Section 4:

Design your monitoring effort

This Section will show you how to:

- **Translate your monitoring purpose and objectives into a plan of action.**

Map out your monitoring journey

Probably the most critical step in developing a successful monitoring effort is designing a plan in advance. Designing your monitoring project up front will keep you from spending time and money unproductively.

You've already decided where you want to go (purposes and objectives). Now, with a design plan, you will document where you are starting from and what it will take to accomplish your goals.

Involve data users

A good reason for putting your monitoring plan down on paper is that you can have the plan reviewed by your primary data users. Determining who they are and involving them early in your process will ensure that the data you collect will be credible and usable. Ultimately, the primary data user is responsible for ensuring accuracy through review of QA/QC procedures.

Build your design

This guide provides general information to help you decide how to design a basic monitoring program for lakes, streams and wetlands. The guide does not include detailed step-by-step descriptions of field and laboratory methods, because there are many existing manuals that provide good descriptions. Some of these are listed in *Appendix C*; others are listed, when appropriate, in this Section.

Determining your monitoring purpose and your data quality needs are important first steps in developing a monitoring plan. In fact, a purpose statement and your data quality objectives should be documented in your plan. Learning how to develop a monitoring purpose is covered in *Section 2* and working with data quality is covered in detail in *Section 3*. Your plan should also give thought to managing the data you collect and converting this data to information. Managing data is discussed in *Section 5*, and converting data to information in *Section 6*. In *Section 6* you will find a series of questions to help assess whether data collected was influenced by natural conditions or the monitoring design. These questions should also be considered during design to help assure you are collecting representative data.

The basic principle behind the use of macroinvertebrates in monitoring is that some are more sensitive to disturbance than others. Therefore, if a site is dominated by a group of organisms that are tolerant of human disturbance and the less tolerant organisms are missing, an impairment is likely.

For example, stonefly nymphs are aquatic insects that are very sensitive to pollution that affects dissolved oxygen and cannot survive if a stream's dissolved oxygen falls below a certain level. If a biosurvey shows that no stoneflies are present in a stream that used to support them, a hypothesis might be that dissolved oxygen has fallen to a point that keeps stoneflies from reproducing, or the lack of dissolved oxygen has killed them outright.

The advantage of a macroinvertebrate biosurvey is that it tells us when the stream or wetland ecosystem is impaired, or "sick," due to pollution or habitat loss. It is not difficult to realize that a stream full of many kinds of crawling and swimming "critters" is healthier than one without much life. It is easier to assess community impairment when macroinvertebrate biosurveys are combined with information about other biological assemblages (such as fishes, algae or plants), and monitoring of physical and chemical information (such as habitat or dissolved oxygen). The two types of monitoring, physical/chemical and biological, provide complementary information. Characterizations of plants and wetland types are important supporting data for wetland macroinvertebrate biosurveys.

Macroinvertebrate data can be used to assess streams and wetlands at several levels. Invertebrates collected and identified by trained professionals can allow for the calculation of an Index of Biotic Integrity score, where you can compare the stream's or wetland's biological community to a regional "index" or reference for similar streams or wetlands to see how the stream compares. Biosurveys you conduct can serve as useful screening tools, which can be followed up with a more detailed biosurvey later if the screening indicates a potential problem. If you want to interpret which conditions and parameters are affecting the invertebrate community, you should also collect information on upstream land use, general chemistry, physical parameters and habitat conditions.

Biosurvey methods vary from relatively simple collection techniques (with family level keys and identification protocols) for education purposes, to more rigorous collection methods and sophisticated analytical techniques. You typically conduct biosurveys when you remove macroinvertebrates from the stream by disturbing the substrate (stream bed materials, plants, woody debris) that harbors the target organisms. You generally will use some form of net (kicknet, dipnets or surber samplers) to collect them as the current washes them downstream. Then, either count and identify the organisms along the stream or wetland (for screening purposes), or preserve them in alcohol and bring them back to the lab for identification and counting (for more detailed assessment). You can store properly preserved macroinvertebrates for several years prior to identification.

Flora (plants)

For wetland monitoring, it is particularly important to identify plants and plant communities. One of three characteristics that define a wetland is the presence of hydrophytic (water-loving) vegetation, which varies depending on the type of wetland. Similarly to the macroinvertebrate community, the wetland plant community can indicate degradation or impairment. For example, the absence of submerged plants in a wetland where they would be expected, the presence of exotic species, or dominance by a single species could indicate stresses or pollution problems.
Identify plant communities and species with simple methods such as noting the presence or absence of communities and species, or with more complex surveys that map out communities and species for the entire area or at representative plots/transects.

Biological monitoring

Macroinvertebrates

Macroinvertebrate monitoring methods range from visually surveying habitat conditions to collecting and identifying organisms in the field to bringing organisms back to the lab for more detailed identification. In general, you collect macroinvertebrates by wading into streams or wetlands and using nets to capture the organisms. The specific collection method depends on the objectives of the study and the habitat type being sampled. Dip nets are useful in sampling multiple habitats (rocks, woody debris, vegetation) from fast-flowing, rocky streams, slow-moving, muddy streams and wetlands, while surber samplers, or kick nets, are often used when sampling is directed specifically at shallow, rocky substrates in streams. You can also use artificial substrates (multi-plate, bag or screen-cage samplers) to collect invertebrates where conditions prevent efficient sampling by hand (e.g., due to depth of the stream or wetland), where adequate invertebrate habitat is lacking or when a consistent quantitative sample is desired.

Sample aquatic plants by identifying and counting the types of plants found in a particular sampling plot placed randomly in the vegetated area, or by identifying and counting the plants along a straight line of a fixed length (a transect) through the habitat. Another relatively simple measurement for lakes is to map out the areas where aquatic plants grow and the maximum depth (or distance from shore) of aquatic plant growth.

One question you will need to answer as you plan a biological monitoring program is the taxonomic level (genus, family, etc.) to which the organisms will be identified (or classified). This decision will depend on your skill in spotting differences between similar organisms, the amount of time you wish to spend on training and the purpose of your monitoring. For example, a relatively simple classification into major groups (orders) is sufficient for increasing awareness about what lives in a stream and acquiring a general understanding of the stream conditions. But you will find identification to the genus level (i.e., very detailed classification) is required for some regulatory uses of the data.

Sampling methods, including the equipment needed and the suggested level of classification, are detailed in the manuals available from the resources identified in *Appendices A* and *C*, and throughout this Section.

Resource-specific consideration (including when and where to monitor)

Lakes

Physical and chemical parameters most frequently measured for lakes include: nutrients (phosphorus and nitrogen), solids, Secchi transparency, alkalinity, chlorophyll-*a*, dissolved oxygen and temperature, and pH. Biological parameters can include aquatic plant communities and types of algae (microscopic plants) or zooplankton (microscopic animals) found in the lake.

In many natural lakes in Minnesota, it is sufficient to sample at one primary site, typically where the lake is the deepest. Lakes with complex basin morphologies (numerous bays) and reservoirs frequently need monitoring at multiple sites. Conduct surveys of aquatic plants along the shoreline, often in a series of paths or "transects" from the shore out towards the deep part of the lake to the point where rooted aquatic plants are no longer found.

Collect most lake parameters from the warm surface waters (epilimnion). Temperature and dissolved oxygen, however, are frequently taken as a depth profile (i.e., taken at 1-meter intervals from the surface to the bottom) and used to assess stratification and vertical mixing of the lake. In addition to surface samples of total phosphorus, it is often advisable to collect samples from the deeper, cooler waters (hypoliminion) during the summer. These measurements will help evaluate whether substantial amounts of phosphorus are being released by the sediments.

Rivers and streams

Do river/stream sampling at a point where the water is well mixed and is most likely to represent the water quality of the reach that is to be assessed. The goal is to get a sample that represents the overall characteristics of the stream at that site.

Physical and chemical parameters most frequently measured for streams and rivers include many of the same parameters described previously for lakes (i.e., nutrients, solids, dissolved oxygen and temperature, turbidity and pH), as well as flow and physical conditions such as habitat. You may also frequently measure biological parameters such as fecal coliform bacteria and macroinvertebrates for streams and rivers.

When monitoring for general chemical, physical or biological parameters, it is generally a good idea to monitor flow. Flow monitoring can involve qualitative observations of relative flow (i.e., high, medium/average, low), or actual measurements of the velocity of the water. Measuring flow accurately, however, can be fairly involved and, at high flow, a significant safety risk. We strongly encourage you to involve a professional for quantitative flow monitoring.

To be representative of the stream or rivers, complete your monitoring activities over a range of conditions. For general chemical parameters and physical parameters such as temperature, this means collecting samples to represent a range of flows and seasons. Biological communities are an indicator of longer-term conditions, so you may not need multiple samples within a single season or year to represent conditions at a specific location. You may want to complete surveys at the same location over time, say annually, to track long-term trends. However, for biosurveys, you need to recognize that different organisms are naturally found in different microhabitats, such as rocky areas, undercut banks, or on woody debris. So, take composite samples that represent different microhabitats, or the same location/habitat type to compare between locations or assess trends.

It is important to determine what your sampling goals are and to take the proper type of sample based upon the habitats available. If you want to collect a quantitative riffle sample, then the stream you are sampling should have riffle-run-pool morphology with ample flow characteristic of the habitats in which riffle-dwelling organisms are present. If you want a quantitative multihabitat sample, take a composite sample that represents different microhabitats present in the stream. You generally conduct stream monitoring during the "open water" season, roughly from March through November. Macroinvertebrate monitoring is conducted in spring, while a large portion of the macroinvertebrate community is mature and near emergence, or in the late summer or early fall during low-flow conditions, when the community is stressed and more susceptible to impairment.

Exhibit 4-4 provides guidance as to minimal and desirable stream and river sampling program designs for eutrophication monitoring.

Exhibit 4-5 provides this information for biological monitoring (both streams and wetlands). *Appendix D* provides sampling frequency and considerations for 303(d) and 305(b) assessments.