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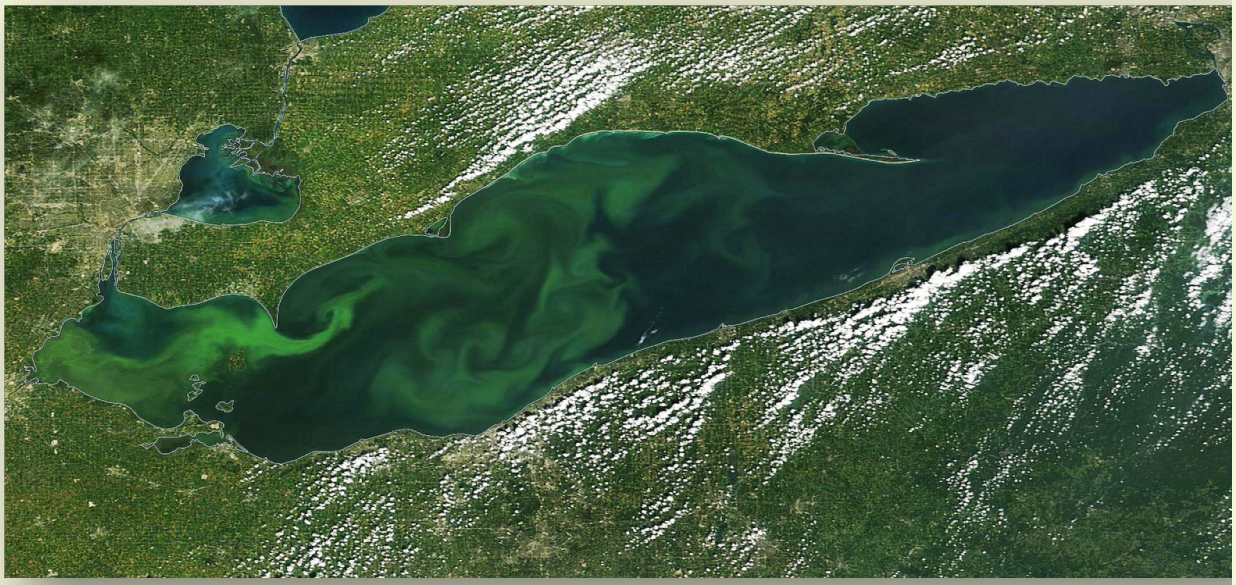

ADDRESSING HARMFUL ALGAL BLOOMS: NUTRIENT REDUCTION POLICIES IN OHIO'S LAKE ERIE BASIN AND OTHER AMERICAN WATER BASINS

November 2016 Update

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Cover Photo: Image of Lake Erie via NASA's MODIS Terra and Aqua Instruments

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Executive Summary

In response to reoccurring Harmful Algal Blooms (HABs), policymakers are seeking ways to reduce nutrient flows to Lake Erie. This report offers ideas on additional nutrient reduction efforts that could be implemented in the Ohio Lake Erie water basin, based on an assessment of current "policy tools" used in the Ohio Lake Erie basin and in other American water basins. We find multiple efforts in Ohio to reduce nutrient flows to Lake Erie. However, we also identify multiple policy tools used in other jurisdictions that do not appear to be used in Ohio's Lake Erie basin. Importantly, we also identify other American water basin programs that have developed ongoing management systems which systematically collect information on nutrient reduction efforts and their impacts, and report on their findings. We suggest that these organizational policy tools and others identified in this report be considered for further investigation and adoption in Ohio (and potentially elsewhere) to address HABs and nutrient flows to Lake Erie.

The content of this report is multi-faceted. The report presents an inventory of policy tools used in the Ohio portion of the Lake Erie basin to reduce nutrient flows to the lake. It also shares results from a review of nutrient reduction efforts carried out by other water basin management programs in the United States (US). To guide these assessments, we use a "policy tools" framework advanced by Christopher Hood several decades ago, in his 1983 book, *The Tools of Government*. Our investigation of nutrient reduction efforts thus identifies policy tools in four major categories:

- regulatory interventions;
- expenditures of funds and resources;
- strategy, planning, and communications efforts, and;
- organizational arrangements.

In Ohio, we identified substantial regulatory efforts, major expenditures, and multiple strategy, planning, and communications efforts, as well as a number of organizational efforts by government(s) to harness resources to reduce phosphorus and nitrogen flows to Lake Erie. We identified multiple regulatory interventions based on the federal Clean Water Act and state-specific statutes in Ohio, including hundreds of traditional wastewater permits with effluent limits and/or monitoring requirements for phosphorus and/or nitrogen, requirements affecting potentially thousands of entities under "general" permits focused on storm-water control, and federal and state requirements addressing nutrient management on agricultural lands. We also identified more than $100 million in federal and state expenditures to encourage and enable nutrient flow reductions in the Lake Erie basin in 2014 alone. In addition, we found and report on multiple strategic planning and communications efforts, engagements by a total of at least ten US federal and Ohio agencies, and multiple efforts by international and Canadian organizations.

In spite of these efforts, it seems clear that the efforts currently in place are not yet good enough. The 2014 shutdown of the Toledo water supply was followed in 2015 by another record breaking HAB in Lake Erie, and additional blooms have been identified in 2016 as well (although to a lesser extent than in 2015). To identify additional and/or alternative approaches to reducing nutrient flows in the Ohio Lake Erie basin, we performed a scan of 32 other water basin programs in the US. That scan led us to perform more detailed investigations of three programs: the Chesapeake Bay Program (CBP), the Long Island Sound Study Program (LISS), and the Tampa Bay Estuary Program (TBEP). Our investigations of these programs revealed policy tools in all four categories identified above, and a number of them were similar to policy tools identified in the Ohio Lake Erie basin.

However, we also identified multiple policy tools used in these three other water basins that do not appear to be used in Ohio's Lake Erie basin. Indeed, we identified policy tools other than those found in the Ohio Lake Erie basin that fell into all four of Hood's categories. We identified ways in which regulatory interventions in these other jurisdictions extend beyond those in place in Ohio, potential additional sources and targets of funds for expenditure, and additional mechanisms for strategic planning and communications. However, perhaps the greatest difference we encountered between policy tools used in the Ohio Lake Erie basin and the other three water basins we investigated in some detail lied in the organizational framework used for harnessing resources and managing multiple nutrient reduction efforts.

In all three of the other water basin programs we investigated in some detail, we were able to identify a clearly defined organization that manages nutrient reduction efforts on an interjurisdictional basis. In each of these cases, that organization appears to: 1) facilitate the implementation of nutrient reduction efforts;2) help ensure a scientific basis for understanding the impacts of societal activities on nutrient loads and ambient water quality conditions, and; 3) implement means for tracking and measuring progress in implementing nutrient reduction efforts and achieving ambient water quality goals.

Based on these findings, we offer potential ideas for strengthening existing nutrient reduction policy responses in the Ohio Lake Erie basin. We present some ideas that are based on our inventory of Ohio Lake Basin nutrient reduction efforts. These ideas focus on next steps or alterations in current policies or practices that hold the potential to enhance their effectiveness and/or provide greater confidence that feasible steps for controlling nutrient flows to Lake Erie are being fully implemented.

We also offer ideas on additional policy tools that might be used to help further reduce nutrient loads to Lake Erie. These ideas emerge from our reviews of policy tools being used in the Chesapeake Bay, Long Island Sound, and Tampa Bay areas. They include a number of policy tools, such as (but not limited to):

- required nutrient management plans and inspections for smaller agricultural operations
- state impairment designations and TMDL requirements
- water quality trading policies
- budget surplus set-aside policies to fund water quality improvements, and;
- state and local fertilizer use regulations and initiatives.

We suggest that all of these policy tools -- and others -- are worthy of further investigation and consideration for adoption in the Ohio Lake Erie basin, and potentially in other jurisdictions as well.

Overall, while current efforts to build multi-jurisdictional agreements to reduce nutrient flows to Lake Erie are important, they are likely to be effective over the long term only if they are accompanied by integrated efforts to understand current nutrient reduction efforts, enhance them in effective ways over time, and develop multi-jurisdictional tracking and accountability structures necessary to measure progress. Our reviews of other water basin programs addressing nutrient related concerns in the US demonstrate that this kind of organizational framework for nutrient reduction efforts is possible. This kind of organizational approach, and other policy tools used by these and other water basin programs, provide useful ideas that can be used to help improve upon current policy responses to HABs and nutrient enrichment in Lake Erie. Our hope is that this report contributes to productive dialogues and concrete progress in these areas.

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Listing of Tables and Figures

I. Acronym Dictionary

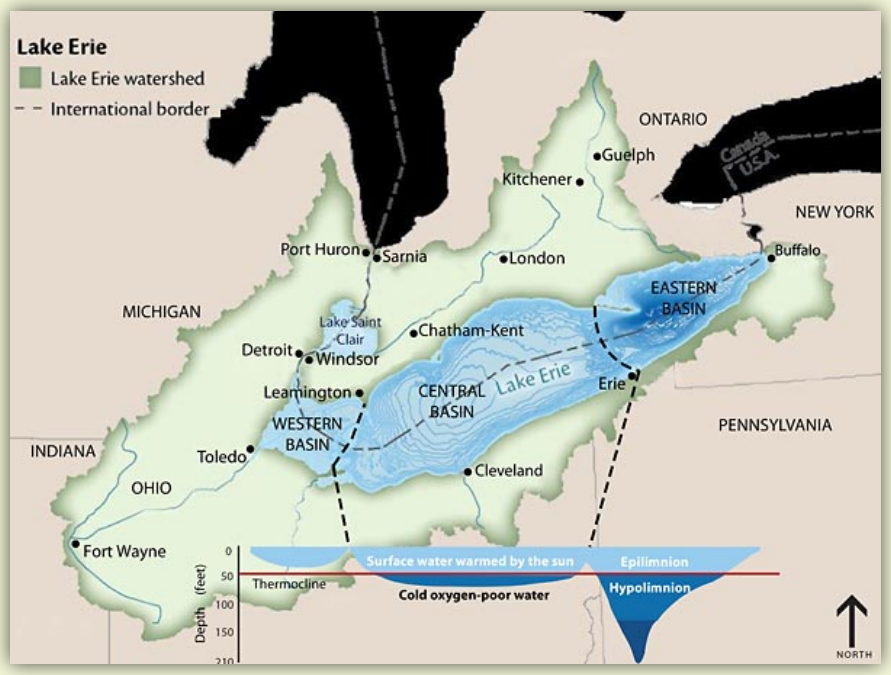
Acronym	Definition
AOC	Area of Concern
APAP	Agricultural Pollution Abatement Program
BMP	Best Management Practice
CAFF	Concentrated Animal Feeding Facility
CAFO	Concentrated Animal Feeding Operation
CBP	Chesapeake Bay Program
CCMP	Comprehensive Conservation and Management Plan
CELCP	Coastal and Estuarine Land Conservation Program
CMAG	Coastal Management Assistance Grants
CPE	Coastal Program Enhancement
CREP	Conservation Reserve Enhancement Program
CSO	Combined Sewer Overflow
CTDEP	Connecticut Department of Environmental Protection
CWA	Clean Water Act
DO	Dissolved Oxygen
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
GLC	Great Lakes Commission
GLC-LENT	GLC – Lake Erie Nutrient Targets (working group)
GLNP	Great Lakes National Program
GLNPO	Great Lakes National Program Office
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement
HAB	Harmful Algal Bloom
IJC	International Joint Commission
LaMP	Lake-wide Management Plan
LEEP	Lake Erie Ecosystem Priority
LISS	Long Island Sound Study Program
LWCF	Land and Water Conservation Fund
MDE	Maryland Department of the Environment
MGD	Million gallons per day
MS4	Municipal Separated Storm Sewer
N	Nitrogen
NEIWPCC	New England Interstate Water Pollution Control Commission
NEP	National Estuary Program
NOAA	National Oceanic and Atmospheric

	Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Source Pollution
NYCDEP	New York City Department of Environmental Protection
OCMP	Ohio Coastal Management Program
ODA	Ohio Department of Agriculture
ODNR	Ohio Department of Natural Resources
ODSA	Ohio Development Services Agency
OEPA	Ohio Environmental Protection Agency
OEPA-DEFA	OEPA Division of Environmental and Financial Assistance
OLEC	Ohio Lake Erie Commission
OPWC	Ohio Public Works Commission
OSG	Ohio Sea Grant
OWDA	Ohio Water Development Authority
P	Phosphorus
POTW	Publicly Owned Treatment Works
RCPP	Regional Conservation Partnership Program
RMP	Resource Management Plan Program
SRP	Soluble reactive phosphorus
SWCD	Soil and Water Conservation District
SWIF	Surface Water Improvement Fund
SWMP	Storm Water Management Permit
TBEP	Tampa Bay Estuary Program
TBNMC	Tampa Bay Nitrogen Management Consortium
TMDL	Total Maximum Daily Load
US	United States
USDOI	United States Department of Interior
USEPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USDA-FSA	USDA – Farm Service Agency
USDA-NRCS	USDA - Natural Resources Conservation Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USNPS	United States National Park Service
VDCR	VA Department of Conservation and Recreation
VDEQ	Virginia Department of Environmental Quality
WIP	Watershed Improvement Plan
WLA	Waste Load Allocation
WPCLF	Water Pollution Control Loan Fund
WQIF	Water Quality Improvement Fund
WRRSP	Water Resource Restoration Sponsorship Program
WWTP	Waste Water Treatment Plant

II. Introduction

In 2014, pollutants from a harmful algal bloom (HAB) in the western basin of Lake Erie contaminated the City of Toledo's water supply. For days, citizens of northwestern Ohio who had relied on Toledo's water supply were forced to find other means of accessing water for consumption and other uses. While the problem in Toledo was significant and severe, it is not unique. Harmful algal blooms stemming from what some observers have called "cultural eutrophication" are becoming more common (Greening et al, 2014). Other observers are finding that changes in climate appear to be raising water temperatures in lakes across the globe, thus creating conditions ripe for the development of HABs in water bodies on both nationwide and global scales (O'Reilly et al, 2015). As a result, policymakers and natural resource agency officials are seeking ways to reduce nutrient loads which give rise to HABs in the Lake Erie basin, and what we learn from the Lake Erie effort is likely to be of interest elsewhere.

This report seeks to inform these nutrient reduction efforts. We present an inventory of policy tools being used in the Ohio portion of the Lake Erie basin to reduce nutrient flows to the lake. We also share the results of an effort to identify and review nutrient reduction efforts being carried out by other water basin management programs in the United States (US). To guide our comparison of policy tools used in the Ohio Lake Erie basin with those used in other US water basins, we use a "policy tools" framework developed by Christopher Hood (1983) several decades ago. We also use our inventory and the information gained from our review of other American water basin programs to offer suggestions for policymakers and public administrators to consider regarding additional policy tools they may want to use in addressing excess nutrient enrichment problems in the Lake Erie basin.



- The Lake Erie Basin (USEPA, 2016)

III. Background

In this section, we overview problems associated with nutrient enrichment and HABs in Lake Erie and summarize key policy responses since the closure of the Toledo water supply in 2014. We also offer a brief review of Christopher Hood's (1983) "policy tools" framework for understanding public sector interventions to address societal problems. We use Hood's framework to organize our inventory of policy tools for reducing nutrient flows, and to structure our discussion of policy tools that could be used to address nutrient enrichment in the Ohio Lake Erie basin.

Harmful Algal Blooms in Lake Erie and Recent Policy Responses

In recent years, Lake Erie has been experiencing symptoms of eutrophication resulting from excess flows of nutrients from agricultural and urban sources. One of the consequences of this nutrient enrichment is the occurrence of large Harmful Algal Blooms (HABs) in Lake Erie – particularly in its western basin. A HAB is any large increased density of algae that is capable of producing toxins (Ohio Sea Grant, 2011). These blooms have received significant attention in recent years, with a (formerly) record-breaking bloom occurring in Lake Erie in 2011. That algal bloom extended from the western basin of Lake Erie near Toledo to the central Lake Erie Basin past the City of Cleveland. In 2014, toxins from a HAB near Toledo were detected in the city's public water system, which uses Lake Erie to supply water for several hundred thousand people in the Toledo area. This contamination, as noted above, resulted in interuptions in the use of water from the city's public water system. Yet another record-breaking HAB spread across Lake Erie in 2015 (Associated Press, 2015). In addition to HABs, excess nutrients have also resulted in anoxic zones within the lake, and nuisance levels of Cladophora[1] (Great Lakes Commission (GLC), 2015).

Excess nutrients and HABs are the result of loadings and elevated concentrations of two key nutrients, phosphorus and nitrogen. Both of these nutrients result from non-point sources, such as agricultural operations and urban storm-water, as well as point-sources of nutrient pollution which flow through discrete pipes or conveyances such as wastewater treatment plant outfalls, Combined Sewer Overflows (CSOs) outfalls, and other sources (OSG 2011, IJC 2014, Ohio Phosphorus Task Force 2013, and the GLC, 2015). HABs have four primary negative impacts (Zingone and Enevoldsen, 2000):

- Risks for human health – Cyanobacteria can produce diverse neurotoxins (such as microcystins[2]) that can harm humans and pets;
- Stresses on living marine resources;
- Negative effects on tourism and on the recreational use of coastal areas, and;
- Damage to the marine ecosystems (can exhaust oxygen supplies).

Phosphorus is the nutrient which is scarce enough in the Lake Erie environment that the growth of plants or algae is directly tied to its abundance (OSG, 2011.) As a result, much of the response to the HAB issue

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[1] Cladophora are true algae (unlike the cyanobacteria that create HABs) that can also create large algal blooms. These blooms can be a nuisance and also cause environmental problems. However, they do not produce toxins associated with HABs (OSU Sea Grant, 2011)

[2] Microcystin is a toxin produced by certain HABs and was the toxin detected in Toledo's public water system in 2014.

has focused on limiting phosphorus loads to Lake Erie. There is also discussion regarding the roles of total phosphorus and dissolved phosphorus in producing HABs in Lake Erie, and informed sources have pointed out that dissolved phosphorus – and particularly soluble reactive phosphorus (SRP), which refers to a method of quantifying orthophosphate – is of particular concern. This is because orthophosphate is bio-available, which means it is the most available form of phosphorus to support algal growth in Lake Erie (Lake Erie LaMP, 2011). In other water bodies, particularly in coastal waters, nitrogen can be the nutrient of greatest concern. However, scholars have also pointed out that nitrogen also plays a role in the development of HABs in Lake Erie (Heath, 2015).

While phosphorus can come from many sources, agricultural operations are reported to be the major source in the Western Basin of Lake Erie (Ohio Phosphorus Task Force, 2013; IJC, 2014; Lucas County Board of Commissioners, 2015). For example, experts have tied the large 2011 algal bloom to agricultural runoff and heavy rains (Michalak et al, 2013). Experts also point out that nutrients emanating from wastewater treatment plants and other urban sources also contribute to nutrient flows to Lake Erie (IJC, 2014; OSG, 2011; GLC, 2015).

- Harmful Algal Bloom (NOAA, 2009)

One recent study also linked climate change to increased lake temperatures globally, and the authors note increased toxic algal blooms are a likely consequence of such warming (O'Reilly et al, 2015). Another recent study referred to "cultural eutrophication" as a societal phenomenon characterized by "a process in which human activities in the watershed and air-shed lead to increased nutrient influxes … water bod(ies), producing levels of over-fertilization that stimulate undesirable blooms of phytoplankton and macro-algae (Greening et al., 2014)." Studies like these suggest that the problems associated with nutrient enrichment and HABs are national and global in scale and will require intensive ongoing management in multiple locations. In this sense, the Toledo water supply crisis of 2014 provides a "wake-up call" regarding the impacts of "cultural eutrophication", as well as an opportunity to explore ways in which policymakers can address a common and growing environmental and water quality problem.

Following efforts to bring in water from external sources to meet immediate needs in Toledo in August of 2014, there were additional policy responses. At the state level in Ohio, these responses included the repurposing of funding from agencies such as Ohio's Environmental Protection Agency (OEPA) and Department of Natural Resources (ODNR) to provide monies to reduce nutrient pollution through the Ohio Clean Lakes Initiative (Ohio Clean Lakes Initiative, 2014). Ohio also provided an additional $2 million in research monies to water researchers in its universities to improve our understandings of HABs

in Lake Erie and ways they can be addressed. The state has also developed new legislation (e.g. Senate Bill 1) and regulations to prohibit the use of agricultural fertilizer on frozen ground, saturated soil, or during certain weather conditions in the western Lake Erie basin and to further investigate nutrient discharges from certain POTWs. Recently enacted state legislation on nutrient discharges from POTWs, for example, requires all major Publically Owned Treatment Works (those with a discharge of over 1 million gallons a day) to monitor both total phosphorus and dissolved reactive phosphorus, and also requires those not subject to a phosphorus limit to complete a study evaluating the technical and financial feasibility of reducing final effluent discharge of phosphorus to one milligram per liter (OLSC, 2015). In June of 2015, Ohio also signed an agreement with Michigan and the Canadian Province of Ontario to reduce phosphorus loads to Lake Erie by 40% by 2025 (Higgs, 2015).

The federal government has also been active in attempting to reduce nutrient flows to Lake Erie and the other Great Lakes through the Great Lakes Restoration Initiative (GLRI), and other existing grant programs from federal agencies such as the US Department of Agriculture (USDA), the USEPA, and the National Oceanographic and Atmospheric Administration (NOAA). For example, the USDA has made an investment to combat nutrient runoff in the Western Basin through the Regional Conservation Partnership Program (RCPP). The RCPP is funding an effort to promote coordination between USDA-NRCS and local partners within the Tri-state Western Basin of Lake Erie (Harden, 2015). Through this partnership effort, $17.5 million will be available to farmers in Lake Erie's Western Basin to implement nutrient reduction BMPs (Ohio Clean Lakes Initiative, 2016).

Also, the US federal government has been involved in ongoing international processes to coordinate nutrient reduction efforts between the US and Canada via the Great Lakes Water Quality Agreement (GLWQA), which was last updated in 2012. Annex 4 of the GLWQA defines a process for addressing nutrient problems in the Great Lakes generally, and in Lake Erie in particular. As the shallowest of the Great Lakes, Lake Erie is particularly susceptible to ill-effects from nutrients and HABs. Annex 4 recognizes three GLWQA goals in regard to phosphorus loadings to the lake, and they focus on minimizing hypoxic zones in the lake, maintaining algal species consistent with healthy aquatic ecosystems in near-shore waters, and maintaining cyanobacteria biomass at levels that do not pose threats to humans or the ecosystem (GLWQA, 2012). To meet these goals, the GLWQA Annex 4 Subcommittee recommended a 40% reduction in total phosphorus loads flowing to the western and central basins of Lake Erie and a 40% reduction in total phosphorus loads from key watersheds in the Lake Erie, including the Maumee River basin which discharges to Lake Erie not far from the City of Toledo.

In February of 2016, the U.S. and Canadian Governments made the 40% phosphorus reduction target an official goal of both nations (USEPA, 2016a). Over the next few years, the two countries plan to use agreed upon mechanisms in Annex 4 of the GLWQA to develop loading allocations to meet this targeted level of phosphorus reduction and to instigate Domestic Action Plans in an effort to achieve the needed reductions. These domestic action plans are expected to define steps to be taken to reduce nutrient loads consistent with the loading allocations made through the Annex 4 process.

While the policy responses described above meet the immediate political need to demonstrate action, they are not likely to fully address the nutrient enrichment and HAB problems facing Lake Erie. This is because the policy responses to date establish symbolic agreements regarding goals, and incremental changes to existing investments and water quality requirements. Without continuing changes in policies and practices, the efforts to date may amount to little more than symbolic politics (Edelman, 1973).

To our knowledge, there has not yet been any significant and comprehensive effort to take stock of the nutrient reduction strategies and tools currently in place (in addition to the recent policy responses described above), and/or to assess their adequacy for the nutrient reduction tasks at hand.[3] The inventory and assessment of nutrient control efforts in Ohio's Lake Erie basin that we present here represents an initial step in this kind of effort.

Policy Tools and Transfers

When one inventories public policies, it is useful to have a framework to aid in understanding the types of policies that are in place and the kinds of additional policy interventions that could be used to achieve one's policy goals. Several decades ago, Christopher Hood (1983) asked scholars and observers to look at government as a set of tools or instruments "which have to be continually drawn upon, combined in various mixes and applied to …. tasks which modern government is (or feels) called upon to undertake." (Hood, 1983, p. xi). We use Hood's framework in presenting the results of the inventory efforts we have undertaken, and to help guide our thinking about additional policy tools that can be considered for addressing nutrient enrichment and the HAB problem in Lake Erie.

Hood (1983) identified four major "resources" of government and argued that each of these resources could be used to "detect" information about what is going on in society and to "effect" the outside world. By looking at government as a set of tools to "detect" and "effect", he suggested, one can gain an enhanced understanding of what government does and the ways in which it interacts with citizens and addresses problems that affect them.

Perhaps not surprisingly, one of Hood's resources of government is "authority", and this refers to "possession of legal or official power" (Hood, p. 5). This resource has traditionally been viewed as the defining property of government (Hood, 1983, p. 5), and it enables government to demand, forbid, guarantee, and/or adjudicate." (Hood, 1983, p. 5). While authority is perhaps the defining tool of government, it is also a tool which may engender controversy because it can restrict liberties and impose burdens on groups and individuals in society.

The second of Hood's resources is "treasure", which refers to money as well as other resources that may be freely exchanged (Hood, 1983, p. 5). Here, government may use its power to collect resources and exchange them in an effort to detect what is going on in society and effect changes within it.

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[3] As we proceeded with this research, we did uncover a Great Lakes Commission (2012) study that reviewed nutrient reduction programs in place in Great Lakes states and provinces, but it did not deal with efforts in the Ohio Lake Erie basin specifically. In addition, it did not specifically compare nutrient reduction efforts for Lake Erie with those in place elsewhere in the country. As such, we used it to inform our project efforts. We also reviewed a recent report commissioned by the Lucas County Board of Commissioners that focused on reviewing the legal tools available to address water quality issues at the state and federal level in Ohio (Lucas County Board of Commissioners, 2015). This report also looked to legal tools in the Chesapeake Bay as a source of potential learning. We build on the foundation produced in the Lucas County report by drilling further into the nutrient reduction programs in Ohio and elsewhere to better understand the outputs of the programs in Ohio as well to get a better sense of what programs are being implemented elsewhere that are not currently being implemented in Ohio.

A third resource of government according to Hood (1983, p. 4) is "nodality", which denotes "the property of being in the middle of information or a social network (not necessarily dead centre)." According to Hood, "nodality" means that government may be in a position to be perceived as a figurehead of central importance and may be in a position to be particularly aware of multiple factors, players or considerations (Hood, 1983, p. 4). As a "credible" figure-head dealing information, government is in a strategic position to craft messages to, and receive messages from, the citizens it serves.

The fourth of Hood's resources of government is "organization". This refers to "the possession of a stock of people with whatever skills they may have (soldiers, workers, bureaucrats), land, buildings, materials and equipment, somehow arranged" (Hood, p. 6). It reflects the ability of government to marshal resources to accomplish the policy goals it establishes.

To improve the readability of this report, we interpret these categories as "regulatory interventions", "expenditures of funds and resources", "government strategies, plans, and communications", and "organizational resources and capacities". According to Hood, all four of these resources provide government(s) with different capacities that can be "spent" in different ways. In this sense, the "tools of government" become the means by which governments choose to spend these four resources and the capacities that are associated with these means.

While Hood and others (Peters and Van Nispen, 1998; Salamon, 2002) have sought to understand the "tools" of government, others have sought to understand the sources of policy innovation. Berry and Berry (2014), for example, argue that policy innovation stems from two sources: 1) internal determinants within the jurisdiction considering a policy change and; 2) the diffusion of policies across jurisdictional boundaries. Internal determinants come in a variety of forms, but Berry and Berry (2014) suggest that they include motivational factors affecting the desire to adopt a new policy (problem severity, public opinion, electoral competition etc.), resources and obstacles to policy change (wealth, legislative and administrative capacities, etc.), and other policies which may have complementary, contingent, or substitutive relationships with the policy being considered.

The second source of policy innovation cited by Berry and Berry (2014) is the transfer of policies across jurisdictions, which they suggest are generated by a different set of causal dynamics. Drawing from previous work in policy diffusion, they suggest that cross-jurisdictional policy transfers arise because of learning processes, imitation, normative pressures, competition, and/or coercion.

What is missing from these discussions of policy innovation and policy transfer, however, is a normative framework. When *should* policies be transferred across jurisdictional boundaries? What criteria should be used in deciding whether particular policy tools should be transferred from one jurisdiction to the next? The policy innovation and transfer literature does not appear to be particularly well developed on this rather fundamental question. Policymakers and practitioners appear to be left to struggle with this set of questions on their own.

IV. Approach and Methods

In order to inform discussions regarding policy tools to reduce nutrient flows to Lake Erie, this research effort seeks to inventory current nutrient reduction policies being used in Ohio's Lake Erie basin. It also seeks to identify nutrient reduction policies and practices used in other American basin-wide water quality programs that might be productively applied in Ohio. As such, our data collection efforts focused on compiling information on the extent and nature of nutrient reduction efforts in Ohio's Lake Erie basin and on investigating policy tools used by other American watershed management programs.

Inventorying Current Efforts to Reduce Nutrient Flows in the Lake Erie Basin

To develop an inventory of nutrient control efforts in the Lake Erie basin of Ohio, we sought to identify and document use of nutrient control efforts in the State of Ohio generally, and in the Lake Erie basin in particular. To do so, we used Hood's policy tools framework as a guide and sought to identify exercises of government regulatory authorities, expenditures of funds and resources, key strategy, planning, and communication efforts such as guidance and information provided by governing organizations, and organizational resources, capacities, and initiatives.

We searched for data and information in these areas through multiple searches on Ohio government agency websites and interviews with officials who are knowledgeable regarding nutrient reductions efforts in the state of Ohio. Our efforts took place over a period of approximately one year in duration and included searches of website material posted by the following federal and state agencies: US Environmental Protection Agency (USEPA); US Department of Interior (USDOI); US Department of Commerce – National Oceanographic and Atmospheric Administration (NOAA); US Department of Agriculture (USDA); Ohio Environmental Protection Agency (OEPA); Ohio Department of Natural Resources (ODNR); Ohio Department of Agriculture (ODA); Ohio Development Services Agency (ODSA); Ohio Public Works Commission (OPWC), and; the Ohio Lake Erie Commission (OLEC).

We also sought out and interviewed multiple state and federal officials who are knowledgeable regarding nutrient control initiatives in the Ohio Lake Erie basin. Our interviews with these officials were intended to: 1) identify nutrient efforts we had missed during our web searches, and; 2) clarify our understandings of the written materials we had collected.

Investigating Other American Water Basin Programs

- Long Island Sound Study Logo (LISS, 2016)

To draw lessons from other water basin programs about ways to address nutrient enrichment problems, we sought to identify water basin management programs around the country. We then screened them in ways we thought would yield cases that would assist us in identifying lessons that would be useful in the Lake Erie watershed. To identify water basin programs in the US to investigate, we held discussions with USEPA officials and conducted independent research efforts to identify water-basin programs throughout the country. 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 USEPA'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 programs to a three-phase screening review in an effort to identify programs that were likely to yield potential useful lessons and insights for the Lake Erie watershed.

During the first phase, we reviewed websites for each of the programs involved -- along with other publicly available information -- to gain a broad understanding of the work 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.

- Chesapeake Bay Program Logo

In the second stage of the screening process, we sought to identify programs that seemed to have potential to reveal insights for addressing nutrient concerns in Lake Erie. 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? and 4) was there evidence of potentially innovative and/or effective policy or management practices being undertaken?[4] Eight programs that addressed nutrients and scored relatively highly across the three other areas were selected for further investigation.

- Tampa Bay Estuary Program Logo (TBEP, 2016)

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

[4] Our review of these programs was at least in part dependent 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 we missed water basin programs that would benefit from further investigations.

for the Lake Erie effort. Based on these further investigations, we chose three programs that appeared likely to yield useful insights for nutrient control efforts in the Lake Erie Basin. They were the Chesapeake Bay Program (CBP), the Long Island Sound Study (LISS) Program, and the Tampa Bay Estuary Program (TBEP).

We then proceeded to investigate these programs and the policy instruments they used in greater detail. These investigations involved additional interviews with program staff(s) and deeper research into secondary information sources. Throughout the process of investigating these water basin programs, we inventoried nutrient control policies and management strategies with particular focus on approaches that we did not see being implemented in the Ohio Lake Erie basin.

LIMITATIONS

As is often the case in policy-related studies, our methods are subject to limitations which affect both the conclusions we can reach and areas for further research and investigation. First, time and resource limitations -- as well as our reliance on publicly available documents and interviews -- mean that we cannot guarantee that we have identified *all* current nutrient reduction efforts in the Ohio Lake Erie basin. However, we did spend a good bit of time collecting data and information, so we believe that we were able to identify most – if not all – significant public sector nutrient reduction efforts being undertaken in the Ohio Lake Erie basin area.[5]

Second, while the other water basin management programs we investigated in some depth all focused on nutrients, they were different than the Ohio Lake Erie basin efforts in other respects. The watersheds differed in size, so policy tools which vary in effectiveness or utility based on size might not transfer well to water basins with differing size characteristics. The watershed basin programs we investigated also differed in the nature and extent of cross-jurisdictional work that is required to coordinate nutrient reduction efforts. Tampa Bay is wholly contained in Florida, while both the Chesapeake Bay and the Long Island Sound Study Programs require coordinated efforts across state governments. Our initial focus in this work is on the Ohio Lake Erie basin, which is wholly contained in one state, but it is also a part of a larger multi-state and cross-national coordination effort, so the multi-jurisdictional characteristics of the watershed programs assessed do vary across the water basins investigated. This additional complexity should be kept in mind as alternative policy tools are assessed, evaluated, and/or implemented in the Lake Erie basin.

In addition, while all three of the other programs we assess seek to address nutrients, they are all associated with salt water receiving waters which may be characterized by greater relative concern about nitrogen than phosphorus (at least in comparison to the fresh water Lake Erie case). However, nitrogen and phosphorus often come from similar kinds of sources and activities[6], so policy tools addressing one of

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[5] However, we should point out that, due to limitations on the availability of geographically available information, we were limited to statewide information on some nutrient reduction programs in the Lake Erie basin. This was particularly true for agricultural programs, which are subject to limits on data availability due to statutory provisions in the federal "Farm Bill" law.

[6] However, it is appropriate to recognize that nitrogen and phosphorus may behave differently in terms of the ways in which they may be transported to surface waters.

these pollutants may often apply to efforts to address the other as well. Collectively, though, the differing characteristics of the watersheds investigated means that factors influencing the effectiveness of policy tools and their utility in the Lake Erie basin are potentially confounded by other differences across the watersheds investigated.

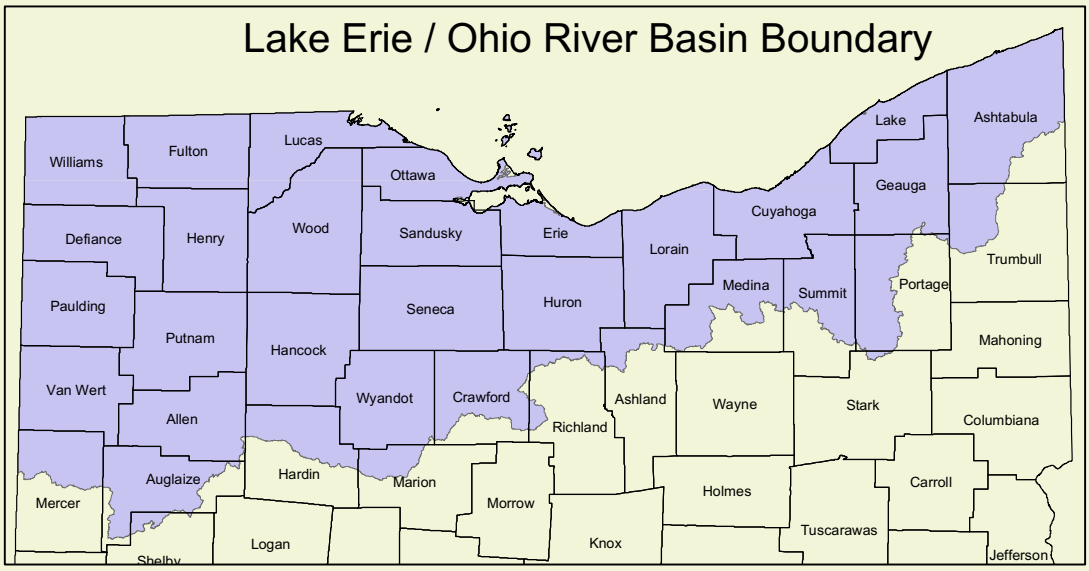
Third, while we set out with the hope of identifying information on the measured effectiveness of policy tools used in other watersheds, we did not find this kind of information available. We did, however, find watershed programs that were making substantial efforts to measure their overall progress against defined nutrient loading criteria and nutrient-related ambient water quality goals, so we chose to focus attention on those efforts in order to enable relevant learning to inform the potential development of similar efforts in the Lake Erie basin. In the end, however, these broad efforts to assess effectiveness are often not tied specifically to particular policy tools, so assessments of the likely effectiveness of differing policy tools in the Lake Erie basin are still likely to require additional research and at least some professional judgment.

In spite of these limitations, the research does develop and convey rather complete and current information on nutrient reduction efforts in the Ohio Lake Erie basin. It also presents an assessment of policy tools that are a part of broader nutrient reduction strategies which are yielding at least some level of progress in their pursuit of water quality improvement goals in other American water basins. As a result, the information presented here can enlighten policymakers and natural resource administrators on policy tools that are being used to reduce nutrient flows in other large American water basins. It can inform their discussions about addressing nutrient enrichment and HABs in Lake Erie.

V. Findings Part 1: Nutrient Reduction Policies in the Ohio Lake Erie Basin

Our investigations of nutrient reduction efforts in the Ohio Lake Erie basin, which is depicted in Figure 1, identified multiple policies in all four of Hood's (government resource) policy tool categories. We summarize key findings below.

Figure 1: Lake Erie/Ohio River Basin Boundary



- Counties within the Lake Erie Basin (OEPA, 2007).

Regulatory Interventions to Reduce Nutrient Flows From Point Sources

We identified multiple instances in which federal and state regulatory authorities are used to achieve nutrient loading reductions in Ohio. Federal authorities exist under the Clean Water Act (CWA) which require point source dischargers of pollutants to waters of the US to obtain a regulatory discharge permit. However, these federal requirements are administered by state agencies in Ohio (and elsewhere as well). To understand regulatory controls for nutrients in Ohio, we thus investigated National Pollution Discharge Elimination System (NPDES) point source permits issued pursuant to the federal CWA, as well as state requirements which apply to releases of nutrients to Ohio waters.

We investigated three kinds of NPDES regulated point source discharges: 1) traditional NPDES permits for facilities discharging wastewaters from sewage treatment facilities and industrial/commercial processes; 2) permits for addressing storm-water discharges from separated and combined sewer systems,

and; 3) potential releases from Concentrated Animal Feeding Operations (CAFOs), which are treated as point sources under the CWA.[7] We share findings regarding nutrient controls currently in place in these three areas below.

Traditional Wastewater Permits

Under Ohio law, NPDES permits in Ohio are issued by the OEPA. 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. Some of these wastewater streams contain nutrients such as phosphorus and nitrogen, while others do not. Because of the organic material contained in human and animal waste, Publicly Owned Treatment Works (POTWs) – which discharge domestic sewage -- have nutrients in their wastewater streams. Industrial and commercial wastewater dischargers, by contrast, may or may not have nutrients in their wastewater streams, depending on the nature of the economic activities in which they engage.

Our review of NPDES wastewater discharge permits listed on the OEPA website in 2015 found that the agency has issued a total of 1,138 NPDES permits for wastewater discharges in the Lake Erie basin[8]. Of these permits, 102 are considered major permits which USEPA and OEPA define as those governing discharges 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 (USEPA, 2016b). The remaining 1,036 permits are considered minor permits, which do not have these characteristics of concern. The information in Table 1 highlights that out of the 102 OEPA major permits in the Lake Erie Watershed, 83 permits (81%) have effluent limits on at least one nutrient (Nitrogen and/or Phosphorus[9]). More specifically, there are 64 major permits (63%) that have effluent limits for both nitrogen and phosphorus, 15 (15%) major permits that have Phosphorus limits only and 4 (4%) major permits have the Nitrogen limits only. There are 19 (19%) major permits that do not appear to have any nutrient limits at all.

Table 1 also highlights the 1,036 minor permits within the Lake Erie Watershed. Of the minor permits, 576 (56%) have Nitrogen limits, but no Phosphorus limits. There are 434 (42%) minor permits that appear to have no nutrient limits whatsoever.

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[7] For all three of these types of point source permits, we investigated current permits in Ohio and the Lake Erie basin, using information available through state agency sources and – in most cases – these sources are available through the websites of the agencies involved. Where needed, we sought clarifications regarding the written information provided from agency staff persons who are knowledgeable regarding the information being investigated.

[8] 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 as of 2015, and are likely to change over time. The procedures used to identify NPDES permittees in the Ohio Lake Erie watershed and to investigate NPDES permit requirements are described in Appendix 2.

[9] The NPDES permits with limits on Phosphorus that we encountered during our review had limits on Total Phosphorus. We did not notice limits for Dissolved Reactive Phosphorus. For ease of presentation, when we use the term Phosphorus in the context of an NPDES permit it refers to Total Phosphorus.

Monitoring of nutrient levels in wastewater effluent provides crucial information about daily, seasonal and event based changes in the flow of nutrients to receiving waters, and permits often contain monitoring requirements to support both compliance assessment for existing nutrient limits and/or to identify cases where nutrient limits should be added to a permit or revised. Table 1 shows that out of the 102 major permits in the watershed, 82 (80%) permits have nutrient monitoring requirements for both Nitrogen and Phosphorus, with 1 and 4 permits with only phosphorous and nitrogen monitoring, respectively. There are 15 permits (15%) with no monitoring requirements for nutrients.

Regarding monitoring requirements for the 1,036 minor permits in the watershed, 313 minor permits (30%) have nutrient monitoring requirements for both Nitrogen and Phosphorus, and 280 minor permits (27%) have no monitoring requirements for nutrients. There are 404 minor permits (39%) with only Nitrogen monitoring and 39 minor permits (4%) with only Phosphorus monitoring.

Table 1[10]
Nutrient Controls in Lake Erie Water Basin NPDES Permits

		Majors	Minors	Total
# of Permits		102	1036	1138
Nutrient Effluent Limits				
	P or N (Any)	83	602	685
	P and N Limits	64[11]	22	86
	N Limits only	4	576	580
	P Limits only	15	4	19
	No nutrient limit	19[12]	434	453
Monitoring Requirements for nutrients in effluent				
	P or N (Any)	87	756	843
	P and N Limits	82	313	395
	N Monitoring only	4	404	408
	P Monitoring only	1	39	40
	No effluent monitoring for nutrients	15	280	295

[10] The figures reported for minor permits differ in this final report from the Final Progress Report submitted to the OSU Water Resources Center in May 2016 because our final quality control process found that 10 of the minor permits were for CAFOs, and were removed from the table. Information on CAFO permits are discussed further below.

[11] Of the 64 major permits listed as having both P and N limits, three did not list nutrient limits in the Final Outfall portion of the permit, but had limits listed for other process points. A review of their fact sheets confirmed that the three plants do indeed limit, treat, and monitor both P and N. All three facilities are POTWs.

[12] Among these 19 major permits without nutrient limits, 11 permits are for various industrial facilities, 7 are for Power Plant facilities and 1 permit is for an Oil Refinery.

While the lack of effluent limits and/or monitoring requirements may seem questionable to those concerned with nutrient flows to Lake Erie, it is useful to remember that not all wastewater streams contain organic material that leads to nutrient discharges. As a result, it is likely that some of the commercial and industrial facilities that have NPDES permits – such as certain kinds of manufacturing facilities, for example – may not have significant nutrient content in their wastewaters.

For this reason, we focused particular attention on permits issued to POTWs, which are very likely to have nutrients in their wastewaters. Table 2 shows the nutrient limits present in the major and minor POTWs within the Lake Erie watershed. All of the major POTWs limit at least one nutrient, and almost 80% (46/56, or 79%) have effluent limits for both phosphorus and nitrogen. Nine of the 56 major POTWs (16.36%) have phosphorus limits but no nitrogen limits, and 1 major POTW (1.18%) has only nitrogen limits. In the case of the minor POTWs, only 15 of the 187 minor POTWs (8%) have limits for both nutrients, and only 2 (1%) permits have only phosphorus limits. A total of 46 (25%) minor permits do not have any nutrient limits.

Table 2
Nutrient Controls in Lake Erie Water Basin NPDES Permits for POTWs

		Majors	Minors	Total
# of Permits		56	187	243
Nutrient Effluent Limits				
	P or N (Any)	56	141	197
	P and N Limits	46[13]	15	61
	N Limits only	1	124	125
	P Limits only	9	2	11
	No nutrient limit	0	46	46
Monitoring Requirements for nutrients in effluent				
	P or N (Any)	56	183	239
	P and N Monitoring	56	147	203
	N Monitoring only	0	35	35
	P Monitoring only	0	1	1
	No effluent monitoring for nutrients	0	4	4

[13] Of the 56 major permits listed as having both P and N limits, three did not list nutrient limits in the Final Outfall portion of the permit, but had limits listed for other outfalls. A review of their fact sheets confirmed that the plants do indeed limit and treat for both P and N.

While it is useful to understand the extent to which NPDES permits contain effluent limits on phosphorus and nitrogen, the content of those limits also matters. In general, more stringent effluent limits will remove more nutrients from the wastewater stream (and the Lake Erie watershed) than less stringent limits. Table 3 highlights monthly phosphorus concentration limits found in major POTW permits in the Lake Erie Basin. In general, current OEPA policy calls for total phosphorus limits of 1.0 mg/l, and this limit is based on a recommendation developed by the International Joint Commission (IJC) in 1980 (IJC, 1980). Limits on nitrogen tend to be site-specific and are based on effluent content and receiving water characteristics, so we have no standard benchmark against which to review this form of effluent limit.

Among major POTWs in the Lake Erie basin, we found that all concentration limits are at or below 1.0 mg/L[14], as was suggested by the IJC for major POTWs discharging to the Great Lakes about 35 years ago. Ten permits have more stringent limits than 1.0 mg/L, with the lowest being .60 mg/L. The remaining 44 permit limits for phosphorus are at the recommended 1.0 mg/L limit.

Table 3 – Monthly Phosphorus Concentration Limits in Major POTWs

Table 3 Stringency of Effluent Permit Limits for Major POTWS in the Ohio Lake Erie Basin	
Monthly Phosphorus Concentration Limits (mg/L)	**Number of Permits**
Over 1.0	0
1.0	44
.99-.80	1
.79-.60	9
Total	54

Source: OEPA NPDES Permits
Note: 2 major POTW permits did not contain monthly concentration limits, but had limits focused on weekly loading and maximum concentration.

Combined Sewer Overflows (CSOs) and Separated Sewer Overflows (SSOs)

Many Ohio communities have combined sewers which accept sanitary and industrial wastewater, as well as storm water runoff (OEPA, 2016). During periods of heavy rainfall, these combined sewers may exceed their capacity to treat the wastewater and storm water in their systems, and this may result in untreated wastewater leaving the system. When this occurs, a "Combined Sewer Overflow (CSO)" has occurred and this may lead to the discharge of large amounts of nutrients (and other pollutants) to the

[14] In 1980, the IJC's Phosphorus Management Workgroup recommended that WWTPs in the Great Lakes should be designed and operated so that the total phosphorus concentrations in their effluents would not exceed a maximum of 1.0 (mg/L) (IJC,1980). However, it appears as though the GLWQA itself calls for a more ambitious 0.5 mg/L goal for major POTWs in the Lake Erie water basin (GLWQA, 2012).

receiving waters. The regulation of CSO's is handled through the NPDES permitting program.[15]. As a result of federal regulatory requirements, NPDES permits in Ohio typically require communities with combined sewers to implement nine minimum control measures (OEPA, 2016). These control measures include (USEPA, 1995):

- Proper operation and regular maintenance programs for the sewer system and CSO outfalls
- Maximum use of the collection system for storage
- Review and modification of pretreatment requirements to ensure that CSO impacts are minimized
- Maximization of flow to the POTW for treatment
- Elimination of CSOs during dry weather
- Control of solid and floatable materials in CSOs
- Pollution prevention programs to reduce containments in CSOs
- Public notification to ensure that the pubic receives adequate notification of CSO occurrences and CSO impacts
- Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls

There are 72 communities in Ohio that have approximately 1,144 permitted CSOs among them (OEPA, 2016). Of the 72 communities in Ohio, many are within the Lake Erie watershed, and may therefore discharge nutrients to the Lake Erie basin when they overflow during or after major storm events. The Ohio Lake Erie Phosphorus Task Force estimated annual phosphorus loadings from CSOs at levels of about 90 metric tons per annum (MTA), which would be a relatively small percentage of the total phosphorus load to Lake Erie compared to the 5,604 MTA from non-point sources and 1,908 from all point sources (Task Force, 2010). The Task Force also noted that there are long term CSO control plans in place, which represent legally binding efforts by communities to address the issue of CSO discharges to Lake Erie (Task Force, 2013).

Relatedly, our review of 56 major NPDES permits for POTWs in the Lake Erie Basin revealed that all of them had monitoring requirements for Sanitary Sewer Overflows (SSO's), which can release untreated sewage and nutrients from separated sewage systems after major rain events.

Storm-water Permitting

Typically, storm-water that is *discharged* to waters of the US is considered a point source and requires an NPDES permit. Permittees, including municipalities and industrial entities, are required to control storm-water discharges through the implementation of Best Management Practices, or BMPs (OEPA Fact Sheet, 2013). Two main types of NPDES storm-water permits are municipal and industrial. The municipal permit program for municipal separate storm sewer systems (MS4s) includes "Phase 1" requirements, which affect municipalities that serve 100,000 or more residents. "Phase 2" requirements apply to communities with fewer than 100,000 residents (OEPA Fact Sheet, 2013). Industrial and construction stormwater permits are not characterized by this distinction based on population, and therefore they each

[15] It is worth noting that permit requirements associated with CSO control may be quite costly, and cities have resorted to litigation in efforts to reduce their financial obligations for CSO control. This can result in significant judicial influence on specific permit requirements through consent decrees (OEPA, 2016).

constitute distinct stormwater permitting categories. OEPA also operates a storm-water permitting program for construction sites to limit the negative impacts of construction activities on Ohio's waters (OEPA Factsheet, 2013).

Under the Small MS4 General Permit (Phase 2), government entities are required to develop, implement, and enforce a Storm Water Management Program (SWMPs) designed to reduce pollution discharges "to the maximum extent practicable through BMP implementation, control techniques and systems, design, and engineering methods (OEPA, 2014). The general permit requires SWMPs to include six minimum control measures (OEPA, 2014):

- Public Education and Outreach on Storm Water Impacts
- Public Involvement/Participation
- Illicit Discharge Detection and Elimination
- Construction Site Storm Water Runoff Control
- Post-Construction Storm Water Management in New Development and Redevelopment
- Pollution Prevention/Good Housekeeping for Municipal Operations

The same or similar requirements appear in Toledo and Akron's individual (Phase I) storm-water permits, which include requirements related to: public education and outreach on storm water impacts, public involvement and participation, illicit discharge program, construction program, post-construction/redevelopment program, Pollution prevention/Good Housekeeping Program, and Industrial and Related Facilities Program.

Table 4
Storm-water Permittees in Ohio Lake Erie Watershed Counties

Municipal Storm-water Permittees		Non-Municipal Storm-water Permittees	
Individual Phase I Permittees	Small MS4 Phase II General Permittees	Construction General Permittees	Industrial General Permittees
2	147	6,943	1,265

Source: OEPA General Permit Lists for Small MS4s, Construction, and Industrial.

As shown in Table 4, individual Phase 1 MS4 permits in the Lake Erie Watershed include two cities: Akron and Toledo (OEPA Storm Water Program, 2016). Government entities listed under the Phase 2 MS4 General Permit are numerous with a total of 147 within counties that are at least partially in the Lake Erie Watershed. There are also 1,265 industrial and 6,943 construction permits within those same counties.

The information on storm-water permits above shows a substantial effort to implement permitting requirements, and these requirements – if implemented – would tend to reduce nutrient loads in the Lake Erie basin. However, we did not locate information that would enable us to understand the extent to which the permit requirements are actually implemented or reduce nutrient loads in the Lake Erie basin.

Animal Feeding Operations

Certain animal feeding operations in Ohio are required to obtain permits from the ODA and the OEPA. We describe the basic requirements of these two agencies' permitting programs below. Large livestock operations, considered Concentrated Animal Feeding Operations (CAFOs), are subject to both USEPA's NPDES CAFO program requirements and the requirements of Ohio's Livestock Environmental

Permitting program. The CAFOs are considered point-sources of pollution under the federal Clean Water Act, and as a result, receive permits with limits on the nutrients that can be discharged (OEPA, 2015). Agricultural operations that are not required to obtain a permit through OEPA or ODA are subject to the state's Agricultural Pollution Abatement Rules, which are enforced by the ODA's Division of Soil and Water Conservation.

Operations that are considered Large CAFOs or Medium CAFOs that discharge or propose to discharge must apply for a NPDES Permit from the OEPA (OEPA, 2015). There are penalties for operations that fail to apply for permits but meet the CAFO definitions, and subsequently discharge during a storm event (OEPA, 2015). Medium sized operations do not need a permit unless they meet the size definition AND discharge (OEPA, 2015). Federal CAFO requirements include (OEPA, 2015):

- Prohibition of discharge from operation's production area, except in the event of a 25-year, 24-hour storm event (or 100-year, 24-hour storm event for certain new facilities) if required records are maintained.
- Development and implementation of a manure management plan that includes best management practices to protect water quality.
- Application of manure based on nitrogen and phosphorus restrictions
- Record keeping
- Submission of annual reports

Currently, the NPDES CAFO program has permitted 35 operations. However, only 15 are within the 35 counties that are at least partially within the Lake Erie Watershed.

The ODA Livestock Environmental Permitting Program shares the same requirements as the OEPA CAFO program. Operators 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 (Hall, 2015). The ODA program also utilizes the same size categories and thresholds for operations. However, the state program also includes a "Major" category. Major CAFFs have 10 times the capacity as Large CAFFs (ODA, 2015). Major CAFFs are required to get additional state and local permits above and beyond what operations in the other categories are required to obtain (ODA, 2015). There are currently 113 ODA permitted facilities within Ohio counties that are at least partially within the Lake Erie Watershed.

Expenditures of Funds and Resources to Reduce Nutrient Flows

There is ample evidence of the use of monetary assets to achieve nutrient reductions in Ohio, and we found evidence of this kind of investment across both point and non-point sources of nitrogen and phosphorus loads to Lake Erie. Indeed, we identified evidence of monetary investments to reduce nutrient loads across four federal agencies and at least six state agencies. We summarize that evidence below.

Investments in Point Source Wastewater Treatment

Ohio utilizes financial assistance programs that benefit from both state and federal funding to help local government entities address point source 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. Starting in 2015, the WPCLF offered $100 million in loans with a 0% interest rate for WWTP projects that would reduce phosphorus discharges (OEPA-DEFA, 2015). Table 5 highlights the contributions of these funds to wastewater planning and construction projects from 2010 to 2015. It shows more than $2.5 billion in investments during this time period.

Table 5
Statewide ODWA/OEPA Funding
for Wastewater Planning and Construction
2010-2015

	Funding ($)
2010	630,877,357
2011	523,441,856
2012	448,084,780
2013	413,393,127
2014	451,854,062
2015*	302,000,000
Total	2,769,651,182

Source: OWDA Annual Report 2011-2014; OEPA-DEFA 2015 Annual Report
* 2015 figure only includes WPCLF loans so it is likely an underestimate of funding provided for wastewater projects in 2015.

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At this time, we do not have information on the proportion of these funds that have been targeted toward projects in the Lake Erie watershed.

Investments in Nonpoint Source Policies and Programs

There are numerous non-point source programs being implemented that are either directly or indirectly related to controlling nutrient flows to Lake Erie. The programs applicable to the Lake Erie Watershed are presented below. They have been separated into Federal and State funded programs. It should be noted that some programs are federally funded but are implemented at the state level by state agencies.

Federally Funded Nonpoint Source Programs

Federal agencies implementing non-point source-related programs include:

- US Environmental Protection Agency (USEPA)
- US Department of Agriculture (USDA)
- US Department of Interior (USDI)
- US Department of Commerce

- LWCF Logo

USEPA implements the Clean Water Act Section 319 Grant Program, the Urban Waters Grant Program, and the Great Lakes National Program. The Clean Water Act Section 319 Program is funded and administered by USEPA, and implemented in Ohio by the OEPA. The cornerstone of Ohio's 319 programs is working with watershed groups and others who are implementing locally developed watershed management plans and restoring surface waters impaired by NPS pollution. The Urban Waters Small Grant Program is also a source of funding for reducing non-point source nutrient loads to Lake Erie. The program focuses on helping local residents and their organizations restore urban waterways (USEPA, 2015). Table 6 summarizes the funding and projects supported by these two programs in Ohio's portion of the Lake Erie Watershed.

USEPA'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. The program focuses on "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: the Maumee, Cuyahoga, and Black Rivers. The Great Lakes Restoration Initiative (GLRI) is a major source of funding for projects located within AOCs as well as other areas of the Lake Erie basin. The outputs of the GLRI funding are in Table 6.

Department of Interior agencies, such as the US Fish and Wildlife Service (USFWS) and the National Park Service (USNPS), 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 (USEPA, 2016c). The USFWS has two programs that may contribute to reducing nutrient loads from non-point sources, at least indirectly. They are:

- National Coastal Wetlands Conservation Grant Program
- North American Wetland Conservation Act

The USNPS is tasked with approving the use of Land and Water Conservation Fund (LWCF) dollars (ODNR, 2015). Since the inception of the LWCF in 1965, Ohio has received more than $140 million for the acquisition, development, and rehabilitation of recreational areas (ODNR, 2015). In Ohio, ODNR is responsible for implementing the LWCF program. The LWCF, along with the USFWS wetland programs' land acquisition efforts in the Lake Erie Basin between 2010 and 2015, are shown in Table 6.

The NOAA, in collaboration with the ODNR Office of Coastal Management, operate programs to reduce non-point source pollution to Lake Erie in Ohio. This effort is operationalized through the National Coastal Zone Management Program at the federal level and Ohio's Office of Coastal Management at the state level. There are a number of grant programs jointly operated by NOAA and ODNR, and they include (ODNR-Coastal, 2016):

- Coastal and Estuarine Land Conservation Program (CELCP)
- Coastal Management Assistance Grants (CMAG)
- Coastal Program Enhancement (CPE)
- Areas of Concern Land Acquisition Grants (AOC Acquisition)

- Property protected by the NOAA-ODNR Coastal Management Program

Two multiagency programs targeting, at least in part, nutrient reductions to Lake Erie 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 began implementation in 2010. The initiative is managed by a Task Force made up of 11 federal agencies. The GLRI is focused on four main areas (GLRI, 2014). 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.

GLRI funding for projects related to nutrients is highlighted in Table 6, along with the activities of the Sustain our Great Lakes Program. 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, Arcelor Mittal (Sustain Our Great Lakes, 2015). The program does receive a "significant" portion of its funding from the GLRI (Sustain Our Great Lakes, 2015).

- Lake Erie Bluffs, Lake County

Table 6 Federal Funding for Non-point Source Projects with Beneficial Nutrient Reduction Impacts in the Ohio Lake Erie Basin: An Overview - 2010- 2015 (excludes Farm Bill funding)										
	Environmental Protection Agency*		Department of Interior**		Department of Commerce – NOAA***		Multiple Agency Programs****		Total	
	Funding	# of Projects	Funding	# of Projects	Funding	# of Projects	Funding	# of Projects	Funding	# of Projects
2010	3,655,916	6	70,000	1	3,448,334	4	$ 24,674,244	44	31,848,494	55
2011	2,448,266	8	1,202,345	4	2,479,475	6	$ 20,465,655	44	26,595,741	62
2012	2,656,209	8	314,440	5	3,059,539	4	$ 20,731,115	45	26,761,303	62
2013	1,037,017	12	145,000	2	105,000	1	$ 20,433,962	45	21,720,979	60
2014	2,609,665	10	75,000	1	479,998	2	$ 29,957,880	53	33,122,543	67
2015	2,903,422	7	194,399	3	1,259,692	3	$ 20,245,340	12	24,602,853	25
Total	**15,638,954**	**51**	**3,001,184**	**17**	**7,756,705**	**20**	**136,508,196**	**248**	**162,906,039**	**336**

* EPA Programs include Section 319 Non-point Source grants and Urban Waters Program grants
** DOI Programs include USNPS Land and Water Conservation Fund and US Fish and Wildlife Service Wetlands Programs
***Department of Commerce-NOAA funds support for all Coastal Grant programs in this column.
****Multiple agency programs include the Great Lakes Restoration Initiative (GLRI) Program and the Sustain Our Great Lakes Program. The GLRI accounts for about 95% of the funding and Sustain Our Great Lakes funds the other 5%. Projects funded by these programs include urban and rural storm-water projects, land conservation and restoration efforts, and research/education/monitoring projects related to nutrients (this category of projects is primarily funded by the GLRI).About 15% of the projects funded by multiple agency programs were for research/education/monitoring efforts.

The USDA has a variety of programs that focus on incentivizing conservation BMPs as well as other programmatic goals. Many of these programs were created by various iterations of the Farm Bill. The 2014 Farm Bill continued or created a series of financial, technical assistance, and easement programs to support the agriculture industry in Ohio and elsewhere. We could not locate publically available watershed or county-specific data on where these funds are spent, so Table 7 highlights the statewide outputs of USDA's Farm Bill program.[16]

Table 7
USDA Program Funding and Implementation in Ohio: 2014

USDA Program*	Agency	Dollars (2014)**	Acreage receiving BMPs, Support, and/or Conservation Easements (2014)
Agriculture Conservation Easement Program	NRCS	$8.816 million	5117.6
Conservation Technical Assistance	NRCS	$10.868 million	303,078
Conservation Stewardship Program	NRCS	$6.941 million	49,717
Conservation Innovation Grants	NRCS	$.998 million***	--
Environmental Quality Incentives Program	NRCS	$24.582 million	103,744
Conservation Reserve Program****	FSA	$15.313 million	150,305
Conservation Reserve Enhancement Program******	FSA/NRCS and ODA	$22.655 million**********	116,917
Forest Legacy Program	Forest Service	$0	0
	Totals	$90.170 million	728,879

Source: Farm Bill Program 2014 Annual Financial Report Documents; USDA-FSA, 2015; USDA, 2015.
*Healthy Forest Reserve Program not included because it did not allocate funds to Ohio in 2014.
** Dollars and acreage figures are statewide numbers.
*** The $998,000 was for a multi-state grant project implemented by the National Corn Growers Association to help improve systems to foster soil health.
**** Figures reported represent current enrollment as of September 2015.
***** The funding and acreage figures are statewide figures. However, as of July 2015, 16 out of the 18 counties fully within the Lake Erie Basin have acreage enrolled in the Lake Erie CREP. There are currently 34,153 acres enrolled in those counties (USDA-FSA, 2015).

[16] However, toward the end of this project we became aware that the USDA Natural Resources Conservation Service can provide information on farm bill programs at the Lake Erie Watershed level upon request. Because this information was received at a later date we were unable to incorporate it into the report.

As shown in Table 7, the agricultural assistance programs represent a $90 million dollar a year (plus) investment in implementing conservation practices on more than 728,000 acres in Ohio. However, the data provided publically by USDA is limited as they are statewide figures (with the exception of CREP program output), and do not speak to the results of USDA's investment in terms of nutrient flow reduction and other environmental impacts.

State Funded Non-Point Source Programs

The State of Ohio funds a number of programs that directly target non-point sources of nutrient flows to the state's waters, as well as programs that indirectly help reduce nutrient flows from non-point sources. The state agencies tasked with implementing state-funded non-point source pollution reductions include:

- Ohio Department of Agriculture (ODA)
- Ohio Department of Natural Resources (ODNR)
- Ohio Environmental Protection Agency (OEPA)
- Ohio Development Services Agency (ODSA)
- Ohio Public Works Commission (OPWC)
- Ohio Lake Erie Commission (OLEC)

The state's primary program for addressing non-point pollution issues on Ohio's farms is the Agricultural Pollution Abatement Program (APAP). The program provides farmers with cost share assistance to develop and implement best management practices (BMPs), and gives the enforcing agency authority to take enforcement actions in response to complaints about agricultural pollution issues and reported violations of the Agricultural Pollution Abatement rules found in the Ohio Adminstrative Code 1501:15-5-01 to 1501: 15-5-20. The ODA Division of Soil and Water Conservation is also tasked with enforcing the updated manure appication restrictions included in Senate Bill 1. It is also the role of the ODA to enforce the Fertilizer Applicator Regulations found in Ohio Administrative Code 901:5-4. This rule requires anyone applying fertilizer on 50 or more acres of land to obtain a certification from ODA. We were unable to locate program output data for the APAP program from 2010-2015.

In January 2016, ODNR's Watershed Management program was moved to the ODA, along with the APAP program. ODNR had allocated $10,974,000 statewide in grants through the Watershed Coordinator grant program from 2009-2014 (ODNR, 2014). These grants include funding for Watershed Coordinators in the Lake Erie Basin that have prioritized nutrient reduction goals. For example, the Blanchard River effort estimates their activities have resulted in a 1271.57 lbs/year reduction in Phosphorus loadings (ODNR, 2014).

In addition to the federally funded programs that ODNR has implemented, which have been discussed above, the agency also implements Nature Works, a recreational land acquisition program. This program is similar to the Land and Water Conservation Fund in that it funds both land acquisition efforts and the creation of recreational facilities such as trails and pavilions on parkland. Table 8 highlights the program's land acquisition efforts from 2010-2015.

OEPA operates two primary state-funded non-point source pollution prevention programs in addition to the federally funded Section 319 Program. The programs are: the Surface Water Improvement Fund (SWIF) and the Water Resources Restoration Sponsorship Program (WRRSP). The SWIF program was

created in 2009 by the State Controlling Board and later codified in the Ohio Revised Code in 2012. Its requirements are tightly aligned with the USEPA's Section 319 program.

The WRRSP program is administered by the OEPA's Division of Environmental Financing and Assistance, and has been a component of the Water Pollution Control Loan Fund (WPCLF) since 2000. The program has provided $170 million for projects since its creation (OEPA-DEFA, 2014). The goal of the program is to counter the loss of ecological function and biological diversity that impact the health of Ohio's water resources (OEPA-DEFA, 2014). The program indirectly targets nutrients through land protection and restoration projects. Since 2010, there have been 56 projects within the Lake Erie 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. Table 8 includes the program's planned activities for 2010-2015.

The Ohio Development Services Agency (ODSA) also offers funding for storm-water related activities through its Green Storm-water Infrastructure Program. The program offers below-market rate loans for the design and construction of green infrastructure as a part of economic development projects (ODSA, 2015). According to the program website, government entities are able to receive up to $5,000,000 through the program (ODSA, 2015). The program was initiated in 2010, and has funded four projects statewide with $28,378,727 in loans. Only one of the four projects was in the Lake Erie Watershed ($5,000,000 loan for Shoppes at Parma storm-water infrastructure project).

The Clean Ohio Green Space Conservation Program is one of three separate Clean Ohio Funds, and it is the one that is relevant to reducing nutrient loads through habitat conservation and restoration. The Green Space program is administered by the Ohio Public Works Commission. It's program outputs are included in Table 8.

The Ohio Lake Erie Commission (OLEC) also plays a role in addressing nutrient issues. Established by the Ohio State legislature in 1997, the Ohio Lake Erie Commission is tasked with ensuring the coordination of state and local policies and programs related to the water quality, toxic pollution control, and resource protection in Lake Erie (ORC 1506.21). The Commission is also responsible for ensuring that Ohio's programs and activities related to protecting Lake Erie are consistent with the Great Lakes Water Quality Agreement (ORC 1506.21)

- Property protected in part by ODNR's Nature Works Program

The OLEC also manages the Lake Erie Protection Fund. This grant program is funded by donations and the purchase of specialty license plates by Ohioans. Grant awards of up to $15,000 each are available to finance research projects and on-the-ground activities focusing on protecting and restoring the Lake Erie watershed. A summary of the projects funded by the Protection Fund since 2010 that support "on the ground" activities relevant to controlling nutrients is highlighted in Table 8.

Table 8: State Funded Non-Point Source Program Projects within the Lake Erie Basin in Ohio 2010-2015												
	Ohio Department of Natural Resources *		Ohio Environmental Protection Agency**		Ohio Development Services Agency		Ohio Public Works Commission		Ohio Lake Erie Commission		Total	
	Funding	# of Projects	Funding	# of Projects	Funding	# of Projects	Funding***	# of Projects	Funding	# of Projects	Funding	Projects
2010	56,250	1	20,442,588	19	0	0	9,617,617	22	58,582	4	30,175,037	24
2011	12,659	1	8,374,371	8	0	0	9,617,617	23	45,000	3	18,049,647	12
2012	9,980	1	11,023,072	17	0	0	9,617,617	23	15,000	1	20,665,669	19
2013	20,000	1	12,283,570	11	0	0	9,617,617	23	45,000	3	21,966,187	15
2014	0	0	11,523,164	17	0	0	9,617,617	23	15,000	1	21,155,781	18
2015	37,463	2	8,670,404	15	5,000,000	1	9,617,617	23****	0	0	23,325,484	18
Total	**136,262**	**6**	**72,287,384**	**87**	**5,000,000**	**1**	**57,705,702**	**137**	**193,582**	**13**	**135,322,930**	**244**

Table 8: State Funded Non-Point Source Program Projects within the Lake Erie Basin in Ohio 2010-2015

Note: ODNR programs included: Nature Works; OEPA Programs included: SWIF and WRRSP. Projects include those that directly and indirectly target nutrient pollution.

* ODNR funding does not include the Watershed Coordinator grant program, which has provided $10,974,000 statewide between 2009 and 2014 (ODNR, 2014). The program was moved to ODA in January of 2016.

** Majority of the funding by OEPA is through the WRRSP program, which is an offshoot of the state's revolving loan program. The state's SRF does receive funding from the federal government, which is then pooled with state funds.

*** We were able to differentiate projects funded from 2010-2015 from those that were funded prior to that time period, but we were not able to connect projects to specific years. As an annual estimate, we have allocated the total amount into equal amounts for each year. **** Because we identified projects funded post-2010 but did not have a year by year breakout for the projects, we equally divided the 137 projects funded since 2010 by year.

Strategy, Planning, and Communication Efforts Focused on Lake Erie

We identified multiple efforts by the State of Ohio, the US federal agencies, and the international organizations with whom they work to define problems associated with nutrient flows to Lake Erie and ways in which they can be addressed. Significant efforts and documents we encountered included the following:

- Lake Erie Binational Nutrient Management Strategy (Lake Erie LaMP, 2011)
- Directors' Agricultural Nutrients and Water Quality Working Group Final Report and Recommendations (2012)
- Great Lakes Water Quality Agreement (Annex 4) (2012)
- Ohio Lake Erie Commission (2013): Lake Erie Protection and Restoration Plan
- Ohio Lake Erie Phosphorus Task Force II Final Report (2013)
- OEPA (with ODA and ODNR): Ohio Nutrient Reduction Strategy (2013)
- International Joint Commission's Lake Erie Ecosystem Priority (LEEP) Report (2014)
- Great Lakes Commission: A Joint Action Plan for Lake Erie (2015)
- US and Canada Agreement on Nutrient Reduction Targets (2016)
- State of Ohio's Western Lake Erie Basin Collaborative Implementation Plan (2016)

In most of these cases, the efforts were focused on characterizing the problem and signaling broad directions through which it could be addressed. However, in these cases, the focus was generally not on targeted communications with specific groups or individuals whose work or behaviors directly yielded nutrient flows to Lake Erie.

We did, however, encounter communications and technical assistance infrastructures that were designed to provide direct communications and assistance to members of the agricultural community. Perhaps the largest and most significant of these efforts was the Soil and Water Conservations Districts (SWCDs), which are established across the state to plan and construct Conservation Works of Improvement, and provide technical assistance on solid and water conservation issues to farmers, communities, and others across the state. There are a total of 88 SWCDs across the state and 35 of these appear to operate in the Ohio Lake Erie Basin.[17] The USDA's recently initiated RCPP program is another significant example of this kind of audience specific effort.

As we looked at the compilation of information and its transmission to government from society, we also identified multiple avenues through which various governing bodies in Ohio gained information regarding nutrients and nutrient flows. These efforts included:

- Research efforts among academic institutions such as the Ohio Sea Grant program, Heidelberg University, the University of Toledo, Kent State University, and a recent Ohio State University initiative funded in part by the Ohio Board of Regents.

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[17] The SWCDs also implement the Ohio Department of Agriculture's Pollution Abatement Program (APAP), in cooperation with ODA's Division of Soil and Water Conservation.

- Complaint based systems for identifying instances of excess nutrient flows to Ohio waterways. For example, the ODA Agriculture Pollution Abatement program has a complaint and request based system which can result in funding support and responses to technical assistance requests. The state can also take enforcement actions to address issues. Individual SWCDs also appear to receive information of various kinds as they go about their activities.

- The Ohio EPA monitors watersheds across the state on regular cycles, and compiles information relating to nutrients as a part of these efforts. The information collected as a part of these efforts is used to ascertain whether water bodies are impaired and subject to federal Clean Water Act total maximum daily load (TMDL) requirements, and it may also be used in developing regulatory requirements for dischargers who must obtained Clean Water Act discharge permits. These kinds of efforts are undertaken throughout the state, including in the Lake Erie basin.

We did not, however, identify any central location or organization to which all of this information from externally oriented efforts was compiled and integrated in ways that enabled its productive use in ongoing management of the Lake Erie watershed.[18] This is a significant point because it means that while citizens and organizations are providing information to government that is relevant to nutrient control, that information does not appear to be managed in a way that optimizes its use to target opportunities for nutrient reductions. This is a missed opportunity, and it also reflects a potential deficiency in current organizational arrangements for nutrient control.

Organization: Engaging Resources for Action to Reduce Nutrient Loads

We found ample evidence of government efforts to organize resources to achieve water pollution control goals, including nutrient reduction. Indeed, as mentioned, above we identified four separate federal agencies – USEPA, USDA, USDOI, and NOAA -- which supported nutrient reduction efforts in the Lake Erie basin in various ways. Within each of these agencies, in turn, we identified multiple programs making efforts to reduce nutrient loads in Ohio generally, and in the Lake Erie basin in particular.

We also found multiple state agencies and organizations that funded and supported efforts to reduce nutrient loads. In total, as noted above, we identified six state government organizations that were involved in nutrient reduction efforts applicable to the Lake Erie basin. And, like the federal agencies, a number of these agencies supported multiple programmatic efforts to reduce nutrient loads.

One organization, the Ohio Lake Erie Commission, which as noted above, is designed to perform a coordinating function across Ohio state agencies with Lake Erie related concerns and/or obligations under

[18] An exception to this general rule in Ohio as a whole may be the Grand Lake St. Mary's watershed, which has been declared to be "distressed" under Ohio law, and has become the subject of an intensive water quality management effort. This watershed, however, is outside of the Lake Erie water basin.

the Great Lakes Water Quality Agreement. The Commission itself is comprised of the directors of key state agencies involved addressing nutrient issues in the Lake Erie basin – the OEPA, ODOT, ODNR, ODSA, ODH, as well as key officials from private sector organizations and community planning organizations (Ohio Lake Erie Commission, 2016). However, it is a small organization with a limited staff and a limited budget, which serves primarily an advisory role to the Governor and as a means by which the state can seek to meet its obligations under the GLWQA. It is an organization that was built to advise on the development of policy, not to steer and guide policy implementation.

In addition, the ODNR's Office of Coastal Management implements the Ohio Coastal Management Program. Through this program, ODNR provides annual grant funding to support technical assistance, and manages a networked program to administer management policies[19] in a variety of areas, including water quality, ecologically sensitive resources, environmental quality, and others (ODNR-OCMP, 2016). Major partners for the program include the Ohio Lake Erie Commission, Ohio Sea Grant, Ohio Soil and Water Conservation Districts, Ohio EPA, and ODNR's Division of Wildlife (ODNR-OCMP, 2016). Through this effort, the Office of Coastal Managmeent has instituted a Coastal Resources Advisory Council, which is designed to advise the director of ODNR on coastal management laws, recommend policies and legislation, review and make recommendations to the director on the development of policies, plans, and programs for long term coastal management, and recommend ways to improve coordination among government agencies (ODNR-OCMP, 2016). The Council is made up of 19 members representing public officials from each shoreline county in Ohio, private property owners, and representatives of the land development and realty industry (ODNR-OCMP, 2016).

While the OLEC and the ODNR Coastal Management Program do provide potentially valuable forums for organizational focus in the coordination of water quality program implementation in the Lake Erie basin, the overall picture of organizational resources and tools that emerges from our investigation is one of fragmented efforts among multiple organizations that have many priority items on their respective agendas. The one organization that is fully devoted to protecting Lake Erie – OLEC -- remains a relatively small organization with limited resources, and which must rely on other organizations to act.

This picture fragmentation is further exacerbated when one recognizes that Ohio is just one of a number of political jurisdictions that have interest in the quality of water in Lake Erie and the control of nutrients that have been giving rise to HABs. Indeed, at least five American states and the Province of Ontario undertake activities which yield nutrient flows to the Lake Erie basin. Within the US, the USEPA provides coordination on Great Lakes issues across the state governments within the Great Lakes Basin through its Great Lakes National Program Office (GLNPO), and its work is shadowed in some respects by the work of the Conference of Great Lakes Governors and Premiers. Both of these organizations are located in Chicago, Illinois, and play important coordinating roles across state governments in the US. The GLNPO, for example, has assisted with the dissemination of GLRI funds, in addition to its ongoing implementation of targeted "areas of concern" programs for each of the Great Lakes. However, while the GLNPO does develop and facilitate important follow up efforts on management plans for each of the Great Lakes, it does not – at least as yet, to our knowledge -- coordinate or operate a focused program of efforts to reduce nutrient loads to the Lake Erie basin to address HABs.

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[19] Examples of policies within the "Ecologically sensitive resources" include regulations to protect wetlands, natural areas and features, and rare and endangered species.

Through the Great Lakes Water Quality Agreement (GLWQA), and the International Joint Commission (IJC) which monitors its implementation, the US and Canada have a mechanism for coordinating nutrient reduction efforts on both sides of Lake Erie. Indeed, the GLWQA itself contains "Annex 4" provisions which are now being used to coordinate the development of goals and objectives for nutrient reduction efforts across the Great Lakes, including Lake Erie. Earlier this year, Environment Canada and the USEPA, which play leading roles on the committee that has been developing targets for phosphorus reduction in Erie, announced their joint establishment of a goal of reducing phosphorus loads to Lake Erie by 40%. This same committee is now working to develop allocations across the two nations to guide their respective nutrient load reduction efforts.

VI. Findings Part 2: Learnings from Nutrient Reduction Efforts in Other Water Basins

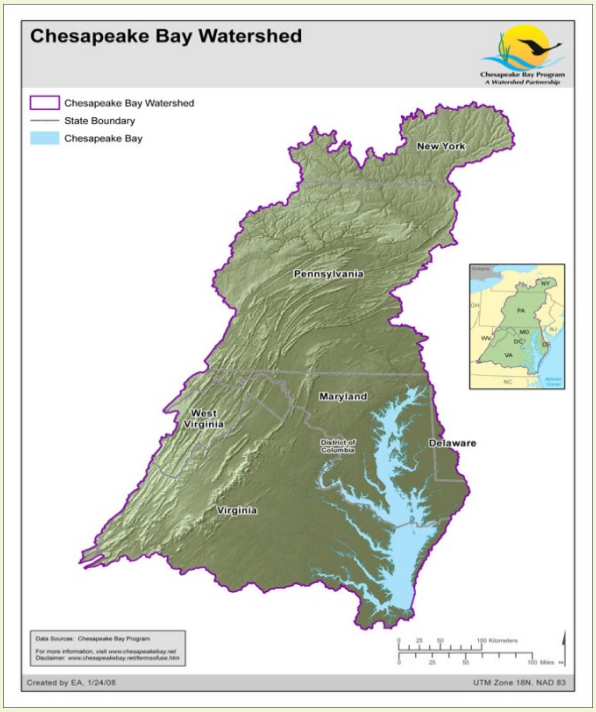
Many of the watershed basin programs we reviewed had been in place since the early 1990's or before, and they provided evidence of partnerships and strategies they had developed to pursue water quality improvement goals. Our review identified that 23 of the 32 (72%) water basin programs we screened included nutrients (nitrogen and/or phosphorus) among their pollutants of concern. However, while we were able to locate published information on water-basin plans and strategic approaches, most of the programs we investigated did not feature abundant information on water quality improvement results achieved over time or detailed information on the effectiveness of particular policy or practice tools. Indeed, we found only a handful of programs that appeared to systematically measure results and advertise specific water quality improvement data and information.

We also found varying levels of specificity in relation to information on policy and practice interventions, as well as a fair amount of overlap in the kinds of nutrient reduction policies and practices uncovered across water basin protection efforts. In many of the water-basins we investigated, we found evidence of regulatory intervention based policy instruments for point source discharges, expenditures of funds and resources to reduce nutrient loads (of nitrogen and phosphorus), government strategies, plans, and information collection and communications efforts, and the marshaling of organizational resources to achieve water quality goals. In this sense, many of the policies and practices we identified were consistent across water basins, including the Ohio Lake Erie basin. We identified multiple government efforts to communicate about the issue of nutrient enrichment and its effects. We also identified ample evidence of the issuance of NPDES permits, grants/funding for non-point source water pollution control projects, and land preservation efforts. In addition, organizational resources typically appeared to be in place to at least some degree in the programs we screened.

However, in spite of these broad similarities across many of the programs investigated, we identified several programs that appeared to focus on nutrients and do so in ways that were guided by clear nutrient reduction goals, documented efforts to measure progress toward them, and at least some evidence of progress and/or success. We found these traits in the CBP, the LISS Program, and the TBEP, and we summarize key findings about the policies and practices they appear to use in the subsections below. In each case, we briefly review the history of the program and results/progress achieved to date, and then we offer a short summary of policy tools used in the program that we did not find to be present in the Ohio Lake Erie basin.

The Chesapeake Bay Program (CBP)

A Brief History[20]:



- Chesapeake Bay Watershed (CBP, 2012)

The Chesapeake Bay watershed lies in the mid-Atlantic region of the US, and spans more than 64,000 square miles. It encompasses parts of six states—Delaware, Maryland, New York, Pennsylvania, Virginia and West Virginia—and the entire District of Columbia. For decades now, the Chesapeake Bay has endured stresses relating to the release of nitrogen, phosphorus, and sediments to the bay. Since at least the early 1980's, observers have documented evidence of nutrient enrichment (Macalaster et al 1983).

In 1983, Maryland, Virginia, and Pennsylvania – along with the District of Columbia, the Chesapeake Bay Commission, and the USEPA – signed the first of a series of Chespeake Bay Agreements, establishing the Chesapeake Bay Program Partnership (Chesapeake Bay Watershed Agreement, 2014). In 1987, the parties updated their agreement and committed to achieving a 40% reduction in nitrogen and phosphorus flows to the bay by 2000. However, in subsequent years, there was limited solid evidence that the parties were achieving these kinds of nutrient reductions and/or significantly improving water quality in the Bay. In 2000, the jurisdictions involved agreed to work together to establish targeted allocations for nitrogen, phosphorus, and sediment. They also re-affirmed an updated version of the Chesapeake Bay Watershed Agreement through which they had been operating up until that time. Shortly thereafter, in 2003, the Bay partners established loading caps of 175 million pounds a year for nitrogen, 12.8 million pounds a year of phosphorus, and an upland sediment cap load of 4.15 million tons a year with responsibilities divided up among the states by major river basin. Each of the states then developed "tributary strategies" outlining the management actions they planned to take in order to achieve their respective nutrient and sediment pollutant load reductions.

The following year, USEPA, working in close collaboration with its state partners, developed and published, on behalf of the larger partnership, a series of Chesapeake Bay specific water quality criteria for dissolved oxygen, water clarity, submerged aquatic vegetation, and chlorophyll a along with a series of designated uses for the Bay's tidal waters (USEPA, 2003). These criteria and designated uses provided a scientific foundation for updated loading reductions estimates and what was to become "the Chesapeake Bay TMDL". Maryland, Virginia, Delaware and DC adopted USEPA's water quality criteria and tidal waters designated uses into their state water quality standards, all of which were subsequently approved by USEPA. It was agreed that USEPA would develop the Chesapeake Bay TMDL, in cooperation with

[20] The historical summary material in this sub-section is drawn largely from the USEPA website, http://www.epa.gov/chesapeake-bay-tmdl/developing-chesapeake-bay-tmdl, accessed February 11, 2016.

the jurisdictions involved. In 2010, USEPA released its Chesapeake Bay TMDL, the largest TMDL developed to date in the US. In the years that followed, legal challanges arose that were subsequently resolved in federal court.[21] Designed to meet water quality standards established for the Bay, the TMDL "sets Bay watershed limits of 185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus, and 6.45 billion pounds of sediment per year – a 25% reduction in nitrogen, 24 percent reduction in phosphorus, and 20 percent reduction in sediment." (USEPA, 2010).

Progress and Results to Date

The CBP has now been in place for more than thirty years. Even so, the Chesapeake Bay remains impaired due to nutrients and sediments (MDE, 2015). In 2013, after a series of interviews and an extensive review of program documents, Layzer and Schulman concluded that "despite nearly thirty years of integrated knowledge production and planning, the watershed has seen minimal ecological improvement" (Layzer and Schulman, 2013, p. 237). Our review, undertaken two or three years later, does not fundamentally challenge this conclusion. However, it does identify more concrete and quantitative evidence of marginal improvements than are cited by Layzer and Schulman.

Since Layzer and Schulman did their work several years ago, the CBP and the states with which it works have begun implementing the Chesapeake Bay TMDL, as well as an accountability framework that was established to enable its success (described briefly below). Through this process, they have systematically reviewed information provided by the states on steps taken to reduce nutrient loads to the bay. The results of this tracking process are publicly available on the Chesapeake Bay Program website.[22] We reviewed these results in February of 2016 and found documentation of reduced nutrient loadings since the 2009 pre-TMDL base year. For 2009, Chesapeake Bay Stat reports a total nitrogen loading to the Bay of about 279 million pounds of nitrogen and about 19 million pounds of phosphorus. By 2015, it reports loadings of about 242 million pounds of nitrogen and 17 million pounds of phosphorus, respectively. These figures suggest nutrient load reductions of 13% for nitrogen and 10.5% of phosphorus. The nitrogen and phosphorus loading goals for 2015 are 207,571,430 pounds and 14,457,190 pounds, respectively, so there is still much work needed to meet the CBP's long term nutrient reduction goals (Chesapeake Bay Stat, 2016).

Longer term indicators of nutrient enrichment in the Bay also appear to show modest signs of improvement. Since 1985, nitrogen concentrations have improved at about 70% of the USGS monitoring sites in the Bay and phosphorus concentrations have improved at about 2/3 of monitoring sites (Langland, et al, 2012). Other monitoring sites have shown degrading conditions or no significant change.

There also appears to be some at least preliminary evidence that the estimated loading reductions discussed above – in combination with other past efforts -- may be having some positive impacts in the

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[21] The TMDL was challenged by the American Farm Bureau Federation, other agricultural associations, and the National Association of Homebuilders in 2011. Subsequent court rulings in 2013 and 2015 were in favor of USEPA and its partners. For more information, see USEPA-Chesapeake Bay Court Decisions (2015): https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-tmdl-court-decisions

[22] To review this system, access https://stat.chesapeakebay.net/?q=node/130&quicktabs_10=1.

bay's ecology. A recent USGS study pointed out that some living resources in the bay are showing signs of recovery, based on recent monitoring of aquatic conditions in the Bay. It reports that "underwater grass acreage has increased by 24 percent, American Shad have continued to return to their Potomac River spawning grounds, and the relative abundance of young striped bass in both Maryland and Virginia waters has recovered from low numbers seen in 2012" (CBP, 2015).

While these positive results are marginal, they are nevertheless quantified and encouraging, particularly when one recognizes the population increases in the Chesapeake Bay region over the past thirty years or so – from about 13 million in the mid-1980s to over 18 million currently (CBP, 2015). And, while the loading reductions described above are estimated based on CBP modeling simulations, the living resource improvements are based on actual monitoring efforts in the bay. For these reasons, Chesapeake Bay Director Nick DiPasquale made the following statement early in 2015:

"The Chesapeake Bay is a vast and complex ecosystem that faces continued challenges … Yet in the face of these … challenges, we are witnessing signs of a system in recovery."

While this is a statement characterized by optimism, it is nevertheless based on at least some reported signs of actual improvement, and a management system that is designed to measure and manage continuing improvements on an ongoing basis.

CBP Policy Tools: Findings and Insights

Our investigation of the CBP revealed evidence of the kinds of regulatory interventions, expenditures of funds and resources, and government strategies, plans, and information collection based policy tools that we found to be used in the Ohio Lake Erie basin. The CBP website contains multiple examples of information documents designed to inform the broad public regarding the Bay's water quality conditions and efforts being made to improve them. States in the Chesapeake Bay region also issue NPDES permits throughout the watershed and multiple sources of grant funds are used to support non-point source nutrient reduction efforts.

We did, however, find policy tools used in the CBP that we did not find in our inventory of policy tools used in Ohio's Lake Erie Basin. These tools are described briefly below, based on Hood's policy tool categorizations. Examples of these tools are also summarized in Table 9.

REGULATORY POLICY TOOLS

We identified at least four authority-based policy tools being developed and/or used in the Chesapeake Bay area that we did not encounter for the Ohio Lake Erie basin. We describe them briefly below.

<u>Regulatory-based CBP Policy Tool 1:</u> Water Quality Criteria and Standards for the Chesapeake Bay (USEPA and Delaware, Maryland, Virginia, and the District of Columbia).

In 2003, USEPA, working directly wth its state and academic partners, developed a set of Chesapeake Bay secific water quality criteria for dissolved oxygen, water clarity, and chlorophyll a, and a corresponding set offive tidal water designations. Maryland, Virginia, Delaware and the District of Columbia (DC) adopted these criteria and designated uses into their water quality standards, all of which

were subsequently approved by USEPA. These water quality standards constitute a fully consistent, 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. While Annex 4 of the GLWQA contains ambient water quality goals for total phosphorus, these goals are not (at least yet) enshrined in state water quality standards.

Regulatory-based CBP Policy Tool #2: Nutrient Management Requirements for Smaller Animal Feeding Operations (AFOs).

While the federal CWA requires regulation of larger AFO's, smaller AFO's are not regulated nationally and they constitute the vast majority of animal feeding operations in the State of Maryland (Shenk, 2015). They are also responsible for significant nutrient loads to the Chesapeake Bay. To address these non-federally regulated AFOs and the nutrient loads they contribute to the bay's watershed, Maryland operates a Nutrient Management Program for animal feeding operations with gross income of $2,500 or more and 8 animal units (or about 8,000 pounds of farm animal(s)). 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 (Shenk, 2015). In total, more than 5,000 AFOs in Maryland are subject to these requirements, and the Maryland Department of Environment (MDE) conducts farm visits for a subset of these AFOs on a regular basis, and also takes enforcement actions when necessary to address non-compliance.[23]

Regulatory-based CBP Policy Tool #3: Water Quality Trading.

There are a few water quality trading programs being developed in the Chesapeake Bay region, and Virginia's may be the furthest along compared to other programs 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 (VDEQ, 2008). 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 (VDEQ, 2008). The General Permit outlines the basic rules for the trading program (VDEQ, 2008), which addresses both point and non-point sources. 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 (VDEQ, 2008). According to VDEQ's 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 19 facilities exceeding their Total Nitrogen and/or Total Phosphorus WLAs used trades to acquire the necessary credits to meet their requirements (VDEQ, 2015).

Regulatory-based CBP Policy Tool #4 – Agriculture Certainty Programs.

Virginia operates a Resource Management Plan (RMP) Program that incentivizes BMP implementation by providing agricultural operations nine years of protection from any new or changed agricultural

[23] The State of Virginia also operates an AFO program for livestock operations that are smaller than federal CAFOs (Shenk, 2015)

regulation for producers who develop an RMP for their operation and implement BMPs specifically tailored to their operations (Chesapeake Bay Commission, 2015).[24]

EXPENDITURE-BASED POLICY TOOLS

We identified two treasure-based policy tools being used in the Chesapeake Bay area, which may be of interest to efforts to address nutrient enrichment in the Lake Erie basin. They are as follows.

Expenditure-based CBP Policy Tool #1 – Virginia Water Quality Improvement Fund.

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 (Virginia Forever, 2013.) The WQIF provides funding for both point source projects and non-point source water pollution control projects (VDEQ, 2012). The WQIF provides funding support for the Agricultural BMP cost-share program, the 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 in cost share for agricultural practices resulting in a reduction of 4.5 million pounds of Nitrogen and 922,192 pounds of Phosphorus (VDCR, 2010). It also reports that over 7,500 practices were implemented on 2,098 farms in that time period, and over 189,000 acres received BMP implementation (VDCR, 2010).

Expenditure-based CBP Policy Tool #2 – 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 (Chesapeake Bay Commission, 2015). Both practices focus on providing livestock watering systems, fencing, and rotational grazing (VDCR, 2016).[25]Maryland also implements an agricultural BMP cost share program that includes funding for livestock exclusions (Chesapeake Bay Commission, 2015).

ORGANIZATION-BASED POLICY TOOLS

Perhaps the defining element of the current day Chesapeake Bay Program (CBP) is its use of a basin-wide *management* framework which seeks to integrate the programmatic stovepipes that tend to characterize our nation's water pollution policies (Hoornbeek, 2012; Kettl, 2002). This management framework consists of at least three key policy tools: 1) a scientific basis consisting of watershed and pollutant transport models; 2) a tracking and accountability framework, and; 3) an institutional foundation

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[24] Maryland also operates an agriculture certainty program (Shenk, 2015)

[25] Maryland also implements an agricultural BMP cost share program that includes funding for livestock exclusions (Chesapeake Bay Commission, 2015).

commensurate with the scope of the bay's water quality problems. We briefly summarize these organizational policy tools below.

Organization-based CBP Policy Tool #1: Watershed and Pollutant Transport Models

The Chesapeake Bay TMDL was established based on a series of linked Chesapeake Bay airshed, watershed, and estuarine water quality and sediment transport models, which enable the establishment of pollutant loading allocations to particular jurisdictions and tributary systems within the Chesapeake Bay watershed, and link the allocations with attainment of the states' Chesapeake Bay water quality standards. These linked partnership-based models also tie pollutant loading information for a range of pollution sources to watershed monitoring information and the loading levels necessary for the achievement of water quality standards for the Bay. The watershed models are based on monitoring data collected since 1984 from tidally affected portions of the Bay (162 monitoring stations) and another set of upland watershed monitoring stations (85 monitoring stations) (USEPA, 2010).

These models and the data upon which they are based enable the development of simulated understandings of the impacts of various nutrient and sediment sources on water quality conditions in both individual tributaries and the tidal portions of the Bay. These simulations may be conducted for both current pollutant release levels and scenarios which reflect actions to implement nutrient reduction activities (more stringent permit limits/discharges, additional land preservation activities, etc.) The transport models enable estimations of the impacts of these various loading scenarios on the achievement of water quality standards for the bay. [26] They also provide key information and capabilities for tracking progress in TMDL implementation and in estimating the impacts of loading reductions and changes in environmental conditions that are associated with them.

Organization-based CBP Policy Tool #2: Tracking and Accountability System

A problem with earlier efforts of the Chesapeake Bay Partnership in the last two decades of the twentieth century was that it was relatively easy for political officials to make commitments about future reductions in nutrient loadings when there was no established system for tracking nutrient reduction implementation efforts. Without the ability to track implementation efforts, there was no means for measuring progress toward the achievement of water quality goals or holding jurisdictions accountable for the loading reductions to which they had committed.

To address this problem, USEPA and the states comprising the Chesapeake Bay Watershed Partnership adopted a strategy for measuring TMDL implementation progress, assuring accountability for reduced nutrient and sediment flows, and meeting deadlines for TMDL implementation. The scientific modeling efforts discussed above provide a foundation for measuring TMDL implementation progress because they enabled estimations of nutrient and sediment load reduction scenarios associated with various point and nonpoint source nutrient control actions. 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 absorption of nutrients), these actions are entered into the CBP modeling systems to estimate

[26] The summary contained here is a very broad overview. For more information on the CBP modeling structure, see Chapter 5 of the Chesapeake Bay TMDL document.

the nutrient loading reductions associated with them for the specific geographic areas affected. The result is an estimation of progress in reducing nutrient loads as actions called for in the TMDL are implemented.

To assure accountability for progress, USEPA and the Chesapeake Bay states have 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. The WIPs must identify nutrient reduction actions sufficient to achieve the targeted nutrient load reductions required of their jurisdiction(s). USEPA then reviews the WIPs as they are developed to assure that this requirement is met, and the states submitting them are then required to alter their WIPs in ways that address USEPA's requirements. States that fail to produce WIPs acceptable to USEPA are subject to "backstop allocations 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." (USEPA, TMDL Executive Summary, 2010).

Organization-based CBP Policy Tool #3: Centralized Implementing Organization

The WIP reviews and other implementation activities of the CBP are coordinated and/or implemented by the federal CBP staff, based in Annapolis, Maryland. The CBP office is situated in EPA Region III (based in Philadelphia) currently employs between 90 and 100 persons, many of whom appear to be on loan from other federal agencies (CBP, 2012). These individuals come from a wide range of backgrounds and 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 with agreed upon quantitative goals and objectives, as well as transparent and publicly available means to measure progress against them.

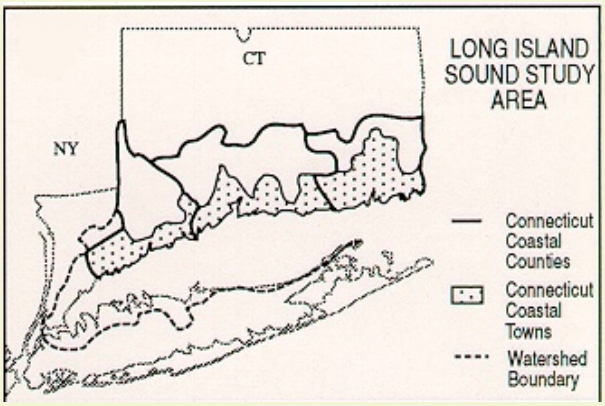
While the CBP program offers a range of policy tools that could be adapted for use in the Lake Erie basin, its integrated organizational management framework – and the scientific, accountability, and institutional structures underlying it – may be the most important set of policy tools to note in relation to the lessons offered for addressing nutrient enrichment issues in the Lake Erie basin.

Table 9:
Examples of Policy Tools Used in the Chesapeake Bay Watershed

Regulatory Tools	*Expenditure Based Tools*	*Organization Based Tools*
Water Quality Criteria and Standards for the Bay and TMDL **Nutrient Management Requirements for Small AFOs** **Water Quality Trading Programs** **Agricultural Certainty Programs**	Virginia Water Quality Improvement Fund Virginia Livestock Exclusion System	Basinwide Watershed and Pollution Transport Models Tracking and Accountability System Centralized Implementing Organization

Long Island Sound Study (LISS) Program

A Brief History



- Long Island Sound Study Area (LISS, 2016)

The Long Island Sound drainage basin is about a quarter the size of the Chesapeake Bay's drainage basin, as it covers about 16,000 square miles of land from New York and Connecticut up into portions of New England (LISS, 2015). The Sound itself stretches about 110 miles and ranges from 60 to 120 feet in depth (LISS, 2015). As an estuary, the Long Island Sound is a bit unusual because it possesses two openings to the sea, one to the west through the East River (which passes by the east side of the Island of Manhattan in New York City) and another to the east that connects directly to the Atlantic Ocean.

One of the more substantial water quality challenges facing the Sound is low levels of dissolved oxygen (DO), which yield anoxic zones that threaten fish and other aquatic species. This DO problem has been recognized for some years now, and it is traceable to large loads of nitrogen which are released to the Sound from wastewater treatment plants in the surrounding urban areas, upstream agricultural sources, air deposition, and the ocean itself.

In recognition of the water quality challenges associated with the Sound's "urban sea", the US Congress appropriated funds targeted to research, monitor and assess the health of the Long Island Sound in 1985. This initial focus on water quality issues in the Sound was followed in 1987 by federal CWA Amendments which authorized establishment of the National Estuary Program (NEP), and the Long Island Sound was identified as one of the estuaries to be given priority consideration through this program (See CWA, Section 320). Through these efforts and the increased attention to the health of the Sound that was associated with them, USEPA and the states of New York and Connecticut established the Long Island Sound Study (LISS), "a Management Conference involving federal, state, interstate, and local agencies, universities, environmental groups, industry, and the public" (LISS, 2015, p. 8).

Since the establishment of the LISS program, stakeholders in Sound's watershed have been developing and implementing plans to address water quality issues associated with hypoxia and nutrient enrichment. In 2001, the USEPA approved a multi-jurisdictional TMDL calling for a 58.5% reduction in nitrogen loadings to the Sound (Tedesco, 2014), a large proportion of which were to be achieved through upgrades to wastewater treatment plants scheduled to occur over a period of approximately fifteen years.

Progress and Results to Date

Over the past 20 or 30 years, the LISS Partnership appears to have made substantial progress in reducing nitrogen loads to the Long Island Sound and in diminishing the impacts of hypoxia in the Sound. These impacts can be measured in a variety of ways, a number of which grow from continuing monitoring of key indicators established through the LISS program.

In 2014, wastewater treatment facilities in the Sound's water basin were reported to have achieved "94% of the nitrogen reduction goal established in the 2000 DO TMDL, which means that 108,000 fewer pounds of nitrogen were discharged into the Sound every day" (LISS, 2015). These reduced discharge levels were accomplished through the development of more advanced nutrient reduction capabilities at wastewater plants throughout the Long Island Sound basin. By 2014, the State of Connecticut had fully met its nitrogen reduction goals under the TMDL, while the State of New York expects to fully meet its nitrogen reduction goals under the TMDL by 2017 (Tedesco, 2016).

Perhaps not surprisingly, given these substantial nitrogen loading reductions, the LISS monitoring program -- and the suite of watershed health indicators associated with it -- also reflects positive water quality trends in the Sound in recent years. The overall trends with respect to hypoxic area size and duration in the Sound appear to be encouraging. In the late 1980's and early 1990's, hypoxic areas with DO concentrations below 3 mg/l exceeded 250 square miles in several years (Denny and Raffa, 2014). However, the hypoxic area in the Sound has been somewhat lower recently, with dimensions of less than 100 square miles in 2013 and 2014. Between 1991 and 2013, the average duration of hypoxia in the Sound was 55 days in the summer. In 2014, that number was 35 days (LISS Status and Trends, 2016). In 2015, there were no open water measurements of severe hypoxia (<2.0 mg/l), the firest tmie this occurred since measurements began in 1991 (Tedesco, 2016).

Positive environmental trends are also evident in the prevalence of Eelgrass, which is an underwater plant that forms meadows that are ecologically important for fish and shellfish. Between 2002 and 2012, eelgrass increased by 29 percent and it increased by 4.5 percent between 2009 and 2012 (Tiner et al, 2013). This finding suggests that improvements in nutrient loading reductions and hypoxic areas are accompanied by indicators of improving habitat as well.

While the water quality trends suggested by the numbers presented above are encouraging, it is important to recognize that they remain subject to both significant variability on a year to year basis and to long term change. In 2012, for example, the size of hypoxic area in the Sound increased dramatically to almost 300 square miles (LISS Status and Trends, 2016) due to climatic, temperature and precipitation related factors. In addition, while the size of the area in the Sound that is subject to severe hypoxia has decreased recently, significant and continuing hypoxia problems are evident in the Sound's western basin where hypoxia develops almost every year (LISS, 2015). These realities mean that nitrogen management problems in the Long Island Sound (and elsewhere for that matter) are not solved once and for all, but rather are subject to both broad environmental and climatic influences and a need for continuing and management efforts.

LISS Program Policy Tools: Findings and Insights

As was the case for other water basin programs reviewed during the course of this work, policy tools used in the Long Island Sound included regulatory tools such as NPDES permits, expenditure-based tools such as grants and funding support, government communications to broad audiences about the conditions of the Sound and the steps necessary to address them, and the development of organizational management approaches to marshal resource to clean up the Sound. The regulatory-based policy tools and organizational management approaches appear different than those in place for Ohio's Lake Erie basin, so we briefly describe policy tools used in those two areas below. These tools are also summarized in Table 10.

REGULATORY POLICY TOOLS

Regulatory-based LISS Policy Tool #1 – Connecticut's Effluent Trading Program.

Most of the major wastewater treatment plants subject to the new and more stringent effluent requirements stemming from the TMDL's 58.5% nitrogen reduction goal are in Connecticut. 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 (CTDEP, 2010) While the loading reduction achievements of the LISS 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. 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 (Denny and Raffa, 2014).

Regulatory-based LISS Policy Tool #2 – New York's "Bubble" Permit Policy for New York City.

Major discharges of nutrients to the Long Island Sound come from the 21 major wastewater treatment plants in the State of New York. 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, which 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.[27] (NYCDEP, 2016).

[27] Four plants – Bowery Bay, Hunts Point, Tallman Island, and Ward's Island – discharge wastewater containing nitrogen to the upper East River. Four other plants – 26th Ward, Coney Island, Jamaica, and Rockaway – discharge wastewater containing nitrogen to Jamaica Bay. Each of these two groups of four wastewater treatment plants is subject to separate and aggregated nitrogen loading limits under the state's "bubble" policy (NYC Nitrogen Control Program Website, accessed Feb. 19, 2016).

ORGANIZATION-BASED POLICY TOOLS

Organization-based LISS Policy Tool #1: A Cross-jurisdictional Coordinating Office

The Long Island Sound EPA Program Office was established by Congress in 1990. By statute, it employs an EPA civil servant as a director and additional staff members who provide assistance to the director. Over time, this EPA Office has integrated its activities with staff and associated professionals from New York, Connecticut, and the New England Interstate Water Pollution Control Commission (NEIWPCC), 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 (LISS, 2016). The LISS operates with funding provided by USEPA, and this support is supplemented by resources contributed by the states of New York and Connecticut, and the NEIWPCC.

Organization-based LISS Policy Tool #2: A Scientific Network with Ties to the LISS Program

Over the years, the LISS has brought together scientists from among its Partnership members to monitor and assess the health of the Long Island Sound. Through these efforts, it has assisted in the establishment of quantitative goals for nitrogen loading reductions and the development of indicators of the Sound's health (LISS History, 2016). The LISS now tracks 60 indicators of the health of the Sound on an ongoing and systematic basis (LISS, 2012).A number of these indicators relate directly to nutrient loads and their impacts on dissolved oxygen levels in the Sound. These indicators include nitrogen trade equalized loads, nitrogen loads from the State of Connecticut, the frequency of hypoxia in the Sound, the duration of hypoxia in the Sound, and the area of anoxic zones (3 mg/l of DO or less). These and other indicators, and the ongoing monitoring efforts that support them, provide a useful scientific basis for managing nutrient reduction efforts in the Long Island Sound watershed basin.

Today, many organizations contribute to the development of scientific information on the health of the Long Island Sound (for an overview see the LISS website, http://longislandsoundstudy.net/research-monitoring/water-quality-monitoring/). The LISS appears to play a facilitating and coordinating role for these efforts and brings information together so it can be used and accessed where 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 (Latimer et al., 2014).

Organization-based LISS Policy Tool #3: Coordinated Planning & Implementation Efforts

With a central EPA office established and integrated with state and local efforts through the LISS program, Connecticut and New York – along with the USEPA – approved their first Long Island Sound Conservation and Management Plan in 1994 (LISS, 1994). This plan established six priority areas of focus for water quality related management efforts in the Long Island Sound. One key area of focus was hypoxia and the very low dissolved oxygen levels associated with it.[28] After approval of the 1994 management plan, the jurisdictions worked cooperatively together on a number of action agreements, which yielded defined efforts and strategies to implement nitrogen reduction efforts. These action plans

[28] The other five areas of focus were toxics, pathogens, floating debris, habitat degradation, and land use (LISS, 2015, p. 9).

were put in place in 1996, 2003, 2006, and 2011, respectively (LISS, 2015), and appear to have been subject on ongoing implementation efforts coordinated through the LISS program.

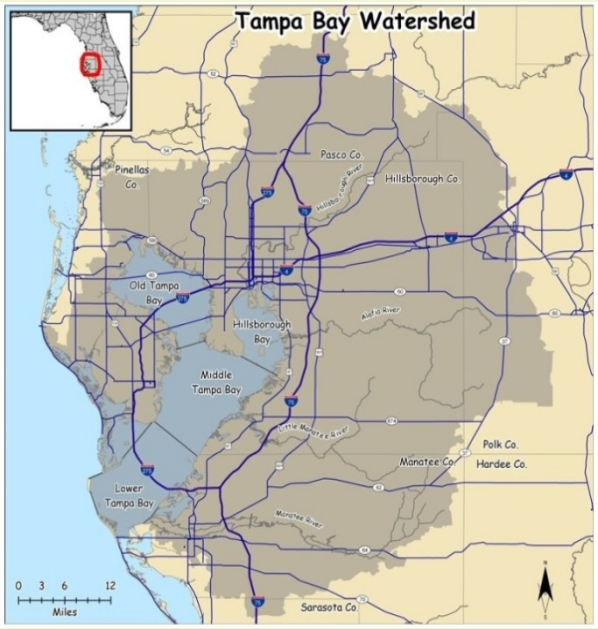
Table 10:
Examples of Policy Tools Used in the Long Island Sound Watershed

Regulatory Tools	*Organization Based Tools*
Connecticut's Effluent Trading Program/TMDL New York "Bubble" Permit Policy for New York City WWTP's	Cross-jurisdictional Coordinating Office Scientific Network with Clear Ties to the Program Coordinated Planning, and Implementation across jurisdictions

Tampa Bay Estuary Program (TBEP)

A Brief History

While the Tampa Bay is much smaller than both the Chesapeake Bay and the Long Island Sound, it is the largest open water estuary in the State of Florida. Tampa Bay extends in a "Y" shape from the Gulf of Mexico, and covers about 400 square miles within a watershed of about 2600 square miles (Greening Presentation, 2014). Nitrogen is the nutrient of concern in the Bay, as it is reported to contribute to eutrophication and its effects on both the Bay and the aquatic life that inhabits it.



-The Tampa Bay Watershed (TBEP, n.d.)

After initial efforts to address nutrient issues in the 1980s, citizen concerns over water quality issues were expressed and given voice through the Tampa Bay Regional Planning Council's Agency on Bay Management (Greening et al, 2014). In 1991, the Tampa Bay Estuary Program (TBEP) was established with support from the USEPA. As was the case with LISS, the TBEP benefited from funding flows enacted through the NEP. The TBEP and its partners also adopted a Comprehensive Conservation and Management Plan (CCMP) that included measureable goals for the achievement of Tampa Bay's designated uses (Greening et al, 2014).

Progress and/or Results To Date

Over the years, the Tampa Bay nutrient reduction effort has yielded substantial progress in cleaning up the Bay (Muellner, 2016). These results are apparent in terms of both reductions in nutrient loadings and water quality indicators in the Bay itself.

Nitrogen loadings to the Tampa Bay in the 1970's are estimated to have been in the range of 10,000 tons a year (Greening, 2008). In the 2000's, those loadings are estimated to have been reduced by more than 50% to about 4,500 tons of nitrogen a year. However, because of population growth in the Tampa Bay Region, the overall level of nitrogen loading reduction is estimated to reflect an 80% reduction in per capita total nitrogen contributions to the Tampa Bay between the mid-1970's and 2010 (Greening, 2008).

These reductions in loadings appear to be having positive effects on the ecological condition in the Bay. In the years between 1974 and 1983, there was almost no attainment of targeted chlorophyll a concentrations in the four sub-basins of Tampa Bay. Targeted levels of chlorophyll a were achieved only in only one of the four basins of the Bay -- the lower Tampa Bay -- in 1974, 1975, 1976, and 1978 (Greening et al., 2014). Between 2006 and 2013, by contrast, chlorophyll a concentration standards were achieved in all four basins of the Bay, although the Old Tampa Bay basin exceeded these targeted concentration levels in 2009 and 2011 (Greening et al, 2014).

With these kinds of improvements in chlorophyll a concentration levels, it is perhaps not surprising that sea-grass has been returning to the bay. Indeed, in 2014, total seagrass coverage measured in the Bay exceeded 40,000 acres (15,000 more than was recorded in 1990), and the 38,000 targeted level of seagrass coverage, for the first time in many years (Greening, 2016)

While these results appear impressive, they alone are not likely to be sufficient over the long term. As population grows, and economic and environmental changes occur, continuing management efforts are likely to be necessary to maintain and improve upon the results achieved to date.

TBEP Policy Tools: Findings and Insights

Like the other programs we investigated, there is evidence of the use of regulatory permits, grant funding, and communications to broad audiences to sensitize them to nutrient issues in the bay and steps that can be taken to address them. There is also evidence of an ongoing and focused management effort, and it appears to have given rise to other policy tools as well. However, we also identified policy tools in the Tampa Bay region that we did not identify in our Ohio Lake Erie Basin inventory. We briefly describe these regulatory-based, government commumication, strategy, and planning-based, and organization-based policy tools below. These tools are also summarized in Table 11.

REGULATORY POLICY TOOLS

Regulatory-based TBEP Policy Tool #1 – State and Local Governments Fertilizer Law.

Florida implements a state Urban Turf Fertilizer Rule, which was most recently updated in 2015. It includes requirements relating to the packaging and application of residential lawn fertilizers. Florida's Urban Turf Fertilizer Rule places requirements on the packaging of fertilizer products (with an emphasis on label requirements), application rates, and the nutrient content of fertilizer products (FDEP, 2015). The state DEP also provides a template local fertilizer ordinance for local governments to use to draft their own local fertilizer requirements and restrictions (FDEP, 2015).

In 2008, TBEP facilitated the development of the Tampa Bay Model Regional Fertilizer Ordinance, which includes elements of the State Rule but 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 from June 1st through September 30th, and also prohibits the sale of Nitrogen lawn fertilizer during this period. Local governments within the Tampa Bay watershed have adopted ordinances for their jurisdictions based on the Tampa Bay model ordinance (Pinellas County letter, 2008).

Regulatory-based TBEP Policy Tool #2 – Policies targeting Air Emissions.

The Tampa Bay Electric company came to an agreement with USEPA and Florida DEP to reduce overall emissions from its power plants in 1999 (Greening et al, 2014). The company's "Selective Catalytic" project reduced nitrogen oxide emissions and repowered a coal-burning power plant to a cleaner natural gas fuel source (Greening et al, 2014). Other plants in the Tampa Bay region – including the Bartow plant run by Progress Energy (now Duke Energy) are also switching from coal to natural gas (Greening et al, 2014; Greening, 2016). Between 2002 and 2010, power plant upgrades 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 (TBEP, 2012).

GOVERNMENT STRATEGY, PLANNING, AND COMMUNICATION-BASED POLICY TOOLS

Communication, Strategy, & Planning-based TBEP Policy Tool #1 – Tampa Bay Nitrogen Management Consortium (TBNMC).

The Tampa Bay Nitrogen Management Consortium (TBNMC) was formed in 1996, and was spearheaded by TBEP with governmental partners and key industries to implement an Action Plan to meet the protective nutrient load targets developed for the Bay (Greening et al, 2014). Industrial partners include fertilizer manufactures, electrical utilities, and agricultural interests (TBEP, 2015). In establishing the TBNMC, the TBEP and community leaders sought to establish a means for both detecting concerns about nutrient reduction efforts and effecting changes in nutrient loadings.

The group's first Action Plan, prior to 1999, called for more than 100 projects that reduced or prevented 224,000 kg of nitrogen from entering Tampa Bay each year (Greening et al, 2014). After 1999, additional projects were undertaken by the Consortium and have been estimated to reduce loads to the Bay by 270,000 kg each year (Greening et al, 2014). 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 the Bay in order to voluntarily meet protective load targets developed for Tampa Bay (Greening et al, 2014).

Communication, Strategy and Planning-based TBEP Policy Tool #2 – Lawn Fertilizer Social Marketing Campaign.

The TBEP has created a public relations campaign focusing on residential lawn fertilizers (befloridian.org). The campaign encourages Floridians to not fertilize their lawns during the summer when heavy rains can sweep nutrients into surface waters. The effort also seeks to support local ordinances to restrict fertilizer use during the summer months.

ORGANIZATION-BASED POLICY TOOLS

As with the CBP and LISS programs, the TBEP focused considerable attention on organizational efforts to engage key members of the Tampa Bay community in efforts to reduce nutrient flows to the Bay. To do so, it built institutional foundations for an ongoing operation, developed a scientific foundation for the program and measuring its progress, and created mechanisms to track and manage progress.

Organization-based TBEP Policy Tool #1: A Public-Private Partnership

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

In the 1990's, their work came to be supplemented in important ways by the TBEP and the TBNMC. The TBEP employs about a half dozen people, and operates with an average annual budget of about $1 million (TBEP, 2015). Its funds come from USEPA Section 320 (NEP) funds, the Southwest Florida Water Management District, and the cities and counties in the Bay area (TBEP, 2015).

The impacts of the TBEP have been 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. In addition, a series of governing and technical committees – along with a Policy Board comprised of local government officials – have expanded institutional support for the program's efforts in the Tampa Bay region.

Organization-based TBEP Policy Tool #2: "Integrated Watershed-Groundwater- Circulation-Ecology Model"

The TBEP and its partners were careful to build a scientific foundation for their work in cleaning up Tampa Bay. They used an integrated watershed-groundwater-circulation-ecology model to guide their work, as the model enabled them to model and test the effects of different nutrient loading reduction efforts, as well as other factors affecting the Bay and its water quality dynamics. These other factors included alterations to bridge openings, varying changes in the delivery of freshwater to the Bay, and potential sea level rise effects (Greening, 2014).

The TBEP's director communicated the importance of building a scientific basis for their work by saying:

"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' (Greening, 2016)."

As was the case in the Chesapeake Bay, developing a scientific model that is grounded in science and accepted as legitimate by key parties appears to be a key step in building support for broadly based nutrient reduction efforts.

Organization-based TBEP Policy Tool #3: Clear Goals and Economically Based Objectives

A centerpiece of the Tampa Bay region's effort to combat nutrient enrichment lied in its establishment of clear and widely accepted goals for water quality improvement. They sought "restoration of the bay water quality to support the recovery of seagrass resources, while maintaining the Bay's fisheries and other designated uses" (Greening et al., 2014). Notably, the group established this goal (and others) with a keen recognition that its achievement would support not only improved water quality in the Bay, but also continuing protection of a natural resource that is of central importance to the health of the Tampa Bay area's economy. [29]

To further define its goal, the TBEP and its partners defined what they believed was adequate sea grass coverage in the Bay --- 38,000 acres of seagrass coverage in the Bay, an amount that is thought to reflect approximately the coverage levels present there in the 1950's (Greening, 2008). The establishment of this rather easily understood goal, in turn, provided a foundation for the creation of chlorophyll a concentration targets that could be easily monitored to assess progress.

Organization-based TBEP Policy Tool #4: Implementation Tracking and Accountability

With clear goals and growing capacities to work toward them in cooperative fashion, the TBEP also played an active role in assisting the Partnership in identifying nutrient reduction efforts and tracking progress in their implementation. The TBEP developed and continues to maintain a database of nutrient reduction projects and activities, and this data base both informs the TBNMC of its progress (Greening, 2016), and serves as a basis for estimating the extent to which nutrient reduction objectives are achieved.

Building partnerships, and trust among the partners, also appears to have contributed productively to the organizational effort and the legitimacy of the tracking and accountability effort. With the TBEP staff serving as neutral facilitators, stakeholders in the region came together to support establishing goals and taking actions to protect water quality in the bay. The ongoing presence of the state and federal regulatory agencies, and their clearly stated interests in ensuring that targeted nutrient reductions were actually achieved through more stringent permit limits, also helped provide further accountability and continuing incentives for progress.

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[29] 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 (TBEP Progress Report, 2015). 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." (TBEP, Progress Report, 2015).

Table 11: Examples of Policy Tools Used in the Tampa Bay Watershed		
Regulatory Tools	*Strategy and Planning Tools*	*Organization Based Tools*
State and Local Fertiziler Law Policies Targeting Air Emissions	Tampa Bay Nitrogen Management Consortium Lawn Fertiziler Social Marketing Campaign	Public Private Partnership Integrated Watershed-Groundwater Cirulation-Ecology Model Clear goals based on Economic Objectives Implementation Tracking and Accountability System

VII. A Summary of Findings and Suggestions for the Future

Table 12 summarizes findings from Sections V and VI above. The entries in plain type within each of the four columns of the table (columns A, B, C, and D) identify types of policy tools that are currently being used in the Ohio Lake Erie basin. By contrast, the entries in *italics* identify policy tools used in the CBP, the LISS Program, and the TBEP that do not appear to be used currently in the Ohio Lake Erie basin.

In general, the findings in Section V -- which inventories nutrient reduction efforts in the Ohio Lake Erie basin -- suggest that federal government agencies and the State of Ohio are already making *substantial* efforts to reduce nutrient flows in the Ohio Lake Erie basin. They are requiring many hundreds of federal and/or state permittees to assess and/or develop nutrient treatment and management capacities.[30] They are spending millions of dollars on nutrient reduction efforts.[31] They are also collecting and disseminating information on nutrient enrichment, HABs, and ways in which these problems can be addressed. And finally, both federal and state governing entities are organizing multiple efforts to address and manage flows of nutrients in the Lake Erie water basin. In spite of these efforts, however, Ohio and its jurisdictional neighbors in the Great Lakes region continue to face challenges and threats associated with nutrient enrichment and HABs.

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[30] Our review identified the following requirements applicable to facilities/organizations regarding nutrients: 1) 684 wastewater dischargers with NPDES effluent limits on nutrients (nitrogen and/or phosphorus) and 843 with monitoring requirements relating to nutrients (Table 1); 2) 147 municipal storm-water systems subject to an NPDES general permit for municipal storm-water, 6,942 permittees subject to an NPDES storm-water general permit for construction, and 1,265 industrial facilities subject to an NPDES to storm-water general permit (Table 4), and; (3) 100 – 150 animal feeding operations subject to CAFO or state AFO requirements in counties that lie at least partially within the Ohio Lake Erie watershed. These requirements supplement the provisions of SB 1, which was enacted in response to the contamination of the City of Toledo water supply in 2014 (see Section III on Harmful Algal Blooms and Recent Policy Responses for more information).

[31] In 2014 alone, USDA appears to have spent more than $90 million on programs to assist farmers in minimizing environmental impacts associate with their operations in Ohio (Table 7). In that same year, other federal agencies appear to have spent about $33 million on programs that have direct or indirect beneficial impacts relating to nutrient reduction in the Lake Erie basin (Table 6), while state agencies appear to have spent another $21 million in that same year in pursuit of this same purpose (Table 8).

Table 12 Policy Tools Used to Address Nutrient Problems in Selected American Water Basin Management Programs: A Comparison of Policy Tools Used in Ohio's Lake Erie Basin with Policy Tools Used in Other Programs				
Government Resource/Policy Tool Category (C. Hood, 1983)	**Overview Summary of Water Basin Program(s) Policy Tools With a Nutrient Reduction Focus**			
	A **Ohio Lake Erie Basin Nutrient Reduction Efforts: 2016 Status Quo**	**B** **Chesapeake Bay Program (CBP)**	**C** **Long Island Sound Study (LISS) Program**	**D** **Tampa Bay Estuary Program (TBEP)**
Regulatory-based Tools	NPDES Permits Agricultural Pollution Abatement/AFO Requirements Prohibition of Winter Ag Fertilizer Applications	NPDES Permits State AFO Requirements *Required Nutrient Mgt. Plans for Small AFOs* *TMDL Requirements* *WQ Trading Policies* *Ag. Uncertainty Programs*	NPDES Permits *WQ Trading Policies* *NY Bubble Permit Policy* *TMDL Requirements*	NPDES Permits *State Fertilizer Reqs.* *TMDL Requirements*
Expenditure-based Tools	Federal NPS Grants State NPS Grants Federal/state WWTP $'s	Federal NPS Grants State NPS Grants Federal/State WWTP $'s *Budget Surplus set-asides* *Livestock Exclusion Support*	Federal NPS Grants State NPS Grants Federal/State WWTP $'s	Federal NPS Grants State NPS Grants Federal/State WWTP's *NMC generated funds*
Strategy, planning, and communication-based Tools	Task Force Reports Strategies & Action Plans Watershed Monitoring	Research Reports Strategies & Action Plans Watershed Monitoring	Research Reports Strategies & Action Plans Watershed Monitoring	Strategies & Action Plans Watershed Monitoring *NMC Consortium* *Fertilizer Social Marketing*
Organization-based Tools	Multiple Agencies, with multiple approaches - OLEC serves high level policy coordination role. ODNR's CMP program networks public/private stakeholders to inform policy. Multi-pronged monitoring approaches.	*Centralized implementation* *Centralized monitoring &scientific approach* *TMDL - Accountability Framework*	*Multi-state Coordination* *Centralized Scientific Modeling/Monitoring* *TMDL- Accountability framework*	*Central Coordination of Implementation* *Centralized Scientific Modeling/Monitoring* *Tracking Framework, backed by TMDL*

Note: Entries in plain-face type are used in the Ohio Lake Erie basin (or are similar to tools used in the Ohio Lake Erie basin), while policy tools listed in italics do not appear to be used currently in the Ohio Lake Erie basin

Below, we offer potential ideas for strengthening existing nutrient reduction policy responses in the Ohio Lake Erie basin. Our suggestions come from two sources. First, we present ideas that are based on our inventory of Ohio Lake Basin nutrient reduction efforts. Here, we look at existing efforts and offer ideas on next steps or alterations in current policies or practices that hold the potential to enhance their effectiveness and/or provide greater confidence that feasible steps for controlling nutrient flows to Lake Erie are being fully implemented.

Second, we offer ideas regarding additional policy tools that might be used to further reduce nutrient loads to Lake Erie. These ideas emerge from among the italicized entries in Table 9 and our reviews of policy tools currently being used in the CBP, the LISS Program, and the TBEP. They include policy tools that do not appear to be used currently in Ohio, based on our inventory of current nutrient reductions in the Ohio Lake Erie basin.

At this point, we offer these suggestions as ideas for consideration, pending further investigation. Because it is possible that there are nutrient reduction efforts that were missed by our inventory effort, it is also possible that some of our suggestions are already being implemented. In addition, we found few – if any – cases where information on the effectiveness of particular policy tools has been fully demonstrated. We therefore recognize that more detailed reviews of these policy tools, the likelihood of their effective application in Ohio, and the most appropriate means for their implementation in Ohio may be appropriate. However, because these tools appear to be parts of strategies that are yielding quantified information and measureable progress relating to nutrient reduction efforts being undertaken elsewhere, we believe that policymakers and water pollution control administrators and stakeholders in Ohio would be wise to consider them seriously. With these thoughts in mind, our ideas for consideration are provided below, and they are organized around Hood's four policy tool categories.

Tools Based on Regulatory Authority

We suggest consideration of the following policy and practice ideas, based on our investigations.

1. The State of Ohio should review existing NPDES nutrient-related permit requirements – as well as available data on nutrient concentrations in wastewater releases -- for dischargers in the Lake Erie basin. Based on these reviews, it should take steps to ensure that appropriate controls on nutrients – and particularly phosphorus -- are in place. More detailed information on our findings to support those reviews is provided below.

    A. Our investigation of traditional NPDES wastewater permits in the Lake Erie basin found that most permits have some form of control on nitrogen and phosphorus. The majority of NPDES permits, 60% (685/1138), have some form of permit limit on nutrients (nitrogen and/or

phosphorus), and 77% of major permits (79/102) have phosphorus limits. In addition, 74% (843/1,138) of all NPDES permits have some form of nutrient monitoring requirement. In interpreting these summary numbers, it is important to recognize that not all permits need to have nutrient limits or monitoring requirements for nutrients. This is because wastewater streams of some NPDES permittees hold little or no potential to yield nutrient contamination.

One group of permittees that holds consistent potential to release nitrogen and/or phosphorus in their wastewater streams is POTWs, which treat domestic sewage. Among POTWs, 81% (197/243) of NPDES permittees appear to have some form of nutrient limit, and about 30% (72/243) appear to have effluent limits on total phosphorus. It is worth noting, however, that 84% (204/243) of POTWs in the Lake Erie basin appear to have monitoring requirements for phosphorus, so information on phosphorus flows in wastewater discharges should be available for further investigation and analysis. For major POTWs, our review suggests nearly all permittees (55/56, or 98%) have effluent limits on total phosphorus, and all 56 major POTWs have monitoring requirements for phosphorus.

These data suggest that OEPA has taken steps to ensure that major POTWs have nutrient limits and monitoring requirements of some kind in place, but minor POTWs and other non-municipal permits should be assessed in some detail in order to determine whether additional nutrient controls are appropriate.

B. While 98% (55/56) of major POTW permits in the Lake Erie basin have effluent limits on phosphorus, 79% of these permits (44/56) have monthly average total phosphorus limits of 1mg/l -- the monthly average concentration recommended by the IJC for major permits in the Great Lakes *several decades ago*. However, some of these POTW permits have limits less than 1mg/l, thus demonstrating that more stringent limits on phosphorus are possible for these larger wastewater dischargers.

   The IJC has recommended that monthly average permit limits at the .5 mg/l concentration levels for major dischargers to Lake Erie be considered (GLWQA, 2012). Currently, just 10 of 56 major POTW permits in the Ohio Lake Erie basin appear to have monthly average concentration limits for total phosphorus below 1mg/l, and there do not appear to be any major permits with a monthly concentration limit for total phosphorus of .5 mg/l or below. Given the level of current concern about nutrient flows -- and particularly flows of phosphorus -- to Lake Erie, it appears appropriate to consider whether effluent limits more stringent than 1mg/l average monthly concentration should be incorporated into major POTW permits on a more widespread basis.

2. The State of Ohio should investigate and consider water quality effluent trading and/or bubble permit programs for nutrient control in the Lake Erie basin.

The Long Island Sound program appears to have implemented a point source-to-point source trading program for nitrogen, which appears to have helped achieve reductions in nitrogen flows to the Long Island Sound more cost-effectively than would otherwise have been possible. This kind of program could be considered for more urban areas of the Lake Erie watershed, where point source-to-point source trades within the same watershed tributary system are possible. To the extent that single operators of multiple wastewater treatment plants discharging nutrients are present, area bubble permitting systems like the one used in New York might also be considered. This kind of program might have applicability for sewage treatment plant operators with multiple wastewater plants discharging to common watersheds.

Perhaps more importantly, Ohio may also want to consider developing a point-to-nonpoint source trading system, which could potentially operate within the confines of Ohio's statewide water quality trading rules that we understand became effective in 2012 (OAC 3745-5). Such a system could provide leveraging and financial support for non-point source management actions in rural areas, based on more stringent effluent limits in NPDES permits. If this kind of system were to be developed in the Lake Erie basin, it would be useful to look at the experiences of some of the Chesapeake Bay area states, as well as Ohio's nutrient trading system in the Miami River watershed in the southwestern part of the state. If this kind of system were developed, it should focus on assuring that the non-point source nutrient reduction actions implemented as a result of trades are for *additional* reductions, above and beyond any reductions called for in current TMDL allocations. This kind of program may be costly to develop and implement, but it may very well be helpful in reducing nutrient reduction costs and/or in leveraging additional nonpoint source nutrient flow reductions through NPDES permit requirements.

3. Ohio should consider developing and implementing more comprehensive and stringent nutrient management requirements on animal feeding operations, perhaps similar to those in Maryland.

   Maryland requires nutrient management plans for many of its animal feeding operations that manage smaller numbers of animals (8 animal units or more than $2,500 in gross income[32]) than are automatically required for CAFO status under USEPA and Ohio regulations (Ohio has adopted the federal CAFO size categories for its Livestock Permitting Program). This lower threshold for the number of animal units needed to be regulated in Maryland is different from

[32]For example, in Ohio and under Federal regulations, the lower threshold for a medium sized- Dairy AFO is 200 animals, which equates to 280 animal units (OEPA, 2015).

Ohio, which has adopted the federal size thresholds for the state AFO regulatory requirements. Currently in Ohio, however, small and non-discharging Medium AFOs can be required to obtain a permit from the state CAFF permitting program after non-compliance with state pollution abatement rules. Currently, Ohio has the ability to require farms that generate or apply more than 350 tons or 100,000 gallons of manure to develop and implement nutrient management plans in distressed watersheds, such as Grand Lake St. Mary's.

Ohio should consider establishing nutrient management plan requirements for smaller agricultural operations. If it does so, it should provide the OEPA and the ODA with the resources necessary to regularly monitor compliance and assist farmers in properly implementing these nutrient management plans in their agricultural operations.

4. Ohio should consider developing initial pollution abatement strategies for nutrients based on the GLWQA Annex 4 process and the water quality goals that underlie them. However, it may also want to consider: 1) creating concentration based water quality standards for nutrients in Lake Erie that are consistent with the GLWQA agreement goals, and; 2) declaring impairment(s) of the Lake consistent with those standards after they are promulgated. This kind of approach might enable continuation of the GLWQA Annex 4 process without the distraction associated with a simultaneous impairment designation, while positioning the region for support from funding mechanisms that are tied to TMDL declarations and greater accountability for allocated nutrient reductions over time.

   The other three water basin programs discussed above (CBP, LISS Program, and TBEP) are all subject to requirements from TMDLs that were established due to non-attainment of existing water quality standards relevant to nutrient enrichment. These water quality standards provide clear and quantitative benchmarks for the ambient water quality goals being pursued for the Chesapeake Bay, for example. Some groups have recommended that Ohio join with other Lake Erie states to declare Lake Erie to be impaired due to nutrients, thus enabling a TMDL that would formally establish both ambient water quality goals and the loading reductions needed to achieve them.

   Currently, as is noted above, parties in the US and Canada are pursuing a similar and separate process under Annex 4 of the Great Lakes Water Quality Agreement (GLWQA) that establishes multiple 40% reduction goals (based on 2008 baseline) for loadings of phosphorus to Lake Erie. These 40% reductions are based on the Lake Ecosystem Objectives outlined in the GLWQA. These three objectives are:

   1) Minimize the extent of hypoxic zones in the waters of the Great Lakes associated with excessive phosphorus loading, with particular emphasis on Lake Erie.

2) Maintain algal species consistent with healthy aquatic ecosystems in the nearshore waters of the Great Lakes
3) Maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health in the waters of the Great Lakes.

According to GLWQA Nutrient Annex Subcommittee (2015), the 40% goals are based on achieving water quality conditions equivalent to those in place in 2012 (a good year for algae concentrations) in nine out of every 10 years. However, each of the three objectives above has a "40%" reduction target. Objective 1 has an associated 40% reduction in total phosphorus entering the Western/Central basins for the US and Canada as a whole. Objective #2 focuses on a 40% reduction in spring total and soluble reactive phosphorus from a list of watersheds (the Maumee and Sandusky Rivers in Ohio are included). Objective #3 has an associated 40% reduction in spring total/soluble reactive P loads from the Maumee River. The GLWQA has also outlined interim total phosphorus concentration limits for each of Lake Erie's basins, and the subcommittee tasked with recommending the load reductions has released expected total phosphorus concentration values for the Basins of Lake Erie if reduction targets are met.

While some (IJC, 2014; GLC, 2015) have called for a declaration of a nutrient impairment for the Western Basin and the enabling of a formal TMDL, it appears that the GLWQA process has established clear water quality objectives that are substantive and easily communicated. These objectives also appear to provide a basis for allocating phosphorus loading allocations between countries and across jurisdictions within them. For this reason, immediate declaration of the TMDL could potentially represent a distraction to a workable process that is already ongoing.

However, over the long term, it is useful to recognize that allocations are more likely to be complied with if they are legally enforceable in some fashion, as well as agreed to by the jurisdictions involved. As a result, over time, as phosphorus load allocations are assigned to the two countries and then to state and local jurisdictions under the Annex 4 process, there may be benefits associated with establishing formal water quality standards for nutrients (consistent with the GLWQA objectives) and then declaring impairments and pursuing one or more TMDLs based on those standards to the extent appropriate. Declaring impairment after cross-national and cross-jurisdictional standards are agreed to might avoid wasted efforts associated with managing two processes to achieve loading allocations that are inherently bi-national. It would also yield two additional benefits. It would: 1) create new opportunities for federal funding tied to TMDLs for nutrient reduction activities in the Lake Erie basin and 2) establish a legal mechanism for pursuing legally binding and appropriately stringent nutrient effluent limits in NPDES permits.

5. Ohio may want to consider developing a Resource Management Plan and Agricultural Uncertainty program, as Virginia has done.

In Virginia, as noted above, agricultural operations that develop and administer a Resource Management Plan may receive assurance of exemption from future regulatory initiatives. This kind of program could encourage agricultural operations to instigate progressive farming practices that minimize releases of nutrients to Lake Erie waters. Maryland has developed a similar program. However, this kind of program would require resources to develop and administer, and could limit the ability of policymakers to pursue important future interventions to limit nutrient flows to Lake Erie. Because knowledge regarding optimal agricultural practices and the areas of the water basin where they are particularly important to implement is likely to grow, there is reason to exercise caution when pursuing this kind of initiative.

6. Ohio should consider establishing state fertilizer requirements, as has been done in Florida.

   Florida's Urban Turf Fertilizer Rule places requirements on the packaging of fertilizer products (with an emphasis on label requirements), application rates, and the nutrient content of fertilizer products (FDACS, 2015). The state also encourages local governments to establish their own lawn fertilizer rules through ordinances, and the TBEP has developed a Tampa Bay Model Regional Fertiziler Ordinance to support this effort. The state DEP also provides a template for local fertilizer ordinances for local governments to use to draft their own rules (FDEP, 2015).

   The IJC has recommended that Ohio (and other state and provincial governments) prohibit the sale and use of phosphorus fertilizers for lawn care (except for establishing new lawns) (IJC, 2014). The GLC Lake Erie Nutrient Targets (LENT) Working Group has also recommended the phasing out of residential phosphorus fertilizer applications (GLC, 2015). The Ohio Phosphorus Task Force has focused on voluntary efforts by the lawn care industry and outreach focused on BMPs for fertilizer application. In 2013, the Scotts Miracle-Gro company, which is an industry leader, eliminated phosphorus from its lawn maintenance line (Task Force, 2013). The company also updated its product packaging to include environmental stewardship practices (Task Force, 2013).

Tools based on Expenditures of Funds and Resources

While both the federal government and the State of Ohio have expended substantial funds to support nutrient reduction efforts in the Lake Erie Basin of Ohio, these expenditures have not (at least yet) been sufficient to reduce nutrient flows as needed to prevent HABs and other impacts associated with nutrient enrichment. For this reason, Ohio policymakers could consider the two following expenditure-based interventions that are being used in the State of Virginia to address nutrient problems in the Chesapeake Bay.

1. Ohio should consider developing a budget surplus set aside policy that is targeted to support nutrient reduction efforts in the Lake Erie basin (and perhaps elsewhere in the state as well).

   As is noted above, Virginia sets aside 10% the state's budget surplus each year to support a Water Quality Improvement Fund. Ohio should consider establishing a budget surplus policy of this kind to support new and ongoing initiatives directed toward reducing nutrient flow in the Lake Erie basin.

2. Ohio should consider developing a livestock exclusion and buffer zone support program to minimize nutrient flows to nearby water bodies.

   As noted above, Virginia provides a cost-share program to support the efforts of farmers who build fencing and/or develop buffers between agricultural lands and nearby water ways. While this kind of program could prove costly, it could also enable reductions in nutrient flows in the Lake Erie basin, as well as monetary support for agricultural operations seeking to reduce the impacts of their operations on nutrient flows to Lake Erie. Virginia's program operates statewide, and Ohio's program might be designed this way as well to spread benefits and improve chances of enactment.

Tools Based on Government Strategy, Planning, and Communication

The Tampa Bay Estuary Program, with support from local governing bodies, appears to have made productive use of central governing roles in their region. To some degree, variations in this approach are implicit in the public-private structure of the Ohio Lake Erie Commission and the new USDA RCPP program. However, Ohio might benefit from considering development of additional initiatives of this kind. We identify models for additional policy tools of this kind below.

1. Ohio should consider engaging with the agricultural community in the state to enable the generation and use of additional geographically based information on the implementation of BMPs and other nutrient reduction based management approaches. As we conducted research underlying this project, we found it difficult to locate geographically specific information on the use of federal funds to implement nutrient controls by farmers and the agricultural community. Without this kind of information it is difficult to determine the extent to which agricultural practices to reduce nutrient loads are being implemented or to gauge their effectiveness. It appears that the difficulties we experienced in this area are not unusual. Rather, they appear at least partially traceable to Section 1619 of the federal Farm Bill (Chite, 2014), which prohibits federal agencies and their agents from releasing information on agricultural operations that is tied to participation federal farm programs. Ultimately, addressing nutrient enrichment problems in

the Lake Erie basin and elsewhere depends on developing, maintaining, and using a solid base of information on nutrient loadings and efforts made to reduce them. The state should consider engaging with the agricultural community to develop this kind of information on a voluntary basis.

2. Ohio should consider developing and supporting initiatives to increase awareness and use of fertilizers on lawns and in other environments.

   In Tampa Bay, the TBEP has facilitated a social marketing campaign designed to encourage both residents and local governments to restrict fertilizer applications during the summer months in urban and suburban areas. Ohio might consider developing and administering a similar campaign in urban areas in the Lake Erie watershed. If successful, it might also be extended further to rural areas with additional support and assistance from the SWCDs in the region.

3. Ohio should consider developing a private-public sector partnership consortium devoted to reducing nutrient flows in the Lake Erie Basin.

   As is noted above, this kind of consortium arrangement was initiated in the 1990's in the Tampa Bay region, and it appears to have been successful in encouraging nutrient reduction efforts in the private and public sectors, and in enabling the raising of funds to be spent on nutrient reduction activities.

   The Tampa Bay region is smaller in area than the Ohio Lake Erie basin, and is considerably smaller than the Lake Erie basin as a whole. For this reason alone, there is some question about the degree to which the benefits of the Nutrient Management Consortium in Tampa Bay could be transferred to Ohio and the Lake Erie basin if such an effort were undertaken. However, as was the case in Tampa Bay, it is clear that Lake Erie yields substantial economic benefits to northern Ohio, and there are certainly private and public sector entities which have interests in reducing nutrient flows to Lake Erie for this reason. As a result, there is value in considering this kind of approach, albeit in ways that recognize the differences between the two situations.

   Because of the large area involved, state level involvement would probably be necessary to generate momentum behind a consortium effort in Ohio. Based on the experience in Tampa Bay, early state efforts of this kind might involve developing (and/or updating) and publicizing an assessment of the economic benefits of Lake Erie and the costs associated with nutrient enrichment of the lake (see Austin et al, 2007 for information on a previous effort to identify economic benefits associated with water quality in the Great Lakes). It would also be important to identify key industry sectors with interests in the health of the lake and/or the overall lake clean-up effort. In Tampa Bay, there was substantial effort made to solidify goals associated with the clean-up effort and to establish clear and quantitative measures of ambient water quality to be

achieved. For this reason, it is important to recognize that there would be value in establishing clear ambient water quality goals and standards, as is suggested above.

One key issue in the generation of this kind of effort is likely to involve the identification of leadership institutions/entities to develop and help guide the work of a consortium of this kind. One candidate for leadership of this kind of effort would be the Ohio Lake Erie Commission, as it is a state entity that is located near Lake Erie and it has a clear Lake Erie protection mission. However, in its current form, the Ohio Lake Erie Commission appears to have a relatively small staff and, as such, somewhat limited capabilities. As a result, it would probably be necessary to re-think and/or bolster its organizational capacities if a major effort of this kind were to be developed. The ODNR's Coastal Resources Advisory Council, which is made up of public and private stakeholders, may also be a good forum to dicuss a broader public-private partnership to address nutrient issues in Lake Erie.

Tools Based on Organization

Perhaps the most obvious need that emerged from our inventory of current nutrient reduction efforts in Ohio is to create a stronger and more coordinated organizational focus for the nutrient reduction activities that are undertaken to reduce nutrient flows to the Lake Erie basin. We identified multiple federal and state organizations and entities that administer multiple nutrient reduction programs and efforts. What we did not find was any organized means to access information across these programs, or to coordinate and target the delivery of their efforts to maximize their nutrient-related impacts. These organizations are spending millions of dollars, but there is no clear and systematic assurance that these funds are being spent in priority areas or on priority projects within those areas.

This situation appears to contrast with the organizational arrangements in place in the three other water basin programs we investigated, all of which could claim at least some measure of quantifiable progress in their nutrient reduction efforts. All three of these programs have a clearly defined organization that facilitates the implementation of nutrient reduction efforts, an established scientific basis for understanding the impacts of various societal activities on nutrient loads and ambient water quality conditions, and a means for tracking and measuring progress in implementing nutrient reduction efforts and achieving ambient water quality goals. For these reasons, we suggest that Ohio consider:

1. Establishing and adequately funding one central organization and tasking it with responsibility for coordinating, tracking, and assuring *implementation of* nutrient reduction efforts across the Ohio Lake Erie basin.

One candidate for serving this role is the Ohio Lake Erie Commission, which – as noted above -- possesses a Lake Erie protection mission. However, as currently constituted, this organization does not appear to have the resources, authority, or capability to be successful in this kind of role. It is governed by a Commission of Agency and Organizational heads that are responsible for a wide range of activities. Its dedicated staff is small, and it is not in a position to directly influence the imposition of regulatory requirements, the targeting of grant funds across multiple state agencies, nor the application of the full range of state agency capabilities toward nutrient reduction efforts in the Lake Erie basin.

By contrast, if one looks at the Chesapeake Bay Program, for example, one finds a robust organization of almost one hundred professionals who have ongoing responsibilities for assuring implementation and effectiveness of programs and activities to achieve defined nutrient reduction goals. In Ohio, there is a need to not only coordinate the thinking of agency heads and private sector leaders, as is currently done by the Ohio Lake Erie Commission, but also to assure coordinated, targeted, and ongoing *implementation* of nutrient reduction efforts. If the state is going to take its efforts to reduce nutrient flows to Lake Erie seriously, it needs to seriously consider identifying and/or developing an organization that is equipped to play this role.

2. Ohio should work actively with other jurisdictions in the Lake Erie basin to establish a basin-wide monitoring and modeling effort that enables an integrated understanding of the ways in which specific nutrient reduction efforts may yield improvements in the quality of water in Lake Erie.

   If one is going to encourage and enable strong and consistent nutrient control efforts, it is necessary to build confidence that the actions required or taken will actually yield the kinds water quality benefits that are being pursued. This requires a strong scientific foundation that is achievable through basin-wide monitoring and modeling efforts. There are many valuable and credible scientific groups and organizations currently studying water quality in Lake Erie. However, their efforts tend to be focused on particular areas (like the Maumee River basin, for example), rather than across the entire water basin. Our interviews and investigations of other water basin programs suggest a need for a basin-wide monitoring and modeling effort that is viewed as credible by a wide array of stakeholders with interests in Lake Erie and the nutrient reduction efforts associated with it. It appears that the state can and should consider doing more in this area. While the state can and should consider looking at further integrating monitoring and/or modeling efforts across the entire Ohio-Lake Erie shoreline, developing a strong and coordinated multi-jurisdictional and basin-wide monitoring modeling approach for the Lake Erie basin as a whole should also be seriously considered.

3. Ohio should develop a coordinated system for tracking the implementation of nutrient reduction efforts in the Ohio Lake Erie basin, and work with other jurisdictions to assure that similar efforts are undertaken throughout the Lake Erie basin.

   It is a maxim of administration and management that one cannot manage progress without measuring it. Unfortunately, however, we found no evidence of any systematic effort to measure the progress of efforts to implement nutrient reductions across multiple programs in the Lake Erie basin. Indeed, it took months for our project team to track down and document the nutrient reduction efforts summarized in the inventory presented above. By contrast, in the Chesapeake Bay and in Tampa Bay, there are ongoing and systematic efforts to track nutrient reduction activities and their estimated impacts on ambient water quality. Developing a credible tracking and accountability system of this kind requires a sound scientific foundation and strong institutional capacities, both of which are described above. While developing these capacities and a tracking system based on them would require substantial investments in organizational capacities, these investments appear necessary if Ohio and other jurisdictions in the Lake Erie basin are to reduce nutrient loads to the Lake Erie basin and successfully combat the HABs that stem from them.

VIII. Conclusion

The contamination of the Toledo water supply in 2014 and recent research have made it clear that the State of Ohio and other jurisdictions in the Lake Erie basin face major challenges now, just as they did a half a century ago when pollution in Lake Erie drew national attention. The nature of this challenge is continuing, as human activities associated with "cultural eutrophication" and the seemingly inexorable march of global climate change appear likely to make concerns about nutrient enrichment and HABs in Lake Erie grow rather than recede over time.

In this context, it is perhaps re-assuring to find, as we do here, that multiple and major efforts are already underway to reduce nutrient loads in the Ohio Lake Erie Basin. In this report, we identify many hundreds of organizations discharging nutrients in the Lake Erie basin that are subject to regulatory requirements, as well as more than $100 million being spent annually to reduce phosphorus and nitrogen loads. We also find numerous efforts to use the nodal role of government to educate key stakeholders and the public on nutrient enrichment issues, and we see multiple public sector organizations pursuing nutrient reduction goals. Unfortunately, in spite of these efforts, it seems clear that they are not yet sufficient to address the problems at hand. The contamination of the Toledo water supply in 2014 was followed by another massive HAB the following summer in 2015. Clearly, it appears that the multiple and major efforts currently being undertaken are not yet good enough.

Here, we offer ideas regarding policy tools to reduce nutrient flows to Lake Erie for consideration by Ohio policymakers and natural resource administrators. We do not assert, at least at this point in time, that all of these suggestions must be immediately implemented. However, we do believe all of these suggestions are worthy of serious consideration, as political commitments across jurisdictions are solidified and allocations of nutrient reduction responsibility across jurisdictions and economic sectors are identified.

As this process occurs, we would suggest several areas of focus for further research and/or investigation. First, while we have sought to identify promising policy tools used by the CBP, the LISS, and the TBEP, a more comprehensive investigation of policy tools for nutrient reduction that are being used can and should be undertaken. The policy tools identified here focus on only three water basins in the US that are affected by nutrient enrichment. During the course of our investigations, we became aware that many states and regions are facing nutrient reduction challenges, and more could be learned about available nutrient reduction policy tools if one looked more comprehensively at a broader array of policymaking jurisdictions that are seeking to address nutrient enrichment problems.

Second, it is apparent from the discussions above that a key need is to further develop and build institutional capacities for nutrient reduction efforts in the Ohio Lake Erie basin. If this is to be done effectively in the Ohio Lake Erie basin and/or in the Lake Erie basin as a whole, a more detailed

investigation of the capacity building efforts undertaken in the Cheasapeake Bay, Long Island Sound, and Tampa Bay cases would be advantageous. Through this kind of effort, one could develop a series of steps and a potential action plan for Lake Erie nutrient reduction capacity development efforts.

Third, while this work has sought to identify policy tools for reducing both nitrogen and phosphorus in Lake Erie, there is evidence that dissolved reactive phosphorus is of particular concern in the Lake Erie basin (Ohio Phosphorus Task Force, 2013). For this reason, it would make sense to conduct follow up investigations to ascertain the extent to which current controls address dissolved reactive phosphorus, and to ascertain ways in which controls in this particular area could be developed across Ohio and the Lake Erie basin as a whole.

Fourth, there would be value in investigating the policy tools identified as being used in the CBP, the LISS, and the TBEP in greater detail in order to assess more comprehensively their utility in Ohio. In making this suggestion, we recognize that deeper consideration of these policy tools would benefit from recognition of multiple potential criteria regarding their advisability. Addressing nutrient reduction challenges in the Lake Erie basin requires policy tools that will be *effective* in reducing nutrient flows to the lake and in hampering the growth of HABs. It also means recognizing the *cost* of needed public sector interventions, as well as *burdens* that will need to be carried by multiple stakeholders whose lives and activities yield flows of phosphorus and nitrogen to the Lake Erie basin. Ultimately, perceptions regarding the *equity* with which those costs and burdens are distributed will affect the success of the overall effort. In this regard, it seems imperative for policymakers to engage with the agricultural community regarding its contributions to nutrient enrichment and the development of HABs, as well as with other stakeholders whose efforts hold the potential to reduce nutrient flows in the Lake Erie basin. Ultimately, an ongoing and broad-based effort may prove to be both most effective and most feasible.

And finally, there is also a need for policymakers and natural resource administrators in Ohio to recognize that a truly integrated Lake Erie basin nutrient reduction effort is necessary to make long term progress in combating excessive nutrient releases to Lake Erie. While the state's recent transfer of multiple nutrient reduction-related functions from the ODNR to the ODA can be interpreted as a way to protect agricultural interests, it may also hold potential to further integrate Ohio's nutrient reduction efforts. Further efforts to integrate policy interventions across institutions must take place not only in Ohio, but also across states and across the US-Canadian border. While efforts to build multi-jurisdictional agreements on the GLWQA's 40% phosphorus reduction goals are laudable, they will be effective only if they are followed by integrated efforts to understand current nutrient reduction efforts and develop multi-jurisdictional tracking and accountability structures to assure ongoing information flows that are necessary to measure progress against the goals that are established and improve upon them over time. Our reviews of several other water basin programs addressing nutrient related concerns in the US appear to demonstrate that this is possible. However, more could be learned from a follow up research effort to investigate other cross-national water management programs to identify lessons on how best to structure these programs to

assure both coordinated implementation and systematic means for holding jurisdictions accountable for successfully carrying out the water pollution control actions to which they have committed.

When Christopher Hood advanced his policy tools framework more than thirty years ago, he indicated that the "tools of government" both "detect" and "effect" what goes on in society. As we inventoried current nutrient reduction efforts, it became clear that governments in the US have been focusing heavily on the latter. As the State of Ohio works with other jurisdictions throughout the Lake Erie basin to address the watershed's "cultural eutrophication" challenges, particular attention should be given to developing and implementing organizational policy tools to *detect* changes in nutrient flows to Lake Erie and use the information gained to target subsequent efforts to *effect* change. If we can preserve, re-focus, and enhance the nutrient reduction efforts currently being undertaken, and couple this with improved efforts to detect, track, and publicly report on the implementation of policy tools intended to "effect" change, we may find that our overall efforts can meet the substantial nutrient reduction challenges that now face us.

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X. Appendices

Appendix 1: List of Basin-Wide Programs Investigated

Below, we list water-basin programs investigated as we conducted this research. We identify 28 programs which participate in the USEPA's National Estuary Program (NEP) and 4 programs that operate outside of the NEP framework.

Programs in the National Estuary Program (NEP)

1. Albemarle-Pamlico National Estuary Program
2. Barataria-Terrebonne National Estuary Program
3. Barnegat Bay Partnership
4. Buzzards Bay National Estuary Program
5. Casco Bay Estuary Partnership
6. Charlotte Harbor National Estuary Program
7. Coastal Bend Bays and Estuaries Program
8. Delaware Center for the Inland Bays
9. Galveston Bay Estuary Program
10. Indian River Lagoon National Estuary Program
11. Long Island Sound Study
12. Lower Columbia Estuary Partnership
13. Maryland Coastal Bays Program
14. Massachusetts Bays Program
15. Mobile Bay National Estuary Program
16. Morro Bay National Estuary Program
17. Narragansett Bay Estuary Program
18. New York-New Jersey Harbor Estuary Program
19. Partnership for the Delaware Estuary
20. Peconic Estuary Program
21. Piscataqua Region Estuaries Partnership
22. Puget Sound Partnership
23. San Francisco Estuary Partnership
24. San Juan Bay Estuary Partnership
25. Santa Monica Bay Restoration Commission
26. Sarasota Bay Estuary Program

27. Tampa Bay Estuary Program

28. Tillamook Estuaries Partnership

Programs Outside NEP

29. Boston Harbor Program

30. Chesapeake Bay Program

31. Great Lakes Program

32. Gulf of Mexico Program

Appendix 2: Permit Coding Methodology

This appendix summarizes procedures used to identify and code NPDES permits in the Ohio Lake Erie Watershed.

Identifying Permits within the Lake Erie Watershed

The Lake Erie Watershed includes 18 counties that are located completely within the watershed's boundary. The watershed also includes portions of 17 Ohio counties that are partially located within the watershed. For NPDES permits in these counties, we needed to identify which permitted facilities were within the Lake Erie Watershed to include in our inventory. To do so, we used the following steps for Major and Minor permits.

Major Permits – Each major permit includes a Fact Sheet that is posted on the OEPA website, and the Hydologic Unit Code (HUC) code (or River Reach number) of the receiving waters is included in that document. Because HUC codes and river reach numbers include two digit numerical indicators for major water basins, we were able to identify permits discharging to the Lake Erie Water basin through the "04" portion of the code, which signifies that the geographic location indicated lies within the Lake Erie Watershed (USEPA, 2016d).

Minor Permits – Because not all minor permits have Fact Sheets, we used an alternative approach to identify whether minor permits discharged to the Lake Erie basin. For these permits, we used publicly

available online Geographic Information Systems tools from the Ohio Department of Natural Resources (ODNR) to identify whether permits discharged to the Lake Erie water basin. The two tools we used were the ODNR's Earth Resource Information Network Watershed Report tool (http://gis4.oit.ohio.gov/ERINWatershed/) and ODNR's High Quality Watershed Interactive Map (https://gis.ohiodnr.gov/website/dsw/highqualitywatershed/). The ERIN tool was replaced by a new set of interactive GIS mapping tools on the ODNR website in early 2016. Both tools allow a user to type in a street address and determine if the address is located in the Lake Erie or Ohio River Watershed. Each NPDES permit includes address information that was used for this purpose.

Coding Nutrient Limits and Monitoring Requirements

For each traditional NPDES permit identified as discharging to the Lake Erie Watershed, we collected information on the county the permit was located in, permit number, major or minor status, the name of the receiving water, HUC code or river reach number, stream network, outfall number, discharge limits for phosphorus and nitrogen, and monitoring requirements for phosphorus and nitrogen. We then compiled the information collected using the data collection form below. Phosphorus and nitrogen limits were documented using concentration specified limits and loading kg/day outlined in the permit. In the case of nitrogen, limits on nitrogen ammonia (NH3), nitrite plus nitrate, and any other forms of nitrogen outlined in the final outfall of each permit were recorded separately in the data collection form. However, limits on nitrogen forms other than NH3 were not common. Limits based on season of the year were also documented.

To analyze the data compiled, we used the data collection forms created to populate a Statistical Package for Social Sciences (SPSS) dataset. In this dataset, we entered information on variables for major permit status, minor permit status, POTW status, Non-POTW status, presence of phosphorus limits, presence of nitrogen limits, presence of any nutrient limit (phosphorus or nitrogen), presence of monitoring requirements for phosphorus, presence of monitoring requirements for nitrogen, and presence of any nutrient monitoring required (phosphorus or nitrogen). Because each of these variables is dichotomous, we used the code "1" for presence and "0" for absence. A coding of "yes" for "nutrient limits" required the permit to have limits on either phosphorus or any form of nitrogen. A coding of "yes" for phosphorus required a limit on phosphorus. And a coding of "yes" for nitrogen required that at least one form of nitrogen be limited in the permit. The same coding structure was used for monitoring requirements. The information compiled through this effort can be found in Tables 1 and 2 of this report. For the major

permits we reviewed with phosphorus limits, we also compiled information on phosphorus concentration limits and it is presented in Table 3 of this report.

Sample Permit Data Collection Form:

County	XXXXXXXX
Applicant Name	XXXXXXXX
Application Number	XXXXXXXX
OEPA Permit Number	XXXXXXXX
Effective Date	May 1, 2013
Expiration Date	January 31, 2018
Receiving Water	Pike Run
Stream Network	Ottawa River to Auglaize River to Maumee River to Lake Erie HUC Code: River Reach No: 04100007-017
Location	Lat: 40 N 47' 03"; Long: 84 W 07' 20"

Outfall	Effluent Characteristic	Concentration Specified Units				Loading kg/day		
		Max	Min	Weekly	Monthly	Daily	Weekly	Monthly
Final Outfall - 001 - Final	Nitrogen – Summer			1.5	1.0		8.5	5.7
	Nitrogen – Winter			4.5	3.0		25.5	17.0

	Phosphorous			1.5	1.0		8.5	5.7
	Discharge	Effluent loadings based on average design flow of 1.5 MGD.						
Downstream-Nearfield Monitoring - Final	Nitrogen – Summer							
	Nitrogen – Winter							
	Phosphorous							
	Discharge							
SSO Monitoring - 300 - Final	Nitrogen – Summer							
	Nitrogen – Winter							
	Phosphorous							
	Discharge	A sanitary sewer overflow is an overflow, spill, release, or diversion of wastewater from a sanitary sewer system. These overflows shall be monitored when they discharge. Only sanitary sewer overflows that enter waters of the state, either directly or through a storm sewer or other conveyance, must be reported under this monitoring station.						

Appendix 3: Web-Links to OEPA Permit Lists

The table below provides website links used to collect data on water pollution permits issued by agencies of the State of Ohio.

Permit Type	Website Link
OEPA- Div of Surface Water: Wastewater NPDES Permits	http://www.epa.ohio.gov/dsw/permits/individuals.aspx
OEPA – Div of Surface Water: MS4 Phase I Permits	http://www.epa.ohio.gov/dsw/storm/index.aspx#108452492-issued-permitspermittee-lists
OEPA – Div of Surface Water: MS4 Phase II General Permit	http://wwwapp.epa.ohio.gov/dsw/permits/MS4_baseline.pdf
OEPA – Div of Surface Water Stormwater: Construction General Permit	http://wwwapp.epa.ohio.gov/dsw/permits/Construction.pdf
OEPA – Div of Surface Water: Stormwater Industrial General Permit	http://wwwapp.epa.ohio.gov/dsw/permits/INDUS.pdf
OEPA – Div of Surface Water CAFO Permit List	http://www.epa.ohio.gov/dsw/cafo/index.aspx#126567134-cafo-npdes-permits-in-ohio
ODA – Livestock Environmental Permitting CAFF Permit List	http://www.agri.ohio.gov/apps/lepp_permits/dlep_permits.aspx
OEPA - CSO Communities List	http://www.epa.ohio.gov/portals/35/cso/OH%20CSO%20Inventory_4_2016.pdf

Appendix 4: Non-Point Source (NPS) Programs

This appendix provides a list of state and federal programs for which we were able to inventory expenditures that directly or indirectly target non-point source pollution in the Lake Erie Watershed. There are a total of 21 programs in our program inventory. Please see Appendix 5 for information related to the activities and expenditures of these programs in recent years.

State NPS Programs

1. ODNR – Nature Works
2. OEPA – Surface Water Improvement Fund
3. OEPA- Water Resource Restoration Sponsorship Program
4. ODSA – Alternative Stormwater Infrastructure Program
5. OPWC – Clean Ohio Greenspace Program
6. Lake Erie Commission – Lake Erie Protection Fund

Federal NPS Programs

7. EPA – Section 319 and Urban Waters Grant Programs
8. DOI – Land and Water Conservation Fund
9. DOI – USFWS North American Wetlands Conservation Act
10. DOI USFWS National Coastal Wetlands Conservation Grant Program
11. DOC-NOAA – Coastal Zone Program (4 types of coastal grants)
12. Multi-agency – Great Lakes Restoration Initiative
13. Multi-agency – Sustain Our Great Lakes Program
14. USDA – Agriculture Conservation Easement Program
15. USDA – Conservation Technical Assistance
16. USDA – Conservation Stewardship Program

17. USDA – Conservation Innovation Grants
18. USDA – Environmental Quality Incentives Program
19. USDA – Conservation Reserve Program
20. USDA – Conservation Reserve Enhancement Program
21. USDA – Forest Legacy Program

Appendix 5: Funding Levels for State and Federal NPS Programs

This appendix highlights the activities and expenditures of state and federal non-point source programs operating in the Lake Erie watershed that our project team was able to identify and inventory. Where possible we outline expenditure and program output information for the years 2010-2015. However, the information that was publically available for each program varied. Expenditure and program output information for USDA Farm Bill programs are provided in the Findings Part I section above rather than in this appendix.

State Funded Non-Point Source Programs

ODNR Nature Works Land Acquisition Efforts in the Lake Erie Watershed since 2010

	2010	2011	2012	2013	2014	2015	Total
# of Projects	1	1	1	1	0	2	6
Funding for Projects	$56,250	$12,659	$9,890	$20,000	0	$37,463	$136,262
Total Acres Protected/Restored	N/A*	20	5.128	.62	0	40+**	65.748+

Source: ODNR (2015)
Note: The vast majority of projects funded by these programs relate to the development of recreational facilities rather than land protection/restoration. However, because the land acquisition efforts are likely to result in the maintenance of lands in natural condition in many instances, they are likely to result in nutrient reduction benefits. Many projects also receive LWCF grants as well.
* City of Green Park Expansion project description did not provide acreage protected for that effort.

OEPA SWIF Funded Projects in the Lake Erie Watershed from 2010-2015

SWIF	Number of Grants	Funding
2010	5	$ 283,868
2011	-	-
2012	8	$ 602,000
2013	-	-
2014	9	$ 867,059
2015	9	$ 866,434
Total	31	$ 2,619,361

Source: (OEPA-SWIF, 2012); (OEPA-SWIF, 2014); (OEPA-SWIF, 2010)

WRRSP Program Activities in the Ohio Lake Erie Watershed 2010-2015

Comprehensive Management Plan Years	Number of Projects on Intended Projects List	Funding
2010	14	$ 20,158,720
2011	8	$ 8,374,371
2012	9	$ 10,421,072
2013-2014	11	$ 12,283,570
2014	6	$ 4,589,220
2014-2015	2	$ 6,037,100
2015-2016	6	$7,803,970
Total	**56**	$69,668,023

Source: WPCLF Comprehensive Management Plans 2010-2015

ODSA Program Activities in the Ohio Lake Erie Watershed 2010-2015

Project	Purpose	Cost
Shoppes at Parma storm water infrastructure project	Storm water infrastructure/ green infrastructure	$5,000,000

Source: Ohio Development Services Agency. (n.d.).

Clean Ohio Fund Green Space Conservation Program Projects Funded within the Lake Erie Watershed from 2010 to 2015

Total Projects	**137**
Total Funding	$ 57,705,702
Total Acres protected or restored	9,595

Source: Ohio Public Works Commission Updated Project List (January 2016).

Lake Erie Protection Fund - Overview of "On the Ground" Lake Erie Protection Fund Activities 2010-2015

Year	# of Projects	Funding
2010	4	$58,582
2011	4	$60,000
2012	1	$15,000
2013	3	$45,000
2014	1	$15,000
2015	0	0
Total	13	$193,582

Source: Lake Erie Protection Fund Grants Summery (2015)

Federally Funded Non-Point Source Programs[33]

EPA – Section 319 and Urban Waters Grant Program Project Funding within the Lake Erie Basin 2010-2015

319 Program	Number of Grants	Funding
2010	6	$3,655,916
2011*	8	$2,448,266
2012	8	$2,656,209
2013*	12	$1,365,476
2014	10	$2,609,665
2015	7	$2,903,422
Total	51	$15,638,954

Source: Urban Waters Small Grants (2015); OEPA 319 Grants List

Note: Projects include those that directly and indirectly target nutrient reduction. There was only one project indirectly targeting nutrients from 2010-2015.

* The Urban Water Program funded two projects in the 2010-2015 timeframe -- one in 2011 which cost $59,680 and one in 2013 which cost $60,000. Total funding provided to the two projects was $119,680.

[33] USDA Farm Bill Program details are presented in the Investments in Non-Point Source Policies and Programs Section above.

DOI – LWCF and USFWS Land Acquisition Projects Funded between 2010-2015 in the Lake Erie Watershed

Projects	Number of Projects (LWCF/USFWS)	Funding (LWCF/USFWS)	Acres Protected
2010	1 (1/0)	**$ 70,000** ($ 70,000/$0)	1.5
2011	4 (3/1)	**$ 1,202,345** ($ 202,345/$ 1,000,000)	82.47
2012	5 (3/2)	**$ 314,440** ($ 164,440/$ 150,000)	203.5
2013	2 (1/1)	**$ 145,000** ($ 70,000/$ 75,000)	58.62
2014	1 (0/1)	**$75,000** ($ 0/$ 75000)	115
2015	4 (1/3)	**$ 1,194,399** ($ 44,399/$ 1,150,000)	2370.42
Total	17	**$ 3,001,184** **($** 551,184/$ 2,637,760)	2831.51+*

Source: Ohio Department of Natural Resources (ODNR) Outdoor Recreation Facility Grants; USFWS North American Wetland Conservation Grants (2015)

Note: There were no projects identified in the Lake Erie Watershed in Ohio between 2010-2015 by the National Coastal Wetlands Conservation Program.

* Does not include acreage conserved through a 2011 USFWS funded project.

DOC – NOAA – Coastal Zone Program (four types of coastal grants)

NOAA-ODNR Coastal Management Grants 2010-2015 in the Lake Erie Watershed

NOAA-ODNR Coastal Management	Number of Projects	Funding
2010	4	$ 3,448,334
2011	6	$ 385,070
2012	4	$ 2,078,611
2013	1	$ 105,000
2014	3	$ 479,998
2015	3	$ 1,259,692
Total	**21**	**$ 7,756,705**

Sources: (ODNR, 2016); (ODNR- Coastal Management Grants, 2016); (NOAA, 2016)
Note: Figure includes projects/funding from the Coastal and Estuarine Land Conservation Program (CELCP), Coastal Management Assistance Grants (CMAG), Coastal Program Enhancement (CPE), and Areas of Concern Land Acquisition Grants (AOC Acquisition).

Multi – Agency – GLRI and Sustain our Great Lakes programs

GLRI Funded Nutrient-Related Projects 2010-2015 and Sustain Our Great Lakes Conservation and Restoration Projects 2010-2015

	GLRI		Sustain Our Great Lakes	
	Grants	Funding	Grants	Funding
2010	42	$ 23,601,600	2	$1,072,644
2011	40	$ 19,431,107	4	$1,034,548
2012	43	$ 19,991,115	2	$740,000
2013	40	$ 17,585,633	5	$2,848,329
2014	52	$ 29,862,880	1	$95,000
2015	11	$ 19,295,340	1	$950,000
Total	233	$ 129,767,675	15	$6,740,521

Source: GLRI Project Listing (2015); Sustain Our Great Lakes Project Listing (2015b):

Note: Because the Sustain Our Great Lakes receives a portion of its funding from GLRI there is likely some duplication represented in this table.