

Information Strategies Work Group  
**National Water Quality Monitoring Council**  
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## **Water Quality Monitoring ‘*Design Guidance*’ and Application Inventory**

The National Water Quality Monitoring Council provides a forum to enhance the consistency and comparability of water quality data and information used to support management decision-making. The acquisition of water quality data, and its conversion into information, requires a number of activities employing a wide range of methods and procedures (Peters and Ward, 2003).

Identification of information goals and selection of methods and procedures, as is widely known, can influence the information obtained as well as its scientific soundness. Thus, agencies which must use water quality data and information in meeting their statutory responsibilities often provide ‘design guidance’ to insure consistency and comparability in water quality monitoring programs under their jurisdiction.

Over the years a number of monitoring design guidance documents have been prepared by various agencies and organizations, along with books on the subject. The National Water Quality Monitoring Council, as part of its mission toward monitoring consistency and comparability across all efforts to monitoring water quality, inventories available monitoring design documents below.

The ultimate question, beyond the inventory of monitoring guidance, is: How effective is the guidance, when applied, in producing monitoring designs that provide consistent and comparable water quality data and information in support of management decision-making? How is such a question of accountability in monitoring design guidance answered? How is the success of design guidance, when applied, to be measured? One way to evaluate the effectiveness of design guidance is to examine the monitoring designs produced according to the guidance. Thus, following the design guidance below are examples of designs produced following the guidance recommendations, as an illustration of the guidance’s application.

It is hoped that the inventory and design examples will help Federal, State and local water quality agencies quickly locate monitoring guidance relevant to their purposes as well as enhance collaboration and cooperation in future monitoring efforts. The inventory and design examples should help the broader water quality monitoring community appreciate the need for reconciling the wide array of guidance and monitoring designs into more common, widely accepted, monitoring guidance approaches and, perhaps, even ‘standards of practice’ for designing, documenting, and operating water quality monitoring programs.

There have been many calls for consistency and comparability in water quality monitoring over the years. Ward (1996) describes 18 reports that were prepared between 1971 and 1995 that called for improved water quality monitoring design and operation. New reports are issued regularly with similar calls for improvement. At the federal level, the Office of Management and Budget has directed agencies to coordinate their data acquisition efforts with the U.S. Geological Survey (USGS)(OMB Circular M-92-01).

To begin to move toward more collaboration and agreement on consistent and comparable methods in the design and operation of water quality monitoring systems, the inventory below will provide an overview of available monitoring guidance, a context for dialogue, and, hopefully, action to begin to work toward a more common set of guidance to the design of water quality monitoring programs in the United States.

### **References**

Peters, C.A. and R.C. Ward. 2003. A framework for 'constructing' water quality monitoring programs. *Water Resources IMPACT*, Vol. 5(5):3-7, September.

Ward, R.C. 1996. Water quality monitoring: where's the beef? *Journal of the American Water Resources Association*, Vol 32(4):673-680, August.

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## **Monitoring Design 'Guidance' and Application Inventory**

Prepared by the Water Information Strategies Work Group of the National Water Quality Monitoring Council

### **National Water Quality Monitoring Council**

Data Analysis Considerations in Producing 'Comparable' Information for Water Quality Management Purposes - Technical Report 01-01 - The purpose of this report is to review the current statistical analysis procedures used by a variety of monitoring entities to produce water quality information and to provide insight into the issues surrounding the difficult task of selecting methods to analyze water quality data in support of management's 'legal' monitoring requirements. Report is available at:  
<http://water.usgs.gov/wicp/acwi/monitoring/pubs/tr/nwqmc0101.pdf>

Data Quality Objectives (DQOs) and Measurement Quality Objectives (MQOs) are or should be the foundation of all monitoring studies as these define the objectives for the monitoring and the data quality needed to respond to those objectives. MQOs are statements that contain specific units of measure such as percent recovery, percent relative standard deviation, standard deviation of X micrograms per liter, or detection level of Y parts per billion. They should be thoroughly specified to allow specific comparisons of data to an MQO. DQOs are statements that define the confidence required in conclusions drawn from data produced by a project. Tools are available at:  
<http://wi.water.usgs.gov/methods/tools/dqomqo/index.htm>

Use the National Environmental Methods Index (NEM) first to compare and contrast the performance and relative cost of analytical, test, and sampling methods for environmental monitoring. NEMI is a free, searchable clearinghouse of methods and procedures for regulatory and non-regulatory analyses. Index is available at:  
[http://www.nemi.gov/servlet/page?\\_pageid=179&\\_dad=portal30&\\_schema=PORTAL30](http://www.nemi.gov/servlet/page?_pageid=179&_dad=portal30&_schema=PORTAL30)

The Water Quality Data Elements (WQDEs), developed by the Methods Board and the National Water Quality Monitoring Council (NWQMC), are intended to address the fundamental question: "How can we tell if water quality datasets are comparable and can therefore be combined for a given use?" WQDEs are lists of the minimum elements or metadata that give a data user information about the data so that they can make an informed decision as to the quality of those data, and the comparability of those data for their question or purpose. WQDEs should be readily available to other interested parties, along with the data, to facilitate information sharing and data exchange. Lists are divided into modules specific to different types of water quality monitoring analyses (e.g., chemical, microbiological, toxicological, biological). The proposed lists are not a set of required information. They are intended as a means to help data collectors and database

managers more effectively characterize their data and thereby, promote the use of those data by others. The WQCEs are available at:

<http://wi.water.usgs.gov/methods/tools/wqde/index.htm>

### **State of Oregon**

<http://www.deq.state.or.us/lab/qa/DEQ03-LAB-0036-SOP.pdf>

The purpose of the Watershed Assessment Mode of Operations Manual (MOMs) is to describe the operations, procedures, equipment and methods used by the Watershed Assessment Section. The reasons for doing this are:

1. To establish, document, and define the procedures upon which the Section operates;
2. To provide material to inform and instruct others who may come into the Section or operate as part of the Section; and
3. To provide material to inform others who are interested in the manner in which the Section operates.

MOMs is divided into five separate chapters: (1) Introduction, (2) General Considerations, (3) Field Sampling Methods, (4) Field Analytical Methods, and (5) Continuous Monitoring Methods. In its entirety, MOMs is primarily useful to new and current Section staff members. However, parts of it, especially the third, fourth and fifth chapters will be useful to those interested in the methods used to obtain the data or to those assisting the Section in sample collection. In addition, those interested in data quality, management, and analysis will be interested in the second and fifth chapters.

### **U.S. Geological Survey**

Techniques for Water Resources Investigations Reports

[\(http://water.usgs.gov/pubs/twri/\)](http://water.usgs.gov/pubs/twri/)

Nine 'books' provide guidance on such topics as: (1) Collection of water data by direct measurement; (2) Laboratory analysis; (3) Modeling techniques; (4) Automated data processing and computations; (5) Instrumentation; and (6) Handbooks for water resources investigations.

National Water Quality Assessment Program (NAWQA) Protocols

[\(http://water.usgs.gov/nawqa/protocols/doc\\_list.html\)](http://water.usgs.gov/nawqa/protocols/doc_list.html)

The National Water-Quality Assessment Program of the U.S. Geological Survey is designed to assess the status of and trends in the quality of the Nation's ground- and surface-water resources and to link the status and trends with an understanding of the natural and human factors that affect the quality of water. The study design balances the unique assessment requirements of individual hydrologic systems with a nationally consistent design structure that incorporates a multiscale, interdisciplinary approach.

## **Natural Resource Conservation Service**

(<ftp://ftp.wcc.nrcs.usda.gov/downloads/wqam/wqml.pdf>)

Recognition of agriculture's contribution to non-point source (NPS) pollutant loadings to streams, lakes, estuaries, and ground water has led to increased emphasis on water quality monitoring in rural watersheds. Conservation Districts and the Natural Resources Conservation Service (NRCS) are often sponsors and cooperators, respectively, of studies and projects to reduce agricultural NPS loadings. The primary purpose of this handbook is to provide these entities and their partners with guidance for gathering and using water quality information to support planning and implementation activities.

## **National Park Service**

(<http://science.nature.nps.gov/im/monitor/vsmTG.htm#Introduction>)

Natural resource monitoring is a major component of park stewardship, and a cornerstone of the NPS Natural Resource Challenge - a program to revitalize and expand the natural resource program within the park service and improve park management through greater reliance on scientific knowledge. The overall purpose for natural resource monitoring is to determine the status and trend in the condition of selected park resources. Monitoring results will be used to assess the efficacy of management and restoration efforts, provide early warning of impending threats, and provide a basis for understanding and identifying meaningful change in natural systems characterized by complexity, variability, and surprises. Monitoring data may help to determine what constitutes impairment and to identify the need to initiate or change management practices.

## **U.S. Environmental Protection Agency**

### Guidance on Choosing a Sampling Design for Environmental Data Collection

<http://www.epa.gov/quality/qs-docs/g5s-final.pdf>

This document, *Guidance for Choosing a Sampling Design for Environmental Data Collection (EPA QA/G-5S)*, will provide assistance in developing an effective QA Project Plan as described in *Guidance for QA Project Plans (EPA QA/G-5)* (EPA 1998b). QA Project Plans are one component of EPA's Quality System. This guidance is different from most guidance in that it is not meant to be read in a linear or continuous fashion, but to be used as a resource or reference document. This guidance is a "tool-box" of statistical designs that can be examined for possible use as the QA Project Plan is being developed.

### Elements of a State Water Quality Monitoring Program

(<http://www.epa.gov/owow/monitoring/elements/>)

The Clean Water Act [CWA] gives States and Territories the primary responsibility for implementing programs to protect and restore water quality, including monitoring and assessing the nation's waters and reporting on their quality. CWA Section 106(e)(1) requires the Environmental Protection Agency (EPA) to determine that a State is

monitoring the quality of navigable waters, compiling, and analyzing data on water quality and including it in the State's Section 305(b) report prior to the award of Section 106 grant funds. The attached document, *Elements of a State Water Monitoring and Assessment Program*, recommends the basic elements of a State water monitoring program and serves as a tool to help EPA and the States determine whether a monitoring program meets the prerequisites of CWA Section 106(e)(1).

#### Consolidated Assessment and Listing Methodology

(<http://www.epa.gov/owow/monitoring/calm.html>)

Section 305(b) of the Clean Water Act requires states and other jurisdictions to submit biennial water quality reports to the U.S. Environmental Protection Agency (EPA). These reports describe the extent to which waters are attaining applicable water quality standards. Under Section 303(d), states identify waters that are not attaining water quality standards, submit a list to EPA of those impaired waters, and develop Total Maximum Daily Loads (TMDLs) for them. Water quality monitoring and data analysis are the foundation of these water resource management decisions. EPA and its partners are working together to develop a consolidated 305(b)/303(d) assessment approach that addresses water quality monitoring strategies, data quality and data quantity needs, and data interpretation methodologies. This effort aims to help states improve the accuracy and completeness of 303(d) lists and 305(b) reports as well as streamline these two reporting requirements.

#### Overview of Source Water Assessment and Protection and the Safe Drinking Water Act

(<http://www.epa.gov/OGWDW/source/chap1.html#s2>)

Documented designs employing Source Water Assessment design guidance:

Twenter, J.A. 2002. Design of a Water Quality Information System for Source Water Assessment: A Denver Water Case Study, Denver, Colorado. MS Thesis, Civil Engineering Department, Colorado State University.

<http://watercenter.colostate.edu/ce545/theses/JTwenter.pdf>

#### Combined Sewer Overflows: Guidance for Monitoring and Modeling

EPA Report Number 832/B-99-002

NPDES Storm Water Sampling Guidance Document, July 1992, EPA Report Number 833/B-92-001

Clean Water Act Section 403 Procedural and Monitoring Guidance, EPA Report Number EPA842-B-94-003: Provides monitoring methods and approaches to use in order to establish more consistency among Regions and National Pollutant Discharge Elimination System-authorized states when conducting a section 403 Ocean Discharge Criteria Evaluation in the permit review process. Describes the procedural or decision making aspects of the section 403 program and the criteria for evaluating perceived potential impact. Also provides summaries of analytical methods used to assess the various physical, biological, and chemical parameters of concern. (120 pgs.)

Design of 301(h) Monitoring Programs for Municipal Wastewater Discharges to Marine Waters, EPA430-9-82-010, 11/82: Provides guidance for designing monitoring programs that meet regulatory requirements in 40 CFR 125.63 and allow continuing assessment of the impact of less-than-secondary discharges on the receiving water marine environment. (135 pp.)

Framework for 301(h) Monitoring Programs EPA430-9-88-002, 9/87: Provides guidance for publicly-owned treatment works on conducting monitoring programs to ensure compliance with 301(h) modified National Pollutant Discharge Elimination System (NPDES) permits. Describes how to design, implement, evaluate, and modify a 301(h) monitoring program. (44 pp.)

Environmental Indicators of Water Quality in the U.S.( <http://www.epa.gov/iwi/help/indic/>) EPA Report Number EPA841-R-96-002: Introduces a core set of 18 national water environmental indicators. Establishes baseline information for tracking trends on water quality. Presents data gaps and improvements needed to make the indicators more reliable. (26 pp.)

Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates: Report Contents EPA841-B-97-002A, 9/97: Includes detailed guidance on making use of support determinations for aquatic life and clarification of other reporting requirements and shows the material to be included in the 305(b) report. (62 pp.)

Report produced following guidance:

2000 National Water Quality Inventory (<http://www.epa.gov/305b/2000report/>)  
Includes a summary of State reports as well as links to those available online.

Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls EPA841-B-96-004, 9/97: Provides details guidance on developing nonpoint source monitoring plans, biological monitoring, data analysis and reporting. (236 pp.)

Monitoring Guidance for the National Estuary Program – Final EPA842-B-92-004, 9/92: Provides the National Estuary Program with guidance on how to design, implement, and evaluate a monitoring program. This document is of use to all coastal and marine managers with monitoring responsibilities. (355 pp.)

Statistical Methods for the Analysis of Lake Water Quality Trends EPA841-R-93-003, 12/93: This manual and the accompanying software in the SAS system presents nonparametric statistical methods for trend assessment in water quality, with an emphasis on lakes. The purpose of the manual and software is to furnish lake program managers with guidance on the application and interpretation of methods for the detection of trends in lake water quality. (107 pp.)

Watershed Monitoring and Reporting for Section 319 National Monitoring Program Projects EPA841-B-91-113, 8/91: Outlines state monitoring and reporting requirements for watershed projects funded under section 319 of the Clean Water Act. Reviews selection criteria for National Monitoring Program Projects. Describes four information files used in reporting: section 305(b) Waterbody System, Management File, Monitoring Plan File, and Annual Report File. Also includes the data input and reporting software package, Nonpoint Source Management System, Version 3.0, and hard copy report forms. (90 pp.)

Guidance for Choosing a Sampling Design for Environmental Data Collection EPA QA/G-5S. This report provides assistance in developing an effective QA Project Plan as described in *Guidance for QA Project Plans (EPA QA/G-5)* (EPA 1998b). QA Project Plans are one component of EPA's Quality System. This guidance is different from most guidance in that it is not meant to be read in a linear or continuous fashion, but to be used as a resource or reference document. This guidance is a "tool-box" of statistical designs that can be examined for possible use as the QA Project Plan is being developed.

Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska EPA/910/9-91-001; Region 10 of EPA. The document provides guidance for designing water quality monitoring projects and selecting monitoring parameters. Although the focus is on forest management and streams in the Pacific Northwest and Alaska, a broader perspective is taken, and much of the information is more widely applicable.

Environmental Monitoring and Assessment Program (EMAP)  
(<http://www.epa.gov/emap/index.html>)

EMAP objectives are to advance the science of ecological monitoring and ecological risk assessment, guide national monitoring with improved scientific understanding of ecosystem integrity and dynamics, and demonstrate the CENR framework through large regional projects. EMAP will develop and demonstrate indicators to monitor the condition of ecological resources, and investigate multi-tier designs that address the acquisition and analysis of multi-scale data including aggregation across tiers and natural resources.

### **Volunteer Monitoring Design Guidance**

The U.S. Environmental Protection Agency provides an overview of available resources for designing a volunteer water quality monitoring program on its website: <http://www.epa.gov/OWOW/monitoring/vol.html>. Included in the materials are guidelines for methods as applied to water bodies located in various parts of the hydrologic cycle and guidelines for quality assurance in monitoring.

### **Related Monitoring Design Guidance Information**

A Guide to Developing Secondary Information Products: Methods Review and Documentation. EPA 260-B-01-006 (Final version of this report is currently being prepared). This 2003 report describes how one should approach existing data sets to obtain, from the data, information about water quality conditions, in a ‘scientifically sound’ manner. In other words, it is difficult, in a scientifically sound manner, to use data for a purpose for which it was not intended. If you must do this, however, this report provides guidance on how it should be done. To illustrate, if you want to determine which stream segments are in violation of a water quality standard and you want to use all available data, this report describes factors you need to consider.

A Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information. EPA 100/B-03/001. This 2003 document describes the assessment factors and considerations generally used by EPA to evaluate the quality and relevance of scientific and technical information.

Enabling Informed Decision-making initiative – WATERS (<http://www.epa.gov/waters/>)

Environmental and Assessment Program: (<http://www.epa.gov/emap/>), in general, and (<http://www.epa.gov/nheerl/arm/>), for specific, and extensive, information on the site selection process for probability surveys in aquatic resources.

## **Examples of International Monitoring Design Guidance**

### **Europe**

European Union’s Water Framework Directive – EU legislative guiding development of a more holistic approach to water management in Europe. The Directive can be viewed at: <http://projects.dhi.dk/waterdir/Water%20framework%20directive%20UK.pdf>

Monitoring Guidance for implementing the WFD can be found in Guidance Document No. 7 entitled **Monitoring under the Water Framework Directive** (Produced by Working Group 2.7 – Monitoring)

A monitoring policy summary can be found at the following website: [http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework\\_directive/guidance\\_documents/0policysummariesofsgui&vm=detailed&sb=Title%5d](http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/0policysummariesofsgui&vm=detailed&sb=Title%5d)

The monitoring guidance document can be found at: [http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework\\_directive/guidance\\_documents/0publishedguidancesdocu&vm=detailed&sb=Title](http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/0publishedguidancesdocu&vm=detailed&sb=Title)

**Technical Report 1.** The EU Water Framework Directive: Statistical aspects of the identification of groundwater pollution trends and aggregation of monitoring results. Report can be found at the same location as the WFD monitoring guidance above.

At the above website are other guidance documents that address a number of the NWQMC monitoring framework cogs as well as issues faced by different Work Groups on the NWQMC.

### **Canada**

Environment Canada. 1998. Pulp and paper technical guidance document for aquatic environmental effects monitoring. National EEM Office, Environment Canada, Ottawa, Ontario (EEM/1998).

Environment Canada. 2000. Guidance for determining follow-up actions when effects have been identified in environmental effects monitoring (EEM). National EEM Office, Environment Canada, Ottawa, Ontario. 6 p.

Environment Canada. 2002. Alternative monitoring methods. National EEM Office, Environment Canada, Ottawa, Ontario. 82 p.

Environment Canada. 2002. Guidance for data assessment. National EEM Office, Environment Canada, Ottawa, Ontario. 37 p.

Environment Canada. 2002. Metal mining guidance documents for aquatic environmental effects monitoring. National EEM Office, Environment Canada, Ottawa, Ontario.

Environment Canada. 2002. Revised guidance for sample sorting and sub-sampling protocols for EEM benthic invertebrate community surveys. National EEM Office, Environment Canada, Ottawa, Ontario. 26 p.

Environment Canada. 2003. Additional technical guidance for conducting redox and sulphide measurements in marine sediments. National EEM Office, Environment Canada, Ottawa, Ontario.

Environment Canada. 2003. Revised technical guidance on how to conduct effluent plume delineation studies. National EEM Office, Environment Canada, Ottawa, Ontario.

### **New Zealand**

Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (<http://www.mfe.govt.nz/publications/water/microbiological-quality-jun03/opening.html>). These guidelines assist councils/agencies in monitoring water quality to better inform their communities of the risks related to swimming at their bathing beaches.

The New Zealand ecological footprint calculator estimates the size of a citizen's personal footprint using averaged national data and information provided by the citizen regarding

things they, individually, buy and use.

<http://www.environment.govt.nz/footprint/personal.html>

The New Zealand Ministry for the Environment is developing a [national environmental standard](#) for human drinking water sources. Following feedback from the Talk Environment Roadshow and Local Government the Ministry is now developing a favoured option. The favoured option is a **monitoring and reporting** standard intended to better inform the community of the quality of their drinking water sources, and to enhance regional council involvement in community water source planning. It is expected that the community can then make more informed decisions about where to take water from and what activities are appropriate in their water supply catchments. The standard will be publicly notified later in the year.

<http://www.mfe.govt.nz/publications/water/proposed-water-standard/water-source-standard.html>

[Protocols for sampling macroinvertebrates in wadeable streams](#)

[New Zealand periphyton guideline: detecting, monitoring and managing enrichment of streams](#)

[The New Zealand Stream Health Monitoring and Assessment Kit \(SHMAK\)](#)