

Monitoring and Evaluating Nonpoint Source Watershed Projects

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Foreword

The diffuse nature of nonpoint sources and the variety of pollutants generated by them create a challenge for their effective control requiring a systematic approach based on assessment, planning, implementation, and evaluation. Monitoring is an important component in all four of these activities. While substantial progress has been made since 1972 in the protection and enhancement of water quality, much work is still needed to identify nonpoint source management strategies that are both effective and economically achievable under a wide range of conditions. Lack of adequate information on best management approaches is the major obstacle in developing effective watershed management strategies. We are relearning previous lessons because we have failed to institutionalize previous lessons learned from intensive monitoring efforts from 1970 to the present. This version of the nonpoint source monitoring guide (guide) incorporates the monitoring lessons learned from the Rural Clean Water Program (RCWP), the Clean Water Act Section 319 National Nonpoint Source Monitoring Program (NNPSMP), and other efforts to provide a state-of-the-reference for monitoring nonpoint source projects. Monitoring plays an important role in addressing the need to evaluate our watershed management efforts and document the lessons learned so we can use them as a foundation for future management efforts.

This guide is written primarily for those who develop and implement monitoring plans for watershed management projects, but it can also be used by those who wish to evaluate the technical merits of monitoring proposals they might sponsor. It is an update to the 1997 *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls* (EPA 841-B-96-004) and includes many references to that document.

The style and technical level of this guidance are intended to make it accessible to both beginners and experts alike. Numerous real-world examples from RCWP and NNPSMP projects are provided to give the reader a true sense of the challenges faced by those who have monitored waters impacted by nonpoint sources. Included in the guidance document are many references to other related resource materials for those seeking additional or more detailed information.

This guidance begins with an overview of the extent and types of nonpoint source problems reported by the States and Tribes. The overview is intended to provide perspective and set the stage for the chapters that follow. Subsequent chapters describe the basic steps involved in designing a nonpoint source monitoring plan, including sections and chapters devoted to biological, photopoint, and land use monitoring. A chapter that focuses on ways to address the many unique challenges associated with nonpoint source monitoring is also included. The chapter on data analysis describes and illustrates techniques ranging from exploratory data analysis to advanced statistical approaches for assessing the effectiveness of both individual best management practices and watershed projects. Pollutant load estimation methods are also described in detail. A chapter on quality assurance and quality control is then followed by a chapter addressing monitoring costs.

Good monitoring design begins with a clear monitoring objective and an understanding of the water quality problem or concern addressed. Because problems and objectives vary, there is no single approach that can be applied to nonpoint source monitoring efforts. It is hoped this guidance provides a foundation that allows practitioners to design monitoring programs that meet their unique needs.

Readers are encouraged to consult the many resources listed in this document. In addition to these resources, readers are urged to contact monitoring and quality assurance experts in academia and at the local, State, Tribal, and federal levels for assistance in developing monitoring plans and analyzing the collected data.

Acknowledgments

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The authors gratefully acknowledge the helpful technical reviews provided by Dr. Brian Fontenot of EPA Region 6, Dr. Marty Kelly of Atkins North America, and Mr. John McCoy of the Columbia Association in Maryland. In addition, the authors thank the many individuals who have contributed to the knowledge base on nonpoint source monitoring and data analysis over the past quarter century or more. The references contained in this document only begin to recognize the contributions of others.

Inspiration for this document was provided long before the 1997 version for which this serves as an upgrade. Mr. James W. Meek, former Chief of the Nonpoint Source Control Branch at EPA Headquarters, was particularly inspirational in his support for developing and documenting improved methods to demonstrate the effectiveness of nonpoint source control measures and programs. The late Dr. Frank J. Humenik, Professor in the Department of Biological and Agricultural Engineering at North Carolina State University, was instrumental in the promotion of long-term monitoring projects to evaluate the effectiveness of approaches to solve water quality problems at the watershed level. Finally, Mr. Thomas Davenport of EPA Region 5 has been the driving force behind EPA's continued involvement in nonpoint source watershed projects that began in earnest with the Model Implementation Program, Nationwide Urban Runoff Program, and Rural Clean Water Program. Mr. Davenport has led the effort to document the effectiveness of nonpoint source pollution control efforts through sound scientific approaches, and he has been the major proponent of developing this upgraded nonpoint source monitoring guidance.

Contents

1	Overview of the Nonpoint Source Problem.....	1-1
1.1	Definition of a Nonpoint Source.....	1-1
1.2	Extent of Nonpoint Source Problems in the United States	1-2
1.3	Major Categories of Nonpoint Source Pollution	1-7
1.3.1	Agriculture	1-7
1.3.2	Urban Sources.....	1-8
1.3.3	Removal of Streamside Vegetation.....	1-9
1.3.4	Hydromodification.....	1-9
1.3.5	Mining.....	1-10
1.3.6	Forestry	1-11
1.3.7	Construction.....	1-12
1.3.8	Marinas	1-13
1.4	Solving the Problem	1-14
1.5	References.....	1-15
2	Nonpoint Source Monitoring Objectives and Basic Designs	2-1
2.1	Monitoring Objectives	2-1
2.2	Fundamentals of Good Monitoring.....	2-4
2.2.1	Understand the System.....	2-4
2.2.1.1	Causes and Sources.....	2-5
2.2.1.2	Pollutant Transport	2-5
2.2.1.3	Seasonality.....	2-6
2.2.1.4	Water Resource Considerations.....	2-7
2.2.1.4.1	Rivers and Streams	2-7
2.2.1.4.2	Lakes, Reservoirs, and Ponds	2-9
2.2.1.4.3	Wetlands	2-12
2.2.1.4.4	Estuaries.....	2-14
2.2.1.4.5	Nearshore Waters.....	2-16
2.2.1.4.6	Ground Water	2-17
2.2.1.5	Climate.....	2-21
2.2.1.6	Soils, Geology and Topography	2-22
2.2.2	Monitor Source Activities.....	2-22
2.2.3	Critical Details	2-23
2.2.3.1	Logistics.....	2-23
2.2.3.2	Quality Assurance/Quality Control and the Quality Assurance Project Plan (QAPP).....	2-24
2.2.3.3	Data Management and Record-keeping.....	2-25
2.2.3.4	Roles and Responsibilities.....	2-25
2.2.3.5	Review of Monitoring Proposals.....	2-26
2.2.4	Feedback	2-27
2.2.5	Limitations of Monitoring.....	2-27
2.3	Monitoring Scale Selection.....	2-28

2.3.1	General Considerations	2-28
2.3.2	Options	2-29
2.3.2.1	Statewide or regional	2-29
2.3.2.2	Watershed	2-29
2.3.2.3	BMP or practice	2-31
2.3.2.3.1	Plot	2-32
2.3.2.3.2	Field	2-32
2.3.2.4	Summary	2-33
2.4	Monitoring Design Selection	2-33
2.4.1	General Considerations	2-33
2.4.2	Design Options	2-33
2.4.2.1	Reconnaissance or Synoptic	2-34
2.4.2.2	Plot	2-35
2.4.2.3	Paired	2-36
2.4.2.4	Single Watershed Before/After	2-38
2.4.2.5	Single-Station Long-Term Trend	2-39
2.4.2.6	Above/Below	2-39
2.4.2.7	Side-by-Side Before/After	2-41
2.4.2.8	Multiple	2-41
2.4.2.9	Input/Output	2-41
2.4.2.10	Summary	2-43
2.5	References	2-44
3	Monitoring Plan Details	3-1
3.1	Variable Selection	3-1
3.1.1	General Considerations	3-1
3.1.2	Selection Factors	3-2
3.1.2.1	Program Objectives	3-2
3.1.2.2	Waterbody Use	3-2
3.1.2.3	Waterbody Use Impairment	3-3
3.1.2.4	Type of Water Resource Sampled	3-3
3.1.2.5	Pollutant Sources	3-3
3.1.2.6	Response to Treatment	3-4
3.1.2.7	Difficulty or Cost of Analysis	3-6
3.1.2.8	Method Comparability	3-7
3.1.2.9	Logistical Constraints	3-8
3.1.2.10	Need for Covariates	3-9
3.1.2.11	Set Priorities	3-9
3.1.3	Physical and Chemical Water Quality Data	3-10
3.1.3.1	Measuring Surface Water Flow	3-10
3.1.3.2	Commonly Measured Physical and Chemical Water Quality Constituents	3-22
3.1.3.3	Surrogates	3-26
3.1.4	Biological Data	3-27
3.1.5	Weather Data	3-30
3.1.6	Watershed Characterization	3-31

3.1.6.1	Topographic Data	3-31
3.1.6.2	Soil Characteristics	3-32
3.1.6.3	Land Use/Land Cover.....	3-32
3.2	Sample Type Selection.....	3-33
3.2.1	General Considerations.....	3-33
3.2.2	Types.....	3-35
3.2.2.1	Grab	3-35
3.2.2.2	Composite.....	3-35
3.2.2.3	Integrated.....	3-36
3.2.2.4	Continuous.....	3-37
3.3	Station Location.....	3-38
3.3.1	Macro-scale.....	3-38
3.3.2	Micro-scale	3-41
3.3.2.1	General Considerations.....	3-42
3.3.2.2	Locations for Flow Measurement.....	3-42
3.3.2.3	Locations for Biological Monitoring.....	3-43
3.4	Sampling Frequency and Duration	3-43
3.4.1	General Considerations.....	3-43
3.4.1.1	Estimating the Mean.....	3-44
3.4.1.2	Detecting a Step or Linear Trend.....	3-45
3.4.2	Minimum Detectable Change (MDC) Analysis.....	3-47
3.4.2.1	Definition and Overview	3-47
3.4.2.2	Steps to Calculate the MDC	3-48
3.4.2.2.1	Step 1. Define the Monitoring Goal and Choose the Appropriate Statistical Trend Test Approach.....	3-48
3.4.2.2.2	Step 2. Exploratory Data Analyses.....	3-48
3.4.2.2.3	Step 3. Data Transformations.....	3-48
3.4.2.2.4	Step 4. Test for Autocorrelation.....	3-49
3.4.2.2.5	Step 5. Calculate the Estimated Standard Error.....	3-49
3.4.2.2.6	Step 6. Calculate the MDC.....	3-50
3.4.2.2.7	Step 7. Express MDC as a Percent Change.....	3-50
3.4.2.3	Examples	3-50
3.4.2.4	Factors Affecting the Magnitude of the MDC.....	3-52
3.4.3	Sampling Duration	3-56
3.5	Monitoring Station Construction and Operation.....	3-56
3.5.1	Grab Sampling	3-57
3.5.2	Perennial Streams and Rivers	3-58
3.5.3	Edge of Field.....	3-60
3.5.4	Structures/BMPs	3-61
3.5.5	Meteorology.....	3-67
3.6	Sample Collection and Analysis Methods	3-69
3.6.1	General Considerations.....	3-69
3.6.1.1	Documentation and Records.....	3-69
3.6.1.2	Preparation for Sampling.....	3-69

3.6.1.3	Cleaning.....	3-69
3.6.1.4	Safety.....	3-70
3.6.2	Field Procedures.....	3-70
3.6.2.1	Field Measurements.....	3-70
3.6.2.2	Grab Sampling.....	3-71
3.6.2.3	Passive Sampling.....	3-73
3.6.2.4	Autosampling.....	3-77
3.6.2.5	Benthic Macroinvertebrate Sampling.....	3-78
3.6.2.6	Fish Sampling.....	3-80
3.6.2.7	Aquatic Plant Sampling.....	3-82
3.6.2.8	Bacteria/Pathogen Sampling.....	3-82
3.6.2.9	Habitat Sampling.....	3-83
3.6.2.10	Specialized Sampling.....	3-83
3.6.3	From Field to Laboratory.....	3-84
3.6.3.1	Sample Processing.....	3-84
3.6.3.2	Sample Preservation and Transport.....	3-84
3.6.3.3	Sample Custody.....	3-89
3.6.3.4	Performance Audits.....	3-90
3.6.4	Laboratory Considerations.....	3-90
3.7	Land Use and Land Treatment Monitoring.....	3-91
3.7.1	General Considerations.....	3-91
3.7.2	Basic Methods.....	3-92
3.7.2.1	Direct Observation.....	3-92
3.7.2.2	Log Books.....	3-93
3.7.2.3	Interviews.....	3-93
3.7.2.4	Agency reporting.....	3-94
3.7.2.5	Remote Sensing.....	3-95
3.7.3	Temporal and Spatial Scale.....	3-97
3.7.4	Monitoring Variables.....	3-98
3.7.5	Sampling Frequency.....	3-98
3.7.6	Challenges.....	3-99
3.8	Special considerations for pollutant load estimation.....	3-101
3.8.1	Sample Type and Sampling Equipment.....	3-102
3.8.2	Sampling Frequency and Timing.....	3-102
3.8.3	Planning and Cost Considerations.....	3-104
3.9	Data Management.....	3-105
3.9.1	General considerations.....	3-105
3.9.2	Data acquisition.....	3-105
3.9.3	Data storage.....	3-106
3.10	Data Reporting and Presentation.....	3-107
3.10.1	General considerations.....	3-107
3.10.2	Communicating with Stakeholders.....	3-107
3.10.3	Final reports.....	3-107
3.11	References.....	3-108

4	Biological Monitoring of Aquatic Communities	4-1
4.1	Overview.....	4-1
4.2	Background.....	4-6
4.2.1	Types of Biological Monitoring.....	4-7
4.2.1.1	Benthic Macroinvertebrates.....	4-7
4.2.1.2	Fish.....	4-7
4.2.1.2.1	Length, Weight, and Age Measurements.....	4-8
4.2.1.2.2	Fish External Anomalies.....	4-9
4.2.1.3	Periphyton.....	4-9
4.2.2	Linkages to Habitat.....	4-10
4.2.3	Limitations of Biological Assessments.....	4-11
4.2.4	Reference Sites and Conditions.....	4-12
4.3	Biomonitoring Program Design.....	4-14
4.4	Biological Assessment Protocols.....	4-30
4.4.1	Field Sampling.....	4-30
4.4.1.1	Benthic macroinvertebrates.....	4-31
4.4.1.2	Fish.....	4-32
4.4.1.3	Periphyton.....	4-32
4.4.1.4	Quality control measures.....	4-33
4.4.2	Sample processing/laboratory analysis.....	4-33
4.4.2.1	Benthic macroinvertebrates.....	4-33
4.4.2.1.1	Sorting and subsampling.....	4-34
4.4.2.1.2	Taxonomic identification.....	4-35
4.4.2.2	Fish (field taxonomic identification).....	4-36
4.4.2.3	Periphyton.....	4-36
4.4.2.4	Quality control measures/data quality documentation.....	4-36
4.4.3	Data reduction/indicator calculation.....	4-37
4.4.3.1	Multimetric indexes.....	4-37
4.4.3.1.1	Metric and index calculations.....	4-44
4.4.3.1.2	Quality control measure.....	4-45
4.4.3.2	Predictive models (observed/expected [O/E]).....	4-45
4.4.3.3	Quantitative decision analysis systems (biological condition gradient [BCG]).....	4-46
4.4.4	Index scoring and site assessment.....	4-47
4.4.5	Reporting assessment results at multiple spatial scales.....	4-48
4.4.5.1	Watershed or area-wide.....	4-48
4.4.5.2	Stream- or site-specific.....	4-50
4.4.5.3	Relative to specific sources.....	4-50
4.5	References.....	4-53
5	Photo-Point Monitoring	5-1
5.1	Introduction.....	5-1
5.2	Procedure.....	5-1
5.2.1	Setting Objectives.....	5-2
5.2.2	Selecting Methods.....	5-3

5.2.2.1	Qualitative Monitoring	5-5
5.2.2.2	Quantitative Monitoring	5-5
5.2.2.2.1	Photo Grid Analysis	5-6
5.2.2.2.2	Transect Photo Sampling	5-7
5.2.2.2.3	Digital Image Analysis	5-8
5.2.3	Selecting Areas to Monitor	5-9
5.2.4	Identifying Photo Points	5-9
5.2.5	Establishing Camera Points	5-11
5.2.6	Marking and Identifying Photo and Camera Points	5-12
5.2.7	Identifying a Witness Site	5-12
5.2.8	Recording Important Site Information	5-12
5.2.9	Determining Timing and Frequency of Photographs	5-13
5.2.10	Creating a Field Book	5-14
5.2.11	Defining Data Analysis Plans	5-14
5.2.12	Establishing a Data Management System	5-14
5.2.13	Taking and Documenting Photographs	5-15
5.3	Equipment Needs	5-17
5.4	Applications of Photo-Point Monitoring	5-19
5.4.1	Comparison Photos	5-19
5.4.2	Repeat Photography	5-19
5.5	Advantages, Limitations, and Opportunities	5-21
5.5.1	Advantages	5-21
5.5.2	Limitations	5-22
5.5.3	Opportunities	5-22
5.6	References	5-25
6	Monitoring Challenges and Opportunities	6-1
6.1	Monitoring Pitfalls	6-1
6.1.1	Design Flaws	6-1
6.1.2	Procedural Problems	6-2
6.2	Lag Time Issues in Watershed Projects	6-4
6.2.1	Project Management Components	6-5
6.2.1.1	Time Required for an Installed or Adopted Practice to Produce an Effect	6-5
6.2.1.2	Time Required for the Effect to be Delivered to the Water Resource	6-6
6.2.1.3	Time Required for the Waterbody to Respond to the Effect	6-7
6.2.2	Effects Measurement Components of Lag Time	6-8
6.2.2.1	The Magnitude of Lag Time	6-8
6.2.3	How to Deal with Lag Time	6-9
6.2.3.1	Recognize Lag Time and Adjust Expectations	6-9
6.2.3.1.1	Characterize the Watershed	6-10
6.2.3.1.2	Consider Lag Time Issues in Selection, Siting, and Monitoring of Best Management Practices	6-10
6.2.3.1.3	Monitor Small Watersheds Close to Sources	6-11
6.2.3.1.4	Select Indicators Carefully	6-11
6.2.3.1.5	Design Monitoring Programs to Detect Change Effectively	6-12

6.3	Integrating Monitoring and Modeling.....	6-12
6.3.1	The Roles of Monitoring and Modeling.....	6-12
6.3.1.1	Monitoring.....	6-12
6.3.1.2	Modeling.....	6-13
6.3.2	Using Monitoring and Modeling Together.....	6-14
6.4	Supporting BMP and Other Databases.....	6-17
6.4.1	General Considerations.....	6-17
6.4.2	International Urban Stormwater BMP Database.....	6-18
6.5	References.....	6-18
7	Data Analysis.....	7-1
7.1	Introduction.....	7-1
7.2	Overview of Statistical Methods.....	7-1
7.2.1	Exploratory Data Analysis and Data Transformations.....	7-2
7.2.2	Dealing with Censored Data.....	7-5
7.2.3	Data Analysis for Water Quality Problem Assessment.....	7-6
7.2.4	Project Planning Data Analysis.....	7-7
7.2.5	BMP and Project Effectiveness Data Analysis.....	7-7
7.2.6	Practice Datasets.....	7-9
7.3	Exploratory Data Analysis (EDA) and Data Adjustment.....	7-10
7.3.1	Steps in Data Exploration.....	7-12
7.3.2	Describe Key Variable Characteristics.....	7-13
7.3.2.1	Central Tendency.....	7-13
7.3.2.2	Variability.....	7-13
7.3.2.3	Skewness.....	7-14
7.3.2.4	Data Distribution.....	7-15
7.3.2.5	Transformations to Handle Non-normal Data with Parametric Statistical Tests.....	7-17
7.3.3	Examination for Extreme, Outlier, Missing, or Anomalous Values.....	7-17
7.3.3.1	Extremes and Outliers.....	7-17
7.3.3.2	Anomalous Values.....	7-19
7.3.3.3	Missing Data.....	7-20
7.3.4	Examination for Frequencies.....	7-20
7.3.5	Examination for Seasonality or Other Cycles.....	7-21
7.3.6	Autocorrelation.....	7-22
7.3.6.1	Methods to Handle Autocorrelation.....	7-28
7.3.6.2	Methods to Handle Autocorrelation Caused by Seasonality.....	7-29
7.3.7	Examination of Two or More Locations or Time Periods.....	7-30
7.3.8	Examine Relationships between Variables.....	7-31
7.3.9	Next Steps.....	7-33
7.4	Dealing with Censored Data.....	7-33
7.4.1	Types of Censoring.....	7-33
7.4.2	Methods for Handling Censored Data.....	7-34
7.4.2.1	Past Methods.....	7-34
7.4.2.2	Using Probability Distribution Theory to Estimate the Summary Statistics.....	7-35

7.4.2.3	Hypothesis Testing with Censored Data.....	7-35
7.5	Data Analysis for Problem Assessment.....	7-36
7.5.1	Problem Assessment – Important Considerations.....	7-36
7.5.2	Data Analysis Approaches.....	7-38
7.5.2.1	Summarize Existing Conditions.....	7-38
7.5.2.2	Assess Compliance with Water Quality Standards.....	7-39
7.5.2.3	Identify Major Pollutant Sources.....	7-41
7.5.2.4	Define Critical Areas.....	7-42
7.5.2.5	Additional Approaches.....	7-44
7.6	Data Analysis for Project Planning.....	7-47
7.6.1	Estimation and Hypothesis Testing.....	7-47
7.6.2	Determine Pollutant Reductions Needed.....	7-48
7.6.3	Estimate Land Treatment Needs.....	7-55
7.6.4	Estimate Minimum Detectable Change.....	7-55
7.6.5	Locate Monitoring Stations.....	7-56
7.7	Data Analysis for Assessing Individual BMP Effectiveness.....	7-56
7.7.1	Analysis of Plot Study Data.....	7-57
7.7.2	Analysis of BMP Input/Output Data.....	7-60
7.7.3	Analysis of BMP Above/Below Data.....	7-63
7.7.4	Analysis of BMP Paired-Watershed Data.....	7-65
7.8	Data Analysis for Assessing Project Effectiveness.....	7-65
7.8.1	Recommended Watershed Monitoring Designs.....	7-65
7.8.2	Recommended Statistical Approaches.....	7-66
7.8.2.1	Paired Watershed.....	7-66
7.8.2.1.1	Analysis of Covariance (ANCOVA) Procedure – Paired-Watershed Analysis.....	7-66
7.8.2.1.2	Multivariate ANCOVA-Paired Watershed with Explanatory Variables.....	7-73
7.8.2.1.3	Multiple Paired Watersheds.....	7-74
7.8.2.1.4	Multiple Time Periods within a Paired-Watershed Study.....	7-75
7.8.2.1.5	Other Statistical Approaches for Paired-Watershed Analyses.....	7-76
7.8.2.2	Above/Below – Before/After.....	7-77
7.8.2.2.1	Comparing Means and Differences between Means.....	7-77
7.8.2.2.2	ANCOVA.....	7-78
7.8.2.3	Nested Watershed.....	7-82
7.8.2.4	Single Watershed Trend Station.....	7-82
7.8.2.4.1	Monotonic Trends.....	7-85
7.8.2.4.2	Step Trends.....	7-90
7.8.2.5	Multiple Watersheds.....	7-90
7.8.3	Linking Water Quality Trends to Land Treatment.....	7-91
7.9	Load Estimation.....	7-93
7.9.1	General Considerations.....	7-94
7.9.1.1	Definitions.....	7-94
7.9.1.2	Issues of Variability.....	7-95
7.9.1.3	Practical Load Estimation.....	7-96
7.9.1.4	Planning for Load Estimation.....	7-99

7.9.2	Approaches to Load Estimation.....	7-100
7.9.2.1	Numeric Integration.....	7-100
7.9.2.2	Regression.....	7-100
7.9.2.3	Ratio Estimators.....	7-104
7.9.2.4	Comparison of Load Estimation Approaches.....	7-104
7.9.3	Load Duration Curves.....	7-105
7.9.4	Assessing Load Reductions.....	7-108
7.10	Statistical Software.....	7-108
7.11	References.....	7-109
8	Quality Assurance and Quality Control.....	8-1
8.1	Introduction.....	8-1
8.1.1	Definitions of Quality Assurance and Quality Control.....	8-2
8.1.1.1	Quality assurance:.....	8-2
8.1.1.2	Quality control:.....	8-2
8.1.2	Importance of QA/QC Programs.....	8-3
8.1.3	EPA Quality Policy.....	8-3
8.2	Data Quality Objectives.....	8-4
8.2.1	The Data Quality Objectives Process.....	8-5
8.2.1.1	(1) State the problem.....	8-6
8.2.1.2	(2) Identify the goal of the monitoring program.....	8-6
8.2.1.3	(3) Identify information inputs.....	8-6
8.2.1.4	(4) Define the boundaries of the study.....	8-6
8.2.1.5	(5) Develop the analytic approach.....	8-7
8.2.1.6	(6) Specify performance or acceptance criteria.....	8-7
8.2.1.7	(7) Develop the plan for obtaining data.....	8-8
8.2.2	Data Quality Objectives and the QA/QC Program.....	8-9
8.3	Elements of A Quality Assurance Project Plan.....	8-9
8.4	Field Operations.....	8-12
8.4.1	Field Design.....	8-12
8.4.2	Sampling Site Selection.....	8-12
8.4.3	Sampling Equipment.....	8-13
8.4.4	Sample Collection.....	8-13
8.4.5	Sample Handling and Transport.....	8-14
8.4.6	Safety and Training.....	8-14
8.5	Laboratory Operations.....	8-15
8.5.1	General Laboratory QA/QC.....	8-15
8.5.2	Instrumentation and Materials for Laboratory Operations.....	8-16
8.5.3	Analytical Methods.....	8-16
8.5.4	Method Validation.....	8-16
8.5.5	Training and Safety.....	8-16
8.5.6	Procedural Checks and Audits.....	8-17
8.6	Data and Reports.....	8-17
8.6.1	Generation of New Data.....	8-17

8.6.2	Use of Historical Data.....	8-18
8.6.3	Documentation, Record Keeping, and Data Management.....	8-18
8.6.4	Report Preparation	8-19
8.7	Geospatial Data.....	8-20
8.7.1	Performance Criteria for a Geospatial Data Project.....	8-20
8.7.2	Spatial Data Quality Indicators for Geospatial Data.....	8-21
8.8	References.....	8-22
9	Monitoring Costs.....	9-1
9.1	Introduction.....	9-1
9.2	Monitoring Cost Items and Categories	9-1
9.3	Cost Estimation Examples	9-3
9.3.1	Cost Estimates for a Diverse Range of Monitoring Options.....	9-4
9.3.1.1	Discussion.....	9-4
9.3.2	Cost Estimates for Watershed-Scale Evaluation of Agricultural BMP Implementation	9-6
9.3.2.1	Discussion.....	9-6
9.3.3	Cost Estimates for Five-Year Trend and Above/Below Monitoring	9-8
9.3.3.1	Discussion.....	9-9
9.3.4	Major Conclusions from Cost Estimation Scenarios	9-12
9.4	Using Minimum Detectable Change to Guide Monitoring Decisions	9-13
9.5	References.....	9-15
	Appendix 9-1. Overview of Cost Estimation Spreadsheets	9-16
	Appendix 9-2. Cost Estimates for a Diverse Range of Monitoring Options	9-22
	Appendix 9-3. Cost Estimates for Watershed-Scale Evaluation of Agricultural BMP Implementation.....	9-29
	Appendix 9-4. Cost Estimates for Five-Year Trend and Above/Below Monitoring.....	9-39

Figures

Figure 2-1. Vertical sediment concentration and flow velocity distribution in a typical stream cross section (after Brakensiek et al. 1979)	2-8
Figure 2-2. Schematic diagram of stream vertical showing position of sediment load terms (after Brakensiek et al. 1979)	2-9
Figure 2-3. Map of water quality monitoring stations in Lake Champlain lake regions (Lake Champlain Basin Program).....	2-10
Figure 2-4. Thermally stratified lake in mid-summer (USEPA 1990). Curved solid line is water temperature. Open circles are DO in an unproductive (oligotrophic) lake and solid circles are DO in a productive (eutrophic) lake.....	2-12
Figure 2-5. Wetlands and waterways of the Inland Bays watershed (DE CIB n.d.).....	2-13
Figure 2-6. Mixing of salt water and fresh water in an estuary (after CBP 1995).....	2-14
Figure 2-7. Salinity in the fall and spring in the Chesapeake Bay (CBF n.d.).....	2-16
Figure 2-8. Basic aquifer types	2-18
Figure 2-9. NO ₃ concentration versus depth to water table (after Rich 2001)	2-20
Figure 2-10. Determining ground water flow patterns (Winter et al 1998).....	2-20
Figure 2-11. Reconnaissance sampling design	2-35
Figure 2-12. Paired sampling design.....	2-37
Figure 2-13. Above/below sampling design	2-40
Figure 2-14. Input/output sampling design	2-42
Figure 2-15. Multiple input pathways for rain garden.....	2-42
Figure 3-1. Cross-sectional area and water velocity for streams and pipes	3-11
Figure 3-2. Traditional crest-stage gage	3-12
Figure 3-3. 120° V-notch weir, Englesby Brook, Burlington, VT	3-14
Figure 3-4. Field application of small Parshall flume.....	3-14
Figure 3-5. Palmer-Bowlus flume.....	3-15
Figure 3-6. 2-foot (0.6 m) H-flume in place for edge-of-field monitoring, East Montpelier, VT	3-15
Figure 3-7. Measuring stream discharge (USGS).....	3-16
Figure 3-8. Delineation of stream-width segments for discharge measurement.....	3-17
Figure 3-9. Measuring the cross-section profile of a stream channel	3-17
Figure 3-10. Measuring discharge from bridge using an ADCP (acoustic Doppler current profiler) unit (USGS 2007)	3-18
Figure 3-11. Measuring discharge from a bridge using a current meter and crane (USGS n.d.).....	3-18
Figure 3-12. Staff gauge in stream.....	3-19
Figure 3-13. Example of a stage-discharge rating for a stream	3-20

Figure 3-14. Stilling well design schematic (Wahl et al. 1995).....	3-21
Figure 3-15. Traditional clock-drive chart recorder at a stilling well.....	3-21
Figure 3-16. Simplified version of the nitrogen cycle.....	3-25
Figure 3-17. Possible sampling locations for a synoptic survey.....	3-39
Figure 3-18. Potential lake monitoring locations.....	3-40
Figure 3-19. Possible groundwater monitoring locations (after USDA-NRCS 2003).....	3-41
Figure 3-20. Schematic of sampling frequency as a function of system type (after USDA-NRCS 2003).....	3-44
Figure 3-21. MDC versus frequency and years of monitoring. Assumes $\rho=0.1$ for 26x/yr and 0.3 for 52x/yr, CV=0.7, and 95% confidence level.....	3-54
Figure 3-22. MDC versus confidence level. Assumes $\rho=0.1$ for 26x/yr and 0.3 for 52x/yr, 7 years of monitoring, and CV=0.7.....	3-54
Figure 3-23. MDC versus coefficient of variation. CV calculated using unadjusted std. dev. Assumes $\rho=0.1$ for 26x/yr and 0.3 for 52x/yr, 7 years of monitoring, and 95% confidence level.....	3-55
Figure 3-24. MDC versus coefficient of autocorrelation (ρ). Assumes 7 years of monitoring, 52x/yr, CV=0.7, and 95% confidence level. MDC = 13% if no autocorrelation is assumed.....	3-55
Figure 3-25. Monitoring station with submersible transducer in stream (Freeman et al. 2004).....	3-59
Figure 3-26. Drawing and field installation of depth-integrated sample arm for automatic samplers (photo by R.T. Bannerman, Wisconsin DNR).....	3-59
Figure 3-27. Edge-of-field monitoring stations. a, b, Wisconsin Discovery and Pioneer Farms (Stuntebeck et al. 2008); c, d, Vermont (Meals et al. 2011a).....	3-62
Figure 3-28. Examples of passive runoff samplers that can be used for edge-of-field or BMP studies (A-Graczyk et al. 2000, B-Waschbusch et al. 1999, C-Brakensiek et al. 1979, and D-Parker and Busch 2013; photo D by P. Parker, University of Wisconsin-Platteville).....	3-63
Figure 3-29. Flow measurement and water quality sampling in stormwater pipes.....	3-64
Figure 3-30. Examples of first-flush runoff samplers (A-Nalgene 2007, B-Barrett 2005, C-GKY 2014).....	3-65
Figure 3-31. Passive sampling setup for lawn runoff (after Waschbusch et al. 1999).....	3-66
Figure 3-32. Examples of automatic samplers with capabilities for variable sampling frequencies (Hach® 2013a, Teledyne Isco 2013a).....	3-66
Figure 3-33. Precipitation gage placement relative to obstructions.....	3-68
Figure 3-34. Photograph of a meteorological monitoring station (Meals et al. 2011a).....	3-68
Figure 3-35. Measuring dissolved oxygen, specific conductance, pH, and water temperature using a hand-held probe.....	3-71
Figure 3-36. Examples of isokinetic depth-integrating samplers (Wilde et al. 2014).....	3-72
Figure 3-37. Depth-specific samplers for lake sampling (Wilde et al. 2014).....	3-73

Figure 3-38. Examples of passive samplers. a, Passive runoff sampler/flow splitter, University of Georgia, Tifton, GA (photo by D.W. Meals); b, Multi-slot divisor (after Brakensiek et al. 1979); c, Water and sediment sampler (Dressing et al. 1987, photo by S.A. Dressing).....	3-74
Figure 3-39. Single-stage passive sampler (diagram: Wilde et al. 2014, photo by D.W. Meals).....	3-75
Figure 3-40. Lysimeters before and after installation (photos by R. Traver, Villanova University).....	3-76
Figure 3-41. Examples of portable and refrigerated autosamplers (Hach® 2013b, Teledyne Iso 2013b).....	3-77
Figure 3-42. Preparing to take samples in a low-gradient stream.....	3-79
Figure 3-43. Using a D-frame net to sample a gravel bottom stream for benthic macroinvertebrates.....	3-79
Figure 3-44. Sampling devices for biological and habitat variables. a, D-frame net; b, Surber sampler (Rickly 2016); c, Ponar dredge (Rickly 2016); d, Hester-Dendy artificial substrate (Rickly 2016); e, Rock basket artificial substrate (Ben Meadows 2016).....	3-80
Figure 3-45. Backpack electrofishing (USEPA).....	3-81
Figure 3-46. Field processing of fish sample: taxonomic identification and data recording.....	3-81
Figure 3-47. Plankton nets (NOAA 2014).....	3-82
Figure 3-48. Churn and cone splitters (FISP 2014).....	3-84
Figure 3-49. Examples of agricultural activity data recording forms.....	3-93
Figure 3-50. Weekly (top panel) and monthly and quarterly (bottom panel, solid and dashed lines, respectively) load time series superimposed on idealized daily load time series (adapted from Richards 1998).....	3-103
Figure 4 1. Using a D-frame net to sample woody snag habitat for stream benthic macroinvertebrates.....	4-8
Figure 4 2. Approach to establishing reference conditions (after Gibson et al. 1996).....	4-13
Figure 4 3. Removing a benthic macroinvertebrate sample from a sieve bucket and placing the sample material in a 1-liter container with approximately 95% ethanol preservative.....	4-31
Figure 4 4. Labelling benthic macroinvertebrate sample containers and recording field data.....	4-32
Figure 4 5. Examining, washing, and removing large components of sample material prior to putting in sample container.....	4-34
Figure 4 6. Percent degradation of subwatersheds as measured by biological monitoring and assessment, Lake Allatoona/Upper Etowah River watershed (Millard et al. 2011).....	4-49
Figure 4 7. Distribution of stream biological assessments in the Lake Allatoona/Upper Etowah River watershed, using a benthic MMI developed by the Georgia Environmental Protection Division (Millard et al. 2011).....	4-51
Figure 4 8. More detailed examination of the Yellow Creek subwatershed, Lake Allatoona/Upper Etowah River watershed, Georgia, reveals a sample location, rated biologically as “poor,” is on a stream flowing through a poultry production operation (Millard et al. 2011).....	4-52
Figure 5-1. Comparison photos.....	5-4
Figure 5-2. Illustration of a photo identification card and a meter board.....	5-6

Figure 5-3. Photo illustrating photo points (A and B) and camera points (1 and 2). Photos of A and B are taken from cameras located at 1 and 2.....	5-10
Figure 5-4. Photo identification card.....	5-16
Figure 5-5. Various potential applications of photo-point monitoring.....	5-21
Figure 6-1. Detection of violation of sampling protocol (R.P. Richards, Heidelberg University, Tiffin, OH).....	6-3
Figure 6-2. Effects of changing (1) a defective probe and (2) a laboratory method detection limit (Meals 2001).....	6-4
Figure 6-3. Lag time conceptual model.....	6-5
Figure 7-1. Right-skewed distribution.....	7-14
Figure 7-2. Quantile plot or cumulative frequency plot of E. coli data, Berry Brook, 1996 (Meals 2001).....	7-16
Figure 7-3. Boxplot of weekly TP concentration, Samsonville Brook, 1995 (Meals 2001).....	7-16
Figure 7-4. Time plot of weekly TP concentration, Godin Brook, 1999 (Meals 2001).....	7-19
Figure 7-5. Time plot of TKN data from three stream stations, 1995-1996 (Meals 2001).....	7-19
Figure 7-6. Percent composition of the orders of macroinvertebrates, Godin Brook, 2000 (Meals 2001).....	7-21
Figure 7-7. Time series plot of weekly E. coli counts, Godin Brook, 1995-1999 (Meals 2001). Red line indicates Vermont WQS of 77 E. coli/100 ml.....	7-21
Figure 7-8. Lag-one plot of streamflow observations, Samsonville Brook, 1994 (Meals 2001).....	7-23
Figure 7-9. A) Time series plot, B) autocorrelation function (ACF) graph, and C) partial autocorrelation function (PACF) graph of Log(10) weekly flow from the Corsica River National Nonpoint Source Monitoring Program Project generated by Minitab. The steps are: Stat > Time Series > Autocorrelation (or Partial Autocorrelation). Identify the time series variable and enter number of lags. Select options for storing ACF, PACF, t statistics, and Ljung-Box Q statistics as desired. Press ok.....	7-25
Figure 7-10. Autocorrelation Function (ACF) graph of weekly flow from the Corsica River National Nonpoint Source Monitoring Program Project generated by JMP. The steps are: Click “Analyze” tab, select “Modeling” followed by “Time Series.” Select Y time series (LFLOW) and X time series (Date).....	7-26
Figure 7-11. A) Time series plot, B) autocorrelation function (ACF) graph, and C) partial autocorrelation function (PACF) graph of data with zero autocorrelation (i.e., independent data with respect to time).....	7-27
Figure 7-12. Boxplots of TSS concentration for three stream stations, 1998 (Meals 2001).....	7-30
Figure 7-13. Scatterplot of weekly TP export from control and treatment watersheds, calibration period (Meals 2001).....	7-31
Figure 7-14. Scatterplot of E. coli vs. streamflow, Godin Brook, 1995-1998, all data combined (Meals 2001).....	7-32
Figure 7-15. Scatterplot of E. coli vs. streamflow, Godin Brook, 1995-1998, where solid circles = winter, open circles = summer (Meals 2001).....	7-32

Figure 7-16. Boxplots of conductivity at three Vermont monitoring stations, October 1999 – September 2000 (Meals 2001).....	7-39
Figure 7-17. Example time series plot of observed aluminum concentrations compared to water quality criteria.....	7-40
Figure 7-18. Cumulative frequency plot of three years of <i>E. coli</i> data from a Vermont stream (adapted from Meals 2001). Red lines represent frequency of observations at or below the VT WQS of 77 cfu/100 ml and the frequency of observations at or below the EPA criterion of 235 cfu/100 ml.....	7-41
Figure 7-19. Map of synoptic sampling results from 41 stations in the Corsica River Watershed (Maryland) for NO ₂ +NO ₃ -N concentration (Primrose 2003). Pink and red shaded subwatersheds represent drainage areas contributing high (3-5 mg/L) and excessive (>5 mg/L) NO ₂ +NO ₃ -N concentrations, respectively.....	7-43
Figure 7-20. Correspondence analysis biplot of Grande Ronde fish data (Drake, 1999).....	7-45
Figure 7-21. Regression of output versus input load (data from Erickson et al. 2010b).....	7-61
Figure 7-22. Effluent probability plot for input/output monitoring of a wet detention pond.....	7-63
Figure 7-23. Conceptualized regression plots for paired-watershed data. The red line indicates the comparison of the treatment watershed from the calibration vs. treatment periods evaluated at the LSMEANS value of 2.5 (the mean of all sampled values in the control watershed over the entire sampling duration (both treatment and calibration period).....	7-69
Figure 7-24. Example of intersecting regression lines (Meals 2001).....	7-75
Figure 7-25. Basic data preparation and analysis procedure for above/below-before/after study in Pennsylvania (Galeone et al. 2006).....	7-80
Figure 7-26. Linking stream nitrate concentration to land cover (Schilling and Spooner 2006).....	7-93
Figure 7-27. Imaginary plot of pollutant flux over time at a monitoring station (Richards 1998).....	7-94
Figure 7-28. Plot of suspended solids loads for the Sandusky River, water year 1985 (Richards 1998). Top, daily TSS samples; Middle, weekly samples; Bottom, monthly samples. Weekly and monthly sample values were drawn from actual daily sample data series. Flux is on y-axis, time is on x-axis, and area under curve is load estimate.....	7-96
Figure 7-29. Weekly (red line in top panel), monthly (red line), and quarterly (black line in bottom panel) suspended solids load time series superimposed on a daily load time series (Richards 1998). Log of flux is on y-axis, time is on x-axis, and area under curve is load estimate.....	7-97
Figure 7-30. Flow-concentration regressions from the Maumee River, Ohio (Richards 1998). Top panel, regression relationship between log of total suspended solids concentration and log of flow for the 1991 water year dataset; Bottom panel, plot of same data divided into two groups based on time of year. Within each season, the regression model is stronger, has lower error, and provides a more accurate load estimate.....	7-102
Figure 7-31. Flow duration curve for the Sevier River near Gunnison, UT, covering the period January 1977 through September 2002.....	7-107
Figure 7-32. Load duration curve for the Sevier River near Gunnison, UT, January 1977 through September 2002. Blue line represents allowable total P load calculated as the product of each observed flow duration interval and the target total P concentration of 0.05 mg/L. Yellow points represent observed total P loads at the same flow duration intervals.....	7-107

Figure 9-1. Breakout of costs for diverse range of monitoring options9-5

Figure 9-2. Cost estimates for watershed-scale assessment of agricultural BMP projects9-7

Figure 9-3. Comparison of labor cost category percentage over time9-8

Figure 9-4. Box plots summarizing cost estimates for five-year monitoring efforts9-10

Figure 9-5. Box plots summarizing five-year labor costs9-11

Figure 9A1-1. Pie chart from simplified spreadsheet9-20

Tables

Table 1 1. National causes of impairment (excerpted from USEPA 2016)	1-4
Table 1 2. National probable sources contributing to impairments (excerpted from USEPA 2016).....	1-5
Table 1 3. National cumulative TMDLs by pollutant (excerpted from USEPA 2016).....	1-5
Table 2-1. Complementary program and monitoring objectives	2-3
Table 2-2. Selected NPS pollutants and watershed source activities to monitor	2-23
Table 2-3. Monitoring scale as a function of objective.....	2-33
Table 2-4. Monitoring design as a function of objective	2-44
Table 3-1. Monitoring variable groups by direct relationship to selected designated water use (adapted from USDA-NRCS 2003).....	3-4
Table 3-2. Monitoring variables by selected water resource types (adapted from USDA-NRCS 2003).....	3-5
Table 3-3. Monitoring variable groups by selected nonpoint source activities (adapted from USDA-NRCS 2003)	3-6
Table 3-4. Representative laboratory analytical costs for selected water quality variables. Costs will vary by region and by laboratory (Dressing 2014).....	3-7
Table 3-5. EPA-recommended preservation conditions and hold times for selected water quality variables (40 CFR 136.3 and NEMI 2006).....	3-8
Table 3-6. Selected physical and chemical water quality variables commonly measured in NPS watershed monitoring programs	3-23
Table 3-7. Selected biological water quality variables commonly measured in NPS watershed monitoring programs	3-28
Table 3-8. Anderson Level II land use and land cover classification system for use with remote sensor data (Anderson et al. 1976)	3-33
Table 3-9. Sample type as a function of monitoring objective (adapted from USDA-NRCS 2003).....	3-34
Table 3-10. Number of total samples per indicated sample frequency and number of years	3-46
Table 3-11. Values of $\sqrt{(X_i - \bar{X})^2}$ for biweekly sampling for selected monitoring durations, assuming X_i is measured as a ‘Date’ or daily variable.....	3-47
Table 3-12. Required containers, preservation techniques, and holding times.....	3-85
Table 3-13. Relationship of water quality and land use/land treatment variables	3-98
Table 4 1. General strengths and limitations of biological monitoring and assessment approaches	4-12
Table 4 2. Comparison of probability-based and targeted monitoring designs	4-15
Table 4 3. Waterbody stratification hierarchy	4-29
Table 4 5. Metrics and associated scoring formulas for four site classes from an example monitoring and assessment program	4-44
Table 4 6. Degradation thresholds to which MMI score are compared for determination of status.....	4-47

Table 6 1. Examples of lag times reported in response to environmental impact or treatment	6-9
Table 7-1. Exploratory data analysis methods (see discussion, section 7.3)	7-2
Table 7-2. Methods for adjusting data for subsequent analysis (see discussion, section 7.3)	7-4
Table 7-3. Methods to deal with censored data (see discussion, section 7.4).....	7-5
Table 7-4. Data analysis methods for problem assessment (see discussion, section 7.5).....	7-6
Table 7-5. Data analysis methods for project planning (see discussion, section 7.6).....	7-7
Table 7-6. Data analysis methods for assessing BMP or watershed project effectiveness (see discussion, sections 7.7 and 7.8).....	7-8
Table 7-7. Practice datasets.....	7-10
Table 7-8. Classification of tests for monotonic (nonparametric) or linear (parametric) trend (adapted from Helsel and Hirsch 2002).....	7-86
Table 7-9. Sampling of available statistics software packages	7-108
Table 8 1. Common QA/QC activities.....	8-2
Table 8 2. Elements required in an EPA Quality Assurance Project Plan. (USEPA, 2001b).....	8-10
Table 8 3. Continuum of Geospatial Projects with Differing Intended Uses.....	8-20
Table 9 1. Costs grouped by type of item or activity.....	9-2
Table 9 2. Costs grouped by project phase or element	9-2
Table 9 3. Summary of scenario costs for diverse range of monitoring options.....	9-5
Table 9 4. Labor costs assumed for watershed-scale evaluation scenarios.....	9-6
Table 9 5. Cost reductions due to lowering of labor and equipment costs	9-12
Table 9 6. Illustration of costs and MDC in response to changes in sampling program in Tillamook Bay, Oregon (Spooner et al. 1987).....	9-14
Table 9A1-1. Sample type and variable set options for simplified spreadsheet	9-17
Table 9A1 2. Grab sampling variable sets	9-17
Table 9A1 3. Load monitoring variable sets.....	9-18
Table 9A1-4. Biological monitoring variable sets	9-19
Table 9A1-5. Sondes monitoring variable sets	9-19
Table 9A1-6. Tabular output from simplified spreadsheet.....	9-20
Table 9A1-7. Annual costs from simplified spreadsheet.....	9-21
Table 9A2-1. Labor costs assumed for scenarios.....	9-23
Table 9A2-2. Total costs for eight diverse scenarios.....	9-28
Table 9A3-1. Driving and labor assumptions for discharge observations as stand-alone trips	9-31
Table 9A3-2. Sampling distances and times within watersheds	9-31
Table 9A3-3. Field work costs for site selection	9-32
Table 9A3-4. Major equipment and materials costs for stations measuring continuous discharge	9-33
Table 9A3-5. Site establishment costs for sites designed for load estimation	9-33

Table 9A3-6. Site demolition and restoration costs9-34

Table 9A3-7. Driving and labor assumptions for land use/treatment tracking9-35

Table 9A3-8. Labor assumptions for data analysis and reporting9-35

Table 9A4-1. Factors used in creating cost estimation scenarios9-39

Table 9A4-2. Watershed characterization costs as function of design and watershed size9-40

Table 9A4-3. Variability of costs for data analysis and reporting9-40

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Acronym List

AA	atomic absorption
ac	acre
ac/ft	acre-foot
ACF	autocorrelation function
ADCP	acoustic Doppler current profiler
AFDM	ash-free dry mass
Ag	silver
Al	aluminum
ANCOVA	analysis of covariance
ANOVA	analysis of variance
APA	acid/alkaline phosphatase activity
ARIMA	autoregressive integrated moving average
As	arsenic
ATTAINS	assessment TMDL tracking & implementation system
Au	gold
BCG	biological condition gradient
BEACH	beaches environmental assessment, closure and health
BioK	biological/habitat with kick net
BMP	best management practice
BOD	biochemical oxygen demand
BOD₅	5-day biochemical oxygen demand
CADDIS	causal analysis/diagnosis decision information system
CAFO	concentrated animal feeding operation
CCA	canonical correlation analysis <i>and</i> canonical correspondence analysis
C-CAP	coastal change analysis program
Cd	cadmium
CEAP	conservation effects assessment project

cfs	cubic feet per second
CI	confidence interval
Cl⁻¹	chloride
cm	centimeter
cms	cubic meters per second
Co	cobalt
COD	chemical oxygen demand
Cu	copper
CV	coefficient of variation
CWA	Clean Water Act
DBI	diatom bioassessment index
DD	detectable difference
DEM	digital elevation model
d.f.	degree of freedom
DIA	digital image analysis
DL	detection limit
DO	dissolved oxygen
DQO	data quality objective
EDA	exploratory data analysis
EDI	equal discharge interval
EMC	event mean concentration
EMMA	environmental monitoring and measurement advisor
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera-Plecoptera-Trichoptera
EWI	equal width interval
Fe	iron
FSA	Farm Service Agency
ft	feet
ft³/s	cubic feet per second
GIS	geographic information system

GPS	global positioning system
H₂SO₄	sulfuric acid
ha	hectare
HBI	Hilsenhoff Biotic Index
Hg	mercury
HNO₃	nitric acid
IBI	Index of Biological Integrity
ICP	inductively coupled plasma
in	inch
IQR	interquartile range
IR	integrated reporting
IWL	Izaak Walton League
kg	kilogram
KS	Kolmogorov-Smirnov
L	liter
Li	lithium
LA	load allocation
LIA	line-intersect analysis
LID	low impact development
LiDAR	light detection and ranging
LOWESS	locally weighted scatterplot smoothing
LS-means	least square means
LSD	least significant difference
LULC	land use/land cover
m	meter
m³/s	cubic meters per second
MA	moving average
MAI	macroinvertebrate aggregated index
MBI	macroinvertebrate biotic index
MDC	minimum detectable change

MDNR	Maryland Department of Natural Resources
mg	milligram
mi	mile
ml	milliliter
MLE	maximum likelihood estimation
mm	millimeter
MMI	multimetric index
Mn	manganese
MOS	margin of safety
MQO	measurement quality objective
mRPD	median relative percent difference
N	nitrogen
NAWQA	national water-quality assessment program
NELAC	national environmental laboratory accreditation conference
NEMI	national environmental methods index
NGO	non-governmental organization
NH₃-N	ammoniacal nitrogen
Ni	nickel
NLCD	national land cover dataset
NNPSMP	national nonpoint source monitoring program
NO₃	nitrate nitrogen
NPDES	national pollution discharge elimination system
NPS	nonpoint source
NRCS	Natural Resources Conservation Service
NRI	national resources inventory
NRSA	national rivers and streams assessment
NSC	nutrient and sediment grab samples
NSL	nutrient and sediment loads
NWQI	national water quality initiative
O/E	observed/expected

P	phosphorus
PACF	partial autocorrelation function
Pb	lead
PCA	principal component analysis
PDTG	percent dominant taxa (generic level)
PGDER	Prince George's County Department of Environmental Resources
PIBI	potential index of biological integrity
POCIS	polar organic chemical integrative samplers
PPCC	probability plot correlation coefficient
PROC AUTOREG	SAS procedure to estimate and forecast linear regression models for time series data
QAP	quality-assurance plan (USGS)
QAPP	quality assurance project plan
QHEI	qualitative habitat evaluation index
QL	quantitation limit
QMP	quality management plan
RCB	randomized complete block
RCWP	rural clean water program
ROS	regression on order statistics
RPD	relative percent difference
RUSLE	revised universal soil loss equation
SA	subjective analysis
SAP	sampling and analysis plan
SAS	SAS Institute, Inc.
Sb	antimony
SCC	suspended sediment concentration
SIMPLE	spatially integrated models for phosphorus loading and erosion
SNT	sondes for nutrients and turbidity
SO₄⁻²	sulfate
SOP	standard operating procedure

SPARROW	spatially referenced regressions on watershed attributes watershed modeling technique
SRP	soluble reactive phosphorus
SSC	suspended sediment concentration
STEPL	spreadsheet tool for estimating pollutant load
STORET	EPA's storage and retrieval database for water quality, biological, and physical data
SWAT	soil and water assessment tool
SWM	statewide monitoring network
SWP	stormwater detention/retention pond
TDS	total dissolved solids
TIGER	topologically integrated geographic encoding and referencing
TIR	thermal infrared
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TNTC	too numerous to count
TP	total phosphorus
TSS	total suspended solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VIF	variance inflation factor
W/D	width-to-depth ratio
WLA	waste load allocation
WQS	water quality standards
WRTDS	weighted regressions on time, discharge, and season
WWTP	wastewater treatment plant
Zn	zinc