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Watershed Based Policy Tools for Reducing Nutrient Flows to Surface Waters: Addressing Nutrient Enrichment and Harmful Algal Blooms in the United States

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WATERSHED BASED POLICY TOOLS FOR REDUCING NUTRIENT FLOWS TO SURFACE WATERS: ADDRESSING NUTRIENT ENRICHMENT AND HARMFUL ALGAL BLOOMS IN THE UNITED STATES

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I. ABSTRACT

In the summer of 2014, pollutants from a harmful algal bloom (HAB) contaminated Toledo, Ohio's public water supply. Thousands of people in the Toledo area were asked not to use publicly supplied

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water. This yielded substantial costs and inconvenience, as well as potential negative health impacts.[1]

The concerns about Toledo's publicly supplied water in the summer of 2014 were related to cyano-bacteria that are associated with HABs, which can develop in lakes and reservoirs where excess nutrient flows occur and lead to water quality degradation.[2] As a result, policymakers are seeking novel policy tools to prevent excess nutrient flows to lakes, reservoirs, and other water bodies - in the United States and elsewhere - as rising temperatures associated with climate change appear likely to yield more significant HAB problems worldwide.[3] Some scholars have sought to identify policy tools to address a broad range of policy problems, while others have identified policy tools to address environmental problems in particular.[4] However, policy tools to reduce nutrient flows and the resultant threats to water quality and safe drinking water are neither well-documented nor understood.

This Article identifies water pollution control policy tools that are used to reduce nutrient flows in the United States and offers preliminary ideas for assessing the propriety of their use in differing circumstances. The policy tools discussed emerge from investigations of major watershed basin programs targeting nutrients in waterbodies of the United States. The watershed programs investigated include

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1. JOHN HOORNBEEK ET AL., ADDRESSING HARMFUL ALGAL BLOOMS: NUTRIENT REDUCTION POLICIES IN OHIO'S LAKE ERIE BASIN AND OTHER AMERICAN WATER BASINS 9-11 (2016). This research was supported by the Ohio State University Water Resources Center and the United States Geological Survey (USGS). Readers of both this article and the full report may note overlaps in content and language in the two documents, as both documents cover similar subject matter, although from differing perspectives. Indeed, in some cases, we used language directly from the original report and made minor changes to it for presentation in this article.

2. *See* Adriana Zingone & Henrik Oksfeldt Enevoldsen, *The Diversity of Harmful Algal Blooms: A Challenge for Science and Management*, 43 OCEAN & COASTAL MGMT. 725 (2000).

3. Catherine M. O'Reilly, et al., *Rapid and Highly Variable Warming of Lake Surface Waters Around the Globe*, 42 GEOPHYSICAL RES. LETTERS 10,773, 10,780 (2015).

4. *Compare* CHRISTOPHER HOOD, THE TOOLS OF THE GOVERNMENT (1983), *and* LESTER M. SALAMON & ODUS V. ELLIOTT, THE TOOLS OF THE GOVERNMENT (2002), *with* Alvin L. Alm, *A Need for New Approaches: Command-and-Control Is No Longer a Cure-All*, 18 EPA JOURNAL 7, 8-10 (1992), *and* WALTER A. ROSENBAUM, ENVIRONMENTAL POLITICS AND POLICY (9th ed. 2014).

efforts to address excess nutrient flows to the Ohio Lake Erie basin, the Chesapeake Bay, the Long Island Sound, and the Tampa Bay watershed in Florida. The investigations conducted include searches for existing written information on pollution control efforts in these watersheds and targeted interviews with key officials from those watersheds.

This Article extends current literature by focusing specifically on identifying policy tools for controlling water pollution relating to nutrients and offering preliminary ideas on ways in which communities and policymakers can begin to address water pollution problems relating to nutrients. This Article builds upon and extends previous works relating to both research on policy tools and recent work on controlling nutrient flows to the Ohio Lake Erie basin.[5]

II. INTRODUCTION

Water managers in the United States and across the globe are concerned about eutrophication and the development of harmful algal blooms (HABs) in surface waters. Indeed, surface waters, including the Great Lakes in North America, often serve as drinking water sources for nearby cities and towns and their protection is a key objective for public health. One prominent recent example of drinking water contamination is the Public Advisory issued for multiple days in Toledo, Ohio due to contamination by pollutants from HABs in Lake Erie, where the City of Toledo Community Water System draws its drinking water.[6] In August of 2014, thousands of people in the Toledo area were asked not to use publicly supplied water. This yielded substantial costs, inconvenience, and carried potentially negative health impacts for citizens in a country that has become accustomed to relying on "safe" drinking water supplied by public water systems.[7]

This Article is based on a study which began in 2015 and sought to identify policy tools that could be used to reduce nutrient flows and combat HABs in the Ohio Lake Erie Basin.[8] While that study was

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5. *See* HOORNBEEK ET AL., *supra* note 1.

6. *See* Savitri Jetoo et al., *The Toledo Drinking Water Advisory: Suggested Application of the Water Safety Planning Approach*, 7 SUSTAINABILITY J. 9787, 9787-90 (2015).

7. *See id.*

8. *See* HOORNBEEK ET AL., *supra* note 1.

written from the perspective of policymakers in Ohio and the Lake Erie basin, it also sought to begin development of an inventory of policy approaches that can be used to reduce nutrient flows and combat HABs in other watersheds. This Article draws on the findings of the initial study and presents information and analyses in ways that may be of interest to a variety of scholars, observers, communities, and governing bodies who intend to reduce nutrient flows and combat HABs. It identifies policy tools being implemented in multiple water basins in the United States to achieve reduced nutrient flows to surface waters. It also offers ideas about policy tools and approaches that policymakers may want to use to reduce nutrient flows, combat HABs, and protect drinking water sources. Our hope is that the Article proves useful in educating future efforts to address excess nutrient flows and harmful algal blooms, while also providing a foundation for further research.

III. BACKGROUND AND LITERATURE REVIEW

A. What are Harmful Algal Blooms?

Algal blooms are a natural phenomenon in aquatic environments. However, harmful algal blooms (HABs) occur when colonies of simple plants grow out of control and produce toxic or harmful effects on people, fish, shellfish, marine animals and birds.[9] Nutrient enrichment, or eutrophication, of waterways is a major factor in HAB development.[10] The two main nutrients responsible for eutrophication are phosphorous and nitrogen. Nutrient pollution sources include point sources, such as waste water treatment plants and storm-water overflows, and non-point sources, such as urban storm-water runoff and agricultural runoff.[11]

HABs can have impacts on human health, environmental health, and economic health:[12]

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9. National Ocean Service, *Why do harmful algal blooms occur?*, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, https://oceanservice.noaa.gov/facts/why_habs.html.

10. *Nutrient Pollution: Sources and Solutions*, EPA (2017), https://www.epa.gov/nutrientpollution/sources-and-solutions.

11. *See id.*

12. *See* Zingone & Enevoldsen, *supra* note 2.

- **Risks to human health:** HABs produce toxins that can sicken people due to consumption of contaminated fish or shellfish, swimming, or drinking the contaminated water.[13] Algal blooms can produce various cyanotoxins, such as microcystin, cylindrospermopsin, and anatoxin-a group.[14] Exposure to these cyanotoxins can have acute health effects in humans ranging from mild skin irritation to serious illness or death. These potential health impacts include: abdominal pain, headache, vomiting and nausea, diarrhea, fever, pneumonia, and in the case of anatoxin-a group, respiratory paralysis leading to death.[15] Concerns about these kinds of risks appear to have led to the closure of the Toledo water supply in the Summer of 2014.
- **Risks to environmental health:** Excessive organic material, such as algal blooms, contribute to hypoxic (low oxygen) conditions as they decay. Such "dead zones" have such low dissolved oxygen levels that fish and other organisms cannot survive.[16] Algal blooms themselves also pose potential microbial health risks for both wildlife and humans.[17]
- **Risks to economic health:** HABs are responsible for economic losses to fisheries, as well as restaurant and tourism industries each year as they can lead to closures of beaches and shellfish beds, and decrease fishing activities from recreational and commercial fisheries.[18]

B. Harmful Algal Bloom Occurrences Globally and in the United States

Eutrophication of coastal marine waters has become a global problem due to elevated human activities that cause nutrient

13. *See id.*
14. *Nutrient Pollution: Health and Ecological Effects*, EPA (2017), https://www.epa.gov/nutrient-policy-data/health-and-ecological-effects.
15. *See id.* (discussing health risks of exposure to cyanotoxins).
16. *Nutrient Pollution: The Effects: Environment,* EPA (2017), https://www.epa.gov/nutrientpollution/effects-environment.
17. *See id.*
18. *See* National Ocean Service, *supra* note 9; *see also Nutrient Pollution: Sources and Solutions*, *supra* note 10.

overloading to water bodies.[19] In addition to recent HAB contamination in Lake Erie, there are also examples of HAB contamination of freshwater systems internationally.[20] A recent study of temperature trends in lakes suggests that lake temperatures across the globe rose rapidly (global mean = 0.34 Centigrade per decade) between 1985 and 2009, and that climate change, along with geomorphic factors, are likely to yield continued warming pressures on lakes around the world. This is likely to yield continued pressures toward the global development of HABs in the future.[21]

In the United States, HABs occur in both fresh and marine water bodies. A 2014 national survey indicated that about 50% of responding states in the United States (38 states and the District of Columbia) reported the presence of HABs occurring every year in some of their freshwater bodies.[22] HABs are not limited to fresh waterbodies, as coastal waters states such as Hawaii and Alaska have experienced HABs as well.[23] HABs in marine waters have also been associated with food poisoning.[24] HABs in freshwater environments, such as Lake Erie, have threatened water supplies.[25]

C. Policy Instruments, the Environment, and Nutrient Control: A Brief Review of Literature

For several decades, policy scholars have sought to improve our understanding of policy instruments (or "policy tools") that can be used to achieve governmental goals. In the 1990's and 2000's, the changing nature of environmental policy problems and the growing sophistication of discussions concerning policy instruments led to an expanding array of scholarly work on environmental policy instruments. More recently, we have seen more specialized attention to policy instruments associated with addressing diffuse (nonpoint)

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19. *See* Zingone & Enevoldsen, *supra* note 2.

20. Jeff Ho & Anna Michalak, *Challenges in Tracking Harmful Algal Blooms: A Synthesis of Evidence from Lake Erie*, 41 J. OF GREAT LAKES RES., 317 (2015).

21. *See* O'Reilly, *supra* note 3, at 10,774, 10,780.

22. *Harmful Algal Blooms-Associated Illnesses: General Information*, CENTERS FOR DISEASE CONTROL AND PREVENTION (2017), https://www.cdc.gov/habs/general.html [https://perma.cc/8LQA-SQF8].

23. *See id.*

24. *See id.*

25. *See* Jetoo et al., *supra* note 6.

pollution sources and improving water quality. However, few scholarly articles have sought to address the issue of policy tools associated with controlling nutrient flows.

One of the early efforts to inventory and understand policy instruments used by governments was Christopher Hood's book, *The Tools of Government*, which suggested that governments possess different kinds of resources that can be used to "detect" what is going on in society and "effect" society in different ways.[26] These resources include "organization," "authority," "treasure," and "nodality," all of which enable government to identify policy relevant information about the societies within which they operate and seek to achieve policy goals. Later works built on the ideas in Hood's book by looking at government policy instruments through a variety of lenses, including interrelationships between political factors and the policy instruments used and patterns of policy instrument choice.[27]

In the 1990's and 2000's, scholars and practitioners began to identify and explore concepts surrounding environmental policy instruments (EPIs), or "new environmental policy instruments" (NEPIs). This led to a growing body of literature focusing on policy tools that can be used to achieve environmental goals. In one relatively early article, Alvin Alm, former Deputy Administrator of the U.S. Environmental Protection Agency (EPA), suggested that environmental policy tools needed to move beyond traditional "command and control" regulations to address a changing mix of environmental problems.[28]

Policy and legal scholars were not far behind. Many of these scholars argued for changes in environmental governance processes that would enable the use of a broader range of policy tools to address "second generation" environmental problems that emanated from diffuse sources.[29]

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26. *See* Hood, *supra* note 4.

27. *See* Michael Howlett & M. Ramesh, *Patterns of Policy Instrument Choice: Policy Styles, Policy Learning and the Privatization Experience,* 12 REV. OF POL'Y RES. 3, 3-24 (1993); *see also* GUY B. PETERS & F.K.M. VAN NISPEN, PUBLIC POLICY INSTRUMENTS: EVALUATING THE TOOLS OF PUBLIC ADMINISTRATION (1998).

28. *See* Alm, *supra* note 4.

29. *See* DONALD F. KETTL, ENVIRONMENTAL GOVERNANCE: A REPORT ON THE NEXT GENERATION OF ENVIRONMENTAL POLICY 5-6 (2002); *see also* B. GUY PETERS

European scholars also played a key role in expanding this literature. They sought to address the relationship between European Union (EU) environmental policies and regulations and EU member state policy instrument choices. This included policies such as eco-taxes, labeling programs, and voluntary environmental agreements.[30]

Over time, as the EPI literature evolved, a growing number of scholars wrote about policy instruments that focused on non-point source water pollution, including problems found in agriculture. This literature came from public policy and economics scholars, as well as legal and regulatory scholars. Policy scholars such as Hardy and Koontz looked at policy structures and processes. They sought to understand policy tools by investigating the manner in which non-point source programs sponsored by the EPA actually operated.[31] Economics scholars focused on economic policy instruments and voluntary agreements, and sought to understand impacts on the adoption of controls and management decisions and the relative efficiency and effectiveness of the instruments chosen.[32]

In an interesting article exploring policy instrument choices for diffuse pollution sources, Gunningham and Sinclair highlighted the complexity of policy instrument choices for diffuse pollution sources. They suggested that, despite the challenges associated with political palatability and economic efficiency, interventionist mixes of policy tools may ultimately be necessary to address the complex challenges of diffuse source water pollution.[33]

& J. HOORNBEEK, *The Problem of Policy Problems*, *in* DESIGNING GOVERNMENT: FROM INSTRUMENTS TO GOVERNANCE 77-105 (2005).

30. Andrew Jordan et al., *European Governance and the Transfer of 'New' Environmental Policy Instruments in the European Union,* 81 PUB. ADMIN. 555, 573 (2003).

31. Scott D. Hardy & Tomas M. Koontz, *Reducing Nonpoint Source Pollution Through Collaboration: Policies and Programs Across The U.S. States,* 41 ENVTL. MGMT. 301, 301-10 (2008).

32. Darrell J. Bosch et al., *Voluntary Versus Mandatory Agricultural Policies to Protect Water Quality: Adoption of Nitrogen Testing in Nebraska*, 17 REV. OF AGRIC. ECON. 1, 13-14 (1995); Francois Cochard et al., *Efficiency of Nonpoint Source Pollution Instruments: An Experimental Study,* 30 ENVTL. & RESOURCE ECON., 393, 393-99 (2005).

33. Neil Gunnigham & Darren Sinclair, *Policy Instrument Choice and Diffuse Source Pollution*, 17 J. OF ENVTL. L. 51, 81 (2005).

While this literature has yielded a rich array of thinking on the ways in which government may intervene in society to achieve environmental policy goals, there have been few efforts to inventory policy instruments actually used by governments as well as minimal efforts to identify policy tools aimed toward reducing nutrient flows and minimizing health and environmental impacts associated with HABs. For example, Dowd pointed out that "the North American literature, in particular, rarely analyzes NPS (nonpoint source) policies already in force."[34]

A search of literature revealed two European studies focusing on policy instruments and the reduction of nutrient loads, however, we found no similarly nutrient-focused policy instrument studies in North America.[35] Notably, both Dowd and Ulen commented on the need for further monitoring of policy and practice changes and their water quality impacts.[36]

IV. METHODS AND DATA

The information and analyses reported in this article seek to begin a process of inventorying nutrient reduction policy tools used in the United States. In doing so, we hope to expand our collective understanding of the kinds of policy tools used to address nutrient enrichment issues, identify at least some considerations relevant to the choice and use of these policy instruments, and provide a foundation for further research that may assess the effectiveness of differing policy tools in addressing nutrient enrichment issues and reducing the impacts of HABs.

To identify water basin programs in the United States to investigate, we held discussions with public sector environmental officials and

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34. Brian M. Dowd et al., *Agricultural Nonpoint Source Water Pollution Policy: The Case of California's Central Coast,* 128 AGRIC., ECOSYSTEMS & ENV'T 151, 151 (2008).

35. B. Ulen et al., *Agriculture As a Phosphorus Source For Eutrophication in the North-West European Countries, Norway, Sweden, United Kingdom and Ireland: A Review*, 23 SOIL USE AND MGMT., 5, 5-15 (2007); Brian Kronvang et al., *Effects of Policy Measures Implemented in Denmark on Nitrogen Pollution of the Aquatic Environment,* 11 ENVTL. SCI. & POL'Y 144, 145 (2008).

36. *See* Dowd et al., *supra* note 34, at 153; *see also* Ulen et al., *supra* note 35 at 5-15.

conducted independent internet-based research efforts to identify water basin programs throughout the United States. Through these efforts, we identified a total of 32 water basin programs to investigate. Twenty-eight of these water basin programs were part of the EPA's National Estuary Program (NEP) and four additional programs were place-based programs set up independent of the NEP. We then subjected these 32 basin-wide programs to a three-phase screening review in an effort to identify programs that were likely to yield potentially useful lessons and insights.[37] Through these screening reviews, we identified three watershed programs to investigate in some detail, above and beyond the Ohio Lake Erie watershed which gave rise to our initial work on this project (see discussion above).

During the first phase of our information collection effort, we reviewed websites for each of the watershed programs we identified—along with other publicly available information—to gain a broad understanding of the problems they were facing and the work that they do. More specifically, we assessed: 1) whether or not nutrients were of concern in the water basin; 2) the likely and/or predominant sources of nutrient flows; 3) stakeholders in the process and the number of jurisdictions involved, and; 4) evidence of potentially innovative and/or effective policy or management approaches to nutrient control. The information compiled came in the form of indicators resulting from each of these four assessments for each of the 32 watersheds investigated.

In the second stage of the screening process, we sought to identify programs that seemed to have potential to reveal insights regarding policies for addressing nutrient concerns. At this stage, we sought to identify promising programs based on the following criteria: 1) Did they address phosphorus and/or nitrogen? 2) Were there notable agricultural contributions to nutrient flows in the basin? 3) Was there evidence of coordinated implementation across jurisdictions? 4) Was there evidence of potentially innovative and/or effective policy or management practices being undertaken?[38] Eight programs that

37. *See* HOORNBEEK ET AL., *supra* note 1, at 15.

38. *See id*. Review of these programs at this stage partially depended on the level of detail provided on each program's website. It is possible that some of the programs are more active in targeting nutrient pollution than is documented on their websites. It is therefore possible, and even likely, that some water basin programs would benefit from further investigation.

addressed nutrients and scored relatively highly across these other areas were selected for further investigation.

We then conducted more in-depth reviews of these eight programs, including discussions with program officials where appropriate, to identify watershed programs that we would investigate in greater detail. During the course of these more detailed investigations, we also asked the officials we talked to whether there were other programs or nutrient reduction efforts that they were aware of that would be likely to yield useful insights for policymakers.

Based on all of these investigations, we chose four programs to review in some detail. They were the Ohio Lake Erie Basin, the Chesapeake Bay Program (CBP), the Long Island Sound Study (LISS) Program, and the Tampa Bay Estuary Program (TBEP).[39] Our investigations of these programs involved additional communications with program staffs and deeper research into secondary information sources. Throughout the process of investigating these water basin programs, we inventoried nutrient control policies and management strategies that appeared to be innovative, and perhaps could be offered as examples for how policymakers in other water basins could begin to address their own nutrient enrichment issues.

To guide this review of policies, we used the "policy tools" framework advanced by Christopher Hood several decades ago, in his 1983 book, *The Tools of Government*.[40] Our investigation of nutrient reduction efforts thus identifies policy tools in four major categories:

- organizational arrangements ("organization"), which refers generally to the people and resources available to government and how they are arranged to pursue policy goals;
- regulatory interventions ("authority"), which refers generally to government's legal powers to compel actions of various types;
- expenditures of funds and resources ("treasure"), which refers generally to government's ability to spend money and exchange resources in pursuit of policy goals; and

39. *See id*. at 16.
40. *See* HOOD, *supra* note 4.

- strategy, planning, and communications efforts ("nodality"), which refers generally to government's ability to occupy a central place in societal networks that enable it to both craft and receive key messages relating to the citizens it serves.

V. SELECTED FINDINGS: NUTRIENT CONTROL POLICY TOOLS USED IN AMERICAN WATER BASINS

Below, we discuss selected findings regarding the policy tools identified through our research, and the discussions are organized based on the four categories of government resources identified by Hood (1983) – "organization," "authority," "treasure," and "nodality". This presentation of findings is followed by a discussion of ideas that may be helpful in ascertaining policy tools that may be appropriate for use in particular communities and circumstances.

A. Organizational Policy Tools ("Organization")

Across the watershed programs we investigated, we found ample evidence of government efforts to organize resources to achieve water pollution control goals, including nutrient flow reduction. Three of the water basins we reviewed possess what appear to be rather well-developed organizational policy tools: The Chesapeake Bay, the Long Island Sound, and Tampa Bay. While we found evidence of organizational policy tools in use in the northern Ohio Lake Erie Basin, they tended to be more fragmented and under-developed when compared to the three basins listed above. For this reason, we focus here on the organizational tools we identified in the other three watershed basins we investigated.[41]

1. Chesapeake Bay Program: Organizational Policy Tools

In the Chesapeake Bay region, we identified the use of watershed and pollutant transport models to support TMDL development and implementation, a multi-state and watershed basin-wide tracking and

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41. *See* HOORNBEEK ET AL., *supra* note 1, at 18 (providing more information on Ohio's organizational policy tools).

accountability system, and a centralized implementing organization. Each of these organizational arrangements is discussed below.

i. Watershed and Pollutant Transport Models

"Total Maximum Daily Loads" (TMDL)[42] for the Chesapeake Bay were created based on a series of linked airshed, watershed, and estuarine water quality and sediment transport models. These models enable pollutant-loading allocations for point and non-point sources to be tied to particular jurisdictions and tributary systems within the Chesapeake Bay watershed, and they link the allocations to attainment of water quality standards applicable to the Chesapeake Bay. These linked models also tie pollutant loading information for a range of pollution sources to watershed monitoring information and the loading levels necessary to achieve water quality standards for the Bay. The watershed models are based on monitoring data collected since the mid-1980's from tidally affected portions of the Bay (162 monitoring stations) as well as another set of upland watershed monitoring stations (85 monitoring stations).[43]

These models and the data upon which they are based enable the creation of simulated understandings of the impacts of various nutrient and sediment sources on water quality conditions in individual tributaries and the tidal portions of the Bay.[44] These simulations can be conducted for both current pollutant release levels and scenarios that reflect actions to implement nutrient reduction activities (for example, more stringent water pollution permit limits on discharges, non-point source nutrient load reduction efforts, added land preservation activities, etc.).[45] The transport models also enable

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42. *Program Overview: Total Maximum Daily Loads (TMDL)*, EPA (2017), www.epa.gov/tmdl/program-overview-total-maximum-daily-loads-tmdl. "A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant." *Id.*

43. *See* HOORNBEEK ET AL., *supra* note 1, at 44.

44. *See id*. The summary contained here is a very broad overview. More information on the CBP modeling structure can be found on the EPA website. *See* EPA, *Section 5: Chesapeake Bay Monitoring and Modeling Frameworks*, *in* CHESAPEAKE BAY TMDL DOCUMENT (2010).

45. *See* HOORNBEEK ET AL., *supra* note 1, at 44.

estimations of the impacts of various loading scenarios on efforts to achieve water quality standards for the Bay.[46] They also yield information and capabilities that enable tracking progress in TMDL implementation, and for estimating the impacts of loading reductions and changes in environmental conditions associated with them.

ii. Tracking and Accountability System for Implementation of Total Maximum Daily Loads (TMDLs)

A problem with early efforts of the Chesapeake Bay Partnership was that it was relatively easy for political officials to make commitments about future reductions in nutrient loadings when there was no system in place for systematically tracking the implementation of nutrient reduction efforts. Lacking ability to track implementation efforts, there was no way to measure progress toward achieving water quality goals or to hold jurisdictions accountable to pollutant loading reduction goals.[47]

EPA and the states comprising the Chesapeake Bay Watershed Partnership addressed this issue by adopting a strategy for measuring TMDL implementation progress, thus enabling accountability for reductions in nutrient and sediment flows and for meeting requirements associated with TMDL targets developed to protect the Bay.[48] These scientific modeling efforts provide a foundation for measuring TMDL implementation progress because they enabled estimations of nutrient and sediment load reduction scenarios associated with various nutrient control actions.[49] As states and localities implement nutrient reduction actions (for example, reducing point source nutrient loads or altering land use practices in ways that enhance ecosystem performance in absorbing nutrients from non-point sources), these actions are entered into the CBP modeling systems in order to estimate nutrient loading reductions associated with them for the specific geographic areas. The result is that policymakers, watershed managers, and the public as whole gain estimates of progress in reducing nutrient loads as TMDLs are implemented.[50]

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46. *See id.*
47. *See id.*
48. *See id.*
49. *See id*.
50. *See id*. at 44-45.

Indeed, estimates of progress in reducing nitrogen and phosphorus loads based on reported control actions are publicly available on the CBP website (tmdl.chesapeakebay.net).

To enable accountability for progress, EPA and the Chesapeake Bay states have also established a system whereby the states develop Watershed Implementation Plans (WIPs) designed to achieve the reductions in nutrient loads called for in their TMDL allocations over time.[51] The WIPs are required to include identification of nutrient reduction actions that are sufficient to achieve the targeted nutrient load reductions contained in the TMDL. EPA reviews these WIPs as they are developed to assure that this requirement is met, and the states submitting them are then required to alter their WIPs to address EPA's requirements.[52] States that do not produce WIPs acceptable to EPA are subject to "backstop" federal actions focused on areas where EPA has the federal authority to control pollution allocations through NPDES permits, including wastewater treatment plants, storm-water permits, and animal feeding operations (see Section 7.2.4 of the Chesapeake Bay TMDL document).[53] In essence, these "backstop" actions serve as a warning that EPA may step in directly to regulate point source discharges subject to Clean Water Act (CWA) controls (see the Federal Water Pollution Control Act, Sections 402 and 303, and 40 CFR Sections 122 and 131 for information relevant to these authorities).

iii. Centralized Implementing Organization for the Chesapeake Bay Program Management

Implementation efforts associated with the CBP are coordinated and/or implemented by the CBP staff, based in Annapolis, Maryland. The CBP office is located in EPA Region III in Philadelphia). It employs between 80 and 90, many of whom appear to be on loan from other federal agencies.[54] These individuals come from a range of

51. *See id.* at 45; *see also* EPA, *Section 7: Reasonable Assurance and Accountability Framework*, *in* CHESAPEAKE BAY TMDL DOCUMENT (2010), at 7-2.

52. *See* HOORNBEEK ET AL., *supra* note 1, at 45; *see also* EPA, *supra* note 51, at 7-2.

53. *See* HOORNBEEK ET AL., *supra* note 1, at 44; *see also* EPA, *supra* note 51, at 7-12.

54. *Office Staff,* CHESAPEAKE BAY PROGRAM (2012), http://www.chesapeakebay.net/about/staff.

backgrounds, and they provide the scientific, policy, and communications expertise needed to link multiple and disparate federal and state program activities into what appears to be relatively coherent watershed management effort that is based upon quantitative goals and objectives, as well as transparent and publicly available means to measure progress toward them.

The CBP's integrated organizational management framework – and the scientific, accountability, and institutional structures underlying it – may be the most important set of policy tools to note in relation to this watershed-based nutrient control effort. To a degree that appears to exceed the other watershed-based efforts we investigated, the CBP appears to provide baseline capabilities for coordinated and multi-jurisdictional actions to control nutrient flows that can lead to excess nutrient enrichment and the development of HABs.

2. Long Island Sound Study (LISS) Program: Organizational Policy Tools

The organizational policy tools used by the LISS program include a cross-jurisdictional coordinating office, an underlying TMDL modeling effort and network for scientific support, and mechanisms that enable coordinated planning and implementation.

i. Cross-jurisdictional Coordinating Office

Like the Chesapeake Bay, the Long Island Sound benefits from centrally coordinated organizational efforts to reduce nutrient flows. The Long Island Sound's EPA Program Office was established in 1990. By statute, it employs an EPA civil servant as a director and additional staff members who assist to the director. Over time, this office has integrated its efforts with staff and associated professionals from the states of New York and Connecticut, as well as the New England Interstate Water Pollution Control Commission (NEIWPCC). This coordination occurs under the auspices of the LISS, which is headquartered in Stamford, Connecticut. The LISS is a partnership of federal, state, and local government agencies, private organizations, and educational institutions working together to restore and protect the

Long Island Sound.[55] The program established a Comprehensive Conservation and Management Plan to guide its efforts to protect and restore Long Island Sound. The plan gives priority to the reduction of nutrient loads, habitat restoration, water quality monitoring, and other restoration goals and activities.[56] It operates with funding provided by EPA and resources contributed by the states of New York and Connecticut, as well as the NEIWPCC.

ii. A Scientific Modeling Effort and Network with Ties to the LISS Program

As is the case with the CBP, the LISS Program has benefited from scientific modeling efforts that have allowed the development of targeted allocations for reductions in nutrient loads. These targeted allocations are documented in the Long Island Sound Nitrogen TMDL, which was finalized in 2001.[57] The targeted loading reductions contained in this TMDL have provided a foundation for the nitrogen loading reductions needed to address nutrient enrichment and oxygen depletion in the Long Island Sound.

Over the years, the LISS has also brought together scientists from among its Partnership members to monitor and assess the Long Island Sound's health. Through these efforts, it has aided the establishment of the TMDL's quantitative goals for nitrogen loading reductions, as well as the development of indicators of the Sound's health.[58] The LISS tracks 60 indicators of the health of the Sound on an ongoing basis.[59] Some of these indicators relate directly to nutrient loads and their impacts on dissolved oxygen (DO) levels in the Sound. These indicators include nitrogen (trade equalized) loads, nitrogen loads from Connecticut, the frequency and duration of hypoxia in the Sound,

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55. *About The Long Island Sound Study*, LONG ISLAND SOUND STUDY (2016), http://longislandsoundstudy.net/about/about-the-study/.

56. *See id.*

57. LONG ISLAND SOUND STUDY OFFICES, LONG ISLAND SOUND COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN 2015: RETURNING THE URBAN SEA TO ABUNDANCE 9 (2015).

58. *See About the Sound: History*, LONG ISLAND SOUND STUDY: A PARTNERSHIP TO RESTORE AND PROTECT THE SOUND (2016), http://longislandsoundstudy.net/about-the-sound/history/.

59. *See* LONG ISLAND SOUND STUDY, SOUND HEALTH 2012: STATUS AND TRENDS IN THE HEALTH OF LONG ISLAND SOUND (2012).

and the area of anoxic zones (3 mg/l of DO or less). These and other indicators, as well as the monitoring efforts supporting them, provide a scientific basis for managing nutrient reduction efforts in the Long Island Sound watershed basin.

Multiple organizations contribute to the development of scientific information on the health of the Long Island Sound.[60] The LISS appears to play a facilitating and coordinating role for these multiple efforts and brings information together so it can be used and accessed as needed. In 2014, Latimer and his colleagues published Long Island Sound: Prospects for an Urban Sea, an edited volume that provides an overview of the health of the sound and the science underlying current management efforts.[61]

iii. Coordinated Planning & Implementation Efforts

Connecticut and New York – along with the EPA – approved their first Long Island Sound Comprehensive Conservation and Management Plan in 1994.[62] This plan established priority areas of focus for water quality related management efforts in the Long Island Sound. One area of focus was hypoxia and the very low dissolved oxygen levels associated with it.[63] After approval of the 1994 plan, the jurisdictions worked together on a number of action agreements, which yielded defined efforts and strategies to implement nitrogen reduction efforts designed to help address low DO levels in the Sound. These action plans were put in place in 1996, 2003, 2006, and 2011, respectively, and they appear to have been subject to ongoing implementation efforts coordinated through the LISS program.[64]

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60. *See Water Quality Monitoring*, LONG ISLAND SOUND STUDY (2016), http://longislandsoundstudy.net/research-monitoring/water-quality-monitoring/.

61. *See* JAMES LATIMER ET AL., LONG ISLAND SOUND: PROSPECTS FOR THE URBAN SEA (2014).

62. EPA, LONG ISLAND SOUND STUDY CCMP (1994).

63. LONG ISLAND SOUND STUDY OFFICES, LONG ISLAND SOUND COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN 2015: RETURNING THE URBAN SEA TO ABUNDANCE 9 (2015).

64. *See id.*

3. Tampa Bay Estuary Program (TBEP): Organizational Policy Tools

In contrast to the situations in the Chesapeake Bay and the Long Island Sound, nutrient reduction efforts in the Tampa Bay region are guided by a public-private partnership. Like the other programs, the TBEP has sought to establish both a scientific foundation to guide decision-making and a system for enabling and tracking implementation progress toward defined ambient water quality goals.

i. A Public-Private Partnership

Institutional foundations for progress in Tampa Bay's water quality clean-up efforts were laid by public and private organizations in the Tampa Bay region. For example, the Tampa Bay Regional Planning Council and the Southwest Florida Water Management District provided continuing support and a focal point for regional concern about water quality in the Tampa Bay.

In the 1990's, the work of these organizations came to be supplemented in important ways by the TBEP and the Tampa Bay Nutrient Management Consortium (TBNMC). The TBEP operates with an average annual budget of about $1 million[65] and employs about a half dozen people. Its financial support comes from the EPA National Estuary Program, the Southwest Florida Water Management District, and the cities and counties in the Bay area.[66] The TBEP's efforts have also been supported and multiplied by the establishment and contributions of the TBNMC, as its 40 plus members have devoted substantial financial and in-kind support to the Bay's clean-up effort. A series of governing and technical committees – along with a Policy Board comprised of local government officials – have also provided institutional support for the program's efforts in the Tampa Bay region.[67]

65. TAMPA BAY ESTUARY PROGRAM, A TAMPA BAY ESTUARY PROGRAM: PROGRESS REPORT (2015).

66. *See* Personal Communications from Holly Greening, to KSU-CPPH (2016) (on file with authors).

67. *See* TAMPA BAY ESTUARY PROGRAM, *supra* note 65.

ii. Integrated Watershed-Groundwater- Circulation-Ecology Model

Like the CBP and the LISS, the TBEP and its partners built a scientific foundation for their nutrient reduction efforts. They used an integrated watershed-groundwater-circulation-ecology model to support their work. The model enabled them to assess the effects of different nutrient loading reduction efforts, as well as other factors affecting the Bay and its water quality dynamics. The other factors included alterations to bridge openings, varying changes in the delivery of freshwater to the Bay, and potential sea level rise impacts.[68]

In 2016, the TBEP's director communicated the importance of building a scientific basis for their work in the following way:

> Numerical targets are needed (for pollutant reductions in the Bay), and it is important that the manner in which progress is measured toward those targets is accepted by all. There is a need to build confidence in the scientific models used. In the Tampa Bay effort, while there was a recognition that the TBEP model may not be perfect, there was a consensus view that it was 'good enough.'[69]

The experience in the Tampa Bay, like the experience in the Chesapeake Bay and the Long Island Sound, appears to suggest that developing a model that is grounded in science and accepted as legitimate by key parties is an important step in building support for broad-based nutrient reduction efforts.

iii. Clear Goals and Economically Based Objectives

A key element of the Tampa Bay region's effort to address nutrient enrichment was its establishment of clear and widely accepted goals for water quality improvement. The region's public-private partnership sought "restoration of the bay water quality to support the

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68. *See* Greening et al., *Ecosystem Responses to Long-Term Nutrient Management in an Urban Estuary: Tampa Bay, Florida,* 151 ESTUARINE, COASTAL AND SHELF SCIENCE A1, A1-16 (2014).

69. *See* Personal Communications from Holly Greening, *supra* note 66.

recovery of seagrass resources, while maintaining the Bay's fisheries and other designated uses."[70]

The group established this goal (and others) with a recognition that its achievement would protect a natural resource that is of key importance to the health of the Tampa Bay region's economy, as well improve water quality in the Bay.[71]

To state its goal more specifically, the partnership defined what it believed was adequate sea grass coverage in the Bay —- 38,000 acres of seagrass coverage in the Bay, an amount that was thought to reflect approximately the coverage levels present there in the 1950's.[72] This rather easily understood goal, in turn, provided a foundation for the creation of chlorophyll-a concentration targets that could be monitored to assess progress.

iv. Implementation Tracking and Accountability

The TBEP, with support from the TBNMC, also played a key role in identifying nutrient reduction efforts and tracking implementation progress. The TBEP developed and maintains a database of nutrient reduction efforts, and this database informs the TBNMC and others of its progress and provides a basis for estimating the extent to which nutrient reduction objectives are achieved.[73]

Based on information obtained from TBEP staff, it appears that building partnerships and trust among partners has contributed to the overall organizational effort, as well as the legitimacy of the tracking and accountability effort. With the TBEP staff serving as facilitators, stakeholders in the region appear to have come together to support

70. *See* Greening et al., *supra* note 68.

71. A study that was jointly conducted by the Tampa Bay Regional Planning Council and the TBEP found that a clean bay contributes $22 billion, or 13% of the total economic activity in the six counties in the Bay's watershed – Pasco, Polk, Pinellas, Hillsborough, Manatee, and Sarasota. *See* TAMPA BAY ESTUARY PROGRAM, *supra* note 65. This same study effort estimated that "nearly half of all jobs (47%, 660,000 of 1.4 million) in the watershed are influenced in some way by the bay." *See id.*

72. *See* HOLLY GREENING, TAMPA BAY NITROGEN MANAGEMENT CONSORTIUM UPDATE (TAMPA Estuary Program ed. 2014); *see also* HOLLY GREENING, WHAT'S WORKING IN TAMPA BAY: NITROGEN MANAGEMENT CONSORTIUM, (TAMPA BAY ESTUARY PROGRAM ed. 2014).

73. *See* TAMPA BAY ESTUARY PROGRAM, *supra* note 65.

establishing goals and taking actions to protect the bay's water quality. At the same time, the presence of state and federal regulatory agencies, and their clearly stated interests in ensuring that targeted nutrient reductions were actually achieved through more stringent permit limits, provided additional support for accountability and continued incentives for progress.

B. Regulatory Policy Tools ("Authority")

Our inventory of regulatory policy tools yielded multiple examples of tools used in Ohio's Lake Erie Basin, the basin in which we investigated these kinds of tools in the greatest depth. They included traditional National Pollutant Discharge Elimination System (NPDES) permitted wastewater dischargers, storm water discharges, and agricultural permitting programs. We also found regulatory controls in other water basins, some of which are built upon the foundation of the Clean Water Act's (CWA's) traditional wastewater permitting program regulatory authorities.

1. Wastewater Permitting and Effluent Discharge Trading Systems

Under the federal CWA, traditional wastewater discharge permits are issued across the United States, including in the states in which the four watershed basin programs investigated here are located[74] . For example, in Ohio, NPDES permits are issued by the Ohio Environmental Protection Agency (OEPA). The OEPA issues permits for discharging pollutants to Ohio's lakes, rivers, and streams to both publicly owned treatment works (POTWs) and commercial and industrial facilities. Our review of NPDES wastewater discharge permits included on the OEPA website found that the agency had issued a total of 1,138 NPDES permits for wastewater discharges in the Lake Erie basin.[75] Of these permits, 102 were considered "major" permits which EPA and OEPA define as those governing discharges

74. JOHN A. HOORNBEEK, WATER POLLUTION POLICIES AND THE AMERICAN STATES: RUNAWAY BUREAUCRACIES OR CONGRESSIONAL CONTROL (2012).

75. It is worth noting that figures regarding numbers of NPDES permits and their characteristics change constantly over time, as new permits are issued and existing permits are re-issued or withdrawn. For this reason, the figures presented in this report represent a snapshot of OEPA NPDES permits in the Ohio Lake Erie basin as of 2015 and are likely to change over time.

of one million gallons a day (MGD) of wastewater flow or which contain pollutants of particular concern to the water bodies to which they flow.[76] Permitting for stormwater discharges, combined sewer overflows, and separated sewer system overflows are also handled through the NPDES program by OEPA. Similar regulatory policy tools are also in place in other states, including those which lie within the Cheseapeake Bay, Long Island Sound, and Tampa Bay watersheds.

As is noted above, the NPDES program is implemented nationwide, most often through state jurisdictions. New York, Connecticut, and Maryland all use potentially innovative policy tools that rely on the basic NPDES program framework as a foundation. In the Long Island Sound watershed, many of the major wastewater treatment plants that are subject to the new and more stringent effluent requirements stemming from the watershed TMDL's 58.5% nitrogen reduction goal are in Connecticut.[77] Connecticut sought to meet these requirements cost effectively by implementing a nitrogen trading program. The program uses an NPDES General Permit which establishes basic effluent discharge requirements in the form of Waste-load Allocations (WLA's), and allows dischargers subject to the permit to trade allocations across their permits.[78] While the loading reduction achievements of the Connecticut wastewater permitting program appear traceable in large part to more stringent effluent limits in NPDES permits, the cost of these achievements has become more affordable due the trading program.[79] The trades themselves are administered (and at times subsidized) by the state through a central "bank," and these trades have resulted in an estimated financial savings of between $300 and $400 million to achieve the nitrogen loading reductions of this program.[80]

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76. *Supplemental Module: NPDES Permit Program,* EPA (2016), https://www.epa.gov/wqs-tech/supplemental-module-npdes-permit-program.

77. *See* Personal Communications from Tedesco Mark, to KSU-CPPH staff (2016) (on file with authors).

78. THE CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION BUREAU OF WATER PROTECTION AND LAND REUSE, CONNECTICUT'S NITROGEN EXCHANGE – AN INCENTIVE-BASED WATER QUALITY TRADING PROGRAM (2010).

79. *See* ROWLAND C. DENNY, CONNECTICUT'S NITROGEN TRADING PROGRAM (2014).

80. *See id*.

In the State of New York, major discharges of nutrients to the Long Island Sound come from the 21 major wastewater treatment plants. Some of the largest of these plants are owned and/or operated by the City of New York, and the state has enabled the city to pool permitted nitrogen discharges together under two WLA "bubble" allocations. This enables the city to achieve its allocated reductions in whatever plants are most likely to yield the needed reductions in the most cost-effective fashion. Under this policy, the City's wastewater treatment discharges to the Upper East River and the Jamaica Bay are subject to an overall discharge cap for nitrogen across its plants discharging to these two aquatic environments.[81]

There are additional water quality trading programs associated with nutrient controls being developed in the Chesapeake Bay region, and Virginia's program may be the furthest along of these programs in its development. Other trading programs involving nutrients are being developed in Pennsylvania and Maryland. The purpose of Virginia's trading program is to offset new or expanded nutrient discharges from NPDES permittees due to growth and development.[82] Virginia has implemented a General Watershed Permit for all discharges in the Chesapeake Bay Watershed that defines new and expanded discharges and governs how facilities can offset those discharges.[83] The General Permit outlines the basic rules for the trading program, which addresses both point and non-point sources.[84] A number of agricultural BMP enhancements can be used to generate nutrient discharge credits for point sources, such as cover crops, continuous no-till agriculture, and land conversion.[85] According to the Virginia Department of Environmental Quality's (VDEQ) 2014 Nutrient Trades Report, 117 of the 136 actively reporting facilities covered under the Watershed General Permit met their WLAs without needing to obtain credits. All

81. *See Nitrogen Control Problem*, NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION (2016), http://www.nyc.gov/html/dep/html/harborwater/nitrogen.shtml.

82. *See* VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY, TRADING NUTRIENT REDUCTIONS FROM NONPOINT SOURCE BEST MANAGEMENT PRACTICES IN THE CHESAPEAKE BAY WATERSHED: GUIDANCE FOR AGRICULTURAL LANDOWNERS AND YOUR POTENTIAL TRADING PARTNERS (2008).

83. *See* VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY, 2014 NUTRIENT TRADES REPORT (2015).

84. *See id.*

85. *See id*.

19 facilities exceeding their Total Nitrogen and/or Total Phosphorus WLAs used trades to acquire the necessary credits to meet their requirements.[86]

2. Regulating Agricultural Sources of Nutrients

Agriculture is a major land use in the Ohio Lake Erie Basin and the Chesapeake Bay watershed. States in these watersheds have been delegated Clean Water Act permitting authority over Concentrated Animal Feeding Operations (CAFOs) by EPA.[87]

Beyond minimum federal requirements, states have some variation in what agricultural operations are considered to be "Animal Feeding Operations" (AFOs) for the purposes of their individual state permitting and regulatory programs.

While the federal CWA requires regulation of larger CAFO's, smaller AFO's are not regulated nationally. There are size thresholds for each category of CAFO (Small, Medium, and Large) based on animal type. Federal CAFO requirements include prohibition of discharges (except in the event of a 25-year, 24-hour storm event), the development and implementation of manure management plans, record keeping, and reporting requirements.[88]

In Ohio, the state's AFO permitting program is administered by the Ohio Department of Agriculture (ODA) and it shares the same requirements as OEPA's CAFO program. Operators of AFOs can submit the same management plans when applying to both the ODA permitting program and the OEPA permitting program because the requirements of the state program are the same as the federal CWA requirements.[89] The ODA program also utilizes the same size categories and thresholds for operations as the federal program administered by OEPA. However, the state program also includes a "Major" category. Major Concentrated Animal Feeding Facilities

86. *See id.*

87. EPA, STATE COMPENDIUM: PROGRAMS AND REGULATORY ACTIVITIES RELATED TO ANIMAL FEEDING OPERATIONS (2002).

88. OEPA, CAFO NPDES PERMIT – GENERAL OVERVIEW OF FEDERAL REGULATIONS (2015).

89. Concentrated Animal Feeding Facility size changed from animal unit definition to small, medium, large, and major. *See Livestock Environmental Permitting*, OHIO DEPARTMENT OF AGRICULTURE, http://www.agri.ohio.gov/divs/DLEP/dlep.aspx.

(CAFFs) have 10 times the capacity of Large CAFFs, and Major CAFFs are required to get additional state and local permits above and beyond what operations in the other CAFF categories are required to obtain.[90]

In Maryland, smaller AFO's constitute the vast majority of animal feeding operations in the state.[91] They are also responsible for significant nutrient loads to the Chesapeake Bay.[92] To address these non-federally regulated AFOs, and the nutrient loads they contribute to the Chesapeake Bay watershed, Maryland operates a Nutrient Management Program for AFO's with gross income of $2,500 or more and 8 animal units (or about 8,000 pounds of farm animals). Maryland's program includes requirements for a range of high priority nutrient management practices, including required setbacks near streams, livestock exclusion measures, manure incorporation/injection and a ban on manure spreading in the winter. In total, more than 5,000 AFOs in Maryland are subject to these state requirements, and the Maryland Department of Environment (MDE) conducts farm visits for a subset of these AFOs on a regular basis. It also takes enforcement actions when necessary to address non-compliance.[93]

3. Agricultural Certainty Programs

In addition to permitting requirements for AFOs, Virginia operates a Resource Management Plan (RMP) Program that incentivizes Best Management Practices (BMP). It does so by providing participating agricultural operations nine years of protection from new or changed agricultural regulations for producers who develop an RMP for their operation and implement BMPs specifically tailored to their operations.[94] Maryland also operates an agriculture certainty program. The Maryland program is also voluntary, and it also provides incentives to farmers to accelerate conservation by following the best management practices.[95]

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90. *See id.*
91. KELLY SHENK, EPA ANIMAL AGRICULTURE PROGRAM ASSESSMENTS (2015).
92. *See id.*
93. The State of Virginia also operates an AFO program for livestock operations that are smaller than federal CAFOs. *See id.*
94. CHESAPEAKE BAY COMMISSION, HEALTHY LIVESTOCK, HEALTHY STREAMS: POLICY ACTIONS TO PROMOTE LIVESTOCK STREAM EXCLUSION (2015).
95. *See* Shenk, *supra* note 91.

4. Florida Lawn Fertilizer Rule

Florida has a state Urban Turf Fertilizer Rule, which was updated in 2015. It includes requirements on the packaging and application of residential lawn fertilizers.[96] The rule places requirements on the packaging of fertilizer products (with an emphasis on label requirements), application rates, and the nutrient content of fertilizer products.[97] The Florida Department of Environmental Protection (FDEP) also provides a template local fertilizer ordinance for local governments, which they can use to draft their own local fertilizer requirements and restrictions.[98]

In 2008, the TBEP facilitated the development of the Tampa Bay Model Regional Fertilizer Ordinance. This model ordinance includes elements of the state rule, but it also includes stronger restrictions on the use and sale of nitrogen lawn fertilizer. Recognizing that fertilizer applied during the summer rainy months in the Tampa Bay watershed can wash into streams, lakes and the estuary, the model ordinance restricts the use of fertilizer containing nitrogen and phosphorus between June 1st and September 30th. It also prohibits the sale of nitrogen lawn fertilizer during this period. Local governments within the Tampa Bay watershed have adopted ordinances for their jurisdictions to limit nutrient flows from lawn fertilizer applications.[99]

5. Air Emissions and Nitrogen Deposition

The Tampa Bay Electric company came to an agreement with EPA and Florida DEP to reduce overall emissions from its power plants in 1999.[100] The company's "Selective Catalytic" project reduced nitrogen oxide emissions and repowered a coal-burning power plant to a cleaner natural gas fuel source.[101] Other plants in the Tampa Bay region – including the Bartow plant run by Progress Energy (now Duke Energy)

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96. FLA. ADMIN. CODE ANN. r. 5E-1.003 (2015).
97. *See id.*
98. FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION, MODEL ORDINANCE FOR FLORIDA-FRIENDLY FERTILIZER USE ON URBAN LANDSCAPES (2015).
99. BRIEF SUMMARY OF PINELLAS COUNTY'S FERTILIZER ORDINANCE (2011).
100. *See* Greening et al., *supra* note 68.
101. *See id*

are also switching from coal to natural gas.[102] Between 2002 and 2010, power plant upgrades are reported to have resulted in a reduction of 95 tons of nitrogen through deposition and two air quality monitors showed a decrease in nitrogen oxide concentrations during the same period.[103]

6. Water Quality Standards

As TBEP Director Holly Greening has suggested,[104] there is value in establishing clear (and, in her view, numerically based) ambient water quality targets to guide nutrient reduction efforts. While the Tampa Bay region worked toward developing their numerical targets in ways that took advantage of existing collaborations as well as more traditional regulatory processes, the federal CWA includes provisions for establishing water quality standards that may give rise to numerically-based water quality targets. These processes have been used in both the Chesapeake Bay region and the Long Island Sound watershed.

In 2003, for example, EPA, working with its state and academic partners, developed a set of Chesapeake Bay-specific water quality criteria for dissolved oxygen, water clarity, and chlorophyll a, as well as a corresponding set of tidal water designations. Maryland, Virginia, Delaware, and the District of Columbia adopted these criteria and designated uses in their state water quality standards, all of which were subsequently approved by EPA.[105] These water quality standards constitute a consistent and shared set of goals and objectives to be pursued through bay clean-up efforts, and therefore provide a definition of success for the region's nutrient-related water quality improvement efforts.

As outlined in the Long Island Sound TMDL, both New York and Connecticut had applicable water quality standards and designated uses for dissolved oxygen.[106] While the TMDL was developed, EPA

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102. *See id*

103. UNDERSTANDING ATMOSPHERIC DEPOSITION IN TAMPA BAY: A PUBLIC SUMMARY (2012).

104. *See* Greening et al., *supra* note 66.

105. *See* EPA, *Section 9: Chesapeake Bay TMDLs*, *in* CHESAPEAKE BAY TMDL DOCUMENT (2010).

106. *See* NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION & CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION, A TOTAL MAXIMUM

worked on draft criteria for DO levels in saltwater ecosystems from Cape Cod to Cape Hatteras. The LISS committed to reevaluating their management goals every five years to take advantage of new information produced by EPA's criteria-development effort.[107] In 2001, EPA approved a multi-jurisdictional TMDL calling for a 58.5% reduction in nitrogen loadings to the Sound, a large proportion of which was to be achieved through upgrades to wastewater treatment plants scheduled to occur over a period of approximately fifteen years.[108]

In Ohio, there are currently no nutrient related water quality standards for the open waters of Lake Erie. The OEPA has been developing water quality standards for streams and rivers to maintain beneficial uses and protect them from excessive nutrients. However, the OEPA and EPA have taken a position to not declare Lake Erie's Western Basin impaired with nutrients.[109] The State of Ohio argues that it is making progress on addressing the nutrient problem.[110] There are ongoing strategy development activities between Ohio and other jurisdictions in the Lake Erie Basin, including an agreement between Ohio, Michigan, and Ontario, as well as the Great Lakes Water Quality Agreement (GLWQA) Annex 4 Process which focuses on nutrient reductions. Both of these agreements include nutrient load reduction targets.[111] However, it should be noted that Michigan state officials came to a different conclusion regarding the need for an impairment

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DAILY LOAD ANALYSIS TO ACHIEVE WATER QUALITY STANDARDS FOR DISSOLVED OXYGEN IN LONG ISLAND SOUND 5-7 (2000).

107. *See id.* at 8.

108. *See id.* at 40, 42, 58.

109. *See* John Seewer, *EPA Won't Declare Lake Erie's Waters in Ohio Impaired*, ASSOCIATED PRESS (May 23, 2017), https://www.usnews.com/news/best-states/ohio/articles/2017-05-23/epa-rejects-declaring-lake-eries-waters-in-ohio-impaired [https://perma.cc/D3CT-U3DA].

110. *See id.* The various iterations of the Great Lakes Water Quality Agreement (GLWQA) have set nutrient reduction targets for Lake Erie and the other Great Lakes. The first targets were established in 1981 for total phosphorus and the targets were reported to have been met through the targeting of point sources. The latest version of the GLWQA, signed in 2012, called for the establishment of new phosphorus load reductions. In February of 2016, the U.S. and Canadian Governments made official a series of phosphorus reduction targets recommended by the GLWQA Nutrient Subcommittee. *See* HOORNBEEK ET AL., *supra* note 1, at 11.

111. *See* HOORNBEEK ET AL., *supra* note 1, at 11.

designation, as Michigan has requested that EPA to designate a portion of Lake Erie as impaired.[112]

C. Financial Expenditures for Nutrient Reduction ("Treasure")

Our investigation found ample evidence of the expenditure of financial resources to reduce nutrient flows to Lake Erie and potentially innovative funding programs in other American water basins as well. These expenditures address both point and non-point sources of nutrient flows, and they are being contributed by both federal and state sources.

1. Federal and State Funds for Point Source Nutrient Reduction

The U.S. federal government supports state revolving loan funds authorized by the CWA, which are supplemented by state funding. Ohio, for example, utilizes financial assistance programs that benefit from both state and federal funding to help local government entities address point source water pollution issues. The Ohio Water Development Authority (OWDA) and the OEPA jointly manage and implement the Water Pollution Control Loan Fund (WPCLF), which provides below market rate loans to public entities for wastewater treatment systems and related planning and construction projects. In addition, the OWDA also manages other loan programs, such as the Fresh Water Fund, the Community Assistance Fund, and the Un-sewered Area Assistance Account in order to benefit communities in Ohio. Starting in 2015, the WPCLF offered $100 million in loans with a 0% interest rate for waste water treatment plant projects that would reduce phosphorus discharges.[113] Overall, through our investigations of federal and state funding programs in Ohio, we were able to identify more than $2.5 billion in investments in point source water pollution control between 2010 and 2015.[114]

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112. *See* Seewer, *supra* note 109.

113. OEPA DIVISION OF ENVIRONMENTAL AND FINANCIAL ASSISTANCE, STATE OF OHIO WATER POLLUTION CONTROL LOAN FUND: 2015 PROGRAM MANAGEMENT PLAN 61 (2014).

114. *See* HOORNBEEK ET AL., *supra* note 1, at 25-26.

2. Federal Non-Point Source Nutrient Reduction Programs

We identified four federal agencies that are implementing non-point source-related programs that provide funding support for projects that may reduce nutrient flows. They include:

- U.S. Environmental Protection Agency (EPA);
- U.S. Department of Interior (DOI);
- U.S. Department of Agriculture (USDA); and
- U.S. Department of Commerce – National Oceanographic and Atmospheric Adminstration (NOAA).

The EPA implements the CWA Section 319 Grant Program, the Urban Waters Grant Program, and the Great Lakes National Program (for the Lake Erie basin and the other Great Lakes). These programs provide support for non-point source pollution reduction efforts. The EPA's Great Lakes National Program (GLNP) is a broad-based program operated in the Great Lakes region. The GLNP is housed at the Great Lakes National Program Office (GLNPO) in Chicago and focuses on addressing environmental concerns in "Areas of Concerns" (AOCs), which are locations that have experienced environmental degradation. The AOCs identified by GLNPO in Ohio include the Ashtabula River, Black River, Cuyahoga River, and Maumee River. Three out of the four AOCs in Ohio are attempting to address nutrient issues in rivers in the Ohio Lake Erie basin: the Maumee, Cuyahoga, and Black Rivers.

DOI agencies, such as the U.S. Fish and Wildlife Service (FWS) and the National Park Service (NPS), offer grants for land conservation and restoration efforts. The permanent protection of natural habitat, such as wetlands, has multiple environmental benefits, including the potential to help filter nutrient flows to water bodies and prevent changes in land use that may lead to new sources of nutrient loads to water resources.[115] The FWS has two programs, the National Coastal Wetlands Conservation Grant Program and the North American Wetland Conservation Act program, that may contribute to reducing nutrient loads from non-point sources, at least indirectly. The NPS is

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115. *Wetlands Classification and Types*, EPA (2017) https://www.epa.gov/wetlands/wetlands-classification-and-types#marshes,

tasked with approving the use of Land and Water Conservation Fund (LWCF) dollars.[116]

The NOAA within the U.S. Department of Commerce, in collaboration with state Coastal Management agencies, operates programs to reduce non-point source pollution to coastal areas, including the Great Lakes (which are characterized as coastal water bodies for purposes of this program). This effort is operationalized through the National Coastal Zone Management Program at the federal level. There are a number of grant programs operated by NOAA and these include:

- Coastal and Estuarine Land Conservation Program;
- Coastal Management Assistance Grants;
- Coastal Program Enhancement; and
- Areas of Concern Land Acquisition Grants.

In the Great Lakes region (including Ohio), two multiagency programs exist that target, at least in part, nutrient reductions to Lake Erie. They are the Great Lakes Restoration Initiative (GLRI) and the Sustain Our Great Lakes program. The GLRI represents a large investment in the Great Lakes. It was created by Congress in 2009 and implementation began in 2010. The initiative is managed by a Task Force made up of eleven federal agencies. The GLRI is focused on four main areas. Two of these areas support projects that reduce nutrient flows: (1) reducing nutrient runoff that contributes to harmful/nuisance algal blooms; and (2) restoring habitat. Sustain Our Great Lakes is a public-private partnership made up of federal agencies, the National Fish and Wildlife Foundation, and the mining and steel manufacturer, ArcelorMittal.[117] This program does receive a "significant" portion of its funding from the GLRI, but additional funds provided by ArcelorMittal and other sources also support its efforts.[118]

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116. *Outdoor Recreation Facility Grants*, OHIO DEPARTMENT OF NATURAL RESOURCES (Aug. 27, 2015), http://realestate.ohiodnr.gov/outdoor-recreation-facility-grants.

117. *See About SOGL*, SUSTAIN OUR GREAT LAKES (2015), http://www.sustainourgreatlakes.org/about/about-sogl/.

118. *See id.*

The USDA has a variety of programs that focus on incentivizing the adoption of conservation BMPs on farms that target, or that may contribute toward, reduced nutrient flows. Many of these programs were created by various iterations of the U.S. Farm Bill. The 2014 Farm Bill continued or created a series of financial, technical assistance, and easement programs to support the agriculture industry. USDA incentive and funding programs include:

- Agriculture Conservation Easement Program;
- Conservation Technical Assistance;
- Conservation Stewardship Program;
- Conservation Innovation Grants;
- Environmental Quality Incentives Program;
- Conservation Reserve Program;
- Conservation Reserve Enhancement Program;, and
- Forest Legacy Program.

In 2014, these programs provided $90 million dollars to agricultural operations statewide in Ohio, and resulted in more than 700,000 acres receiving best management practices, support, and/or conservation easements.[119]

3. State Funding Programs to Reduce Nutrient Flows from Point and Non-Point Sources

We also found examples of state funding programs to target non-point sources of nutrient flows. In Ohio, the Water Resource Restoration Sponser Program (WRRSP) is administered by the OEPA's Division of Environmental Financing and Assistance, and has been a component of the WPCLF (Ohio's revolving loan fund for water infrastructure) since 2000. The program has provided $170 million for projects since its creation.[120] The goal of the program is to counter the loss of ecological function and biological diversity that impacts the health of Ohio's water resources. The program also indirectly targets nutrients by funding land protection and restoration projects. Since 2010, there have been 56 projects within the Lake Erie

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119. *See* HOORNBEEK ET AL., *supra* note 1, at 30.
120. *See* OEPA DIVISION OF ENVIRONMENTAL AND FINANCIAL ASSISTANCE, *supra* note 113.

Basin listed on the program's annual Project Priority List, with $69,668,023 allocated for those projects according to the program's management plans.[121]

In Virginia, the Virginia Water Quality Improvement Fund (WQIF) is funded by bond funds and a 10% portion of the state's budget surplus from the previous year.[122] The WQIF provides funding for point source, as well as non-point source water pollution control projects.[123] The WQIF provides funding support for the Agricultural BMP cost-share program, the federally supported Conservation Reserve Enhancement Program (CREP), water quality initiatives, and Cooperative Nonpoint Source Pollution Program projects with local governments. From July 1, 2007 to June, 30, 2008 the State of Virginia reported that the WQIF provided $12.3 million statewide in cost share for agricultural practices resulting in a reduction of 4.5 million pounds of Nitrogen and 922,192 pounds of Phosphorus.[124] It also reports that over 7,500 practices were implemented on 2,098 farms in that time period, and over 189,000 acres benefited from BMP implementation.[125]

Another program supported by the WQIF is the Virginia Livestock Exclusion System. Virginia's Agricultural BMP Cost Share Program addresses livestock exclusions by providing cost share funding for two key state-approved practices: Stream Exclusion with Grazing Land Management and Livestock Exclusion with Reduced Setback.[126] Both practices focus on providing livestock watering systems, fencing, and

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121. OEPA DIVISION OF ENVIRONMENTAL AND FINANCIAL ASSISTANCE, STATE OF OHIO WATER POLLUTION CONTROL LOAN FUND: 2010-2015 PROGRAM MANAGEMENT PLANS (2010-2014)

122. VIRGINIA FOREVER, INVESTING IN THE COMMONWEALTH'S LAND AND WATER: VIRGINIA FOREVER'S FIVE-YEAR PLAN 2015-2019 38-9 (2013).

123. VIRGINIA DEPARTMENT OF ENVIRONMENTAL EQUALITY, VIRGINIA WATER QUALITY IMPROVEMENT FUND GUIDELINES 2 (2012).

124. VIRGINIA DEPARTMENT OF CONSERVATION AND CREATION, VIRGINIA WATER QUALITY IMPROVEMENT FUND AND THE COOPERATIVE NON-POINT SOURCE POLLUTION PROGRAM 2 (2010).

125. *See id*.

126. *See* CHESAPEAKE BAY COMMISSION, *supra* note 94, at 19.

rotational grazing.[127] Maryland also implements an agricultural BMP cost share program that includes funding for livestock exclusions.[128]

D. Strategy, Communications, and Planning Based Policy Tools ("Nodality")

During the course of our review of nutrient reduction efforts in the four water basins, we found that the Tampa Bay nutrient management effort offered good examples of innovative strategy, communications, and planning based policy tools.

1. Tampa Bay Nitrogen Management Consortium (TBNMC)

The Tampa Bay Nitrogen Management Consortium (TBNMC) was formed in 1996, and was subsequently facilitated by TBEP to implement an Action Plan to meet the protective nutrient load targets developed for the Tampa Bay.[129] Private sector partners included fertilizer manufactures, electrical utilities, and agricultural interests.[130] In establishing the TBNMC, community leaders sought to establish a means for both detecting concerns about nutrient reduction efforts and effecting changes in nutrient loadings, both of which are activities that utilize "nodality" resources of government, according to Hood's taxonomy of policy tools.[131]

Prior to 1999, the TBNMC's first Action Plan called for more than 100 projects that reduced or prevented 224,000 kg of nitrogen from entering Tampa Bay each year.[132] After 1999, additional projects were undertaken and they have been estimated to reduce nitrogen loads to the Bay by 270,000 kg each year.[133]

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127. VIRGINIA DEPARTMENT OF CONSERVATION AND RECREATION, NAME OF PRACTICE: STREAM EXCLUSION WITH GRAZING LAND MANAGEMENT 1 (2016).

128. *See* CHESAPEAKE BAY COMMISSION, *supra* note 94, at 6.

129. *See* Greening et al., *supra* note 68.

130. *See id.*

131. *See* HOOD, *supra* note 4, at 4-7; *see also* TAMPA BAY ESTUARY PROGRAM, *supra* note 65 at 6.

132. *See* Greening et al., *supra* note 68.

133. *See id.*

Between 1992 and 2013, participants in the TBNMC are reported to have invested over $430 million in projects and actions to reduce nutrient loads to Tampa Bay.[134]

2. Lawn Fertilizer Social Marketing Campaign

The TBEP also created a social marketing campaign focused on residential lawn fertilizers to encourage Floridians to not fertilize their lawns during the summer when heavy rains can sweep nutrients into surface waters.[135] This effort also supports local ordinances to restrict fertilizer use during the summer months.

VI. DISCUSSION

Below, we discuss our findings regarding the extent to which the four watershed programs we investigated make use of policy tools drawn from Hood's four major policy instrument categories. We also offer some initial ideas that may help policymakers and communities in the United States and elsewhere in selecting policy tools to aid them in addressing nutrient enrichment issues.

A. Tools Based on Organization ("Organization")

Among the four major watershed programs we investigated, three – the CBP, the LISS program, and the TBEP—have well-developed and centralized organizations to guide and manage their efforts to reduce nutrient flows to the surface water bodies they are trying to protect. However, at the time of our assessment, we did not find an analogous coordinating organization focusing on nutrient control in the Ohio Lake Erie basin.[136] The discussion below highlights key insights emerging from our work and discusses progress reported by the organizational entities that are facilitating nutrient reduction efforts in the Chesapeake Bay, the Long Island Sound, and Tampa Bay.

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134. *See i*d.

135. BEFLORIDIAN, http://befloridian.org/ (last visited Jul 26, 2017).

136. Even so, it is worth noting that the International Joint Commission, an international body guided by representatives of the United States and Canada under the Great Lakes Water Quality Agreement is playing an important role in seeking to inform and, to the extent possible, coordinate Canadian and American efforts to address nutrient problems in Lake Erie.

In the Lake Erie basin of Ohio, we identified multiple organizations with responsibilities for the protection of the Great Lakes and Lake Erie, but no single organization with primary responsibility for managing all efforts to reduce nutrient flows to Lake Erie. The EPA's Great Lakes National Program Office, for example, is based in Chicago, Illinois and has broad responsibility for the Great Lakes as a whole, as well as the multiple problems and issues associated with their management. The Ohio Lake Erie Commission and the Coastal Zone Management Program in Ohio are both Lake Erie focused, but neither is focused primarily on nutrient flows, and neither has had primary water basin-wide and cross-jurisdictional responsibility like the organizations which seek to address nutrient issues in the Chesapeake Bay, Long Island Sound, and Tampa Bay. It is worth noting, however, that at the time we are completing work on this article, the Ohio State Legislature has recently enacted legislation that appears to strengthen the coordinating role of the Ohio Lake Erie Commission in guiding strategic efforts to address water quality problems in Lake Erie and in making recommendations regarding policies associated with "the Great Lakes Water Quality Agreement and other international, federal, and state compacts and agreements."[137]

In contrast to the situation in the Ohio Lake Erie basin, the CBP, the LISS Program, and the TBEP have all taken responsibility to document and report on progress in implementing nutrient reduction efforts, and in achieving improvements in ambient water quality associated with those efforts. For example, by the end of 2014, the LISS program reported wastewater treatment facilities "achieved 94 percent of the nitrogen reduction goal established in the 2000 Dissolved Oxygen Total Maximum Daily Load (TMDL), which means 108,000 fewer pounds of nitrogen were discharged into the Sound every day."[138] Perhaps not surprisingly in this context, the LISS program also reported water quality improvements associated with these efforts in the Long Island Sound. These improvements related to the size and

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137. *See* OEPA, PROTECTING LAKE ERIE AND ALL OUR DRINKING WATER SOURCES, PROVIDING COMMUNITY AND BUSINESS ASSISTANCE AND STREAMLINING GOVERNMENT (2017).

138. *See* LONG ISLAND SOUND STUDY OFFICES, *supra* note 63, at 14.

duration of hypoxic (low oxygen) areas within the Sound's waters and the presence of eelgrass which supports shellfish populations.[139]

The CBP has also reported progress in reducing nutrient flows to the Chesapeake Bay (www.chesapeakestat.com). Our review of the Chesapeake Bay Stat program on the CBP website (tmdl.chesapeakebay.net) in 2016 revealed substantial reductions in estimated loads of nitrogen and phosphorus flowing to the Chesapeake Bay, for example.[140] Indicators of nutrient enrichment within the ambient waters of the Chesapeake Bay appear to have shown modest improvement, as about 65 to 70% of the United States Geological Survey (USGS) monitoring sites show improvements in nitrogen and phosphorus concentrations in the Bay between 1985 and the end of the first decade of the 21st century.[141] These figures, along with reports of evidence of improvements for certain living resources in the Bay, led CBP director Nick DiPasquele to make the following statement in 2015:

> The Chesapeake Bay is a vast and complex ecosystem that faces continued challenges . . . Yet in the face of these . . . [c]hallenges, we are witnessing signs of a system in recovery.[142]

This statement is admittedly an optimistic one made by a senior official with a potential interest in showing signs of progress associated with the program he manages, but it is based on information flowing from a system of nutrient management that is designed to both measure and report on progress.

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139. *See* Tedesco, *supra* note 77; *see also* RALPH TINER ET AL., 2012 EELGRASS SURVEY FOR EASTERN LONG ISLAND SOUND, CONNECTICUT AND NEW YORK (2013).

140. *See* HOORNBEEK ET AL., *supra* note 1.

141. *See* LANGLAND ET AL., NUTRIENT AND SUSPENDED-SEDIMENT TRENDS, LOADS, AND YIELDS AND DEVELOPMENT OF AN INDICATOR OF STREAMWATER QUALITY AT NONTIDAL SITES IN THE CHESAPEAKE BAY WATERSHED, 1985–2010 26 (2012).

142. *See* Catherine Krikstan, *Experts consider Chesapeake Bay an ecosystem in recovery,* CHESAPEAKE BAY NEWS (Feb. 3, 2015), http://www.chesapeakebay.net/blog/post/experts_consider_chesapeake_bay_an_ecosystem_in_recovery [https://perma.cc/7FP7-KPGL].

The TBEP has also reported quantifiable measures of progress in reducing nutrient flows to Tampa Bay. Some years back, the director of the TBEP reported that nitrogen loads to the Tampa Bay had diminished by more than 50% between the 1970's and the 2000's, even with substantial increases in population in the Tampa Bay region during that time period.[143] These loading reductions appear to have had positive effects on ambient water quality in the bay as well, as the director and her colleagues also reported on monitoring results showing that chlorophyll-a concentrations in the four major basins in the Tampa Bay had improved considerably between the 1970's and the 2000's.[144]

By contrast, our interviews and investigations of progress in addressing nutrient flows in the Ohio Lake Erie basin produced no water basin-wide reports concerning loading reductions for phosphorus or nitrogen across the Ohio Lake Erie watershed, nor associated improvements in nutrient related impacts on Lake Erie. Indeed, the monitoring being done by academic and government affiliated scientists in the Ohio Lake Erie region appears to be suggesting HAB trends that are not moving in positive directions.[145]

While the observations on reporting associated with nutrient reduction implementation efforts, nutrient loads, and ambient water quality fall well short of conclusive evidence that focused water quality management organizations are the "cause" of the positive trends identified (indeed, there are reasons to believe that the explanation is probably more complicated than that), they do suggest that focused organizational resources enable the development of monitoring and reporting systems that can help communities measure and manage their progress in reducing excess nutrient flows to key water bodies.

As we stated in our earlier report, "[i]t is a maxim of administration and management that one cannot manage progress without measuring it."[146] For this reason alone, it appears appropriate for communities and jurisdictions with concerns about excess nutrient flows to establish and administer centralized watershed based organizations that have

143. *See* Greening et al., *supra* note 72.
144. *See* Greening et al., *supra* note 68.
145. *See* INTERNATIONAL JOINT COMMISSION, A BALANCED DIET FOR LAKE ERIE: REDUCING PHOSPHORUS LOADINGS AND HARMFUL ALGAL BLOOMS (2014).
146. *See* HOORNBEEK ET AL., *supra* note 1 at 68.

responsibility for monitoring and managing nutrient flows. And, based on our investigations of the CBP, the LISS, and the TBEP, these organizations and the communities and watersheds they serve may benefit from helping to coordinate assigned responsibilities for generating scientific information, tracking and reporting on nutrient reduction progress, and providing focus and coordination for nutrient reduction efforts and monitoring ambient water quality for signs of progress. While developing these centralized capacities and tracking and reporting systems requires substantial investments, these investments may very well be necessary if sustainable nutrient reductions are to be achieved.

B. Tools Based on Regulatory Authority ("Authority")

We identified regulatory tools being used in all four of the watershed basins we investigated. Some of these tools stemmed directly from regulatory requirements associated with the federal CWA, while others were state-specific.

In all four watersheds, regulatory officials issue NPDES permits to limit wastewater flows, and we identified detailed information on nutrient requirements in these permits in the Ohio Lake Erie basin. While many of these permits set limits on nutrient discharges from wastewater treatment plants, others apply limits to commercial organizations. In addition, under the federal CWA, states with regulatory authorities in all four of these watersheds issue permits for stormwater management efforts of various kinds, and states with larger agricultural operations – such as Ohio and Maryland – issue permits for CAFO's as well.

We also encountered state-specific regulatory requirements relevant to nutrient management practices of various kinds. These practices included more stringent requirements for smaller AFO's in Maryland, effluent trading and (bubble) transfer programs such as those in Connecticut and New York, declared water quality impairments (and associated TMDLs) such as the one in place in the Chesapeake Bay, and fertilizer application rules at the state and local levels like those in Florida which apply to the Tampa Bay region. All of these state-specific regulatory initiatives appear tailored to the specific circumstances in which they developed. Some or all of these kinds of initiatives may be worthy of attention by other jurisdictions facing nutrient enrichment and/or HAB issues.

C. Tools based on Expenditures of Funds and Resources ("Treasure")

Like regulatory controls based on government "authority," we found evidence of the use of tools based on "treasure" in all of the jurisdictions we investigated. Many of the funding programs we identified are administered by federal government agencies, such as the EPA, the DOI, the USDA, and NOAA. While many of these federal programs operate on a nationwide basis, some – like the GLRI and NOAA Coastal Zone Management Program – operate only in specific regions of the country.

We also identified multiple state-specific forms of funding support. For example, Ohio operates multiple funding programs which provide support for both point and non-point source projects seeking to reduce nutrient flows. And Virginia operates an ongoing program to enable the use of state budget surplus funds to address nutrient and other water quality issues. Communities and jurisdictions facing nutrient enrichment issues can identify federal funding opportunities to support nutrient control initiatives, while also taking advantage of any state-specific programs from which their nutrient control efforts may benefit. In cases where these kinds of programs do not currently exist, communities with nutrient enrichment concerns and relevant governing authorities may want to look into developing them.

D. Tools Based on Government Strategy, Planning, and Communication ("Nodality")

We also identified the use of policy tools to collect and disseminate information which draw on the central ("nodal") role of government across the watersheds we investigated.

In the Ohio Lake Erie Basin, for example, we identified a growing array of nutrient reduction efforts developing shortly after the record-setting Lake Erie HAB in 2011 and the Toledo water system advisory in 2014. A number of these efforts sought to enable useful coordination by farmers and the agricultural community in identifying agricultural areas where nutrient releases are substantial and in sharing information about nutrient reduction management practices. However, we also found that these kinds of efforts appear to grow from multiple sources, in all likelihood due to the fragmented organizational arrangements used to manage nutrient reduction efforts in the Ohio Lake Erie basin.

In the Tampa Bay area, we found evidence of ongoing nodal communications involving a sustaining consortium of public and private sector organizations, as well as concerted efforts to provide education on nutrient reduction approaches. The social marketing campaign undertaken by TBEP to encourage local governments and residents to restrict fertilizer application during the summer months is one such example. Communities and jurisdictions seeking to address nutrient enrichment issues and/or combat HABs may want to consider these kinds of nodal policy interventions as they define and implement nutrient reduction policy strategies.

E. Selecting Policy Tools

The processes by which governments adopt policies previously used by other governments have been studied for decades,[147] and empirical research in this area has grown tremendously. However, while the empirical literature is growing in this area, there appears to be little work addressing when and how governments *should* borrow policy tools from others. How should government jurisdictions with nutrient enrichment issues consider addressing these issues? In the paragraphs that follow, we offer some initial ideas on steps that jurisdictions and policymakers may take as they seek to identify and select policy tools to aid them in addressing nutrient enrichment problems facing their communities.

At this point, given what we know and have learned, we would suggest that jurisdictions with nutrient related concerns consider taking several steps. First, they should assess their own particular nutrient enrichment problems. Nutrient enrichment problems can take multiple forms—and basic information on the nature of the problem is

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147. *See e.g.*, Jack Walker, *The Diffusion of Innovations Among the American States*, 63 THE AM. POL. SCI. REV. 311 (1969); MAJONE GIANDOMENICO, EVIDENCE, ARGUMENT, AND PERSUASION IN THE POLICY PROCESS (1989); Berry Frances & William D. Berry, *State Lottery Adoptions as Policy Innovations: An Event History Analysis*, 84 THE AM. POL. SCI. REV. 395 (1990); Brady Baybeck et al., *A Strategic Theory of Policy Diffusion via Intergovernmental Competition*, 73 J. OF POL. 232 (2011).

needed to develop appropriate response actions. What are the visible symptoms of the problem? To what extent have these problems been tied scientifically to excess nutrient flows? What nutrients are of particular concern (nitrogen, phosphorus, both?). What are the leading sources of excess nutrients causing the problem – point vs. non-point sources, rural vs. urban sources, agricultural contributions, etc.?

Among the watersheds we investigated, for example, we saw different approaches to addressing nutrient problems in the Long Island Sound than we saw in the Chesapeake Bay region, at least in part because of differences in problem characteristics and nutrient sources in these two regions. In the Long Island Sound, controls on point sources appear to have been of central importance in achieving notable progress in addressing the region's dissolved oxygen (DO) problems. The CBP, by contrast, has been dealing with a rather wide range of nutrient sources, including sources that have close ties to agricultural practices – a problem that also appears evident in the Ohio Lake Erie basin.

Second, jurisdictions should consider assessing their own capacities and current nutrient control efforts. Given the problem characteristics defined in the first step above, how many governing jurisdictions must be involved to address the problem fully, and what jurisdictions are they? Among the jurisdictions we investigated in the United States, all had multi-jurisdictional characteristics, but the nature and complexity of these characteristics varied. For example, one might suggest that it should be easier to address nutrient problems across local governments in a watershed in a single state, as was the case for Tampa Bay, than it is to address nutrient issues in multi-state (Chesapeake Bay, Long Island Sound) or even multi-national contexts (Lake Erie Basin).

After comparing the geographic scope of the problem with the scope of existing governing jurisdictions, an inventory of current nutrient control policies and capacities would seem to be appropriate. What nutrient control policies are currently in place across the jurisdictions, and what –if anything – is known about their effectiveness? Are there sufficient legal authorities and financial resources to alter current strategies and/or develop new ones? Who in the jurisdiction has concerns about the nutrient problems that have been discovered? Can the energy and expertise of these stakeholders be drawn upon through appropriate nodal communications to address the problem? Is there an organization in place that is acceptable to all of the key jurisdictions and stakeholders to help steer policy and management responses to address the problem across the entire water basin?

And finally, what additional policy actions can and should be taken to reduce nutrient flows where needed, and how can their desirability be assessed? This article, and the underlying research that gave rise to it, have inventoried multiple policy tools that are currently being used to address nutrient enrichment concerns in the United States, and the tools identified provide a foundation on which nutrient reduction efforts can draw. Unfortunately, however, while we did encounter some (often anecdotal) information on the effectiveness of overall policy interventions in several watersheds with nutrient problems, we found little evidence regarding the effectiveness of the individual policy tools.

While this finding clearly suggests a need to do more research and analysis of specific nutrient reduction policy tools, it also suggests that communities may be forced in the interim to rely on more subjective assessments of effectiveness, and perhaps also the fits of various policy tools identified with their own particular circumstances. Have other jurisdictions with similar nutrient problems effectively used particular mixes of policy tools? Does the jurisdiction have the will and capacity to implement tools that appear as though they are working elsewhere? And, does the nutrient problem assessment and community governance/capacity self-assessment (see steps 1 and 2 above) yield ideas for ways to improve upon current nutrient reduction efforts? And finally, to the extent that current capabilities are not optimal, are there steps that can be taken to build nodal communication and organizational capacities in ways that will yield more effective responses over time? By answering these kinds of questions, jurisdictions with nutrient enrichment problems may begin to develop ways to identify initial strategies that enable them to adjust and improve their policy responses over time.

VII. CONCLUSION

The contamination of the Toledo water supply in 2014 should draw our attention to the challenges associated with addressing what Greening and colleagues have called "cultural eutrophication."[148]

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148. *See* Greening et al., *supra* note 68.

These challenges are continuing, as global climate change appears likely to yield concerns about nutrient enrichment and HABs that increase over time.[149]

In this context, it is perhaps re-assuring to find, as we do here, that multiple and major nutrient reduction efforts are already underway in major water basins across the United States. In this article, we identify regulatory policy tools, such as traditional nutrient discharge permitting as well as other less widely used regulatory approaches, such as agricultural certainty programs. We also find numerous monetary investments in nutrient controls and efforts to use the nodal role of government to educate key stakeholders and the public on nutrient enrichment issues. We also see multiple public-sector organizations pursuing nutrient reduction goals. Unfortunately, in spite of these efforts, it appears clear that current efforts are not yet sufficient to fully address the problems at hand – even in water basins where existing organizations are actively monitoring and managing nutrient problems in ways that yield positive reports on the progress made.

In this article, we offer ideas regarding policy tools to reduce nutrient flows for consideration by communities, policymakers, and natural resource administrators. We do not assert that these policy tools will be applicable to all waterbodies facing nutrient enrichment issues. Rather, we suggest that they serve as an introductory menu that, accompanied by the application of systematic steps and follow up research, may assist nations, states, and local governments in addressing the cultural eutrophication challenges that are facing modern communities and societies in the twenty-first century.

149. *See* O'Reilly, et al., *supra* note 3.