**Toward a Cleaner Lake Erie Working Group**

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August 28, 2018

Chairman Hackett, Chairman Hill, and members of the Toward a Cleaner Lake Erie Working Group. Thank you for the opportunity to testify today. I am Dr. Cathann Kress, Vice President of Agricultural Administration and Dean of the College of Food, Agricultural, and Environmental Sciences at The Ohio State University. I appreciate the opportunity to highlight the great work of our faculty, staff, and students to address restoring Lake Erie. The issues in the lake and in Ohio’s inland rivers and streams require a multi-disciplinary approach to answering complex issues and wicked challenges.

1. **Trends in region**

The Lake Erie basin contains some of the most productive farmland in the world and is critical for current and future global food production; eleven million people also rely on Lake Erie for clean drinking water. Since the 1990’s the algal bloom size, frequency, and toxicity in the Western Lake Erie Basin has been increasing. However, the impact and potential responses to the algal blooms has implications for more than just farmers and people in northwest Ohio. Decisions made will impact agriculture across the region, the Lake Erie ecosystem, the local economy such as tourism, property values, and other industry, and likely impacts we have yet to fully understand in terms of food costs, health, and other significant issues.

Essentially, we all want the same thing - to preserve Lake Erie. Where there is disagreement however, is how best to ensure that future. A significant question at the center of this issue is how do we sustain the ecosystem quality, viable agricultural production, and ensure a safe and affordable food and water supply for Ohio and the region ALL AT THE SAME TIME?

Immediately after my testimony, you will hear from some of the scientists who are working to examine these issues and they will offer specifics about what is known at this time- from long-term studies, through data analysis and other evidence.

You’ll also hear about some of the lingering puzzles such as: why dissolved reactive phosphorous is increasing when changes in agricultural efforts should have reduced the risk, how can we understand the drivers of toxicity which are harder to predict than drivers of blooms, and the potential impact of stored soil phosphorous.

1. **Dynamics Impacting Water Quality**

Most of the research which has been done on dynamics points to land use, the capability to do instream research is a relatively new capability which means our data has a gap not fully explored. Based on land use, the focus for the dynamics I will discuss will be on agricultural issues but given our School of Environment and Natural Resources, Stone Lab, and partnerships with other colleges within The Ohio State University, we are attempting to more broadly address all significant dynamics needing consideration.

**Tillage dynamics**

There has been a significant increase in use of conservation tillage in the Western Lake Erie Basin since the 1990s; current estimates suggest that roughly 63% of Western Lake Erie Basin cropland has some type of conservation tillage. Conservation tillage is estimated to have decreased erosion, which would be expected to decrease loss of sediment-bound phosphorous (and total phosphorous).

The impact of conservation tillage on the phosphorous issue is one of the major areas for further research (particularly new work focused on the Maumee River basin; much of the published literature is from other areas). A key challenge is to find ways to preserve all the good that conservation tillage has done to reduce erosion and loss of particulate phosphorous while also reducing loadings of dissolved reactive phosphorous. The proper management of conservation tillage land is a key topic for future work for both our researchers and our extension specialists working directly with producers on-site.

**Tile drainage**

Tile drainage systems are essential components of productive cropping systems in the Western Lake Erie Basin; roughly 86% of agricultural land in the Maumee River watershed is tile drained, however, subsurface tiles are known to increase conveyance of phosphorous through subsurface pathways.

**Economic Efficiencies of Phosphorous Reduction**

Assuming we are changing agricultural policy to prioritize efficiency instead of yield - there are options – such as paying farmers to implement conservation practices which would be cheaper than a mandate.

Most Cost Efficient Way to Reduce Phosphorous



**Climate Trends**

About one-third of the increased dissolved reactive phosphorous load in the Maumee River since 2002 is due to increased runoff volume. Higher rainfall/runoff years (particularly spring runoff) are strong predictors of the likelihood of a harmful algal bloom in Lake Erie. Warmer temperatures also contribute to warmer lake conditions and increases the frequency and severity of algal blooms. Predicted climate changes in coming decades may make it more difficult to meet phosphorous-reduction targets, even if there is full compliance with regulations and best practices.

**Conservation practice use**

Natural Resources Conservation Service estimates that 99% of cropland acres in Maumee River watershed have at least one conservation practice. There is still a lot of room for improvement to increase conservation practices:

* 1. 35% of cropland has practices that address all five Natural Resources Conservation Service resource goals
  2. 58% of cropland receives phosphorous applications at or below crop needs
  3. 13% of acres still get some winter application

Adoption of 4R nutrient stewardship practices (right fertilizer source at the right rate, at the right time and in the right place), including subsurface placement, can reduce phosphorous losses to some extent, but additional conservation practices are needed.

This information leads us to ask, what is driving farmer behavior to adopt practices beneficial to reduce phosphorous in Lake Erie?

1. **Broader Implications**

Behavioral Research

The Ohio State University College of Food, Agricultural, and Environmental Sciences faculty, most notably Dr. Robyn Wilson, have conducted repeated surveys in the Maumee River watershed since the early 2000s. Results highlight drivers of farmer behavior and point to areas for targeted interventions. A majority of the farming population is using or is willing to consider using best management practices to reduce risks of phosphorus losses from their fields. As a rule of thumb, one-third use or are willing to incorporate best practices, one-third are hesitant but considering use of best management practices, and one-third are unlikely to change their practices in short-term. Highlights of 2018 survey results:

* + - 86% regularly use soil tests
    - 74% willing to use subsurface placement in future
    - 55% willing to use cover crops in future, but unlikely to do so without incentives to offset short-term costs and risks

Models suggest that if all farmers who indicate a willingness to adopt 4Rs (Right Time, Right Place, Right Rate, Right Source), subsurface placement of fertilizer, and use cover crops were to do so, the Maumee River would be able to realize the 40% reduction in total phosphorous and dissolved reactive phosphorous in most years. The biggest barrier to adoption is not concern or knowledge about nutrient loss or water quality, rather, many farmers are not convinced that best management practices will be feasible to implement or likely to be effective at decreasing phosphorous-losses. Voluntary adoption will not occur without policies and programs to build farmers confidence in their ability to implement cost-effective solutions. Financial and logistical barriers to using best management practices are real and create difficulty in rapidly expanding use of many practices. Evidence of practice effectiveness has been inconsistent and lacking in the region; it may not always be clear what set of practices are a best fit for a particular farm or field. In addition, farmers will need better cost-benefit information, site-specific decision support tools, and technical assistance in order to more rapidly adopt and execute the placement of recommended practices. Demonstration farms offer promise, but critical research on their impact and effectiveness at motivating changes in behavior is required. More information about the actual costs and benefits associated with specific best management practices is needed to address farmer concerns.

Accelerated adoption of recommended practices is necessary, as current adoption rates of recommended practices range from only 20-50% on average (Prokup et al., 2017). A recent panel study (by Beetstra et al) compared 2015 adoption levels to 2017 adoption levels among the same group of farmers in the Western Lake Erie Basin. Preliminary results from the panel study found that overall adoption rates between 2015 and 2017 were essentially the same for cover crops and subsurface placement (i.e, approximately 35% for subsurface placement, and 28% for cover crops)



Graphic: Increase in actual use (2015 and 2017) and interest/willingness to use (2016 and 2018) various best management practices in Maumee River watershed.

**Precision Agriculture (John Fulton and colleagues)**

As a national leader in Precision Agriculture that includes site-specific management of nutrients, John Fulton and his colleagues are focused on improving placement of nutrients and nutrient use efficiency. Imagery is providing the ability to track crop health, vigor and stress of corn over the growing season and help inform in-season application decisions on corn (Khanal et al., 2018).

Research continues on developing improvements and best management practices for broadcast fertilizer spreaders to more accurately place nutrients while meeting expectations of the 4Rs (Right Time, Right Place, Right Rate, Right Source) to nutrient stewardship (Fulton et al., 2013).

**Tri-State Guidelines (Steve Culman, Laura Lindsey, etc.)**

From 2014 – 2017, 300+ on-farm strip trials were conducted across Ohio evaluating corn, soybean and wheat response to nitrogen, phosphorous and potassium fertilizer. Yield responses to phosphorous and potassium fertilizer in soils at or above the current maintenance range were very rare. Long-term data from three sites show that when Ohio soils are in the current maintenance range, they can supply sufficient phosphorous and potassium to meet corn and soybean demand for many growing seasons without fertilization. One important note, farmers have long been in a race to increase yield as an indicator to being a successful farmer. We are now asking farmers to forgo yield as the measure of record, and to focus on maximizing profitability by not focusing on yield. Corn, soybean and wheat are yielding more grain with less nutrients; grain nutrient removal per bushel of grain is lower than it was twenty years ago.

When soil test phosphorous levels are in the current Tri-State recommended range (i.e., maintenance range), the responses of corn and soybean to phosphorus fertilizer are very rare. Over-fertilization (i.e., applying twice as much phosphorous than is removed in crop grain) did not appear to build soil test phosphorous at these three sites. Implications for these findings are unclear but call into question a sole reliance on the build-up and maintain philosophy of the Tri-State Fertilizer Recommendations.

**On-Field Ohio (Libby Dayton and Jeff Hattey)**

The On-Field Ohio tool is based on Edge of Field research funded mainly by United States Department of Agriculture and commodity groups. The research used on-field observation stations to connect different combinations of field characteristics (slope, soil type, soil test levels), crop rotations, and farm management practices with measured levels of phosphorous runoff in surface and drainage tile waters. Based on this research, the tool generates customized individual farm-level simulations that link user-provided data about soil test levels, crop rotation and tillage history, and use of various management practices to predict phosphorous-losses from surface vs. subsurface pathways and distinguishes particulate from dissolved phosphorous. College of Food, Agricultural, and Environmental Sciences faculty and staff are actively training individual farmers and their farm advisors to use the tool to assess the phosphorous-losses associated with current farm management behaviors and to identify the potential impacts on phosphorous-losses of alternative farm management strategies for their specific farm. Simulations for representative soils and fields across the state using the tool demonstrate that significant predicted reductions in phosphorous-losses can be achieved by shifting crop rotation, tillage, and fertilization practices. Sediment bound-phosphorous runoff is driven mostly by factors related to erosion (like crop rotation & tillage practices, as well as in-field erosion management strategies). Surface dissolved and tile total and dissolved phosphorous runoff are significantly influenced by soil test phosphorous-levels, as well as fertilizer/manure application rates and placement methods. Bottom line – because every farm has a unique setting and history, it is difficult to provide sweeping recommendations for farm management that should be used in the same way by all farmers in every corner of the state. The tool uses information about a particular farm to identify the specific management strategies that would be most likely to reduce phosphorous-losses at that location.

A key point to keep in mind is that the current version of the tool is a first step but can still be improved. For example, we would like to incorporate data from an expanded number of edge-of-field study sites to encompass a wider range of Ohio counties and management practices. We also envision a future revision of the tool that would incorporate more years of data to make the statistical model that underlies the On-Field Ohio tool’s estimates more robust and reliable. Finally, we see opportunities to improve the user interface and output options for the On-Field Ohio tool based on feedback from the first year experience with farmer and consultant users.

**Manure Management Work (Glen Arnold)**

Manure operations (especially in northwest Ohio) struggle to find time and land to apply manure; crop farmers imported a lot of phosphorous in the form of inorganic fertilizer to the region; if we can find ways to incorporate more manure as a source of nutrients on regional crop fields, this would help reduce total phosphorous imports and could improve soil health/quality. The Ohio State University Extension faculty, Glen Arnold has been doing extensive on-farm and on-station field trials to develop new methods that would allow manure to be spread on more cropland. Promising results suggest that liquid manure can be used as a side-dress on growing corn and wheat without damaging the plants and can serve as a reliable source of nutrients; this new method provides a new time window for manure application and is gaining acceptance among producers in Ohio.

**Multi-Model Assessment (Jay Martin and Margaret Kalcic)**

Efforts are underway by five different Soil and Water Assessment Tool modeling groups to ‘pool’ their models in order to get a more robust estimate of the impacts of different configurations of best management practices on reducing phosphorous-runoff in Maumee Watershed. Funded by Harmful Algal Bloom Research Initiative, results suggest that it is possible to maintain production and improve water quality at the same time. Soil testing and adhering to 4Rs (Right Time, Right Place, Right Rate, Right Source) is important starting point and subsurface placement of fertilizer is one of most promising practices in our models. Targeting best management practices works better than random placement but widespread adoption will be needed; for instance, scenarios that approached the targets required multiple practices on over half of farm fields across the Maumee watershed. It will be important to mix/match best management practices to fit with different farmer preferences and situations. There are multiple pathways which will help meet 40% reduction targets. It will be easier to meet the target for total phosphorus (TP) than for dissolved reactive phosphorus (DRP). Bottom line – to achieve goals, need to see adoption of multiple best management practices on more than 50% of fields. Additionally, the project used heavy stakeholder engagement/input to improve the models and to ensure agricultural and conservation groups are aware of and participate in model development and interpretation of results. This engaged approach serves as a role model for future efforts to continuously improve the watershed models we use to guide best management practices and conservation program implementation.

There is not consistency between The Ohio State University-led multi-model Soil and Water Assessment Tool effort and identification of ‘distressed’ watersheds by Ohio Environmental Protection Agency. Based on this data, we are unclear about the science behind the statement that these watersheds are distressed "due to increased nutrient levels resulting from phosphorus attached to soil sediment" and are not confident that soil sediments are the cause of increased dissolved reactive phosphorous to Lake Erie. There is strong overlap between the Harmful Algal Bloom Research Initiative multi-model critical source areas for dissolved reactive phosphorous and these proposed "watersheds in distress." However, the multi-model critical source areas are derived from model simulations rather than measured data, so agreement or disagreement with these areas should not necessarily be cause to support or not support the Executive Order.

**Economic and Policy Work (Brent Sohngen and colleagues)**

Reliance on voluntary approaches to promote farmer adoption of best management practices must overcome the financial and logistical problems that discourage or prevent many farmers from using new practices (most of which do not offer direct financial benefit to the farm operation). Public cost-share or subsidies for best management practices adoption is often required, but can be expensive – particularly if not targeted to individual fields or sub-watersheds that are responsible for a greater share of nutrient losses to Lake Erie. The annual federal Farm Bill conservation program payments to Ohio Farmers has reached $80 million per year in 2016 (includes Conservation Reserve Program, Environmental Quality Incentives Program, etc.). $32 million of this was spent in the Lake Erie Basin (about $8/acre of cropland) and Conservation Reserve Program acres in the Maumee basin jumped from zero in the early 1980s to roughly 130,000 acres since 1990; they have been relatively flat since that time. Most conservation programs in the Western Lake Erie Basin to date have focused on reducing soil erosion. While soil erosion rates have declined, the amount of sediment-bound phosphorous has reduced less quickly. This suggests that there needs to be more effort to focus on practices that reduce dissolved phosphorous losses. Where we can find win-win solutions (e.g., best management practices that make farms more profitable while also reducing runoff) – adoption is usually rapid.

Market-based approaches to incentivizing conservation practice adoption have not been widely used in Ohio, but economists believe they can produce greater gains for less cost. Example: Tradable pollution permits (cap and trade). Ohio does have mechanisms for nutrient credit trading (e.g., the successful Alpine Cheese program developed with Ohio State University leadership in the Sugarcreek Watershed), but the model has yet to be adopted in other areas of the state. For a nutrient credit trading program to succeed, there must be an organization (usually a regulated point-source) that has sufficient resources and a financial incentive to invest in paying to improve best management practices use that reduces nonpoint runoff (because that would be less expensive than implementing further point-source reduction solutions). At present, there are not many regulated point-source actors.

Economic impacts of Lake Erie Harmful Algal Blooms

A number of faculty in the Department of Agricultural, Environmental, and Development Economics have attempted to quantify the economic impacts of Harmful Algal Blooms to individual landowners and the commercial tourism and fishing industry around Lake Erie. Surveys suggest that Lake Erie anglers spend $67 million/year (with multipliers, = $114 million/year to local economy); Harmful Algal Blooms have reduced spending by 13-21%. Beach closures due to Harmful Algal Blooms are estimated to cost roughly $8 million. Home values in Grand Lake/St. Mary’s and Buckeye Lake were reduced by an estimated $152 million due to HABs; no studies have been completed to come up with an estimate of the impacts of Harmful Algal Blooms on Lake Erie shore property owners (but there is an active project underway). Overall impacts of Harmful Algal Blooms estimated by Howard et al (2017) are up to $480 million/year. Estimates of Net Social Benefits (benefits – costs) from expanded efforts to reduce phosphorous losses and Lake Erie Harmful Algal Blooms are ongoing in the Department of Agricultural, Environmental, and Development Economics (using integrated assessment models).

Costs of Harmful Algal Blooms Reduction

Few studies have been done to estimate the total direct and indirect costs of implementing programs to reduce Harmful Algal Blooms on farmers and taxpayers. Sohngen did a study in 2015 to compare the estimated costs and benefits of implementing a phosphorous tax; they found that achieving a stable reduction in phosphorous losses would increase phosphorous fertilizer prices by 138% and cost farmers $38 million/year, or $8/acre. Estimates of costs for implementing best management practices suggest that farmers in Ohio watersheds might require payments to farmers of roughly $27/acre to use cover crops – cover crops are the most cost-effective way to reduce phosphorous losses, $63/acre to follow nutrient management plans, and $108/acre to install filter strips. The cheapest approach would appear to be to implement a direct payment to farmers who demonstrate phosphorous reduction, a phosphorous tax or market-based trading program (cap and trade).

Surveys of the Ohio general public done by faculty in the College of Food, Agricultural, and Environmental Sciences indicate a high level of concern about water quality problems (particularly with respect to Lake Erie). The surveys also indicate a willingness to contribute to an expanded public effort that would reduce Harmful Algal Blooms (equal to roughly $150 million/year for every 10% reduction in Harmful Algal Blooms frequency or severity); or about $480-$600 million/year to achieve the 40% reduction goal set by the International Joint Commission.

1. **Research Gaps and Priorities**

It’s clear that even with all the research and analysis to date, the lack of detailed information on actual farm practices at the field level and over time in the basin limits our ability to fully document and model fertilizer application and evaluate the effectiveness of changes. These changes include practices such as expanding adoption of 4R (4Rs (Right Time, Right Place, Right Rate, Right Source) practices and more realistic models of how changes in practices affect nutrient runoff. Farmer surveys, especially if the survey pool is sufficiently large and representative, can help in this regard, as would more detailed reporting of local practices. Collaborative agreements with private sector actors (particularly nutrient service providers) are being actively explored to help increase availability of field-level data on actual soil fertility and fertility management behaviors over time, while protecting privacy interests of farmers.

Other areas worthy of further consideration include the cost/benefits to farmers associated with individual conservation best management practices and the ways these costs/benefits vary by farm type and location. Particularly for management of manure (where there is little research). Overall comparisons of the relative costs and benefits to the farm and agribusiness sector, fishing/tourism industries, citizens/taxpayers, landowners, and ecosystem services associated would prove useful in determining future policies and incentives. This could also ensure effective ways to make nutrient trading programs more viable and successful in Ohio.

Additionally, research about the potential implications and benefits of greater use of manure as a fertilizer source for soil health, with particular attention to optimal use of manures that minimize risks of nutrient runoff to waterways is important. As is continuing to improve techniques for better utilization of manure in Ohio crop production.

Legacy phosphorous dynamics are a major area in need of further research. Dr. Jay Martin is principal investigator on a major new United State Department of Agriculture grant that will partner with private sector nutrient service providers to explore the extent of high-legacy phosphorous soils in the state, and to test how different approaches to crop and soil management are drawing down excessive soil phosphorous levels. This is a crucial gap to be addressed.

Looking to the future, it’s not just research that’s needed but more effective tools. We are working with Natural Resources Conservation Service administrators to see how and when the revised Phosphorous Index / On-Field Ohio Tool could replace the old index for the purposes of conservation program planning and implementation. This tool was designed to replace the old Ohio “Phosphorous Risk-Index” which was based more on crude qualitative rating scales.

1. **Role of The Ohio State University**

The Ohio State University can provide assistance including state campus components such as the twelve research stations which make up the [Ohio Agricultural Research and Development Center](http://www.oardc.ohio-state.edu/), Extension, and Stone Lab, and partnerships among all the colleges. The Ohio State University Research and Extension has developed a suite of information that can help inform the policy process and find a pathway forward in an agreement between stakeholders to improve water quality in Ohio’s streams, rivers, and lakes.

The significance of The Ohio State University’s research and other partners in the region will continue. While many programs to date have been focused on reducing soil erosion, there is reason to increase research in other areas. For example, market based solutions to incentivizing conservation practices have not been utilized at all. Economists believe they can produce greater gains at a fraction of the cost. Furthermore, incentivizing manure storage remains a critical component as well. Earlier, I mentioned Dr. Robyn Wilson’s behavioral research. Her data gives us a strong indication about practice adoption. This will be valuable information for the group to consider.

The Tri-State Fertilizer Guidelines have been reviewed and ultimately remain similar.  The guidelines have been refocused examine maximizing farmer profitability. On-Field Ohio has been developed and we should focus on this as an effective tool for minimizing run-off risk by utilizing soil types, slope, and farmers inputting soil test levels. To do so will require training and continuing to enhance its interface.

With over 140 faculty and staff just in our college conducting research and programs related to water quality, there is still a lot we need to know. We need to know the role of the intensified rain and drought seasons. There is strong evidence that weather is the single biggest driver of the problem. We need more overall comparisons of the relative costs and benefits to the farm and agribusiness sector, fishing/tourism industries, citizens/taxpayers, landowners, and ecosystems associated with the Western Lake Erie Basin. There is also a need for more information on the cost benefits of manure management.

Those of us at The Ohio State University remain committed to our land grant university mission and serving the people of our state. We believe the solutions are in the science and implementation of the findings. Our researchers are working in the areas necessary to assist decision-makers, producers, environmentalists, and citizens as we seek to preserve Lake Erie. In addition, the Ohio State University Extension is a key partner in the implementation and communication of the findings. We thank you for your support of our efforts and will work diligently to provide the unbiased and critical research and data needs for the future.