required to have an EPA-approved quality assurance project plan. Even if you don't receive EPA funding, you will find that preparing a written plan helps ensure that your data are used with confidence, now and in the future. (See *The Volunteer Monitor's Guide to Quality Assurance Project Plans* (EPA 841-B-96-003 September 1996) for more information.)

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