Measuring Water Quality Improvements:
TMDL Implementation Progress, Indicators, and Tracking

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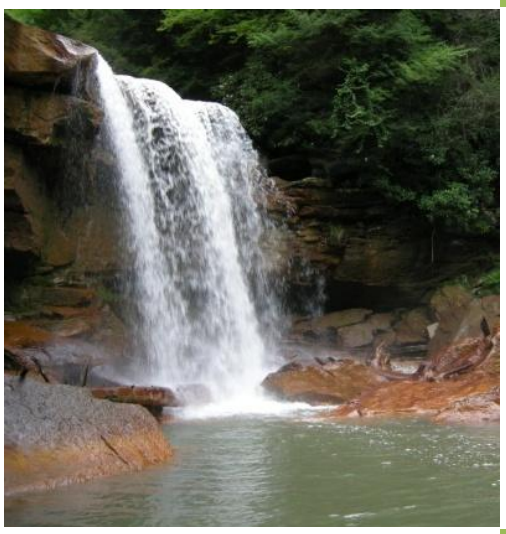

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Downstream Strategies
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ABBREVIATIONS

ADB	Assessment Database
ASIWPCA	Association of State and Interstate Water Pollution Control Administrators
ATTAINS	Assessment TMDL Tracking and Implementation System
BMP	best management practice
CALM	Consolidated Assessment and Listing Methodology
CWA	Clean Water Act
DIP	Detailed Implementation Plan
FWPCA	Federal Water Pollution Control Act
FY	fiscal year
GRTS	Grants Reporting and Tracking System
ICIS	Integrated Compliance Information System
IMWG	State-USEPA Incremental Measures Workgroup
ISGS	Illinois State Geological Survey
KSU	Kent State University
LA	load allocation
MPCA	Minnesota Pollution Control Agency
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTTS	National TMDL Tracking System
NWPG	National Water Program Guidance
OIG	Office of Inspector General
PCS	Permit Compliance System
SP	strategic planning
STORET	STOrage and RETrieval
TMDL	total maximum daily load
US	United States
USEPA	United States Environmental Protection Agency
WLA	wasteload allocation
WQ	water quality
WRC	Water Resources Center

EXECUTIVE SUMMARY

In recent years, state environmental agencies and the United States Environmental Protection Agency have developed and approved tens of thousands of Total Maximum Daily Loads for impaired waters across the country. Total Maximum Daily Loads set the amount of a pollutant that a water body can receive and still comply with water quality standards. They also allocate pollutant loading reductions among pollution sources; reductions that are needed to bring water bodies into compliance with water quality standards. While there has been significant progress in developing Total Maximum Daily Loads since the 1990s, we are still learning about the extent to which pollutant loading reductions described in Total Maximum Daily Loads are being implemented.

This report summarizes and synthesizes recent studies that assess progress in implementing Total Maximum Daily Loads and describes indicators that can be used to understand progress in watershed restoration. It also overviews efforts to improve the ability of state and federal agencies to document progress in Total Maximum Daily Load implementation and water body restoration progress. The report recommends that the United States Environmental Protection Agency and state environmental agencies consider new indicators of implementation progress, accelerate current efforts to document water restoration progress, and expand research and communications across federal and state programs to build knowledge of Total Maximum Daily Load implementation and watershed restoration activities. Aggressive efforts in these areas hold the potential to supplement our nation's desired focus on "watershed management" with information that is actually needed to prioritize and manage water quality improvement efforts on a watershed basis.

The project team undertook a series of activities that enabled development of this report. These activities included:

- reviewing available literature on Total Maximum Daily Load implementation and the development of indicators on implementation progress;
- attending a conference of state Total Maximum Daily Load coordinators in United States Environmental Protection Agency Region 5;
- conducting a Total Maximum Daily Load implementation workshop with state officials and other water professionals at the 2009 Water Environment Federation Specialty Conference on Total Maximum Daily Loads; and
- participating in a series of meetings involving the State-United States Environmental Protection Agency Incremental Measures Workgroup, a group of state and federal officials that has identified concerns with existing measures of water quality restoration progress and developed alternative measures.

Through its literature review and other activities, the project team identified eight major studies on Total Maximum Daily Load implementation and watershed restoration to summarize and synthesize in this report. Four of the studies focused on Total Maximum Daily Load implementation progress, while the remaining four focused on indicators of progress and tracking systems.

The findings presented in the report lie in three main areas: (1) the prevalence of Total Maximum Daily Load implementation and the factors that drive it, (2) indicators of implementation progress, and (3) current efforts to understand and report on progress. The paragraphs that follow summarize key findings in these areas, and they also provide a brief description of recommendations growing from this work.

First, the findings here suggest that action is being taken by state and local stakeholders to implement recommendations found in Total Maximum Daily Load documents, but these actions are not comprehensive or consistent across all established Total Maximum Daily Loads. While the studies reviewed suggest that at least some planning and implementation activities are being undertaken in a majority of cases, they also

indicate that there are cases in which few—if any—implementation efforts are undertaken after Total Maximum Daily Load approval. The studies reviewed also suggest that environmental improvements are not consistently achieved after Total Maximum Daily Load approval. Drawing on a subset of the studies investigated, the report also suggests that several factors appear to be useful in predicting Total Maximum Daily Load implementation progress. Viewed in totality, for example, existing studies suggest that Total Maximum Daily Load implementation for point sources tends to occur more reliably than for nonpoint sources. Other factors that appear likely to influence Total Maximum Daily Load implementation progress include stakeholder engagement in Total Maximum Daily Load development, financial support for nonpoint source project implementation, the active engagement of state agency personnel in Total Maximum Daily Load implementation efforts, and the existence of watershed planning processes. However, while the studies reviewed provide information on Total Maximum Daily Load implementation in certain geographic areas, they also suggest that efforts to understand Total Maximum Daily Load implementation are not complete or widespread. Our knowledge of Total Maximum Daily Load implementation and watershed restoration progress is therefore incomplete and there is a need for further research in this area.

Second, the studies reviewed highlight many different indicators that could be used to assess Total Maximum Daily Load implementation progress, and these indicators can be tied to different kinds of conceptual frameworks for ongoing assessments. As a result, there is a need for improved communications across federal and state water quality agencies and programs (e.g., Total Maximum Daily Load programs, point source permitting, nonpoint source grants, farm programs) to designate appropriate indicators of Total Maximum Daily Load implementation and watershed restoration progress. And finally, while there are opportunities for productive leadership on implementation indicators at multiple levels of government, it is also clear that additional information—above and beyond the indicators themselves—is necessary to make full and productive use of indicators to manage water quality issues on a watershed basis. For example, geographic information on contributing sources, information on pollutants and impairments, and knowledge of specific pollutant reduction efforts are all needed to support ongoing and watershed-based adaptive management efforts to restore impaired waters.

And third, while there is significant interest in Total Maximum Daily Load implementation and indicators of watershed restoration progress among federal and state officials, there appear to be few complete efforts to compile information on progress in ways that can support ongoing adaptive management efforts at the watershed level. The United States Environmental Protection Agency's strategic planning processes are useful and include indicators relating to water quality improvement, but observers suggest that they have not as yet been fully successful in reflecting actual watershed restoration progress at sub-national levels. The studies reviewed here appear to support this suggestion, as they identify progress in Total Maximum Daily Load implementation that does not appear to be well accounted for by existing national indicators.

At the state level, efforts to develop indicators and track progress in watershed restoration appear to be highly variable. Washington, for example, has an effectiveness monitoring program in place and Minnesota has undertaken significant efforts to develop indicators and systems for tracking progress since passage of its Clean Water Legacy Act in 2006. Virginia has also developed ongoing indicators of water quality improvement. However, while many states seek to identify progress in a variety of ways, fully operating systems for identifying and tracking Total Maximum Daily Load and watershed restoration progress do not appear to be common among the states.

One promising effort to investigate indicators of watershed restoration progress was the establishment of a joint United States Environmental Protection Agency and state workgroup during the summer of 2009. The Incremental Measures Workgroup was charged with reviewing current national measures of progress and identifying ways to improve our understanding of the impact that the national water quality program has had on water quality restoration progress. Between August 2009 and December 2010, the Incremental Measures Workgroup held a number of meetings and conference calls to assess indicators in the United States

Environmental Protection Agency Strategic Plan and to develop alternative indicators for consideration at the national level. The Incremental Measures Workgroup developed four alternative indicators and, in December 2010, offered two indicators—one relating to watershed planning and one related to water quality improvement—for consideration by the agency. This report also overviews the work of the Incremental Measures Workgroup, and includes discussions of the criteria by which it assessed indicators of water restoration progress and descriptions of the indicators that it forwarded for review by senior agency staff.

This report also offers recommendations to guide future efforts to develop and use indicators of Total Maximum Daily Load implementation and watershed restoration progress to help foster improvements in water quality throughout the United States. It suggests that serious consideration be given to the two new measures forwarded by the Incremental Measures Workgroup, and also recommends that further work be done to develop indicators that are tied to the actual implementation of projects to reduce pollutant loads to impaired watersheds. By tying indicators of actual implementation to specific Total Maximum Daily Loads and watersheds, states, the United States Environmental Protection Agency, and others can build needed bridges between identified water quality impairments that need to be addressed and actual water quality improvement efforts. In the end, it is this link that can help force disparate water quality programs (e.g., point source permitting, nonpoint source grants) to become tied more explicitly and more uniformly to the protection of watersheds and long term progress toward the goals of the Clean Water Act. In addition, because the project team found that knowledge regarding watershed restoration progress is still quite limited, the report also suggests a need for accelerated research and stakeholder engagement to improve our collective understanding of Total Maximum Daily Load implementation and watershed restoration progress.

The national water quality program now stands at a turning point. Water pollution control efforts need to be prioritized at the watershed level to enable more efficient and effective progress in restoring impaired water bodies and in protecting water bodies that are not impaired. Total Maximum Daily Loads, the implementation of recommendations contained in them, and the development of indicators and processes for communicating about progress hold the potential for enabling the kind of watershed-based prioritization that is necessary to further progress toward the Clean Water Act's ambitious goals. If implemented, we believe that the recommendations made here can contribute productively to this process.

1. INTRODUCTION

In spite of almost four decades of major federal and state efforts to improve water quality in the United States (US), waters throughout the US remain polluted from a wide range of sources. According to the United States Environmental Protection Agency (USEPA), 50% of assessed river and stream miles, 66% of assessed lake acres, and 64% of assessed bay and estuary areas do not meet state water quality standards (USEPA, 2011). As a result of these widespread water quality problems, over the last decade and a half, the USEPA and state environmental agencies have developed more than 44,000 total maximum daily load (TMDL) assessments to allocate pollutant load reductions among key sources that contribute to the contamination of these water bodies (USEPA, 2011). As these figures suggest, the scale of the nation's water quality problems are reasonably well known.

Unfortunately, the same cannot be said about our efforts to clean up the water bodies that have been contaminated. While government agencies have been investing monies in water pollution control, imposing regulatory controls, and implementing projects to control diffuse sources of water pollution, we do not have well-developed ways to understand how these pollution abatement efforts are connected to actual water quality problems. This is a cause for concern because it means that we cannot effectively tie policy decisions about where to invest resources and efforts with feedback regarding the efforts' effectiveness in cleaning up particular water bodies.

This obvious deficiency in our system for managing water quality has become more evident in recent years as TMDLs have been developed that include both pollutant load allocations and recommendations for implementation actions that can enable these allocations to be met. USEPA and some state environmental agencies have sought to address this deficiency by conducting and sponsoring studies of TMDL implementation in various parts of the country. There has also been discussion about developing indicators and tracking systems to monitor TMDL implementation and watershed restoration progress. Several studies have been conducted to assess national and state efforts in this area as well.

This report serves five purposes. First, it summarizes and synthesizes information from recent studies of both TMDL implementation progress and efforts to develop and track indicators of this progress. Second, the report draws lessons from these studies to help in the identification and potential use of various indicators of TMDL implementation progress. Third, the report outlines key questions that should be addressed in determining ways to improve our knowledge of TMDL implementation. The questions posed can also provide a foundation for discussions regarding ways in which TMDL implementation indicators may be used and tracked productively in the future. The fourth purpose of this report is to provide an overview of work done in connection with the work of the State-USEPA Incremental Measures Workgroup (IMWG), a group established by USEPA and the states to recommend possible incremental measures of progress in TMDL implementation and watershed restoration. And fifth, the report provides suggestions for next steps which can be taken to enable the use of TMDLs and efforts to measure TMDL implementation progress to foster improvements in the nation's water quality protection programs.

Methodologically, the research team undertook a series of activities to develop the knowledge base underlying this report. We reviewed available literature about TMDL implementation and held several discussions with knowledgeable USEPA officials about current work in this area. We also participated in a conference of state TMDL coordinators in USEPA Region 5 in Red Wing, Minnesota (in April 2009) and in a workshop on TMDL implementation in Minneapolis, Minnesota (in August 2009). Through these efforts, we identified eight major studies relating to TMDL implementation, four of which focused on assessing progress in this area and four of which focused on topics relating to indicators and tracking systems. We also collected insights from water quality program professionals and gathered targeted information from various Web sites. In addition, in 2010, we participated in a series of meetings—both long-distance by phone conference and in-person in Washington, DC—with the IMWG, a group of state and federal officials who were tasked with

identifying concerns with existing measures of water quality restoration progress and developing potentially improved measures for future consideration.

The report proceeds in Section 2 by providing background information on the nation's water quality protection programs, and the role of TMDLs and the study of TMDL implementation in those programs. In Section 3, we overview one major framework for understanding TMDL implementation progress and summarize recent studies that quantify progress achieved in several states and regions of the country. Section 4 is structured similarly, but focuses on studies of TMDL implementation indicators and tracking systems. Following the presentation of study results, Sections 3 and 4 describe what we have learned from these studies—lessons that may prove useful in the identification of TMDL implementation indicators and the improvement of our knowledge base concerning TMDL implementation progress.

Section 5 then addresses a series of key questions that should be addressed as efforts to improve our knowledge base on TMDL implementation proceed on national and sub-national levels. In so doing, it provides evaluative criteria which can be used as a foundation for analyses of alternative measures of TMDL implementation progress. In Section 6, we apply these criteria to analyze a series of measures developed by the IMWG, and review other analyses and the conclusions reached by the group during a meeting held in December 2010. In Section 7, the concluding section, we offer thoughts on next steps that states and USEPA may want to take in developing and using information to enhance current efforts to implement TMDLs and improve water quality restoration progress.

2. BACKGROUND[1]

Prior to World War II, water quality management in the US was viewed as the province of state and local governments. Federal engagement in water pollution policy began shortly after World War II, and grew in piecemeal fashion for the next two decades. Around 1970, several national events called attention to the growing environmental movement—the 1969 burning of the Cuyahoga River in Ohio, the Santa Barbara oil spill in 1969, and the first Earth Day in 1970—and, in 1972, Congress re-wrote and passed the Federal Water Pollution Control Act (FWPCA) to emphasize federally imposed technology-based regulatory controls on industrial dischargers and municipal sewerage systems. These controls took the form of a new permitting program, the National Pollutant Discharge Elimination System (NPDES), which required the issuance of permits for all point source discharges to waters of the US.

At the same time, however, Congress retained language in the new law reflecting the established water quality-based approach to water pollution control. This approach relied upon the states to develop water quality standards for use in assessing the need for water pollution controls and, subsequently, in implementing controls for specific pollution sources. Many observers were critical of this approach at the time because it had failed to ensure that states would actually address water pollution problems within their jurisdictions. Even when water quality problems were identified using this approach, it was often difficult to identify the specific sources of those problems with enough certainty to impose or facilitate appropriate corrective actions. Even so, the language in Section 303 of FWPCA was included in the re-written 1972 FWPCA to address water quality problems that remained after technology-based regulatory controls on industries and municipal sewerage systems had been applied.

In the 1970s and 1980s, USEPA developed dozens of "effluent guideline" regulations to enable efficient issuance of technology-based permits. The agency also worked with states to issue thousands of permits under NPDES to control point source discharges. To a large degree, these technology-based permit controls have been successful, as pollutant loads from point sources have diminished considerably since 1972 (ASIWPCA, 2004). While water quality problems growing from point source discharges are still evident, there has been a growing recognition that nonpoint sources now contribute to a very large proportion of the nation's water quality problems.

In 1987, the federal government took more direct aim at these problems and amended FWPCA with a new program—Section 319—that required states to develop nonpoint source water quality assessments and then establish management plans to address the problems that were identified. The amendments also included provisions for a new grant program to assist states in addressing nonpoint source pollution. Funding for this program increased during the 1990s and additional funds were added to support projects in watersheds targeted by TMDLs. Additional federal programs to address water pollution from agricultural and mining activities have also been enacted, providing support for projects that help restore impaired water bodies.

All of these programs—the NPDES program and the various programs in place to address nonpoint source water pollution—provide a means for controlling pollution to impaired water bodies. In this sense, they are tied to the TMDL program, which has become increasingly important in recent years as the primary means by which impaired waters are identified and targeted for specific kinds of control actions to clean them up.

[1] Portions of this section drawn from Hoornbeek et al. (2008).

2.1 The TMDL program

For the first twenty years of its existence, Section 303(d) of FWPCA lay dormant and was largely ignored by both USEPA and the states. This section requires states to identify waters for which technology-based controls are not sufficient to ensure compliance with water quality standards. The water bodies identified through this process are considered to be impaired and in need of restoration. It also requires that states establish TMDLs for pollutants in these watersheds and submit them to USEPA for approval.

Since the mid-1990s, Section 303 (d) has become increasingly important. Its growing importance is attributable to the need to assess water quality conditions in thousands of water bodies throughout the US (Barvenik et al., 2007, p. 1). A series of court cases has also required more complete compliance with this section (Houck, 1999). These factors led to the establishment of more-formal TMDL programs by USEPA and states.

This transition toward a more formal TMDL program included a focus on the preparation of TMDLs that identify a water body's load capacity: the maximum amount of a pollutant the water body can receive without violating water quality standards. The TMDL program's major accomplishments have thus come in the form of the production and formal approval of documents that characterize impaired water bodies and develop allocations of allowable levels of pollutant discharge. If the pollutants from industrial sources and sewage plants flow through pipes or discrete conveyances to water bodies, then they are classified as point sources. The TMDL assigns wasteload allocations (WLAs) to these point sources and addresses the need for pollution reductions through NPDES permits.

When the discharge of pollutants takes place diffusely from other sources—including agricultural and residential lands, forests, and erodible stream banks—the pollutants are regarded as stemming from nonpoint sources. In TMDLs, nonpoint source pollution is addressed through load allocations (LAs). Pollution reductions from these sources are aided through a variety of programs, including Section 319 grants and other assistance administered by the US Department of Agriculture and the Office of Surface Mining Reclamation and Enforcement in the US Department of the Interior.

By almost any measure, the TMDL program's accomplishments since the mid-1990s have been substantial. TMDLs have been developed for waters in all fifty states, and they have covered a wide range of pollutants, including total suspended solids, nutrients, metals, and oxygen-demanding substances. What is more, the pace of TMDL development and approval has increased rapidly in recent years. Between 2004 and 2006, for example, about 12,000 TMDLs were approved by USEPA, bringing the total number of approved TMDLs to approximately 24,000 (Barvenik et al., 2007). This rate of progress seems to have been maintained since 2007, as USEPA's Assessment TMDL Tracking and Implementation System (ATTAINS) database now documents more than 44,000 approved TMDLs (USEPA, 2011).

2.2 TMDL implementation

While the progress achieved in developing TMDLs is both impressive and quantifiable, progress on the implementation of TMDLs is far less clear. It is in this context that interest in the implementation of TMDLs and their impacts on water quality has been increasing in recent years. There is, therefore, a growing need to document the extent to which water pollution control actions recommended in TMDLs are being implemented.

Unfortunately, measuring TMDL implementation progress is not a clear cut exercise. Implementation actions can come from a variety of sources, and they may address a wide range of pollutants. No centralized authority exists to monitor and track these highly diffuse implementation practices. In addition, there is no widely accepted set of indicators that can be used to assess implementation progress. Because states have been working to both develop TMDLs and implement ongoing NPDES and Section 319 programs, they have not yet developed well-integrated systems for linking implementation actions recommended in TMDLs to the

activities and outputs of their water quality programs. As noted by Hoornbeek et al. (2008), there is a mismatch between statutory goals for water quality and the resources available to achieve them. Monitoring diffuse implementation practices is an expensive endeavor, and previous research has identified resource constraints as a major inhibitor to implementation progress.

2.3 Studying TMDL implementation: growing interest

Because of the concerns and interests noted above, USEPA and several states have initiated studies that seek to improve the body of knowledge relating to TMDL implementation. Some of these studies document the extent to which implementation is occurring and identify factors that appear to contribute to TMDL implementation progress. Others seek to assess existing federal and state systems for identifying implementation progress and reporting results.

Based on a review of existing literature conducted in spring 2009 and on discussions with USEPA officials, it appears that eight substantial studies have been completed since 2005; these studies are listed in Box 1.

Taken together, these studies provide a significant knowledge base that is relevant to TMDL implementation and the ongoing management and tracking thereof. Sections 3, 4, and 5 of this report seek to identify what we have learned collectively from these efforts, and use this knowledge base to help identify and assess potential indicators and next steps for building and sharing knowledge regarding TMDL implementation progress.

Box 1: Studies of TMDL implementation

Studies of implementation progress (addressed in Section 3).

Mann et al. (2005)
Mann, L., McBride, R., Butler, A., Hasim, B. 2005. **Implementation of Washington's TMDL Program: 1998-2003.** USEPA, Region 10. 39 pages.

Benham et al. (2006)
Benham, B., Zeckoski, R., Yagow, G., Ekka, S. 2006. **TMDL Implementation – Characteristics of Successful Projects.** Center for TMDL and Watershed Studies at Virginia Tech. 370 pages.

Hoornbeek et al. (2008)
Hoornbeek, J., Hansen, E., Ringquist, E., Carlson, R. 2008. **Implementing Total Maximum Daily Loads: Understanding and Fostering Successful Results.** Center for Public Administration and Public Policy, Kent State University. 154 pages.

Norton et al. (2009)
Norton, D., Olsen, A., Kratt, K., Hansen, E., Hughes, I., and Abdelmajid, N. 2009. **Sampling TMDL Implementation Rates and Patterns in North Central US.** USEPA Office of Water. Water Environment Federation TMDL Conference Proceedings. pp 1308-1318.

Studies of implementation tracking (addressed in Section 4).

Barvenik et al. (2007)
Barvenik, S., McGhee-Lenart, R., Tam, L., Engelberg, D. 2007. **Total Maximum Daily Load Program Needs Better Data and Measures to Demonstrate Environmental Results.** USEPA, Office of Inspector General. 30 pages.

USEPA (2008)
USEPA. 2008. **Total Maximum Daily Load (TMDL) Implementation Tracking Needs Assessment: Current Status and Future Needs for States in Regions 5, 6, and 10**. Contract #68-C-02-109, prepared by The Cadmus Group, Inc. for USEPA. 37 pages.

Grayzeck et al. (2008),
Grayzeck, S., Sleeper, F., Wing, S. 2008. **Developing an Effectiveness Tracking and Reporting Framework for Implementing the Clean Water Legacy Act.** Water Resources Center, University of Minnesota. 60 pages.

USEPA (2010a)
USEPA. 2010a. **State Approaches and Needs for Measuring, Tracking, and Reporting on Water Quality Improvements.** Contract #EP-C-08-002, prepared by The Cadmus Group, Inc. for USEPA. 107 pages.

3. TMDL IMPLEMENTATION PROGRESS

Since 2005, researchers have investigated progress in implementing TMDLs across several states and regions. In particular, studies by Mann et al. (2005), Benham et al. (2006), Hoornbeek et al. (2008), and Norton et al. (2009) quantify various indicators of TMDL implementation.[2] In this section, we summarize and synthesize the results of these four studies. We also identify key elements of knowledge that have emerged from these efforts and discuss the implications of these studies for choices about indicators that might be used to track TMDL implementation progress on an ongoing basis.

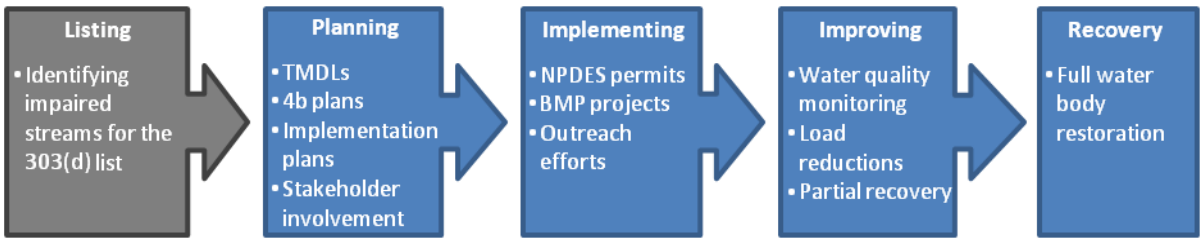
To help synthesize the findings and conclusions in these studies, we use USEPA's Clean Water Act (CWA) impaired waters pipeline framework (Norton et al., 2011). This framework recognizes five categories of TMDL progress (Figure 1):

1. listing,
2. planning,
3. implementing,
4. improving, and
5. recovery.

Before TMDLs can be developed, impaired water bodies must be identified and placed on state 303(d) lists—the listing stage. Because listing occurs prior to TMDL development and implementation, we do not include this stage in our discussion below.

In the planning stage, TMDLs and implementation plans are developed, and stakeholders may strategize about implementation efforts. Actions toward reducing pollution occur during the implementing stage, with modifications to NPDES permits, the implementation of nonpoint source controls, and—in some cases—efforts to monitor water bodies. The improving stage includes load reductions at pollution sources and improvements in ambient water quality in affected surface waters. Finally, the recovery stage is reserved for full water body restoration.

Figure 1: Five stages of the Clean Water Act impaired waters pipeline



A summary of knowledge identified through the four studies that focus on TMDL implementation progress is presented in Section 3.1. Each summary identifies the study, its purpose(s), its methodologies, and its results and conclusions. This information seeks to inform the reader regarding the key elements of each study; readers seeking more detailed information can and should read the studies themselves. The summaries are followed by a discussion of what we know about TMDL implementation as a result of these studies in Section 3.2 and an overview of lessons learned about the sources of variation in TMDL implementation rates in Section 3.3.

[2] These studies, as well as others, are available on USEPA's Results Analysis website: http://www.epa.gov/owow/tmdl/results/index.html

3.1 Results of recent studies: a summary

The four studies of TMDL implementation progress that we identify range both in the scope of their inquiry and in their focus. Table 1 describes key characteristics associated with each study.

Table 1: TMDL implementation progress studies: key characteristics

	Reports on specific indicators	Reviews all TMDLs within a geography	Summarizes progress at the state or regional level	Summarizes progress at the TMDL watershed level
Mann et al. (2005)	✓	✓	✓	✓
Benham et al. (2006)	✓			✓
Hoornbeek et al. (2008)	✓	✓	✓	
Norton et al. (2009)	✓		✓	

As Table 1 indicates, each of the four studies reported on a specific set of indicators. Two studies examined all approved TMDLs within one or two states (Mann et al., 2005 and Hoornbeek et al., 2008). Three studies summarized implementation progress at the state or regional level, while the fourth study (Benham et al., 2006) reviewed success stories associated with 17 different watersheds located throughout the country. Both the Mann et al. (2005) and Benham et al. (2006) studies summarized implementation progress at the watershed level. The Hoornbeek et al. (2008) study also compiled data at the watershed level, but its results are reported as combined summary figures for two states: Ohio and West Virginia. The Norton et al. (2009) study assessed TMDL implementation progress at the level of individual water bodies and stream segments in USEPA Region 5, rather than at the watershed level. More detailed summaries of each of these studies are provided below.

3.1.1 *Implementation of Washington's TMDL Program 1998-2003*

Source

Mann et al. (2005)

Purpose

This report evaluated TMDL implementation progress for TMDLs approved between 1998 and July 2003 in Washington State.

Methodology

All 308 TMDLs approved in Washington between January 1, 1998 and July 31, 2003 are addressed in the report. However, data were reported at the watershed level, and the 308 TMDLs are within 28 TMDL-limited watersheds. While data sources for this study were not explicitly identified, detailed information was provided for each watershed, including whether a Detailed Implementation Plan (DIP) had been completed, whether ambient monitoring data was available in the watershed, whether point and/or nonpoint source implementation efforts were underway, and whether water quality improvements were taking place. The study also provides a brief synopsis of general progress and specific projects for each of the 28 watersheds in the study sample. These synopses focus on management and planning measures, although they also include an assessment of whether water quality in the affected watersheds was improving.

Results and conclusions

In Washington, DIPs are typically completed within one year of TMDL approval. They provide a strategy and timeline for the identification and reduction of pollution sources. At the time of publication (February 2005), DIPs had been approved in 18 of the 28 project areas studied, and another seven DIPs were expected to be completed in 2005. Implementation projects were occurring in 27 of these watersheds and water quality improvement had been documented in 13. For at least 6 of these 13 watersheds, improvement was taking place at or ahead of the schedule set forth in the DIP.

3.1.2 *TMDL Implementation – Characteristics of Successful Projects*

Source

Benham et al. (2006)

Purpose

This study identified watersheds in which TMDLs have been successfully implemented, which is defined as cases in which water quality improvements are known to have occurred. It also evaluated characteristics of those watersheds and TMDL actions of relevant agencies and stakeholders to identify factors that appear to be associated with water quality improvements and successful TMDL implementation.

Methodology

The authors used a nonrandom sampling method, selecting 17 successful watersheds in 12 states. This was done with a goal of identifying indicators that helped achieve the observed success. It should be noted that as a result of this nonrandom sample, the results of this study are not representative of the greater statistical population of TMDL implementation. The watersheds studied were identified through conversations with appropriate state agency employees and through a search of success stories collected by USEPA. Collectively, the watersheds were impaired by a range of pollutants, including sediment, nutrients, chemicals, bacteria, high temperature, ammonia, pH, and solid waste (Benham et al., 2006, p. 8). Thirteen of these watersheds "were dominated by nonpoint sources of pollution" (Benham et al., 2006, p. 8).

Case studies were conducted for each of the 17 selected watersheds in an effort to identify factors that contribute positively toward water quality improvements and successful TMDL implementation. Data and documents from the Internet and from involved agencies were reviewed with a focus on the following topics:

a. "Applicable water quality standards
b. Degree of impairment in terms of applicable water quality standards
c. Approach used to develop the TMDL (modeling or other, specific model(s), developer, stakeholder involvement, etc.)
d. Actual TMDL and supporting loading and concentration data in terms of spatial loadings
e. Scientific reasonableness of proposed reductions (are they likely to be attainable)
f. Public involvement during the TMDL development process (degree of active participation)
g. Approach used to develop the implementation plan and differences from the approach used to develop the TMDL (modeling or other, specific model(s), developer, stakeholder involvement)
h. Usefulness of data and information from the TMDL study in the development of the implementation plan
i. Public involvement during the implementation plan development process
j. Implementation plan loading reductions and phases (temporal and spatial loading reductions, specificity of plan in terms of contributors, etc.)

k. Scientific reasonableness of proposed implementation plan reductions (phases, likelihood of attainment of proposed water quality improvements)
l. Identification and availability of required resources
m. Proposed water quality and progress monitoring system
n. Progress towards implementation (actions taken, water quality improvements)
o. Degree to which the implementation plan is facilitating implementation (strengths and weaknesses)." (Benham et al., 2006, p. 5-6)

The authors then created matrices that systematically associated the presence or absence of the characteristics and actions noted above with each of the 17 case study watersheds. Factors that promoted or hindered implementation were then identified and listed for each watershed.

Results and conclusions

Through the process of association described above, the authors identified factors that hindered and fostered TMDL implementation. They found that the following factors hindered TMDL implementation:

- lack of funding,
- lack of baseline or follow-up data, and
- occurrence of natural disasters.

By contrast, they found that the following factors contribute to successful TMDL implementation:

- government funding and involvement,
- stakeholder involvement,
- TMDL quantification that sets achievable reductions,
- targeted and staged implementation of diverse projects, and
- outreach and education.

While Benham and his colleagues suggested that appropriate strategies vary by pollution source, they also suggested that there are some overarching principles of success. In watersheds dominated by nonpoint sources, stakeholders play an important role in implementation on private land, whereas publicly-owned lands are "often more straightforward as there is typically a single stakeholder" (Benham et al., 2006, p. 11). In point source–dominated watersheds, the authors found that the "[a]ctive engagement of point sources can accelerate attainment of water quality standards" (Benham et al., 2009, p. 11).

3.1.3 *Implementing Total Maximum Daily Loads: Understanding and Fostering Successful Results*

Source

Hoornbeek et al. (2008)

Purpose

This study assessed the implementation of USEPA-approved TMDLs in Ohio and West Virginia. In so doing, it addressed three specific questions:

- To what extent are TMDLs being implemented in Ohio and West Virginia?
- What factors facilitate progress in the implementation of TMDLs in these two states?
- What steps can be taken to facilitate further progress in the implementation of TMDLs?

Methodology

To address these questions, the research team reviewed 63 USEPA-approved TMDL reports for impaired waters in Ohio and West Virginia. The TMDLs contained in these reports were approved between 1998 and September 2006, and they addressed a total of 174 specific report-pollutant combinations. The researchers' review focused on identifying pollutants and their sources, and on collecting information that could be used to assess TMDL implementation progress. The information contained in these reports was analyzed in combination with other publicly available documents that are relevant to TMDL implementation in Ohio and West Virginia. This process enabled an assessment of TMDL implementation progress at the report level (rather than by individual stream segment) for the 174 pollutants and 63 watersheds addressed in the study (Hoornbeek et al., 2008, p. 3).

The researchers surveyed state TMDL staff, TMDL developers, state agency staff members with knowledge of TMDL implementation activities in particular watersheds, and other stakeholders (Hoornbeek et al., 2008, p. 21). They also reviewed major NPDES permits in TMDL-limited watersheds. These reviews were undertaken to determine if recommendations contained in approved TMDLs had been incorporated into NPDES permits. Consequently, the authors relied on written information and the knowledge and perceptions of state environmental officials—rather than environmental sampling and analysis—to develop their findings and reach their conclusions (Hoornbeek et al., 2008, p. 3).

The study measured implementation progress based on four stages that were adapted from and are generally consistent with the stages contained in the CWA impaired waters pipeline. More specifically, the study assessed progress at four stages of the TMDL implementation process:

1. planning and management,
2. implementation of controls,
3. partial recovery, and
4. water body restoration.

Within these stages, the study utilized specific indicators:

1. The presence or absence of state officials who are knowledgeable regarding implementation of the approved TMDL report,
2. The presence or absence of groups taking responsibility for TMDL implementation,
3. The presence or absence of implementation projects that seek pollutant load reductions,

4. Whether major NDPES permits are being made more stringent for pollutants targeted in the approved TMDL reports,
5. Whether ambient monitoring downstream from implementation actions is being undertaken,
6. Whether pollutant load reductions for TMDL-limited pollutants are known or believed to be occurring,
7. Whether water quality improvements have been demonstrated, and
8. Whether the watersheds in question have been fully restored.

Collectively, these measures cover each of the four major (non-listing) stages of the CWA impaired waters pipeline.

To identify likely driving factors for TMDL implementation, statistical models were employed to ascertain the extent to which predictor variables identified by current literature on water quality program implementation predict two kinds of measures of implementation progress: the existence of a group to foster TMDL implementation and the estimated occurrence of pollutant load reductions (Hoornbeek et al., 2008, p. 26). The results of these analyses—along with insights drawn from a review of TMDL reports, interviews, and other sources—enabled the development of a set of potential changes in practices and policies that can be used to help accelerate TMDL implementation progress in the future (Hoornbeek et al., 2008, p. 26-27).

Results and conclusions

The study found that recommendations contained in approved TMDLs were being implemented in Ohio and West Virginia. Well over half of the TMDL-limited watersheds assessed had planning and management efforts underway, and pollutant load reductions were believed to be occurring in almost half of the watersheds studied. However, measured improvements in water quality were occurring less frequently and full water body restorations were rarer still. The results reported for each of the indicators above are summarized below:

1. At least one state official was knowledgeable regarding TMDL implementation activities in 71% of the watersheds studied.
2. At least one local or regional group was working to implement TMDL-recommended actions in 57% of the TMDL-limited watersheds.
3. At least one load-reducing project addressing a TMDL-limited pollutant was underway in 65% of these watersheds.
4. Of the major NPDES permits for which the TMDL report contained clearly recommended pollutant load reductions, 89% (17 of 19) contained more stringent effluent limits that were imposed after USEPA's approval of the TMDL.
5. Instream monitoring for TMDL-limited pollutants was taking place in 44% of the TMDL-limited watersheds.
6. Pollutant load reductions were known or believed to be occurring in 46% of the TMDL-limited watersheds.
7. Knowledgeable state officials interviewed for the study suggested that 19% of the TMDL-limited watersheds studied had experienced water quality improvements as a result of implementation activities.
8. Full recovery of the watershed from the impairments specified had occurred in only 3% of the watersheds studied.

Using statistical (probit) analyses, the study identified a number of factors that appear to help drive TMDL implementation progress. The following factors were found to be strong predictors of whether there was a group in the watershed taking responsibility for implementing the recommendations contained in the TMDL: (1) the existence of a state grant to support a watershed coordinator, (2) local/regional group participation in TMDL development, (3) state agency involvement in TMDL implementation, and (4) high population density.

Similar analyses were conducted to identify strong predictors of perceived reductions in pollutant loads after USEPA approval of the TMDL. These analyses identified the following factors as strong predictors: (1) the existence of a group taking responsibility for TMDL implementation, (2) the existence of a state grant to support a watershed coordinator, (3) approval or endorsement of a watershed plan (for nonpoint sources only), (4) time (with increasing time from USEPA approval, perceived load reductions become more likely), and (5) population density (however, in this case, higher population densities reduce the likelihood of perceived load reductions).

These statistical analyses and other observations made during the research process enabled the study team to make the following recommendations for facilitating greater progress in fostering TMDL implementation:

1. Engage local and regional groups in TMDL development.
2. Provide funding to implement projects to reduce pollutant loads and improve water quality.
3. Engage state officials in implementation processes.
4. Create standardized formats for TMDL reports so those implementing them can easily access and apply their recommendations.
5. Develop indicators of implementation progress and track progress against them.
6. Educate and engage key audiences —farmers, health officials, and stormwater utilities—in TMDL implementation and its tracking and management.

Finally, the study suggested that there is a widespread recognition among water quality stakeholders in Ohio and West Virginia that implementing TMDLs is important for the success of national- and state-level water quality improvement efforts (Hoornbeek et al., 2008, p. 88).

3.1.4 *Analysis of TMDL Implementation Rates in USEPA Region 5*

Sources

Norton et al. (2009)
USEPA (2009)

Purpose

This study evaluated TMDL implementation progress in USEPA Region 5, including Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin.

Methodology

USEPA selected 138 TMDLs out of 2,228 in Region 5 listed in the National TMDL Tracking System (NTTS). The TMDLs were selected by using a probabilistic sample representative of all the region's TMDLs (within a +/- 10% margin of error) and various subpopulations, and were grouped by TMDL age and type. Types included TMDLs with nonpoint sources only and TMDLs that included both nonpoint and point sources. TMDLs were selected in proportion to the total number of TMDLs in each state, but "[t]he study was not designed to obtain state-level statistically valid results" (Norton et al., 2009, p. 1310).

Protocols and quality assurance procedures were established to ensure the timely and consistent collection of the required data:

- basic TMDL information,
- point and nonpoint source implementation activities outlined in the TMDL or implementation plan,
- the status of permitting and best management practice (BMP) implementation activities outlined in the TMDL or implementation plan,

- additional NPDES facilities, and
- Section 319 projects or other nonpoint source projects not included in the TMDL documents (Norton et al., 2009, p. 1309).

Information was gathered from relevant documents; when necessary, follow-up contact was initiated with state officials to fill in the data gaps (Norton et al., 2009, p. 1312).

Approved information sources were used to determine implementation progress, and only projects that had occurred were counted as implemented (Norton et al., 2009, p. 1310). In addition to post-TMDL projects, any projects completed within three years prior to TMDL approval were counted toward TMDL implementation (Norton et al., 2009, p. 1310).

The study provided estimates of TMDL implementation progress for two major indicators:

- partial-to-full progress in developing an implementation plan, and
- partial-to-full progress in planning, funding, and installing BMPs that address the LAs and in incorporating the WLAs in NPDES permits.

The study also reported on the two components of this measure separately.[3]

For each state, the report summarized the TMDL characteristics, point and nonpoint source implementation progress, information sources, and agency contacts. The data provided fall exclusively in the planning and implementation categories of the CWA impaired waters pipeline.

Results and conclusions

Summary statistics for USEPA Region 5 suggest a high level of implementation progress in all subpopulations. The lowest reported partial-to-full TMDL implementation rate in Region 5 was 72.7% for the subpopulation including only nonpoint sources of pollution (Norton et al., 2009, p. 1313). The overall reported rate was 80.3% (Norton et al., 2009, p. 1313). It is important to note that "partial implementation" in this report included those TMDLs "having any combination of actions listed under the implementation definition above that are verified as having occurred or [being] currently active" (USEPA, 2009, p. 37). Furthermore, while "full implementation" was reserved for those TMDLs with "all point or nonpoint control actions completely put into practice onsite," this designation was independent of improvement in water quality (USEPA, 2009, p. 37).

"An important observation made during the collection of data for this report was that in no state was all of the required information already compiled" (USEPA, 2009, p. 34). The report also suggests that it would be easier to link projects to TMDLs if project lists (e.g., USEPA's 319 Grants Reporting and Tracking System (GRTS) had a TMDL watershed field (USEPA, 2009). As it is, geographic data are often spotty in GRTS, resulting in difficulty in determining the location of documented projects.

[3] Full implementation is defined as all the practices (i.e. BMPs, permits) planned for implementing a TMDL were verified as completely installed. Partial implementation was used to describe all samples that displayed a mix of some installed/some not installed practices, or some installed/some unverified practices (Norton et al., 2009, p. 1310).

3.2 What we know

Collectively, the studies summarized above have added significantly to our understanding of TMDL implementation in the US. Just seven years ago, one would have been hard pressed to identify even one study that addressed this issue, much less shed significant light on key questions such as the extent to which TMDL implementation is occurring or the factors that drive it. Thanks to these studies and the overall efforts of USEPA's TMDL Program Results Analysis Project, we now have concrete evidence relevant to these and other important TMDL implementation-related questions.

However, while our knowledge base on TMDL implementation has expanded considerably, it is still limited in some important respects. The subsection that follows outlines several of these limitations. It is followed by a subsection that identifies areas where our knowledge of TMDL implementation now appears to be relatively strong.

3.2.1 *The limits to our knowledge*

While the studies above are filled with interesting and useful information, they are, collectively, subject to some clear limitations. The first of these limitations relates to geography. The Benham et al. (2006) study addresses 17 watersheds in 12 states, but focuses only on success stories with documented water quality improvements. Consequently, the evidence it offers cannot be used as a basis for estimates of the extent to which TMDL implementation or related activities are actually occurring on a broad basis at any geographic scale. The other three studies collectively address a total of eight states, six of which are Midwestern states. This means that virtually all of the evidence available comes from a relatively small proportion of the states in the country.

A second limitation centers on the fact that only three of the studies provide information on water quality improvements, and each of these studies is subject to limitations that make it difficult to draw very strong conclusions about the extent to which TMDL implementation is leading to water quality improvement. Once again, the selection bias that is inherent in studying only success stories limits the utility of Benham et al.'s (2006) results regarding the achievement of water quality improvements through TMDL implementation. The Mann et al. (2005) and Hoornbeek et al. (2008) studies do not have this shortcoming, but they are subject to other limitations. In Mann et al.'s (2005) case, the limitation relates to the focus on Washington State, which is believed to be more active than many other states in its water quality protection efforts (Ringquist, 1993; Hoornbeek, 2005; Hoornbeek, 2011; USEPA, 2010a). In Hoornbeek et al.'s case (2008), some may question reliance on verbal reports from knowledgeable state officials rather than reviews of objective water quality data. These limitations mean that there is still some uncertainty regarding the extent to which actual water quality improvements are flowing from TMDL implementation efforts.

This uncertainty is compounded by limitations relating to the extent and nature of water quality monitoring that takes place after TMDL implementation activities commence. Only two of the four studies—Mann et al. (2005) and Hoornbeek et al. (2008)—address the issue of water quality monitoring effectiveness in a broad-based way. Nearly two-thirds (18 of 28) of the watersheds in Mann et al.'s (2005) study were reported to have instream monitoring data available to evaluate the effectiveness of TMDL implementation, but this means that water quality data were not available for 10 of the 28 (36%) watersheds in the sample. Thus,

while Washington State is known to have a relatively strong monitoring effectiveness program (USEPA, 2010a; Onwumere and Plotnikoff, 2003), the lack of monitoring data in 10 watersheds adds further uncertainty to our estimates of the extent to which TMDL implementation leads to water quality improvement.

The Hoornbeek et al. (2008) study also addresses the issue of monitoring, but it does so indirectly through the reports of knowledgeable state officials. It finds that less than half (44%) of the TMDL reports in the study sample are thought to have been subject to ambient monitoring efforts related to TMDL implementation. By contrast, the Benham et al. (2006) study finds that instream monitoring is present in a high proportion of the cases in its sample of TMDLs, but the sample is highly biased because—as is noted above—it focuses only on cases of known water quality improvement (and monitoring must be in place to know there is improvement). Consequently, the studies available suggest that monitoring information that is necessary for assessing water quality improvement is frequently not available, and—in all cases—there is still some uncertainty about the extent to which the monitoring undertaken is adequate and appropriate for assessing water quality improvements.

A final limitation relates to the factors that drive TMDL implementation progress. Only two of the four studies address this issue. Benham et al. (2006) identify a number of factors that appear to be present in multiple cases of TMDL implementation progress, and their data are suggestive in this regard. However, it is again difficult to reach strong conclusions based on a sample that is biased to successful cases. The Hoornbeek et al. (2008) study uses more rigorous analytical strategies to identify likely driving factors, but limited sample size constrained these analyses to explaining the presence (or absence) of a group fostering implementation and the existence of perceived load reductions. Taken together, these limitations mean that there is still significant room for improving our understanding of the factors that drive TMDL implementation.

3.2.2 *Taking stock of what we know*

In spite of the limitations summarized above, it is no exaggeration to say that ***we know much more about TMDL implementation now than we did five or ten years ago***. Several areas of improvement are worthy of attention in this regard.

First, ***we know that TMDL implementation is indeed occurring***. All four of the studies summarized above make this clear for virtually all geographic areas that are included in the scope of their respective inquiries. All four studies document both planning and implementation efforts in more than half of the cases in their sample. In addition, all three of the studies that make use of water quality improvement measures—Mann et al. (2005), Benham et al. (2006), and Hoornbeek et al. (2008)—identified at least some cases where water quality improvements are attributable to TMDL implementation. These findings mean that managers of NPDES and Section 319 programs are using information generated by TMDL studies to help them target water quality improvement efforts—at least in some cases.

Unfortunately, it is equally clear from these studies that ***TMDL implementation is not occurring in all cases***. All three of the broad-based studies analyzed—Mann et al. (2005), Hoornbeek et al. (2008), and Norton et al. (2009)—identified USEPA-approved TMDLs for which no implementation activities could be identified. This means that it is quite likely that at least some TMDL studies are gathering dust on shelves around the country, as the water quality problems they analyze either remain unaddressed or worsen in breadth or magnitude. This situation, in and of itself, is a problem that is worthy of further attention from both policymakers and water quality managers.

Perhaps not surprisingly, the studies summarized above also make it clear that ***we can document higher levels of activity at the earlier stages of the CWA impaired waters pipeline than at later stages.*** All three of the broad-based studies—Mann et al. (2005), Hoornbeek et al. (2008), and Norton et al. (2009)—document substantial TMDL implementation–related activities at the planning and implementation stages of the CWA impaired waters pipeline. By comparison, evidence of water quality improvements and full recoveries is more

limited. And indeed, very few cases of full water body recovery are identified at all. This drop-off in measured progress between the earlier and later stages of the CWA impaired waters pipeline highlights the importance of monitoring efforts in identifying what kinds of implementation projects are working. It also suggests that there is a need both for an improved understanding of the monitoring strategies that are currently being used and probably for more extensive monitoring efforts as well.

The four reviewed studies also provide some important information about factors that may help drive TMDL implementation progress. First, based on evidence from Benham et al. (2006), Hoornbeek et al. (2008), and Norton et al. (2009), ***TMDL implementation for point sources occurs more reliably than it does for nonpoint sources***. It appears that governing agencies frequently lack nonpoint source regulatory levers that could help them assure follow-up action after TMDL reports are approved. Even for point sources, for which a regulatory framework exists, both the Hoornbeek et al. (2008) and Norton et al. (2009) studies demonstrate that implementation of TMDL recommendations does not occur automatically. Both studies find cases in which TMDLs suggest changes in permit requirements that have not yet been implemented, thus highlighting the fact that even regulatory actions require time and coordination among water quality managers if they are to be implemented effectively.

The Benham et al. (2006) and Hoornbeek et al. (2008) studies also identify ***other factors that appear to help facilitate TMDL implementation progress***. Both studies highlight the value of engaging key stakeholders during TMDL development and enabling them to become advocates for TMDL implementation; the importance of providing financial support to foster implementation progress in cases where nonpoint sources are involved; the merit of engaging state agency personnel in TMDL implementation; and the value of implementation planning processes in facilitating TMDL implementation progress. While the studies use different methodological approaches, similarities in their findings lend credence to the conclusions they reach about driving factors for TMDL implementation.

Though there are limitations to the interpretive range of conclusions that can be reached based on the studies summarized above, it is clear that they have added substantially to our understanding of TMDL implementation. In addition, the efforts made in these studies to measure progress at different stages of the CWA impaired waters pipeline highlight the fact that many different indicators can be used to measure progress. These same studies provide a base of information that can be used to inform future efforts to identify appropriate indicators of TMDL implementation and, potentially, to track progress using them as well.

3.3 Lessons from recent studies

The four studies summarized above are useful in part because they provide insights about ways in which indicators of TMDL implementation progress might be identified and constructed. The indicators used to measure implementation progress in these studies are potential options for use in tracking systems that might be developed and operated at the federal and sub-national levels. The results of the studies also provide insights that are relevant to decisions that must be made in selecting indicators and making them operational on an ongoing basis. The subsections that follow address both of these topics.

3.3.1 *Indicators of TMDL implementation progress: options for the future*

Collectively, the four studies summarize data relating to several dozen factors that are related in various ways to TMDL implementation.[4] A more limited number of these variables, however, are reported as major indicators that are unique and independent measures of TMDL implementation progress.[5] In total, we

[4] A large listing of variables assessed in the four studies can be found in Appendix B.

[5] We define major indicators as ones that are reported to indicate TMDL implementation progress and are not a sub-category of another indicator within the same CWA impaired waters pipeline stage.

identified sixteen major indicators across the four studies. Table 2 identifies the major indicators associated with each of these studies, and provides information on the units of analysis with which they are associated (watershed or stream segment/water body), as well as the CWA impaired waters pipeline stage in which they are applied.

Table 2: Major indicators used in existing studies of implementation progress

Study	Major indicator	CWA impaired waters pipeline stage	Unit of analysis
Mann et al. (2005)	Detailed Implementation Plan	Planning	Watershed
	Monitoring data available	Implementing	Watershed
	Water quality improvement	Improving	Watershed
Benham et al. (2006)	Water quality improvement	Improving	Watershed
	Removal from 303(d) list	Recovery	Watershed
Hoornbeek et al. (2008)	Knowledgeable official	Planning	Watershed
	Responsible group	Planning	Watershed
	Project(s) underway	Implementing	Watershed
	More stringent NPDES permits	Implementing	Watershed
	Post-TMDL monitoring	Implementing	Watershed
	Load reductions—perceived	Improving	Watershed
	Water quality improvement	Improving	Watershed
	Water body restoration/delisting	Recovery	Watershed
Norton et al. (2009)	Partial-to-full completion of implementation plan	Planning	Stream/water body
	Partial-to-full implementation of point and nonpoint source controls	Implementing	Stream/water body

While this table makes it clear that there is a range of ways in which TMDL implementation progress can be measured, it also demonstrates that the studies summarized above measured progress with some very similar indicators.

Table 3 lists the eleven unique indicators adopted by these studies, based on the four[6] stages of the CWA impaired waters pipeline. It shows that there are multiple indicators at the early stages of the pipeline, but fewer indicators at the latter stages. However, as will become evident from the discussion below, even identical indicators can be made operational in differing ways and this can result in differing results. Nevertheless, the eleven indicators shown in this table represent potential options for incorporation into long-term systems for building greater knowledge about TMDL implementation progress.

Table 3: Unique major indicators from recent implementation progress studies, by Clean Water Act impaired waters pipeline stage

Planning stage	Implementing stage	Improving stage	Recovery stage
Knowledgeable official	Project(s) underway	Water quality improvement	Water body restoration/delisting
Responsible group	More stringent permits	Load reductions – perceived	
Detailed Implementation Plan	Monitoring		
Partial-to-full completion of implementation plan	Partial-to-full implementation of point and nonpoint source controls		

[6] While there are five stages to the CWA impaired waters pipeline, only the last four are relevant to TMDL implementation. For more information on the listing stage, see the discussion on page 7 in Section 3.

3.3.2 *Measuring implementation progress: the choice of indicators affects implementation rates*

This subsection presents information on the extent of TMDL implementation progress measured by the four studies summarized above. In so doing, it shows significant variation in the extent of progress achieved—both by the CWA impaired waters pipeline stage and, in some cases, by the specific indicator that is chosen and the way it is made operational. In this context, readers should note that the results from the studies cited are not strictly comparable because of these differences in the indicators chosen and the ways in which they are made operational.

In broad terms, variation in implementation rates appears to be attributable to three overarching factors. First, and most importantly, variation in the proportion of TMDLs (or TMDL-limited watersheds) in which implementation progress is being made is traceable to true differences in the extent of implementation that is occurring. In general, higher percentages of TMDL-limited watersheds and stream segments/water bodies are demonstrating more progress at the planning and implementing stages than at the improving and recovery stages. Indeed, more than half of the TMDL-limited watersheds and water bodies in all four studies showed evidence of implementation progress at the planning and implementing stages of the CWA impaired waters pipeline. This is understandable because work at early stages in the pipeline (planning and implementation of corrective actions) is typically necessary to enable the kinds of water quality outcomes that are sought at later stages of the pipeline. In addition, the significant challenges associated with TMDL implementation—the organization and cooperation of highly decentralized groups contributing to implementation, the lack of centralized tracking responsibility or authority at any level of government, limited resources, and court settlement agreements and consent decrees forcing states to focus more on the continued development of new TMDLs—it is appropriate that "partial implementation" be seen as a positive, at least for the short term.

Second, variation in implementation rates may be attributable to differences in the indicators chosen, even within a single CWA impaired waters pipeline stage. For example, it may be systematically more likely that projects will be implemented than that monitoring will be conducted to assess the effectiveness of projects after they are implemented. While both of these activities are evidence of implementation behavior, they may vary in their probability of occurrence. If projects are not being implemented, then there may be less reason to instigate a monitoring program. On the other hand, projects may be instigated to reduce pollutant loads without resources and expertise being made available to assure that monitoring for project impacts is conducted. The point here is that indicators do matter. Because some actions are more difficult or costly to perform, they are likely to be executed less frequently. When choosing and establishing indicators for assessing or tracking water quality improvement efforts, it makes sense to keep this reality in mind.

And third, some of the variation in the proportion of TMDLs that are implemented at various stages of the CWA impaired waters pipeline may be attributed to the manner in which the indicator is assessed or constructed. Two types of sub-factors are potentially important in this regard. The first is the universe of cases that are being assessed. The universe of cases, in turn, is affected by both the unit of analysis that is selected (watershed versus stream segment or water body) and the particular pool of TMDLs that is selected for analysis or tracking. If there are systematic differences in implementation rates based on the units of analysis or among different pools of USEPA-approved TMDLs (as might occur for different states or for TMDLs that have been in place for varying amounts of time), then some of the variation observed in implementation rates is likely to be attributable to these factors.

The second type of sub-factor has to do with the metrics chosen during the construction of the indicator. For example, if we are assessing implementation activities relating to the incorporation of WLAs into permits, one would expect a higher proportion of permits to be "implemented" if the criterion for implementation is the incorporation *of at least one* WLA into a permit limit for a particular pollutant than if the measure was the incorporation *of all* WLAs for all pollutants targeted for that permit by a TMDL. Because TMDLs and TMDL

reports may contain WLAs for more than one pollutant in many cases, it may very well take more time, and possibly more work, to implement all relevant WLAs than it does to implement only one. In other words, while different metrics may seek to measure the same "indicator" (more stringent permits, for example), the particular metrics that are chosen are likely to affect the implementation rates that are identified and reported. These reported implementation rates, in turn, are likely to affect perceptions regarding the effectiveness of current implementation efforts.

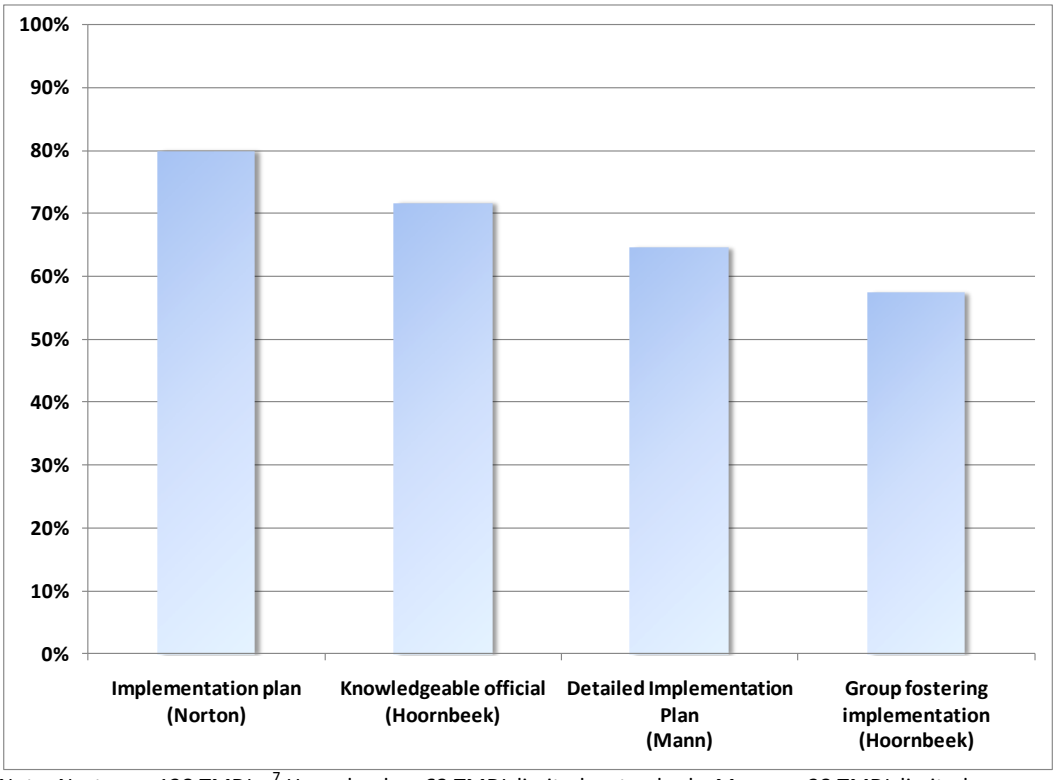
Box 2: Major factors affecting reported implementation rates

Implementation progress: actual differences in the degree to which implementation is occurring in the areas studied.
Indicator selection: differences in what aspects of progress are counted as implementation.
Indicator construction:
TMDL universe: watersheds or stream segments? Geography?
Metric construction: how is the indicator quantified?

The influence of all three of these overarching factors is apparent in the results that are reported in the studies summarized above. Figure 2 presents data on planning activity rates for major indicators from three of the studies summarized above. While all four of the measures reveal planning rates of over 50%, there is significant variation across the indicators. The highest rate of planning activity is documented in the Norton et al. (2009) study for the states in Region 5. While this may be due to planning emphases within these states, it may also be attributable to the rather broad definition of "implementation plan" that is used in the Norton et al. (2009) study. For this study, implementation plans consist of "documentation of planned specific actions and schedules for those actions to be taken in order to reduce pollutant loading consistent with a TMDL" (USEPA, 2009, p. 37). Implementation plans, the study suggests, may be found in a variety of places, including: (1) as a stand-alone document, (2) a part of a TMDL document, (3) as a permit-related document, or (4) as a 319-related document or watershed plan (USEPA, 2009, p. 37). This broad definition means that many different kinds of activities within a watershed may enable the production of a document that meets USEPA (2009) and Norton et al.'s (2009) definition of an implementation plan.

By contrast, the DIPs that Mann assesses in Washington State are specific documents that are typically completed within one year of completion of a TMDL report (Mann et al., 2005, p. 2). While the Norton et al. (2009) measure does tap the concept of an implementation plan, it does so more broadly than the DIP concept measured by Mann et al. (2005). Many other definitions of an implementation plan can also be envisioned, and the implementation rate for development of these plans is likely to depend on the definition used.

Figure 2: Implementation activity at the planning stage: results from recent studies



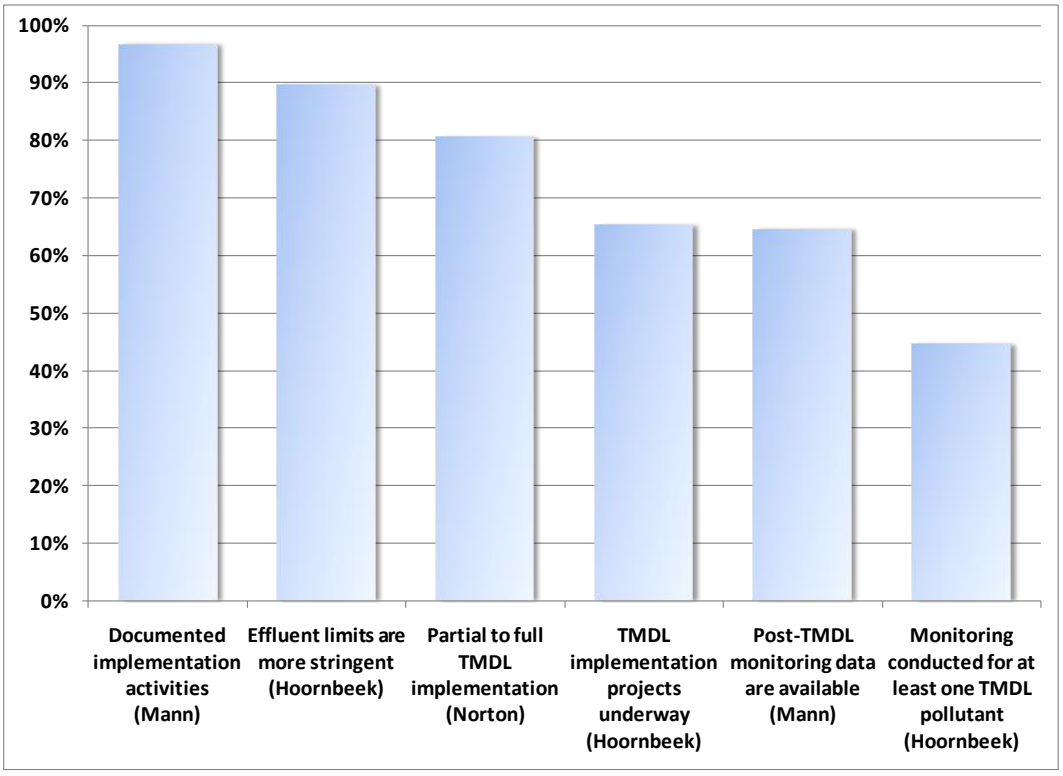
Note: Norton n=138 TMDLs;[7] Hoornbeek n=63 TMDL limited watersheds; Mann n= 28 TMDL limited watersheds. While these indicators fall within the same stage of the CWA impaired waters pipeline, the measures illustrated are not directly comparable to one another.

The two planning measures identified in the Hoornbeek et al. (2008) study of Ohio and West Virginia are also instructive because they demonstrate that implementation rates may be affected not only by the indicator metrics that are chosen, but also by the choice of indicator. This study reports that its authors were able to identify knowledgeable state officials in 71% of the TMDL-limited watersheds in West Virginia and Ohio, but only 57% of these watersheds also had a group that has accepted responsibility for TMDL implementation. Obviously, in this case, identifying an official who is engaged enough in implementation to be knowledgeable about it is a more lenient indicator of planning activity than the existence of a group that is taking responsibility for TMDL implementation.

Figure 3 below presents implementation rates for six indicators of activity at the implementing stage of the CWA impaired waters pipeline. Here, one sees a rather broad range of implementation rates that depend on the indicator that is chosen. The existence of some form of point or nonpoint source implementation activity is present in almost all (96%) of the watersheds assessed in Washington State by Mann and her colleagues. By contrast, the rate of post-TMDL monitoring identified by Hoornbeek and his colleagues for Ohio and West Virginia is less than 50%. Once again, the choice of indicator appears to matter.

[7] The Norton et al. (2009) study has a different unit of analysis than the other studies. Norton et al. (2009) focuses on individual TMDLs while the other studies use watersheds within which TMDLs have been developed to address individual impairments as their units of analysis.

Figure 3: Implementation activity at the implementing stage: results from recent studies



Note: Mann n= 28 TMDL-limited watersheds; Hoornbeek, *Permits in which effluent limits are more stringent,* n=19 permits across 63 TMDL-limited watersheds; Hoornbeek, *Implementation projects and monitoring conducted,* n=63 TMDL-limited watersheds; Norton n=138 TMDLs. While these indicators fall within the same stage of the CWA impaired waters pipeline, the measures illustrated are not directly comparable to one another.

The implementation rates in this figure also suggest that the metrics used to assess progress affect the implementation rates that are uncovered. The indicators of implementation for point and nonpoint sources displayed here from the Hoornbeek et al. (2008) study suggest that there are higher rates of implementation for point than nonpoint sources in Ohio and West Virginia. While this is the case if the metric for WLA incorporation is based on the existence of at least one permit limit that has become more stringent since approval of the TMDL, the picture changes if the metric is changed to require that *all permit limits in place currently* be consistent with the WLA's in the TMDL report. Using this measure, the **implementation rate would drop to about 53% (10/19) from the 89% figure that is shown in Figure 3** (Hoornbeek et al., 2008, p. 50).

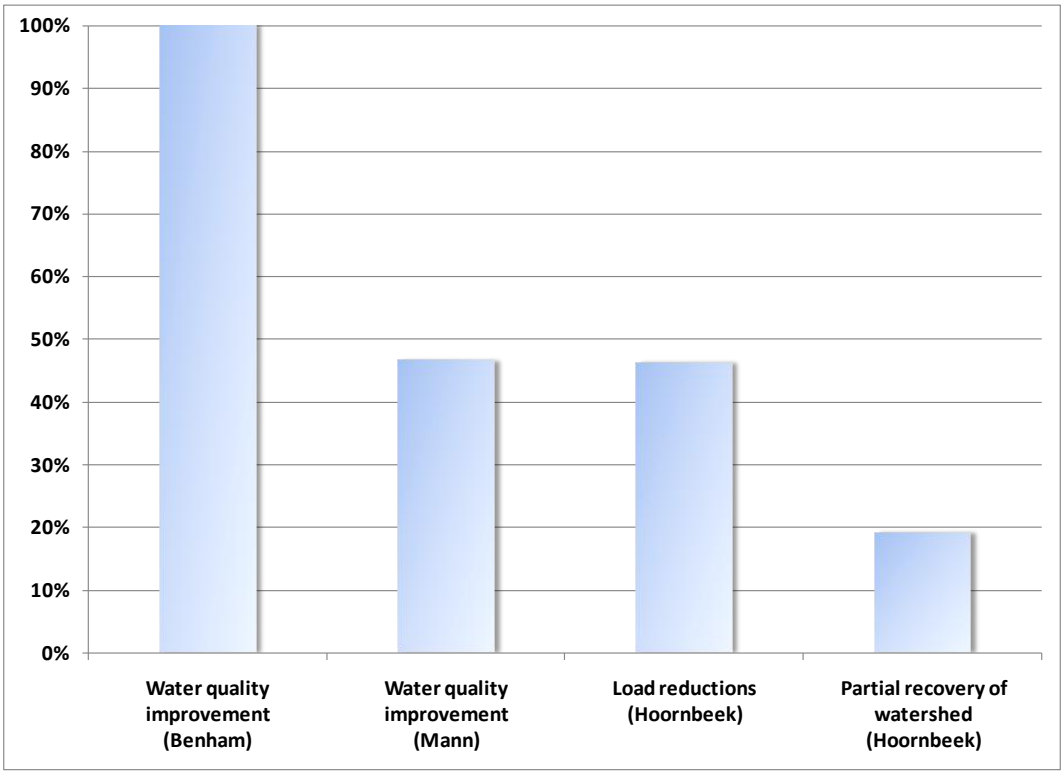
The effect of the universe of TMDLs assessed also appears to be present in the results reported in this chart. The Mann et al. (2005) study documents that monitoring data are available for 64% of the TMDL-limited watersheds assessed in Washington State, while the Hoornbeek et al. (2008) study identifies post-TMDL monitoring in 46% of the TMDL-limited watersheds in West Virginia and Ohio. As noted above, Washington State is known to have a reasonably active effectiveness monitoring program (Onwumere and Plotnikoff, 2003; USEPA, 2010a), so their relatively strong performance on this indicator should not be surprising.

Figure 4 reinforces the influence of the universe of TMDLs assessed on implementation rates in rather stark fashion. The Benham et al. (2006) study focuses only on watersheds that are identified as having experienced water quality improvements through TMDL implementation efforts. Consequently, 100% of the TMDLs assessed in that study are improving as a result of these efforts. The two broad-based studies that assessed

measures at this stage of the CWA impaired waters pipeline—the Mann et al. (2005) and Hoornbeek et al. (2008) studies—show rates of water quality improvement that are far lower than the rates in the Benham study (46% and 19%, respectively).

Interestingly, this same chart demonstrates that the choice of indicators also matters. Hoornbeek et al.'s (2008) assessment reveals that load reductions are perceived to be occurring in 46% of the TMDL-limited Ohio and West Virginia watersheds that are assessed. By contrast, water quality improvements are identified in only 19% of the same sample of watersheds. This difference in improvement rate makes it clear that load reductions (or at least the belief that they are occurring) are more likely to occur than improvements in ambient water quality. While both of these measures signify improvements, they indicate the presence of a different kind or level of improvement.

Figure 4: Implementation activity at the improving stage: results from recent studies



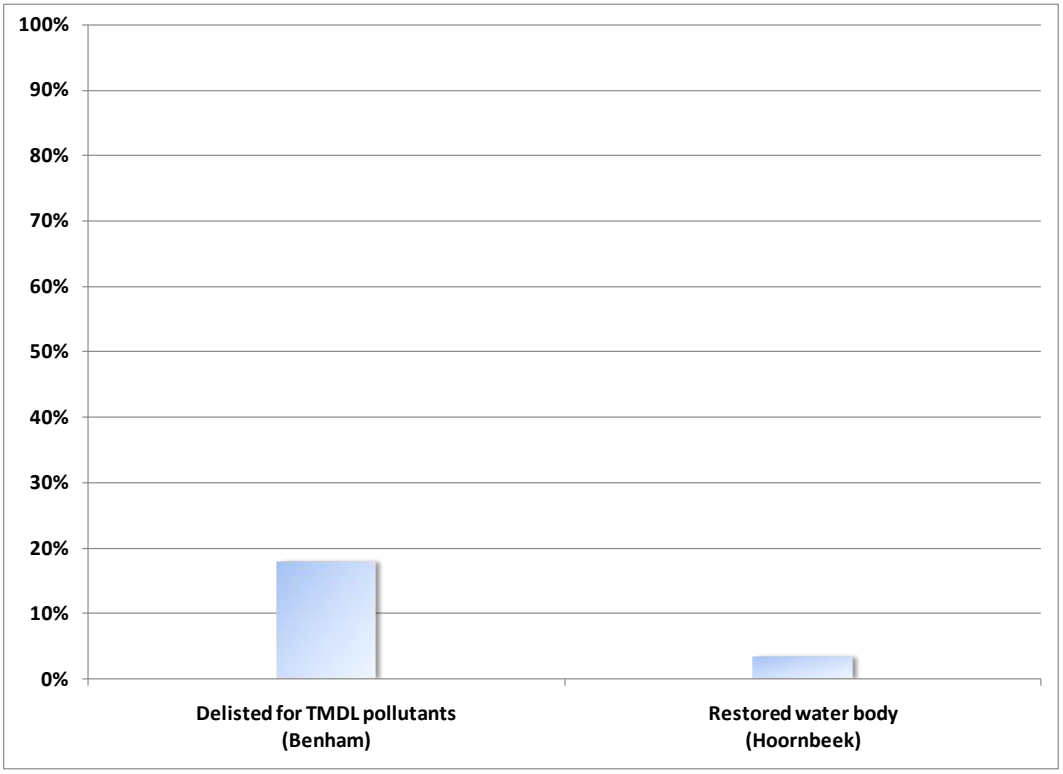
Note: Benham n=17 TMDL-limited watersheds; Mann n=28 TMDL-limited watersheds; Hoornbeek n=63 TMDL-limited watersheds. While these indicators fall within the same stage of the CWA impaired waters pipeline, the measures illustrated are not directly comparable to one another.

Figure 5 illustrates that fully restoring water bodies is a difficult task. It also points to the effects of both the universe of TMDLs being assessed and the choice of metrics on reported implementation rates.

Neither of the two studies that measure recovery report more than 20% of TMDL-limited water bodies in their samples as recovered. This statistic is particularly important because one of the studies, Benham et al. (2006), limits its universe of cases to watersheds in which there are documented water quality improvements—a highly biased sample, to say the least. Even in this case, the proportion of water bodies found to be recovered is only 18%. There are many types of pollutants and pollution sources, and water quality standards are often restrictive (in Ohio, for example, water bodies must meet water quality standards not only for pollutants but also for biological health), so it is indeed difficult to achieve compliance with water quality standards in many water bodies. This conclusion is reinforced by both studies.

The results from the Benham et al. (2006) and Hoornbeek et al. (2008) studies also point to potentially different ways in which water body restoration might be defined. Hoornbeek et al. (2008) use a more lenient criterion than do Benham et al. (2006). For Hoornbeek et al. (2008), a water body is recovered when the water quality problems being addressed in the TMDL are corrected and the state environmental agency makes an official statement to this effect—typically in their Integrated Report to USEPA. Benham et al. (2006) require the actual delisting of the water body from category 5 status to category 1 status, which reflects compliance with water quality standards.[8]

Figure 5: Implementation activity at the recovery stage: results from recent studies



Note: Benham n=17 TMDL-limited watersheds; Hoornbeek n=63 TMDL-limited watersheds. While these indicators fall within the same stage of the CWA impaired waters pipeline, the measures illustrated are not directly comparable to one another.

This difference in choice regarding appropriate metrics is exemplified by how the two studies address West Virginia's North Fork of the South Branch Potomac River. In 2006, West Virginia included this water body in a listing of recovered water bodies in Appendix C of its Integrated Report. The TMDL had been developed for fecal coliform, and when that contamination was alleviated, the state changed the water body's status. Benham et al. (2006) observed the same data, but noted that the water body had not yet been moved to category 1 from category 5 in the body of the report. This, according to Benham et al. (2006), was because the state had not yet monitored the water body to assure that it was not contaminated by other pollutants or impaired in some other way (Benham, 2006, p. D-57). Consequently, the North Fork South Branch Potomac River is not included among the 3 (of 17) water bodies that are declared recovered in Benham et al.'s (2006) report. It is, however, one of the two water bodies that Hoornbeek et al. (2008) found to be impaired and then recovered in their study of Ohio and West Virginia.

[8] Full descriptions of the Integrated Report categories are provided in Appendix A.

Thus, rates of TMDL implementation vary considerably according to the CWA impaired waters pipeline stage, the indicator(s) selected, and the manner in which the indicators chosen are constructed. The key issues identified above for the construction of indicators include the universe of TMDLs chosen (pool of TMDLs assessed and units of analysis) and the choice of metrics.

With these issues identified, the section that follows summarizes recent studies relating to indicators and tracking of TMDL implementation progress, discusses what we know and do not know as a result of these studies, and identifies lessons relating to indicators and tracking that grow out of those studies and other sources.

4. TMDL IMPLEMENTATION INDICATORS AND TRACKING

While the studies of TMDL implementation reviewed in Section 3 improve our knowledge base, they also raise questions about the development of indicators and ways to measure and track them on an ongoing basis.

Until recently, we knew little about the ways in which federal and sub-national agencies established indicators to track TMDL implementation. However, USEPA has recently sponsored several studies of TMDL implementation indicators and tracking that might be used in these systems. These studies have been supplemented by a substantial effort in Minnesota to develop a strategic framework for identifying water quality improvement progress and tracking it on a regular basis.

This section summarizes these four studies. It then proposes and substantiates five postulates of knowledge about current systems and indicators for tracking TMDL implementation. The final subsection then draws from the previous ones—as well as the studies introduced in Section 3—and provides information that may be used to help establish systems for measuring TMDL implementation progress on a regular basis.

4.1 Results of recent studies: a summary

As noted above, four major studies have been published within the last four years that address indicators and tracking relating to the implementation of TMDLs. Three of these studies were funded by USEPA and one was developed by the University of Minnesota with support from the Minnesota Pollution Control Agency (MPCA). Table 4 lists these studies and identifies whether they inquire into indicators and tracking systems that are national, statewide, watershed-wide, or local in scope. The subsections that follow summarize each of these studies, and include descriptions of their purposes, methodologies, and findings.

Table 4: Studies of indicators and tracking of TMDL implementation

Study	National	Statewide	Watershed-wide	Local
Barvenik et al. (2007)	✓			
USEPA (2008)		✓		
Grayzeck et al. (2008)		✓	✓	✓
USEPA (2010a)	✓	✓		

4.1.1 *Total Maximum Daily Load Program Needs Better Data and Measures to Demonstrate Environmental Results*

Source

Barvenik et al. (2007)

Purpose

The purpose of this project was to identify issues relating to the TMDL program that would help future program evaluations. The objectives included collecting information on "the status of TMDL development and implementation, the USEPA's resource investments, and performance measures" (Barvenik et al., 2007, p. 1). The scope of the review broadened as the USEPA Office of Inspector General (OIG) staff examined the program in more detail, so they expanded their focus to include issues associated with TMDL program data and performance measures.

Methodology

This study was conducted between August 2006 and May 2007. The documents reviewed for this study included USEPA's fiscal year (FY) 2005-2008 Annual TMDL Performance Plans; two surface water quality measures that USEPA reports annually; FY 2005 and 2006 Performance and Accountability Reports; the Strategic Plan for 2006-2011; and the National Water Program Guidance (NWPG) for FY 2006-2008 (Barvenik et al., 2007). The authors also used publicly available USEPA databases of TMDLs and NPDES permits. In addition to the document and database reviews, the authors interviewed USEPA headquarters officials; staff from the Office of Wetlands, Oceans, and Watersheds; state TMDL staff from Georgia and Kansas; and USEPA regional TMDL staff from Regions 1, 3, 4, 7, and 10 (Barvenik et al., 2007).

Results and conclusions

The authors suggested that limitations on available data prevented determinations regarding TMDL program results (Barvenik et al., 2007). USEPA tracks NPDES and other TMDL-related permits through NTTS, but this study found the database to be incomplete, with 64% of point source–related TMDLs having associated permits entered in NTTS (Barvenik et al., 2007).

In general, the report addressed a range of issues associated with some of the USEPA's metrics for measuring program accomplishments. It focused significant attention on the need for additional indicators relating to TMDL implementation progress. In this area, it recommended that USEPA:

1. "Require regions to ensure that point source–related TMDLs in the National TMDL Tracking System are associated with NPDES identifiers;
2. Demonstrate that TMDLs are being implemented by annually reporting on the progress of TMDL implementation activities completed nationwide including the number of TMDLs:
    a. That have all WLAs incorporated into NPDES permits,
    b. That have implemented load allocations through at least one best management practice funded through the Section 319 program, and
    c. For which implementation data are not available to EPA;
3. Demonstrate the results of implemented TMDLs by annually reporting on the progress of water quality improvements resulting from TMDLs nationwide" (Barvenik et al., 2007, p. 12-13).

The USEPA Office of Water responded to this report on July 10, 2007, and this response is included in the final report. It initially non-concurred and argued that the recommendations as written were not feasible due to resource limitations and other difficulties associated with implementation. In March 2008, after the initial response and subsequent modifications, however, the Office of Water and the USEPA OIG both concurred on the report and a corrective action plan. The Office of Water response also described ways in which USEPA planned to follow up on the report's other recommendations.

4.1.2 *TMDL Implementation Tracking Needs Assessment: Current Status and Future Needs for States in USEPA Regions 5, 6, and 10*

Source

USEPA (2008)

Purpose

At present, there is "no standardized process for tracking on-the-ground [TMDL] implementation efforts and progress" (USEPA, 2008, p. 4). In order to address this problem, USEPA is developing a CWA impaired waters pipeline as "an organizational framework for developing, assessing, and interpreting results measures. The pipeline identifies key stages along the TMDL process including listing, planning, implementation, and recovery" (USEPA, 2008, p. 4).

This study assessed TMDL implementation tracking in nine states, both in terms of systems that are currently in place, and with regard to state needs and desires for development of a national- or state-level system. States included in the study were Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin (Region 5); Alaska and Washington (Region 10); and New Mexico (Region 6).

Methodology

Interviews with "state TMDL, 303(d), and information systems personnel; conference calls with USEPA regional and headquarters staff, and web-based research" formed the basis for the report (USEPA, 2008, p. 4).

Results and conclusions

Report findings included:

- TMDL implementation faces many challenges, including lack of a regulatory framework for requiring TMDL implementation.
- The states included in the study use a variety of different indicators and tracking systems.
- Several states make use of federal tracking systems, including ATTAINS, Assessment Database (ADB), STOrage and RETrieval (STORET), and GRTS, all maintained by USEPA.
- State tracking systems include Excel- and Access-based applications (Alaska, Illinois, and Indiana) and ORACLE/GIS databases (Wisconsin), among others.
- Washington has developed a computer application called the TMDL Management System that includes basic data on all TMDLs that are in progress or that have been developed, and also includes provisions for some basic data on implementation (USEPA, 2008, p. 16).
- Alaska was found to have "no predefined categories or indicators for TMDL tracking" (USEPA, 2008, p. 5). Indicators that are consistently tracked by individual states include: 319 and other grant-funded nonpoint source projects; 303(d)-listed streams targeted by implementation actions; NPDES permits relevant to TMDLs; development of implementation plans; and biological indicators.
- Some states, such as Wisconsin, are beginning to hire TMDL implementation coordinators.

State perspectives on system development were noted.

- Most of the interviewed states are open to using a USEPA-developed tracking system. Other states prefer to use their existing systems and do not want to shift to a national system that is not directly compatible with their own (USEPA, 2008).
- Desired tracking system features include:
  - Web- or GIS- interface;
  - ability to track progress in stages;
  - compatibility with GRTS, STORET, and ADB, and with specific software programs;
  - ability to input information at different scales (state, county, watershed, and stream segment);
  - use of standardized indicators;
  - flexibility to add new impairments, indicators, and TMDLs within a single water body;
  - easy to learn;
  - access to raw data; and
  - ability to track non-TMDL–related restoration efforts within the watershed.
- Desired tracking categories include:
  - basic TMDL information (water body, ID, pollutants, etc.);
  - existence of an implementation plan;
  - responsible individuals, agencies, permittees;
  - status of required NPDES permit modifications;
  - projects;
  - "water quality monitoring triggers;" and
  - water quality improvement.
- Tracking system benefits include:
  - centralized data storage,
  - TMDL program guidance,
  - facilitation of program efficiency evaluation,
  - ease of data dissemination, and
  - facilitation of inter-agency communication and inter-program coordination.
- Concerns include:
  - lack of necessary personnel and funding for system development and ongoing maintenance;
  - compatibility of a national tool with existing state tools;
  - the use of subjective measures for implementation tracking; and
  - "concern over a tool too tightly linked to TMDL development, potentially limiting the ability to move directly into restoration activities without a TMDL" (USEPA, 2008, p. 25).

USEPA's perspectives were also compiled.

- Desired tracking system features include:
  - ability to track incremental progress,
  - ability to track projects funded by USEPA as well as those funded by other sources,
  - ability to query and export data,
  - both programmatic and environmental indicators, and
  - both subjective and quantitative indicators.
- Tracking system benefits include:
  - ease of inter-state comparison,
  - mechanism for prioritization of monitoring and implementation efforts,
  - facilitation of reporting on water quality improvement,
  - demonstrated efficiency of 319 and other funding programs, and
  - consolidation of information currently tracked by multiple agencies and associated with various programs.

4.1.3 *Developing an Effectiveness Tracking and Reporting Framework for Implementing the Clean Water Legacy Act*

Source

Grayzeck et al. (2008)

Purpose

In 2006, Minnesota enacted the Clean Water Legacy Act. This law is part of the state's efforts to achieve and maintain water quality standards through protection and remediation of surface waters as required in Section 303(d). Water quality monitoring in general and TMDL development specifically have been expanded in the state due to the state Legislature's allocation of funds in recent years. Funding has also been increased for restoration and protection projects. In order to track not only projects and funding, but also results, this report proposes a tracking framework to integrate data from multiple state agencies, facilitating evaluation of water quality improvement and program efficacy.

Methodology

The Water Resources Center (WRC) at the University of Minnesota worked with a steering team consisting of one representative from each of five state agencies: Board of Water and Soil Resources, Minnesota Department of Agriculture, Department of Natural Resources, Minnesota Pollution Control Agency, and Public Facilities Authority. Additional input was gathered from representatives of these and other institutions including USEPA Region 5, a TMDL contractor, and the University of Minnesota, among others. Over the course of several months, this stakeholder group held three meetings. At these meetings, they reviewed existing data and databases; discussed ideas for frameworks and indicators gleaned from interviews with a broader group of stakeholders; and developed the final framework along with other recommendations.

Results and conclusions

The resulting Clean Water Legacy Effectiveness Tracking Framework includes measures in four major categories, at a variety of spatial scales. The four categories are: Partnerships/Leveraging, Environmental Indicators, Social Indicators, and Organizational Performance Table 5 (Grayzeck et al., 2008).

Table 5: The Clean Water Legacy Effectiveness Tracking Framework

Category	Description
Partnerships/leveraging	"[H]ow well are agencies coordinating with other state agencies, with local units of government, with citizens, and with organizations like the University of Minnesota?"
Environmental indicators	"What are the physical results of the 'effort'?"
Social indicators	"[C]hanges in attitudes and behaviors that impact water quality"
Organizational performance	"How well is the organization (state agency, local unit of government, etc.) doing at managing a program or project?"

Source: Grayzeck et al. (2008, p. 4).

Each of these categories contains measures appropriate to different scales: state, eight-digit HUC, and project levels. The project level may be defined by subwatershed, political, or other appropriate boundaries.

In addition to proposing the framework, WRC and the steering committee agreed on a number of key recommendations for its successful implementation (Grayzeck et al., 2008):

- Staff from the agencies represented on the steering committee should be consulted to discuss the suggested indicators and make modifications or substitutions to the framework.
- Following these discussions, WRC and the steering committee should have a final meeting to share feedback and select indicators for inclusion in the framework. Once indicators are selected, a gap analysis should be conducted to identify the data that are not being collected at present.
- A communication plan for reporting results documented by the Clean Water Legacy Effectiveness Tracking Framework needs to be developed.
- Implementation plans should include elements and indicators from the framework.
- A database system should be built to track data collected by various agencies to document progress measured by framework indicators.
- Some additional indicators are still missing from the framework. An example is a measure of the effectiveness of Clean Water Legacy Act–funded research projects.
- While framework data will be entered by several agencies, some party should be selected to be responsible for coordinating framework implementation.
- The framework and tracking system should be reevaluated after two years.

4.1.4 *State Approaches and Needs for Measuring, Tracking, and Reporting on Water Quality Improvements*

Source

USEPA (2010a)

Purpose

Every three years, USEPA must develop a five-year strategic plan. The 2006-2011 Strategic Plan included a goal of improved water quality in at least 250 watersheds nationwide by 2012. Achieving and reporting water quality improvements will require a joint effort by USEPA and state and local agencies. This study documents indicators and approaches that selected states are currently using to measure and document water quality improvement. The study also notes gaps in data collection and tracking methods, and makes recommendations to help close these gaps.

Methodology

USEPA identified nine states for the study: Alaska, Iowa, North Carolina, Oregon, Texas, Virginia, Washington, Wisconsin, and Wyoming. The states were chosen from numerous USEPA regions to represent a range of sizes, geographies, climates, and hydrologic characters. A questionnaire was distributed to each state via e-mail. The level of detail in the responses varied significantly. Following return of the questionnaires, telephone interviews were conducted with each state. Up to eight staff from each state participated in the interviews. Information gathered from the questionnaires and interviews was compiled and shared with the states to further confirm and clarify reported details.

Results and conclusions

The report provided findings on the current status according to states:

- Among interviewed states, “the state ambient monitoring program” is the most common data source used to determine water quality improvements. According to the report, these data are not typically at an appropriate scale for analyzing improvement in particular stream segments.

- Often the water quality data that are collected are not centrally or electronically tracked, and thus are difficult to assess for improvement.
- There is a general lack of data regarding nonpoint source projects and their impacts to water quality.
- Lack of funding is the primary roadblock to data collection and tracking.
- All states conduct some level of physical, chemical, and biological monitoring.
- A desire exists to make more use of biological data, remote-sensing data, and studies of BMP effectiveness.
- Innovative approaches in Wyoming include looking at "changes in physical channel attributes, observable changes at permanent photo points, output from load reduction models for completed projects, and operation and maintenance information from project sponsors."
- Many states have their own planning measures that may not overlap with USEPA strategic planning (SP) measures. Wyoming uses measures that apply to national requirements.
- Most states do not have a consistent method, based on data, for deciding which watersheds they will monitor for project effectiveness. Some states select watersheds based on data availability, staff knowledge of BMP locations, Endangered Species Act listings, or suggestions from stakeholders who believe their watershed has experienced improvement. Washington is one state that has established a protocol for effectiveness monitoring. Virginia does not use "preset criteria for selecting specific watersheds. Rather, they report on all watersheds that have sufficient data to illustrate improving trends or attainment with water quality standards." (USEPA, 2010a, p. 15)
- Some states are implementing strategies to achieve and better document water quality improvements. In Iowa, 319 funds will be reserved for smaller watersheds, and a portion of the funds will be devoted to monitoring for program effectiveness. Wisconsin has implemented three-tiered monitoring: Tier 1 provides baseline data; Tier 2 identifies a cause and degree of impairment; Tier 3 takes place after projects and permit modifications have been implemented to evaluate effectiveness.

The report also offers a broader conclusion, and suggests that there is a lack of adequate data and monitoring to support "efforts to report on water quality improvements and meet Measure SP-12 reporting needs" (USEPA 2010a, p. 4).

Recommendations for program modifications included the following:

- Create targeted effectiveness monitoring.
- Develop biological indicators.
- Improve inter-agency and inter-program collaboration.
- Develop state tracking systems.
- Revise the Consolidated Assessment and Listing Methodology (CALM).

4.2 What we know

The studies presented above suggest that efforts to identify indicators and track implementation progress are in their early stages of development. However, when information from these studies is combined with information gleaned from attendees at the 2009 Water Environment Federation workshop on TMDL implementation in Minnesota and other sources, we can postulate five elements of knowledge that may be helpful in assessing how to proceed with the identification of indicators of TMDL implementation progress and the potential development of systems for tracking TMDL implementation.

4.2.1 *Federal and state officials are interested in knowing more about TMDL implementation*

Three of the four studies summarized above reflect a clear interest among federal and state officials in learning more about TMDL implementation. Barvenik et al. (2007), for example, recommends that USEPA regional offices expand their reporting of information relating to TMDL implementation. In response, the Office of Water has indicated its desire to improve data system linkages to enable better information relevant to TMDL implementation and to continue assessing options for additional analyses of TMDL implementation and has come to an agreed-upon corrective actions plan with the OIG (Barvenik et al., 2007). And indeed, over the past several years, the Office of Water has sponsored numerous studies and forums to increase knowledge and communication about TMDL implementation.

The studies summarized above and other information also suggest that there is significant interest among the states in learning more about TMDL implementation. The USEPA (2008) report finds that "nearly all" of the states they interviewed see value in developing and implementing tracking systems for TMDL implementation (USEPA, 2008, p. 1). This interest contributed to the establishment of a workgroup, which is discussed in Section 6 of this report. Furthermore, the very existence of the Grayzeck et al. (2008) study demonstrates substantial interest in understanding and tracking water quality improvement activities in Minnesota. And finally, the establishment of a TMDL implementation coordinator in Wisconsin and targeted implementation efforts in other states (USEPA, 2008) suggests that some states are already seeking to move ahead with efforts to identify indicators of implementation progress and to establish systems to track progress in various ways.

4.2.2 *There is limited nationwide information on TMDL implementation indicators and tracking*

While the USEPA's TMDL Program Results Analysis Project (Norton et al., 2007) is improving our knowledge of TMDL implementation progress (see discussion in Section 3), it is clear that there is much work to be done if we are to generate continuing growth in this knowledge base at the national and sub-national levels. While the federal government has established water quality–related measures relevant to TMDL implementation progress in its Strategic Plan, systems for assessing progress against at least some of these measures do not yet appear to be well-developed (USEPA, 2010a).

Our knowledge of state-level efforts to assess and track TMDL implementation is also in its early stages. We do not have consistent, comparable, or reliable information on state efforts to identify appropriate indicators of TMDL implementation progress, nor do we have complete and current information on efforts to track these kinds of indicators after they are identified. However, as the study summaries above suggest, we do have the benefit of intensive studies on some states and broader studies that touch on interests and progress in up to nine states (USEPA, 2008 and 2010a).

Among most of the states for which information on TMDL implementation progress and tracking is available, tracking efforts do not appear to be very well developed. A number of states addressed in current studies have modest efforts underway (USEPA, 2008 and 2010a), and those states that have put significant effort into identifying indicators or developing tracking systems (Washington, Minnesota, and Wisconsin, for example) are still relatively early in the process of developing and managing these systems.

Table 6 summarizes information that has been compiled from several sources during the course of this research. It provides information on indicators of TMDL implementation progress and related variables that are currently tracked in some form by the listed twelve states. It also lists indicators that state environmental agency staff thought would be desirable to track on an ongoing basis. Information sources relevant to each state are also provided. It is important to emphasize here that the information contained in this table is

compiled from multiple sources and has not been independently verified as a part of this project, and should be updated with verification processes before it is considered authoritative and reliable.

Table 6: Available information on current and desired data elements for state tracking systems

State	Current data elements	Desired data elements	Source
Alaska	• Basic information about water bodies • Relevant restoration actions	• Completed watershed management plan in place • Responsible parties identified • Funding availability/source	USEPA (2008 and 2010a)
Illinois	• Locations of TMDLs developed and in progress • Section 319 projects (both within and outside of TMDL watersheds) • Conservation 2000 projects • Social indicators • 303(d) information • Funding allocations • Implementation schedules	• Implementation or watershed plan approval (date) • Permits approved (date) • Implementation started (date) • Implementation completed (date) • Monitoring/assessment results • Water body restored • Number of acres with BMPs implemented • Number of acres with conservation tillage/set-aside acres • NPDES permit issuances that include TMDL allocations • Implementation on a county-wide basis • Natural Resources Conservation Service (NRCS) BMP annual report information	USEPA (2008); ISGS (2009)
Indiana	• TMDL development • 319 project information • Water quality data	• Implementation plan completed • Percentage of measures that have been implemented • Monitoring trigger	USEPA (2008)
Iowa	• Monthly: monitored streams are assessed according to the water quality index, a composite measure including dissolved oxygen, e. coli, five-day biochemical oxygen demand, total phosphorous, nitrate + nitrite, total detected pesticides, pH, total dissolved solids, and total suspended solids		USEPA (2010a)
Michigan	• Locations of grant-funded nonpoint source projects • Estimated load reductions from grant-funded nonpoint source projects • NPDES permit status	• Number, location, description of implementation activities • Load reductions achieved • Watershed grants • Watershed groups, meetings, public involvement • Compliance and enforcement activities • Education and outreach	USEPA (2008)
Minnesota	• Nonpoint source projects from 319 program and state programs • Water quality data • Stream gage data	• Economic data (planned) • GIS data for projects (planned) • Flow analyses (planned)	USEPA (2008)
New Mexico	• Wasteload allocations • Grant progress updates	• 319 grants	USEPA (2008)

North Carolina	• Water quality assessments • Planning efforts • Permits		USEPA (2010a)
Ohio	• NPDES permit compliance • Water quality	• Biological indicators (planned)	USEPA (2008)
Washington	• State staff responsible for TMDL development and implementation • Status of report development • 303(d) and 305(b) information • Capability to integrate water monitoring data in the future • NPDES permits affected by the TMDL • BMPs being implemented and locations • Estimated and actual activity cost • Funding sources	• Implementation plan developed (one plan at time of submittal, a second more detailed plan one year later) • BMP implementation status • Monitoring triggers • Overall progress toward restored water	USEPA (2008)
Wisconsin	• Water body status • Pollutant levels • Impairments • Watershed planning recommendations • Updates on 319 projects • Physical, biological, and chemical data	• Effectiveness monitoring (planned) • SP-12 indicators (planned)	USEPA (2008 and 2010a)
Wyoming	• Approved watershed plans' implementation status • 303(d) list status • Restored watersheds • Permanent locations for photographic documentation of physical improvement • Load reduction estimates from computer models • Operation and maintenance data from existing projects		USEPA (2010a)

Note: Information presented here was not confirmed with states during this project and may be incomplete or out-of-date. An indicator being listed in the Desired column does not necessarily imply that it is not currently tracked. Indiana tracks some indicators, but does not currently have a TMDL implementation tracking system in place. Implementation data from various organizations are supplied to Indiana Department of Environmental Management and compiled in hard copy.

While the data elements presented in Table 6 clearly suggest that a number of states are both tracking variables that are relevant to TMDL implementation and thinking about indicators they might want to track in the future, the indicators in place do not appear to represent anything close to comprehensive systems for assessing TMDL implementation progress. Rather, in most cases, these indicators appear to be a compilation of indicators generated by a range of existing water quality programs that are not yet tied in any systematic way to agendas for action that are established in TMDLs. This point is reinforced by USEPA's findings with respect to TMDL implementation in USEPA Region 5. This study stated that "in no state (in EPA Region 5) was all of the required information already compiled (let alone compiled in a central database or tracking system)" (USEPA, 2009, p. 34).

Overall, therefore, it appears that there is significant state interest in TMDL implementation indicators and tracking. Indeed, this interest appears to exceed the resources that are being devoted to it. As a result, there still appears to be relatively limited historical experience at the state level that can be used to derive lessons for application elsewhere.

4.2.3 *Program integration is required to increase our knowledge of TMDL implementation*

The studies summarized above, as well as the TMDL implementation progress studies summarized in Section 3, make it clear that successful TMDL implementation depends on actions taken in a range of water quality programs at the federal, state, and local levels. In many cases, it also depends on efforts by nonprofit watershed groups and others in the private sector. While the idea of coordinating all these public, nonprofit, and private sector actors on a national level is appealing, it may not be feasible in the near-term due to the expense of developing a national system, among other potential issues. However, there are certainly efforts that can be undertaken to better integrate information flows relating to TMDL implementation across programs authorized by the FWPCA. Some of these efforts focus on building stronger intersections among staffs of various FWPCA programs, and others relate to building stronger connections among data elements in information systems at federal and state levels.

At least three water quality program intersections are evident from the studies reviewed above. First, if point source controls called for in TMDLs are to be implemented effectively, then WLAs must be integrated into NPDES permits. The WLA issues are typically addressed by state discharge permitting programs with federal oversight, and successful implementation requires that permit writers know about TMDLs where they exist, read and understand them, and then accurately incorporate their recommendations into NPDES permits.

A similar—although not identical—knowledge base is required for managers of Section 319 programs if they are to address the LAs identified in TMDLs. If these individuals are to target funds toward restoring impaired waters, they need to know about TMDLs where they exist; be aware of the pollutants, impairments, and LAs they should target; and take action to deliver funds to priority needs as identified in TMDLs.

And finally, to build knowledge regarding TMDL implementation, and to develop TMDLs that effectively target high priority implementation actions, close ties between TMDL program managers and federal and state water quality monitoring programs are necessary. One of the most common areas of focus in efforts to assess TMDL implementation progress has to do with monitoring the effectiveness of implementation actions. Building strong ties between TMDL program managers and those who manage and conduct federal and state monitoring programs is therefore of key importance in building more robust systems of information to support effective and adaptive TMDL implementation.

Some of the studies reviewed above highlight the existence of different information systems that might be put to use in the process of developing workable tracking systems related to TMDL implementation. USEPA (2008) points to a number of different databases that may be of use in the development of systems for tracking TMDL implementation.

However, none of the data and reporting systems mentioned in this report have been established with TMDL implementation specifically in mind. As a result, there is still much work to be done before information contained in these systems could be used systematically and consistently to track TMDL implementation progress. Key among the tasks to be undertaken in this regard would be to establish agreed-upon indicators for TMDL implementation tracking, and this is a topic to which we return below.

4.2.4 *Multiple conceptual frameworks are available to guide indicator choice and tracking*

Studies completed to date suggest that we can develop indicators of TMDL implementation progress according to at least two conceptual frameworks. And, as noted in Section 3, there is also variation among the studies with regard to whether they use sampling or canvassing approaches and whether they focus on particular water bodies or entire watersheds. All of these framework variations may be applicable to the specification of TMDL implementation indicators and the development of systems for tracking TMDL implementation progress.

The first of the two conceptual frameworks identified in the studies conducted to date can be called a "stages" framework because it assumes that TMDL implementation occurs in stages and can be measured in stages as well. The CWA impaired waters pipeline is perhaps the quintessential example of the "stages" conceptual framework, although it is not the only one. Mann et al.'s (2005) approach appears to have been the first study that operates on the basis of this framework, and it addresses two kinds of measures: implementation activity and water quality improvement. Hoornbeek et al. (2008) expanded on Mann et al.'s (2005) approach by adopting a modified version of the CWA impaired waters pipeline framework (Norton et al., 2007) and examining a number of specific measures of TMDL implementation progress. Hoornbeek et al. (2008) suggest that TMDL implementation progress can be assessed in terms of four categories of progress: (1) planning and management, (2) implementation of controls, (3) partial recovery, and (4) water body restoration. The Norton et al. (2009) study also uses a "stages" framework, as it considers rates of partial and full TMDL implementation. In so doing, it draws a distinction between the two levels of progress based on the extent to which actions called for in approved TMDLs have been implemented.

Grayzeck et al. (2008) offer a second kind of conceptual framework that focuses on implementation progress in differing sectors, and we therefore label it a sector-based conceptual framework. This framework identifies sectors of activity that are thought to foster implementation progress, and offers indicators of progress based on those sectors of activity. As noted above, the approach forwarded by Grayzeck et al. (2008) focuses on a fourfold characterization of implementation progress: (1) organizational performance, (2) social indicators, (3) environmental indicators, and (4) partnerships and leveraging. Their focus is on creating a broad structure that may be used at multiple levels in the implementation processes. Consequently, it may accommodate a wide set of measures at differing geographic scales, including states, regions/basins, major watersheds, and projects.

Box 3: Conceptual frameworks for assessing TMDL implementation progress

Stages framework. This framework is built around the concept that implementation occurs in stages and that indicators, measurement systems, and tracking arrangements can be organized in ways that reflect sequential progress through various steps of implementation. The CWA impaired waters pipeline is an example of this kind of framework.

Sector framework. This framework is built around sectors of activity that are believed to lead to successful implementation. The recently developed Effectiveness Tracking and Reporting Framework for implementing Minnesota's Clean Water Legacy Act is an example of this approach.

The Norton et al. (2009) study also introduces the idea of sampling-based strategies for assessing progress, a contrast to the full canvass of approved TMDLs approach used by Mann et al. (2005) and Hoornbeek et al. (2008). In its response to the USEPA OIG (Barvenik et al., 2007), the Office of Water also advances a sampling approach as a cost-effective way of assessing overall TMDL implementation progress, without incurring all of the costs associated with canvassing for information about TMDL implementation from all known TMDLs.

Another framework-related question relating to the assessment of TMDL implementation progress is whether assessments are made at the water body or watershed level. On a national level, USEPA tracks the development of TMDLs at the water body (or segment) level, and numerous water bodies or segments may be included in any one watershed. However, only one of the studies summarized above measured TMDL implementation progress on the water body or segment level: Norton et al. (2009). All of the rest of the studies address assessments carried out at the watershed level (Benham et al., 2006; Hoornbeek et al., 2008;

Mann et al., 2005). The question of whether to use water bodies or watersheds as the primary unit of analysis for measuring implementation progress will be present in any effort to measure and track TMDL implementation progress, regardless of whether the system follows a stage, sector, or some other kind of conceptual framework.

4.2.5 *Potential indicators and elements for TMDL implementation tracking are numerous*

In addition to the indicators used to assess TMDL implementation progress discussed in Section 3, the four studies reviewed above reveal numerous additional potential indicators of TMDL implementation progress. Indeed, a review of these studies yields approximately twenty additional potential indicators of TMDL implementation progress that are not included among the eleven indicators shown in Table 3. These latter indicators are identified in Box 4, and a large listing of variables relating to TMDL implementation uncovered in the eight studies assessed for this report can be found in Appendix B.[9] In addition, two indicators forwarded to USEPA for consideration by the IMWG are provided in Appendix C.

Box 4: Additional potential indicators of TMDL implementation progress

- Number of acres with BMPs implemented
- Number of acres with conservation tillage/set-aside acres
- NRCS BMP annual report information
- Percentage of measures that have been implemented
- Grants from state agencies or other sources (Clean Michigan Initiative, and potentially other sources)
- Biological indicators
- Significant improvement has occurred with a 90% or greater level of confidence, where improvement is defined as significant watershed-wide improvement in one or more water quality parameters
- A "multiple lines of evidence approach" in which the cumulative weight of several lines of evidence is used to assess whether a watershed-wide improvement has occurred
- Number of lakes/streams with citizen volunteers
- Actual versus expected water quality by region/ecoregion
- Number/percent of recreational and drinking water impairments restored
- Percent of stream miles eroding/percent of stream miles that are buffered
- Percent adoption of key non-regulated BMPs for a given land use
- Percent of land covered by a non-regulated BMP
- Behavioral tracking for non-regulated measures
- Local government compliance with stormwater pollution prevention program
- Percent adoption of key urban runoff stormwater BMPs for a given area
- Percent compliance with NPDES permits
- Tons of pollutant per capita
- Actual occurrence of activities consistent with a designated use

[9] This list includes both indicators of TMDL implementation progress and other variables that may be desirable to identify and track in connection with TMDL implementation, but which are not direct measures of TMDL implementation progress.

When the indicators in Box 4 are combined with the major indicators in Table 3, it becomes clear that there are numerous potential indicators of TMDL implementation progress that have been identified in this study alone. If differing ways of constructing these indicators are taken into account, the number of potential measures of TMDL implementation progress could expand considerably—well into the dozens and perhaps into the hundreds. This, of course, raises questions about how to decide upon particular indicators to represent TMDL implementation progress, and then possibly how to track them as well. We return to this point in Section 5, after identifying several lessons that have emerged from our review of these four studies of TMDL implementation indicators and tracking systems.

4.3 Lessons from recent studies

The information provided earlier in this section yields several additional lessons that can be taken into account in assessing possible indicators of TMDL implementation progress and in deciding upon ways to improve our base of knowledge regarding TMDL implementation. These lessons are described briefly in the subsections that follow.

4.3.1 *There is an opportunity for national and state leadership on TMDL implementation*

As noted above, there is now wide interest and concern regarding whether and how the recommendations contained in TMDLs are implemented through NPDES permits, water quality monitoring programs, Section 319 programs, and other means. This has been apparent for several years now, and it has continued to be apparent during the course of this research.

As a result of this interest and concern, there is now an opportunity for leadership at national and state levels relating to TMDL implementation generally, and ways in which we can build and communicate our knowledge base in particular. At the national level, this leadership can be exercised by USEPA and/or the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA). And, to their credit, both USEPA and ASIWPCA are active in this area. As is noted above, USEPA has sponsored a number of studies of TMDL implementation, as well as conferences and gatherings to help produce and share information in this area. ASIWPCA has engaged its membership in this area as well.

States—and even groups of states under the auspices of a USEPA regional office—can also exercise leadership in defining indicators and in establishing means by which information on progress using these indicators can be developed and shared. In all cases, these efforts can take place with the goal of informing ongoing water quality management processes at the sub-national level.

It is important to note, however, that focused effort is important in this kind of process. As the Office of Water pointed out in its response to the Barvenik et al. (2007) OIG report, resources devoted to tracking progress are resources that have not been devoted directly to actual water quality improvement efforts. While developing indicators and understanding progress is of critical long-term importance because it helps ensure that we devote resources where they can be used most effectively, there is a point of diminishing returns where the cost of additional indicator development and tracking comes to outweigh the benefits achieved through this kind of investment. This point is important to keep in mind as the numbers of potential "good ideas" regarding indicators to track start to multiply.

4.3.2 *Collaboration among water quality programs is important for defining successful indicators*

The TMDL program can be viewed as a "nexus" program within the overall context of the nation's water quality improvement efforts. It draws insight from water quality monitoring programs and then depends on the NPDES program, the Section 319 program, and other external efforts to ensure that its recommendations are implemented. The studies above make it clear that current program managers are thinking about implementation in terms of other water quality programs, but it is less certain that leaders of federal and

state permitting, monitoring, and Section 319 programs are fully engaged in current discussions about TMDL implementation. To the contrary, the studies on TMDL implementation that have been conducted (Hoornbeek et. al, 2008, for example) suggest that information on TMDL implementation is widely dispersed and does not appear to be compiled in centralized ways that foster either understanding of TMDL implementation progress or coordinated efforts to manage pollution reduction activities in particular watersheds.

Over the long run, it is unlikely that indicators developed solely within the TMDL program will be successfully implemented because implementation progress depends on support from other key elements of national and state water quality programs. Consequently, the success of national- and state-level efforts to enable TMDL implementation progress will depend on whether these partners in the national water quality protection program can be engaged to support both common indicators of progress and the implementation of recommendations contained within TMDLs.

4.3.3 *Implementation indicators are useful, but other information is also important*

The large number of implementation indicators identified above makes it clear that there are many choices that could be made in developing either further information on TMDL implementation, or tracking systems for specified indicators. However, it is also apparent that this is only part of what is involved in improving our understanding of TMDL implementation and in developing tracking systems that can enable us to do this on an ongoing basis.

For example, if we are to assess TMDL implementation progress, is important to specify not only indicators of progress but also the TMDL(s) for which progress is being tracked, geographic information on the projects involved, and the pollutants and impairments that are in need of correction. Choosing indicators of progress—while an essential and important first step—is just one set of decisions in a longer sequence of efforts that need to be undertaken if we are to build a stronger base of knowledge on TMDL implementation.

Furthermore, if a decision is made to develop a tracking system for TMDL implementation at any level, then additional questions arise about where to house that system, who should be involved in developing and maintaining it, and ways in which it might be accessed. In interviewing states, USEPA (2008 and 2010a) identified several components related to both processes and indicators that state agency officials would like to see in tracking systems. On the technical side, state officials would like a Web-enabled tool that is easy to update and query, that tracks projects from different funding sources, and that includes programmatic and environmental measures of incremental improvement, both qualitative and quantitative (USEPA, 2008). Identified data needs also include increased reliance and tracking of biological measures and remote sensing and GIS data, as well as effectiveness ratings for BMPs (USEPA, 2010a).

At the end of the day, however, choices regarding information needed to understand TMDL implementation progress, the design of potential tracking systems, and the indicators of TMDL implementation progress that are chosen will depend on the specific information and management needs that are identified by key officials at multiple levels in the nation's water quality management system. The following section describes several key questions that are relevant to the choice of TMDL implementation indicators (and potentially other data elements and tracking system characteristics) at the national, state, watershed, and local levels. The answers to these questions would seem to be appropriate starting points in the selection of appropriate indicators and, eventually, the design and implementation of systems for building knowledge about and tracking TMDL implementation progress.

5. TMDL IMPLEMENTATION INDICATORS: PROGRAM NEEDS, TYPES OF INDICATORS, AND POTENTIAL EVALUATIVE CRITERIA

While the studies summarized in the previous sections have improved our knowledge of TMDL implementation considerably, they do not provide clear guidance for identifying indicators or building tracking systems to improve our knowledge of TMDL implementation. To address these issues, USEPA (2008) proposed the establishment of a group of state officials to work with USEPA staff to address key questions that must be answered to guide the development of indicators and tracking systems (USEPA, 2008, p. 30).

This section poses four questions that should be addressed if more robust efforts are undertaken to develop TMDL implementation indicators, improve our knowledge of TMDL implementation progress, or create implementation tracking systems:

1. What are the major water quality program needs?
2. What indicators of TMDL implementation progress should be considered?
3. What criteria should be used to evaluate alternative indicators?
4. What can be done at the national level to foster progress?

While the questions are important ones, the discussions below are illustrative and seek only to provide insight and guidance for further investigation and consideration by appropriate state and federal officials. These officials, in turn, may choose to develop recommendations on indicators of implementation progress and appropriate steps to improve our knowledge base regarding TMDL implementation. They may also go one step further to establish tracking systems for TMDL implementation.

It is important to note the challenges involved with the implementation of complex tracking systems for TMDL implementation, in terms of both financial resources and the time it would take to get such systems in place. As noted by USEPA (2008), states that do not already have developed tracking systems often have no source of funding to develop their own tracking system, and states that do have tracking systems often have limited funding for ongoing development. Therefore, it is appropriate for states to have the opportunities to choose indicators that best fit their current water quality programs and TMDL implementation practices. This will minimize costs and enable transition to new systems for tracking implementation progress for states that choose to use these systems. The discussion below explores the needs of the nation's water quality programs at national and sub-national levels, what indicators should be considered, and what criteria should be used to evaluate selected indicators of progress.

5.1 What are the major water quality program needs?

If a system for tracking TMDL implementation progress is to be useful, it should be based on water quality program needs. These needs may be different at the national and sub-national levels. By focusing attention on identifying the highest priority needs at various levels of the US water quality management system, we may be able to narrow our focus to those indicators that successfully address priority needs. While priority needs are best identified by key national, state, and local officials, some needs at each level do seem apparent. The national and sub-national needs defined below are illustrative and are intended to prompt thought and discussion on the part of key water quality program stakeholders.

5.1.1 *National needs*

At the national level, the major needs for information tracking will depend on applicable measures in USEPA's Strategic Plan and updates to those measures that are envisioned in the future. There may also be other

needs that become important for assessing national progress and guiding decision-making relating to the national water quality program.

As part of its 2011-2015 Strategic Plan, USEPA established several targets for the restoration of surface waters (USEPA, 2010b). Major 2015 targets relating to TMDL implementation are to:

- achieve full water body restoration (meet water quality standards for all pollutants and impairments) in at least 3,360 water bodies and to
- eliminate at least one cause of impairment to at least 40% of impaired water bodies within at least 330 impaired watersheds.

These strategic objectives are incorporated into the USEPA NWPG (USEPA, 2010a). Because USEPA updates its Strategic Plan regularly, it is possible that these measures will give way to new measures in the future. Needs relating to any new measures should also be accounted for in the design, development, and management of indicators and tracking systems developed for TMDL implementation.

Information on TMDL implementation progress can serve an important role in documenting progress toward these national water quality goals and objectives. The OIG, for example, recommended that USEPA track and report information on the number of TMDLs for which WLAs are incorporated into permits and the number of TMDLs for which TMDL-generated LAs have been implemented through BMPs funded through the Section 319 program (Barvenik et al., 2007). As was noted previously, the USEPA Office of Water did not concur with OIG's recommendations initially because of concerns about the cost and feasibility of operating a tracking system of this kind at the national level. However, the Office of Water and the OIG were eventually able to concur on both the report and a corrective action plan in March 2008. In this sense, the Office of Water continues to suggest that there is value in learning and communicating about TMDL implementation progress (Barvenik et al., 2007).

There are a number of databases available to store information and enable its accessibility to local, state, and federal governments, as well as other relevant actors. ATTAINS, which operates under Office of Water control, is the database to which states report mandated information on their surface water quality. The Permit Compliance System (PCS) and Integrated Compliance Information System (ICIS) are under USEPA Office of Enforcement and Compliance control and house enforcement information on wastewater discharges and their compliance status. PCS and ICIS are based on state agreements with USEPA and are difficult to modify, possibly limiting their usefulness to their original purposes (USEPA, 2008 and 2009). GRTS tracks nonpoint source projects funded through Section 319 grants.

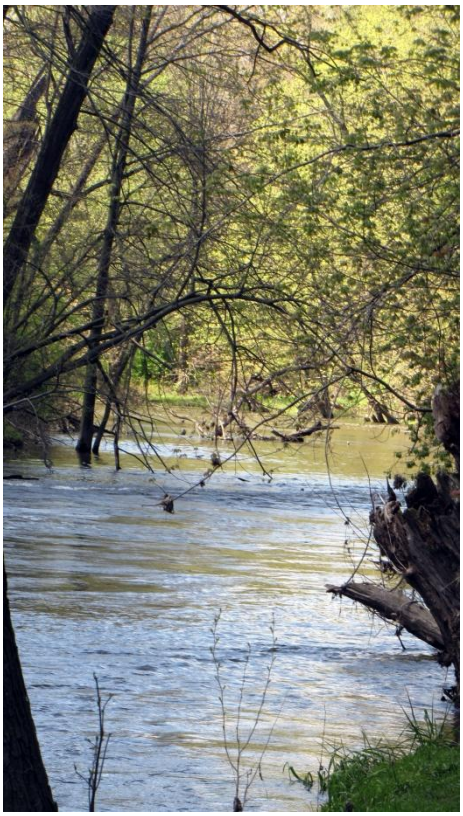
While full water body restoration is the ultimate goal of the national clean water program, interim progress is necessary to assure continuing progress toward the achievement of full restoration of water bodies throughout the country. For this reason, USEPA and state personnel have discussed the addition of one or more measures of interim progress that would help USEPA and other agencies determine whether they are on track to meet their long-term strategic goals, thus allowing them to revise national plans and activities accordingly.

Toward this end, in 2010, USEPA included potential proposed measures in its 2011 NWPG. The measures were developed by the IMWG, a group of state and USEPA officials who were tasked with developing or revising national incremental measures of water quality improvement progress. The IMWG was established in August 2009 and its work is discussed further in Section 6 of this report.

5.1.2 *State, watershed, and local needs*

Needs for implementation progress are likely to vary across states, watersheds, and among local government jurisdictions. State programs are organized differently, and the nature and role of TMDL implementation efforts may therefore vary across states as well. At the watershed level, impairment problems vary

significantly and this means that information needs are also likely to vary. And finally, at the local level, some local government jurisdictions are quite involved in TMDL implementation–related activities, while other local governments have little concern or involvement in TMDL implementation.



At all of these levels, developing useful indicators of progress and/or tracking TMDL implementation can serve a variety of common purposes. For example, indicators and tracking may help state, watershed, and local stakeholders to:

- identify gaps in their current water quality improvement strategies,
- develop guidance for future implementation progress,
- target implementation efforts to increase restoration efficiency and effectiveness, and
- report progress to higher-level agencies and stakeholders.

If undertaken on a widespread basis, developing indicators and tracking systems designed to address these needs might also foster progress toward other water program goals, including the protection of unimpaired waters and drinking water supplies.

5.2 What indicators of TMDL implementation progress should be considered?

As is evident from the discussions above, one could imagine tracking dozens of different potential indicators of TMDL implementation progress. However, it is important to recognize that there are appropriate and practical limits on the number of indicators to be tracked. Indeed, it seems appropriate for a limited number of indicators to be identified by national and sub-national officials who are responsible for protecting and restoring the nation's waters, and then re-evaluated periodically so they can be updated and adjusted as needed. To facilitate this process, the discussions below offer several ideas relating to broad types of indicators that could be considered.

5.2.1 *Potential national indicators*

While there is a wide range of potential national indicators that could be used, four types of indicators stand out. Three of these types of indicators correspond to USEPA's SP measures and one type is a potential addition.

Full water body restoration

A key goal of the FWPCA is to restore the integrity of the nation's waters, and one of the central strategic objectives in USEPA's current Strategic Plan is to achieve full water body restoration (meet water quality standards for all pollutants) in at least 3,360 water bodies. Synergistically, the current CWA-required integrated reporting processes provide a mechanism for states to report this information. For this reason, reporting full water body restorations on a regular basis seems to be an appropriate indicator for consideration.

The problem is that full water body restoration is not yet particularly common. Attainment of compliance with water quality standards for some pollutants, such as nutrients, takes many years, especially when the majority of the sources are nonpoint sources. This is due at least in part to the fact that most states do not

have regulatory mechanisms to control nonpoint sources. Also, reductions in pollutant loads may require significant time before a response may be detected in the receiving water for certain pollutants (e.g., nutrients).

Another potential difficulty relating to this kind of indicator can be traced to the pollutant-specific manner in which TMDLs are prepared. It is quite possible for implementation actions recommended in a TMDL to be fully and successfully carried out without fully restoring a water body. This is because even implementation efforts that eliminate a particular source of pollution targeted by a TMDL will not fully restore a water body to water quality standard compliance if it is also affected by other pollutants or sources of impairment. Consequently, even full and completely successful TMDL implementation may not yield full water body restoration.

In summary, while full water body recovery is certainly an appropriate objective in light of the goals of the FWPCA, it is an objective that is often quite difficult to achieve—particularly over shorter time horizons.

Elimination of the causes of impairment at the water body level

The FWPCA also calls for the elimination of point source discharges and the establishment of fishable and swimmable waters throughout the US. A central objective of USEPA's current strategic plan is to eliminate the specific causes of water body impairment; therefore, one indicator of TMDL implementation progress that might be considered is the elimination of specific causes of impairment that are identified in USEPA-approved TMDLs.

At this point, however, it is not entirely clear how progress on this strategic measure is being, or should be, measured. In some cases, particular TMDLs focus on specific causes of impairment, such as point source discharges. However, in other cases, they may focus broadly on nonpoint source runoff from farms, or urban stormwater runoff, for example. In these latter cases, it can become difficult to know the *specific* causes of impairment that would need to be eliminated to demonstrate implementation progress according to this measure. Furthermore, even if the specific causes of impairment are known and accounted for in the TMDL, keeping track of all causes and knowing when they are actually being removed is likely to be a time-consuming and resource-intensive process.

Elimination of the causes of impairment at the watershed level

Many recent discussions of national water quality improvement efforts have focused on the benefits of addressing water quality improvement problems on a watershed scale. And indeed, the studies reviewed above suggest that both observers of state and federal water quality programs and state programs themselves are tending to diagnose problems and identify progress at the watershed level. The value of this approach is also recognized explicitly in SP-12, which is based on one of the key strategic objectives in USEPA's 2011-2015 Strategic Plan (USEPA, 2010b). As noted above, this objective suggests a need to eliminate at least one cause of impairment to at least 40% of impaired water bodies within at least 330 impaired watersheds.

Identifying improvements according to this kind of measure may not be easy in all cases. This is due in part to the fact that TMDLs are written to reduce loads associated with particular pollutants, and reducing pollutant loads may or may not eliminate the cause of impairment. By their nature, impairments refer to the condition of water bodies in comparison to state water quality standards that have been established. In some cases, states establish water quality standards on the basis of biological criteria rather than on the basis of particular pollutants. As a result, implementing recommendations contained in TMDLs may not always remove underlying causes of impairment, and this means that reporting on this kind of measure may require substantial amounts of information relating not only to TMDLs, but also to water quality standards and likely sources of impairments.

Difficulties associated with reporting on this kind of measure are revealed in one recent study of nine state water quality programs (USEPA, 2010a). It found that just one of the nine states conducts the kind of watershed monitoring necessary to gauge progress toward this strategic objective (USEPA, 2010a, p. 4). Consequently, it appears, there is a need to think further about appropriate indicators of progress for this strategic measure and how reporting might take place on a national scale.

Other interim measures

The three types of indicators outlined above are driven specifically by FWPCA requirements and objectives contained in USEPA's Strategic Plan. However, all three indicators are outcome measures, so their accomplishment may take place only after significant efforts are undertaken to produce outputs and impacts that enable their achievement. In addition, it is not yet clear how the states and USEPA will be able to establish and report on specific measures of progress relevant to two of these three objectives (the second and third above), so it may be difficult to know there is progress even if progress is actually occurring.

For this reason, it may be appropriate to add one or more measures of progress that reflect water quality program outputs or impacts, or partial recovery outcomes. This addition would allow measurements of progress that fall short of full accomplishment of the SP objectives. In the event that current strategic goals are not fully achieved by 2015 (which seems at least possible, and perhaps even likely), these interim measures would enable useful communication about the progress that has been achieved and the creation of an information base upon which to rely in developing future water quality program planning at the national level.

A range of interim measures might be useful in this regard. One approach might involve counting positive impacts at either the water body or watershed level. In general, these impacts might include improvements resulting from TMDL implementation—both documented water quality improvements and documented pollutant load reductions. Another measure that could be used might involve identifying and counting concrete planning or project outputs in the water bodies and watersheds targeted by TMDLs. And finally, one participant in our TMDL implementation discussion session at the 2009 Water Environment Federation TMDL conference in Minneapolis suggested the use of observational indicators, such as whether water body or watershed uses are observed to be met by state water program officials. These are just three possible approaches to interim measures. Other appropriate alternative approaches may very well be available. The common theme running through these suggestions is that it is important to identify where progress is being made and how—even if we cannot yet observe the actual accomplishment of outcomes envisioned by USEPA's SP objectives.

5.2.2 *Potential state, watershed, and/or local indicators*

The number of potential indicators that could be used at sub-national levels is very large. Indicators used in existing studies and by states that are currently making efforts to measure and track various aspects of TMDL implementation number into the dozens and many of them are listed in Appendix B. These indicators provide a good foundation for discussions of potential indicators for use at the sub-national level. There may also be other useful indicators that have not been used in the past and that are not listed in the appendices.

Because of the large number of potential indicators, it seems appropriate to think about the options in terms of broad categories at this point in time. In this context, four broad national options for encouraging and guiding state efforts to develop and make use of TMDL implementation progress indicators are identified and summarized briefly below. These broad national options are presented below in sequential order, with options that envision lower levels of national support and intervention preceding options suggesting higher levels of national support and intervention.

Adhere to national-level indicators and leave all other program targets to state discretion

The CWA provides for the delegation of ongoing water quality management to state governments. While there are certainly good reasons to establish national measures to assess nationwide progress and to provide broad guidance for national water program efforts, state water quality programs vary considerably and officials in those programs may be best able to determine if specific TMDL implementation measures and tracking systems are appropriate. According to this line of thinking, there is little reason for national groups, or even groups of state officials, to encourage states to establish indicators beyond those that are identified and tracked nationally.

States can benefit from national assistance and/or should add at least one state-specific outcome- or impact-level measure to existing national indicators

A second line of thinking suggests that states should think about the water quality impacts and outcomes they are trying to achieve, and it recognizes that state-specific influences on water quality programs can sometimes divert attention away from this key question. Those espousing this view might suggest ongoing national assistance to state governments in developing and using indicators of TMDL implementation progress, or even the establishment of some baseline set of nationwide recommendations to help state officials who are trying to focus attention on the need to identify clear impacts or outcomes that they are trying to achieve.

States should identify indicators or measures of progress at the watershed and/or local levels

According to this line of thinking, states should establish not only state-level goals and indicators, but also clear expectations about specific results (outcomes, impacts, and/or outputs) that should be achieved at the watershed and/or local levels. Because current water quality problems are drawn disproportionately from nonpoint sources that are often not regulated at the state level, this line of thinking suggests that there may be a need to provide state officials with additional leverage to make it possible to foster concrete water quality improvement actions at the watershed and/or local levels in cases where sub-national arrangement or dynamics deter this kind of focus. A set of national recommendations or requirements might be helpful in this regard.

States should establish measures of implementation progress at the state, watershed, and/or local levels and report to USEPA (presumably at the regional level) regularly on their progress

While this line of thinking also recognizes the need for measures of progress to be established at the sub-national level, it suggests reporting requirements or regimens to help ensure the ongoing fidelity of sub-national efforts to the measures that are established. The reporting processes and requirements established can help ensure transparent use of these measures, and they might also foster more explicit discussions among sub-national stakeholders regarding ways in which results may be achieved. Where indicators are compatible across states, reporting would allow USEPA to aggregate results.

The broad options for national and sub-national indicators outlined above are presented for illustrative purposes only. They are designed to enable discussions of more specific indicators to take place in the context of recognized and accepted definitions of potential federal and state roles. Further discussion of these (and other broad options) could take place in appropriate contexts, such as a forum of state officials developed to provide educated advice to USEPA and leaders of state environmental agencies. Regardless of the broad option(s) selected, however, it is important to identify criteria that may be used to evaluate more specific indicators from among the many options available.

5.3 What criteria should be used to evaluate alternative indicators?

The subsections that follow identify and discuss five kinds of criteria that may be applied productively to evaluations of alternative indicators. Other criteria may be applied in addition to, or in place of, those that are discussed below.

5.3.1 *Adequacy for addressing program needs*

One key criterion for evaluating any potential indicator is the extent to which it actually reflects an important objective of the water quality programs in question. For example, an indicator for full restoration of an impaired water body would score well on this criterion because it corresponds quite directly to statutory goals contained in the FWPCA and in many state laws. By contrast, an indicator consisting of how much money is spent on an impaired water body may not score as well according to this criterion if it is tied to the need for full compliance with water quality standards because waters can remain impaired even after the expenditure of large amounts of money. All else being equal, indicators that measure program objectives directly are more useful than indicators that measure program objectives indirectly.

It is useful to point out that program needs vary across jurisdictions. However, two broad categories of need were identified through the course of conducting analyses in support of the work of the IMWG. The first such need relates to measuring progress so officials can know when existing program efforts are being successful. However, a second broad category of program need also emerged. It relates to understanding progress in sufficient detail to enable productive targeting of future water quality improvement actions. For example, learning that a growing number of stream miles are in compliance with water quality standards can provide reassurance that water quality improvement progress is occurring. However, just knowing that a growing number of river miles are being successfully restored does not necessarily yield insight on specific actions that can be taken to accelerate water quality improvement progress in the future. Additional information is needed for this purpose, and it might be productively captured if, for example, additional indicators relating to geographic locations of pollution control actions were also identified and tracked.

5.3.2 *Ease of data collection and analysis*

Because resources for water quality programs are limited, it is important that the indicators chosen be ones that can be measured efficiently and effectively. Indicators that are expensive or difficult to measure on a continuing basis often are not measured because of competing demands. As a result, the adoption of these kinds of measures may even be less helpful than ignoring the measurement issue altogether because they may lead officials to believe that useful measures have been established when in fact they have not. To be useful, indicators must be measurable, and they are not measureable on any consistent basis if it is not practically possible for them to be monitored as needed. Because the ability to actually measure progress is of critical importance, one could argue that this kind of feasibility criterion is the most important criterion of all.

5.3.3 *Potential for comparability among jurisdictions*

Indicators that are used as parts of a larger system of performance measurement and monitoring must be consistent across the jurisdictions and problem situations encountered if they are to be used successfully to guide decision-making on a large scale. For example, it is not appropriate to set priorities based on measures that favor one area over another. While this does not mean that all indicators measured in any one situation must apply to all situations, it does mean that broad-based indicators that are applied at national or statewide levels should be ones that have meaning in a range of different circumstances. These broader measures may, in turn, be supplemented by measures that are specific to particular watersheds or localities. However, it may not be advisable to completely replace these broader measures with narrow, site-specific ones.

5.3.4 *Consistency with existing programs*

Across the US, there are valuable water quality programs operating at the national, state, watershed, and local levels. In developing indicators of progress, it is appropriate to recognize that the indicators chosen should not—wherever possible—undermine existing programs that are successful in achieving water quality goals. While the discussions above suggest that efforts to develop and track indicators of TMDL implementation progress are not yet well-developed, they have also identified several state programs that are moving ahead productively in this area. Consequently, in developing national indicators and recommendations regarding sub-national indicators, it is appropriate to understand current leading efforts and make an effort to identify indicators that are likely to work effectively in combination with these existing efforts. If this can be done, new efforts to measure and track TMDL implementation progress can benefit from existing work, and that work—in turn—may also benefit from the newer indicators and tracking systems that are developed.

5.3.5 *Collaboration with other water quality programs*

As the discussion in Section 4 suggests, TMDL implementation is almost inherently an issue of coordination among differing components of federal and state water quality programs. For this reason, it is important for indicators that are developed to be endorsed by, or at least acceptable to, key federal and state officials with responsibilities related to TMDL implementation. As noted above, these officials would be drawn at least in part from NPDES, Section 319, and water quality monitoring programs. Any indicator developed should therefore be one that is likely to be accepted and used by one or more of these groups of water quality officials.

The five criteria above provide a useful starting point for thinking about and selecting appropriate indicators for TMDL implementation progress. However, these criteria will not implement themselves. To be useful, the criteria summarized above must be combined in some useful way into a framework that enables optimal decisions to be made. Such a framework might include weightings that reflect the relative importance of

these criteria as well as processes for including other appropriate criteria that are not mentioned above. In the end, however, a systematic identification of criteria and responsiveness to new criteria are likely to enable key decision-makers to identify optimally useful indicators for application in different situations and at different scales (national, state, watershed, and local) of the nation's overall water quality management systems. It is also appropriate, in this context, to recognize that optimal criteria may change over time, and it may therefore be appropriate to build into the system processes for reevaluating current indicators periodically and altering them as needed.

5.4 What can be done at the national level to foster progress?

While state agencies are taking steps to assist USEPA in tracking core indicators relating to the development of TMDLs, there are not yet well-developed systems and indicators in place for tracking TMDL implementation progress. In fact, beyond the core indicators contained in the USEPA Strategic Plan, states, watersheds, and localities are being left largely to their own devices to ascertain whether and how to measure their progress toward clean water goals.

USEPA has supported a number of efforts to assist states by sponsoring forums and discussions among state TMDL programs on issues associated with measuring and tracking TMDL implementation. And the agency has also commissioned a number of studies that have advanced our understanding of TMDL implementation progress, as well as current and desired components of state tracking systems and potential indicators.

Ultimately, however, states, watershed organizations, and local stakeholders will need to ascertain whether to establish indicators of progress above and beyond any that are established by USEPA. They will also have to decide whether and how to track progress according to any indicators that they choose to establish.

USEPA can assist states with this process by continuing to support events, studies, and other opportunities for information exchange. It can also engage a forum of high-level state officials who can provide input on appropriate revisions to USEPA's current strategic objectives. A group of this kind might also assist in developing options and recommendations to enhance our current knowledge of TMDL implementation and further the establishment of appropriate indicators of TMDL implementation progress for use at sub-national levels.

6. ASSESSING NATIONAL INDICATORS: THE INCREMENTAL MEASURES WORKGROUP

The preceding section of this report discusses variations in TMDL implementation–related information needs, types of TMDL implementation indicators, and criteria that may be used to evaluate indicators of TMDL implementation progress. This section applies insights from those discussions by discussing the work of a joint State-USEPA effort to improve knowledge regarding TMDL implementation and water quality restoration progress at the national level.

The IMWG was developed out of the desire to encourage cooperation between state water quality program officials and USEPA, as well as to address needs related to measuring progress in TMDL implementation, water quality restoration, and the protection of waters currently attaining water quality standards. The IMWG consisted of state water quality officials, USEPA regional officials, and USEPA headquarters officials. It was formed in August 2009 and was charged to "develop or revise national incremental measures of water quality to fully capture the environmental improvements made by states and EPA towards full attainment" of water quality standards (Guilarian, 2009).

In spring 2010, the Kent State University (KSU) research team began working with the IMWG to provide assistance that would facilitate the group in providing recommendations to USEPA for new incremental measures of TMDL implementation and water quality restoration progress. As a part of this effort, the KSU team was asked to present the results of its analytical work to date, provide targeted analyses, and organize and facilitate a meeting on the topic of incremental measures with state and federal water quality experts.

The discussions that follow review potential measures of incremental progress that were developed by the IMWG, analyses of these measures that were conducted by the KSU team and participating states, and the discussions and proposals emerging from an IMWG meeting held December 8-9, 2010 in Washington, DC. This section also provides an overview of the meeting as well as the proposals made by the IMWG to USEPA headquarters staff in December 2010.

6.1 Potential future measures of incremental progress

The IMWG recognized that there are interim steps between TMDL development and full water body restoration. It looked at the current measures[10] to find ways to account for incremental improvements in water quality restoration and to recognize state efforts that achieve this kind of progress. For the most part, the state participants found utility in reporting on the current measures. However, some of the current measures were found to have gaps. For example, current water quality measures do not adequately capture reductions in certain pollutants, such as bacteria. While few, if any, state participants are looking to replace the current measures, IMWG members expressed the view that current measures do not adequately capture interim steps and incremental improvements in the process of restoring water bodies. At the same time, the IMWG acknowledged the need to minimize reporting burdens, so as not to take state staff time away from the work of cleaning up polluted water bodies. With these thoughts in mind, the IMWG explored the concept of proposing new measures to better capture interim steps and incremental improvements in the process of restoring water bodies.

The IMWG developed a set of draft incremental measures as a means to fill gaps identified in the current suite of measures used by USEPA and state water quality agencies. They also published these measures in the draft FY 2011 NWPG (USEPA, 2010c) to enable input from outside parties. The following subsections list and describe the proposed measures of incremental progress developed and reviewed by the IMWG. The first three measures are roughly associated with a corresponding stage of the CWA impaired waters pipeline

[10] See Appendix E.

(planning, implementing, and improving), while the last measure focuses on maintaining water quality in unimpaired water bodies.

6.1.1 *Measure #1: planning measure*

The first proposed measure corresponds to the planning stage of the CWA impaired waters pipeline. The measure language reads as follows:

"The number of 9-element watershed management plans[11] to protect or restore surface water quality in each state" (USEPA, 2010c, Appendix H, p. 1). Under this proposed measure, the states would supply USEPA with "a simple count of watershed management plans credited by the State as containing the 9 key elements prescribed by EPA" (USEPA, 2010c, Appendix H, p. 1).[12]

It was envisioned that States would have the option to use GRTS or a companion database to support their Section 319 programs to tally and report the number of nine-element watershed management plans to the States' corresponding USEPA regional staff.

6.1.2 *Measure #2: implementing measure*

The second proposed measure discussed by the IMWG represents the implementing stage of the CWA impaired waters pipeline:

"Miles of impaired rivers and streams, and number of lake acres,[13] addressed by watershed plans where nonpoint source load reductions are being achieved by implementation of [BMPs]"(USEPA, 2010c Appendix H, p. 3).

This measure would be reported every even numbered year in the Integrated Report. States would report two numbers as ratios each cycle. The first would be "the number of miles of rivers and streams meeting the measure divided by the total number of miles of rivers and streams wholly or partially impaired by nonpoint sources." States would report a second number for lake acres in the same fashion. Appendix H of the Office of Water's draft FY 2011 NWPG, released in February 2010, notes that this measure uses a "rolling baseline" approach, which allows the states to get credit for their work regardless of when use impairments were detected after the baseline year of 2002.

6.1.3 *Measure #3: improving measure*

The third proposed measure corresponds to the improving stage of the CWA impaired waters pipeline:

a. "Number of waters listed as impaired in 2002 that now have improved water quality conditions compared to 2002";
b. "Number of other assessed waters that now have improved water quality conditions compared to 2002" (USEPA, 2010c, Appendix H, p. 6).

This measure is designed to capture the status of waters not currently meeting water quality standards, but which have nevertheless experienced improvements in water quality. State agencies would have flexibility in choosing the methodology used to report the improving measure, so long as they follow the guidelines highlighted in Appendix H of the draft FY 2011 NWPG**.** For example, states would have the option to report on improvements based on physical/chemical water quality results or improvements based on an evaluation

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[11] USEPA defines "watershed management plan" as a document prepared by state or local interests to protect or restore surface water quality (USEPA, 2010c).

[12] The nine key elements are prescribed by USEPA for the purposes of the CWA Section 319 Nonpoint Source Program, and are outlined in the 2003 USEPA Nonpoint Source Grant Guidance (USEPA, 2010c).

[13] Refers only to water bodies fully or partially impaired due to nonpoint sources.

of biological integrity using an established biologic assessment methodology.[14] Measure #3 would be reported as the number of water bodies meeting the two criteria above, and would be reported every even-numbered year in the Integrated Report.

6.1.4 *Measure #4: maintaining measure*

The fourth proposed measure of progress is associated with the idea of maintaining water quality in water bodies that have not (at least yet) been impaired:

"Number of waters fully supporting or partially supporting designated uses where water quality is maintained[15] and protected, as measured by water quality or aquatic life indicators" (USEPA, 2010c Appendix H, p. 8).

The number of water bodies meeting the above criteria would be would be reported every even-numbered year in the Integrated Report. According to Appendix H of the draft FY 2011 NWPG, state agencies would have options on what types of waters to include. For example, states could include designated priority watersheds, special classification waters, or waters with targeted restoration work underway.

6.2 Analysis of proposed measures

The IMWG and the KSU project team analyzed the proposed measures once they were developed. The analyses examined if the measures were practical for agencies to report and whether they achieved their intended goal of filling gaps identified in the current measures of progress. Working independently, state IMWG representatives and the KSU team focused on the issues discussed above and evaluated the draft measures according to the criteria specified in Section 5.3.

KSU's assessment of the proposed measures was therefore based on the following criteria:

- National and state program needs
    - Adequacy for enhancing measurement of progress
    - Adequacy for enabling targeting of water quality improvement actions
- Ease of data collection
- Comparability of the measure across states
- Consistency with existing state programs
- Ability to foster productive collaboration with other federal programs

Along with KSU's analysis, select states represented in the IMWG "test-drove" the four proposed measures as they appeared in the draft FY 2011 NWPG. The testing took place over a two-month period. One state official within the IMWG compiled the individual states' experiences into a single document (Stiles, 2010). The subsections that follow summarize results from KSU's analysis and the state "test runs" as compiled in this document. A summary of the KSU analysis matrix form is provided in Appendix D.

[14] See Appendix H of the Office of Water's draft 2011 NWPG for the full methodological requirements for all four proposed measures.

[15] Maintained is defined as "maintenance of assessed level of use attainment despite the addition of measurable and/or modeled impacts from increased stressors (USEPA, 2010c, Appendix H, p. 8)."

6.2.1 *Assessment of measure #1: planning measure*

State testing

Six states "test drove" the planning measure and provided information on their experiences to the IMWG. The planning measure was the easiest measure to report on, as it requires a simple count of watershed plans containing the nine elements required by USEPA. According to the "test run" results, counts of nine-element plans provided by the states ranged from seven to 276. In addition to the difference in the number of nine-element watershed plans tallied by the states, testing of the measure also uncovered other instances of diversity among the states (Stiles, 2010).

First, there was variety in the scale of watershed areas covered by watershed plans among the states. The scale of areas covered ranged from eight-digit HUCs in Kansas to 10-digit HUCs in Alabama, and 12-digit HUCs in Massachusetts. Second, differences in "dialects" of what constitutes a nine-element plan were noted. For example, Kansas's tally of nine-element plans included USEPA-approved plans, final drafted plans awaiting approval, and newly developed plans just passing Kansas Department of Health and Environment review, while Minnesota included in its count TMDL implementation plans, 319 implementation plans, and two sets of state-funded projects (Stiles, 2010).

The states expressed agreement on a number of issues surrounding the measure. First, they agreed that the task of tallying the number (and perhaps type) of nine-element watershed plans should remain with the states, and that the final counts should be reported to their regions through the annual Section 319 program reporting process. Second, the states agreed that watershed plan approval is a State function, and USEPA should not be placed in a position to approve plans funded outside of the Section 319 program. The states also agreed that all watershed plans should be credited, including those that address a TMDL, those that address impairment before a TMDL is established, and those that provide protection to unimpaired waters (Stiles, 2010).

KSU analysis

According to the KSU analysis, the planning measure scored high on adequacy for enhancing measurement of progress, as it is useful to know how many watershed plans have been developed in order to understand incremental progress toward water quality standard compliance. The adequacy for this new measure to enable targeting of water quality improvement actions is uncertain, as some watershed plans will enable targeting better than others. The planning measure requires a simple count of nine-element watershed plans, a relatively simple task, which results in a high rating for ease of data collection for the measure. Due to the geographic and programmatic diversity among states (what counts as a nine-element plan), the planning measure can be expected to be only moderately comparable across states. The planning measure is highly consistent with existing state programs, especially the Section 319 program. While plans are used for the Section 319 program, there are questions about what constitutes an adequate plan, which creates uncertainty about whether the planning measure would foster productive collaboration with other federal programs.

The KSU team found a number of uncertainties and issues with the planning measure and provided potential "improvements" that could be considered. Two key uncertainties are encapsulated in the following questions: 1) Do states or USEPA decide which watershed plans count or qualify? 2) Should there be geographic specificity to plans that count under this measure (e.g., 12-digit or eight-digit HUCs)? The KSU team also suggested to the IMWG that it consider accounting for differences in geography within the measure. For example, states could report the percent of certain HUC-sized watersheds with approved watershed plans.

6.2.2 *Assessment of measure #2: implementing measure*

State testing

Five states tested the proposed implementing measure, which linked nonpoint source implementation done under a watershed plan to the number of impaired stream miles or lake acres that benefit from that implementation. The states that tested the measure found obtaining the information on the number of miles/acres and the number of plans to be easy and straightforward. There were significant variations among the states according to this measure. The estimated length of influenced streams ranged from 283 to 2,279 miles, while the area of influenced lakes ranged from 14,506 to 67,632 acres. States made assumptions regarding the impact of implementation: In tributary subwatersheds, the impact of implementation practices is assumed to be limited to the immediate stream segments within that subwatershed, while implementation practices located in lake watersheds tend to be assumed to benefit the entire surface area of the lake, regardless of the placement of the implementation practices within the watershed (Stiles, 2010).

Determining the load reductions in the identified stream miles or lake acres was found to be problematic by the states. The states found data from the implementers to be limited, as not all implementation practices are supported by Section 319 program funding, and as a result, they are left largely unreported. States also noted that it is often difficult to geo-locate implementation activities, and that certain pollutants are not tracked in current databases or tracking systems. In addition, the issues noted in the analysis of the planning measure surrounding the geographic and programmatic diversity among states were raised again in the analysis of the implementing measure (Stiles, 2010).

KSU analysis

The KSU team found the implementing measure to score high on the adequacy for enhancing measurement of progress. The measure was found to moderately enable targeting of water quality improvement actions. If specific waters were known, it would help targeting efforts; however, the number of miles alone (which is what is called for in the measure) does not help with targeting. It is also uncertain whether or not the data needed for this measure could be easily obtained. State testing of this measure seemed to allay this concern. How well the implementing measure could be compared across states is also uncertain, however. If the location and impact data are already in GRTS, it may be comparable, but if the data are not already in a national database it could be difficult. Also, the ability to compare across states depends on how miles and acres are calculated and load reductions determined in each state. The measure was also found to be moderately consistent with existing state programs as it uses data that appear to be a part of GRTS. Partially as a result of these uncertainties, it is also uncertain whether the new measure would foster productive collaboration with other federal programs.

There were a number of uncertainties and issues highlighted. First, identifying stream reaches may not necessarily generate a number of miles. Second, the determination that a load reduction has occurred can be done in many ways, adding to the uncertainty issues of comparability across states. The KSU team also suggested that it may be beneficial to consider using a project count, perhaps tied to a requirement that the project will a) reduce pollutant loads or b) improve pollutant assimilation into receiving waters.

6.2.3 *Assessment of measure #3: improving measure*

State testing

Three states tested the improving measure, while two other states provided comments to the IMWG. The measure asks the states to report the number of "assessed waters that now have improved water quality conditions" (USEPA, 2010c, Appendix H, p. 6). The states that tested this measure were pleased with the measure's ability to track progress in water quality, but found it to be complex and labor-intensive. States also noted issues with assessing trends in water quality over time. Sample size, parameter variability, geography, and hydrology all affect the interpretation of trends in water quality. In addition, the states noted that distinguishing data or stations by listing status can be problematic (Stiles, 2010).

The states also raised concerns with the measure's linkage to the Integrated Report reporting cycle of two years, arguing that a four-to-six year cycle would better allow for enough data to distinguish trends from natural variability. Due to the complexity surrounding data collection and statistical procedures, some states may be more capable of conforming to the measure's reporting requirements than others. However, the states noted that the measure language provides flexibility to address some of the concerns related to the complexity of data collection and analysis (Stiles, 2010).

KSU analysis

The KSU project team found the improving measure to have a high adequacy for enhancing measurement of progress. It was found to have only moderate adequacy for enabling targeting of water quality improvement actions, as numbers of waters alone would not help target. However, if specific water body and geographic location information were provided, this would help with targeting efforts considerably. Ease of data collection for this proposed new measure is uncertain, as some data may be readily available, while other data might be quite difficult and time consuming to collect. Comparability of the proposed measure across states is only moderate, as states have varying options for how to measure improvements. The consistency of this proposed measure with existing state programs is also uncertain, as it could require collection or analysis of additional data. The proposed measure is deemed to be moderate in fostering collaboration with other federal programs, as water quality assessment programs may have concerns over consistency with processes used in the Integrated Report. The KSU team also pointed out that it is important to consider what constitutes a reportable improvement in water quality.

6.2.4 *Assessment of measure #4: maintaining measure*

State testing

Four states commented on the maintaining measure. There was consensus that the measure was worthwhile and had potential to display success in maintaining water quality standards within waters facing increased stressors. However, the states noted the measure needed work to clarify its purpose. The states found reporting on the water condition response–oriented variables, such as physio-chemical trends, biological condition, and changes in benthos/fish/ambient parameter indicators, to be complicated. States also noted complications and increased workloads when trying to obtain or assess the stresses and mitigating practices within watersheds over time. In addition, for many of the same reasons as the improving measure, the states recommend a longer reporting cycle than the two years outlined in the measure language, as well as pushing back the proposed 2012 startup date (Stiles, 2010).

KSU analysis

The Kent State analysis further highlighted the many uncertainties associated with this measure. As the measure language stands now, it is uncertain how well the measure would enhance measurement of progress. The measure is unlikely to enable targeting of water quality improvement actions, as waters that are currently maintaining water quality standards are not likely to be priorities for remediation. Also, given that stressor information does not seem to be based on standardized, accessible data sets, data collection efforts may be difficult and too large of a burden for many states. This measure is also unlikely to be easily comparable across states as it may be difficult to generate consistent data for stressors and possible mitigating actions. The KSU team found this measure to be moderately consistent with existing state programs because it is basically asking states to report the inverse of the 303(d) list, minus waters with no changes in development or other stressors.

The KSU team identified a number of issues surrounding the maintaining measure as well as suggestions for potential improvements. First, it may be necessary to define stressors and possible mitigating actions more specifically in order to remove many of the uncertainties noted above. Second, the unit of measurement is vague. It may be necessary to define what units are to be used, such as stream miles and lake acres, or "number" of waters. In short, simplifying the measure, possibly by providing more specific definitions of stressors, or by eliminating the need for information on stressors, could improve its usefulness.

6.3 December 2010 USEPA incremental measures meeting

The IMWG met face-to-face in December 2010 in Washington, DC to discuss the issues it had identified in the past as well as to review the analyses of the new measures of progress by selected states and the KSU project team. At the end of the two-day meeting, the IMWG was to decide whether to submit to USEPA headquarters any of the proposed measures for inclusion in the draft FY 2012 NWPG, and perhaps in the future, in USEPA's Strategic Plan. The group also had the option of making adjustments to current national measures of progress used by USEPA.

Briefly, the purposes of the meeting were as follows:

- Review the current SP measures
    - Identify gaps in current SP measures and discuss potential ways to fill those gaps, including:
        - Proposed new measures #1 - #4
        - Proposed ideas for making potential adjustments to existing measures
- Reach consensus on which—if any—new or revised measures should be proposed for inclusion in the draft FY 2012 NWPG

The subsections that follow summarize discussions relevant to these purposes.

6.3.1 *Review of current measures*

The IMWG reviewed current measures of progress used to evaluate the efficiency and effectiveness of the nation's water quality programs, and it sought to identify gaps in the current measures. Gaps result in an incomplete picture of the status of the nation's water, and limit the states' and USEPA's ability to make the necessary adjustments to water quality programs that could improve their efficiency and effectiveness. During the December 2010 meeting, the IMWG reviewed the current measures and discussed the gaps that they had identified previously.

The current suite of measures is documented in the FY 2011 NWPG (USEPA, 2010d, Appendix A, p. 1) and includes both strategic planning (SP) and water quality (WQ) measures. SP measures include the following:

- SP-10: Number of water bodies identified in 2002 as not attaining water quality standards where standards are now fully attained [Target measure: cumulatively reported]
- SP-11: Remove the specific causes of water body impairment identified by states in 2002 [Target measure: cumulatively reported]
- SP-12: Improve water quality conditions in impaired watersheds nationwide using the watershed approach [Target measure: cumulatively reported]

WQ measures include the following:

- WQ-9a: Estimated annual reduction in million pounds of nitrogen from nonpoint sources to water bodies (Section 319–funded projects only)
- WQ-9b: Estimated annual reduction in million pounds of phosphorus from nonpoint sources to water bodies (Section 319–funded projects only)
- WQ-9c: Estimated annual reduction in tons of sediment from nonpoint sources to water bodies (Section 319–funded projects only)
- WQ-10: Number of water bodies identified by states (in 2000 or subsequent years) as being primarily nonpoint source–impaired that are partially or fully restored [cumulative]
- WQ-21: Number of water segments identified as impaired in 2002 for which states and USEPA agree that initial restoration planning is complete (i.e., USEPA has approved all needed TMDLs for pollutants causing impairments to the water body or has approved a 303(d) list that recognizes that the water body is covered by a watershed-related plan [i.e., Category 4b or Category 5m])

Gaps in current measures

As noted above, most states found utility in reporting on the current measures; however, they also found a number of gaps. Some IMWG members suggested that the current measures do not adequately capture interim steps and incremental improvements in the process of restoring water bodies. Others argued that the current measures do not capture reductions in certain pollutants such as bacteria and total suspended solids, and that efforts to reduce contamination from these pollutants do not receive appropriate credit. The IMWG

agreed that the current measures fall short in painting a complete picture of the overall status of the nation's efforts to improve and protect water quality, particularly in the planning, implementing, and improving stages. Participants argued that the planning stage is the foundation for future improvements in water quality and expressed concern that USEPA is missing an opportunity to account for the effort that goes into development of watershed management plans.

Time constraints associated with the near-term deadline for USEPA and the broader federal process of approving additions or changes to national measures led the workgroup to decide that the meeting would focus on proposed measures #1 and #3, and ideas for accounting for bacteria in current or proposed new measures. It also determined that the fate of proposed new measures #2 and #4 would be determined later.

6.3.2 *The Workgroup's Proposals*

By the end of its two-day meeting in Washington, DC, the IMWG submitted two proposals to USEPA's management. The first was an adjustment of the existing WQ-21 measure, a measure of progress in the planning stage, as well as the addition of a brand new measure intended to enable interim measurement of improvements in water quality.

Proposed changes in WQ-21

As noted above, gaps had been identified in the planning stage of water quality improvement efforts. Workgroup members noted that there was currently no effort to track the development of nine-element watershed management plans, a vital step in dealing with nonpoint source pollution. Therefore, the workgroup proposed a change to the existing WQ-21 measure. WQ-21 originally measured the "number of water segments identified as impaired in 2002 for which states and USEPA agree that initial restoration planning is complete." The workgroup agreed that adding a WQ-21(b) to the current measure, which took account of the development of nine-element watershed plans, was an appropriate way of filling the gap identified in the current measures.

The workgroup used the following language to define the proposed WQ-21(b): "Number of water segments identified as impaired in 2002 for which States and USEPA agree that a 9-element watershed management plan[16] is complete to restore surface water quality."[17]

Proposed improving measure

In addition to the gap identified in the planning stage, the workgroup identified a need for a measure that would create a more complete picture of progress in the improving stage of the CWA impaired waters pipeline. The workgroup proposed a new measure designed to show the "relative change" in the water quality of impaired waters. The workgroup also used this new measure as an opportunity to address the gap associated with the current measures' inability to capture reductions in bacteria within a water body.[18]

The workgroup used the following language to define the new improving measure: "State demonstration of trends in improved water quality, i.e., (a) Percentage of monitoring stations showing improvement; and/or

[16] A watershed management plan is defined as "a document prepared by State or local interests to protect or restore surface water quality and which contains the 9 key elements prescribed by EPA for the purposes of the Clean Water Act section 319 Nonpoint Source Program. Such plans may or may not be approved by a given State, but they are incorporated into the State's NPS management program" (USEPA, 2010c, Appendix H, p. 1).

[17] See Appendix F for the full proposal submitted to USEPA management.

[18] They do so by providing language in the methodology to include bacteria as an impairment to be reported on by the states.

(b) Percentage of waters in 'healthy' or 'good' condition based on state-wide statistical (probability) survey increases over time."[19]

At the time of this writing, these two proposed measures have been submitted to USEPA Headquarters and are being considered for inclusion in the FY 2012 NWPG.

Next steps for the IMWG

At the conclusion of the December 2010 meeting, the IMWG discussed its future. While the members did not express a strong view about continuing the IMWG in exactly its current form, there was sentiment expressed about the value of continuing state-USEPA discussions about improving measures of progress in TMDL implementation, water quality restoration, and the protection of waters currently attaining water quality standards.

Potential future activities include:

- Continued interaction between current IMWG members and USEPA staff and management on issues associated with the two proposed measures as needed.
- Continued discussions within the IMWG or its successor about the two remaining proposed measures:
    - Implementing measure (#2): The view was expressed by IMWG members that a revision of SP-11 to focus on sources rather than causes/pollutants would begin to address the need for a good implementation measure.
    - Maintaining measure (#4): IMWG members suggested that the value of a measure that focused on maintaining water quality in water bodies that have not been determined to be in violation of state water quality standards might be addressed through the "Healthy Watersheds" initiative in some manner.

At the time of this writing, no final decision had been made regarding the continuation of the IMWG or the establishment of successor mechanisms to enable the continuation of a federal-state dialogue on incremental measures of TMDL implementation and water quality restoration progress.

[19] See Appendix F for full proposal.

7. CONCLUSION: WHERE FROM HERE?

For almost forty years, USEPA, states, local governments, and private sector entities have implemented water pollution control programs authorized in the CWA. These efforts have resulted in reductions in pollutant loads to US waterways and water quality improvements (ASIWPCA, 2004). TMDLs now hold the potential to help guide a transition to a new era of water pollution control, one that can build on the successes of the past while addressing the problems of today and the future.

When Congress enacted the CWA in 1972, one Congressional staffer commented that Congress had included Section 303(d) in the law as "a game plan for the next generation" (Houck, 1999, p. 24). It is now 2011, and the "next generation" has arrived. Due to extensive efforts since the mid 1990s, the country has developed a large number of TMDL documents that can now be used to help transition the nation's water quality programs toward management approaches that more closely resemble the "watershed" focus that has received substantial attention since at least the 1980s. However, although key elements of the "game plan" are largely in place, the game plan itself has not yet been implemented.

This report has taken stock of studies and other work undertaken over the last six years to understand TMDL implementation progress and ways in which it can be measured and reported. We have reviewed and summarized eight major studies authored by a variety of experts and observers. We have participated in conferences and meetings sponsored by nonprofit environmental organizations, state water quality administrators, and USEPA. We have also had the opportunity to work with a group of expert water quality administrators from state environmental agencies and USEPA. We have sought to capture much of what we learned from these experiences in this report.

What we have learned can be summarized briefly in three areas, all of which have been addressed in this report:

- TMDL Implementation and the factors that drive it,
- indicators of progress, and
- current efforts to understand and report on progress.

Overviews of what we have learned in these areas provide a foundation which can be used to help define appropriate next steps for measuring and enabling progress in TMDL implementation and water quality restoration. And these next steps, in turn, provide a foundation for broader efforts to transition CWA implementation toward a new and more productive era of water pollution control. The discussions that follow address the three topics above, and offer ideas on where efforts to assess TMDL implementation may productively go from here.

TMDL implementation and the factors that drive it

Studies conducted over the last six years suggest that recommendations in TMDL documents are being implemented in states throughout the country, although not comprehensively and not in all cases. The four major studies on TMDL implementation reviewed in this report (Mann et al., 2005; Benham et al., 2006; Hoornbeek et al., 2008; USEPA, 2009) suggest that state and local stakeholders are taking action to implement recommendations contained in TMDL documents. Indeed, in the studies we reviewed, recommendations from well over half of the TMDLs (or the watershed-based TMDL reports in which they are embedded) are being implemented in some fashion. However, these same studies also suggest that these actions are not comprehensive. There are watersheds in which TMDL implementation efforts are not highly visible, and there may also be watersheds addressed by TMDLs in which implementation is not occurring at all.

The studies reviewed here include more cases of TMDL implementation progress at earlier stages of the CWA impaired waters pipeline (planning and implementation) than at later stages (improving and recovery). This is not surprising for several reasons. First, it is easier and less expensive to identify planning and implementation actions than it is to measure improvements in water quality or to certify that a water body has recovered from impairments that had been identified in the past. Second, it is also easier in reality to undertake efforts to develop watershed plans and implement projects than it is to actually improve water quality and restore water bodies. And finally, it appears that, as a nation, we are not investing the time, attention, and resources that are needed to ascertain whether the actions we are taking to improve water quality are actually accomplishing their intended effects. Even if our planning and implementation actions were 100% effective in enabling water quality improvements, we would not be able to know this based on the information we are currently compiling. While this is understandable given the tight fiscal times in which we live, it nevertheless limits our ability to understand the full extent of the progress that is being accomplished through current efforts.

Even so, we are beginning to understand what can be done to foster progress in implementing TMDLs and in restoring watersheds to compliance with water quality standards. Two of the studies reviewed in this report (Benham et al., 2006; Hoornbeek et al., 2008) sought to identify factors that appear to predict TMDL implementation progress. These studies suggest that stakeholder engagement in TMDL development, financial assistance, state agency engagement in the implementation process, the existence of a group taking responsibility for TMDL implementation progress, and the existence of an approved watershed plan are all positively related to various measures of TMDL implementation progress. While additional research is appropriate to test and verify these conclusions—and to build upon them as well—these findings do provide some basis for guiding efforts to foster greater levels of TMDL implementation in the future.

Taken as a whole, these insights put us far ahead of where we were in our knowledge of TMDL implementation six years ago, even as they also highlight the fact that our current understanding and efforts are subject to important limitations.

Indicators of progress

As this report makes clear, there are many potential indicators that could be used to understand TMDL implementation and watershed restoration processes. And, as Section 4 suggests, there are at least two frameworks that can be used to guide indicator selection and efforts to foster TMDL implementation (Norton et al., 2007; Grayzeck et al., 2008). Released in 2008, the Minnesota framework (Grayzeck et al., 2008) complements the CWA impaired waters pipeline framework that has been articulated by USEPA (Norton et al., 2007; Norton et al., 2011). Both of these frameworks are potentially useful in supporting state efforts to develop indicators of TMDL implementation and watershed restoration progress.

There has been progress in developing and using indicators of TMDL implementation at both the state and national levels. At the state level, Minnesota and Washington have developed initial indicators that are giving structure to their efforts to identify TMDL implementation and watershed restoration progress (Grayzeck et al., 2008; Onwumere and Plotnikoff, 2003; Mann et al., 2005; and USEPA, 2010a). At the national level, USEPA's Strategic Plan includes indicators on watershed restoration and the causes and sources of impairment (US EPA, 2010b). These indicators (SP-10, SP-11, and SP-12) and others are summarized in the IMWG meeting minutes in Appendix E. However, it appears that state monitoring and information systems are not as complete as they could be to enable accurate and consistent reporting on these measures (USEPA (2010a) discusses SP-12).

The work of the IMWG reflects a valuable attempt to link national- and state-level thinking on indicators and how to structure them. The two measures forwarded by the IMWG to USEPA for consideration in December 2010 reflect further progress, as they provide potential national-level measures of planning progress and progress in improving water quality (short of full water body recovery). Both of these suggested indicators, if

adopted in current or revised forms, could enable states to demonstrate incremental progress toward achieving water quality standards compliance for impaired water bodies.

In summary, it appears that there is progress being made by the states and USEPA in developing measures and in beginning to use them. However, the progress thus far is limited in scope, as national indicators still focus primarily on measures that are quite difficult to achieve, and sub-national indicators appear varied and are not yet fully linked with national ones. As we reach this conclusion, however, it is important to recognize that indicator selection and use is a complex process, and one that will require ongoing efforts if it is to be useful in re-aligning national and sub-national water quality protection efforts toward a "next generation" agenda which is defined by adaptive efforts to manage water quality at the watershed level.

Current Efforts to Understand and Report on Progress

The research underlying this report also makes it clear that there is significant interest in TMDL implementation and water quality restoration progress at both the national and sub-national levels in the US. This same research also suggests, however, that the levels of interest still appear to exceed the amount of time, attention, and resources being devoted to ensuring that recommendations contained in TMDLs are implemented to achieve watershed restoration goals.

The very existence of the eight studies that are summarized earlier in this report testifies to the interest that has been gathering around the concept of TMDL implementation—both at the national and sub-national levels. USEPA provided funding support for this report, for many of the studies it summarizes, for the work of the IMWG, and for other efforts to understand and foster progress on TMDL implementation. State officials from a large number of states have devoted their energies to engage in these efforts, and at least two states—Washington and Minnesota—have developed innovative efforts to foster progress in TMDL implementation and watershed restoration (Onwumere and Plotnikoff, 2003; Mann et al., 2005; and Grayzeck et al., 2008). Other states are also developing budding efforts to understand and foster TMDL implementation progress (USEPA, 2009; Norton et al., 2009; USEPA, 2010a).

However, while interest is growing, there are signs that these high levels of interest have not yet led to the widespread adoption of standard practices relating to TMDL implementation. The studies summarized here suggest that TMDLs are often incorporated in point source permits and—to perhaps a somewhat lesser degree—in nonpoint source water pollution control practices as well. However, they also suggest that TMDL reports remain one of many inputs into largely separated practices for point source permitting and Section 319 grant allocations. At least two of the studies summarized here (USEPA, 2009; Hoornbeek et al., 2008) found that information on the implementation of actions called for in TMDLs remains scattered in many places rather than consolidated in ways that enable structured and adaptive management of watersheds, as was envisioned by the National Research Council of the National Academy of Sciences some years back (National Research Council, 2001). While this situation is understandable given the major efforts that have been undertaken to develop and approve TMDLs in recent years, systems for understanding and reporting on TMDL implementation progress are likely to continue being haphazard until this situation is corrected.

Approved TMDLs provide a potential foundation for efforts to translate the rhetoric of adaptive watershed management into practice, but the research reviewed here suggests that this is not yet occurring on a widespread basis. Indicators of TMDL implementation and watershed restoration progress hold the potential to draw attention to the value of using TMDLs not only as an input into other programs, but also as a foundation for managing water quality control efforts on a watershed basis.

Where to go from here?

While we now understand TMDL implementation better than we did six years ago, our efforts to implement a new TMDL-based "game plan" are still in their infancy. The TMDL program provides what is probably the best hope for transforming the rhetoric of watershed management into something that approximates the concept in reality (Houck, 1999). Based on this and previous studies, we offer the following suggestions to guide future efforts to develop and use indicators of TMDL implementation and watershed restoration progress to help foster improvements in water quality throughout the country.

First, given the positive energy and work contributed by the IMWG, it seems important for USEPA to seriously consider the two alternative measures that were developed by this group. Unless significant problems are encountered, it probably also makes sense to begin using the suggested indicators (or some variation on them) as the IMWG has recommended. By using measures that focus on incremental progress at earlier stages of the CWA impaired waters pipeline, USEPA and the states will begin to build a knowledge base that is organized geographically by TMDL and watershed, and—over the long term—this should enable both better assessments of progress and improved efforts to target and accelerate progress in the future. While the new suggested measures may not prove to be perfect, the process of considering and implementing them, if this is undertaken, is likely to foster the kind of learning and adjustment that is now needed in the nation's water quality program.

Second, while the *planning* and *improving* measures forwarded by the IMWG are likely to be beneficial, it also seems appropriate to convene a federal-state effort to define workable national indicator(s) for the *implementing* stage of the CWA impaired waters pipeline. This effort could build on previous discussions by the IMWG, and should incorporate both point and nonpoint source implementation activities. In the long run, a workable indicator at the *implementing* stage of the CWA impaired waters pipeline will bring focus on building closer connections between the wasteload and load allocations in TMDLs and the CWA's existing NPDES and Section 319 programs. We *implement* permit changes and Section 319 grants in order to restore and maintain water quality. National indicator(s) that tie projects to particular TMDLs and watersheds will help states, USEPA, and others to become more efficient and effective in achieving these water quality objectives.

And third, to facilitate and maintain alignment of federal and state measures of progress, USEPA and state governments should continue to support research and discussions on: TMDL implementation and the factors that drive it; implementation indicators; and systems for understanding and reporting on TMDL implementation progress. While the research summarized in this report is useful, we still do not have a complete nationwide picture of TMDL implementation progress. Our knowledge of factors driving implementation is preliminary. And we would benefit from knowing more about ways in which TMDLs can be managed and written to foster effective implementation.[20] Further research in all of these areas would allow USEPA and the states to "aim before shooting," a concept advanced by a former USEPA Administrator that is too often forgotten in the rush of day-to-day activities.

As important as further research, however, is a continuation and expansion of the kind of focused dialogues that have taken place around the concept of TMDL implementation and watershed restoration over the past several years. The IMWG's work, while difficult at times, reflected a productive and focused effort by USEPA and a number of state officials to enable better understandings of TMDL implementation progress at the national level. This kind of dialogue has yielded initial progress, but it is not—in and of itself—adequate. To facilitate a transition from a programmatically oriented water quality program based on permits and Section

[20] A finding of one of the studies we reviewed (Hoornbeek et al., 2008) was that TMDL documents are not always written in ways that enable easy implementation, and that TMDL report formatting can be strengthened in this area. One state, Ohio, took steps to improve the format of its TMDL documents after reviewing the results of this study. Because guidelines for TMDL development are established at the national level, a broader look at this issue seems appropriate.

319 grants to a program based on watershed analysis and restoration efforts, it is important for federal and state officials to dialogue at high levels about the connections between permits and Section 319 grants, on the one hand, and TMDL implementation and watershed restoration progress on the other. Discussions of watershed restoration indicators can enable this kind of dialogue and focus on watershed-based management in ways that isolated discussions of permitting and grant projects alone rarely accomplish.

And, while federal-state discussions are important for fostering needed dialogues between USEPA and state environmental officials, there should also be a focus on providing incentives and assistance for states and their watershed stakeholders to engage in discussions about indicators of TMDL implementation and watershed restoration progress within their borders. In the end, effective and adaptive watershed management requires a focus on planning, implementation, and water quality improvements at the watershed level. All too often, however, key discussions that address connections among the stages in the CWA impaired waters pipeline are overlooked in the rush of other priorities.

Finally, across all of these discussions, it is appropriate to expand the scope of dialogue over time. While stakeholders share a concern about TMDL implementation and watershed management, the research summarized here suggests that there is a need to continue building discussions that *cross* point, nonpoint, and water quality assessment activities. Developing indicators based on TMDLs and watershed restoration strategies holds the potential to enable these discussions to progress further. If we are to implement a new "game plan" based on TMDLs and watersheds, the rosters of participants involved in the discussions will have to extend to water quality programs beyond the TMDL program and—at least eventually—to stakeholders outside of USEPA and state environmental agencies as well.

The national water quality program now stands at a turning point. Water pollution control efforts need to be prioritized at a watershed level to enable more efficient and effective progress in restoring impaired water bodies and protecting water bodies that are not impaired. TMDLs, the implementation of recommendations contained in them, and the development of indicators and processes for communicating about progress hold the potential for enabling the kind of watershed-based prioritization that is necessary to further progress toward the CWA's ambitious goals. It is our hope that this report and the recommendations provided here contribute productively to this process.

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APPENDIX A: INTEGRATED REPORT CATEGORIES

Category	Description
Category 1	All designated uses are supported, no use is threatened.
Category 2	Available data and/or information indicate that some, but not all, designated uses are supported.
Category 3	There is insufficient available data and/or information to make a use support determination.
Category 4	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed.
Category 4a	A State-developed TMDL has been approved by USEPA or a TMDL has been established by USEPA for any segment-pollutant combination.
Category 4b	Other required control measures are expected to result in the attainment of an applicable water quality standard in a reasonable period of time.
Category 4c	The non-attainment of any applicable water quality standard for the segment is the result of pollution and is not caused by a pollutant.
Category 5	Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.
Category 5m	Voluntary subcategory for states with comprehensive mercury reduction programs.

APPENDIX B: VARIABLES RELEVANT TO TMDL IMPLEMENTATION

Table 7: Indicators and other variables relevant to TMDL implementation from studies of TMDL implementation progress.†

Study	Major indicators	Other indicators	Other relevant variables
Benham et al., 2006*	Water quality improvement	Funding was available for implementation.	Type of watershed strategy.
	Improved status on the 303(d) list	Significant interest, involvement, and cooperation of watershed stakeholders.	Type of calculations used in TMDL, if applicable.
		Significant interest, involvement, and cooperation between local, tribal, state, regional, and/or federal agencies.	Stakeholder meetings occurred and WERE DOCUMENTED during TMDL development…
		The watershed strategy provided specific guidance to target implementation efforts at specific polluters and/or specific locations in need of remediation.	A single person or entity was specifically identified to lead the implementation project. Many times, a single person was hired as part of the implementation project.
		Awareness and/or educational activities targeted at stakeholders occurred during TMDL implementation.	Regulations on nonpoint sources of pollution already existed or were developed as part of the implementation effort.
		Significant interest, involvement, and cooperation of permitted dischargers in the watershed. These dischargers often contributed additional resources, motivation, or expertise to the TMDL development and/or implementation effort.	Additional monitoring data were collected specifically during the TMDL study to help identify spatial distributions of pollution...OR...pollutant sources were identified according to their location in the watershed.
		A watershed group was created as a result of the development of the TMDL and/or watershed strategy.	Stakeholder meetings occurred and WERE DOCUMENTED during development of the watershed strategy.
			Technical assistance for the implementation of BMPs was integral to implementation.
			A watershed interest group was active prior to the development of the TMDL.
			The implementation process followed a staged approach, with interim goals and milestones.
			Water quality trading has been a part of the implementation effort.
Hoornbeek et al., 2008**	A state/federal official was identified as being knowledgeable about implementation of the TMDL in question.	Nonpoint source load reduction for pollutants of concern in the TMDL had occurred since USEPA approval of the TMDL.	

	A local or regional group is working to foster implementation of this TMDL.		
	At least one project identified that seeks to reduce pollutants or improve assimilation of pollutants from sources recommended for action in this TMDL.		
	Water quality monitoring TMDL-limited pollutants since approval of the TMDL.		
	Effluent Limits contained in major NPDES permits reflect TMDL recommendations.		
	Load reduction of any kind for pollutants of concern in the TMDL had occurred since USEPA approval of the TMDL.		
	Water quality improvements downstream from a TMDL implementation action for a TMDL-limited pollutant.		
	Water body restoration ascertains whether the state regulatory agency has declared the water body restored in its integrated 303/305 submission to USEPA.		
Mann et al., 2006	A Detailed Implementation Plan has been completed.	Non point implementation range from fencing projects and off-stream watering troughs, piping of irrigation ditches, to low-impact development retrofits (e.g. Rain gardens)	
	Post-TMDL monitoring data are available.	Point Source regulations regulated through NPDES	
	Projects have been implemented.		
	Water quality improvement documented.		
Norton et al. 2009***	TMDLs...with an implementation plan	Partial to full progress in developing an Implementation Plan	Partially to fully implemented TMDLs…that were developed through multi-TMDL or watershed-TMDL analysis
	Partial to full TMDL implementation for all types and dates of TMDLs	Partial to full progress in planning, funding and installing Best Management Practices…that address the Load Allocation of a given TMDL, through Section 319 (or, to the extent available, other) projects	
		Partial to full progress in incorporating the Waste Load Allocations…of a given TMDL in National Pollutant Discharge Elimination	

	System…(or other) permits
	Partial to full TMDL implementation for TMDLs including point sources
	Partial to full TMDL implementation for TMDLs including only nonpoint sources
	Partial to full implementation for TMDLs…approved in FY 2003 or earlier
	Partial to full implementation for TMDLs… approved between FY 2004 and FY 2007

*Modified after Benham et al., 2006, Table C-3, p. C-5. ** Modified from Hoornbeek et al., 2008, Table 7. ***Modified from USEPA, 2009, p 1; 27-28.
†"Major indicators" are those that were reported to indicate TMDL implementation success and that were not subcategories of other reported indicators. "Other indicators" were either subcategories of the major indicators, or, in the case of Benham et al. (2006), were deemed supporting indicators in the study's successful watersheds. "Other relevant variables" include characteristics about TMDLs and implementation efforts that are not indicators of implementation progress.

Table 8: Indicators and other variables relevant to TMDL implementation from studies of TMDL implementation tracking.†

Study	Indicators	Other relevant variables
USEPA, 2008	Implementation plan development and approval	TMDL information including water body ID, pollutants addressed, etc.
	Responsible implementation parties identified	Funding source
	Allocations incorporated into permits	Date of implementation or watershed plan approval
	Completed projects	Date of approved permits
	Monitoring / assessment results	Water quality monitoring triggers
	Restoration evaluation	Social indicators
	Funding availability	Funding allocations
	Implementation started	Stream gage data
	Implementation completed	Water flow analyses
	Water body restored	GIS data for projects
	Number of acres with BMPs implemented	Economic data
	Number of acres with conservation tillage / set aside acres	Water quality data in STORET
	Number and status of NPDES permit issuances that include TMDL allocations	Wasteload allocations
	Implementation on a county-wide basis	State staff responsible for TMDL development and implementation
	NRCS BMP annual report information	Status of report development
	319 and other nonpoint source project details	303(d) listings being addressed
	303(d) information	Activity location
	Conservation 2000 efforts	Dates, timeframes
	Implementation schedules	Funding sources
	Percentage of measures that have been implemented	Lead implementation party / agency
	Number, location, description of implementation activities	Estimated activity cost and actual activity cost
	Load reductions achieved	Watershed planning recommendations
	Watershed grants	
	Watershed groups, meetings, public involvement	
	Compliance and enforcement activities	
	Education and outreach	
	Biological indicators	
	Status of water bodies	
	Pollutant levels	
	Impairments	
USEPA, 2009	Water quality monitoring	

	Monitoring data from the 305(b)/303(d) Integrated Reports	
	"[R]emoval of one or more of the impairment causes identified in 2002 for at least 40 percent of the impaired water bodies or impaired miles/acres" (p 16)	
	"[S]ignificant improvement has occurred with a 90 percent or greater level of confidence, where improvement is defined as a significant watershed-wide improvement in one or more water quality parameters associated with the impairments" (p 16)	
	"A 'multiple lines of evidence approach'…that the cumulative weight of several lines of evidence is used to assess whether a watershed-wide improvement has occurred" (p 16)	
Barvenik et al., 2007	"[N]umber of TMDLs…that have all wasteload allocations incorporated into NPDES permits" (p 12)	
	"[N]umber of TMDLs…that have implemented load allocations through at least one best management practice funded through the Section 319 Program" (p 12)	
	"[N]umber of TMDLs…for which implementation data are not available to EPA" (p 12)	
Grayzeck et al., 2008*	Number of lakes with citizen volunteers/Number of stream sites or miles with citizen volunteers	Quantity and quality of water quality data
	Number and Percent of 8-digit HUC watersheds monitored and assessed	Local climate data availability
	Percent of waters with upward trends/downward trends	Land cover data availability – collected every 5 years
	Actual versus expected water quality by region/eco-region	Flow volume/rate trends over longer periods of time
	Water quality at the watershed level	Land cover/land use
	Number/Percent of recreational impairments restored	Watershed vulnerability
	Number/Percent of drinking water impairments restored	Percent of current listings incorporated into TMDLs…transitioning into Number of 8-digit HUC watersheds fully addressed by completed TMDLs
	Percent of stream miles eroding, Percent of stream miles buffered	Percent of locally led TMDLs
	Number of 8-digit HUC watersheds with completed (MPCA approved) implementation plans	Percent of TMDL study effort/outputs in sequence with overall watershed management plan/approach
	Percent adoption of key non-regulated BMPs for a given land use	Ratio of non-regulated (nonpoint source) $ from state, federal, LGU, landowner
	Percent of land covered by a non-regulated BMP	Ratio of regulated (point source) $ from state, federal, LGU, landowner
	Targets/benchmarks for non regulated activities in TMDL/watershed implementation plans ADOPTED	Creation of GIS and/or web interactive tools for sharing and coordinating information between agencies
	Critical source areas reported against implementation of practices in those critical areas	Number of participants at various public meetings, tracking complaints
	Paired watershed studies of BMP effectiveness	Social attitudes

	Estimated BMP reduction measurements	Research Projects
	Actual BMP reduction measurements	Feedlot measure
	Targets/benchmarks for non-regulated activities in TMDL/watershed implementation plans MET	Industrial measure
	Behavioral tracking for non-regulated measures	
	LGU compliance with permits and stormwater pollution prevention program in MS4s	
	Percent adoption of key urban runoff stormwater BMPs for a given area	
	Percent compliance with NPDES permits	
	Tons of pollutant per capita	
	Targets/benchmarks for regulated activities in TMDL/watershed implementation plans ADOPTED	
	Targets/benchmarks for regulated activities in TMDL/watershed implementation plans MET	

* Modified after Grayzeck et al., 2008, Appendix C.

† "Indicators" are clear measures of implementation progress. "Other relevant variables" include characteristics about TMDLs and implementation efforts that are not necessarily indicators of implementation progress. Some of these might be indicators if given a more clearly defined context.

APPENDIX C: PROPOSED MEASURE LANGUAGE

Potential Future Measures of Incremental Progress in Restoring Water Quality

EPA invites comments on the following four potential future measures under subobjective 2.2.1 (Restore and Improve Water Quality on a Watershed Basis). They are designed to enhance measurement of incremental progress toward meeting water quality standards. These measures are being considered for inclusion in the FY 2013-2018 EPA Strategic Plan and/or the National Water Program Guidance for 2012. Comments should be sent to Ms. Vinh Nguyen, EPA Office of Water, EPA (4102M), 1200 Pennsylvania Ave. NW, Washington, DC 20460, or by email to nguyen.vinh@epa.gov, by April 2, 2010. In particular, EPA invites responses to the questions shown in the "Questions for Reviewers" below.

Measure #1 ("Planning" Measure)

Measure Language: The number of 9-element watershed management plans to protect or restore surface water quality in each State

Type of Measure: Indicator measure, Cumulative measure

Measure Contact: TBD

Measure Definition

Terms and phrases:

Watershed management plan is a document prepared by State or local interests to protect or restore surface water quality and contain the 9 key elements prescribed by EPA for the purposes of the Clean Water Act Section 319 Nonpoint Source Program.[21] Such plans may or may not be approved by a given State, but they are incorporated into the State's nonpoint source management program.

9 key elements refer to the "a…i" components outlined in the 2003 EPA Nonpoint Source Grant Guidance.[22]

[21] *Handbook for Developing Watershed Plans to Restore and Protect Our Waters, March 2008, pages 215 to 2-17, available at* http://www.epa.gov/nps/watershed_handbook/pdf/ch02.pdf.

[22] Nonpoint Source Program and Grants Guidelines for States and Territories, October 2003, available at (a) identify causes and sources of impairment
(b) estimate expected load reductions
(c) describe needed NPS management measures
(d) estimate needed technical and financial assistance
(e) public information and education
(f) implementation schedule for NPS management measures
(g) measurable milestones to track implementation progress
(h) criteria to indicate progress in improving water quality
(i) monitoring plan to assess performance in meeting criteria

Methodology for computation of results:

The measure is a simple count of watershed management plans credited by the State as containing the 9 key elements prescribed by EPA
http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2003_register&docid=fr23oc03-39.pdf

The Regions will query their States to inventory the number of watershed management plans they have acknowledged as containing the 9 key elements

The States may tally the number of such plans through their 319 Grants Reporting and Tracking System (GRTS) database or a companion database used to support the State's nonpoint source management program.

This measure differs from the proposed measure for total maximum daily load (TMDL) nonpoint source implementation in that this measure is aimed at counting those plans that direct the implementation of nonpoint source TMDLs or management practices to be installed ahead of any TMDL development. Such plans represent the bridge between the planning stage and implementation stage for non-point source impaired waters, with or without TMDLs.

The inventory of such plans will grow in accordance with new watershed plans developed addressing different waters than those covered by existing plans; revision of an existing management plan will not count toward the inventory.

Watershed management plans may be counted without regard to geographic scope or hydrologic unit size. Watershed management plans may not overlap or cover common watersheds.

Units: Each independent watershed management plan, containing the 9 key elements, will be designated as one unit. This measure will accumulate the number of these units for each State.

Universe: The universe for this measure is indeterminate at this time. Nevertheless, using the current count of 303(d) listed waters (44,023) and approved TMDLs (40,426) and the conventional wisdom that about 90% of these waters are impacted wholly or partly by nonpoint sources, the initial estimate of the universe is approximately 76,000. This number does not include Category 4b waters nor does it account for watershed plans addressing multiple waters and TMDLs. The first inventory of this measure will indicate the progress in developing watershed management plans consistent with EPA philosophy on what constitutes a good plan. Given the number of impaired waters identified across the nation as being impacted by nonpoint sources, some bounds on the universe of this measure may be realized as experience is gained in tallying the number of these plans and relating them to other measures, including the number of impaired waters and the number of TMDLs influenced by nonpoint sources.

Baseline: Zero, as of 2002. The concept of the 9 key elements in watershed plans came out with the 2003 guidance.

Questions for Reviewers
1.1 What will be the state submittal process for these watershed management plans so that EPA can tally them? Will these watershed management plans be submitted annually with Clean Water Act Section 319 reporting? 1.2 How will we determine these plans contain nine elements as prescribed by EPA? TMDLs are reviewed by EPA – leading to approval and establishment – whereas watershed management plans are not reviewed and approved by EPA. 1.3 Discussions during the drafting of this measure included counting watershed management plans completed for watersheds for which a TMDL has been established. Would a measure tracking watershed management plans limited to those watersheds for which a TMDL has been established prove more useful than a measure tracking all watershed management plans?

Measure #2 ("Implementing" Measure)

Measure Language: Miles of impaired rivers and streams, and number of lake acres, addressed by watershed plans where nonpoint source load reductions are being achieved by implementation of Best Management Practices (BMPs).

Type of Measure: Indicator measure, Cumulative measure. Reported every two years coincident with the 303(d) reporting cycle (even years)

Measure Contact: Marjan Peltier (peltier.marjan@epa.gov) 404-562-9240

Measure Definition

Terms and phrases

Miles of impaired rivers and streams or lake acres refers only to those assessment units with nonpoint source load contributions. If an assessment unit is only impaired due to point sources, then the number of miles or acres in that assessment unit is not reflected in this measure.

Addressed by watershed plans refers to any watershed plan or equivalent planning document addressing the "9 elements" as defined in the October 23, 2003 Section 319 Guidance. Equivalency determination is at state discretion.

Nonpoint source load reductions are being achieved is an achievement based on projected load reductions from the Section 319 Grants Reporting and Tracking System (GRTS). Unlike Measure WQ-9 which only includes reporting for Nitrogen and Phosphorus, this measure includes reductions for any pollutants of concern. It is anticipated that during the period this measure is tracked as an indicator, procedures for load reduction calculations for pollutants other than N, P and sediment will be developed by EPA and interested states. EPA is seeking comments on this critical component.

Implementation of BMPs refers to structural, behavioral or programmatic Best Management Practices (BMPs). Examples of structural BMPs include stream restoration, stormwater retrofitting, streamside fencing, manure sheds and similar devices, etc. As an example of a behavioral BMP, farmers in Kansas are advised to manage the application of the herbicide atrazine, to mitigate its wash-off and transport to surface waters during runoff periods. The BMPs alter the method and timing of atrazine application, including applying

before April 15 (50% reduction), incorporating the herbicide in the soil (67% reduction) or post-emergence application (67% reduction). In all cases, the practice is behavioral and does not rely on the installation of structural controls. Programmatic BMPs reflect formal adoption of land use practices or programs (e.g., mandatory buffers, protective ordinances, septic tank pump-out programs, etc.). Implementation of BMPs can be funded through any program, but tracking is only expected for BMPs funded by EPA and/or the state water quality agency. Documentation of implemented BMPs should be available, but does not need to be reported.

Methodology for computation of results:

In each reporting cycle, two numbers would be reported as ratios:

> The number of miles of rivers and streams meeting the measure divided by the total number of miles of rivers and streams wholly or partly impaired by nonpoint sources; and,
>
> The number of lake acres meeting the measure divided by the total number of lake acres wholly or partly impaired by nonpoint sources.

This measure uses a "rolling base" approach (see Universe and Baseline below). This "rolling base" approach allows the states to get credit for their work regardless of when use impairments were detected after 2002.

If this measure were to begin in 2012, activity under the measure would be captured starting with the 2010 reporting cycle.

Units: Number of river and stream miles, and the number of lake acres, reported separately.

Universe: The total universe has not yet been estimated, and will change over time. The universe consists of the number of miles of rivers and streams, and number of lake acres, impaired partially or wholly by nonpoint sources, as of the reporting cycle. Assessment units so influenced would be identified from the total universe of impaired waters in the most recent listing cycle. The number of miles or acres associated with the identified assessment units would then be calculated. Please note that as subsequent listing cycles occur, the universe would change. Therefore, cycle-to-cycle comparisons are only valid as a ratio of miles or acres with load reductions due to BMP implementation to the denominator of the total number of impaired miles or acres influenced by nonpoint sources for that reporting cycle. State-to-state comparisons are not advised.

This measure is not intended to encourage states to increase the number of miles or acres addressed by BMPs from year to year. Rather, targeting of resources and integration of programs is encouraged. However, ratios provided each reporting cycle could be used for management decisions such as resource allocation, grants targeting and monitoring design. It is anticipated that for areas receiving programmatic attention, that water quality improvements can be captured over time and reflected in the Measures #3 and #4 below, or ultimately in measures SP-10, SP-11 or SP-12.

Baseline: Zero, as of 2002. Since the 9 elements were defined in 2003, the baseline for this measure is a subset of the impaired waters list of 2002. However, due to resource considerations, it is not intended for states to back track this measure to that date. The baseline of miles of rivers and streams and lake acres, is, therefore, deemed to be zero

Database: To capture the full scope of implementation, a national implementation database, or its equivalent, is needed that can capture activities by the full universe of federal agencies with environmental mandates, state efforts and local investments.

Questions for Reviewers
2.1 Load reductions: EPA recognizes that universally accepted methodologies for calculation of load reductions associated with all nonpoint source pollutants are not yet available. Further, variability in State water quality standards may complicate development of methodologies for pollutants such as pathogens. EPA solicits comments on the range of nonpoint source-influenced pollutants that should be included in reporting. It is anticipated that striving to define load reductions during the "Indicator Measure" period, will help provide stimulus for the development of needed methodologies. *2.2 Geographic extent of load reductions: EPA recognizes that determining the scope of influence of any given BMP is challenging. Is a 100-foot buffer on 1000 feet of stream only ameliorating the associated assessment unit, or are the effects more far reaching? Which impaired segment or segments get credited for a county-wide construction ordinance? Which stressors? Is a statewide agricultural practice credited to every impaired assessment unit impacted by that agricultural practice? In most instances the answer lies in the associated watershed plan. Although many plans do not include the desired degree of specificity to answer some of the above questions, it is hoped that tracking this measure can provide impetus for more specific watershed plans that target implementation activities based on load reductions to particular impairments in the watershed. EPA anticipates that quality control of this element will be left at the discretion of the states so that flexibility in best professional judgment can be appropriately applied. EPA is soliciting comments on the feasibility and needed flexibility of this computation.* *2.3 Data system: Although the Grant Reporting and Tracking System (GRTS) is primarily used for tracking and reporting grant requirements, it could be the appropriate and most cost-effective mechanism to generate the necessary reporting for this measure. In order for GRTS to serve this purpose, the field associated with affected impaired assessment units needs to be universally populated by the states. The system will also need to accommodate load reduction entries associated with other pollutants. Two other fields are recommended but would not be required during the Indicator status period: (a) A "yes/no" field indicating whether a Total Maximum Daily Load (TMDL) has been developed for the associated impaired water(s), and (b) a date entry for the year in which the TMDL was developed. It is hoped that states can use the information in these two fields to manage resources and set priorities based on whether a TMDL was developed or the lag time between the development of a TMDL and the implementation of the watershed plan. Specifically, this information could shed light on the utility of giving lower priority for development of a TMDL for certain pollutants when water quality improvement could be achieved through immediate implementation of watershed plans for certain pollutants, e.g., pathogens. Also it would be possible to judge the efficacy of resource use for each pollutant to judge if development of a TMDL facilitated implementation. Where TMDLs exist, watershed plans can incorporate the TMDL implementation schedule to add planning value. EPA is soliciting comments on all aspects of the use of the GRTS database for tracking this measure.*

Measure #3 ("Improving" Measure)

Measure Language:

(3a) Number of waters listed as impaired in 2002 that now have improved water quality conditions compared to 2002. (3b) Number of other assessed waters that now have improved water quality conditions compared to 2002.

Type of Measure: Indicator measure, Cumulative measure

Measure Contact: Larry Merrill (Merrill.larry@epa.gov) 215-814-5452

Measure Definition

Terms and phrases:

Impaired waters means waters that were listed as impaired in 2002.

Improved water quality conditions means improvements in water quality as described in Methodology below.

Assessed waters include waters with sufficient water quality data and may include impaired waters not identified in the 2002 inventory of impaired waters or listed after the 2002 baseline. This can include waters included in probabilistic surveys.

Methodology for computation of results:

This measure will generally be reported every two years, in conjunction with the Integrated Report submission cycle. There may be annual updates for states that choose to report results in annual updates of IR reports. Each water quality agency submitting biennial water quality assessment reports should prepare an analysis of incremental water quality improvements. Analysis shall be based on adequate available data and may be reported for one or more parameters as data allows. Results are to be reported when applicable water quality standards are not yet met but improvements in water quality are evident. If this measure is adopted in 2012, initial reporting will be based on the 2012 Integrated Report cycle. Updates will be provided in succeeding IR reports. Improvements may be based on physical/chemical water quality results or evaluation of biological integrity using an established biologic assessment methodology. Options on statistical evaluation will be provided; agencies may use current statistical procedures used in assessment reporting. For measure 3a, evaluation should be based on comparison to baseline conditions (2002 results). For measure 3b, evaluation should be based on comparison to baseline conditions (2002 results) or, when reporting on impaired waters listed after the 2002 baseline, comparison to results in initial year of listing. Waters may be included if any one of the following criteria is met:

> A data assessment using suggested VADEQ analytical approaches (see appendix) shows a significant (10% or greater) change in the higher water quality interval or in a defined index score.
> Current trend data analysis used by a reporting agency indicates a significant improvement in water quality as defined by the agency based on a statistical analysis.
>
> Water quality assessment results for one or more listed impairments show improvement in the two most recent reporting cycles and other impairments do not show decline (2002 inventory of

impaired waters) or in a core set of pollutants (e.g., nitrogen, phosphorus, bacteria and total suspended solids) for other waters.

For agencies with a biologic condition gradient, a water moves from one tier to a higher tier.

For agencies with a biologic index assessment process, the assessment scores show an increase in at least two consecutive reporting cycles.

For agencies employing a probabilistic survey, waters show improved conditions as defined by the agency in at least two consecutive survey periods (overall comparison of results; special emphasis should be provided to repeat sites included in the surveys).

For other than listed waters, the scale of reporting shall be determined consistent with the reporting agency's assessment methodology and should remain stable through subsequent reporting.

Units: Number of water bodies.

Universe:
For measure 3a, the number of impaired waters in 2002 (39,503).

For measure 3b, other assessed waters in 2002 (2002 ATTAINS statistics: 695,504 river miles assessed out of 3,692,830 in the United States; 14,831,882 lake acres assessed out of 40,600,000; and 30,446 estuary square miles out of 87,369)

Baseline: Zero, as of 2002.

Questions for Reviewers
3.1 Will reporting linked to IR schedules limit extra work or will this measure require substantial additional resources? 3.2 Do the multiple options allow sufficient factors to include waters under this measure? 3.3 Is the inclusion of measure 3b, allowing for reporting on other assessed waters not in the 2002 universe of impaired waters, a good idea? 3.4 Do states wishing to do a statistical review (the VADEQ method or another method) have the ability to do this now? 3.5 Will it be feasible to begin reporting with the 2012 IR report cycle?

Measure #4 ("Maintaining" Measure)

Measure Language: Number of waters fully supporting or partially supporting designated uses where water quality is maintained and protected, as measured by water quality or aquatic life indicators.

Type of Measure: Indicator measure, Cumulative Measure

Measure Contact: Larry Merrill (Merrill.larry@epa.gov) 215-814-5452

Measure Definition

Terms and phrases:

Maintained means maintenance of assessed level of use attainment despite the addition of measurable and/or modeled impacts from increased stressors. Waters reported under this measure are waters that should have evidenced a decline in overall water quality but by maintaining a level of assessed uses show a 'net' incremental improvement.

1. Maintenance may be based on biological, chemical and or physical parameters/ properties that can reliably indicate conditions in the water or the contributing watershed, including habitat, biotic communities and water chemistry.

2. Indications of maintained status may include:
   a. No increase in pollutant loads despite additional sources,
   b. Same or fewer number of impairment causes,
   c. No change in an accepted measure of degradation,
   d. No further degradation in landscape conditions (e.g., no change in impervious cover, forest cover lost, preserved/conserved land, including riparian buffers).
   Retention of assessment status from one reporting cycle to the next.

Methodology for computation of results:

This measure will generally be reported every two years, in conjunction with the Integrated Report submission cycle. There may be annual updates for states that choose to report results in annual updates of IR reports.

Agencies have options on what types of waters to include. Waters may include designated priority watersheds, special classification waters (e. g., High Quality/Special protection Waters), waters with targeted restoration work underway or other significant waters as determined by the agency. Recommended that waters reported under this measure be based on a minimum four year interval when assessing change (i.e., for waters reported in 2012, base conditions would be 2008 or earlier).
If this measure is adopted in 2012, initial reporting will be based on the 2012 Integrated Report cycle. Updates will be provided in succeeding IR reports.

Example: Mill Creek Watershed was assessed in 2002 and was found to be only partially supporting its three designated uses. During the period between 2002 and 2008, the Mill Creek Watershed experienced a growth in population and in total wastewater volume. However, low-impact development initiatives enabled percent impervious cover in the watershed to show no discernible increase and wastewater treatment improvements maintained overall pollutant loads. Assessment results for the 2008 Integrated Report showed Mill Creek with the same level of use attainment as in 2002.
Units: Number of water bodies.
Universe: All assessed waters in 2002 (2002 ATTAINS statistics: 695,504 river miles assessed out of 3,692,830 in the United States; 14,831,882 lake acres assessed out of 40,600,000; and 30,446 estuary square miles out of 87,369)

Baseline: Zero as of 2002.

Questions for Reviewers
4.1 Will reporting linked to IR schedules limit extra work or will this measure require substantial additional resources? 4.2 Are there suggested additional factors to be used for determining if waters are under stress? 4.3 Is the first reporting cycle of 2012 feasible? 4.4 Is the inclusion of a maintenance/protection measure a good idea?

APPENDIX D: KSU MEASURE RATING CRITERIA AND MATRIX ANALYSIS

A. Adequacy for addressing program needs

1. **Enhance measurement of incremental progress toward meeting water quality standards**

    a. **High**=Provides a measure of progress toward water quality standards (either directly or in relation to the corresponding CWA impaired waters pipeline stage – planning, implementation, recovery, etc.), and is likely to demonstrate progress in cases where progress is occurring.
    b. **Moderate**=Provides a measure of progress, but there are likely to be multiple cases where significant progress is occurring that are not captured by the data to be collected.
    c. **Low**=Does not provide a measure of progress and/or the measure is likely to miss so much progress that it is not useful.

2. **Enables targeting**

    a. **High**=Enables targeting inherently because of the data collected to enable the measure.
    b. **Moderate**=Enables targeting, as long as certain conditions are met or certain additional information is collected (for example, the watershed plan is written in a way that makes priority actions clear or information on implementation progress is accompanied by geographic information).
    c. **Low**=Does not enable targeting in a clear and demonstrable way.

B. Ease of data collection (refers to inherent difficulty of the chore)

1. **High**=Collecting data on this measure is a simple matter and its compilation in the form(s) suggested should not cause any significant difficulties.
2. **Moderate**=Collecting data on this measure will involve some effort, but it is an effort that is within the technical and resource capabilities of state agencies.
3. **Low**=Collecting data on this measure will involve a substantial effort that cannot be reasonably expected of most state agencies under current circumstances.

C. Potential for comparability across states

1. **High**=The measures used mean the same thing in different states and they are likely to accurately portray relative progress among the states.
2. **Moderate**=The measures may mean the same thing in different states, but differences among the states and their practices mean that the measures may not accurately reflect relative progress among the states.
3. **Low**=The measure means different things in different states and it will therefore lead to data that are not comparable across states.

D. Consistency with existing state programs and indicators (addresses expected additional burden and potential for national efforts to under-cut or compromise current progress by states that are moving forward with useful indicators)

1. **High**=States are already collecting data on this measure effectively, and the use of these data for measurement purposes creates little or no additional burden for the states involved.
2. **Moderate**=States may be collecting much of the data that are needed to report on this measure, but some additional work is likely to be necessary to adjust what they are doing in order to meet this need.
3. **Low**=Data of this kind are not currently being collected in most states and collecting data for this measure will require a new data collection/compilation effort and/or may under-cut currently successful efforts.

E. Fosters collaboration with other programs ("political/institutional" feasibility of furthering integrated water quality improvement efforts)

1. **High**=This measure is a natural indicator for other TMDL-related federal programs, and is likely to be embraced by officials working in other federal programs.
2. **Moderate**=This measure will require other programs to give some additional thought to their practices and procedures, but – after full consideration – they are likely to determine that it makes sense not to obstruct its use.
3. **Low**=This measure is likely to require large changes in other programs, which contradicts useful existing program directions, or is likely to engender significant opposition.

This matrix applies KSU's rating criteria to the four incremental measures under consideration by the IMWG.

Incremental measure	Criteria						Uncertainties and issues	Potential "improvements" that could be considered
	Adequacy for enhancing measurement of progress	Adequacy for enabling targeting of water quality improvement actions	Ease of data collection	Comparability of the measure across states	Consistent with existing state programs	Fosters productive collaboration with other federal programs		
1. The number of nine-element watershed management plans to protect or restore water quality in each state	**High**	**Uncertain** • Some plans will enable targeting better than others • Depends on specificity of recommend's & geographic info provided	**High**	**Moderate** • Some plans cover wider geography, but would only count once	**High**	**Uncertain** • While plans are used for 319 program, there are questions about what constitutes an adequate plan	• Consider how to handle plans in states with USEPA review versus plans in other states • Should there be greater geographic specificity?	• Account for differences in geography and universe (i.e., % of certain HUC-size watersheds with approved TMDLs & approved plans)
2. Miles of impaired rivers and streams or lake acres addressed by watershed plans where nonpoint source load reductions are being achieved by implementation of BMPs	**High**	**Moderate** • Number alone does not help target • If specific waters are known, it would help with targeting efforts	**Uncertain** • May be straightforward if data already in GRTS • Load reduction determinations may be difficult	**Uncertain** • May be comparable if data already in GRTS • Depends on how miles and acres are calculated & load reductions are determined across states	**Moderate** • Uses data that appear to be a part of 319 reporting	**Uncertain** • The 319 program may have something to say about this, as it overlaps with GRTS	• Identifying stream reaches does not necessarily generate a number of miles • Determination that load reduction has occurred can be done in many ways	• Consider using project count, perhaps tied to a requirement that the project will: a) reduce pollutant loads, and/or b) improve pollutant assimilation
3. Report of waters with improvements in water quality assessment results (Group 1: 2002 inventory of impaired waters; Group 2: other assessed waters)	**High**	**Moderate** • Number alone does not help target • If specific waters are known, it might help with targeting efforts	**Uncertain** • Some data may be at agencies' fingertips; other data may require research	**Moderate** • States have several options for measuring improvements	**Uncertain** • Good, if use data that states already have • However, it could require collection or analysis of additional data	**Moderate** • Assessment program may have concerns over consistency with 303(d)/305(b) processes	• What constitutes an improvement? Issues of seasonality, flow, pollutant vs. impairment, and required time and samples raise questions	
4. Report of waters with maintenance/ protection of designated uses as measured by water quality or aquatic life indicators	**Uncertain** • Many uncertainties	**Low** • Maintained/ protected waters are not priorities for remediation	**Low** • Does not seem to be based on standardized, accessible data sets	**Low** • Difficult to generate consistent criteria for stressors and mitigating actions	**Moderate** • Inverse of 303(d) minus waters with no changes in development	**Moderate**	• Defining stressors & mitigating actions • Unit of measurement is vague: stream miles/lake acres, or "number" of waters	• Simplify, possibly by providing more specific definition of stressors, or possibly by eliminating the need for stressors

APPENDIX E: DECEMBER 2010 INCREMENTAL MEASURES WORKGROUP MEETING MINUTES

US Environmental Protection Agency and State
Incremental Measures Workgroup Meeting

December 8 - 9, 2010

Washington DC

Meeting Participants

USEPA Headquarters
Benita Best-Wong
Sarah Furtak
Yu-Ting Guilaran
Susan Holdsworth
Kristie Moore
Tomeka Nelson
Vinh Nguyen
Shera Reems
Wendy Reid
Dov Weitman
Santina Wortman
Chris Zabawa

USEPA Regions
Larry Merrill, USEPA Region 3
Margherita Pryor, USEPA Region 1 (phone)
Steve Schaff, USEPA Region 7
Paul Thomas, USEPA Region 5

Meeting Facilitators: KSU Team
Laura Blake, The Cadmus Group
Josh Filla, KSU
Evan Hansen, Downstream Strategies
John Hoornbeek, KSU

States
Kyle Ament, Iowa DNR (phone)
Susan Davies, Maine DEP (phone)
Kim Groff, Massachusetts DEP (phone)
MaryAnn Nusom Haverstock, Connecticut DEP
Scott Hughes, Alabama DEM
Traci Iott, Connecticut DEP (phone)
Heather Jennings, North Carolina DWQ (phone)
Craig Lott, Virginia DEQ (phone)
Norm Marcotte, Maine DEP (phone)
Cam McNutt, North Carolina DWQ (phone)
Jane Peirce, Massachusetts DEP (phone)
Jeff Risberg, Minnesota PCA
Don Smith, Virgnia DEQ
Kathy Stecker, North Carolina DWQ (phone)
Roger Stewart, Virginia DEQ
Tom Stiles, Kansas DHE

Other
Lori Belangia, ASIWPCA

Background/meeting purpose

In 2009, a state/USEPA workgroup was formed to develop proposed new measures to track incremental progress in watershed restoration. The purpose of this meeting was to:

- Review the current strategic planning measures.
- Identify gaps in current strategic planning measures and discuss potential ways to fill those gaps, including:
    - Proposed new measures #1 - #4.
    - Proposed ideas for making potential adjustments to existing measures.
- To reach consensus on which—if any—new or revised measures should be proposed for inclusion in the 2012 Water Program Guidance.
    - Acceptable measures need to be reportable, nationally consistent, and verifiable.
- Identify next steps for the workgroup.

Desired accomplishments for meeting

At the start of the meeting, the participants were asked to identify what they would like to get out of this meeting; responses included:

- Work through kinks, get a feel for what's reasonable for incremental measures moving forward, and move at least one of the proposed new measures on to the next round. (Schaff)
- Come out of meeting with a strong sense of direction for what we can expect to report on for incremental measures so that we can, first, get credit for the interim steps that states are taking to work on implementing TMDLs for achievement of water quality standards; and second, create information that can help states make adjustments in our overall strategy in how we're implementing TMDLs so we can become more effective in achievement of water quality standards. (Stiles)
- Reach consensus or conclusion on work conducted over past year; and make decision on incremental measures and move forward. (Hughes)
- Reach agreement on one or two items. (Thomas)
- Make progress on moving incremental measures forward in some form, even if not all of them make it into the water program guidance. (Risberg)
- Make sure that if we establish additional/different measures, they are useful and not just informational. (Marcotte)
- Identification of what is missing in order to enable us to report on the proposed new measures, especially measure #4. (Pryor)
- Find ways to move proposed new measure #3 forward. (Lott)
- Make a decision about fate of this workgroup. (Guilaran)

Review of current measures

Guilaran gave a brief overview of the current measures of water quality restoration progress. Those include:

- SP Measures:
    - SP-10: Number of water bodies identified in 2002 as not attaining water quality standards where standards are now fully attained. [Target measure: cumulatively reported]
    - SP-11: Remove the specific causes of water body impairment identified by states in 2002. [Target measure: cumulatively reported]
    - SP-12: Improve water quality conditions in impaired watersheds nationwide using the watershed approach. [Target measure: cumulatively reported]
- WQ Measures:
    - WQ-9a: Estimated annual reduction in million pounds of nitrogen from nonpoint sources to water bodies (Section 319–funded projects only).
    - WQ-9b: Estimated Annual reduction in million pounds of phosphorus from nonpoint sources to water bodies (Section 319–funded projects only).
    - WQ-9c: Estimated annual reduction in tons of sediment from nonpoint sources to water bodies (Section 319–funded projects only).
    - WQ-10: Number of water bodies identified by states (in 2000 or subsequent years) as being primarily nonpoint source–impaired that are partially or fully restored. [cumulative]
    - WQ-21: Number of water segments identified as impaired in 2002 for which states and USEPA agree that initial restoration planning is complete (i.e., USEPA has approved all needed TMDLs for pollutants causing impairments to the water body or has approved a 303(d) list that recognizes that the water body is covered by a watershed related plan [i.e., Category 4b or Category 5m]).

Stiles shared his perspective on gaps in current measures and why there is a need to consider alternative measures. Demonstrating on-the-ground success is difficult for numerous reasons (e.g., scale, funding, extent of pollution, human behavior). States/USEPA came together in August 2009 to discuss this challenge. At that time, the workgroup recognized there are interim steps between TMDL development and full water body restoration. The workgroup looked at the current measures to find ways to account for incremental improvements and give credit to states for interim steps. The utility of the current measures was discussed. For the most part, the states find some utility in reporting on the current measures. Some of the measures have gaps; for example, current WQ measures don't capture reductions in other pollutants (e.g., bacteria, TSS).Very few states are looking to replace current measures; however, states believe that current measures do not capture interim steps and incremental improvements in the process of restoring water bodies. At the same time, the workgroup acknowledged the need to minimize reporting burden, so as not to take state staff time away from the work itself. The workgroup began exploring the concept of proposed new measures to better capture interim steps and incremental improvements in the process of restoring water bodies.

Reems mentioned that WQ-21 is a difficult measure to report, and has not been a high priority measure for states/regions. One of the reasons why is that there is a big focus on WQ-8a and WQ-8b (the state-developed TMDLs and total developed TMDLs), which help to evaluate TMDL development pace. Also, although a water body can be counted for WQ-21 if listed in Category 4b, the bar has been set high for Category 4b so there are very few cases out there.

Pryor concurred with Stiles that bacteria is a key pollutant not currently acknowledged in the WQ measures. Efforts to reduce bacteria impairments do not receive credit in the current measures. This is a major issue for the New England states.

Pryor also asked the workgroup to consider whether there are ways to cut across goals in USEPA's Water Program Guidance and Strategic Plan (e.g., document reductions in bacteria and reopening of beaches). We need a better nexus between measures, instead of measuring everything in silos.

Hoornbeek asked, to what degree do people view the four proposed new measures as starting to fill the gaps identified thus far? Stiles said that the four proposed new measures do begin to address these gaps, especially on *planning* and on *improving*. We know we've still got some work to do with the *implementation* and *maintaining* measures.

Guilaran and Stiles grouped the current measures as follows:

- Planning: WQ-8
- Implementing: SP-11, WQ-9
- Improving: SP-12, WQ-10
- Recovery: SP-10

SP-10 is full attainment, while the other SP and WQ measures are meant to capture interim progress. WQ-21 is an indicator/planning measure. Guilaran asked the workgroup, are there gaps not currently addressed in these (above) measures? Stiles said yes, there are gaps; for example, in planning and in improving.

Risberg expressed his concern about the meaningfulness of measures to the public. Is the sole purpose of tracking these items for USEPA's purposes? He also mentioned the lack of acknowledgement of reductions in stormwater runoff and wastewater treatment facility improvements in the current WQ measures. The WQ measures also don't have targets, so it's hard to judge what the reported information means (is it a lot of progress, not a lot?).

Zabawa mentioned that SP-10 and SP-11 have received a lot of attention as they have a fairly rigid reporting process, with much of the supporting data coming from states' Integrated Reports. The other measures provide for greater interpretation of how they are met.

Stiles agreed with Risberg that when states first encountered SP-11, many of the states interpreted 'causes' as 'sources.' It turned out this was not the correct interpretation. It was suggested that the workgroup consider that the wording in SP-11 be altered to change 'causes' to 'sources.' This puts the focus on the removal of the impairment (e.g., stream bank erosion) instead of on the pollutant (e.g., sediment).

Hughes believes that the major gap is in the planning measure; this is the foundation of how you achieve what is needed to report on other measures. USEPA is missing an opportunity to account for effort that goes into development of watershed management plans.

USEPA Water Program Guidance & Strategic Plans: processes for change

Nugyen works on strategic measures in the Office of Water. Nugyen reviewed the process for changing or adding new measures to USEPA's Water Program Guidance. A copy of the Measure Definition Template was provided to the workgroup; the document outlines information and data needs for new measures.

Nugyen explained that there are limitations in changes that can be made to 'budget' measures (i.e., SP-10, SP-11, SP-12, and WQ-9a, WQ-9b, WQ-9c, WQ-8a, and WQ-8b), as any proposed change needs to be justified to Office of Management and Budget. Any proposed changes to 'budget' measures would be to the 2013 Office of Management and Budget submission. Proposed changes would need to be submitted in August 2011.

Nugyen explained that current efforts by the workgroup are to inform the 2012 NWPG, so she reviewed the timeline for proposing changes. All program offices must submit proposed changes by December 10th. All

proposed changes are then compiled and distributed to all offices for review/comment. If regions comment that the proposed new measure is non-reportable, then Office of Wetlands, Oceans, and Watersheds management will make a decision regarding viability of the measure. Final agreement for changes must be made by January 10th. The Assistant Administrator will review proposed changes at the end of January. The draft guidance is then delivered to the Office of the Chief Financial Officer on February 12th. The draft guidance will be published February 19th for 30-day comment, with the final guidance published April 30th.

Nugyen told the workgroup that USEPA management prefers outcome measures, as they show environmental change. Indicator measures are good tools for testing measures; however, they don't get much attention as they don't have targets. Outcome-oriented measures are viewed more favorably than output measures. She also told the workgroup that proposing all four new measures is not a viable option, as USEPA is trying to streamline the process. Therefore, the workgroup should pick the one or two proposed new measures that they believe are achievable, reportable, and outcome focused.

Nugyen told the workgroup that they need to also think about the process for reporting/tracking data to support any proposed new measures. The data collection process for reporting on any new measures begins October 1, 2011. Reporting occurs mid-year (e.g., May 2012) and end-of-year (e.g., September 2012), so the proposed new measures would need to have results by mid-year and end-of-year. Measures should be reportable by all states/regions.

Given the timeline identified by Nugyen, it was acknowledged that the timeline is tight. Stiles pointed out that if the deadline is the end of this meeting, then we need to refocus the rest of the meeting. **The workgroup decided that the rest of the meeting will focus on proposed new measures 1 and 3, as well as suggested changes to SP-11 and ideas for accounting for bacteria in current or proposed new measures.** The fate of proposed new measures 2 and 4 will be determined at a later time.

Nugyen also told the workgroup (for future reference), if they ever want to propose new measures to include in a future Strategic Plan, they should first include indicator measures in program guidance to test them out and collect critical information (e.g., What is the baseline? What is the universe? Are there data?). After a year, if the measure works well, then propose it for inclusion in the Strategic Plan. Just remember that a five-year target is needed for Strategic Plan measures.

Discussion of specific measures: planning measure (#1): number of nine-element watershed plans to protect or restore surface water quality in each state

The workgroup was referred to a handout for the draft template for proposed new measure #1.

Prior to this meeting, the workgroup conducted a pilot test run of the proposed new measures. In addition, as part of the KSU project, the proposed new measures were evaluated against a predefined set of criteria. Stiles and Hansen reported on the outcomes of those efforts.

Stiles commented that proposed new measure #1 is a simple, but informative measure. States participating in the test run all indicated that the watershed plans themselves did contain all of the nine elements. But we did see a divergence in consistency among states, which was to be expected given the variety of programs. Watershed scale was variable (HUC-8 to HUC-12). The format and what constitutes a watershed plan is variable; some look like the classic 319 plan, others take the form of a TMDL implementation plan. There are three main purposes for watershed plans: 1) implementing TMDLs on a watershed basis (with focus on nonpoint source); 2) preempting the development of a TMDL; and 3) protecting waters currently meeting WQS (high quality waters). There are still questions about the review process for watershed plans and what role states and USEPA have in the review process. There was recognition that watershed plans are a gateway to the next stage – implementation. Finally, there was consensus from the participating states that this is a popular measure that fulfills the need to document the significant effort that goes into watershed management planning.

Hansen referred the workgroup to a handout that summarizes results from the evaluation of the proposed new measures against a predefined set of criteria. Hansen walked the workgroup through the results of the evaluation. This proposed new measure scores high on adequacy for enhancing measurement of progress; it's useful to know how many watershed management plans have been developed. The adequacy of this proposed new measure for enabling targeting of water quality improvement actions is uncertain, as some watershed plans will enable targeting better than others. Counting the number of watershed plans (i.e., data collection) will be easy. The proposed new measure will be moderately comparable across states. The proposed new measure is consistent with existing state programs, especially the Section 319 program. It's uncertain if this proposed new measure would foster collaboration with other federal programs. Important considerations include: Who makes the decision regarding which watershed plans count/qualify (states or USEPA)? Should there be specific geographic specificity (e.g., HUC-12, HUC-8).

Guilaran summarized USEPA's few concerns about this measure. USEPA's Nonpoint Source Branch Chief (Whitman) mentioned the need for consistency of watershed plans that would qualify to be counted in this proposed new measure, and a need for minimum standards for which watershed plans qualify (e.g., nine elements, being implemented). Also, the geographic area needs to be defined (i.e., the size of watershed covered by a watershed plan). Also, reviewing watershed plans to determine if they qualify to be counted in this measure will put a significant resource demand on USEPA. Stiles pointed out that few (if any) state programs are consistent (states have different designated uses, different WQS, different delisting criteria, etc.). Instead of reviewing each and every watershed plan, maybe USEPA can conduct spot audits of a subset of watershed plans to review for adequacy. Schaff commented that most of the regions currently review watershed plans, so this may not add a lot of work. Merrill, however, mentioned that it does take a significant amount of time to review the watershed plans. Thomas said, in his region, some watershed plans are reviewed, but not all are reviewed. Not all watershed plans will be perfect. However, state members of the group suggested that it's important to give credit for time spent developing these watershed plans, as they are a building block for meeting WQS.

Schaff commented that this proposed new measure has minimal likelihood of ever becoming a Strategic Plan/budget measure. Given that, perhaps it doesn't need as rigorous of scrutiny. Stiles suggested adding a sunset clause to give the measure a finite lifespan (e.g., 3 years).

Guilaran asked the workgroup, if this is an output measure (that will never graduate to strategic or budget measure), how do we justify the merit of the measure to USEPA management? Stiles said it helps keep people moving down the pipeline for the next steps and next measures. Schaff said perhaps the graduation is that, a few years down the line, the measure changes to "implemented" from "developed."

Reems commented that WQ-21 could be revised to include 319/watershed plans. This might eliminate the need to create a new measure, but still captures this gap/need.

Guilaran pointed out two items that need to be further explored – the geographic extent covered by watershed plans and how watershed plans will be reviewed (by regions) in a consistent manner. Also, Guilaran would like to see data (to help with justification) on how much funding states are putting into the development of the watershed plans.

Wortman was asked if GRTS could help to inform this measure. For example, if GRTS were to track the number of watershed plans developed. Nusom-Haverstock said there is opportunity to use GRTS. Risberg said this would be an issue for watershed plans developed using solely state funds, as GRTS is tied to 319 funding. Region 3 developed a watershed plan tracker.

There was also discussion about what to do with watershed plans developed using funds aside from 319? There was disagreement among the workgroup about whether or not to count them in the proposed new measure. It was pointed out that the source of funding should not qualify or disqualify watershed plans.

Whether or not the watershed plan meets the nine elements should be the factor that qualifies or disqualifies the watershed plans.

Weitman provided his perspective on the proposed new measure. The fundamental question is, should we be counting watershed plans or 'counting' actual improvement of water quality? When we were a very young program, we thought it made sense to count the number of watershed plans because state implementation was at a basic level. So, we counted the number of watershed plans developed, and we set a goal that was easily met. Very few of the watershed plans had been reviewed by USEPA. We ended up dropping the measure as it was very easy to achieve and it was never known what added information was provided by this measure. Virtually every state now has success stories of cases where waters that were impaired are no longer impaired; and that can be linked to on-the-ground actions. USEPA's Web site has more than 200 success stories, with more to come. Now that we're tracking the successes itself, why step back and count the number of planning documents? We're now at a more sophisticated point of counting waters that have been remediated (this is the ultimate proof of success). Another major concern raised by Weitman is the resources required to review every single watershed plan submitted for the measure. Also, there is a huge disparity among the complexity of the projects. No two watershed plans are the same; this makes it difficult to compare one watershed plan against another.

Stiles reiterated that this proposed new measure provides an opportunity for states to obtain credit for all of the hard work that goes into the development of a nine-element watershed plan. This proposed new measure also provides accountability for how a significant amount of 319 funding has been spent (i.e., on developing the watershed plans). Planning has a negative connotation; it's seen as a paper shuffling exercise. However, to states, planning is the foundation that establishes why we're implementing, where we're implementing, and how we intend to implement. Weitman agreed that while there are some excellent watershed plans, there are still a number of watershed plans that are less than adequate. However, using this proposed new measure as the way to improve those watershed plans is not a good approach. It will become a fight over beans, taking focus away from the real issue. States may rush to develop watershed plans for the sake of counting beans. We don't want low quality watershed plans (for which there is no funding) sitting on a shelf. Stiles responded it's unlikely that this proposed measure would trigger a mass development of watershed plans by the states. Most states are developing purpose-driven watershed plans that are implementable.

McNutt commented that North Carolina focuses restoration efforts at a smaller spatial scale. They agree that their watershed plans are better now, as people now develop them with the intent of implementation. He would like to know how to get credit for the on-the-ground efforts, including non-319 activities. Hughes mentioned that in Alabama, local stakeholders provide input on watershed plan development. The ability to develop large numbers of watershed plans is limited by stakeholder capacity.

Pryor pointed out that in order to develop a planning measure that is meaningful, we need to work through all of the impediments. However, if state efforts put toward development of the watershed plans are not credited, how many states will continue to develop watershed plans?

Guilaran asked the workgroup if we should continue to pursue this proposed measure given all of the issues brought up during this meeting. Merrill and Reems threw out the idea of adding watershed plans to WQ-21 (via a proposed revision to existing language) instead of proposing a completely new measure. **The workgroup agreed that this is the better way to go, so the workgroup proceeded to work to develop revised language to measure WQ-21. See final draft template for proposed measure WQ-21(b).**

Discussion of specific measures: improving measure (#3): number of waters listed as impaired in 2002 that now have improved water quality conditions, and number of other assessed waters that now have improved water quality conditions compared to 2002

The workgroup was referred to a handout for the draft template for proposed new measure #3.

Prior to this meeting, the workgroup conducted a pilot test-run of the proposed new measures. In addition, as part of the KSU project, the proposed new measures were evaluated against a predefined set of criteria. Stiles and Hansen reported on the outcomes of those efforts.

Stiles said this proposed new measure may be better termed 'relative change' instead of improving. This proposed new measure has had the most momentum behind it (from the workgroup). We took on the Virginia approach for reporting on the measure (see draft template for more info). We found that the tie back to 303(d) status limits the amount of data that can be used. There are also some issues separating out noise of hydrologic variation. There's also a question of which and how many sites to include in the evaluation; also, which pollutants to include in the analysis. The current language provides significant flexibility for states to decide how to report on this measure (e.g., which pollutants).

Hansen referred the workgroup to a handout that summarizes results from the evaluation of the proposed new measures against a predefined set of criteria. Hansen walked the workgroup through the results of the evaluation. This proposed new measure has high adequacy for enhancing measurement of progress. It has moderate adequacy for enabling targeting of water quality improvement actions, as number alone does not help target. Ease of data collection for this proposed new measure is uncertain, as some data may be readily available, some not so much. Comparability of the proposed new measure across states is moderate, as states have several options for how to measure improvements. The consistency of this proposed new measure with existing state programs is currently uncertain, as it could require collection or analysis of additional data. The proposed new measure is moderate in fostering of collaboration with other federal programs (assessment programs may have concerns over consistency with 305(b)/303(d) process). An important consideration includes, what constitutes an improvement?

Stiles pointed out that the proposed new measure needs to be water body specific (vs. HUC 12-based SP-12). Also, the proposed new measure should not be specific to waters with a TMDL.

It was asked if USEPA would allow the states to define whether or not water is improving and simply report on number of water bodies that are improving. Holdsworth said it's important to have/see the analysis conducted to make the determination.

Blake asked the workgroup, how does this proposed new measure differ from SP-12? Stiles said SP-12 is reported on the HUC-12 level; not all states can report improvements on the HUC-12 level. This measure will not be bound to the watershed scale. Also, this proposed measure would not be tied specifically to waters with a TMDL. Holdsworth commented that this measure delinks the measure from the 303(d) list.

Holdsworth asked about the need to define the sample size (in the language for the proposed new measure). The workgroup said this would be dictated by the statistical analysis itself. Blake pointed out that although SP-12 is watershed-focused, the measure contains good language on items such as how the states must define improvement (for example, defining improvement with a 90% confidence level, etc.). Given this language is already accepted by USEPA, why not borrow some of this language as part of the effort to revise the language in the proposed measure #3? The workgroup took a closer look at specific language in SP-12 and decided to borrow select language from Option 2a, Section b1 for the proposed new measure.

Holdsworth asked for clarification on what is being measured by this proposed new measure – stations or waters? Reporting on this measure would need to have supporting documentation that discusses the extent of waters covered by the trend assessment. Some workgroup members said that if water body, it could be

defined by some spatial extent (e.g., miles of water body, surface area, etc.). Stiles said that the point of this proposed new measure is to focus on an individual station, not necessarily a water body, so the term 'stations' should be used instead of 'water.'

Stiles pointed out that this proposed new measure also addresses the bacteria "issue."

The workgroup discussed the reporting frequency for this proposed measure and it was agreed upon that it would be too much of a burden to ask states to report on it every two years. The workgroup identified six years as a good reporting frequency. The proposed new measure would become effective in 2014.

The workgroup continued to work together to revise the language for proposed Measure #3. See the final draft template for proposed measures.

Next steps for the measures and the workgroup

1. The workgroup recommended forwarding the two revised measures (WQ-21 and workgroup measure #3) for consideration by USEPA for inclusion in the forthcoming NWPG. USEPA was requested to distribute the final templates for the proposed new measures (#3 and the revision of WQ-21) to USEPA offices for review/comment. If the regions comment that the proposed new measures are non-reportable, then Office of Wetlands, Oceans, and Watersheds management would make a decision regarding viability of the measure. If the measures are deemed viable, the Assistant Administrator will review the proposed changes for possible inclusion in the new NWPG. The current state-USEPA group expressed willingness to continue interacting with USEPA staff and management on issues associated with these two measures as/if needed.

2. By April 2011 or sooner if possible, develop a straw man version for adjusting Measure SP-11 to focus on sources, rather than causes. This approach would also address the issue of pathogenic contamination which was discussed during the meeting. If Office of Management and Budget objects, then this issue could be dropped.

3. While this workgroup did not express a strong view about continuing the current workgroup in exactly its current form, there was sentiment expressed about the value of continuing state-USEPA discussions about measures.

4. With regard to the two remaining proposed measures, there was value seen in continued discussions. However, potential ways to address the needs for these measures were also discussed as follows:
    - Implementing Measure (#2): miles of impaired rivers and streams or lake acres addressed by watershed plans where non point source load reductions are being achieved by implementation of BMPs. The view was expressed that a revision to SP-11 to focus on sources rather than causes/pollutants would begin to address the need for a good implementation measure.

Maintaining Measure (#4): number of waters fully supporting or partially supporting designated uses where water quality is maintained and protected, as measured by water quality or aquatic life indicators. The view was expressed that the value of a "maintaining" measure might be addressed through the "Healthy Watersheds" initiative.

APPENDIX F: INCREMENTAL MEASURES WORKGROUP PROPOSAL TEMPLATES

FY 2012 National Water Program Guidance Measure Definition Template

1) FY 2012 Measure (ACS) Code:

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2) FY 2012 Measure Language: WQ-21(b): Number of water segments identified as impaired in 2002 for which States and USEPA agree that a 9-element watershed management plan is complete to restore surface water quality.

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3) Type of Measure:

a) Indicator measure: XX
b) Cumulative measure: XX

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4) USEPA Measure Contact: Dov Weitman

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5) FY 2012 Measure Definition:

a) **Terms and phrases:**

- *Water segment* – A water body (or "segment") as identified in state-submitted Section 303(d) lists, Section 305(b) reports, and Integrated Reports, for the 2002 reporting cycle. See USEPA's guidance for such reporting under "303(d) Listing of Impaired Waters Guidance" at http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/guidance.cfm
- *Watershed management plan* is a document prepared by State or local interests to protect or restore surface water quality and contain the 9 key elements prescribed by USEPA for the purposes of the Clean Water Act Section 319 Nonpoint Source Program.[23] Such plans may or may not be approved by a given State, but they are incorporated into the State's nonpoint source management program.
- *9 key elements* refer to the "a…i" components outlined in the 2003 USEPA Nonpoint Source Grant Guidance.[24]

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[23] *Handbook for Developing Watershed Plans to Restore and Protect Our Waters, March 2008, pages 2-15 to 2-17, available at* http://www.epa.gov/nps/watershed_handbook/pdf/ch02.pdf.

[24] *Nonpoint Source Program and Grants Guidelines for States and Territories*, October 2003, available at http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2003_register&docid=fr23oc03-39.pdf

(a) identify causes and sources of impairment

(b) estimate expected load reductions

(c) describe needed nonpoint source management measures

(d) estimate needed technical and financial assistance

(e) public information and education

(f) implementation schedule for nonpoint source management measures

(g) measurable milestones to track implementation progress

(h) criteria to indicate progress in improving water quality

(i) monitoring plan to assess performance in meeting criteria

b) **Methodology for computation of results:**

- The measure is a simple count of impaired water segments addressed by watershed management plans where USEPA and States agree the plan contains the 9 key elements prescribed by USEPA.
- If more than one watershed management plan exists for the water segment, the water segment gets counted only once.
- The States may use the Grants Reporting and Tracking System (GRTS) to identify the watershed management plan and the Assessment TMDL Tracking and Implementation System (ATTAINS) to verify the number of impaired water segments.
- A water segment may be counted under both WQ-21(a) and WQ-21(b) because it is a progression from the TMDL development and analysis, i.e., WQ-21(a), to the development of the watershed management plan, i.e., WQ-21(b) that enable the accomplishment of the necessary pollutant load reductions. In some cases watershed management plans may be completed prior to the development of TMDLs.

c) **Units:** Water Segment

d) **Universe:** The universe consists of an estimated 39,503 water bodies identified by states or USEPA as not meeting water quality standards in 2002. Thus, 2002 is the baseline year for this measure. This universe is sometimes referred to as the "fixed base" or "SP-10 baseline." The universe includes all waters in categories 5, 4a, 4b, and 4c in 2002. Of these waters, 1,703 are impaired by multiple pollutants including mercury, and 6,501 are impaired by mercury alone (see discussion of mercury in Methodology above). Impairments identified after 2002 are not considered in counting waters under this measure; such impairments may be considered when revising this measure for future updates of the Strategic Plan

e) **Baseline:** Will be established in FY 2012 with the first reporting cycle.

FY 2012 National Water Program Guidance Measure Definition Template

1) FY 2012 Measure (ACS) Code:

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2) FY 2012 Measure Language: State demonstration of trends in improved water quality, i.e.,

(a) Percentage of monitoring stations showing improvement; and/or
(b) Percentage of waters in "healthy" or "good" condition based on state-wide statistical (probability) survey increases over time

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3) Type of Measure:

a) Indicator measure: XX
b) Cumulative measure

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4) USEPA Measure Contact: Susan Holdsworth

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5) FY 2012 Measure Definition:

f) **Terms and phrases:**
Improvement means:

- For individual monitoring stations, statistical procedures demonstrate that improvement has occurred with a 90 percent or greater level of confidence. For purposes of this measure, "statistical procedures" are those procedures capable of showing statistically significant change in the water quality parameters or related indicators (e.g., seasonal Kendall trend test, Wilcoxon sign rank).
- Evidence of an improving trend in a related biological indicator/index.
- For statistical (probability) survey, using spatially representative survey design (95% confidence interval is ± 15) report over time an increasing percent of state waters in "healthy" or "good" condition by water body type (e.g., lakes, streams and rivers, wetlands, estuarine or coastal waters).

g) **Methodology for computation of results:**

- For individual monitoring stations, total number and percentage of stations by parameter (e.g., N, P, TSS, bacteria, and biology and state discretionary parameters); percent improving, staying the same, declining, and insufficient data; include not monitored.
- For statistical (probability) survey, percentage and amount of waters by parameter (e.g., biology, habitat, sediment, N and P, and state discretionary parameters); percent in state defined condition classes (e.g., good, fair, poor or pass, fail); include not monitored.

h) **Units:**

- For individual monitoring stations: Number and percentage of stations
- For statistical (probability) survey: Number and percentage of state waters by water body type

i) **Universe:**
- For individual monitoring stations: Stations included in the ambient trend network as designated by the States. Note – need to add footnote about the addition of stations.
- For statistical (probability) survey: Population of water bodies represented is defined in the survey design.

j) **Baseline:**
For both individual monitoring stations and statistical (probability) survey the starting point is at state discretion based on study design

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Start

2014 Integrated Report

Frequency

Every six years (2014, 2020, 2026)