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Integrated Water Resource Management (IWRM) in the United States: An Inquiry into the Role of Total Maximum Daily Loads (TMDLs)

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Integrated water resource management (IWRM) has become a focal point of discussion about water management. While there are differences in viewpoint regarding IWRM's use and effectiveness, two key elements that are discussed in relation to the concept of IWRM are 1) developing more holistic perspectives, and 2) engaging stakeholders in water management processes. We investigate the relationship between these two key elements of IWRM and water management practices associated with Total Maximum Daily Loads (TMDLS) in the United States (US). Drawing data from all 63 TMDL reports approved by the US Environmental Protection Agency (USEPA) between 1998 and 2006 for the states of Ohio and West Virginia, we assess whether these key elements of IWRM are incorporated into TMDL practices. We also conduct preliminary tests to assess the relationship between these key elements of IWRM and watershed restoration progress as perceived by state environmental officials.

The data we collect suggest that Ohio and West Virginia are creating holistic information on watershed management as they develop TMDL reports and that they are engaging stakeholders in TMDL processes in a number of cases. We also find positive associations between the incorporation of key elements of IWRM and perceived progress in watershed restoration. The data we present also suggest that steps are being taken to implement TMDLs in Ohio and West Virginia, but they indicate that the progress being achieved is modest compared to the ambitious goals of the American Clean Water Act. Our data and analyses are limited in several key respects. However, they do suggest that broad-based watershed planning and stakeholder engagement—practices consistent with IWRM—may contribute positively to TMDL implementation and watershed restoration progress. They also suggest that TMDL processes could play a positive role in supporting more aggressive IWRM efforts in the future.

Keywords: water pollution, water policy, Clean Water Act (CWA), Total Maximum Daily Loads (TMDLs), Integrated Water Resource Management (IWRM), holistic water management, stakeholder engagement, collaborative watershed management.

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1. Introduction

Integrated Water Resource Management (IWRM) has been a focal point of discussions about water management across the globe (Global Water Partnership-Technical Advisory Committee (GWP-TAC), 2000; Lenton & Muller, 2000). While some argue that IWRM provides a pathway toward "better water management" (Lenton and Mueller, 2000), others suggest that it has not lived up to its promises (Medema et al., 2008). In the United States (US), the rhetoric of IWRM has often been overshadowed by alternative discourses such as "watershed management" and "ecosystem based management" (EBM),[1] but at least two key elements of these various discourses are similar. All of them emphasize: 1) the importance of holistic perspectives on water management and 2) the value of stakeholder engagement in decision-making about water resources.

This article investigates the use and impacts of these two key IWRM principles—holistic perspectives on water management and stakeholder engagement—in American water pollution policy. More specifically, it assesses whether the US is using these two principles in total maximum daily load (TMDL) practices being implemented in two states: Ohio and West Virginia. The article also presents information on the extent to which implementation recommendations contained in TMDL reports are being implemented in these states and tests whether variations in perceived watershed restoration progress are associated with variations in the use of these IWRM principles. We find that IWRM principles are being incorporated into TMDL practices in Ohio and West Virginia to at least some degree, and that watershed restoration progress is positively associated with the presence of broad-based watershed planning and the engagement of stakeholders in TMDL development and implementation. However, due to limitations relating to our sample of TMDL reports and the analytical methods used, we view our results as suggestive rather than conclusive. As a result, we recommend further research to verify and build upon the findings presented here.

2. Background

While the broad view that IWRM seeks to "promote coordination and integration as a means of achieving more holistic water management and improving water resource sustainability" (Medema et al., 2008) appears to be widely held, the scholarly and professional literature includes varying definitions of IWRM (Davis, 2007 and Medema et al., 2008 provide overview discussions). Observers also highlight a range of elements that they believe are central to IWRM.[2] The GWP-TAC, for example, focuses on water as a finite

[1] For one example of recent IWRM-related discourse in the US, see USACE, 2010.
[2] It is noteworthy that observers trace the history of IWRM in differing ways. Some focus on its recognition of multi-dimensional aspects of water management and trace the concept back many decades (see Biswas, 2004), while others focus more explicitly on the attention paid to the IWRM concept in the 1990's during and after international conferences in Rio de Janeiro and Dublin (GWP-TAC, 2000).

and vulnerable resource (that should be managed holistically), participatory approaches, important roles of women, and the idea of water as an economic good (GWP-TAC, 2000). Matondo (2002) says that IWRM[3] is "participatory," "technically and scientific informed," and tied to catchments that are consistent with the "natural units by which nature manages water." Implicit in these lists of key IWRM elements, and others (see Davis, 2007, for example), are concepts relating to holistic perspectives on water quality management and stakeholder engagement. These two concepts are used here as foundations for analyses of the relationships between IWRM and TMDL practices in the US.

While Congress enacted TMDL provisions in Section 303(d) of the Clean Water Act (CWA) about forty years ago, TMDL programs have become increasingly prominent features in American water quality management over the last two decades. Section 303(d) requires states to establish TMDLs for impaired water bodies, which quantify the maximum amount of a pollutant that can enter a water body while still enabling it to comply with water quality standards. TMDLs also allocate those pollutant loads among specific water pollution sources, and these allocations provide quantitative foundations for specific controls on water pollution releases. While federal law and policy generally guide state TMDL practices, state environmental agencies have latitude to approach their TMDL responsibilities in differing ways.

External observers have also expressed differing views about TMDLs. Some have been critical and have suggested that TMDLs are without a sufficient scientific foundations (Freedman et al., 2003; Keller & Cavallaro, 2008) and that proposed changes to strengthen TMDL practices represent an extension of the command and control regulatory structures that have been built into federal law (Adams, 2000; Stephenson & Shabman, 2001). Others have been more supportive. They suggest, by contrast, that "TMDLs are not part of a federal command and control regulatory regime" (McCully, 2002, p. 246) and that TMDLs hold the potential to help enable more effective "ambient-based" water quality management (Elshorbagy et al., 2005) as well as stakeholder engagement (Sabatier et al., 2005, p. 3–5). Yet another viewpoint is that "TMDLs hold the best prospect of those now available for coming to grips with the last major, unregulated sources of water pollution" in the US (Houck, 1999, p. 168).

There do not yet appear to be studies that evaluate TMDL practices in relation to IWRM. This article begins to fill this gap. We first provide a brief overview of American policymaking processes and the historical development of US clean water policies. Second, we describe our research approach, including the hypotheses investigated and the data and methods used to evaluate them. Third, we assess whether TMDL processes are yielding "holistic" data collection processes and broad based watershed planning processes, consistent with IWRM. Here the focus is on the value of integrating policies *horizontally* across watersheds and broad geographic areas and *technically* across pollutants and sources of water quality problems. Fourth, we assess the extent to which the

[3] It is worth noting, however, that Matondo uses the term Integrated Water Resource Planning and Management (IWRPM), rather than IWRM.

TMDL process is yielding *sector-based* integration by enabling stakeholder involvement in water quality management processes (GWP-TAC, 2000; Lenton & Muller, 2000). Finally, we assess the impact of IWRM principles by evaluating the extent to which key elements of IWRM are associated with the implementation of recommendations in TMDL reports and watershed restoration progress. We close with a summary and discussion of our findings and conclusions, as well as with suggestions regarding future research.

3. Overview: American Policymaking and the Development of US Clean Water Policies

In the US, policy integration of almost any kind is difficult to achieve. The nation's federal constitution fragments policymaking vertically and its separation of powers among executive, legislative, and judicial branches of government fragments policymaking horizontally. At the sub-national level, states divide authority among local governments in ways that make horizontal integration of water quality control actions across local jurisdictions difficult to achieve. America's legal and cultural tradition of protecting property rights introduces yet another source of policy fragmentation because it creates additional (although arguably appropriate) legal burdens for policies that require actions affecting private property. Finally, the CWA's differentiation of federal regulatory authorities based on water pollution source further fragments water pollution policy implementation (Lowry, 1992; Hoornbeek, 2011). It is thus not surprising that past analyses of American water pollution policy have found little evidence of integrated and effective water pollution policies (Lowry, 1992; Layzer, 2008; Hoornbeek, 2004 & 2011).

Prior to World War II, water quality management in the US was viewed as the province of state and local governments. Concerted national involvement in water pollution policy began in 1948 with passage of the original CWA[4] and grew in piecemeal fashion until 1972. In that year, Congress passed legislation that re-wrote the CWA to emphasize federal technology-based regulatory controls on industrial dischargers and municipal sewerage systems. These controls took the form of a new regulatory permitting program, the National Pollutant Discharge Elimination System (NPDES), which required permits for *point source* pollution discharges to waters of the US. Point sources of water pollution include industrial and municipal wastewaters that flow through discrete pipes and conveyances, and they are distinguished in national policy from *non-point sources* (NPSs), which flow diffusely over land to surface waters such as rivers, lakes and streams. In 1972, Congress also enacted Section 303(d) of the new law, in large part to provide "a game plan" (Houck, 1999, p. 24) for addressing water pollution problems that remained after full implementation of NPDES regulatory controls.

For two decades or more, the implementation of the 1972 law and its successor amendments focused on implementing a range of functionally distinct nationally

[4] However, the US federal government was involved in water *quantity* management and navigation efforts for many years prior to its engagement in water pollution control.

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authorized programs for addressing point and non-point sources, and this programmatic separation still fragments water pollution control efforts today. This separation means that priorities and implementation processes are organized around categories such as the issuance of NPDES permits, the provision of grants and loans to local governments to support wastewater treatment services, the distribution of NPS grants, and watershed planning, rather than around priority watershed-based problems. To a large degree, these efforts have been successful, as pollutant loads from point sources are reported to have diminished considerably (ASIWPCA, 2004). While water quality problems growing from point source discharges are still evident and important, NPS water pollution now contributes to a large proportion of the nation's water quality problems (USEPA, 1996; USEPA, 2000; USEPA, 2007).

Congress created another CWA program in 1987 to address NPS water pollution. The new Section 319 of the CWA required states to develop NPS water quality assessments and management plans to address the problems that are identified, and it also included a new grant program to supply funds to states to help them address NPS water pollution problems. Funding for the 319 grant program increased substantially in the late 1990s to support NPS water pollution control projects in watersheds targeted by TMDLs.[5] To access these additional "incremental" 319 grant funds, states across the nation were required to have in place broad-based (endorsed/approved) watershed plans that included nine key federally specified elements prior to using these ("incremental") funds to implement non-point source water pollution control projects (US Federal Register, 2003). These elements include information on pollutant reductions required by the TMDL processes, which address multiple pollutants, pollution sources, and water body impairments on a watershed basis.

Since that time, 319 grant funds and funds from voluntary grant programs administered by other federal agencies have become key policy tools for implementing NPS pollutant reductions called for in TMDLs. Nevertheless, the 319 program remains modest compared to the size of the NPS pollution problems it seeks to address, even as supplemented by other voluntary federal grant programs in the US departments of Interior, Agriculture, and Commerce. These latter programs address water pollution problems from mining, agriculture, and coastal development practices and—like the CWA's 319 grant program—they also support projects that seek to help restore water bodies that are impaired due to NPSs.

While neither the federal government nor many American states possess direct regulatory authority over NPSs, the TMDL provisions in Section 303(d) require states to identify waters for which technology-based controls are not sufficient to ensure compliance with water quality standards. States are also required to report maximum allowable pollutant loads and source-specific pollutant loading allocations to USEPA. The Section

[5] In 1999, the USEPA approximately doubled the size of the 319 grant program from just over \$100 million to \$200 million in annual appropriations and mandated that the additional funds be used to target water quality problems identified as requiring TMDLs (for more information, see Hoornbeek, 2011, pages 157 and 294).

303(d) provisions requiring these actions, however, lied dormant for the first twenty years of the 1972 law's existence and were largely ignored by both USEPA and the states until the 1990s. Since the mid-1990s, however, TMDLs have become increasingly important because of the widely recognized need to address NPSs and a series of court decisions that required more complete compliance with section 303(d) by USEPA and the states (for more information on this litigation, see Houck, 1999). These court decisions, in turn, have helped to foster significant growth in the federal TMDL program and the development of state TMDL programs. And, while the federal government has oversight responsibility to approve TMDLs for state waters, the water quality standards that determine total allowable loadings and the allocation of these loads among pollution sources are typically developed by state agencies. In this sense, states have flexibility to allocate required pollutant reductions among discharges to impaired water bodies, and stakeholder engagement is one way they can gain insight to help them determine the most appropriate allocations.[6]

Today, in the second decade of the twenty-first century, the NPDES regulatory permitting program, voluntary federal grants for NPSs, watershed planning requirements associated with the receipt of grant funds, and a wide range of state-specific programs stand at the foundation of efforts to restore water bodies that are identified as impaired by state TMDL programs around the country. Collectively, the states and USEPA have issued NPDES permits to control thousands of point source water pollution discharges (Hoornbeek, 2011). Since the mid-1980s, USEPA has also provided more than $3 billion in 319 grants to support projects to reduce pollutant flows from NPSs (Hoornbeek, 2011). And collectively, voluntary NPS water pollution grants administered by all federal agencies yield investments that substantially exceed this amount. These federal programs are supplemented by an array of regional, state, and local programs that focus on specific geographic areas and/or problems. The end result is an array of water pollution control programs around the country that are grounded in one way or another on federal programs to achieve their objectives. These federal programs, however, are not always well integrated with one another on a watershed basis and—as a result—water pollution controls are not always as effective as they could be (Hoornbeek, 2011).

4. Research Approach and Methods

We evaluate several hypotheses that are grounded in IWRM and are applied here to TMDLs and their implementation. They are:

1) TMDL practices involve holistic data collection processes that address:
   a. multiple pollutants,
   b. multiple types of water pollution sources,

[6] At the same time, from the viewpoint of water pollution dischargers, collaboration around TMDL processes is one way in which they may be able to have input and, potentially, influence on the ways in which watersheds are actually managed.

c. broad-based watershed planning, and
d. the use of holistic information in managing watershed restoration efforts.

2) Stakeholders engage in the development of TMDL reports and in the implementation of pollution reduction recommendations contained in them, and
3) Key elements of IWRM—holistic data collection strategies, broad-based watershed planning, and stakeholder engagement—are positively associated with watershed restoration progress.

To evaluate these hypotheses, we rely on data and information collected between 2006 and 2008 for a comprehensive study of TMDL implementation in Ohio and West Virginia.

We focus on Ohio and West Virginia for three reasons: 1) their water pollution programs reflect differing levels of water pollution policy activism based on past studies (Hoornbeek, 2005; Ringquist, 1993), as Ohio is considered to be more aggressive in its efforts to address water quality issues than is West Virginia; 2) they take different approaches to implementing their TMDL programs;[7] and 3) they are geographically proximate to each other and the researchers. Effectively, this latter geographic consideration enabled more complete, consistent, and in-depth data collection efforts than would have been possible if the states were widely separated geographically. While these two states are instructive for conducting useful and in-depth assessments of TMDL practices, similar studies of additional states are appropriate to enhance the external validity of the results presented here.

Data informing the analyses presented here are drawn from reviews of all 63 TMDL reports approved by USEPA between 1998 and 2006 for Ohio and West Virginia, as well as reviews of written records and surveys and interviews with more than forty state officials associated with the development and implementation of these TMDL reports. Because USEPA tracks TMDLs on the basis of individual pollutants and specific stream segments and/or water bodies, this canvass of all USEPA-approved TMDL reports included hundreds of individual TMDLs across these two states. It reflects a complete inventory of all USEPA approved TMDLS for these two states as of 2006.

As we reviewed each of the 63 TMDL reports, we collected information on the extent to which TMDL practices are yielding holistic information on water quality problems. We determined the extent to which they cover broad geographic areas. We also identified the number of pollutants and types of pollution sources they address. In addition, we reviewed records on state- and USEPA-endorsed watershed plans to determine if the TMDL reports in our sample were accompanied by broad-based watershed planning processes that were

[7] For example, West Virginia administers its TMDL program in centralized fashion, as TMDLs are developed by the West Virginia Department of Environmental Protection (WVDEP) and, in the past, by USEPA. By contrast, Ohio generally develops and administers its TMDL program on a decentralized basis, as it relies on five regional offices to develop TMDL reports and implement their recommendations. The two states also report to two different USEPA Regional Offices—Region V in Chicago (for Ohio) and Region III in Philadelphia (for West Virginia)—and may thus capture variations in USEPA regional practices.

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grounded in accepted key elements of a watershed-based plan. This information is useful because, if endorsed watershed plans are in place, it suggests that the information collected through the TMDL process is also being used to support broad-based watershed planning. Collectively, positive findings in relation to these indicators would support the first hypothesis above. They would also suggest that TMDL processes seek to address water quality problems more holistically than is likely to occur under the separate and largely independent program management strategies used for the NPDES, existing voluntary federal grant programs, and/or other functionally oriented federal and state programs.

To assess the role of stakeholder engagement (hypothesis 2), we collected information on the extent to which external stakeholders were involved in TMDL development and implementation. With regard to the *development* of TMDLs, we rely on brief surveys of lead developers of each TMDL report to assess stakeholder engagement in developing the 63 TMDL reports in our sample. The surveys asked whether external stakeholders had written letters, taken part in TMDL-related meetings, provided data, and/or assisted in writing TMDL reports. In general, we consider the latter two forms of involvement—providing data and assisting in writing—to constitute significant involvement, as writing letters and/or attending meetings could potentially indicate little more than responses to notice and comment opportunities rather than the more collaborative forms of engagement envisioned by IWRM.

To collect information on stakeholder involvement in the *implementation of TMDL recommendations,* we consulted statewide listings of watershed groups to identify known groups that *could be* contributing to TMDL implementation. We then interviewed state official(s) who were identified by their colleagues as experts on watershed restoration activities in the geographic areas covered by the TMDL reports. During these interviews, we asked the state officials to identify whether or not they knew of watershed groups that were *actually* taking responsibility for implementing TMDL recommendations. We also called their attention to the lists of known watershed groups we had compiled to help ensure that they did not inadvertently forget to address one or more known watershed groups. We also collected information on the types of stakeholders[8] that participated in the most recent meeting(s) of these watershed groups.

During the interviews, we also collected information about progress made in *implementing TMDL report recommendations*. We asked the officials about four factually based measures of TMDL implementation progress, each of which reflects a differing level of watershed restoration progress: 1) local/regional group (stakeholder) involvement in TMDL implementation, 2) the presence of at least one watershed restoration project, 3) the achievement of (estimated) pollutant load reductions for at least one TMDL-limited pollutant, and 4) monitored water quality improvements stemming from implementation of recommendations in TMDL reports. The data collected through these interviews were then supplemented by reviews of published information where appropriate.

[8] We asked specifically about the following types of groups: 1) watershed organizations, 2) environmental or conservation groups, 3) point source dischargers, 4) NPS dischargers, 5) state agencies, 6) federal agencies, 7) local governments, 8) university personnel, and 9) others.

The end result of these data collection efforts is a body of information that can be used to assess the extent to which holistic data collection efforts, broad-based watershed planning and management, and stakeholder engagement efforts are being undertaken in the areas covered by the TMDL reports. Our data collection efforts also yielded profiles of watershed restoration progress in areas covered by the TMDL reports. While the data are perceptual and are therefore potentially subject to issues of bias and interpretation (Leach, 2002), the questions posed were largely factual and they were directed toward regulatory officials with significant expertise and knowledge. As a result, while we cannot completely dismiss the potential for bias or oversight, the data presented are arguably more reliable than data collected from other less knowledgeable individuals or individuals with stronger advocacy biases.

To analyze the data, we provide descriptive summaries of our results to evaluate hypotheses 1 and 2. To assess hypothesis 3, we conduct chi-square tests to evaluate associations between the presence of holistic data collection, broad-based watershed planning, and stakeholder engagement efforts on the one hand, and the extent of watershed restoration progress on the other. These associations, in turn, provide at least a preliminary indication of the extent to which TMDL practices consistent with key elements of IWRM have positive impacts on watershed restoration progress.

5. Findings

5.1. Hypothesis 1: Holistic Data Collection and Broad-based Watershed Planning and Management

While USEPA-approved TMDL reports in Ohio and West Virginia do not typically reference IWRM, they often generate holistic information. Both states integrate their TMDL programs with basin-wide approaches for assessing watershed health and water quality. This watershed-based approach enables the collection of information that provides conceptual foundations for pollution control strategies that are more holistic than is achieved by processes that rely on the independent operation of NPDES permitting, NPS grants, and other programs. In addition, more than 80% of the TMDL reports in our sample appear to address water quality problems on a broad-based watershed scale, as they address geographic areas of 23 square miles or greater. Some of the TMDL reports in the sample cover areas of 1000 square miles or more.

TMDL reports in both states also address multiple pollution sources and pollutants. More than 80% of the TMDL reports addressed more than one type of pollution source, and more than half addressed both point and NPSs. NPSs were particularly common, as 98% (62/63) of the TMDL reports addressed at least one type of NPS.[9] Sixty-three percent

[9] These NPSs included: agricultural activities; mining efforts; diffuse storm-water contamination; soil-discharging wastewater systems (e.g., septage systems); a lack of adequate riparian protection around streams and waterways; flow alteration structures (dams, etc.); roads; and legacy pollutant sources from past industrial activities.

(40/63) of the TMDL reports addressed point sources.[10] In addition, ten categories of individual pollutants were identified across the TMDL reports,[11] and almost three-quarters of the reports (73%) addressed multiple pollutants. On average, almost three pollutants were addressed in each TMDL report (2.76 per report).

However, while the TMDL reports in both states appear to provide a technical foundation for holistic integration of relevant information, we found that broad-based watershed planning was not yet in place in a number of cases. Watershed plans that had been endorsed by appropriate regulatory authorities as including required elements of an endorsed watershed based plan (for purposes of accessing Section 319 "incremental" grant funds) were present in only 41% of the TMDL-limited areas in our sample.

Table 1 provides detailed information on the data collected from our TMDL report reviews and on the presence of endorsed watershed plans in the two states. Watershed-based

Table 1
TMDLs and Holistic Water Pollution Information:
Insights on TMDL Reports and Watershed Planning in Ohio and West Virginia

State	A. Range of Watershed Sizes (Square Miles)	B. # (%) of TMDL Reports Written on a Watershed Basis (%)	C. # (%) of TMDL Reports with > 1 targeted source type (%)	D. # (%) of TMDL Reports with > 1 targeted Pollutant (%)	E. # (%) of Broad-based Watershed Plans Endorsed for the TMDL-Limited Area (as of 2008)
Ohio	23-1,034	26/26 (100%)	24/26 (92%)	22/26 (85%)	16/26 (62%)
West Virginia	.29-2,307+*	26/37 (70%)**	29/37 (78%)	24/37 (65%)	10/37 (27%)
Total	.29-2,307+	52/63 (83%)	53/63 (84%)	46/63 (73%)	26/63 (41%)

Data Sources: Data for columns A, B, C, and D were drawn from reviews of TMDL reports in Ohio and West Virginia that were approved by USEPA between 1998 and 2006. The data for column E were provided by the Ohio Department of Natural Resources and WVDEP.
*The range shown reflects the areas covered by all USEPA-approved TMDL reports from West Virginia that were included in our sample, except two Ohio River TMDL reports that include watershed areas in more than one state.
**The 11 West Virginia TMDLs coded here as not being written on a watershed scale are not typical of the TMDLs currently written in West Virginia. All of them were written by USEPA Region 3 in the early years of the TMDL program. They are smaller in scope than the other 26 TMDL reports in the sample (all are less than 23 square miles). Most of them addressed TMDLs for small lakes and one addressed a Superfund site.[12]

[10] These point sources included: mining operations, permitted storm-water systems and discharges (separate and combined sewers), municipal wastewater systems, concentrated agricultural activities, and industrial discharges.
[11] The ten pollutant categories identified were: metals (other than mercury), nutrients, sediment, ammonia, organic enrichment, salinity/total dissolved solids, polychlorinated biphenyls, pesticides, pathogens, and acidity/alkalinity.
[12] This evolution of TMDL Reports in West Virginia raises an interesting question: are TMDL reports becoming more holistic over time? While we do not assert an answer to this question, one could hypothesize a trend in this direction. Because the TMDL program has grown in recent years as a result of litigation, one might expect that TMDL practices are becoming more holistic over time as issues that gave rise to litigation are resolved and state agencies become less hampered by lawsuits and more able to take broad-based views of their TMDL work. However, further research is necessary to evaluate this hypothesis.

TMDL reports that include multiple pollution sources and pollutants are closer to the rule than the exception in both Ohio and West Virginia. However, the data also suggest that TMDL data collection practices appear to be more aligned with IWRM principles in Ohio than in West Virginia. This is because TMDLs in Ohio appear more likely to: 1) be written on a watershed basis, 2) address more than one type of targeted pollution source, and 3) include more than one targeted pollutant. A higher proportion of TMDL-limited geographic areas were also the subject of endorsed watershed plans in Ohio than in West Virginia.

Perhaps most importantly, however, we did not find well established watershed-based *management* systems for ensuring that information collected through TMDL processes was actually used to guide project prioritization and the conduct of restoration activities on an ongoing basis in either state. Rather, we found that data from approved TMDL reports were typically made available for use by separate organizations and/or organizational units with responsibilities for planning, NPDES permitting, and/or voluntary grant and technical assistance programs, etc. In the hands of these differing programs, information from approved TMDL reports was incorporated into independent prioritization schemes for planning, permit issuance, grant distribution, and the like. We did not encounter any cases where all of the information on watershed problems and actions implementing TMDL recommendations were integrated in one place for prioritization and management, as one might expect a from a truly integrated system for prioritizing and conducting watershed restoration efforts. Furthermore, the implementation of TMDL recommendations was not systematically tracked in either state during the time period in which we were collecting data (2006–2008).[13] Thus, while the TMDL process appeared to be aiding in the development of more holistic bases of information for watershed planning, it did not yet appear to be yielding the kind of holistic and integrated *management* processes that are envisioned by IWRM.

5.2. Hypothesis 2: TMDL Processes and Stakeholder Engagement

The CWA does not require stakeholder engagement in TMDL development or implementation (except insofar as traditional notice and comment procedures are required), but scholars have suggested that there is a tie between the growth of collaborative water governance and TMDL processes (Sabatier et al., 2005, p. 3–5). While TMDL reports are not typically conceived of as “consensus” documents, we did find evidence of stakeholder engagement in TMDL *development* processes—particularly in Ohio. All of the TMDL reports we reviewed from both states were written by government organizations (either directly or via external contract), but communications with the officials who took the lead in writing the TMDL reports suggested that external stakeholders were involved in TMDL development processes in a number of cases. Table 2 summarizes survey responses from these officials regarding external group engagement in TMDL development processes.

[13] After the initial report identifying the results of this research was released, however, Ohio Environmental Protection Agency (OEPA) made changes in its TMDL implementation processes to enable more consistent adherence to recommendations contained in TMDLs.

Table 2
Stakeholder Involvement in TMDL Development:
A Glimpse from Ohio and West Virginia

	A. No Known Involvement*	B. Some Involvement: Wrote Letters and/or Attended Meetings	C. Significant Involvement: Contributed Data and/or Helped Write the TMDL**
Ohio	7/26 (27%)	6/26 (23%)	13/26 (50%)
West Virginia	20/37 (54%)	17/37 (46%)	0/37 (0%)
Total	27/63 (43%)	23/63 (37%)	13/63 (21%)

Data Sources: For Ohio, results were obtained through an email survey conducted in cooperation with OEPA staff. In West Virginia, the results were drawn from communications with USEPA Region 3 and WVDEP staff.
*These data, which are coded as "no known involvement," include three cases, one in Ohio and two in West Virginia, where the regulatory officials who were contacted indicated that they "did not know" whether or not any stakeholder involvement had occurred.
**For TMDL reports in this column, some stakeholders also wrote letters and/or attended meetings; however, if stakeholders undertook "significant" efforts to assist in TMDL development, they are included only in column C.

The data in Table 2 reveal that stakeholder groups were involved in developing TMDLs for more than half of the reports in the sample, although stakeholder engagement in TMDL development processes was more prevalent in Ohio than in West Virginia. Some involvement includes writing letters or attending meetings, which could be attributable to standard notice and comment procedures rather than more comprehensive collaborative engagement as envisioned by IWRM. Even so, 21% of all approved TMDLs in the sample benefited from more significant stakeholder engagement, such as the provision of data and/or report writing assistance. All of this more extensive stakeholder engagement occurred in Ohio.

We also collected information on the involvement of watershed groups in *implementing* recommendations contained in TMDL reports. Knowledgeable officials suggested that a group was taking action to implement recommendations contained in 57% (36/63) of the TMDL reports. We also collected information on the composition of these groups by asking whether various types of stakeholders were involved in the most recent watershed group meeting. Overall, these data suggested wide participation among stakeholders in the groups that were taking responsibility for TMDL implementation, as 75% of the responsible groups identified had six or more different types of stakeholders represented at the group's last meeting, and the median number of stakeholder types in the groups was seven. Notably, in cases where watershed groups were taking responsibility for TMDL implementation, both point and NPS dischargers were relatively common participants. In Ohio, for example, at least 15 of the 23 watersheds with responsible groups appear to have included a point or NPS discharger.[14] Table 3 summarizes responses regarding watershed group involvement in TMDL implementation.

[14] In Ohio, the knowledgeable officials we interviewed reported point and/or NPS discharger participation in 15 of the 17 cases in which data were reported. These same officials reported not knowing about the range of recent participation in six cases.

Table 3
Watershed Groups Taking Responsibility for TMDL Implementation:
A Glimpse from Ohio and West Virginia

	Known Group Involvement	No Known Group Involvement
Ohio	23/26 (88%)	3/26 (12%)
West Virginia	13/37 (35%)	24/37 (65%)*
Total	36/63 (57%)	27/63 (43%)

*In 18 of these 24 cases in West Virginia, no knowledgeable state official could be identified. The results in these watersheds were thus coded as characterized by "no known group involvement". While it is important to recognize that the coding of these 18 areas is effectively assumed rather than observed, these data were retained because the lack of a knowledgeable state official probably means that watershed protection efforts are not widespread in these areas. Project team efforts to identify watershed groups in these areas produced no evidence to suggest otherwise.

Overall, these data suggest that stakeholders are involved in implementing TMDL report recommendations in many watersheds. However, their involvement is not consistent across states or areas addressed by USEPA-approved TMDL reports. Involvement appears more extensive in Ohio than in West Virginia. Additionally, we could not identify or locate evidence of any watershed group involvement in areas covered by 43% (27/63) of the TMDL reports.

While these data suggest that stakeholders are engaged in TMDL implementation in a number of cases, they do not demonstrate consistent, informed, and focused implementation efforts by stakeholders over long periods of time. In fact, state officials could identify water quality monitoring taking place downstream from a TMDL implementation project for only 28 of the 63 (44%) TMDL reports we investigated. Thus, while stakeholder engagement does appear to play a role in water quality management processes in Ohio—and also in West Virginia to a lesser extent—our data do not suggest that collaborative engagement in TMDL implementation is as thorough and focused as IWRM would be likely to advocate.

5.3. Hypothesis 3: Watershed Restoration Progress and its Relationship to Key Elements of IWRM

Interviews with knowledgeable state officials revealed a mixed picture regarding the extent to which water quality problems identified in TMDL reports are actually addressed. These officials identified at least one watershed restoration project addressing at least one TMDL-limited pollutant in 65% (41/63) of the geographic areas covered by TMDL reports. However, while these responses indicate that implementation efforts are being made in a number of cases, the projects identified typically appear to represent only small portions of the efforts necessary to fully restore the impaired watersheds.

The interviews also revealed information on the perceived environmental benefits of restoration efforts. Officials identified specific cases where pollutant loading reductions had occurred for at least one TMDL-limited pollutant (from point and/or NPSs) in 46% of the geographic areas investigated. However, in many of these cases, the pollutant reductions were not yet accompanied by known water quality improvements. Knowledgeable officials could identify monitored improvements in water quality downstream from a TMDL implementation effort in only 19% of the watersheds investigated. Successful watershed restoration was identified in only 3% of the cases.

Table 4 summarizes the discussion above regarding watershed restoration progress. It also provides state-specific information on the extent of progress. The data suggest that while progress is being made in implementing TMDL report recommendations in a majority of cases, the extent of progress varies across states and the TMDL-limited areas investigated. For example, while implementation efforts associated with almost two-thirds (65%) of TMDL reports include at least one load-reducing project, efforts to implement TMDLs are achieving loading reductions (46%), known water quality improvements (19%), and watershed restoration (3%) in fewer cases. This suggests that there are multiple factors affecting implementation progress at different stages of the watershed restoration process, and that progress becomes more difficult and/or takes more time at each stage of the process.

Table 4
Implementing TMDLs: Pollutant Reducing Projects, Water Quality Improvements, and Watershed Restoration

Geographic Scope	A. Identified Implementation Project(s) to Reduce Pollutants	B. Pollutant Loading Reductions	C. Water Quality Improvements (or "partial recovery")	D. Restoration of Watershed for TMDL-limited Pollutant(s)
Ohio	23/26 (88%)	17/26 (65%)	6/26 (23%)	0/26 (0%)
West Virginia[15]	18/37 (49%)	12/37 (32%)	6/37 (16%)	2/37 (5%)
Total	41/63 (65%)	29/63 (46%)	12/63 (19%)	2/63 (3%)

Data Sources: Data for columns A, B, and C were obtained through interviews with state officials who are knowledgeable regarding TMDL implementation. Data for column D were drawn from Ohio and West Virginia 303(d) reports for 2008. The totals were previously reported by the authors and their colleagues (see Hoornbeek et al., 2012).[16]

[15] The West Virginia figures in columns A, B, and C of Table 4 reflect the number of cases in which progress was identified based on information provided by knowledgeable state officials. However, in 18 West Virginia watersheds, no knowledgeable state official could be identified. The results in these watersheds were therefore also coded as "no progress" identified. While it is important to recognize that the coding of these 18 watersheds is effectively assumed rather than observed, these data were retained because it seems likely that the lack of a knowledgeable state official means that TMDL implementation activity is not likely to be widespread or perhaps even existent in that watershed. Project team efforts to identify TMDL implementation activities in these watersheds produced no evidence to suggest otherwise.

[16] Both the referenced article and this one are based on data collected during the same time period from the same two states. However, while this article focuses on the relationship between IWRM and TMDL practices in the United States, the referenced article focuses more specifically on progress in TMDL implementation, the role of watershed groups in TMDL implementation, and connections between collaborative watershed management and national water policy.

What explains the differences in watershed restoration progress across the geographic areas addressed by the TMDL reports in our sample? If advocates of IWRM are correct, we might expect to find positive associations between key elements of IWRM and watershed restoration progress.

To evaluate whether holistic data collection processes and broad-based watershed planning are associated with watershed restoration progress, we conducted chi square tests of the relationships between indicators of holistic data collection and broad-based watershed planning on the one hand and watershed restoration progress on the other hand. The results of these tests are shown in Table 5.

While the results in Table 5 appear to suggest that holistic data collection processes have—at best—relatively weak associations with watershed restoration progress, they also reveal two statistically significant bi-variate associations. First, the relationship between the presence of multiple pollutants addressed in the TMDL report and the existence of at least one pollution reduction project shows a relationship that appears statistically significant. And second, the relationship between multiple types of pollution sources and water quality improvements also appears as statistically significant. However, these results are relatively weak.[17]

However, the comparatively strong and statistically significant associations between the presence of an endorsed watershed plan and measures of watershed restoration progress

Table 5
Associations between Measures of Holistic Data Collection and Watershed Planning and Measures of Watershed Restoration Progress: Pearson Chi Square Test Results

	Measures of Holistic Data Collection and Watershed Planning		
	Holistic Data Collection Processes?		Watershed Planning?
Watershed Restoration Progress Measure	Multiple Pollutants Addressed in TMDL Report Chi Square Value (Significance)	Multiple Types of Pollution Sources are Addressed in TMDL Report Chi Square Value (Significance)	Endorsed Watershed Management Plan in Place Chi Square Value (Significance)
At Least One Project Implemented?	3.327 (.068)	*1.189 (.275)**	14.442 (.000)
Pollutant Loading Reduction Achieved?	2.589 (.108)	*.174 (.677)**	26.529 (.000)
Water Quality Improvement?	*2.617 (.106)**	*3.384 (.066)**	*6.958 (.008)**
	N = 63	N = 63	N = 63

*The chi square test results shown in italics have at least one cell with an expected count of less than five.

[17] With significance values of .068 and .066, respectively, these relationships are significant only at the .10 level. In addition, because one might logically expect a higher likelihood of pollutant reducing projects when the number of pollutants and/or the number of sources increases, these bivariate relationships may say little about the potentially positive impacts of holistic data collection processes. In addition, as is noted above, the chi square results for the relationship between the existence of multiple pollution sources addressed in the TMDL and water quality improvements does not meet standard expectations regarding expected cell counts.

are noteworthy because they suggest that when TMDL information is made available for use in watershed planning efforts, then watershed restoration progress becomes more likely. In interpreting these results, however, it is important to remember that endorsed watershed plans expand eligibility for grants under Section 319, so the progress achieved in these cases may be attributable to enhanced funding opportunities rather than to the broad based nature of the planning conducted. It is also important to note that collaborative engagement among stakeholders is an encouraged part of these watershed planning processes, so it is also possible that the watershed restoration improvements associated with this planning may be attributable as much or more to stakeholder engagement than to the holistic information base being compiled. In short, because the results represent tests of independence between two variables and not causation, follow-up evaluations should be done to account for other variables that may affect watershed restoration progress.

Nevertheless, these results do make an important, and perhaps obvious, point about the impacts of key elements of IWRM on watershed restoration progress. While holistic data collection processes may yield information that can be used to support watershed restoration planning and progress, they mean little unless the data are actually used to support actual planning and management activities. In this context, it is also significant that we were not able to identify (at the time we collected our data) any systematic and institutionalized means through which progress in TMDL implementation is regularly evaluated on a state-wide basis to inform subsequent watershed restoration efforts in either state.

We also test associations between a second key element of IWRM—stakeholder engagement—and measures of watershed restoration progress. The test results are displayed in Table 6 and suggest statistically significant relationships in many cases. In fact, the test results suggest generally that we can reject the null hypothesis of independence between both stakeholder engagement in TMDL *development* and TMDL *implementation* on the one hand and all three measures of watershed restoration progress on the other hand.

For stakeholder engagement in TMDL development, test results for two measures of stakeholder engagement are presented. For the measure associated with any form of stakeholder engagement in TMDL development (letter writing and meeting attendance, as well more significant involvement), the results are statistically significant for all three measures of watershed restoration progress. For the measure of significant involvement, which envisions more in-depth engagement, the test results are statistically significant (at the .05 level) for the relationships with two of the three measures of watershed restoration progress—the existence of an implementation project and the achievement of loading reductions.[18]

The chi square test results in Table 6 also reveal statistically significant associations between the existence of an active watershed group taking responsibility for TMDL implementation and all three measures of watershed restoration progress. And, as one

[18] Although it is important to recognize that the first of these results occurs in a chi square test that does not meet the condition of all cells having expected values of 5 or more (as indicated by the italics).

Table 6
Associations between Measures of Stakeholder Engagement in TMDL Practices and Measures of Watershed Restoration Progress: Pearson Chi Square Test Results

	Measures of Stakeholder Engagement		
	Engagement in TMDL Development		Engagement in TMDL Implementation
Watershed Restoration Progress Measure	Significant Involvement: Data Provision &/or Assistance in Writing the TMDL Report	Any Involvement: Significant Involvement, Meeting Attendance &/or Letter Writing	Local Group Taking Responsibility for Implementing TMDL Recommendations
	Chi Square Value (Significance)	Chi Square Value (Significance)	Chi Square Value (Significance)
At Least One Project Implemented?	*5.344* (.021)*	20.953 (.000)	38.188 (.000)
Pollutant Loading Reduction Achieved?	6.292 (.012)	7.689 (.006)	34.077** (.000)
Water Quality Improvement?	*1.460* (.227)*	7.214 (.007)	11.118** (.001)
	N = 63	N = 63	N = 63

*For the chi square test results shown in *italics*, at least one cell has an expected cell count of less than five.
**These chi square test results relating to perceived pollutant loading reductions and perceived water quality improvements were previously reported by the authors and their colleagues (Hoornbeek et al., 2012). Please see this work for further discussion of the relationship between collaborative watershed management in TMDL implementation and watershed restoration progress.

might expect because of the more direct connection between TMDL implementation and watershed restoration progress, the associations here appear to be even stronger than is the case for stakeholder engagement in TMDL development. Overall, however, the results shown in Table 6 do suggest that stakeholder engagement, as predicted by IWRM, is a promising strategy for enabling watershed restoration progress—at least in these two states.

The findings above present evidence that watershed restoration progress is being achieved in Ohio and West Virginia, and that broad-based watershed planning and stakeholder engagement efforts relating to TMDL reports are positively associated with the progress being achieved. The results also point out that while holistic data collection efforts may be helpful, they are truly impactful only if the resulting information is actually used to plan and manage watershed restoration actions. In Ohio and West Virginia, broad based planning efforts have been in place in some cases, but ongoing efforts to assess, track, and manage TMDL implementation progress were not in place at the state level—at least through 2008. And finally, while the association between *significant* stakeholder engagement in TMDL development and watershed restoration progress may not be as strong as some might expect, the overall associations between measures of stakeholder engagement and watershed restoration progress are relatively strong—a finding that is consistent with the expectations of IWRM.

6. Summary and Discussion

While some may argue that TMDLs are a mere extension of past regulatory efforts, our review of practices associated with all USEPA approved TMDL reports in Ohio and West Virginia through 2006 suggests that TMDL practices often incorporate key elements of IWRM.

Consistent with IWRM's emphasis on holistic watershed management, TMDL reports for Ohio and West Virginia are frequently written on a watershed scale, and the vast majority of the reports address multiple pollutants (73%) and multiple pollution sources (84%). USEPA data suggest that Ohio and West Virginia are not alone: 89% of TMDLs from a nationwide sample are approved through the submission of reports that contain more than one individual TMDL (USEPA, 2009). We also find that endorsed broad based watershed plans were in place in 41% of cases in these two states as of May 2008. Thus, while Ohio and West Virginia appear not to be unique in undertaking holistic data collection efforts—a key element of IWRM, their efforts to enable use of that information in broad-based watershed plans were not complete at the time our data were compiled.

The findings also suggest that stakeholder engagement—a second key element of IWRM—is also apparent in the development and implementation of TMDL reports, although to varying degrees across the two states. Lead state officials indicated that stakeholders were involved in the development of more than half of the TMDL reports in our sample. And in 13 Ohio watersheds, these groups appeared to have made *significant* contributions to TMDL development by providing data and/or assisting in the writing of TMDL reports. Similarly, interviews with knowledgeable state officials identified 36 TMDL reports (of 63, or 57%) for which watershed groups were engaged in implementing TMDL recommendations. While these figures suggest that stakeholders can and do involve themselves in the TMDL process, they also make it clear that this kind of involvement is not present across all TMDL limited watersheds.

To the extent more is done to foster TMDL processes that are consistent with IWRM principles, positive impacts may very well result. Ohio and West Virginia are implementing recommendations from TMDL reports in a number of cases, and—in a subset of these cases—these efforts appear to be giving rise to positive environmental results. Furthermore, the findings presented here suggest that key elements of IWRM—broad-based watershed planning and stakeholder engagement in TMDL development and implementation—are associated with watershed restoration progress.

However, our investigations also reveal reasons for skepticism about the influence of IWRM on watershed *management*. We found few—if any—cases where implementation priorities were clearly identified and ranked in meaningful ways by officials or organizations that are in a position to allocate limited resources in a holistic fashion to set meaningful priorities for watershed restoration. In addition, as we sought out information on TMDL implementation progress, we did not find that state regulatory officials—or anyone else for that matter—were systematically reviewing TMDL implementation recommendations to determine if they were being carried out.

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Rather, our discussions with state officials frequently turned to the question of whether functionally based programs in the two states had yet funded grants or implemented permit controls that account for TMDL report recommendations. In both states, the broad-based information developed through the TMDL process was thus used primarily to inform "stove-piped" programs relating to planning, NPDES permit issuance, and voluntary NPS abatement grants, rather than to create an integrated *watershed-based* process for establishing implementation priorities, monitoring progress, and guiding short-term TMDL implementation choices.[19] Thus, while the TMDL program appears to be generating holistic information that could be used to guide priorities for existing programs, our investigations reveal that these kinds of efforts were not yet well developed—at least in Ohio and West Virginia as of 2008.

7. Conclusion

Can TMDLs provide a foundation for more effective IWRM in the US? Based on the evidence presented above, the answer to this question appears to be a qualified "yes." Our evidence—while based on just two American states—suggests that key elements of IWRM are being incorporated into TMDL programs, although not in consistent fashion. The evidence also provides reasons for optimism about the impact of key elements of IWRM because it suggests that broad-based watershed planning and stakeholder engagement in TMDL processes are associated in a positive and statistically significant fashion with watershed restoration progress.

While these results are encouraging in some respects, they also make it clear that current American water pollution control practices and the impacts of the incorporation of key IWRM elements are still far from optimal. We found numerous cases where the incorporation of key elements of IWRM is limited or non-existent. Some TMDLs are pollutant- and/or source- specific, and there are multiple watersheds in which we could identify no evidence of stakeholder engagement. We also identified a lack of systematic efforts to use holistic information generated by TMDL reports to actually *manage* water resources on a watershed basis. Perhaps relatedly, the watershed restoration progress identified remains modest in comparison to what is needed to fully restore the impaired watersheds involved. In this sense, our results complement, rather than contradict, past studies that criticize IWRM-based efforts because they are failing to restore watersheds that are experiencing environmental degradation (Layzer, 2008).

We also acknowledge that the data and results here are subject to important limitations. These limitations include a reliance on the perceptions of state officials rather than

[19] It is important to note here that both states do have ongoing watershed assessment processes in place, and—hopefully—the assessments conducted can be compared over time to identify pollution and biological quality trends. Theoretically, these trends can yield guidance for implementing control actions in the future. However, neither state appears to be systematically tracking the control actions that are taken. And, even if these control actions were being tracked, the assessment processes appear to be operating over time frames that are too long to meaningfully inform TMDL implementation processes on an ongoing basis. There would seem to be value, therefore, in doing more to ensure that the TMDL process informs priorities on an ongoing basis.

objective data on pollutant discharges and water quality conditions, the use of bi-variate tests that do not address alternative explanations for watershed restoration progress, and the use of rather modest measures of watershed restoration progress. As a result of these limitations, the results presented here should not be interpreted to provide conclusive evidence of the effectiveness of IWRM in fostering better water management. Rather, further research is needed before debates about the effects of IWRM on American water quality management can be fully resolved.

Even so, our results do suggest that TMDL processes could play a role in supporting IWRM efforts in the US. They also raise an important question: To what extent is the inability to achieve consistent and complete restoration of impaired watersheds traceable to insufficient incorporation of key elements of IWRM *rather than* the choice of IWRM over traditional regulatory approaches to water quality management? In the US at least, the task now, it appears, is to determine how we can best use the tools of *both* “traditional” water quality management and key elements of IWRM to achieve environmental results. While regulatory approaches continue to be important in American water quality management, the findings here suggest that key elements of IWRM are also important to consider.

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