Innovation in Outcomes-Based Water Quality Policy: A Case Study from the Yahara Watershed, Wisconsin, USA

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ABSTRACT This case examines the risks and opportunities for stakeholders involved in an experimental water quality management program in Wisconsin, USA. This program pays for pounds of pollution reduced through soil conservation practices on farm fields and other high-runoff areas across the landscape—nonpoint sources of pollution—by redirecting funds from the sewerage plant and municipal point sources of pollution. Uncertain monitoring and modeling of pollution sources used for program payments and accountability create perceived and real risks to program participants and the environment, including the threat of regulatory enforcement, lost revenue, and failure to achieve environmental outcomes. On the other hand, in this case study, regulatory flexibility also opened a space for stakeholder dialog and programmatic cooperation that could lead to more adaptive and locally acceptable watershed pollution control in the future.

KEY MESSAGE

• Recognize different actors with unique perspectives involved in water quality management
• Consider the potential benefits and risks of local regulatory flexibility and experimentation in land and water policy
• Understand the sources of uncertainty in monitoring and modeling nutrient pollution

INTRODUCTION

Outcomes-based programs governing land and water management by monitoring and modeling environmental indicators are increasingly common [1–3]. These programs rest on the assumption that it is possible to produce acceptable estimates of environmental outcomes, such as pollution reduction. We present the case of an experimental outcomes-based program for water quality to illustrate the opportunities and challenges of incorporating environmental data into governance. The challenges lie in both uncertainty about data, and the social, political, and cultural contexts within which data are collected and used as products of both scientific practice and social processes [4, 5].

CASE EXAMINATION

Yahara Watershed Improvement Network (WINs): An Experiment in Water Quality Regulation

This case examines the risks and opportunities for stakeholders involved in an experimental water quality regulatory program. The program is a compliance option for phosphorus pollution reduction in Wisconsin, USA, called the Watershed Adaptive Management Option (WAMO). Runoff of nutrients such as phosphorus from urban and agricultural land results in eutrophic water bodies in the Midwest and in the Gulf of Mexico, meaning that there may be insufficient oxygen to support aquatic life [6]. Thus, nutrient pollution reduction in this region is particularly important. Our case study program, dubbed Yahara WINs, began as a pilot program in 2012 in the Yahara Watershed in southern Wisconsin (Figure 1). Yahara WINs is a flexible approach to water quality regulation as it redirects funds from the sewerage plant and municipal point sources of...
pollution to pay for soil conservation practices on farm fields and other high-runoff areas across the landscape—nonpoint sources of pollution [7].

The primary challenge of Yahara WINs is that it rests on incomplete environmental monitoring and modeling of pollution sources, creating uncertainty about program outcomes. Uncertainty has resulted in perceived and real risks to program participants and the environment, including the threat of regulatory enforcement, lost revenue for farmers, and failure to achieve environmental outcomes. On the other hand, the effort may result in short- or long-term water quality improvement by increasing the implementation of soil conservation practices across the watershed and building collaborative capacity to address a persistent problem. In this way, Yahara WINs could provide a model for more adaptive and locally acceptable pollution control in other watersheds. Uncertainty and opportunities for innovation are likely to coexist through the program's ongoing development.

We followed the implementation of the Yahara WINs pilot project from 2012 through 2016 as researchers and participant-observers. We attended quarterly public meetings and reviewed relevant documents including the rules of the Wisconsin Department of Natural Resources (DNR). We conducted interviews with 31 regional leaders involved in the project's inception or implementation in 2013 through 2014. Interviewees included staff of watershed municipalities, the DNR, the County Conservation Department, sewerage districts, and farmers. (For more detail on quantitative and qualitative methods, see [8].)

**Policy Context**

The Yahara WINs program is shaped by federal and state laws. The Clean Water Act (CWA) gives the U.S. Environmental Protection Agency (EPA), as well as states with delegated responsibility, authority to set water quality goals, monitor water bodies, and require certain polluters to reduce their discharges of specified nutrients and chemicals. The CWA deals differently with point and nonpoint sources of pollution. Point sources such as industrial and municipal treatment facilities with a pipe releasing effluent are required

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**FIGURE 1.** The Yahara Watershed is located in south central Wisconsin, USA. Primary land cover types are agricultural and urban. Data from the National Land Cover Database (2011).
to have an approved permit specifying the amount of pollution that can be released. In contrast, nonpoint sources such as agricultural runoff are largely addressed through voluntary options such as best management practice (BMP) programs funded through the U.S. Department of Agriculture. One exception to this dichotomy is animal feeding operations, some of which are considered point sources and are required to create nutrient management plans. The CWA also requires states to establish a Total Maximum Daily Load (TMDL) specifying how much pollution is allowed in any water body that does not meet water quality criteria set by the state.

One approach to reduce the overall cost of pollution control is allowing point sources to pay nonpoint source polluters, such as farmers, to reduce pollution before it reaches the treatment facility [9]. Wisconsin’s WAMO is one such program, created as a compliance option under the state’s 2010 Phosphorus Rules, NR 102 and NR 217 (Wisc. Adm. Code). The Phosphorus Rules, in turn, keep the state in compliance with its responsibility to implement the CWA. A WAMO allows a regulated point source polluter to meet phosphorus criteria by reducing polluted runoff throughout an entire watershed (i.e., meeting an acceptable in-stream phosphorus concentration), rather than regulating based on the concentration of pollution leaving a pipe [10]. Permittees have the flexibility to try different options for reducing phosphorus in a water body, as long as water quality is shown to improve at the end of a permit term [11]. DNR requires monitoring at the end of a permit term, but interim progress can be estimated through models [10]. If the point source does not comply with its permit through a WAMO, the utility must choose a different compliance approach, likely the installation of technological upgrades.

Yahara WINs, the first WAMO project to be implemented and the subject of this case study, began its pilot phase in June 2012 (Figure 2). This project responded to a TMDL for the Rock River Basin, which includes the Yahara Watershed. Nonpoint pollution sources in the Yahara include agricultural runoff from dairy, corn and soybean farms, urban lawns, roads, and construction sites [12, 13]. To comply with the TMDL, a major regional point source polluter, the Madison Metropolitan Sewerage District (MMSD), decided to pursue a WAMO permit (estimated to cost $100 million over 20 years) in lieu of making technological plant upgrades estimated to cost sewerage district rate payers up to $270 million immediately [14]. MMSD led 30 regional organizations, primarily municipalities, as well as utilities, nonprofits, and regulatory agencies, to test procedures and practices via a pilot project, ahead of applying for a full-scale permit. MMSD is a regulated entity, as are municipalities, called municipal separate storm sewer systems (MS4s) in the CWA due to concentrated runoff through storm sewers. Both MMSD and MS4s are paying into Yahara WINs in order to reduce the cost of their own permit compliance. Project leaders submitted a full-scale permit application in 2017, and as of summer 2018, the application was still under review. Should the permit be granted, MMSD is allowed four 5-year permit cycles before the in-stream standard must be reached.

The pilot project pays watershed farmers to implement practices such as cover cropping, buffer strips, and better manure management; it also funds urban efforts such as leaf removal and installation of green infrastructure such as rain gardens. Funds for the Yahara WINs pilot project came from water utilities of 21 municipalities (annual contributions ranging from $779,000 to $9,000 for the largest and smallest municipalities), a grant from two Wisconsin-based environmental non-profits, a grant from the U.S. Department of Agriculture, and in-kind staff contributions from the county conservation department and volunteer water monitors. Despite these cost savings and the project’s potential for innovation, significant risks, including regulatory sanction and failure to meet environmental goals, are associated with signing onto this compliance option, which partly stem from the uncertainty associated with monitoring and modeling program outcomes.

**RISKS AND OPPORTUNITIES OF OUTCOMES-BASED REGULATORY EXPERIMENTATION**

**Uses of Monitoring and Modeling to Understand Water Quality Outcomes**

In water quality policy and management, monitoring tracks and records current physical states of water bodies at particular locations. Commonly monitored indicators in freshwater systems include nutrient pollution levels or the number and type of macroinvertebrates in a stream. Yet monitoring data are also uncertain: a limited number of monitoring sites often prohibits understanding water quality conditions across a watershed; and rainfall variability makes it difficult to rely on monitored data to accurately report nutrient reduction progress over short time scales [15, 16].

In contrast, modeling can provide estimates of water quality across an entire watershed through mathematical
calculations based on what is known about land use, land management, weather and in-stream processes. However, sources of modeling uncertainty include inputs and difficulties accounting for temporal and geographical scales [17]. Common land management practices are used as model inputs, such as types of crops planted on farms, but modelers may not be aware of all relevant practices to include if they are not reported by landowners and managers [18]. Even among common land management practices, water quality impacts are well known in the short term at a small geographic scale, but their effects are not as clear across a large watershed [19]. Time lags in the effects of land management and legacy contaminants also create difficulties in estimating the future impacts of current practices [20]. Thus, neither monitoring nor modeling provides a full picture of all biophysical and social processes in a watershed, which can lead to uncertainty in interpreting the data from either of these sources.

**Stakeholders’ Perceptions of Yahara WINs Risks and Opportunities**

As Yahara WINs moved toward a full-scale WAMO permit, the stakeholders involved navigated and acknowledged differences between expected environmental improvements shown by models and monitored improvements needed to comply with regulations. Regulated entities face possible sanction by the DNR and EPA if modeled expectations are not met. All public entities are open to citizen suit under the CWA for failure to improve water quality. Farmers implementing new conservation practices may lose revenue due to decreased harvests. All parties face the risk of failure to meet individual and organizational goals should the program fail to improve water quality. Yet many partners may benefit from the regulatory flexibility of a WAMO, which allows network building and policy and technical innovation. In this section, we examine these opportunities and risks, considering the experiences of four stakeholder groups in Yahara WINs—MMSD, municipalities, farmers and a citizen action group.

**Risk: Regulatory Enforcement**

Historically, MMSD has played a technical role in wastewater treatment for primarily urban and suburban populations. Risks have been mitigated by MMSD’s ability to prove compliance to regulators through design standards. Under a WAMO, MMSD, municipalities and the DNR face the threat of regulatory enforcement should Yahara WINs fail to result in monitored in-stream phosphorus reduction at the end of the permit term. MMSD has consistently argued, in the words of one leader, that...
“research suggests that the timeline required to see the lakes respond is likely longer than [a] ten- to fifteen-year timeline.” In 2013, in order to mitigate this risk, MMSD and other regulated point sources successfully advocated to the Wisconsin legislature and DNR to add five years to the compliance timeline.

Like MMSD, town and city administrators and engineers are concerned about their risk of regulatory enforcement. They also feel responsible to municipal residents for balancing goals of improving water quality and keeping utility costs down. Compounding these concerns, municipalities contributing funds to Yahara WINs have less control over program organization than they would with an individual MS4 permit within municipal boundaries. One town administrator felt unable to assess program involvement risks because program leaders guarded information too closely: “There is a closed controlled feeling to the way the project is being managed; too many sidebar conversations and negotiations.” Others were pessimistic about the commitment of upstream dairy farmers to improve practices and about the possibility of seeing water quality improvement within the permit timeline.

Many in the agricultural community do not trust modeling of BMP outcomes, which is how farmers’ contributions to watershed nutrient pollution reduction are estimated. One farmer said in an interview that he dislikes Soil Nutrient Application Planner (SNAP)-Plus, a field-scale model used to estimate runoff, because it does not always match up with results from a monitoring station at the edge of his field (even though it is not designed to match, since it is based on average decadal rainfall):

“We ran [our edge-of-field monitoring gage] for two and a half years and we averaged about three quarters of a pound of phosphorus leaving that field per acre. When I run [the same field] in the SNAP-Plus model, with the exact [crop] rotation as what I am doing, I come up with 2.2 pounds per year. Quite a difference. So there you gotta be careful . . . if we start taking models and we start making rules and regulations based off the models.”

Inaccurate assessment of BMP contributions would mean that farmer pollution reductions will not be given the weight they deserve in watershed-wide calculations, and, should federal or state nonpoint rules change, farmers could be held accountable for monitored or modeled nutrient pollution reductions.

Risk: Failure to Improve Water Quality

The potential for policy innovation offered by Yahara WINs must be weighed against the risk that an untested program may be merely “kicking the can down the road,” in the words of one hydrologist in the Yahara Watershed. Rather than addressing water quality problems today through higher levels of spending and stricter regulatory enforcement, Yahara WINs could pass on the risk of continued water quality deterioration to communities downstream. This failure could result from incorrect interim model estimates about water quality improvement, increasing livestock and development in the watershed, higher than expected rainfall that would bring more nutrients into waterways, or other uncalculated changes.

Citizen action groups advocate for consistent monitoring to prove the effectiveness of public effort and reduce the risk of water quality improvement failure. A representative of Midwest Environmental Advocates, a group involved in drafting Wisconsin’s Phosphorus Rule, said:

“Our stance has always been, monitoring more often is the most appropriate way to determine whether you’re meeting your obligations [or] whether you’re setting up a water quality disaster without knowing it.”

This group is aware of the uncertain ability of modeling to accurately estimate water quality outcomes, and finds the risk unacceptable.

Opportunity: Watershed Partnerships

The partnerships facilitated by Yahara WINs, particularly those between MMSD, urban stormwater ratepayers, and farmer groups, could build bridges between urban and rural stakeholders. In order to implement the program, MMSD and municipalities, the point sources responsible for meeting water quality standards, coordinated funding and implementing pollution reduction practices throughout the watershed. The long permit timeline is one aspect of the program that allows for partnership-building. As explained above, MMSD and municipalities negotiated a 20-year compliance timeline to account for the potential lag in in-stream pollution reduction and the ability to demonstrate that reduction through monitoring and modeling. This time period gives partners the opportunity to
experiment with pollution reduction practices while building relationships among stakeholders.

Addressing water quality at the watershed scale may be able to more efficiently target the largest sources of pollution (nonpoint sources), which may in turn lower sewerage district’s utility fees. The administrator of a lakefront village explained,

“If we took the $300,000 we’re spending on our stormwater utility to do little things in the village now and we put it onto . . . a rural farm with a manure pit, our money we’re spending could do a lot more to improve the quality of the lake. When you tell people that, they say, ‘That’s fine, we want to spend the money where it’s needed, so we’re going to make a difference.’”

Paying into Yahara WINs to reduce upstream agricultural runoff is compelling to some lakeside residents and may offer greater opportunity for watershed-wide water quality improvement.

Farmers have an opportunity to publicly demonstrate their cooperation in water quality improvement through Yahara WINs. At the same time, they receive support for BMP adoptions and avoid involvement with federal conservation programs that some worry could open them up to the risk of regulatory enforcement. Through the program, farmers enter into contracts to implement certain practices with MMSD through County conservation brokers, without connection to federal conservation payment programs. On the other hand, the final payment structure for BMP implementation will likely be different from traditional federal programs, which pay for number of acres treated with a conservation practice (practice-based pay). Proposed Yahara WINs payments, on the other hand, will be based on pounds of phosphorus load reduced from a field (outcomes-based pay). A downside of this structure is that payments may be unequally allocated across the watershed, a consequence of the outcomes payment structure of the program that could benefit some farmers over others.

**CONCLUSION**

This case study examined an experimental effort to improve water quality by focusing on nonpoint source pollution reduction in a collaborative and adaptive policy framework. Yahara WINs is a unique example of point and nonpoint sources of pollution working together to improve water quality, yet the program is accompanied by uncertainty in pollution monitoring and modeling that creates opportunities and/or risks for the entities involved. As water quality policy implementation evolves in varied settings, careful consideration of how monitoring and modeling are used in planning and enforcement will be critical for ensuring a fair process for differently positioned participants and for achieving ecological outcomes.

**CASE STUDY QUESTIONS**

1. What are some challenges to implementing a WAMO, as opposed to a traditional regulatory approach that measures pollution at the end of a pipe?

2. The new policy approach offered by Wisconsin's WAMO, as well as other outcomes-based policies, are premised on the expectation that scientific tools (e.g., water quality monitoring and modeling) can reliably demonstrate permit compliance. What are the implications for science and policy if those expectations cannot be met?

3. How did the sewage district, municipalities, farmers and citizen groups respond to the incomplete information offered by modeling and monitoring pollution?

4. In what ways does Yahara WINs reveal historic tensions between urban and rural watershed pollution sources?

5. The Yahara Watershed is a high capacity area (e.g., it contains a mid-size and relatively wealthy city) with sustained public support for improving water quality. What might be the pitfalls of implementing a WAMO project in lower capacity places?

**AUTHOR CONTRIBUTIONS**

Wardropper contributed conceptualization, investigation, analysis, writing and editing. Gillon and Rissman contributed conceptualization, investigation, and editing.

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**COMPETING INTERESTS**

The authors have declared that no competing interests exist.

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