Part B — Integrated Monitoring Design for Comprehensive Assessment and Identification of Impaired Waters

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10. Selecting Metrics or Indicators of Water Quality Standards Attainment

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10. Selecting Metrics or Indicators of Water Quality Standards Attainment

This chapter provides recommendations for selection of water quality indicators to serve as measures of water quality standards (WQS) attainment status. These recommendations are based on the report of the Intergovernmental Task Force on Monitoring Water Quality (ITFM 1995). They serve as a starting point for states as they tailor selection of indicators according to their WQS and data quality objectives (DQOs). This chapter also presents considerations for identifying additional or supplemental indicators that could be included in followup or site-specific monitoring.

The first activity a state may undertake in designing a water quality monitoring framework is identifying the appropriate indicators and their endpoints for making attainment/impairment decisions. The state, territory, or authorized tribe's WQS drive this selection process. The state should have a mechanism for interpreting data on water quality indicators within the context of its standards, including designated uses, narrative or numeric criteria, and antidegradation policies. This mechanism may be referenced in the state, territory, or authorized tribe's approved WQS or alternatively in other implementing regulations or policies or procedures documents such as the continuous planning process or consolidated assessment and listing methodology. Other factors that influence a state's selection of indicators and are related to the sampling effort include the cost of collecting and analyzing samples, the variability of the indicator in the environment, the level of precision desired by decision makers, and the sampling frequency required to meet the DQOs (U.S. EPA 1991).

Indicators could include chemicals, biological indices, fish tissue action levels, risk assessment levels, and other measures used to assess attainment with WQS. The monitoring design framework recognizes that selection of indicators is part of an iterative process that also includes establishing appropriate monitoring sites or locations. Key elements of the state's assessment methodology are identification of core or first-tier indicators and a process for developing supplemental indicators.

Limited resources will affect actions and decisions for many water quality monitoring programs. Optimal use of resources may dictate, for example, that a state establish a tiered or staged approach in its monitoring design. This may involve an initial round of monitoring for a baseline set of indicators. A subsequent round(s) of targeted monitoring would follow for additional pollutants of concern.

10.1 What Indicators of Water Quality (e.g., physical, chemical, biological) Does the State Use as Baseline or Core Measures Statewide?

The objective in developing a baseline or core set of indicators for measuring attainment with WQS is not to limit monitoring programs to core indicators, but rather to identify a sound baseline for water quality assessment decisions. The core set of indicators includes physical, chemical, and biological measures of a waterbody. These indicators are appropriate measures of the ability of a waterbody to support its intended uses regardless of the degree of disturbance in the surrounding land use and watershed. Core indicators provide a scientifically valid foundation for consistent, practical, and cost-effective water quality assessments at the statewide level.

The Intergovernmental Task Force on Monitoring Water Quality (ITFM) identified potential indicators for describing water quality and presented rationales for their use in meeting water quality management objectives (ITFM 1995). Indicators included biological response and exposure, chemical response and exposure, physical habitat, and watershed-level stressors. The ITFM provided a general ranking of the indicators as high, medium, or low to describe the extent to which water resources support the uses designated under state WQS. The ITFM also stated that the appropriateness of an indicator for any given monitoring program would depend on the selection criteria, waterbody type, and management objectives.

Using the ITFM recommendations for water quality indicators as a starting point, Table 10-1 presents baseline or core indicators and supplemental indicators for water quality monitoring.

Core indicators are considered most important for measuring water quality for designated uses. Designated uses include aquatic life, recreation, public water supply, and fish and shellfish consumption. Core indicators could be used for initial water quality assessments and would be applied at both statewide and watershed scales. The core indicators should be supplemented with additional indicators based on the characteristics of the watershed, designated uses, and potential stressors (point and nonpoint sources) influencing the waterbody. Supplemental indicators might be used for followup monitoring to target the causes of water quality impairment or be included in the initial monitoring effort at a Statewide, watershed, or waterbody scale.

10.2 How Does the State Select Supplemental Indicators?

In addition to the core indicators listed in Table 11-1, supplemental indicators may be appropriate and should be included in the monitoring design framework as needed. This is particularly important for listing impaired waters needing total maximum daily loads (TMDLs) under section 303(d) of the Clean Water Act. Before a TMDL can be calculated, the pollutant or pollutants causing the impairment must be identified.

When selecting supplemental indicators, states should consider conditions that may cause or contribute to nonattainment of applicable WQS. For example, are there sources in the watershed that separately or collectively might contribute pollutants in amounts or combinations that could cause an exceedance of a water quality criterion, create toxic conditions, or accumulate in sediment or fish tissue? The following discussion presents basic considerations that may guide the process for determining the need for supplemental indicators for a monitoring design framework. Principal considerations include current and historical point sources, nonpoint sources, geology/hydrology, and land-use patterns. Other factors may include suspected pervasive pollutants such as those transported by atmospheric processes, or emerging pollutant concerns that the state might want to screen.

Table 10-1. Water quality indicators for general designated categories

Core and Supplemental Indicators				
	Aquatic Life & Wildlife	**Recreation**	**Drinking Water**	**Fish Consumption**
Baseline or Core Indicators **(Applied Statewide)**	*Condition of Biological Communities (EPA recommends the use of at least two assemblages) *Dissolved Oxygen *Temperature *Conductivity *pH *Habitat Assessment *Flow *Landscape conditions (*e.g.,* % cover of land uses) Additional indicators for lakes: *Eutrophic condition Additional indicators for wetlands: *Wetland hydrogeomorphic settings and functions	*Pathogen Indicators (*E.Coli*, enterococci) *Nuisance Plant Growth *Flow *Chlorophyll *Landscape conditions (*e.g.,* % cover of land uses) Additional indicators for lakes: *Secchi Additional indicators for wetlands: *Wetland hydrogeomorphic settings and functions	*Trace metals *Pathogens *Nitrates *Salinity *Sediments/TDS *Flow *Landscape conditions (*e.g.,* % cover of land uses)	*Pathogens *Mercury *Chlordane *DDT *PCBs *Landscape conditions (*e.g.,* % cover of land uses)
Potential Supplemental Indicators **(Applied at the watershed scale)**	*Toxicity *Nutrients *Hazardous chemicals in water column or sediment *Health of organisms	*Nutrients *Hazardous chemicals *Aesthetics	*VOCs (in reservoirs) *Hydrophyllic pesticides *Nutrients *Hazardous chemicals *Algae	*Other hazardous bioaccumulative chemicals

10.2.1 Point Sources in the Watershed

Point sources in the watershed may contribute pollutants that cause or contribute to nonattainment of WQS. Information about the type of facility and nature of discharges (e.g., process water or stormwater) contributes to an understanding of potential pollutants. Information about discharge characteristics should be available through permit applications and discharge monitoring reports. Many permittees are required to submit the results of a complete priority pollutant scan with their initial permit application and subsequent renewals. The permittee's file should also include compliance history information and wasteload allocation data and analyses. It is important to consider the potential cumulative impacts to a waterbody resulting from multiple sources of pollutants. Unless a TMDL has been completed for the waterbody, it is common for individual permits to be issued without consideration of other sources of regulated pollutants.

Point sources may have existed historically but may no longer be active. Historical sources may have contributed pollutants or contaminants to the environment that are still tied up within bed sediments in the waterbody or in soils at the site.

10.2.2 Nonpoint Sources in the Watershed

Nonpoint sources generally are related to land-use practices. Land use (e.g., rural, agricultural, urban, industrial) often dictates what indicators may be most suitable for water quality monitoring. Current and historic land-use practices in the watershed should be identified. Information about agricultural and animal husbandry practices, pesticide usage, urban/impervious surfaces, land management practices (e.g., forestry, mining), and best management practice (BMP) that would mitigate pollutant impacts should be reviewed. Past land-use practices may be very different from current practices, and residual pollutants may be present in the bed sediments in the water or in soils at the site. A discussion of pollutants associated with different land-use types and sources is presented in the third edition of Guidance for Assessing Chemical Contaminant Data for Use In Fish Advisories (U.S. EPA 1998) (see http://www.epa.gov/ost/fish) and in the ITFM Technical Appendix L, Ground Water Quality Monitoring Framework (ITFM 1997). Table 4-3 of the Guidance (U.S. EPA 1998) lists chemical contaminants by watershed type that bioaccumulate in fish tissue.

10.2.3 Geology and Hydrology

Geologic and hydrologic processes within and upstream from a watershed generally establish water quality conditions within the watershed. In some cases, weathering and transport processes for certain geologic areas may result in increased concentrations of metals, particularly arsenic, cadmium, mercury, and selenium. Increased concentrations may be found both in the water column and in underlying sediments (U.S. EPA 1998). Disturbances from land-use practices may aggravate already marginal natural water quality conditions.

10.3 How Do Core and Supplemental Indicators Fit Into the Monitoring Design?

Use of core and supplemental indicators may be integrated into a monitoring design framework in several ways. To illustrate the use of these indicators within a monitoring design framework, two simple frameworks are presented: staged monitoring and integrated monitoring. Chapter 11 provides a more detailed discussion of monitoring design frameworks and their advantages and disadvantages.

10.3.1 Staged Implementation of Core and Supplemental Indicators

An initial round of monitoring is conducted. Samples are collected for core indicators as appropriate for the WQS assigned to the waters from which the samples come. This round of monitoring is intended to assess the attainment/impairment status of waters represented by the sampling design. If a broad-scale, probability-based design is used for the assessment, then data collected during the initial round of monitoring are representative of all waters within the population from which samples were selected. These data provide a representation of the properties of waters that attain WQS or criteria as well as of those waters that are impaired. If a finer scale, targeted design is used, then these data represent the properties of the specific waterbodies or segments of waterbodies sampled and tested.

A second round of monitoring focuses on waters identified as impaired or having the potential to be impaired (based on analysis of ancillary data collected to help identify attributes of impaired waters). This round is focused on specific waters or waterbodies, so supplemental indicators are selected based on consideration of watershed characteristics and applicable WQS. During the second round of monitoring, these supplemental indicators are monitored at the sampling sites in addition to the core indicators. Further rounds of monitoring using supplemental and core indicators may be conducted, as appropriate, to better identify/delimit impaired waters, specific problems, and potential stressors or sources.

10.3.2 Integrated Implementation of Core and Supplemental Indicators

When the sampling framework is developed (statewide, watershed-specific, or waterbody segment-limited), appropriate core and supplemental indicators should be identified and included in the monitoring design. A monitoring design should include the core indicators appropriate for the designated uses and supplemental indicators based on consideration of watershed characteristics influencing each sampling location. Monitoring is conducted of all sampling stations specified in the monitoring design. Data from the monitoring may be used to assess the attainment/impairment status of waters represented by the sampling design. In some cases, analysis of samples for supplemental indicators may be delayed pending the results of first-tier indicator analysis. This may save money by reducing analytical costs associated with samples collected from waters where first-tier indicators show that water is attaining WQS.

10.4 References

Intergovernmental Task Force on Monitoring Water Quality (ITFM). 1995. The strategy for improving water-quality monitoring in the United States Technical appendix D: Indicators for meeting management objectives–summary and rationale matrices.

ITFM. 1995. The strategy for improving water-quality monitoring in the United States Technical appendix L: Ground water quality monitoring framework.

U.S. Environmental Protection Agency (U.S. EPA). 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska EPA Region 10. EPA/910/9-91-001.

U.S. EPA. 1998. Guidance for assessing chemical contaminant data for use in fish advisories (see http://www.epa.gov/ost/fish).